



Effect of Temporal Variation in Mineralization of Nutrients through Sewage Sludge, Farm Yard Manure and Vermicompost in Soil

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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

Soil amendment by organic matter (O.M.) has been widely accepted as an efficient nutrient-management technique in agriculture. The study was conducted as pot culture experiment at the Rajiv Gandhi South Campus, Barkachha Banaras Hindu University (B.H.U.) Mirzapur, which is

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located in the Vindhyan zone of Mirzapur district at 25° 10" latitude, 82° 37" longitude with an altitude of 427 meters above the sea level. The soils of the study region are mostly having poor fertility and shallow depth. Different sources of organic manures Sewage Sludge (S.S), Farm Yard Manure (FYM) and Vermi-Compost (V.C.) with different doses (10, 20 and 30 grams) were applied in pot along with soil and were incubated for 90 days. Required amount of water was added to soil in order to keep it moist as and when required. pH, electrical conductivity(E.C) , O.M. and nutrient content (N, P, K and S) had shown significant changes due to different treatments applied in soil. Applications of organic amendments in this study indicated considerable changes in the basic soil physio-chemical properties, different levels of available nutrient and their release pattern. With increase in doses of S.S and V.C. soil pH also increased but, it was decreased with increase in doses of FYM. Increase in the dose of S.S., F.Y.M. and V.C. had increased the E.C. and O.M. of soil. The available N content decreased with increase in the incubation interval. The available P increased from 30 Days After Incubation (DAI) to 60 DAI but it decreased at 90 DAI. Availability of S content increased with increase in duration of incubation period.

Keywords: *Organic matter; sewage sludge; farm yard manure; vermicompost; electrical conductivity; days after incubation.*

1. INTRODUCTION

Soils are vital to life, as it provide the medium for plant growth, habitat for many insects and other organisms, act as a filtration system for surface water, carbon storage and atmospheric gas maintenance. A significant soil function is to store and supply plants with nutrients. Soil fertility is called the capacity to perform this role. The amount of clay and O.M. in a soil directly affects its fertility. In particular, higher levels of clay and O.M. may result in greater soil fertility. Maintaining soil quality is the most efficient way of ensuring enough food to sustain life. Sewage sludge mixtures with biochar for vermicomposting resulted in higher reproduction rates, and thus could allow faster and more efficient conversion of sewage sludge into vermicompost [1]. FYM is the most common natural fertilizer and one of the most effective soil fertilizers [2]. Mineral, organic and natural fertilization also promotes the growth of microorganisms as a major source of nutrient conversion enzymes in soils [3]. FYM supplies all the major nutrients (N, P, K, Ca, Mg, S) and micro-nutrients (Fe, Mn, Cu and Zn) required for plant growth. It therefore serves as a mixed fertilizer. FYM also enhances the capacity to hold soil water. Vermicomposts are materials derived from earthworms and microorganisms promoting the biological deterioration of organic wastes. Decreased of soil pH due to the application of organic manures in the range of 0.4–0.9 units compared with the control. In contrast, the Soil Organic Carbon (S.O.C.) content, mineral N, available P and available K increased distinctly due to the application of all types of organic manures [4]. One of the unique

features of vermicompost is that many of the nutrients are converted to their usable forms during the cycle of processing of different organic wastes by earthworms. Therefore, Furthermore, the increasing humification level in OM is often associated with the higher agricultural value of final compost or vermicompost (Zhang et al., 2014).

