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EFFECT OF BIOCHAR AND FARMYARD MANURE ON SOIL CHEMICAL PROPERTIES AT DIFFERENT PERIODS OF INCUBATION

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ABSTRACT

This study was aimed to examine the effects of biochar and FYM on soil chemical properties with the objective of recommending their use in soil and crop management practices.An incubation experiment of 240 days duration was conducted to monitor the variations in soil pH, electrical conductivity (EC), soil mineral nitrogen, soil available phosphorus and soil available potassium due to the application of rice husk biochar and coconut frond biochar at Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani, Trivandrum, Kerala during May 2019 to December 2019. The experiment was conducted in two different types of soils (laterite and sandy) at College of Agriculture, Vellayani, Trivandrum, Kerala. Periodic sampling and analysis of the samples were conducted at monthly intervals. With change in type of organic amendment used and days of incubation there were significant changes in soil chemical properties. The results of this experiment indicates that application of FYM and biochars had a positive effect on soil chemical properties. Comparatively biochar application showed long term effects on soil chemical properties than FYM.

(Key words: Biochar, FYM, soil chemical properties)

INTRODUCTION

Soils are the medium which provide all the nutrients, oxygen, water etc. needed for plant growth. Continuous cultivation without the addition of adequate organic manure could lead to depletion of nutrients from the soil resulting into low fertility. Maintaining organic matter content and organic carbon balance of soil are important to keep the soil fertile (Bakðienë *et al.,* 2014). Application of organic manures like FYM, biochar etc. directly affect the organic matter content in the soil, improve physico-chemical characteristics of soil, and boost microbial activity, resulting in a good fertile soil. There are number of studies explaining role of FYM in improving soil organic carbon content (Chandrashaker *et al.,*2014).

Application of biochar as a soil amendment has been started considering its ability to improve highly weathered and degraded soils, as a sustainable technology in a similar way as that of FYM that has been practiced historically to increase soil fertility, soil organic matter, microbiological activities and soil structure (Kundu *et al*., 2007). Biochar is a carbon rich, stable solid, produced by thermo-chemical decomposition of biomass under limited levels of oxygen and can last in soil for a longer period. The quality that attracts biochar is its porous nature that is responsible for its large surface area, which advances its efficacy in adsorbing and retaining water and nutrients without loss for many years than any other conventional organic source. This ability to absorb nutrients will help to reduce fertilizer requirements as well as environmental damage related to fertilizer application, like runoff of phosphorus into surface water, leaching of nitrogen into ground water etc. (Lehmann, 2007).

From a chemical point of view, polycondensed aromatic structure is the most striking feature of biochar due to dehydration during thermo chemical reactions (Mohan *et al*., 2018).

This structure is also responsible for its relative recalcitrance compared to other organic matter in the environment (Lehman *et al.,* 2006). In addition, basic ash compartments lead to a high pH value. Adding biochar to soil can have benefits like raising the soil pH, increasing water holding capacity, improving cation exchange capacity (CEC) and retaining nutrients which results in improved crop yield (Chan *et al*., 2007).

Several studies demonstrated that the quality of the feedstock and production conditions such as pyrolytic

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temperature and residence time has a significant influence on the quantity, quality and the elemental composition of biochar (Naeem *et al.,* 2014; Dume *et al.,* 2015). Agricultural residues and wood processing residues, algae, municipal solid waste, livestock/poultry waste, wastewater/sewage sludge, and biosolids are some of the feedstocks used for biochar production (Duku *et al.,* 2011). The composition and quality characteristics of biochars such as recovery percentage, porosity, density, water holding capacity, nutrient content, CEC, and pH are strongly influenced by the type, nature, and origin of the feedstock (Punnoose and Anitha, 2015).The aim of this study was to evaluate the soil amended with FYM and biochar in terms of chemical properties through a laboratory incubation experiment.

