Effects of carbon sources and levels on soil microbial dynamics and N, P mineralization

Sara [1, 2]*, Dost Muhammad[2],

[1]Directorate of Outreach Agriculture Research KP, Peshawar-Pakistan
[2]Department of Soil and Environmental Sciences, The University of Agriculture, Peshawar-Pakistan

Abstract

Soil microbial biomass carbon (MBC) and nitrogen (MBN) reflect microbial size and soil fertility status, and they serve as the living nutrient pool in soil. The study was conducted to assess the effect of various organic sources including poultry manure (PM), farmyard manure (FYM), compost (CM) and biochar (BC) with varying levels of mineral fertilizers on soil microbial dynamics and nutrient(N, P) mineralization under laboratory incubation experiments. The organic amendments were applied based on 0.25, 0.5 and 1.0 % C of soil (w/w) in combination with 75, 50 and 25 % of recommended doses of NPK (120:90 and 60 kg N, P_2O_5 and K_2O ha^{-1}), respectively. After application of amendments the soil was incubated (16 days) for CO_2 emissions and 28 days for N, P mineralization. The rate of CO_2 evolution significantly increased with C levels but declined with time and the highest CO_2 evolution at any time was exhibited by compost followed by PM, FYM and BC that could be associated with higher readily available fraction of C. Soil microbial biomass C and N significantly increased in compost at 1% C level in combination with inorganic fertilizer. Nitrogen and phosphorous mineralization was increases as the incubation period increases (28 days). However, the net release of N and P decreased with an increase in C levels that could be associated both with immobilization as well the fact that higher levels received lower (25%) NPK levels. However, compost and PM treated soils maintained higher N and P which is associated with their higher fraction of labile nutrients. These results suggest that continuous application of organic sources improves the N and P mineralization, SMB and their activity. Thus, regular application of carbon sources could be used as a strategy to improve the soil health of less fertile alkaline calcareous soil.

Key words: Farm yard manure, Poultry manure, Biochar, Compost, Microbial biomass carbon, Microbial biomass nitrogen.

INTRODUCTION

Maintaining and improving soil fertility for sustainable agriculture is becoming mercurial due to the increasing complexity of the nutrient problems. Organic matter is a substance that has many desirable characteristics which influence the soil's physical, chemical and biological properties (Bungau, et al., 2021). The soil organic matter (SOM) is referred to as the "life of the soil" and has long been recognized as a reservoir of plant nutrients and a major factor in the stabilization of soil structure. It is a primary storehouse of C and N and to some extent P, S and minor elements of agricultural soils (Boincean et al.,2019). Soil fertility and crop productivity are greatly influenced by the dynamics of C and N in soils. These dynamics depend on the amount and nature of organic residues entering the soil. These factors that interact with C and N cycling include microbial biomass, light fraction of organic matter and water-soluble organic matter (Luo et al.,2019). The quantity and quality of organic matter representative of humic and non-humic substances are greatly influenced by vegetation, climate, soil reaction and biological conditions. The labile and humified organic matter will have a strong impact on soil fertility and many need to be taken into consideration in the development of fertilizer recommendations. Humus, the most important and largest constituent of organic matter is formed by the decomposition of plant and animal residues by microorganisms. Humus exerts a pronounced influence on the physical, chemical and biological properties of the soil (Raiesi et al.,2021).

Soil properties are strongly correlated with the carbon content which is the usual indicator for SOM. Soil carbon storage within the soil is most beneficial for agriculture and the environment. Carbon is the chief element present in soil organic matter comprising 48 to 50% of the total weight (Taneja et al.,2022). Soil organic fraction consists of microbial cells plant and animal residues at various stages of decomposition, humus and highly carbonized compounds such as charcoal graphite and coal (Yenani et al.,2021).

The importance of organic matter in the maintenance of soil health and productivity is well known. In tropical climates soil organic matter is subjected to rapid decomposition and mineralization due to higher oxidation, leading to a reduction of soil organic matter content and indirectly reducing fertility and crop productivity (Rao et al.,2019). Inorganic carbon in the soil is generally very stable but SOC is very reactive and a large quantity can be lost through intensive agriculture land use change, deforestation, burning and removal of crop residue, climatic and rainfall changes, over-grazing soil degradation, soil desertification, shifting cultivation, etc (Raza et al.,2021). At present situation, more terrestrial organic matter has been lost in the form of carbon dioxide than it has been sequestered in soils (Flach et al.,2019). Rashmi, et al.(2020) reported that Imbalanced, improper and indiscriminate applications of yield-enhancing technologies are the other major factors favoring organic carbon loss in the recent past.

Agriculture has long relied on animal dung as a source of fertilizers. When manure is applied, several other soil characteristics that support soil health are impacted(Rayne & Aula, 2020).In medium to long term application periods, using animal dung can increase soil organic matter. Manure hence helps to increase soil aggregate stability, water infiltration, and water retention while decreasing soil bulk density and compaction(Urra et al., 2019). Poultry litter is also regarded as a source of organic matter that includes significant plant nutrients and enhances the condition of the soil (Popov et al., 2020) Application of poultry manure enhances soil's physical and chemical characteristics, moisture content, total soil porosity, total N, and accessible P (Jafari Tarf et al., 2022).It is sustainable to apply poultry manure to cropland to improve soil health, diversify agroecosystems, and boost farm productivity (Burton et al., 2017). By enhancing carbon (C) sequestration, nutrient and water retention, and other soil health qualities, biochar have the potential to be used in soil improvement (Novak et al., 2016). Biochar has the ability to improve the features of soil health due to its elemental makeup and capacity to raise pH, hold water in its pore space, and bind nutrients and metals on its functional groups.(Hersh et al., 2019). Biochar is utilized as an amendment to restore soil health due to its wide ranrge of chemical and physical properties(Liyanage et al., 2021) A potential strategy to consistently enhance soil health and encourage crop growth is adding biochar to the soil(Guo et al., 2020).This project is therefore proposed to improve our understanding regarding the effect of organic sources along with inorganic sources on soil CO_2 emissions, soil microbial biomass carbon and nitrogen and N, P mineralization in alkaline calcareous soil in the semi-arid environment.

III. MATERIALS AND METHODS

The impact of organic amendments and mineral N, P and K fertilizer on nutrient (N, P) mineralization, microbial activity, and microbial biomass was studied using laboratory incubation experiment. For that we used organic sources (Farmyard manure, Poultry manure, Biochar and Compost) based on 0.25, 0.50 and 1 % Carbon levels in combination with inorganic fertilizers sources such as 75, 50 and 25 % recommended dose of NPK along with control and 100 % NPK. Bulk soil samples (0–15 cm) of the field experiment's soil were taken for incubation tests. For microbiological research, the soil sample was sieved and kept refrigerated. The amendments were applied to the soil and incubate it for microbial studied. The soil samples were split into two equal parts half were fumigated and half were unfumigated.

From each unfumigated sample50g of soil were taken and incubated for 2,4,8 and 16 days. CO_2 production was calculated by the procedure of alkali trapping technique followed by Shah et al. (2010).

$$CO_2 \text{ ug g}^{-1} \text{ soil day}^{-1} = \frac{(Blank - Sample) \times 22000000 \times N of\ HCL}{1000 \div Soil\ Weight \div No.of\ Days}$$

For microbial biomass study 50g of each unfumigated and fumigated sample were taken and incubated for 16 days. Microbial biomass carbon and microbial biomass nitrogen in soil were determined by the fumigation technique described by Brookes et al. (1985).