Sewage sludge is an undesirable by-product of methods for wastewater treatment. Biotreatment of wastewater before and after sedimentation creates sewage sludge. A significant amount of industrial and municipal waste has been generated annually in India and its disposal has now become a serious problem. Municipal governments around the world are concerned to establish a clean, efficient and feasible disposal process [5]. Several cities around the world are gradually considering sewage sludge composting because it has several advantages over other strategies for disposal. Furthermore, the application of composts to agricultural soils has many advantages, including providing the soil with a whole range of nutrients. Sewage sludge not only contains plant nutrients and organic matter but it may carry pollutants such as heavy metals and pathogenic organisms. Main role of organic manure in soils is to maintain and upgrade soil organic carbon. Soil organic matter controls the distribution of nutrients and metal ions between soil particles and solution [6]. High specific surface area of humus (800–900 m² g⁻¹), CEC (150–300 c mol kg⁻¹) and presence of various functional groups like carboxylic and phenolics, are responsible for the complex formation with metal ions which govern the retention and mobility of different metal ions in

soil [7]. In general, for every tonne of carbon in soil organic matter about 100 kg of nitrogen, 15 kg of each phosphorus and sulphur becomes available to plants as organic matter is broken down [8]. Soil consists of numerous minerals bound and associated with organic matter and parent materials upon which a soil is developed. They also cover a broad range of available and exchangeable micronutrients conferring to their composition. The nutrient accessibility in soil is measured by composition of parent materials and the effects of edaphic and biological factors in soil such as redox potential, pH, soil microbial activity, their interaction with coexisting ions, reaction with soil minerals and organic matter. Reduction in concentration of free cation in soil solution occurs due to binding of metals to organic matter, however, dissolution of these organo-metallic complexes enhances the phyto-availability of nutrients and metal cations at root-rhizosphere interface by increasing total dissolved ion concentration. The phytoavailability of these cations depends on mobility of metal-dissolved organic carbon (DOC) complexes and their dissociation kinetics. The Azospirillum with spent grain was due to its effect on decrease soil pH and solubilization and chelation effect of bio-organic wastes in calcareous soil [9]. The mineralization of compounds found in bio-organic wastes leads to a decrease in calcareous soil pH; consequently, micronutrient availability increased in the soil after 21 weeks of incubation. The obtained results agree with the results presented by [10] Under subtropical climatic conditions, intensive cultivation and a low input of

organic matter have caused decrease in the organic matter contents in Indian soils, which is generally in lower category. Therefore, in recent years the application of organic fertilizers has been emphasized from researchers investigating the sustainability and productivity of agricultural soils.

2. MATERIALS AND METHODS

The present investigation entitled “Study the Temporal variation in mineralization of nutrients through S.S., F.Y.M. and V.C. in Soil” was conducted as a pot culture study, March to June of 2019, followed by laboratory analysis of the collected soil samples. The experiment was performed at the Rajiv Gandhi South Campus, Barkachha (BHU) Mirzapur campus, which is located in the Vindhyas zone of Mirzapur district at 25° 10” latitude, 82° 37” longitude with an altitude of 427 meters above the sea level. Under pot experiment, the soils of the study region are mostly having poor fertility and shallow depth. A pot experiment was performed to see the effects of farm yard manures, sewage sludge and vermicompost on soil nutrients release in the 2nd week of March to the 2nd week of June 2019, at Rajiv Gandhi South Campus, Barkachha, (BHU), Mirzapur. Different doses of farm yard manure, sewage sludge and vermicompost were applied in pot along with soil and it was incubated for 03 months. Required amount of water was added to soil as and when required in order to keep it moist.