MATERIALS AND METHODS

The laboratory incubation experiment was carried out to study the effect of biochar and FYM on soil chemical properties, at the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani, Trivandrum, Kerala during May 2019 to December 2019. The biochar produced from pyrolysis of rice husk and coconut frond was used in the experiment. Chemical characters of biochar like pH and EC (Anonymous, 1985), total N% (Jackson, 1958), total P % and K% (Anonymous, 1985) were analyzed and the data is given in Table 1.

Soil samples were collected from College of Agriculure, Vellayani, Trivandrum, Kerala and farmers field Murukumpuzha, Trivandrum, Kerala for the study. Surface soil (0-15 cm) samples were collected randomly from each site and mixed thoroughly to get a homogenous sample per site. The characteristics of the initial soil samples are given in Table 2. The air dried and sieved (2 mm sieve) soil (5 kg) from each site was taken into plastic container and the treatments were imposed and mixed thoroughly. The treatments included a control and farm yard manure (FYM), rice husk biochar (RHB) and coconut frond biochar (CFB) at 25, 50 and 75 g 5kg^{-1} soil. The soil samples with different treatments were arranged in a completely randomized design in triplicate and were incubated separately for 8 months (240 days). Distilled water was used to maintain the soil at field capacity during the entire period of incubation. Periodic sampling and analysis of the samples were done at 30, 60, 90, 120, 150, 180, 210 and 240 days.

Soil pH was determined by potentiometry and EC by conductometry at 1:2.5 soil: water suspension (Jackson, 1958). Soil mineralizable nitrogen was determined by the Macrokjeldahl distillation and titrimetry method after extraction with 2 M KCl (Hesse, 1971). Available P was determined by Bray-1 method (Bray and Kurtz, 1945) and exchangeable K was extracted using ammonium acetate and determined using flame photometer (Jackson, 1958).

Treatment details

T1-Absolute control (5kg soil alone)

T2-5kg soil + 25g PHB T7-5kg soil + 75g CFB

T3-5kg soil + 50g PHB T8-5kg soil + 25g FYM

T4 - 5kg soil + 75g PHB T9-5kg soil + 50g FYM

T5-5kg soil + 25g CFB T10-5kg soil + 75g FYM

T6-5kg soil + 50g CFB

RESULTS AND DISCUSSION

Influence of biochar on soil chemical properties

Effects on soil pH

In laterite and sandy soil pH had an increasing trend up to 90 days for all the treatments but after on 90 days the pH of absolute control and FYM treated soils declined but the biochar treated soil showed an increasing trend up to 180 days of incubation thereafter, showing a decline (Table 3, 4). Among the different treatments, 5kg soil + 75g CFB registered significantly higher value (7.20, 6.85), followed by 5kg soil + 50g CFB (7.07, 6.55) and 5kg soils + 25g CFB (6.79, 6.30) respectively for laterite and sandy soils.At all stages of incubation, the lowest pH was recorded for the soil alone treatment. These results are in line with Sekar (2012), who reported that the highest soil pH was observed in biochar treated soil, while the lowest value was recorded in control.Elengoan (2014) reported similar results where an increase in soil pH was observed with the application of biochar during the initial stages of incubation. Such increase was directly related to the increase in quantity of biochar applied. The increase in soil pH due to the application of biochar would be due to the fact that biochar is generally dominated by carbonates of alkali and alkaline earth metals and due to ash present in the biochar and also because of high surface area and porous nature of biochar which increases the cation exchange capacity (CEC) of the soil. Rondon *et al*. (2007) reported significant increase in soil pH from 5.04 to 5.41with the application of biochar at 0 and 90 g kg^{-1} respectively and it might be due to increase in soil CEC from 108.2 to 131.5 mmol$_e$ kg^{-1} after increasing quantity of biochar applied from 0 to 90 g kg^{-1}. Galinato *et al*. (2011) revealed that soil pH could improve from 4.5 to 6 by the application of 30.62 metric tons of biochar acre^{-1}.

