EFFECT OF TEMPORAL VARIATION IN MINERALIZATION OF NUTRIENTS THROUGH SEWAGE SLUDGE, FARM YARD MANURE AND VERMICOMPOST IN SOIL

ABSTRACT

Soil amendment by 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 (BHU) Mirzapur, which is located in the Vindhyan zone of Mirzapur district at 25º 10" latitude, 82º 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 (S.S, FYM and 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, 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 physico-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, FYM 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 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.

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 organic matter (OM) in a soil directly affects its fertility. In particular, higher levels of clay and OM may result in greater soil fertility. Maintaining soil quality is the most efficient way of ensuring enough food to sustain life. Soil quality is defined as "the ability of a particular soil to work within the boundaries of ecosystem and land use, maintain biological productivity, maintain environmental quality, and maintain plant, animal and human health" (Doran and Parkin, 1994). Farmyard manure (FYM) is the most common natural fertilizer and one of the most effective soil fertilizers (Slowinska-Jurkiewicz et al., 2013). Mineral, organic and natural fertilization also promotes the growth of microorganisms as a major source of nutrient conversion enzymes in soils (Bielinska and Mocek-Plociniak, 2012; George et al., 2002; Kramer and Green, 2000). FYM supplies all the major nutrients (N, P, K, Ca, Mg, S) and micronutrients (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. Earthworms eat and break organic waste into finer particles through a grinding gizzard and derive their food from microorganisms which develop on them. Scientific research has identified the viability of using earthworms as a treatment technique for many waste stream (Hand et al., 1988; Raymond et al., 1988; Harris et al., 1990; Logsdon, 1994). The action of earthworms in this process is physical, mechanical and biochemical to convert organic wastes to organic fertilizer. The nutrient level in vermicompost is always higher, particularly the (macro or micro-nutrients) than the compost derived from other methods (Kale, 1998). 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, vermicomposts have higher level of available nutrients like nitrate or ammonium nitrogen, exchangeable phosphorous and soluble potassium, calcium and magnesium derived from the wastes (Buchanan et al., 1988). Nevertheless, the heavy use of mineral fertilizers and certain poor cultivation practices such as stubble burning can significantly reduce the organic matter content of soils influencing directly the physical, chemical and biological properties of these soils and the risk of degradation. Consequently, the above mentioned agronomic practices could lead to soil mineralization and desertification (Tejada et al., 2001).

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 (Kaur et al., 2012). Nutrient potential of sewage sludge is estimated to be more than 3,50,000 tonnes N, 1,50,000 tonnes P and 200,000 tonnes K per year (Juwarkar et al., 1991). 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 (Shi et al., 2012). 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 (Sparks, 2003; Kleber et al., 2015).. Applying an adequate amount of manure and fertilizer is an important cultivation practice to obtain the yield, maintain quality of crops, environmental protection and soil sustainability (Oenema et al., 2009; Atafar et al., 2010). 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 (Hoyle, 2013). 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. Chelation of micronutrients with organic matter is greatly responsible for addition of root accessible forms of these nutrients, it also prevents formation of insoluble forms such as carbonates and oxides in soil (Schulin et al., 2009). There is an unanimity that soil organic matter plays a significant role in the sustainability of farming systems (Swift and Woomer 1993) and it is an important indicator in assessment of soil quality and productivity (Larson and Pierce 1994). 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.

2.1 MATERIALS AND METHODS

Site Description

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 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, which is located in the Vindhyan zone of Mirzapur district at 25º 10" latitude, 82º 37" longitude with an altitude of 427 meters above the sea level. Pot experimentThe 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, Banaras Hindu University, 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.

Experimental soil

The bulk of soil to perform the pot experiment was obtained from the agricultural farm of, RGSC, Barkachha, Banaras Hindu University, Mirzapur. It was air dried, traces of rocks, stones and root pieces were removed.

Collection of FYM

Farm yard manures was collected from dairy farm at Rajiv Gandhi South Campus, Barkachha, Banaras Hindu University, Mirzapur.

Collection of sewage sludge

Sewage sludge 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.

Collection of vermicompost :Vermicompost was collected from Agri business shop at Mirzapur in granules form.

Analyses of soil samples

Soil pH :

The pH of soil was measured by pH meter (Chopra and Kanwar, 1982). 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.