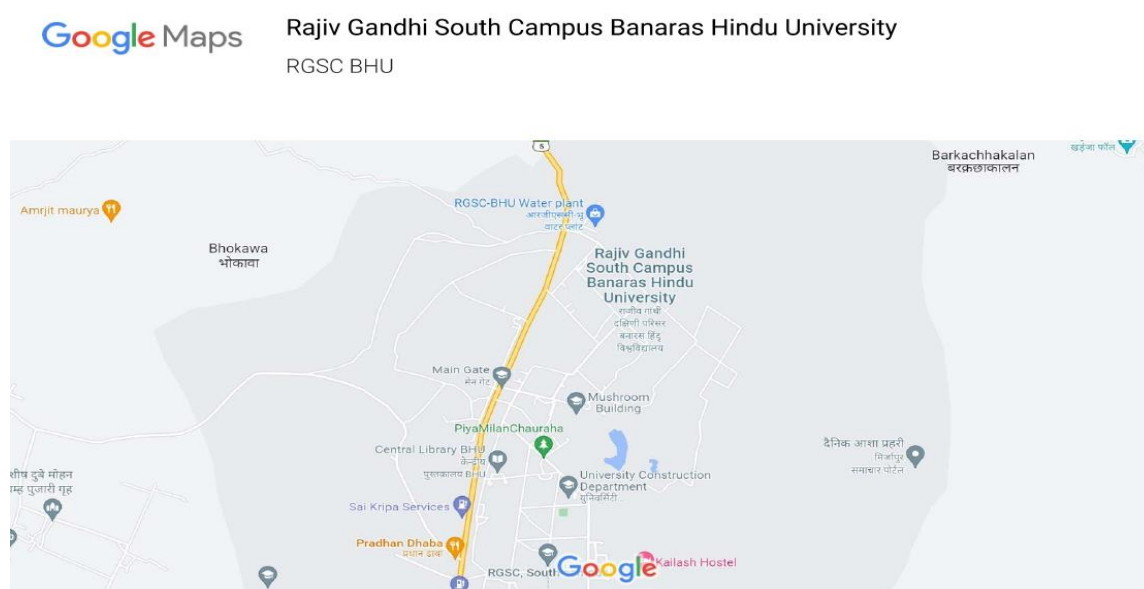


Fig. 1. Map of the study area

The bulk of soil and FYM to perform the pot experiment was obtained from the agricultural farm of, RGSC, Barkachha, BHU, Mirzapur. It was air dried; traces of rocks, stones and root pieces were removed. S.S. was collected from sewage treatment plant, Ganga pollution control unit Mirzapur in the month of March. The sewage sample was moist at the time of collection so it was air dried and applied on dry weight basis. Vermicompost was collected from Agri business shop at Mirzapur in granules form.

The pH of soil was measured by pH meter [11]. The instrument was calibrated with buffer solution of pH, 4.0, 7.0 and 9.2. The pH of a soil-water suspension of 1:2.5 (10 g soil with 25 ml distilled water) was prepared. The suspension was stirred with the help of glass rod and the pH electrode was inserted and the pH meter reading was noted. The soil water suspension designed for the assessment of pH was used in estimation of the electrical conductivity of the soil. The electrode of the conductivity meter was inserted in clear part of the suspension and the EC of the soil was measured and presented in unit dS m⁻¹ [12]. Organic carbon content in soil was estimated by chromic acid wet digestion method [13]. One gram of soil was added in a 500 mL conical flask. Then 10 mL of 1 N K₂Cr₂O₇ solution and 20 ml of concentration sulphuric acid were added, the flask was swirled 2-3 times and allowed to rest for 30 minutes in undisturbed condition. After half hour 200 ml of deionized water as added followed by 1 mL of diphenyl amine indicator and 10 ml of orthophosphoric acid. The suspension was titrated against 0.5 N ferrous ammonium sulphate solution till the colour changes from brown to blue to green colour

$$\% \text{Organic 'C' in soil} = \frac{(B - S) \times 0.003 \times 10 \times 1 \times 100}{B \times \text{wt. of soil}}$$

Where,

B = Volume of 0.5 N FAS consumed for blank titration
S = Volume of 0.5 N FAS consumed for sample titration

Treatment details

T₁ : Control
T₂ : 10 g kg⁻¹ Sewage Sludge
T₃ : 20 g kg⁻¹ Sewage Sludge
T₄ : 30 g kg⁻¹ Sewage Sludge
T₅ : 10 g kg⁻¹ FYM

T₆ : 20 g kg⁻¹ FYM
T₇ : 30 g kg⁻¹ FYM
T₈ : 10 g kg⁻¹ Vermicompost
T₉ : 20 g kg⁻¹ Vermicompost
T₁₀ : 30 g kg⁻¹ Vermicompost

The data obtained in present study during different intervals was assessed critically by using completely Randomized Design (CRD). The statistical analysis was performed following standard procedures as per outlined by Gomez and Gomez, [14].

