RESEARCH ARTICLE

IMPACT OF LONG TERM FYM APPLICATION ON MICRONUTRIENT STATUS OF SOIL AFTER 52 YEARS OF EXPERIMENTATION

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Abstract: Soil organic carbon plays an important role in improving physical, chemical and biological properties of soil. With the application of organic material reduction of free micronutrient cation concentration in soil solution occurs due to formation of organometallic complexes which enhance phyto-availability, and control mobility of micronutrients in the soil profile. This study was conducted with the objective to see the effect of long term application of farm yard manure (FYM)on DTPA extractable micronutrients in soil having varying levels of organic carbon content. A long term experiment was initiated in 1967 at the experimental farm of Department of Soil Science, CCS Haryana Agricultural University, Hisar India, consisting of 3 levels of FYM (15, 30 and 45 Mg ha^{-1} till 2007-08) and 5, 10 and 15 Mg ha^{-1} from 2008-09 onwards. A control without FYM was maintained. The treatments which show wide difference in organic carbon content after 52 years were selectedT1 (FYM_0 t + N_0 kg/ha), T2 (FYM_5 t + N_0 kg/ha), T3 (FYM_5 t + N_{120} kg/ha), T4 (FYM_{15} t + N_0 kg/ha), T5 (FYM_{10} t + N_{120} kg/ha) and T6 (FYM_{15} t + N_{120} kg/ha).Organic carbon content of selected treatments were 0.49, 0.95, 1.40, 1.62, 1.78 and 1.96%. From the study it was observed that DTPA extractable Zn, Fe and Cu increased significantly with increasing content of organic carbon in all the soils and their concentration in soil varied from 0.96 to 1.14, 0.84 to 2.51, 4.04 to 6.4 and 0.96 to 1.26 mg kg^{-1} respectively. DTPA extractable Mn also increased numerically in all soil but the effect on DTPA extractable Mn was not found significant.

Keywords: Micronutrients, Organic carbon, Long term FYM, DTPA extractable micronutrients

INTRODUCTION

Essentialities of micronutrients are well-known, out of cationic micronutrient iron, magnesium, zinc and copper are most important because they perform various functions in plants when present in a balanced proportion. Sole application of high analysis fertilizer followed to high yielding varieties, crop nutrition become exhaustive for soil especially in case of micronutrients. With the addition of nitrogen, phosphorus and potassium green revolution came into existence but need of innovative fertilization is required to maintain sustainability of soil (Bindraban *et al.*, 2015) as micronutrients are needed less than 0.5 g ka-1 of plant dry weight, also being associated with organic molecule as a cofactor (Barker and Pilbeam, 2015).Soil organic carbon plays an important role in improving physical, chemical and biological properties of soil. A wide range of micronutrients has been reported by many researchers Cu, Fe, Mn and Zn per kg soil in range of 2-100 mg (Lindsay, 1979) 20,000 to 550,000 mg, 450–4000 mg (Noll, 2003) and 10–300 mg (Barber, 1995) in agricultural soils respectively. With the application of organic material reduction of free cation concentration in soil solution occurs this is due to binding of these metal ions with organic matter and formation of organometallic complexes which enhance phyto-availability in the root rhizosphere interface and also control mobility of these nutrients in the soil profile. Soluble forms of zinc and iron with organic matter is helpful in maintaining plant available form of nutrients and even prevents formation of insoluble forms such as oxides and carbonates (Schulin *et al.*, 2009). Application of organic manure shows several benefits in soil including enhanced cation exchange capacity, soil structure, water holding capacity, drainage management, reduction in soil salinity and improvement of aeration etc. Exogenous application of organic matter improves microbial exudation of organic ligands protection against root pathogens helps in development of plant roots which eventually improves micronutrient uptake of plants. Application of farm yard manure (FYM) in addition to fertilizers is found helpful in retention of soil productivity and maintaining nutrient supplying capacity of soil (reference) Farm yard manure is itself a reservoir of nutrients, maintain buffering capacity of soil, at the same time application of high amount of organic matter form more metal humus complex which reduces availability of some micronutrients. Majority of information available in literature on impact of FYM application on micronutrient is based on short term study (reference) The information on long term use of FYM on micronutrient content in soil is limited, hence, present study is planned to understand the impact of different levels of FYM application on extractable micronutrients of soil in a long term pearl millet wheat rotation on coarse loamy soil, at experimental farm of CCSHAU Hisar, India.