Compared to rice husk biochar, coconut frond biochar treated soil showed high value for soil pH probably due to the higher pH of coconut frond biochar (8.3) than the rice husk biochar (7.8).The pH of biochar is strongly influenced by the type, nature, and origin of the feedstock. Punnoose and Anitha (2015) reported that pH was significantly higher in the coconut petiole biochar (8.5) treated soils followed by wild growth (7.7) and the least was observed in herbal waste residue biochar (7.5).

Effects on soil EC

It was noticed that there was a significant increase in the EC of the soil with increasing days of incubation upto three months in laterite soil for all the treatments, but after three months the absolute control and FYM treated soil showed a decreasing trend in soil EC, whereas biochar treated soil showed an increasing trend up to six months of incubation, later showed a decline (Table 5). With regard to biochar levels, the EC was increased with increasing rate of biochar application and the highest value of 0.4 for 5kg soil + 75g CFB was observed during 180 days of incubation followed by 5kg soil + 75g CFB (0.36) and 5kg soil + 75g RHB (0.36). In sandy soil also the biochar treated soil showed an increasing trend in soil EC up to six months of incubation, whereas the absolute control and FYM treated soil recorded increasing trend in soil EC only up to three months thereafter, showed a decline (Table 6).

During incubation, the mean EC of the biochar treated soil showed significant increase from 0.56 dS m^{-1} at the beginning of the experiment to 0.61, 0.63, and 0.65 dS m^{-1} on 30, 60 and 90 days of incubation respectively. Increase in EC recorded by the application of biochar at different levels, increased with the increasing rate of application. The rise in EC of the soil at all levels might be due to the greater proportion of soluble salts added through biochar, leading to an increase in electrolyte content (Elangoan, 2014). Mohan *et al*. (2018) also reported that the EC values of coconut shell biochar or rice husk biochar water suspensions are higher than those of the control soil.

Effects on mineralizable nitrogen

Biochar can efficiently balance the inorganic nitrogen in the soil, affecting the rate of nitrogen mineralization and finally plant growth (Song *et al*., 2006; Liu *et al*., 2018). The present study revealed that in both the type of soils all the treatments were superior to absolute control during the entire period of incubation and with increasing quantity of FYM and biochar application the amount of mineralizable nitrogen also increased (Figure 1 and 2). Upto ninety days of incubation the highest amount of mineralizable nitrogen was for FYM treated soil i.e.134 mg kg^{-1} and 108 mg kg^{-1} in laterite and sandy soil respectively. But after ninety days of incubation mineralizable nitrogen in FYM treated soil was declined. There was a slow increase in mineralizable nitrogen in biochar applied soil up to 210 days of incubation, and then it showed a slight decrease. The highest nitrogen mineralization among the biochar treatments was during the 6^{th} month for 5kg soil + 75g RHB, 147 and 107 mg kg^{-1} in laterite and sandy soils respectively. Biochar in soil could absorb nitrification inhibiting compound like phenolics and these could have promoted promote nitrification indirectly (DeLuca *et al.,* 2006).

Effects on soil available phosphorus

The effect of different treatments on soil available phosphorus was highly significant in both the types of soil; there was a progress in the available phosphorus content of the biochar treated soil with progress in days of incubation up to 180 days. Initially the highest quantity of available phosphorus was in FYM treated soil up to 60 days (110.6 kg ha^{-1}) for laterite soil and 90 days (86.5 kg ha^{-1}) in case of sandy soil later on it started to decrease. In laterite and sandy soil the highest content of available phosphorus was at 5kg soil + 75g RHB (118.12 kg ha^{-1}, 81.38 kg ha^{-1}) followed by 5kg soil + 75g CFB (111.47 kg ha^{-1}, 73.62 kg ha^{-1}) respectively at 180 days (Table 7, 8).

