TARABA JOURNAL OF AGRICULTURAL RESEARCH
ISSN: 978-978-923-450-9
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©tajar publication 2022

EFFECTS OF FARMYARD MANURE AND UREA FERTILIZERS ON TOTAL ORGANIC CARBON AND MICROBIAL BIOMASS CARBON IN A SANDY LOAM SOIL

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Received 20th May, 2022 Accepted 18th July, 2022

ABSTRACT

A two-year pot experiment study was conducted to evaluate the influence of farmyard manure and urea fertilizer application on total soil organic carbon, microbial biomass carbon and dehydrogenase activity in a sandy loam soil. The experiment was laid out in a randomized complete block design with four replications. Treatments comprised of five levels of farmyard manure at 0, 2.5, 5.0, 7.5 and 10 t/ha, and five levels of urea fertilizer at 0, 50, 75, 100 and 125 kg/ha, applied solely and in combinations. Results obtained showed that Soil treated with Farm yard manure and mixed manure respectively increased total soil organic carbon/microbial biomass carbon by 25%/48% and 58%/53% when compared to sole urea and the control. Dehydrogenase activity was significantly (P<0.05) increased by all treatments compared to control. Total soil organic carbon ranged from 1.22% – 1.87% while microbial biomass carbon ranged from 16.50 µgC/g to 116.07 µgC/g and dehydrogenase activity ranged from 2.46 µTPF/g/h to 3.61 µTPF/g/h. Results generally indicate that addition of farmyard manure in combination with urea was the most favourable than either addition of farmyard manure alone or the application of urea alone.

Keywords: Farmyard manure; urea fertilizer; organic carbon; microbial biomass; dehydrogenase activity

INTRODUCTION

Application of organic and inorganic fertilizers was reported to have considerable effects on the total organic carbon and microbial biomass in soils. Microbial populations and their activities in soil control organic matter decomposition and soil nutrient elements transformations resulting in a continuous change in the total organic carbon content and microbial biomass in the soil. Organic fertilization is however more complicated than mineral fertilization. This is because nutrients in organic fertilizers have to undergo decomposition and mineralization by microbial metabolism in order for nutrients to be available to plants for uptake in contrast to mineral fertilizers whose plant nutrient content is known and can directly be taken up by plants (Ding *et al.*, 2012). Changes in soil organic matter due to different fertilization practices can be characterized by evaluating the increase or decrease in total organic carbon content in topsoil (Ibrahim *et al.*, 2018). Soil organic carbon is important to chemical composition and biological productivity, including fertility and nutrient holding capacity of a field. Soil carbon is important for maintaining soil quality and prevention of nutrients loss through erosion and leaching. An increase in soil organic carbon typically results in a more stable carbon cycle, sequestration of atmospheric carbon and

enhanced overall agricultural productivity (Ding *et al.,* 2012).

The soil microbial biomass constitutes 1–3% of the total soil organic carbon content. Soil microbes also store a substantial amount of nutrients such as nitrogen and phosphorus as the C:N and C:P ratios in microbes are relatively low compared to plant nutrient ratios (Zechmeister-Boltenstern *et al*., 2015). Several environmental factors, including soil moisture, oxygen availability, oxidation-reduction potential, pH, organic matter content, depth of the soil profile, temperature, season of the year, heavy metal contamination and soil fertilization or pesticide use can affect significantly dehydrogenase activity in the soil environment (Nur *et al.*, 2013). Dehydrogenases play a significant role in the biological oxidation of soil organic matter by transferring hydrogen from organic substrates to inorganic acceptors. Many specific dehydrogenases transfer hydrogen to either nicotinamide adenine dinucleotide or nicotinamide adenine dinucleotide phosphate (Agnieszka and Zofia, 2012). In another report, Moeskops *et al.* (2012) found that active dehydrogenases can utilize both O_2 and other compounds as terminal electron acceptors, although anaerobic microorganisms produce most dehydrogenases. Therefore, dehydrogenase activity reflects metabolic ability of the soil and its activity is considered to be proportional to the biomass of the microorganisms in soil (Kumar *et al., 2013*). However, the relationships between an individual biochemical property of soil dehydrogenase activity and the total microbial activity is not always obvious, especially in the case of complex systems like soils, where the microorganisms and processes involved in the degradation of the organic compounds are highly diverse (Salazar *et al.*, 2011). The objective of this study was to assess and compare the effects of farmyard manure and urea, and their combined effects on total soil organic carbon and microbial biomass carbon by measurement of the dehydrogenase activity in the soil.

