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A Comparison of Different Fractions of Organic Carbon and Organic Nitrogen under Different Land Use Systems of Haryana

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ABSTRACT

A study on soil organic carbon and organic nitrogen fractions under different land use system of Haryana was carried out to evaluate the changes in soil quality caused by different land use systems at Department of Soil Science CCS HAU, Hisar. Different land use systems viz., cotton-wheat, rice-wheat, sugarcane-sugarcane pearl millet-wheat (zero tillage), pearl millet-wheat (conventional tillage), citrus orchard, guava orchard and vegetables were selected for the study. Soil samples replicated five times were selected from each land use systems along with their uncultivated soils and analyzed for organic carbon and organic nitrogen fractions, available nutrients, pH, EC and CEC. The total organic carbon was found highest under horticulture land use system and highest content (9.72 g kg^{-1}) was found in guava orchard, however, lowest 4.84 g kg^{-1} was observed under pearl millet-wheat land use system. The highest microbial biomass carbon, light fraction carbon and heavy fraction carbon content was observed under guava orchard i.e. 238.14 mg kg^{-1}, 1.76 g kg^{-1} and 7.51 g kg^{-1} ,while highest DOC content (386.00 mg kg^{-1}) was found under cotton-wheat cropping system. Similarly, total hydrolysable nitrogen, amino acid-N, amino sugar-N, ammonia-N and hydrolysable unknown-N fractions of organic nitrogen found to vary as 347.20-1003.20, 133.20-273.00, 74.60-165.60, 175.8-245.80, 71.00-372.00 and 170.90-576.4 mg kg^{-1} under different land use system. All these fractions of organic nitrogen found higher under guava orchard while ammonia-N was noticed higher under sugarcane-sugarcane land use system. The total nitrogen and organic nitrogen fractions content observed to increase with increased content of TOC and found higher under horticulture land use system.

Key words: *Organic carbon pools, Organic nitrogen fractions, Available nutrients, Land use systems, Cultivation.*

INTRODUCTION

Conversion of forests to agricultural land uses is of a great concern to ecologists as it reduces litter inputs[27,32], and alters biogeochemical cycles, especially that of nitrogen (N) and carbon (C), both at regional and global scales[30].

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These biogeochemical changes are directly linked with the future productivity and stability of the derived land uses[4]. At different spatial and time scales, vegetation cover helps in protecting the soil from harsh climatic conditions mostly soil erosion. The presence of dense vegetation affords the soil adequate cover thereby reducing the loss in macro and micro nutrients that are essential for plants growth and energy fluxes[16]. Land-use changes affect the soil carbon storage and cause quantitative and qualitative changes on soil organic matter, and consequently on physical and chemical characteristics that directly affect the nutrient availability to the plants[2]. According to Du Preez and Synman,[12] loss of SOM results in soil degradation and once organic matter is lost, recuperation is slow process and both C and N are needed for its restoration. Soil organic carbon (SOC) and its fractions are considered as good indicators of soil quality and environmental stability[28], therefore their monitoring and management in human-induced land use change (LUC) is important for global C cycle[44]. Soil organic carbon and nitrogen are the key contributors to soil productivity directly through controlling the availability of soil N and indirectly through regulating the soil properties. Soil organic matter, of which carbon is a major part, holds a great proportion of nutrients, cations and trace elements that are important to plant growth. The soil organic carbon affects important functional processes in soil like the storage of nutrients, mainly N, water holding capacity, and stability of aggregates[34]. The distribution of SOC within different pools is an important consideration for understanding its dynamics and diverse role in ecosystems[24,3]. Different carbon pools changes rapidly in response to land use change[14]. Soil organic carbon fractions, such as microbial biomass carbon and light fraction organic carbon, generally respond more rapidly to changes in land use systems than total organic carbon content. Soil microbial biomass (SMB) act as a source and sink of available nutrients, thus defines nutrient transformation in terrestrial ecosystems[35]. Any changes in it may also affect the cycling of SOC. It is highly responsive to changes in land use and management than SOC[15]. Nitrogen is the most required plant nutrient and very dynamic in behaviour as it is available in several chemical forms[6]. Most of the N occurs in organic forms with almost half of it in the amino acid fraction, which along with the amino sugar fraction constitutes the major component of the mineralizable N pool in soil[25]. Soil nitrogen has been assessed mainly as mineral N, especially nitrate, organic N or potentially mineralizable N, as stored in the soil organic matter. Dynamic properties such as soil organic matter (SOM), cation exchange capacity (CEC), total Nitrogen (TN), soil pH and texture are sensitive to land use practices and can provide valuable information about important soil processes such as nutrient cycling, decomposition and formation of SOM, and overall productivity potential[24].