Microbial biomass carbon and nitrogen was calculated by the procedure followed by Horwath and Paul (1994) as given:

$$\text{Microbial biomass } * CO_2 = \frac{(Blank - Sample) \times 0.1}{1000} \times \frac{10^6 \times 22}{(weightof\ soil \times No.of\ Days)}$$

$$\text{Microbial Biomass C} = \frac{*Reading\ of\ CO2 \times 12}{44}$$

$$\text{Microbial biomass C} = \frac{(fumigated\ C\ Reading - unfumigated\ C\ Reading)}{0.45}$$

For microbial biomass-N, the same soil samples were run for total mineral N and microbial biomass-N was calculated as described by Horwath and Paul (1994).

Mineral N=$\frac{(Sample-Blank)\times KCL\times 70)}{(Weight\ of\ soil\times Extract\ Take)}$

Microbial Biomass N=$\frac{(Fumigated\ N-Unfumigated\ N)}{0.54}$

For N and P mineralization study 500 g from each unfumigated sample were taken and incubated for 28 days. For mineral N and P sample were taken out at 0, 7, 14, and 28 days and analyzed for total mineral N and extractable P. Total mineral N was determined by the procedure of Mulvaney (1996).

$$N\ (mg\ kg^{-1}) = \frac{(Sample - Blank) \times Nof\ Hcl \times meq\ N \times Volume\ made}{(Weight\ of\ sample(g) \times (Volume\ taken\ for\ distillation)} \times \frac{10^6 mg}{kg}$$

The extractable phosphorus concentration in soil samples was determined by the AB-DTPA extraction method as described by Soltanpour and Schwab (1977).

$$Phosphorus\ (P)(mg\ kg^{-1}) = \frac{(Instrumental\ Reading \times Volume\ made)}{(Weight\ of\ sample \times Volume\ taken)}$$

3.9 Statistical Analysis

The data were analyzed statistically according to Steel et al. (1996) and means were compared using the LSD test ($P \leq 0.05$) by statistical packages statistix 8.1.

RESULTS AND DISCUSSION

Short-Term Effects of carbon sources and levels on Soil Microbial Dynamics

Effect of organic sources and levels on microbial activity or CO_2 emissions in incubation

Microbial activity in incubation as influenced by carbon sources and level in the short-term are presented in Table 1. Results regarding carbon sources when data averaged across carbon levels and days maximum soil microbial activities was recorded in the treatment which receiving compost during all days intervals followed by other sources while minimum microbial activities was recorded in the treatment which receiving biochar. Results regarding carbon levels when data averaged across carbon sources and days maximum soil microbial activities was recorded in the treatment which receiving 1 % carbon level followed by 0.50 % while minimum was recorded in 0.25 % carbon level. Results regarding control vs rest maximum soil microbial activities was recorded in the treatment which receiving combine application of organic and inorganic fertilizers while minimum soil microbial activities was recorded in control plot. (Gopal Ramdas et al., 2017) reported that the organic and inorganic sources of nutrients had a significant (P< 0.05) impact on soil enzyme activities. In flooded and transplanted rice soils, the use of organic sources of nutrients, particularly FYM, increased microbial and enzyme activity. The use of FYM as an organic farming method is more beneficial when the goal is to conserve more soil organic matter and increase microbial activity.(Ogbonna, 2012) reported that the composting organic wastes enhances soil organic matter and other nutrients, which has the added benefit of increasing soil quality and so enhancing agriculture's long-term viability. Their use also boosts microbial activity, which improves nutritional availability.

Table 1 Short-term effect of carbon sources and levels on microbial activity (μg g^{-1} soil day^{-1}) in soil during lab incubation experiment

	Day 2	Day 4	Day 8	Day 16
Carbon Sources (CS)				
FYM	214c	130b	54c	37bc
PM	234b	139b	76a	41ab
BC	203d	115c	45d	35c
COMP	253a	154a	67b	46a
LSD	7.08	8.8	4.2	5.2
Carbon Levels (CL)				

0.25	186c	115c	43c	34c
0.5	225b	137b	61b	40b
1	268a	152a	78a	45a
LSD	6.1	7.6	3.6	4.5
Control	110	64	29	23
NPK	193	105	47	30
Rest	226	134	61	40
Control Vs Rest	**	**	**	**
NPK Vs Rest	**	**	*	*
CS*CL	NS	NS	NS	NS

Means followed by same letter (s) in a column do not differ significantly at $p < 0.05$

FYM, BC, PM, COMP, CS, CL and Y stand for farmyard manure, biochar, poultry manure, compost, carbon sources, carbon level and year, respectively.

Carbon levels at 0.25, 0.5 and 1.0 % received 75, 50 and 25 % or recommended dose of NPK

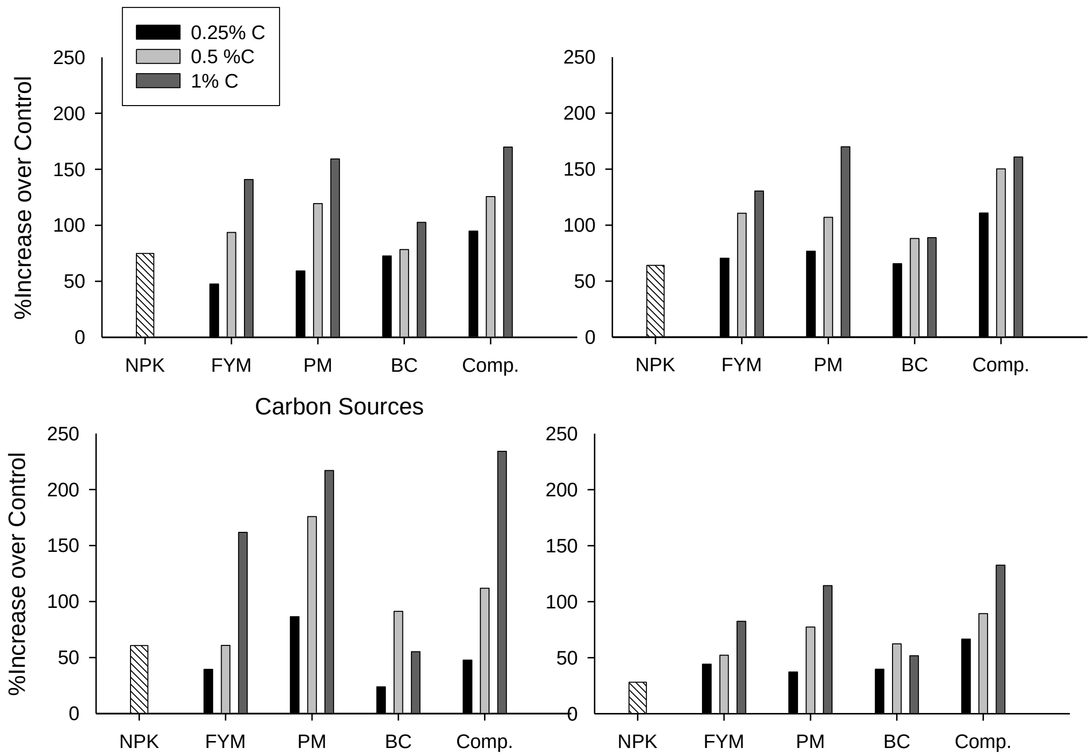

Figure 1 **Increase (%) over control in CO_2 emission on different days due to Carbon sources application along with carbon levels.**

Short term effect of carbon sources and levels on soil microbial biomass carbon

The results obtained on soil microbial biomass-C (MBC) as affected by added organic sources and their levels showed that MBC was significantly ($P \leq 0.05$) greater in the organic sources treated plots than in the control (Table 2). The highest MBC of 387 µg g^{-1} soil was obtained with the added compost which was statistically at with poultry manure while the lowest was 351µg g^{-1} in the biochar treatment. The data further revealed that differences in MBC were also significant ($p<0.05$) between the carbon levels (Table 4.31). The MBC was significantly greater for 1 % C level compared with 0.25 and 0.5% C levels. The highest MBC of 395 µg g^{-1} soil was obtained for treatment receiving organic sources based on 1% C level compared with 335 µg g^{-1} soil in the 0.25% C levels. These results indicated that MBC increased with increasing levels of organic sources. The data also revealed that control vs rest and NPK vs rest were found significant. Organic sources along with NPK show better results compared to applying NPK alone. The interaction between carbon sources and levels was non-significant.