MATERIAL AND METHODS

A two-year pot experiment was conducted with the aim of investigating the influence of sole and combined application of farmyard manure and urea fertilizers on the soil organic carbon and microbial biomass carbon by measurement of the dehydrogenase activity, DHA, using soils collected (0 – 30 cm depth) from the new Modibbo Adama University, Yola, Teaching and Research Farm. The farm is located on Latitude 9° 16' N and Longitude 12° 35' E at 152m above sea level in the Northern Guinea Savannah agro-ecological zone. The location has an average annual rainfall of 700 mm to 1000 mm and temperature ranges from 15.2 – 39 °C. Temperature characteristics in Adamawa State are typical of the West African Savanna climate, high throughout the year because of high radiation, relatively evenly distributed throughout the year (Adebayo, 1999). The experiment was laid out in a randomized complete block design with four replications. Treatments comprised of five levels of farmyard manure at 0, 2.5, 5.0, 7.5 and 10 t/ha, and five levels of urea fertilizer at 0, 50, 75, 100 and 125 kg/ha, applied solely and in combinations. A single replication involving all treatments comprised of 25 pots, each filled with 3 kg of soil. Except for control pots, farmyard manure treatment at different levels were applied and incubated for two weeks before application of urea. Urea was applied as split dose, half dose at two weeks after incubation, half at four weeks after incubation. Soil samples were collected from each pot for routine laboratory analysis prior to the experiment.

Laboratory Analysis

Particle size distribution was determined by Bouyoucos hydrometer method (Jaiswal, 2008). Soil pH was measured electrometrically using glass electrode pH meter in a soil-water ratio of 1:2.5 (Hendershot *et al.*, 1993). Total nitrogen was determined by micro-Kjeldahl digestion technique method (Bremner, 1982).

Exchangeable bases were determined by the neutral ammonium acetate procedure buffered at pH 7.0 (Thomas, 1982). Phosphorous was determined by Bray ll method according to the procedure of Nelson and Sommers (1982).

Total Soil Organic Carbon

The total soil organic carbon was determined based on soil organic carbon by Walkley and Black **(**Titration and Colorimetric Method, 1934) as modified by Global Soil Laboratory Network (GLOSOLAN, 2019).

Soil Microbial Biomass Carbon

The soil microbial biomass carbon was estimated by using the chloroform fumigation extraction method (Witt *et al.*, 2000), where 35 g of fresh soil was fumigated with 2 ml ethanol-free $CHCl_3$ and incubated for 24 hours in the dark at 25 °C. The fumigated soils were extracted with 140 ml of 0.5 M K_2SO_4, and unfumigated control soils were extracted immediately without fumigation. The resulting extracts were filtered and examined by the TOC analyzer (Elementarvario). The soil microbial biomass carbon was calculated as the difference between fumigated and unfumigated sample with a conversion factor of 0.38 (Vance *et al.*, 1987).

Enzyme Activity

Dehydrogenase activity was measured in soil samples of 6 g that were incubated at 37 °C for 24 hours in the presence of 3% triphenyltetrazoliumchloride. The red-coloured product (triphenyl-formazan) was extracted with ethanol, and measured in a spectrophotometer at 485 ηm (Thalmann, 1968). All analyses were made in triplicate and average values were further processed.

Statistical Analysis

The basic statistical values i.e., average and standard deviations (SD) were calculated using Microsoft Excel (Microsoft Corporation, Redmund, USA) and Statistica Cz 8.0 (Stat. Inc. Tulsa, USA). Data were analyzed by analysis of variance and the treatment means compared by least significance difference, LSD, at $P < 0.05$) according to the procedures outlined by Little and Hills (1978).