3. RESULTS AND DISCUSSION

The observed data was statistically analyzed using standard procedures to draw valid conclusions. The data recorded has been shown in tables and figures and differential responses found have been described in this chapter.

The data pertaining to the properties of initial soil, FYM and vermicompost has been depicted in Table 1 The initial soil collected from agriculture research farm R.G.S.C. Barkachha, B.H.U. had pH 7.25, EC-0.208 dS m⁻¹ and organic carbon 3.25 g kg⁻¹. It was deficient in available N (8.34 mg kg⁻¹), P (3.52 mg kg⁻¹) and S (5.61 mg kg⁻¹) and medium in available K (82.6 mg kg⁻¹). The sewage sludge used in the present study had pH 6.49, EC-3.14 dS m⁻¹, organic carbon 85 g kg⁻¹, available primary nutrients N, P, K and S contents were 387.2, 59.4, 487.8 and 26.89 mg kg⁻¹, respectively. The FYM collected from dairy farm RGSC had pH 6.87, EC-2.45 dS m⁻¹, organic carbon 72.9 g kg⁻¹, available primary nutrients N, P, K and S contents were 232.6, 54.2, 345.9 and 34.6 mg kg⁻¹, respectively. The vermicompost applied in present study had pH 7.14, EC-2.89 dS m⁻¹, organic carbon 68.2 g kg⁻¹, available primary nutrients N, P, K and S contents were 340.9, 62.5, 421.6 and 42.8 mg kg⁻¹, respectively.

The data regarding soil pH as influenced by sewage sludge, FYM and vermicompost has been shown in Table. From the data, it is evident that the soil pH varied non-significantly with the application of sewage sludge, FYM and vermicompost. During 30 DAI the soil pH varied from 6.82 to 7.53, maximum being in treatment T₄ (30 g kg⁻¹ SS), whereas lowest was found in T₇ (30 g kg⁻¹ FYM). The soil pH increased at 30 DAI and reduced at 90 DAI.

Table 1. Properties of initial soil sewage sludge FYM and vermicompost

Parameter	Initialsoil	Sewagesludge	FYM	Vermicompost
pH	7.25	6.49	6.87	7.14
EC(dSm ⁻¹)	0.208	2.59	2.45	2.89
Organic carbon(g kg ⁻¹)	3.25	85.0	72.9	68.2
Available N(mg kg ⁻¹)	98.3	387.2	232.6	340.9
Available P(mg kg ⁻¹)	3.52	59.4	54.2	62.5
AvailableK(mg kg ⁻¹)	82.6	487.8	345.9	421.6
Available S(mg kg ⁻¹)	5.61	26.89	34.6	42.8

Table 2. Effect of sewage sludge, FYM and vermicompost application on soil p^H

Treatments	pH(1:2.5 Soil-Water)		
	30DAI	60DAI	90DAI
T ₁ -Control	7.19	7.12	7.03
T ₂ -10g kg ⁻¹ SS	7.24	7.26	7.14
T ₃ -20g kg ⁻¹ SS	7.45	7.62	7.21
T ₄ -30g kg ⁻¹ SS	7.53	7.69	7.19
T ₅ -10g kg ⁻¹ FYM	7.15	7.19	7.14
T ₆ -20g kg ⁻¹ FYM	6.95	7.24	6.29
T ₇ -30g kg ⁻¹ FYM	6.82	7.39	6.67
T ₈ -10g kg ⁻¹ VC	7.24	7.37	7.19
T ₉ -20g kg ⁻¹ VC	7.32	7.36	7.02
T ₁₀ -30g kg ⁻¹ VC	7.39	7.42	6.82
SEm±	0.25	0.30	0.26
CD(P=0.05)	NS	NS	NS