The increase in availability of phosphorus may be due to the discharge of soluble phosphorus from biochar and its high ion exchange capacity which may modify the availability of phosphorus by the mechanism of anion exchange capacity or by influencing the activity of cations like Ca, Mg, Fe and Al that interacts with phosphorus (Elangoan, 2014). This is in support with the results of Glaser *et al.* (2002) and Lehmann *et al.* (2003), who recorded a rise in extractable P in soils treated with different charred materials. Ippolito *et al.* (2012) also noticed an increase in available P with increasing rate of application of biochar.

Effects on soil available potassium

The quantity of available potassium in biochar amended laterite soil was considerably increased with increasing duration of incubation up to 150 days and later on slightly decreased (Table 9). The highest amount of available potassium was present at 150 days of incubation in 5kg soil + 75g CFB (347.2 kg ha^{-1}) followed by 5kg soil + 50g CFB (313.6 kg ha^{-1}) and 5kg soil + 75g RHB (298.6 kg ha^{-1}). But up to 90 days of incubation the maximum amount of available potassium was seen in soil treated with 5kg soil + 75g FYM (302.4 kg ha^{-1}) and later it showed a decreasing pattern. These can be due to the difference in rate of decomposition of FYM and biochar.

In sandy soil also almost same type of pattern is visible (Table 10). There was a rise in available K content upto 150 days of incubation in biochar treated soil, later it showed a declined , where as in FYM treated soil increase was observed only upto 90 days of incubation. Here also the highest amount of available potassium content was in 5kg soil + 75g CFB at 150 days of incubation (291.2 kg ha^{-1}) followed by 5kg soil + 50g CFB (265.06 kg ha^{-1}) and 5kg soil + 75g RHB (257.6 kg ha^{-1}).

Elangoan (2014) also reported that there was a significant increase in available potassium in biochar amended soil with the increasing periods of incubation up to 60 days and then started to decrease slightly up to 90 days of incubation in all the treatments including control, increase in the biochar induced K transformation may be the reason for it. Gaskin *et al.* (2010) conducted an experiment in a soil belonging to Ultisol deficient in base cations and found that biochar addition increased the potassium availability in the surface soil. Lehmann *et al.* (2003) reported that leaching loss of soil K could reduce by the application of charcoal.

Table 1. Chemical characters of FYM and biochars used in this study

Properties	Rice husk biochar	Coconut frond biochar	FYM
pH	7.80	8.30	6.10
EC (dS m^{-1})	0.80	4.20	0.08
Total nitrogen (%)	0.84	0.44	0.80
Total phosphorus (%)	0.03	0.11	1.04
Total potassium (%)	0.20	0.54	0.46

Table 2. Initial characteristics of experimental soils

Soil properties	Laterite soil (College of Agriculture, Vellayani, Kerala, India)	Sandy soil (Murukkumpuzha, Kerala, India)
pH	5.23	4.83
EC (dS m^{-1})	0.15	0.05
Mineralizable nitrogen (mg kg^{-1})	66.64	102.85
Available phosphorus (kg ha^{-1})	51.07	21.65
Available potassium (kg ha^{-1})	138.13	59.73

Table 3. pH in laterite soil during incubation periods

Treatments	Incubation period (days)							
	30	60	90	120	150	180	210	240
T1-Absolute control (5kg soil alone)	5.26	5.28	5.29	5.26	5.22	5.16	5.19	5.05
T2-5kg soil + 25g PHB	5.43	5.48	5.56	5.60	5.81	6.01	5.95	5.85
T3-5kg soil + 50g PHB	5.53	5.55	5.62	5.70	6.15	6.22	6.17	6.03
T4-5kg soil + 75g PHB	5.79	5.83	5.97	6.20	6.62	6.74	6.70	6.60
T5-5kg soil + 25g CFB	6.08	6.17	6.21	6.49	6.72	6.79	6.74	6.68
T6-5kg soil + 50g CFB	6.17	6.22	6.27	6.63	6.90	7.07	6.87	6.80
T7-5kg soil + 75g CFB	6.33	6.43	6.52	6.74	7.04	7.20	7.14	7.05
T8-5kg soil + 25g FYM	5.30	5.42	5.40	5.36	5.28	5.19	5.23	5.14
T9-5kg soil + 50g FYM	5.41	5.46	5.43	5.39	5.32	5.24	5.27	5.19
T10-5kg soil + 75g FYM	5.51	5.52	5.50	5.45	5.41	5.29	5.33	5.23
SEm (±)	0.033	0.312	0.016	0.022	0.029	0.025	0.012	0.022
CD(0.05)	0.100	0.935	0.047	0.067	0.088	0.076	0.037	0.067