MATERIALS AND METHODS

Experimental site and treatment details

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The study was conducted in an ongoing long term experiment running since 1967 at the research farm of Department of Soil Science, CCS Haryana Agricultural University, Hisar India. The coordinates of experimental site are between 29.16^0 N latitude and 75.75^0 E longitude in north western part of India. The climate of area is semi-arid with a mean annual rainfall of 443 mm during 2018-19.The experimental treatment consisted of 3 levels of FYM (15, 30 and 45 Mg ha^{-1} till 2007-08) and 5, 10 and 15 Mg $ha^{-1}$from 2008-09 onwards. The modes of application are: every summer season, in every winter season and in both the season. An control without FYM was also maintained. These 10 treatments (3 levels of FYM x 3 modes of application + 1 control) were assigned in the main plots and each main plot was divided into three sub-plots(10x6) m receiving fertilizer N at 0, 60 and 120 kg ha^{-1} in the form of urea. Out of these treatments, 6 treatments were selected based on the organic carbon content ranging from lowest (0.49%) to highest level (1.96%). The details of the treatments are as followed, T1 (FYM_0 t + N_0 kg/ha); T2 (FYM_5 t + N_0 kg/ha); T3 (FYM_5 t + N_{120} kg/ha); T4 (FYM_{15} t + N_0 kg/ha); T5 (FYM_{10} t + N_{120} kg/ha) and T6 (FYM_{15} t + N_{120} kg/ha). The initial properties of soil at the time of experiment in 1967 were as pH 8.2, organic carbon (%) 0.47, Available N 200 kg ha^{-1}, Available P 26 kg ha^{-1}, Available K 498 kg ha^{-1}.

Sample collection and analysis of soil properties

Surface soil (0-15) samples were collected from each selected treatment using a augur after harvesting of wheat in May, 2019. Five core samples were collected from each plot and were mixed thoroughly and a composite sample were prepared. Samples were air dried, grounded with the help of wooden mortar and pastel and sieved through 2mm sieve for organic carbon estimation 0.2 mm sieve were used and stored for analysis. The samples were analyzed for pH, EC, organic carbon, CEC, $CaCO_3$, and DTPA extractable Zn, Fe, Mn and Cu content of soil.

A soil-water suspension was prepared in the ratio of 1:2 (10 g soil with 20 ml of distilled water) and pH was measured with the help of pH meter. The soil water suspension prepared for determination of pH was used to determine the electrical conductivity of the soil. Soil suspension was allowed to settle till supernatant become clear after that Electrical conductivity was measured with the help of EC meter and expressed as dSm^{-1}.Organic Carbon content in the soil was determined using rapid titration method(Walkley and Black, 1934).

Soil samples were analyzed for extractable micronutrient content using DTPA (Lindsay & Norvell 1978) and their concentration in aliquot were estimated using atomic absorption spectrophotometer (Model-AA240FS). Analysis of variance (ANOVA) was carried out using the CRD and Least Significant difference (LSD) was calculated on soil data for treatment means at 5% probability using OPSTAT software.

RESULTS AND DISCUSSION

Soil chemical properties

Perusal of data from Table 1revealed that pH decreased with increasing level of organic carbon content of soil but decrease is not significant. Over the 52 years of long term application of FYM there was a decrease in soil pH from the initial value 8.1 at the start of experiment in 1967,maximum pH 7.8 was observed in treatment T_1(with no FYM application). Minimum pH was observed in T_6 (with15 t of FYM application). The pH value observed were 7.8,7.8, 7.7,7.7,7.6 and 7.6 in case of T_1,T_2, T_3, T_4, T_5 and T_6 respectively. The decrease in pH was non-significant for all the treatments. This decrease in soil pH may be because of increased organic acid synthesis in high organic matter containing soil as a result of decomposition (Vasak *et al.,* 2015; Zhang *et al.,* 2016). Electrical conductivity of soil increased with increase in organic matter content. Electrical conductivity varies from 0.41 to 1.18 (dS m^{-1}) from T1 to T6 respectively. The increase in EC was 51.21, 82.92, 100, 153.65 and 187.80 % for T_2, T_3, T_4, T_5 and T_6 respectively over control (T_1) with no FYM application over the years. Lowest EC was observed in $T_1$and highest in T_6. This increase in EC may be due to solubilizing effect of organic acids various compounds in soil or addition of several plant acids during decomposition of organic matter (Bahadur *et al.,* 2013; Kumara *et al.,* 2014) and increase in base saturation of the soil (Hati *et al.,* 2007).The cation exchange capacity of soils ranged from 11.13 to 18.70 [cmol(p+) kg^{-1}] from soil 1 to Soil 6 respectively. The increase in CEC content was 10.15, 24.25, 59.92, 62.26 and 68.1% T_2, T_3, T_4, T_5 and T_6respectively over control.CEC was found significantly increased over control (T1 with no FYM application) in all other treatments(with FYM application). This increase in CEC with the increasing levels of organic carbon might be due to incorporation of organic matter and their decomposition provided a store house for exchangeable cations. Higher content of organic carbon provides higher surface area (Verma *et al.,* 2010 and Subehia *et al.,* 2013).