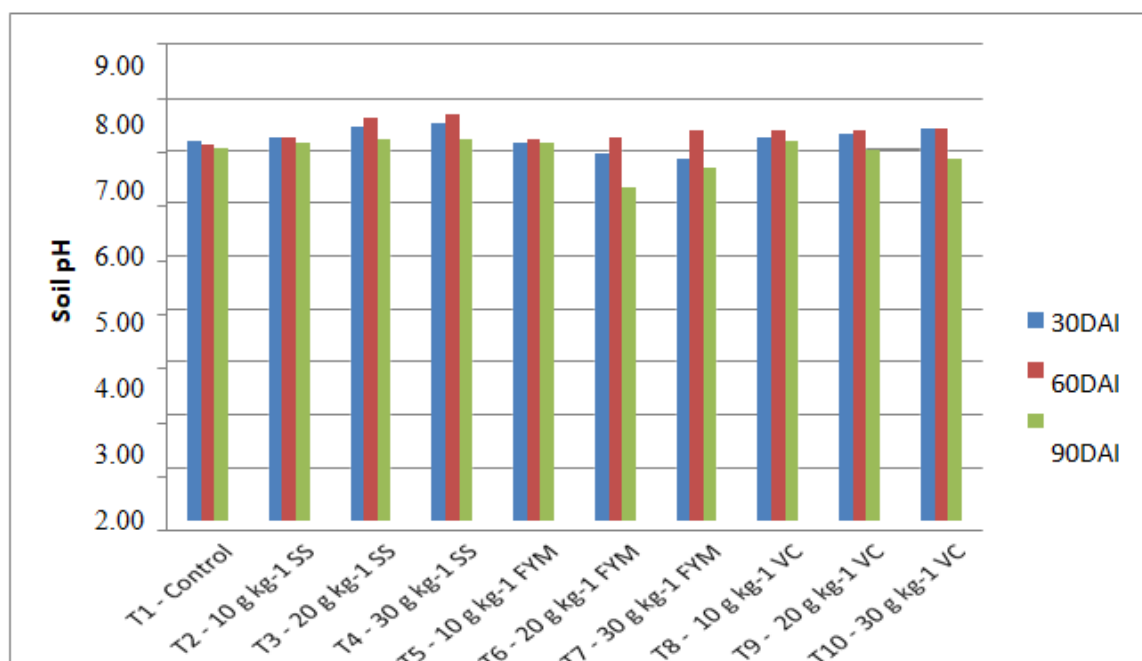


Fig. 2. Effect of sewage sludge, FYM and vermicomposting application on soil pH

Further, at initial period of incubation (30 DAI) there was an increase in soil pH with increase in doses of sewage sludge as well as vermicompost, however, it decreased with increase in doses of FYM. The increase in soil pH was attributed to the increase in basic cations present in sewage sludge with higher level of sludge [15,16]. Application of sewage sludge may increase or decrease the soil pH, which depends on salt accumulation in sewage sludge and source of sewage effluent. Similar results were also reported by Meena et al. [17] where, the application of FYM showed significant decrease in soil pH over control. Bhat et al., [18] reported significant decrease in pH and increase in organic carbon in soils receiving domestic sludge as compared to 100% recommended NPK. The maximum p^H 8.0 recorded in treatment T₉ (BC₂₀ SS₃₀ RN₅₀) and minimum in treatment T₁ (Control) followed by T₂ (100% RDF) reported by [19]. Maximum and significantly higher increment and P mineralization was found with the application and vermicompost @ 5 ton ha⁻¹ followed by Farm Yard Manure @ 10 ton ha⁻¹ followed by Sewage sludge @ 20 ton ha⁻¹ [20]. According to Silva et al. [21]. The chemical stabilization Sludge (CSS) method made the microbial activity more efficient resulting the higher degradation of soil carbon and phosphorus, hence this method, more appropriate for the rapid release of nutrients into the soil, promotion higher maize yield.