Electrical conductivity :

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 (Sparks, 1996).

2.2.3 Organic Carbon (Walkey and Black, 1934) : Organic carbon content in soil was estimated by chromic acid wet digestion method (Walkley and Black, 1934). One gram of soil was added in a 500 mL conical flask. Then 10 mL of 1 N $K_2Cr_2O_7$ solution and 20 mL of conc. 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

2.4 Statistical Analysis and Interpretation of data

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, (1984).

3.1 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.

3.1.1 Physico-chemical properties of initial soil, sewage sludge, FYM and vermicompost

The data pertaining to the properties of initial soil, FYM and vermicompost has been depicted in table no.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.

Table no. 1 Properties of initial soil sewage sludge FYM and Vermicompost

Parameter	Initial soil	Sewage sludge	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
Available K (mg kg^{-1})	82.6	487.8	345.9	421.6

Available S (mg kg^{-1})	5.61	26.89	34.6	42.8

3.1.2 Effect of sewage sludge, FYM and vermicompost on physicochemical properties of soil

Soil pH

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 nonsignificantly 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.

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 (Latare et al., 2014). Biodegradation of humic substances present in sewage sludge produces organic acids which may cause a temporary reduction in soil pH (Singh and Agrawal 2010). Parkpain et al. (2000) reported increase in soil pH of acidic soil of Thailand upon sewage amendment. 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. (2013) where, the application of FYM showed significant decrease in soil pH over control. Bhat et al., 2013 reported significant decrease in pH and increase in organic carbon in soils receiving domestic sludge as compared to 100% recommended NPK. The decrease in pH was ascribed to the acid production during

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

Treatments	**pH (1:2.5 Soil - Water)**		
	30 DAI	**60 DAI**	**90 DAI**
T_1 - Control	7.19	7.12	7.03
T_2 - 10 g kg^{-1} SS	7.24	7.26	7.14
T_3 - 20 g kg^{-1} SS	7.45	7.62	7.21
T_4 - 30 g kg^{-1} SS	7.53	7.69	7.19
T_5 - 10 g kg^{-1} FYM	7.15	7.19	7.14
T_6 - 20 g kg^{-1} FYM	6.95	7.24	6.29
T_7 - 30 g kg^{-1} FYM	6.82	7.39	6.67
T_8 - 10 g kg^{-1} VC	7.24	7.37	7.19
T_9 - 20 g kg^{-1} VC	7.32	7.36	7.02
T_{10} - 30 g kg^{-1} VC	7.39	7.42	6.82
SEm±	0.25	0.30	0.26
CD (P=0.05)	NS	NS	NS