Table 4. pH in sandy soil during incubation periods

Treatments	Incubation period (days)							
	30	60	90	120	150	180	210	240
T1-Absolute control (5kg soil alone)	4.97	5.01	4.99	4.93	5.01	4.77	4.64	4.57
T2-5kg soil + 25g PHB	5.15	5.22	5.32	5.41	5.55	5.71	5.63	5.52
T3-5kg soil + 50g PHB	5.24	5.31	5.42	5.51	5.66	5.78	5.69	5.59
T4-5kg soil + 75g PHB	5.35	5.41	5.55	5.70	5.93	6.19	6.07	5.91
T5-5kg soil + 25g CFB	5.69	5.72	5.82	6.03	6.17	6.30	6.25	6.15
T6-5kg soil + 50g CFB	5.85	5.93	6.04	6.17	6.31	6.55	6.40	6.30
T7-5kg soil + 75g CFB	6.07	6.11	6.21	6.44	6.61	6.85	6.75	6.64
T8-5kg soil + 25g FYM	5.03	5.13	5.20	5.12	5.06	5.06	4.85	4.73
T9-5kg soil + 50g FYM	5.16	5.24	5.27	5.22	5.17	5.19	5.03	4.89
T10-5kg soil + 75g FYM	5.20	5.32	5.36	5.31	5.25	5.19	5.27	5.00
SEm (±)	0.030	0.019	0.023	0.021	0.021	0.019	0.038	0.016
CD(0.05)	0.090	0.059	0.069	0.062	0.064	0.059	0.113	0.048

Table 5. EC inlaterite soil during incubation periods (dS m-1)

Treatments	Incubation period (days)							
	30	60	90	120	150	180	210	240
T1-Absolute control (5kg soil alone)	0.17	0.19	0.21	0.19	0.17	0.13	0.17	0.12
T2-5kg soil + 25g PHB	0.18	0.23	0.25	0.27	0.29	0.31	0.30	0.29
T3-5kg soil + 50g PHB	0.20	0.25	0.27	0.29	0.31	0.34	0.32	0.31
T4-5kg soil + 75g PHB	0.21	0.25	0.28	0.30	0.32	0.36	0.33	0.32
T5-5kg soil + 25g CFB	0.19	0.24	0.26	0.28	0.30	0.33	0.37	0.30
T6-5kg soil + 50g CFB	0.20	0.27	0.28	0.30	0.33	0.36	0.34	0.32
T7-5kg soil + 75g CFB	0.22	0.28	0.29	0.31	0.34	0.40	0.38	0.36
T8-5kg soil + 25g FYM	0.21	0.25	0.25	0.22	0.20	0.18	0.15	0.17
T9-5kg soil + 50g FYM	0.23	0.27	0.28	0.26	0.22	0.2	0.17	0.18
T10-5kg soil + 75g FYM	0.25	0.29	0.30	0.28	0.25	0.22	0.19	0.20
SEm (±)	0.007	0.005	0.005	0.006	0.007	0.006	0.007	0.007
CD(0.05)	0.020	0.016	0.015	0.017	0.020	0.018	0.021	0.028

Table 6. EC insandy soil during incubation periods (dS m-1)