Excess of salts especially Na in soil may affect plant growth, measurement of electrical conductivity of soil provides information about salinity status of the soil. The data pertaining to EC of soil is presented in Table 3 and Fig. 3 The data showed that the EC significantly varied with the application of SS, FYM and VC in all study intervals. The EC ranged between 0.254 to 0.728, 0.289 to 0.589 and 0.220 to 0.484 dS m⁻¹ during 30, 60 and 90 DAI, respectively. The highest EC during all study intervals was recorded in treatments amended with sewage sludge (T₄- 30 g kg⁻¹), whereas, the lowest was recorded in control. In general it was found that the EC decreased with subsequent increase in incubation interval. Increase in the dose of SS, FYM and VC increased the electrical conductivity of soil. The higher EC in sewage sludge amended soils was attributed to the high amount of metallic salts. With V.C. and FYM also, the EC was found more as it contribute some salts. The increase in EC of soil with the addition of SS has also been reported by several researchers [18]; Meena et al. [17]; Latore et al., [15]. The EC of

soil ranged between 0.18 to 0.25 dS m⁻¹. The minimum of EC (0.18 dS m⁻¹) was recorded in control (T₁) and the maximum (0.25 dS m⁻¹) in treatment T₇ (BC₁₀ SS₃₀ RN₅₀) where biochar was applied along with sewage sludge [19].

Perusal of data presented in table and Fig. 4 shows that the organic carbon content in soil varied significantly with sewage sludge, FYM and VC. From the data, it is evident that the organic carbon content ranged between 3.18 to 7.86 g kg⁻¹, 3.16 to 7.94 g kg⁻¹ and 3.12 to 8.04 g kg⁻¹, respectively at 30, 60 and 90 DAI. During 30 DAI the highest organic carbon content (7.68 g kg⁻¹) was recorded in treatment T₄ (30 g kg⁻¹ SS) followed by (6.45 g kg⁻¹) T₃ (20 g kg⁻¹ SS). In general with increase in doses of sewage sludge, FYM and Vermicompost, the organic carbon content increased, similarly with advancement in incubation days the organic carbon content also increased in subsequent treatments. Similar results were also recorded at 60 DAI and 90 DAI. The highest organic carbon content at the end of the experiment was recorded in treatment T₄ (30 g kg⁻¹ SS). The lowest organic carbon content was recorded in control where no any organic source of nutrient was added. As the sewage sludge, FYM and Vermicompost contains high amount of organic matter, which after humification increased the organic carbon content. The organic carbon content has direct relationship with soil fertility as it helps in binding of nutrients. The organo-mineral and SG treatments revealed the highest values of SOC, while the Az and control had the lowest values of SOC [22]. Now a days more emphasis is being given to residue incorporation in field instead of its burning to improve soil organic matter. Other practices like crop rotation, cover crops and application of sewage sludge application is being practiced to increase the carbon content of soil. In comparison to control it is found that there is significant build up of organic carbon in soil this might be attributed to more carbon load of sewage sludge, FYM and vermicompost. Similar results were also reported by Latore et al. [23]. According to Rusanescu et al. [24], the impact dewatered sewage sludge vermicomposting on pH value, electrical conductivity, perisity, moisture content, nitrogen content, water retention capacity, metal content and the development of agricultural crops, highlighting the positive impact of vermicompost application on the soil. Adding vermicompost to the soil has been observed to improve development [25].