Note - SS- Sewage sludge , FYM – Farm Yard Manure, VC- Vermicompost

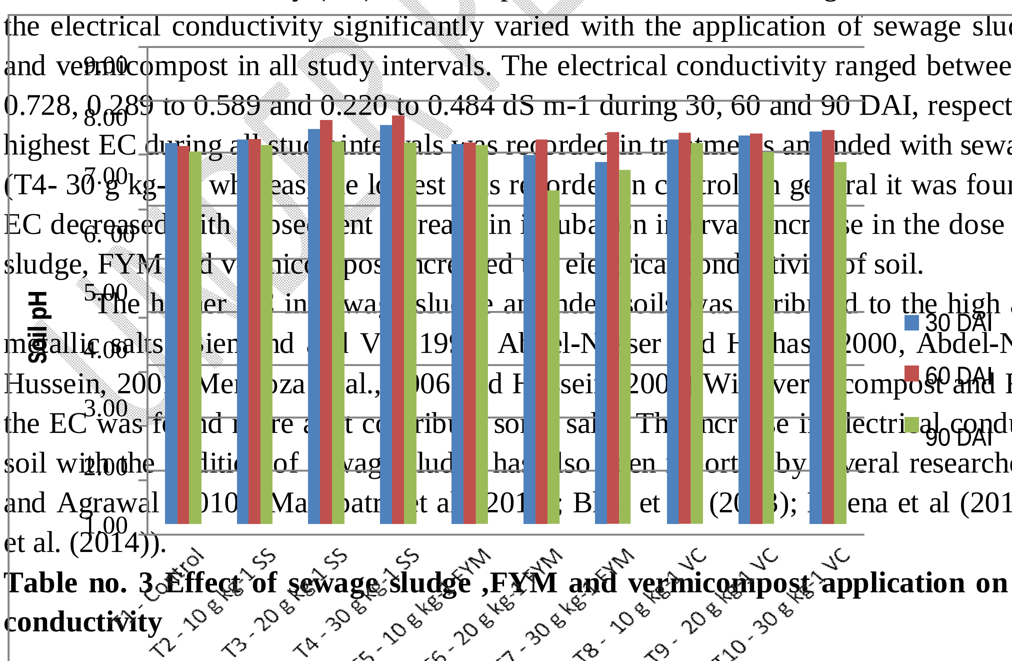

Fig. 1 Effect of sewage sludge, FYM and vermicompost application on soil pH

3.1.3 Electrical conductivity (dS m-1)

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 electrical conductivity (EC) of soil is presented in Table 3and fig 2 The data showed that the electrical conductivity significantly varied with the application of sewage sludge, FYM and vermicompost in all study intervals. The electrical conductivity 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- [illegible] whereas [illegible] e lowest [illegible] s recorded in control [illegible] n general it was found that the EC decreased with [illegible] bsequent [illegible] rea [illegible] in incubation interval [illegible] ncrease in the dose of sewage sludge, FYM [illegible] d v [illegible] micompost increased [illegible] electrical conductivity of soil.

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Table no. 3 Effect of sewage sludge ,FYM and vermicompost application on electrical conductivity

	EC (dS m^{-1})

	Treatments	30 DAI	60 DAI	90 DAI
	T_1 - Control	0.254	0.289	0.220
	T_2 - 10 g kg^{-1} SS	0.542	0.426	0.340
	T_3 - 20 g kg^{-1} SS	0.669	0.573	0.456
EC ($dS\ m^{-1}$)	T_4 - 30 g kg^{-1} SS	0.728	0.589	0.484
	T_5 - 10 g kg^{-1} FYM	0.456	0.322	0.274
	T_6 - 20 g kg^{-1} FYM	0.524	0.368	0.383
	T_7 - 30 g kg^{-1} FYM	0.689	0.574	0.424
	T_8 - 10 g kg^{-1} VC	0.442	0.372	0.266
	T_9 - 20 g kg^{-1} VC	0.498	0.382	0.288
	T_{10} - 30 g kg^{-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