These results indicated that MBC increased with increasing levels of organic sources. The data also revealed that control vs rest and NPK vs rest were found significant. Organic sources along with NPK show better results compared to applying NPK alone. The interaction between carbon sources and levels was non- significant.

Short term effect of carbon sources and levels on soil microbial biomass nitrogen

Like MBC, the MBN was also significantly (P≤0.05) greater in organic sources treated plots relative to control and NPK alone treatment in lab incubation (Table 2). The response of MBN to the organic amendment was almost similar. On average, the maximum MBN of 24 µg g^{-1} soil was obtained in soil receiving the compost which was statistically similar to poultry manure compared with 19 µg g^{-1} soil in the farm yard manure treatment. The data further revealed that differences in MBN were also significant ($p<0.05$) between the carbon levels treatment. The MBN was significantly greater for organic sources applied based on 1% C level compared with 0.25 and 0.5% C level. On average, the maximum MBN of 26 µg g^{-1}soil was obtained for treatment receiving organic sources based on 1% C level compared with 19 µg g^{-1} soil for that receiving organic sources based on 0.25% C level. It was also observed that the control vs rest and NPK vs rest were significant. In this study higher microbial biomass N was recorded in the treatment which receives compost it may be due to the higher availability of N (Havlin, 2020). In results regarding microbial biomass higher N was recorded in the treatment which receive organic source at 1 % application than other levels it may be due to higher application of organic sources than other levels (Sichone & Mweetwa, 2018).

Carbon to nitrogen (C/N) ratio in soil microbial biomass

Our data showed that the C/N ratios in SMB were not significantly affected by the added organic sources (Table 2). The C/N ratios in SMB decreased with increasing carbon levels. The lowest C/N ratio in SMB of 15 was obtained in soil receiving the highest level (1%) of the organic source compared with the lowest level (0.25% C). The data further revealed that differences in C/N ratios of MBC between the organic sources were not significant, the lowest C/N ratio in SMB of 15 was obtained for treatment receiving biochar compared with other organic sources Moreover, the C/N ratios in SMB of control vs rest were significant. The interactive effects of organic sources and levels on C/N ratios in SMB were statistically non-significant (Table 28).The soil C:N ratio is one of the important indicators that explain the nutrient release dynamics of added soil organic amendments. Changes in the C/N ratio of SMB may affect the availability of carbon and nitrogen to microorganisms, as well as the microbial composition in soil. The C/N ratio in soil microbial biomass could be depending upon the type of C present in biochar and other organic matters. Nicolardot et al. (2001) observed that the C/N ratio in soil microbial biomass was directly correlated with the C/N ratio of amended organic matter.

Table 2 Soil Microbial Biomass C, N and C/N ratio in lab incubation as influenced by Carbon sources and levels

	Biomass C	Biomass N	C/N ratio
Carbon Sources (CS)			
FYM	357b	19b	18 NS
PM	368ab	23a	16
BC	351b	22ab	15
COMP	387a	24a	16
LSD			
Carbon Levels (CL)			
0.25	335c	19b	17NS
0.5	367b	22b	16
1	395a	26a	15
LSD			
Control	305	15	20
NPK alone	324	19	17
Rest	366	22	17
Control Vs Rest	**	*	*
NPK Vs Rest	*	*	-
CS*CL	NS	NS	NS

Means followed by the same letter (s) in a column do not differ significantly at $p < 0.05$

FYM, BC, PM, COMP, CS, CL and Y stand for farmyard manure, biochar, poultry manure, compost, carbon sources, carbon level and year, respectively.

Carbon levels at 0.25, 0.5 and 1.0 % received 75, 50 and 25 % or recommended dose of NPK

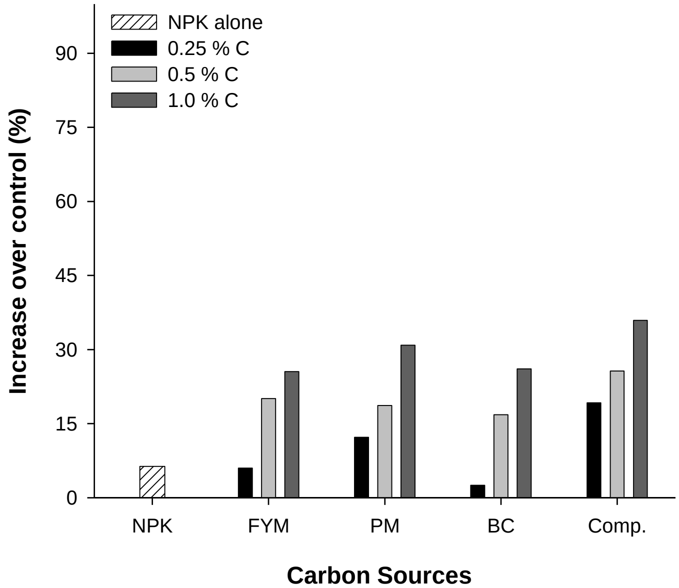

Figure 2 **Increase (%) over control in microbial biomass carbon due to Carbon sources applications along with carbon levels.**

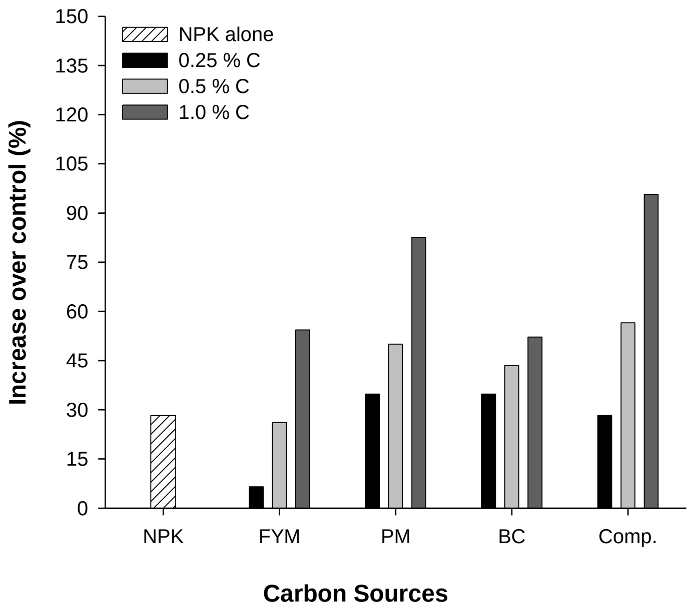

Figure 3 **Increase (%) over control in microbial biomass nitrogen due to Carbon sources applications along with carbon levels.**