Organic carbon content increased fromT_1 to T_6which explains the effect of FYM application over 52 years. Organic carbon of selected soils ranged from 0.46% to 1.96% from treatment T_1 to T_6 respectively. The increase in organic carbon content was 108.69, 204.34, 252.17, 286.95 and 326.08% for T_2, T_3, T_4, T_5 and T_6respectively over control (T_1). Winter application of FYM maintained more organic carbon than summer application for similar amount of FYM applied. When the FYM along with N were applied in both the seasons it gave significantly higher organic carbon content over other treatments.

DTPA extractable micronutrients

A perusal of data in table 3 revealed that DTPA extractable Zn content in surface soil increased with the increase in organic carbon content from treatment T_1 to T_6. Zn content in the soil varied from 0.96 mg kg-^{1} to 1.14 mg kg-^{1}. Zn content was found significantly high by16.66% and 18.75 % in T_5 and T_6respectively over control (T_1). Zn content of T_1, T_2, T_3 and T_4were found statistically at par. Increase in DTPA extractable Zn was 4.16, 11.45, 5.20, 16.66 and 18.75% in case of T_2, T_3, T_4, T_5 and T_6 respectively over control. pH was negatively correlated with DTPA extractable Zn (r = -0.936**), Organic carbon content was positively correlated with DTPA extractable Zn (0.870*),Results are supported by the findings of Randhawa and Singh (1997) and Sharma *et al.* (2008).Similarly DTPA extractable Fe content in surface soil increased with the increase in organic carbon content from treatment T_1 to T_6. Fe content in the soil varied from 0.84 mg kg^{-1} to 2.51 mg kg^{-1}. Fe content was found statistically significantly high 155.95% and 198.80% in T_5 and T_6respectively over control.

Fe content of T_1, T_2, T_3 and T_4were found statistically at par. Increase in DTPA extractable was Fe was 51.19, 58.33, 115.47, 155.95 and 198.80% in case of T_2, T_3, T_4, T_5 and T_6respectively over control (T_1). It can be seen that pH is negatively correlated with DTPA Fe (r = -0.920**), Organic carbon content was positively correlated with DTPA Fe (r = 0.941**),Scrutiny of data in table 3 showed that DTPA extractable Mn content in surface soil increased with the increase in organic carbon content from 4.04 mg kg^{-1} to 6.4 mg kg^{-1}. Increase in DTPA extractable wasMn was 17.5, 30.76, 40.91, 48.44 and 58.41 % in case of T_2, T_3, T_4, T_5 and T_6 respectively over control (T_1).The increase in Mn content with organic carbon was found non-significant, pH is negatively correlated withDTPA Mn(r = -0.935**), Organic carbon content was positively correlated with DTPA Mn(0.994**).

DTPA extractable Cu content varied from 0.96 mg kg^{-1} to 1.26 mg kg^{-1}. Cu content was found statistically significantly high 26.04 % and 31.25 % inT_5 and T_6 respectively over control. The Cu content ofT_1T_2, T_3 and T_4were found statistically at par. Increase in DTPA extractable was Cu was 4.16, 7.29, 18.75, 26.04 and 31.25 % in case of T_2, T_3, T_4, T_5 and T_6 respectively over control (T_1).andpH is negatively correlated with DTPA Cu (r = -0.938**),Organic carbon content was positively correlated withDTPA Cu (0.926**).

Availability of Zn in soil is influenced by soil pH (Anderson and Christensen, 1988), DTPA extractable Zn increases with decrease in soil pH(Alloway, 2008). Large amount of non-available Zn become available in soil because high organic matter promotes dissolution of Zn in the soil by preventing Zn fixation on mineral surfaces (Moharana *et al.*, 2017). Organic matter addition leads to formation of stable complexes formation with Zn and decreases precipitation of Zn to some extent (Arbad *et al.*,2014).