Table 3. Effect of SS, FYM and VC application on EC

Treatments	EC(dSm ⁻¹)		
	30DAI	60DAI	90DAI
T ₁ -Control	0.254	0.289	0.220
T ₂ -10gkg ⁻¹ SS	0.542	0.426	0.340
T ₃ -20gkg ⁻¹ SS	0.669	0.573	0.456
T ₄ -30gkg ⁻¹ SS	0.728	0.589	0.484
T ₅ -10gkg ⁻¹ FYM	0.456	0.322	0.274
T ₆ -20gkg ⁻¹ FYM	0.524	0.368	0.383
T ₇ -30gkg ⁻¹ FYM	0.689	0.574	0.424
T ₈ -10gkg ⁻¹ VC	0.442	0.372	0.266
T ₉ -20gkg ⁻¹ VC	0.498	0.382	0.288
T ₁₀ -30gkg ⁻¹ VC	0.585	0.429	0.313
SEm±	0.033	0.025	0.044
CD(P=0.05)	0.254	0.289	0.220

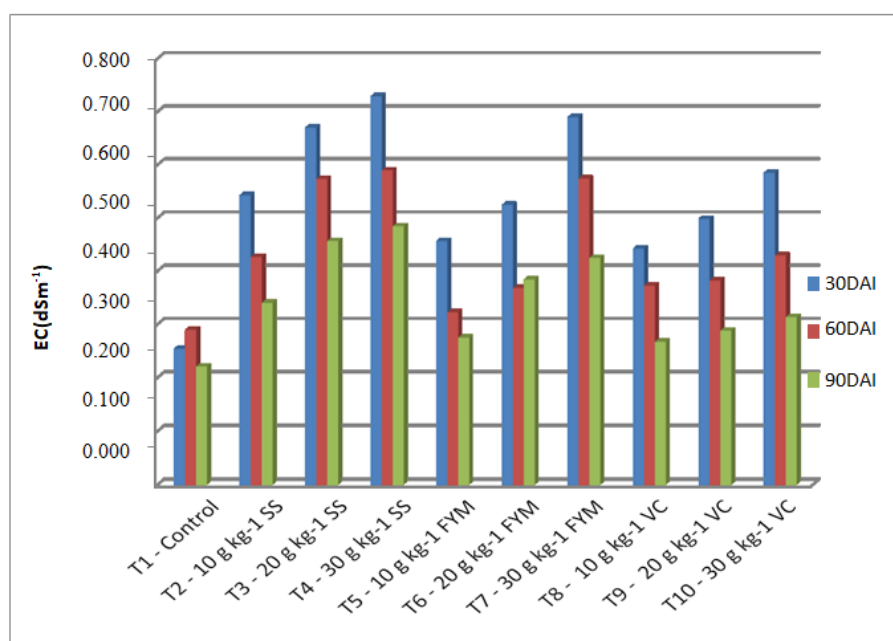


Fig. 3. Effect of sewage sludge, FYM and vermicompost application on soil electrical conductivity

Table 4. Effect of sewage sludge, FYM and vermicompost application on organic carbon

Treatments	OC(g kg ⁻¹)		
	30DAI	60DAI	90DAI
T ₁ -Control	3.18	3.16	3.12
T ₂ -10gkg ⁻¹ SS	5.36	5.78	5.89
T ₃ -20gkg ⁻¹ SS	6.45	6.82	6.97
T ₄ -30gkg ⁻¹ SS	7.86	7.94	8.04
T ₅ -10gkg ⁻¹ FYM	4.56	4.88	5.14
T ₆ -20gkg ⁻¹ FYM	5.64	5.83	6.08
T ₇ -30gkg ⁻¹ FYM	5.87	5.92	6.28
T ₈ -10gkg ⁻¹ VC	4.12	4.32	4.41
T ₉ -20gkg ⁻¹ VC	4.19	4.54	4.66
T ₁₀ -30gkg ⁻¹ VC	5.21	5.39	5.48
SEm±	0.28	0.26	0.20
CD(P=0.05)	0.84	0.77	0.59