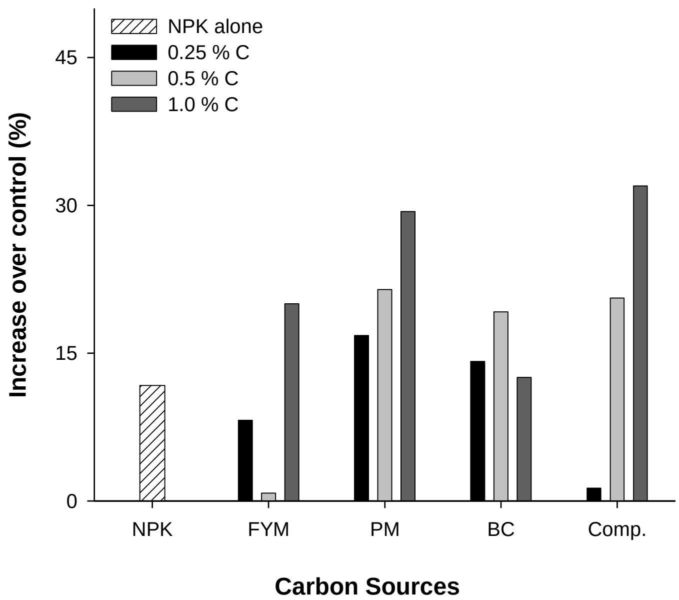

Figure 4 **Increase (%) over control in C/N ratio due to Carbon sources applications along with carbon levels.**

Effect of carbon sources and levels on N Mineralization (short term)

Carbon sources and carbon levels had a significant effect ($P \leq 0.05$) on mineral N on all incubation days (Table 3). The data on all incubation days (0, 7, 14, 28) show that in carbon sources, maximum mineral nitrogen (32,38,50,58 ug/g) was recorded in the treatments receiving compost followed by poultry manure, FYM and BC. Among the carbon levels the mineral nitrogen maximum which receives 0.25 % C along with 75% NPK in all incubation days followed by 0.5%C (50%NPK) and 1%C (25% NPK). All the amended plots have maximum mineral nitrogen over control. The interaction between carbon sources and carbon levels was found non-significant ($P<0.05$) during 0, 7, 14 and 28 days of incubation periods (Table 4.32). Among the days at day 0 and 7 has no significant effect .Day 14 and 28 has significantly higher mineral nitrogen than day 0 and 07.This show that due microbial activity in soil increase decomposition which increases mineralization due to which mineral nitrogen were higher. In this research mineral N increases with compost application it may be due to higher decomposition of compost and already decompose nutrients present in compost (Darwich et al., 2012). Higher N content was recorded in the treatment which receive 1 % organic source application than other levels it may be due to higher application of organic sources ultimately it have large amount of available nutrients which are needed for higher yield of crops (Khan et al., 2017).

Table 3 Short term effect of carbon sources and levels on N mineralization in soil during lab incubation experiment

	0 Day	7 Day	14 Day	28 Day
Carbon Sources (CS)				
FYM	30a	36a	46^{NS}	56a
PM	31a	36a	48	55a
BC	27b	31b	44	48b
COMP	32a	38a	46	58a
LSD	2.4	3.07	3.7	2.8
Carbon Levels (CL)				
0.25	34a	38a	50a	57a
0.5	30b	37b	47b	56a
1	27a	31b	40C	50b
LSD	2.09	2.67	3.2	2.4
Control	21	23	22	23
NPK	24	29	32	33
Rest	30	35	46	54
NPK Vs Rest	*	*	*	*
Control Vs Rest	**	**	**	**
CS*CL	NS	NS	NS	NS

Means followed by same letter (s) in a column do not differ significantly at $p < 0.05$

FYM, BC, PM, COMP, CS, CL and Y stand for farmyard manure, biochar, poultry manure, compost, carbon sources, carbon level and year, respectively.

Carbon levels at 0.25, 0.5 and 1.0 % received 75, 50 and 25 % or recommended dose of NPK.

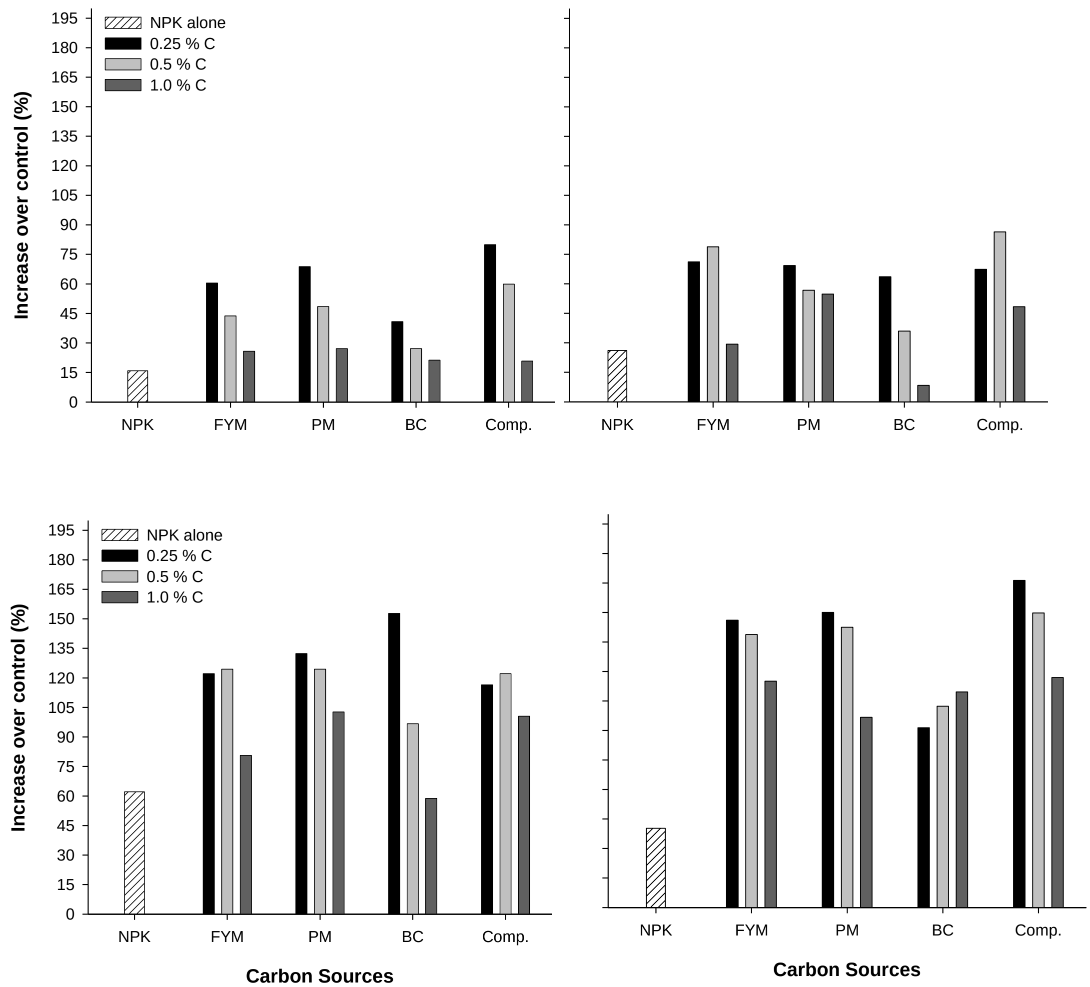

Figure .5 **Increase (%) over control in nitrogen mineralization on different days due to Carbon sources applications along with carbon levels.**

Effect of carbon sources and levels on P mineralization (short term)

Carbon sources and carbon levels had a significant effect ($P \leq 0.05$) on mineral phosphorous on all incubation days (Table 4).On day 0 in carbon sources the mineral p on compost, farmyard manure poultry manure and biochar are statistically similar. On day 07 and 14 the compost and poultry were statistically similar as well as farmyard manure and biochar show at far result. On day 28 result show compost and poultry manure was significantly higher mineral p then farmyard manure and biochar. Among the carbon levels the mineral phosphorous will be maximum where it receive0.25 % C in the form carbon sources along with 75% NPK in all incubation days followed by 0.5 and 1% C (50 and 25% NPK).