Solubility of Fe is pH dependent (Fageria *et al.*, 2002), lower pH of high organic matter containing soil may increase the concentration of DTPA extractable Fe (Aulakh and Malhi 2005, Bhatt *et al.*, 2020). Higher cotent of Fe in high organic matter containing soil may be due to the amount of Fe present in the manure (Li *et al.*, 2010). Kumar and Singh (2010) also reported increase in DTPA-Fe content with the application FYM as compared to 100 per cent NPK alone as chemical fertilizer.

Manganese availability is considered to be closely correlated to soil pH (Hardy *et al*., 2013). Increase in DTPA extractable Mn with application of manure was due to decrease in soil pH due to microbial decomposition of organic matter, which releases manganese, as well as complexing agents, such as organic acids and humic substances, thatfacilitated the movement of manganese from the solid phase into solution (Wei *et al.*, 2006 andLi *et al.*, 2007, Parven *et al.*, 2020). Furthermore, the decomposition of added organic matter would have providedprotons to the soil solution and decreased soil Eh values (as well as pH), thereby enhancingthe dissolution and reduction of Mn, and hence increasing its availability (Zhang *et al.*, 2015).

The increase in Cu level with increase in organic matter may be due to decrease in soil pH (Li *et al*., 2010). Copper availability increased with decrease in soil pH becauseincrease in soil pH induces hydrolysis of hydrated Cu which can lead to a stronger Cuadsorption by the clay minerals and organic matter (Fageria *et al.*, 2002). High DTPA extracted Cu in high organic carbon containing soil may be due to formation of Cu humus complex or relatively high stability with humus decrease chances of fixation or precipitation in soil and simultaneously increases its availability. Our findings are supported by other researchers who reported significant increase in DTPA Cu content with the application of organic matter (Kharche *et al.*, 2013, Kumar *et al.*, 2012, Parven *et al.*, 2020, Bhatt *et al.*,2020).

Organic manure application in long term was found helpful in maintaining organic carbon content of soil. Amount of DTPA extractable micronutrients were increased with increasing levels of organic carbon content of soil. DTPA extractable micronutrients content was found significantly high by 18.75 %, 198.80% and 31.25 % in Soil containing 1.96% of organic carbon content(Soil 6) over control in case of Zn, Fe and Cu. DTPA extractable Mn increased numerically with increased organic carbon content but the increase was not statistically significant.

Table 1. Initial properties of soil

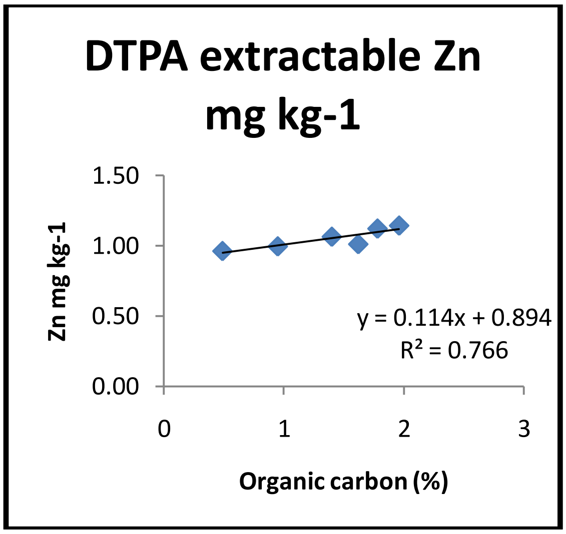
Soil	pH	EC (dS m^{-1})	OC (%)	CEC [cmol(p+) kg^{-1}]
Soil 1	7.8	0.41	0.46	11.13
Soil 2	7.8	0.62	0.96	12.26
Soil 3	7.7	0.75	1.40	13.83
Soil 4	7.7	0.82	1.62	17.80
Soil 5	7.6	1.04	1.78	18.06
Soil 6	7.6	1.18	1.96	18.70
CD (p=0.05)	0.4	0.01	0.06	0.45