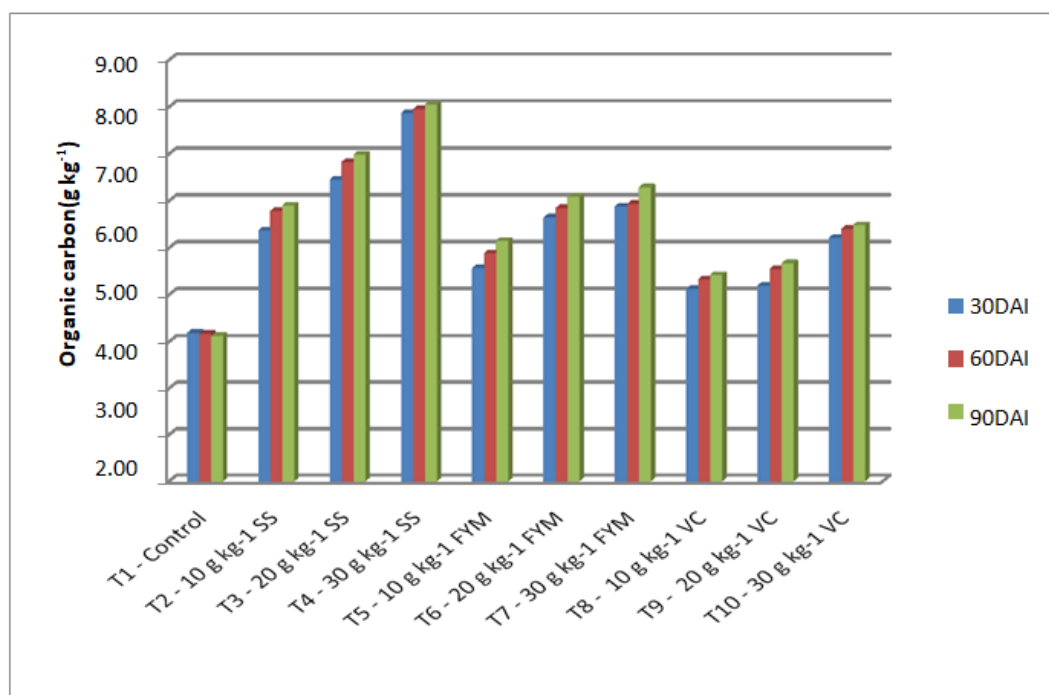


Fig. 4. Effect of sewage sludge, FYM and vermicompost application on organic carbon content in soil

4. SUMMARY AND CONCLUSION

Sewage sludge, FYM and vermicompost are popular sources of organic matter as well as nutrients. Different materials have variation in their physical and chemical properties, however it depends upon the properties of base material used for its preparation. Their decomposability varies from months to years. The present investigation entitled "Study the temporal variation in mineralization of nutrients through Sewage Sludge, Farm Yard Manure and Vermicompost in Soil" was conducted as pot culture experiment. The effect of sewage sludge, FYM and vermicompost on soil physico-chemical properties and nutrient content of soil was recorded at different intervals. In this chapter various findings recorded during course of investigation has been summarized.

- The soil pH varied non significantly with the application of sewage sludge, FYM and vermicompost at all the study interval.
- At initial period of incubation (30 DAI) there was an increase in soil pH with increase in doses of sewage sludge as well as vermicompost, however, it decreased with increase in doses of FYM.
- The EC decreased with subsequent increase in incubation interval. Increase in

the dose of sewage sludge, FYM and vermicompost increased the electrical conductivity of soil.

- In general with increase in doses of sewage sludge, FYM and vermicompost, the organic carbon content significantly increased, similarly with advancement in incubation days the organic carbon content also increased in subsequent treatments.

Based on the above study it may be concluded that application of sewage sludge and vermicompost affects the physico-chemical properties of soil. The sewage sludge had more pronounced effect in terms of organic carbon while vermicompost had more pronounced effect on soil.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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