All the amended plots have maximum mineral phosphorous over control. The interaction between carbon sources and carbon levels were found non-significant (P<0.05) during 0, 7, 14 and 28 days of incubation periods .Among the days at day 0 and 7 has similar mineral phosphorous. Day 14 and 28 has significantly higher mineral phosphorous than day 0 and 07.This show that microbes present in soil gradually increase decomposition which increases mineralization due to which mineral phosphorous were higher in later incubation days compared to early incubation period. In this study P mineralization increases with increases duration it may be due to with increases duration microbial activity increases which ultimately increases P mineralization (Bobrecka-Jamro et al., 2013). And maximum P mineralization was recorded in the treatment which are treated with 1 % organic level application it may be due to higher microbial activities (David N. Ogbonna, 2012).

Table 4 Short-term effect of carbon sources and levels on P mineralization in soil during lab incubation experiment

	0 Day	7 Day	14 Day	28 Day
Carbon Sources (CS)				
FYM	3.2bc	3.5b	4.5b	4.8b
PM	3.6ab	4.1a	5.1a	5.4ab
BC	3.0c	3.6b	4.1b	3.8c
COMP	3.7a	4.6a	5.2a	5.9a
LSD	0.4	0.5	0.5	0.6
Carbon Levels (CL)				
0.25	3.6a	4.8a	5.6a	5.9a
0.5	3.4ab	4.1b	4.9b	5.1b
1	3.1b	3.1c	4.0c	5.9a
LSD	0.4	0.4	0.4	0.5
Control	2.4	1.73	2.4	2.1
NPK	3.2	3.6	3.3	3.2

Rest	3.4	4.0	4.9	5.0
Control Vs Rest	**	**	**	**
NPK Vs Rest	-	-	*	*
CS*CL	NS	NS	NS	NS

Means followed by same letter (s) in a column do not differ significantly at $p < 0.05$

FYM, BC, PM, COMP, CS, CL and Y stand for farmyard manure, biochar, poultry manure, compost, carbon sources, carbon level and year, respectively.

Carbon levels at 0.25, 0.5 and 1.0 % received 75, 50 and 25 % or recommended dose of NPK

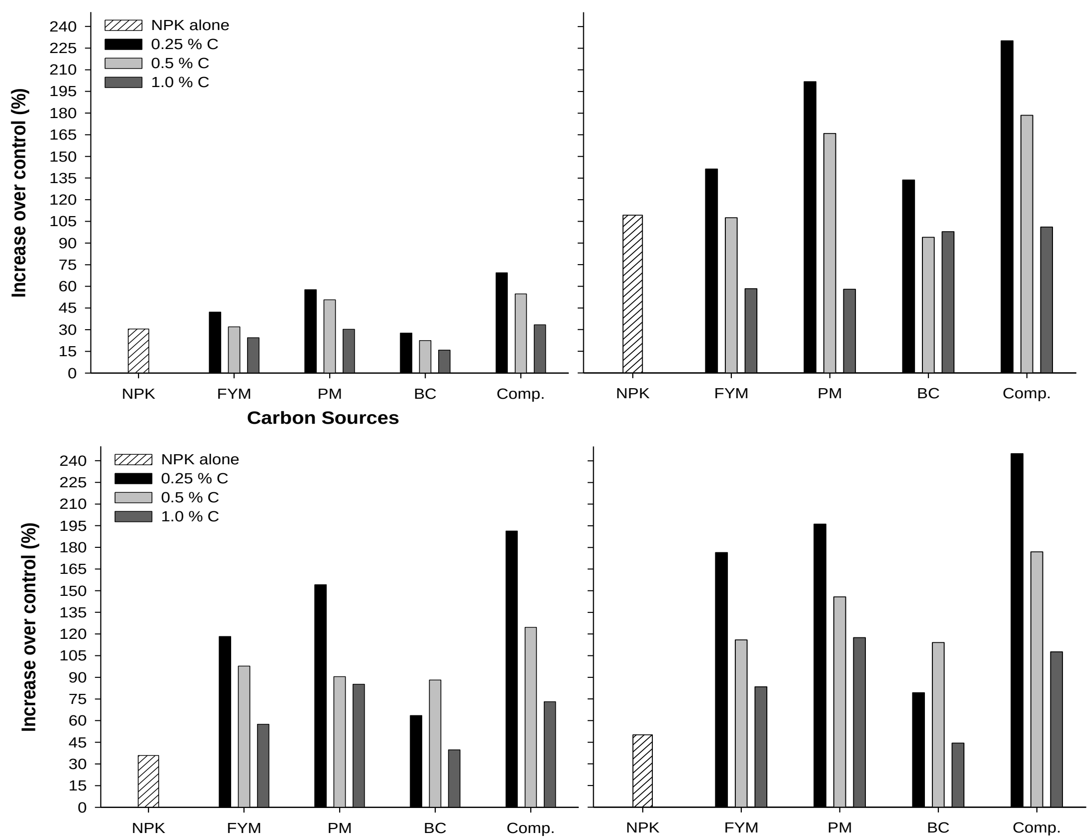

Figure 6. Increase (%) over control in mineral phosphorous on different days due to Carbon sources applications along with carbon level

Discussion

Microbial Activity (CO_2)

CO_2 emissions increases from the organic sources treated plot in 16 days of incubation period.CO_2 emissions from the compost treated plots increase in all incubation days as compared to other organic sources it is due to easily decompose nature of compost the microbes attack and degrade the easily decomposed matter first and release CO_2(Khatoon at al.,2017). The rate of CO_2 evolution was higher in all treatments at the beginning of incubation and thereafter gradually declined. Reduced microbial activity, as indicated by a drop in CO_2, might be attributed to two factors: first, a decrease in easily biodegradable organic matter; and second, a moderate stable microbial activity subsequently, suggesting that decomposition had progressed to the advanced stage (Islam et al 2021). It also shows the stability of the end product or compost (Hwang et al., 2020).Because of the high content of labile carbon (C) and nitrogen (N), in composts promote nutrient availability and microbial activity (Bai et al. 2014).

After compost the higher CO_2 emission from poultry manure and farmyard manure it is due to higher nutrient content in these manure (Hwang et al., 2020). Similar results were reported by Awasthi et al. (2020). The results of Sistani et al. (2019) also in line with our results that Poultry litter treatment produced significantly higher CO_2 emissions. CO_2 emissions were higher in soil supplemented with organic P sources (PM and FYM) than in soil supplied with mineral sources (Adnan et al., 2018).

Biochar has also been found to reduce CO_2 emissions due to its low degradable C content, resulting in an increase in C sink in soil (Darby et al., 2016). Because of the resistant character of carbon molecules in biochar has greater soil stability compared to other easily decomposable organic materials (Ok et al. 2015). Similarly Méndez et al. (2013) observed that when biochar was mixed with soil and incubated for many days, it reduced CO_2 emissions significantly.