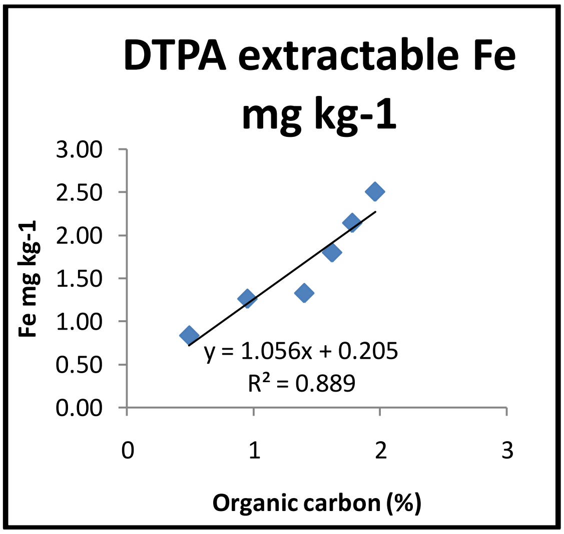
Table 2. DTPA extractable micronutrients with varying levels of organic carbon content

Soil	Zn	Fe	Mn	Cu
Soil 1	0.96	0.84	4.04	0.96
Soil 2	1.00	1.27	4.747	1.00
Soil 3	1.07	1.33	5.283	1.03
Soil 4	1.01	1.81	5.693	1.14
Soil 5	1.12	2.15	5.997	1.21
Soil 6	1.14	2.51	6.4	1.26
CD (p=0.05)	0.10	0.97	NS	0.18

Table 3. Correlation between DTPA extractable micronutrients and different soil properties.

	DTPA Zn	DTPA Fe	DTPA Mn	DTPA Cu	pH	EC (dS m^{-1})	OC (%)	CEC [cmol(p+) kg^{-1}]
DTPA Zn								
DTPA Fe	0.864^{*}							
DTPA Mn	0.884^{*}	0.970^{**}						
DTPA Cu	0.844^{*}	0.991^{**}	0.956^{**}					
pH	-0.936^{**}	-0.920^{**}	-0.935^{**}	-0.938^{**}				
EC (dS m^{-1})	0.935^{**}	0.984^{**}	0.983^{**}	0.968^{**}	-0.953^{**}			
OC (%)	0.870^{*}	0.941^{**}	0.994^{**}	0.926^{**}	-0.923^{**}	0.964^{**}		
CEC [cmol(p+) kg^{-1}]	0.761^{NS}	0.952^{**}	0.958^{**}	0.969^{**}	-0.907^{*}	0.925^{**}	0.948^{**}	





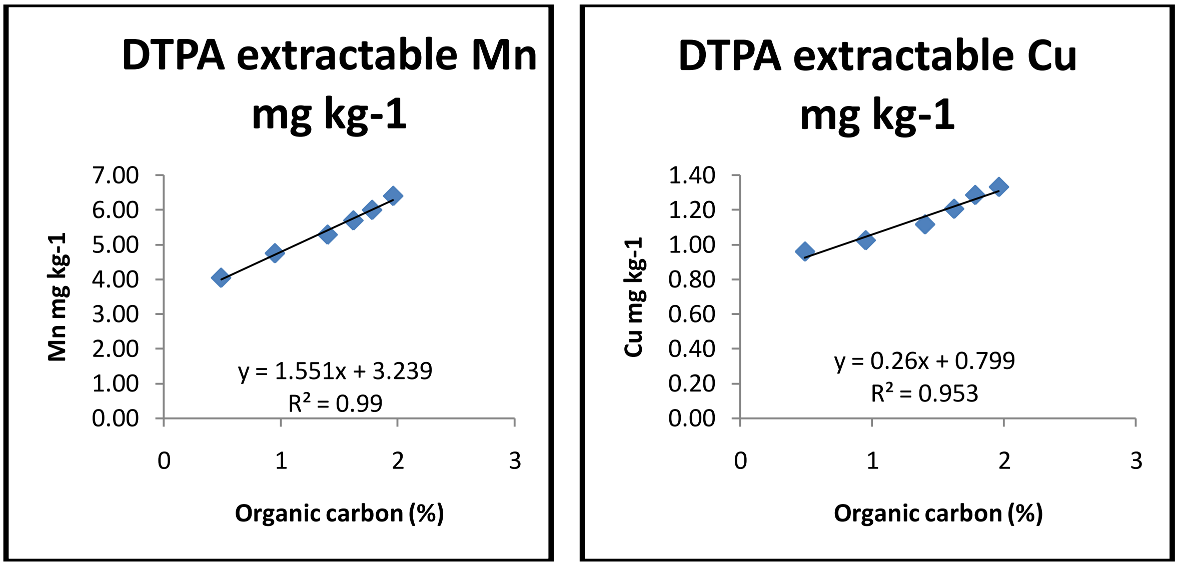


Fig 1: Graph between DTPA extractable micronutrients and organic carbon content of soil.

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