Treatments	Incubation period (days)							
	30	60	90	120	150	180	210	240
T1-Absolute control (5kg soil alone)	0.08	0.10	0.11	0.09	0.08	0.06	0.05	0.04
T2-5kg soil + 25g PHB	0.10	0.13	0.15	0.17	0.19	0.21	0.19	0.17
T3-5kg soil + 50g PHB	0.11	0.14	0.16	0.20	0.22	0.24	0.23	0.21
T4-5kg soil + 75g PHB	0.13	0.16	0.18	0.22	0.24	0.26	0.24	0.22
T5-5kg soil + 25g CFB	0.12	0.15	0.17	0.20	0.23	0.25	0.24	0.23
T6-5kg soil + 50g CFB	0.14	0.16	0.19	0.21	0.25	0.28	0.26	0.24
T7-5kg soil + 75g CFB	0.17	0.19	0.21	0.23	0.27	0.29	0.27	0.25
T8-5kg soil + 25g FYM	0.17	0.18	0.19	0.17	0.16	0.14	0.12	0.10
T9-5kg soil + 50g FYM	0.18	0.20	0.22	0.21	0.18	0.16	0.14	0.12
T10-5kg soil + 75g FYM	0.18	0.21	0.23	0.21	0.19	0.17	0.16	0.14
SEm (±)	0.005	0.004	0.006	0.005	0.004	0.005	0.005	0.022
CD(0.05)	0.014	0.013	0.018	0.015	0.016	0.013	0.015	0.065

Table 7. Available phosphorus in laterite soil during incubation periods (kg ha-1)

Treatments	Incubation period (days)							
	30	60	90	120	150	180	210	240
T1-Absolute control (5kg soil alone)	53.27	52.52	51.14	46.18	37.44	33.78	29.64	24.41
T2-5kg soil + 25g PHB	65.07	71.28	74.10	76.30	82.69	88.77	83.14	73.69
T3-5kg soil + 50g PHB	67.03	77.57	82.69	96.54	101.09	110.17	105.46	93.78
T4-5kg soil + 75g PHB	82.43	99.01	104.42	108.90	113.49	118.12	107.85	102.38
T5-5kg soil + 25g CFB	59.86	65.57	68.17	71.41	76.53	85.56	82.39	69.02
T6-5kg soil + 50g CFB	65.29	74.40	78.62	93.40	98.29	104.16	99.86	88.66
T7-5kg soil + 75g CFB	70.05	82.82	90.04	100.3	109.38	111.47	107.18	98.03
T8-5kg soil + 25g FYM	71.17	78.51	72.83	75.67	77.01	60.74	51.10	51.59
T9-5kg soil + 50g FYM	88.20	99.23	86.42	96.35	98.84	71.34	57.82	57.71
T10-5kg soil + 75g FYM	100.9	110.6	92.54	99.75	103.71	83.81	69.70	69.14
SEm (±)	1.511	1.172	1.008	0.662	1.656	0.694	0.569	0.681
CD(0.05)	4.533	3.517	3.025	1.988	4.969	2.082	1.709	2.042

Table 8. Available phosphorus in sandy soil during incubation periods (kg ha^{-1})

Treatments	Incubation period (days)							
	30	60	90	120	150	180	210	240
T1-Absolute control (5kg soil alone)	25.61	27.06	24.08	19.78	17.62	16.72	14.93	13.88
T2-5kg soil + 25g PHB	36.06	42.14	50.62	55.88	60.18	63.84	58.20	47.71
T3-5kg soil + 50g PHB	47.18	52.22	56.41	63.35	65.78	68.13	62.27	54.32
T4-5kg soil + 75g PHB	55.47	58.53	62.12	73.09	77.61	81.38	75.30	70.33
T5-5kg soil + 25g CFB	35.50	39.72	43.01	49.28	51.44	57.46	55.55	41.88
T6-5kg soil + 50g CFB	42.33	46.77	52.41	56.78	61.71	65.96	60.51	51.63
T7-5kg soil + 75g CFB	52.37	55.81	58.46	62.83	69.66	73.62	66.34	57.86
T8-5kg soil + 25g FYM	59.43	66.64	73.78	61.26	52.22	45.02	34.57	18.14
T9-5kg soil + 50g FYM	68.73	77.95	79.14	74.70	70.26	63.91	53.72	35.91
T10-5kg soil + 75g FYM	74.74	82.88	86.50	85.38	80.52	73.54	60.81	42.07
SEm (±)	2.489	2.193	9.070	1.812	0.464	0.566	0.496	0.470
CD(0.05)	7.467	6.579	27.211	5.436	1.393	1.697	1.488	1.410