Microbial biomass carbon and nitrogen in soil

Our findings clearly indicated that the addition of manure increased SMB-C and N. However, the highest level of SMB-C and N occurred in treatment plots that received the highest manure level (1% C) in combination with chemical fertilizers. Compost enhances soil physicochemical qualities, soil microbial biomass (SMB), soil disease resistance, and soil organic matter (SOM) (Waqas,.2018) . Al-Suhaibani et al.(2020) suggested similar results that incorporating organic composts, either alone or in combination with chemical fertilizers, resulted in a significant increase in the diversity and activity of soil microbial biomass. The results of Liuet al.(2021) indicated the addition of composted organic manure enhanced MBC and MBN respectively, as compared to chemical N fertilizer application. Our results are also in line with

Cao et al.(2018) who reported that microbial biomass carbon (MBC) and nitrogen (MBN), were effectively increased by biochar and compost. Iqbal et al.(2021) reported that increases in MBC and MBN may have occurred because organic fertilizer improved the soil's physicochemical and biological qualities, resulting in higher mineral N absorption and uptake by the crop. Increased mineral N content in the soil could support microorganisms, as demonstrated by higher microbial biomass nitrogen (MBN). MBC and MBN increased the most in the FYM 100% N fertilizer treatment because biochar provided habitat while FYM and N fertilizer gave energy to the microorganisms (Sugihara et al., 2010). Similarly Irfan et al. (2019) reported that biochar application to arid cereal crops significantly increases soil microbial biomasses (MBC and MBN) and enzyme activity. Soil enzyme (urease and dehydrogenase) activity was significantly improved with the addition of 1% C biochar and N fertilizer to the soil. Biochar addition with N fertilizer definitely has a good influence on microbial biomasses and enzymatic activity in the dryland region when compared to biochar addition without N fertilization. The combination of biochar and N fertilizer resulted in larger pools of MBC and MBN, particularly at the top soil (0-10 cm) layer (Oladele et al., 2019). Biomass carbon plays a very important role in biogeochemical processes which are influenced by the addition of different organic and inorganic fertilizers in soils (Cerny et al., 2008). Soil organic matter, nutrients and water contents, physical and chemical properties, and climatic parameters have a great effect on microbial biomass in soils (Tomich et al. 2011). In this study higher microbial biomass was recorded in the treatment which is treated due to compost it may be due to higher microbial activities in soil than other organic sources in the first year (Sichone & Mweetwa, 2018). Organic farming with the addition of compost has been shown to favor soil biota and provide better results in terms of biomass carbon and nitrogen compared to intensive farming with inorganic fertilizers (Santos et al. 2012; Amaral and Abelho, 2016) While in the second year higher microbial activities was recorded in the treatment which is treated with poultry manures it may be due to decomposition of PM lesser than that of Compost reported by (Shah et al., 2017). Adediran et al., (2005) reported significant increase in total microbial biomass in the soil with the application of compost.

Nitrogen mineralization

Soil organic matter is one of the greatest carbon and nitrogen reserves in many ecosystems, which can significantly increase plant nutrition (Marzi et al., 2019) .Nitrogen mineralization was significantly increase as incubation period increases. Compost poultry manure and farm yard manure has same nitrogen mineralization in all incubation days. Nitrogen mineralization an increase as incubation period extended it is due to the degradation of organic sources .Microorganism decomposes the organic matter and release nitrogen (Marzi et al., 2020). Mineral N increases with compost application it may be due to higher decomposition of compost and already decompose nutrients present in compost (Darwich et al., 2012). Poultry manure showed higher mineralization rates than farm yard manure, which is consistent with their low C:

N ratios Sharma et al., 2016). Li et al. (2020) reported that amounts of C and N in residues determine whether net N mineralization or net N immobilization occurs.

In our results the rate of nitrogen mineralization was lower from biochar treatment in all incubation days. The decrease in the amounts of $NO_3 - N$ with an increase in biochar quantity could be attributed to N immobilization, which might induce from microbes and physical protection of SOM by the biochar (Zhu et al.,2017). Jien et al.(2018) also proposed similar results that N immobilization in biochar-added soil was most likely produced by biochar sorption over native SOM. Chen et al. (2014) and Jien et al. (2015) suggested that sorption over native SOM could result in a protective mechanism that reduces mineralization of native SOM and causes negative N release. Prayogo et al. (2014) mineral N decreased significantly and rapidly with the addition of biochar or/and straw, possibly due to N adsorption and retention.

Phosphorous mineralization in soil during lab incubation experiment

Soil phosphorous mineralization was increase as incubation days increases in compost and poultry manure treated plot. Adnan et al. (2017) reported that the increase in P may also be due to the release of significant amounts of CO_2 during organic matter decomposition and complexing of cations such as Ca_2+, which is primarily responsible for P fixing in alkaline and calcareous soils. Bhambure et al. (2018) suggested that increased microbial biomass carbon by boosting microbial activities and boosted phosphatase and dehydrogenase activities, which are responsible for P solubilization. The incubation study demonstrates the use of compost in combination with inorganic fertilizers to improve soil nutrient supply capacity, nutrient use efficiency, and soil fertility for crop development.

According to Adnan et al. (2019), poultry manure reduce soil pH by releasing H+ ions and increase the availability of P in soil from both applied and indigenous sources. We discovered that P availability increased with time; however, this increase was more pronounced in the soil treated with poultry manure than in un-treated soil. This could be due to the fast mineralization of organic P and the solubilization of Ca-P via acidifying and chelating mechanisms releasing unavailable P into the mobile pool(Adnan et al.,2017). Khan and Sharif (2012) summarize that P availability reduces in calcareous soils, although poultry manure has the potential to mitigate the negative effects of liming on P availability. Poultry manure fertilization boosts the microbial population. For improved soil P nutrition, calcareous soils must be treated with poultry manure. Additionally poultry manure has the potential to boost P availability in both calcareous and non-calcareous soils. The incubation study demonstrates the use of compost in combination with inorganic fertilizers to improve soil nutrient supply capacity, nutrient use efficiency, and soil fertility for crop development.

Farmyard manure also increases the p mineralization as the incubation days increases. As the days of incubation increase the due to microbial activity degradation of farmyard manure increases (Anjum and Khan. (2021). Ikram et al.(2019) shows that phosphate fertilizer premixing with farmyard manure enhances phosphorus availability in calcareous soil for higher wheat productivity. The use of inorganic phosphate in combination with farmyard manure is an efficient strategy for increasing plant-available P in soil and the agronomic efficiency of P fertilizer.

The lower phosphorus mineralization was observed in biochar treatment plots. Organic carbon content may play an essential influence in phosphorus losses (Simmonds et al., 2016). In general, farmyard manure and vermicompost contain more organic acid groups such as humic and fulvic acids than biochar, which increases competition for adsorption sites between hydroxyl functional groups and phosphate ions. This could result in a decrease in phosphorus adsorption. In biochar treatments, however, lower mobile carbon availability and the presence of Ca on the biochar surface may result in the creation of a stable organic-metal complex that can be adsorbed to the soil via cation bridging (Yadav et al., 2019). The biochar amendment lowers nitrogen and phosphorus losses in soil by absorbing and retaining NO_3-N, NH_4-H, and phosphate (Thangarajan et al., 2018).

4. 12 Conclusion

In laboratory incubation experiment that CO_2 emissions, microbial biomass C and N and mineralization of N and P were more from the treatment receiving organic sources (compost and poultry manure) along with mineral fertilizer. Due to the mineralization/ decomposition of organic sources and their nutrient release are different at different times in soil solutions. That's why different organic sources performed differently in plant growth some organic sources decomposed easily and some organic sources take time to decompose and sequester more carbon during experimentation as compared to easily decomposed sources.

REFERENCES

Adnan, M., Fahad, S., Khan, I. A., Saeed, M., Ihsan, M. Z., Saud, S., ... & Wu, C. (2019). Integration of poultry manure and phosphate solubilizing bacteria improved availability of Ca bound P in calcareous soils. 3 Biotech, 9(10), 1-10.

Adnan, Muhammad, Zahir Shah, Muhammad Sharif, and Hidayatur Rahman. (2022). Liming induces carbon dioxide (CO2) emission in PSB inoculated alkaline soil supplemented with different phosphorus sources. Environmental Science and Pollution Research 25, no. 10 (2018): 9501-9509.

Al-Suhaibani, N., Selim, M., Alderfasi, A., & El-Hendawy, S. (2020).Comparative performance of integrated nutrient management between composted agricultural wastes, chemical fertilizers, and biofertilizers in improving soil quantitative and qualitative properties and crop yields under arid conditions. Agronomy, 10(10), 1503.