RESULTSAND DISCUSSION

Properties of the Experimental Soil

Result of soil analysis carried out prior to the experiment (Table 1) showed that the soils used in this study is sandy loam and has been classified as Typic-Haplustalf by Musa *et al.* (*2007*). The pH of the soil is near neutral with very low electrical conductivity. Soil pH is an important factor affecting all microbial activities and related processes in soil (Bibhuti and Dkhar, 2012). There were significant *(P<0.05)* changes in soil pH following the addition of different organic treatments compared to the control in the present study. The soil pH was found to be greater in pots that received farmyard manure treatments than in the control pot as also reported by Gelsomino and Cacco (2004), suggesting that addition of organic amendments induced a significant *(P<0.05)* increase in soil pH which is attributed to the chemical composition of the farmyard manure. Tang and Yu (1999) reported that the concentration of organic anions in residues and the degree of decompositions of plant residues were important parameters influencing the direction (decrease or increase) and magnitude of changes in the pH of amended soils. The decomposition of organic materials release calcium (Ca) and magnesium (Mg) nutrients, which could slightly increase the soil pH (Ramaswami and Son, 1996). Organic carbon, N, P and K contents of the soils were low indicating that the soils are of low fertility status. The low organic carbon content is due to low organic matter level which might not be unconnected with the scanty vegetation cover and high rate of organic matter decomposition in the area due to high temperature. Zak *et al.* (1994) elucidated the importance of soil organic C, total N, and Olsen P, which were found to be greater in manure amendments, with a significant effect on the composition and population of the soil microbial community. Marked response in terms of organic carbon level, microbial biomass carbon and

dehydrogenase activity is therefore expected from the application of organic and inorganic fertilizers such as farmyard manure and urea. Such benefit will tend to improve the fertility status of the soils. This can exert direct influence on microbial activities and organic matter buildup which will undoubtedly help in maintaining the soil fertility and subsequently lead to higher organic residue return to the soil.

Table 1: Properties of the Experimental Soil

Parameters	Values
Sand (%)	71.70
Silt (%)	19.00
Clay (%)	9.30
Textural class	Sandy loam
Porosity (%)	48.37
WHC (%)	14.33
pH	6.13
EC(ds/m)	0.05
O.C (g/kg)	1.08
Organic matter (%)	0.34
Total-N (g/kg)	0.30
AV-P(mg/kg)	8.65
Ca^{2+} (cmol/kg)	4.87
Mg^{2+} (cmol/kg)	1.17
Na^{+} (cmol/kg)	0.17
K^{+} (cmol/kg)	0.93

Key: WHC (water holding capacity); EC (electrical conductivity);

OC (organic carbon); Total-N (Total nitrogen); AV-P (available phosphorus).

Table 2: Chemical composition of farmyard manure used

Parameters	Values
Moisture (%)	9.30
Total nitrogen (%)	1.10
Organic carbon (%)	24.82
C : N ratio	20.68
Total P_2O_5 (%)	0.68
pH (1:2.5 H_2O)	7.12
E.C. (ds/m)	0.06

Total Organic Carbon Content in Soil

The total organic carbon content in the soil ranged from 1.45 g/kg to 1.87 g/kg due to farmyard manure and 1.38 g/kg to 1.56 g/kg due to urea (Table 3). Interaction figures showed that farmyard manure effect ranged

from 1.20 g/kg to 1.87 g/kg which means that farmyard manure and urea increased total organic carbon content significantly *(P<0.05)* by about 25% compared with the control. The highest significant *(P<0.05)* effect of farmyard manure and urea application on total organic carbon content was observed at 7.5 t/ha and 10.0 t/ha with urea at 100 kg/ha and 125 kg/ha levels. Hao *et al.* (2008) reported that the application of organic manure in combination with inorganic fertilizer linearly increased total organic carbon levels as obtained in the present experiment. This is further supported by the report of Ibrahim *et al.* (2018). The higher values for total organic carbon in organically treated pots might be due to their greater content and enrichment by the organic amendment.

Table 3: Total soil organic carbon content (g/kg) in experimental soil

	Farm Yard Manure, FYM, level (t/ha)					
Urea Level (kg/ha)	0	2.5	5.0	7.5	10.0	Urea means
0	1.08	1.20	1.41	1.52	1.70	1.38
50	1.08	1.22	1.43	1.54	1.73	1.40
75	1.11	1.25	1.45	1.59	1.81	1.44
100	1.14	1.32	1.53	1.64	1.84	1.49
125	1.13	1.45	1.62	1.71	1.87	1.56
FYM Means	1.11	1.29	1.49	1.60	1.79	