Table 9. Available potassium in laterite soil during incubation periods (kg ha^{-1})

Treatments	Incubation period (days)							
	30	60	90	120	150	180	210	240
T1-Absolute control (5kg soil alone)	156.8	164.2	160.5	149.3	138.1	123.2	112.0	93.3
T2-5kg soil + 25g PHB	168.0	179.2	201.6	235.2	272.5	268.8	235.2	190.4
T3-5kg soil + 50g PHB	179.2	205.3	235.2	257.6	287.4	276.2	250.1	224.0
T4-5kg soil + 75g PHB	197.8	220.2	253.8	280.0	298.6	291.2	268.8	235.2
T5-5kg soil + 25g CFB	171.7	194.1	224.0	246.4	291.2	272.5	242.6	216.5
T6-5kg soil + 50g CFB	190.4	224.0	257.6	268.8	313.6	298.6	265.1	238.9
T7-5kg soil + 75g CFB	212.8	242.6	280.0	294.9	347.2	306.1	302.4	283.7
T8-5kg soil + 25g FYM	197.8	209.1	246.4	224.0	190.4	168.0	145.6	134.4
T9-5kg soil + 50g FYM	220.2	227.7	265.1	238.9	205.3	182.9	171.7	141.8
T10-5kg soil + 75g FYM	231.4	250.1	302.4	268.8	216.5	190.4	179.2	156.8
SEm (±)	5.92	7.16	8.04	5.69	7.25	7.44	7.06	7.70
CD(0.05)	17.75	21.46	24.12	17.06	21.75	22.30	21.18	23.10

Table 10. Available potassium in sandy soil during incubation periods (kg ha^{-1})

Treatments	Incubation period (days)							
	30	60	90	120	150	180	210	240
T1-Absolute control (5kg soil alone)	70.9	78.4	67.2	63.5	56.0	44.8	41.1	37.3
T2-5kg soil + 25g PHB	85.9	97.1	123.2	145.6	190.4	160.5	145.6	123.2
T3-5kg soil + 50g PHB	112.0	138.1	168.0	194.1	216.5	209.1	186.6	168.0
T4-5kg soil + 75g PHB	156.8	171.7	201.6	224.0	257.6	231.5	220.2	197.8
T5-5kg soil + 25g CFB	138.1	153.1	186. 7	209.1	246.4	238.9	224.0	212.8
T6-5kg soil + 50g CFB	156.8	179.2	205.3	240.0	265.1	257.6	235.2	220.3
T7-5kg soil + 75g CFB	179.2	201.6	220.2	253.8	291.2	280.0	268.8	246.4
T8-5kg soil + 25g FYM	123.2	175.5	149.3	126.9	115.7	93.3	78.4	63.5
T9-5kg soil + 50g FYM	156.8	205.3	179.2	164.3	134.4	126.9	112.0	89.6
T10-5kg soil + 75g FYM	186. 7	224.0	201.6	186.7	168.0	145.6	134.4	115.7
SEm (±)	6.77	8.04	7.06	8.45	6.36	7.25	7.52	5.92
CD(0.05)	20.31	24.13	21.18	25.35	19.07	21.75	22.57	17.75