Anjum, & Khan, A. (2021). The decomposition of soil organic matter is modulated by soil amendments. Carbon Management, 12(1), 37-50.

Awasthi, M. K., Duan, Y., Awasthi, S. K., Liu, T., & Zhang, Z. (2020). Influence of bamboo biochar on mitigating greenhouse gas emissions and nitrogen loss during poultry manure composting. Bioresource technology, 303, 122952.

Bai SH, Blumfield TJ, Reverchon F. (2014) The impact of mulch type on soil organic carbon and nitrogen pools in a sloping site. Biol Fertil Soils 50:37–44

Bhambure, A. B., Mahajan, G. R., & Kerkar, S. (2018). Salt tolerant bacterial inoculants as promoters of rice growth and microbial activity in coastal saline soil. Proceedings of the National Academy of Sciences, India Section B: Biological Sciences, 88(4), 1531-1538.

Bobrecka-Jamro, D., G. Kruczek, M. Romaniak, W. Jarecki and J. Buczek. (2013). Effect of the dose and method of top-dressing with nitrogen on the yield and quality of winter wheat grain. Acta Scientiarum Polonorum. Agricultura, 12(4).

Boincean, B., Dent, D., Boincean, B., & Dent, D. (2019). Changing the Farming Paradigm. Farming the Black Earth: Sustainable and Climate-Smart Management of Chernozem Soils, 1-18.

Bordoloi, S., Gopal, P., Boddu, R., Wang, Q., Cheng, Y. F., Garg, A., & Sreedeep, S. (2019). Soil-biochar-water interactions: role of biochar from Eichhornia crassipes in influencing crack propagation and suction in unsaturated soils. Journal of Cleaner Production, 210, 847-859.

Brookes, P. C., A. Landman, G. Pruden and D. S. Jenkinson.(1985). Choloroform fumigation and the release of soil nitrogen: A rapid direct extraction method to measure microbial biomass nitrogen in soil. Soil Biology and Biochemistry,17: 837-842.

Bungau, S., Behl, T., Aleya, L., Bourgeade, P., Aloui-Sossé, B., Purza, A. L., ... & Samuel, A. D. (2021). Expatiating the impact of anthropogenic aspects and climatic factors on long-term soil monitoring and management. Environmental Science and Pollution Research, 28(24), 30528-30550.

Cao, Y., Gao, Y., Qi, Y., & Li, J. (2018). Biochar-enhanced composts reduce the potential leaching of nutrients and heavy metals and suppress plant-parasitic nematodes in excessively fertilized cucumber soils. Environmental Science and Pollution Research, 25(8), 7589-7599.

Chen CP, Cheng CH, Huang YH, Chen CT, Lai CM, Menyailo OV, Oleg V, Fan LJ, Yang YW. (2014) Converting leguminous green manure into biochar: changes in chemical composition and C and N mineralization. Geoderma 232:581–588

Darby, I., Xu, C. Y., Wallace, H. M., Joseph, S., Pace, B., & Bai, S. H. (2016). Short-term dynamics of carbon and nitrogen using compost, compost-biochar mixture and organo-mineral biochar. Environmental Science and Pollution Research, 23(11), 11267-11278.

Darwich, M. A., E. I. Maaz and H. M. R. M. Ahmed.(2012). Effect of mineral nitrogen, sulphur, organic and bio-fertilizations on some physicaland chemical properties and maize productivity in saline soil of Sahl El-Tina. Journal of Applied Sciences Research, 8(12).

Ogbonna, D. N., N.O. Isirimah and E. Princewill.(2012). Effect of organic waste compost and microbial activity on the growth of maize in the utisoils in Port Harcourt, Nigeria. Afric. J. Biotech, 11(62): 12546-12554.

Flach, K. W., Barnwell, T. O., & Crosson, P. (2019). Impacts of agriculture on atmospheric carbon dioxide. In Soil organic matter in temperate agroecosystems (pp. 3-13). CRC Press.

Guo, M., Song, W., & Tian, J. (2020). Biochar-Facilitated Soil Remediation: Mechanisms and Efficacy Variations. In Frontiers in Environmental Science (Vol. 8).

Havlin, J. L. (2020). Soil: Fertility and Nutrient Management. In Landscape and Land Capacity.

Hersh, B., Mirkouei, A., Sessions, J., Rezaie, B., & You, Y. (2019). A review and future directions on enhancing sustainability benefits across food-energy-water systems: The potential role of biochar-derived products. In AIMS Environmental Science (Vol. 6, Issue 5).

Horwath, W.R. and W.R. Paul. (1994). Microbial biomass. In: Weaver, R.W., Angle, J.S., Bottomley, P.S., Bezdicek, D., Smith, S. Tabatabai. A., Wollum, A. (Eds.), Methods of Soil Analysis. Part 2.

Hwang, H. Y., Kim, S. H., Kim, M. S., Park, S. J., & Lee, C. H. (2020). Co-composting of chicken manure with organic wastes: characterization of gases emissions and compost quality. Applied biological chemistry, 63(1), 1-10.

Ikram, W., Akhtar, M., Morel, C., Rizwan, M., & Ali, S. (2019). Phosphate fertilizer premixing with farmyard manure enhances phosphorus availability in calcareous soil for higher wheat productivity. Environmental Science and Pollution Research, 26(31), 32276-32284.

Iqbal, A., He, L., Ali, I., Ullah, S., Khan, A., Akhtar, K., & Jiang, L. (2021). Co-incorporation of manure and inorganic fertilizer improves leaf physiological traits, rice production and soil functionality in a paddy field. Scientific Reports, 11(1), 1-16.

Irfan, M., Hussain, Q., Khan, K. S., Akmal, M., Ijaz, S. S., Hayat, R., ... & Rashid, M. (2019). Response of soil microbial biomass and enzymatic activity to biochar amendment in the organic carbon deficient arid soil: a 2-year field study. Arabian Journal of Geosciences, 12(3), 1-9.

Islam, M. R., Bilkis, S., Hoque, T. S., Uddin, S., Jahiruddin, M., Rahman, M. M., ... & Hossain, M. A. (2021). Mineralization of farm manures and slurries for successive release of carbon and nitrogen in incubated soils varying in moisture status under controlled laboratory conditions. Agriculture, 11(9), 846.

Jafari Tarf, O., Akça, M. O., Donar, Y. O., Bilge, S., Turgay, O. C., & Sınağ, A. (2022). The short-term effects of pyro-and hydrochars derived from different organic wastes on some soil properties. Biomass Conversion and Biorefinery, 12(1), 129-139.

Jien SH, Wang CC, Lee CH, Lee TY. (2015) Stabilization of organic matter by biochar application in compost-amended soils with contrasting pH values and textures. Sustainability 7(10):13317–13333

Jien, S. H., Chen, W. C., Ok, Y. S., Awad, Y. M., & Liao, C. S. (2018). Short-term biochar application induced variations in C and N mineralization in a compost-amended tropical soil. Environmental Science and Pollution Research, 25(26), 25715-25725.

Khan M, Sharif M .(2012) Solubility enhancement of phosphorus from rock phosphate through composting with poultry litter. Sarhad J Agric 28:415–420

Khan, A. A., H.Bibi, Z.Ali, M.Sharif, S.A.Shah, H.Ibadullah, K. Khan,I. Azeem, and S.Ali. (2017). Effect of compost and inorganic fertilizers on yield and quality of tomato. Academia Journal of Agricultural Research, 5(10).

Khatoon, H., Solanki, P., Narayan, M., Tewari, L., Rai, J. P. N., & Hina Khatoon, C. (2017). Role of microbes in organic carbon decomposition and maintenance of soil ecosystem. International Journal of Chemical Studies, 5(6), 1648-1656.