	Urea	FYM	Urea x FYM
SE	0.04	0.07	0.09
LSD at 5%	NS	0.15	0.16

Soil Microbial Biomass Carbon

Results obtained (Table 4) showed that average microbial biomass carbon content ranged from 15.49 µgC/g to 78.38 µgC/g soil due to urea application and 12.76 µgC/g to 13.57 µgC/g due to farmyard manure application. Interaction results revealed significant values of 16.50 µgC/g to 116 .07 µgC/g at the application rate of 10.0 t/ha farmyard manure and 125 kg/ha urea increased microbial biomass carbon content by 54% compared with the control non-fertilized which was a significant *(P<0.05)* increase. The lowest microbial biomass carbon content, 11.94 µgC/g was found in the control. According to Ding *et al.* (2012), high quality farmyard manure brings into the soil stabilized organic substances which are not subjected to further degradation with which in the long-term period large amounts of carbon inputs from manure became gradually stabilized in the soil. These results are consistent with previous observations which documented that microbial biomass was considerably greater in soils which received farmyard manure than those which received only urea fertilizer (Hao *et al.*, 2008; Šimon and Czakó, 2014).

Table 4: Soil microbial biomass carbon (µgC/g) in experimental soil

	Farm Yard Manure, FYM, level (t/ha)					
Urea Level (kg/ha)	0	2.5	5.0	7.5	10.0	Urea means
0	11.94	12.76	9.96	15.88	13.57	12.22
50	15.49	16.50	25.15	24.01	38.78	23.99
75	32.89	37.64	42.09	47.29	52.59	42.50
100	56.31	64.96	85.27	85.89	103.42	79.17
125	78.38	90.95	104.65	112.53	116.07	100.52
FYM Means	38.46	44.56	53.42	57.12	64.89	

	Urea	FYM	Urea x FYM
SE	2.61	2.39	5.46

LSD at 5%	5.68	4.79	11.13

Dehydrogenase Activity

Results for dehydrogenase activity is presented in Table 5. Dehydrogenase activity is only present in viable microbial cells and reflects the total range of oxidative activity of soil micro flora (Kadian *et al.,* 2012). Dehydrogenase activity increased significantly *(P<0.05)* due to farmyard manure and urea application to soil. Agnieszka and Zofia (2012) reported that soil enzymatic activity is strongly connected with soil organic matter content. Higher organic matter level can provide enough substrate to support higher microbial biomass, hence higher enzyme production and consequently higher activity indicating positive correlation between dehydrogenase activity and organic matter content. In this study, the highest dehydrogenase activity (3.61µTPF/g/h) was obtained with the interaction of the addition of 10 t/ha farmyard manure and 125 kg/ha urea as compared to the control which showed 2.02µTPF/g/h. Šimon and Czakó (2014) reported that easily decomposable components of organic residues may have a strong effect on dehydrogenase activity and metabolism of soil microorganisms. On the contrary, dehydrogenase activity is less influenced or even inhibited by separate mineral nitrogen fertilization (Saha *et al.*, 2008). However, in this experiment, no inhibitory effect of urea was recorded on dehydrogenase activity.

Table 5: Dehydrogenase activity (µTPF/g/h) in experimental soil

	Farm Yard Manure, FYM, level (t/ha)					
Urea Level (kg/ha)	0	2.5	5.0	7.5	10.0	Urea means
0	2.02	2.11	2.15	2.19	2.81	2.13
50	2.05	2.46	2.83	2.88	2.95	2.63
75	2.08	2.76	2.79	2.85	2.97	2.69
100	2.08	2.77	2.85	3.13	3.32	2.83
125	2.14	3.23	2.97	3.55	3.61	3.10
FYM Means	2.07	2.67	2.72	2.92	3.13	

	Urea	FYM	Urea x FYM
SE	0.22	0.48	0.63
LSD at 5%	NS	1.07	1.13

SUMMARY AND CONCLUSION

The soil used in this study is sandy loam soil (Typic-Haplustalf) with near neutral pH and low organic matter content. Results generally indicate that addition of farmyard manure in combination with urea produced the highest total soil organic carbon (1.87 g/kg), soil microbial biomass carbon (116.07 µgC/g) with resulting dehydrogenase activity of 3.61 µTPF/g/h over none addition. Addition of farmyard manure alone also significantly *(P<0.05)* increased total soil organic carbon by 25% and soil microbial biomass carbon by 48%, but the application of urea alone did not show significant *(P<0.05)* effect on all the three attributes measured.

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