Note - SS- Sewage sludge , FYM – Farm Yard Manure, VC- Vermicompost

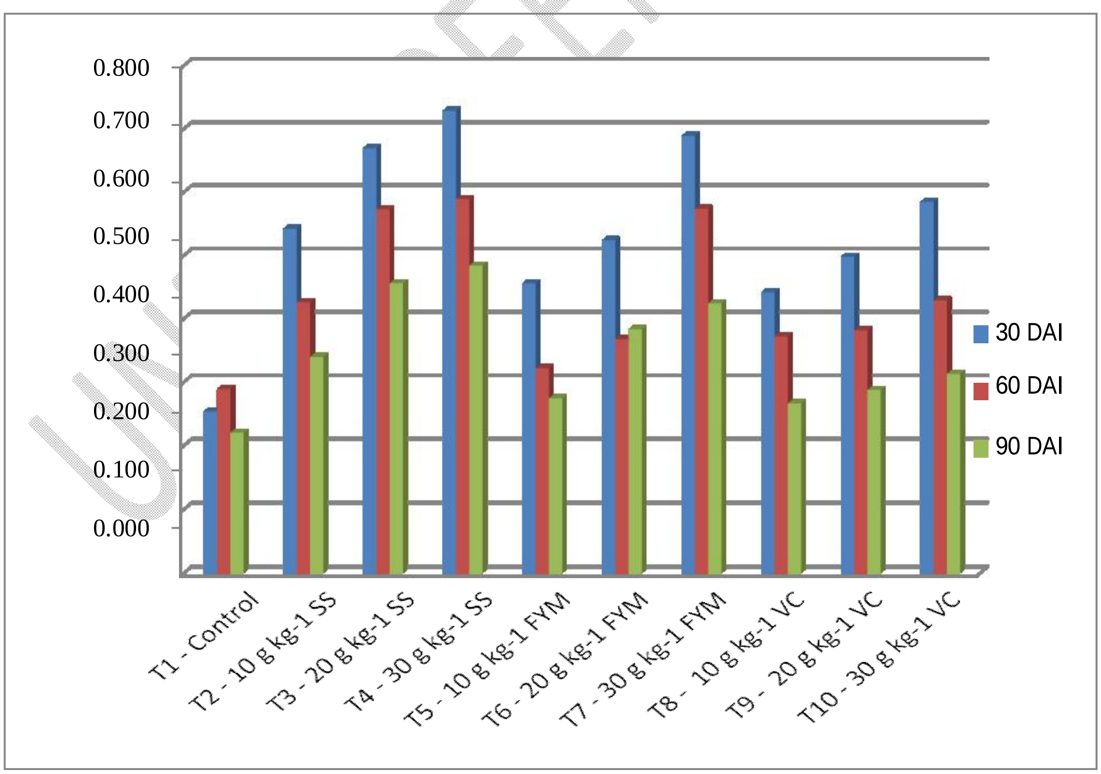


Fig 2: Effect of sewage sludge, FYM and vermicompost application on soil electrical conductivity

3.1.4 Organic Carbon (g kg-1)

Perusal of data presented in table and fig 3 shows that the organic carbon content in soil varied significantly with sewage sludge, FYM and vermicompost. 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. 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 Deshmukh et al. (2004), Singh and Agrawal (2010), Orman et al. (2014).

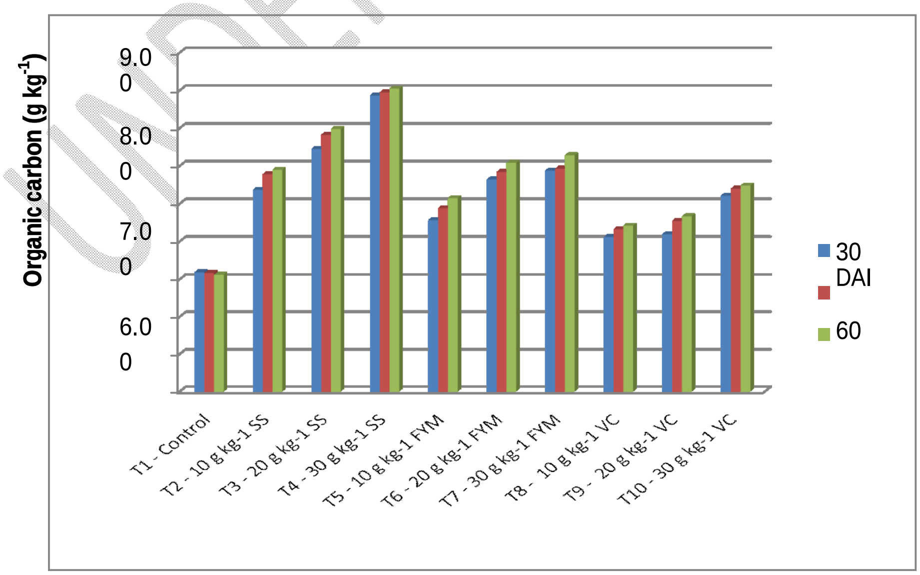
Table no. 4 Effect of sewage sludge ,FYM and vermicompost application on organic carbon

Treatments	OC (g kg^{1})		
	30 DAI	**60 DAI**	**90 DAI**
T_1 - Control	3.18	3.16	3.12
T_2 - 10 g kg^{-1} SS	5.36	5.78	5.89
T_3 - 20 g kg^{-1} SS	6.45	6.82	6.97
T_4 - 30 g kg^{-1} SS	7.86	7.94	8.04
T_5 - 10 g kg^{-1} FYM	4.56	4.88	5.14
T_6 - 20 g kg^{-1} FYM	5.64	5.83	6.08
T_7 - 30 g kg^{-1} FYM	5.87	5.92	6.28
T_8 - 10 g kg^{-1} VC	4.12	4.32	4.41
T_9 - 20 g kg^{-1} VC	4.19	4.54	4.66

T_{10} - 30 g kg^{-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

Note - SS- Sewage sludge , FYM – Farm Yard Manure, VC- Vermicompost

Fig.no. 3 Effect of sewage sludge, FYM and vermicompost application on organic carbon content in soil



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 physic-chemical properties of soil. The sewage sludge had more pronounced effect in terms of organic carbon while vermicompost had more pronounced effect on soil.

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