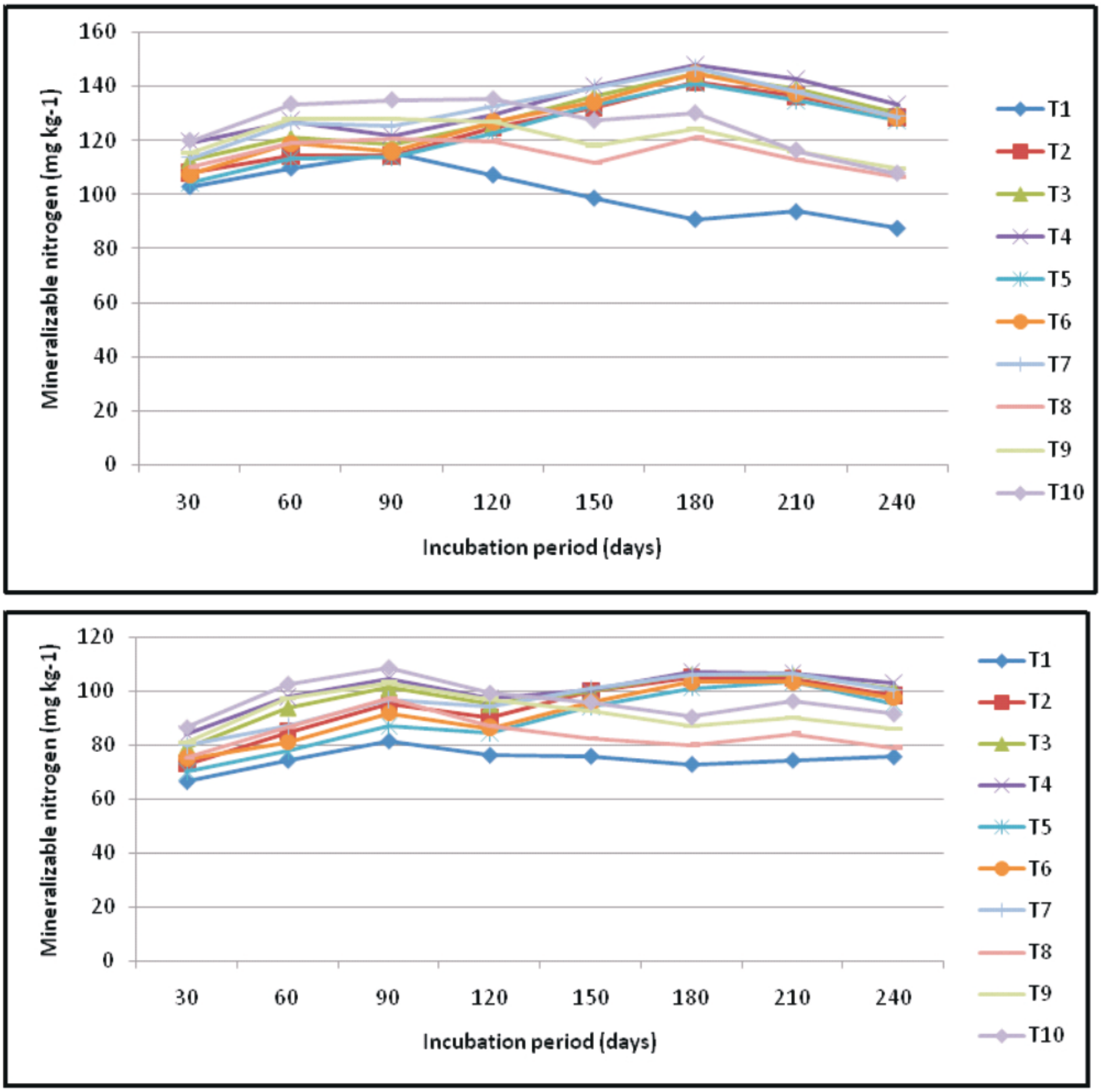

Figure 2. Mineralizable nitrogen in sandy soil during incubation periods (mg kg^{-1})

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