Li, F., Sørensen, P., Li, X., & Olesen, J. E. (2020). Carbon and nitrogen mineralization differ between incorporated shoots and roots of legume versus non-legume-based cover crops. Plant and Soil, 446(1), 243-257.

Liu, D., Ding, Z., Ali, E. F., Kheir, A., Eissa, M. A., & Ibrahim, O. H. (2021). Biochar and compost enhance soil quality and growth of roselle (Hibiscus sabdariffa L.) under saline conditions. Scientific Reports, 11(1), 1-11.

Liyanage, L. R. M. C., Sulaiman, M. F., Ismail, R., Gunaratne, G. P., Dharmakeerthi, R. S., Rupasinghe, M. G. N., Mayakaduwa, A. P., & Hanafi, M. M. (2021). Carbon mineralization dynamics of organic materials and their usage in the restoration of degraded tropical tea-growing soil. Agronomy, 11(6).

Luo, X., Fu, X., Yang, Y., Cai, P., Peng, S., Chen, W., & Huang, Q. (2016). Microbial communities play important roles in modulating paddy soil fertility. Scientific Reports, 6(1), 1-12.

Marzi, M., Shahbazi, K., Kharazi, N., & Rezaei, M. (2020). The influence of organic amendment source on carbon and nitrogen mineralization in different soils. Journal of Soil Science and Plant Nutrition, 20(1), 177-191.

Mulvaney, R.L. (1996). Nitrogen - Inorganic forms. p. 1123-11184. In Sparks, D.L. (ed.), Methods of Soil Analysis Part.3- Chemical Methods, SSSA Book Series No. 5. SSSA, Inc., ASA, Inc., Madison, Wisconsin, USA.

Nicolardot, B., Recous, S. & Mary, B. (2001).Simulation of C and N mineralisation during crop residue decomposition: A simple dynamic model based on the C:N ratio of the residues. Plant and Soil **228**, 83–103 .

Novak, J. M., Ippolito, J. A., Lentz, R. D., Spokas, K. A., Bolster, C. H., Sistani, K., Trippe, K. M., Phillips, C. L., & Johnson, M. G. (2016). Soil Health, Crop Productivity, Microbial Transport, and Mine Spoil Response to Biochars. In Bioenergy Research (Vol. 9, Issue 2).

Ok YS, Chang SX, Gao B.(2015) SMART biochar technology—a shifting paradigm towards advanced materials and healthcare research. Environ Technol Innov 4:206–209.

Oladele, S., Adeyemo, A., Adegaiye, A., & Awodun, M. (2019). Effects of biochar amendment and nitrogen fertilization on soil microbial biomass pools in an Alfisol under rain-fed rice cultivation. Biochar, 1(2), 163-176.

Popov, V. N., Korneeva, O. S., Iskusnykh, O. Y., & Iskusnykh, A. Y. (2020). Innovative ways to process poultry waste. Proceedings of the Voronezh State University of Engineering

Technologies, 82(1).

Prayogo C, Jones JE, Baeyens J, Bending GD.. (2014) Impact of biochar on mineralization of C and N from soil and willow litter and its relationship with microbial community biomass and structure. Biol Fertil Soils 50:695–702.

Rahman, G. K. M., Rahman, M. M., Alam, M. S., Kamal, M. Z., Mashuk, H. A., Datta, R., & Meena, R. S. (2020). Biochar and organic amendments for sustainable soil carbon and soil health. In Carbon and nitrogen cycling in soil (pp. 45-85). Springer, Singapore.

Raiesi, F. (2021). The quantity and quality of soil organic matter and humic substances following dry-farming and subsequent restoration in an upland pasture. Catena, 202, 105249.

Rao, D. L. N., Aparna, K., & Mohanty, S. R. (2019). Microbiology and biochemistry of soil organic matter, carbon sequestration and soil health. Indian Journal of Fertilisers, 15(2), 124-138.

Rashmi, I., Roy, T., Kartika, K. S., Pal, R., Coumar, V., Kala, S., & Shinoji, K. C. (2020). Organic and inorganic fertilizer contaminants in agriculture: Impact on soil and water resources. In Contaminants in agriculture (pp. 3-41). Springer, Cham.

Rayne, N., & Aula, L. (2020). Livestock manure and the impacts on soil health: A review. Soil Systems, 4(4), 64.

Raza, S., Zamanian, K., Ullah, S., Kuzyakov, Y., Virto, I., & Zhou, J. (2021). Inorganic carbon losses by soil acidification jeopardize global efforts on carbon sequestration and climate change mitigation. Journal of Cleaner Production, 315, 128036.

Sharma, V., Mir, S. H., & Sharma, A. (2016). Nitrogen mineralization as influenced by different organic manures in an inceptisol in the Foothill Himalayas. Communications in Soil Science and Plant Analysis, 47(2), 194-202.

Sichone, R.and A.M. Mweetwa.(2018). Soil Nutrient Status and Cowpea Biological Nitrogen Fixation in a Maize-Cowpea Rotation Under Conservation Farming. Journal of Agricultural Science, 10(6).

Simmonds, B., McDowell, R. W., & Condron, L. M. (2016). The effect of soil moisture extremes on the pathways and forms of phosphorus lost in runoff from two contrasting soil types. Soil Research, 55(1), 19-27.

Soltanpur, P.N. and A.P. Schawab. (1977). A news soils test for simultaneous extraction of macro and micro-nutrients in alkaline soils. Commun. Soil Sci. Plant Anal. 8: 195-207.

Steel, R.G.D and J.H. Terrie. (1996). Principles and procedures of statistics: A biometrical approach. 2nd ed. McGraw-Hill, New York

Taneja, P., Vasava, H. B., Fathololoumi, S., Daggupati, P., & Biswas, A. (2022). Predicting soil organic matter and soil moisture content from digital camera images: comparison of regression and machine learning approaches. Canadian Journal of Soil Science, 102(03), 767-784.

Thangarajan, R., Bolan, N.S., Kunhikrishnan, A., Wijesekara, H., Xu, Y., Tsang, D.C., Song, H., Ok, Y.S., Hou, D.(2018). The potential value of biochar in the mitigation of gaseous emission of nitrogen. Sci. Total Environ. 612, 257–268.

Urra, J., Alkorta, I., & Garbisu, C. (2019). Potential benefits and risks for soil health derived from the use of organic amendments in agriculture. In Agronomy (Vol. 9, Issue 9).

Vu QD, de Neergaard A, Tran TD.(2015) Greenhouse gas emissions from passive composting of manure and digestate with crop residues and biochar on small-scale livestock farms in Vietnam. Environ Technol 36:2924–2935

Waqas, A. (2018). Metal-Microbe Interaction in Municipal Solid Waste Compost Amended Soil and its Effect on Maize (Zea May L.) Growth (Doctoral dissertation, University of Agriculture, Faisalabad.).

Yadav, V., Karak, T., Singh, S., Singh, A. K., & Khare, P. (2019). Benefits of biochar over other organic amendments: responses for plant productivity (Pelargonium graveolens L.) and nitrogen and phosphorus losses. Industrial Crops and Products, 131, 96-105.

Yenani, E., Santoso, H., & Sutanto, A. (2021). Organic fertilizer of coffee peel with PUMAKKAL starter formula for sustainable plantation cultivation. In Journal of Physics: Conference Series (Vol. 1796, No. 1, p. 012038). IOP Publishing.

Zhu, L. X., Xiao, Q., Shen, Y. F., & Li, S. Q. (2017). Effects of biochar and maize straw on the short-term carbon and nitrogen dynamics in a cultivated silty loam in China. Environmental Science and Pollution Research, 24(1), 1019-1029.