MATERIAL AND METHODS

Study area and site description

The study was conducted in the "Haryana Agriculture University" Hisar, Haryana. The soil samples were collected from different sites at different location in the state. The selected sites were under a particular land use system since longer period, samples were collected, which are correct representative of particular LUS. The description of experimental sites is given below:

LUS	Geographical Location	Soil texture	Annual mean temp. (^{0}C)	Annual rainfall (mm)
Agriculture 1.Cotton-wheat	CRS Sirsa Latitude:29° 53' N Longitude: 75° 01' E	Loamy-sand	5.1-46.7	375
2.Rice-wheat	RRS Kaul Latitude: 29° 42' N Longitude: 77° 02' E	Loam	5.9-40.2	700

3.Pearlmillet-wheat	Research Farm, Dept. Of Soil Science Latitude: 29° 10' N Longitude:75° 46' E	Sandy-loam	1.9-46	450
4.Pearlmillet-wheat/zero tillage	Research Farm, Dept. Of Agronomy Latitude: 29° 10' N Longitude: 75° 46' E	Sandy-loam	1.9-46	450
5.Sugarcane	RRS Uchani Latitude: 28° 16' N Longitude: 77° 05' E	Clay-loamy	6-39,	766
Horticulture 1.Citrus	Research Farm, Dept. Of Horticulture Latitude: 29° 10' N Longitude: 75° 46' E	Sandy-loam	1.9-46	450
2.Guava	Research Farm, Dept. Of Horticulture Latitude: 29° 10' N Longitude: 75° 46' E	Sandy-loam	1.9-46	450
Vegetable 1.Tomato/potato/ cauliflower/brinjal	Research Farm, Dept. Of Vegetable Science Latitude: 29° 10' N Longitude: 75° 46' E	Sandy-loam	1.9-46	450

Soil sampling and analysis

1. Collection and preparation of soil samples

Surface (0-15) soil samples from each land use system were collected from five different locations by an auger from each selected site in June, 2015. Soil samples were collected, air dried, grounded and sieved (2mm) chemical analysis.

2. Analysis

2.1Organic Matter Pools Analysis

2.1.1 Dissolved Organic Carbons (DOC)

Fifty ml of deionised water was added into 10 g of soil and shaken, later subjected to centrifuge at 8000 rpm. The solution was filtered and dissolved organic carbon was determined by dichromate acid oxidation method[8].

2.1.2 Microbial Biomass Carbon (MBC)

Microbial biomass was determined by the Chloroform ($CHCl_3$) fumigation method proposed by Vance *et al.*[42]. Each moist soil sample was fumigated with ethanol free $CHCl_3$ for 24 hours. Following fumigant removal, the soil was extracted with 0.5 M K_2SO_4 (1: 4, soil: solution ratio) by shaking, followed by filtration and estimation of carbon by dichromate oxidation method. Biomass carbon is the difference between the extracted carbon in fumigated and non-fumigated soil.

2.1.3 Light and Heavy carbon Fractions

Light fraction of soil organic matter in soil samples was isolated by densimetric method modified by Janzen *et al.*[17]. The represented soil samples (10 g) of coarsely ground soil (<2 mm) were dispersed with a NaI solution (40 ml) having specific gravity of 1.70 g cm^{-3}.

Suspensions were allowed to equilibrate for 48 hours and than light fraction are removed by vaccum. The unsuspended material represented heavy fraction (HF). The LF and HF was washed with successive aliquots each of $CaCl_2$ and distilled water, dried, ground and analyzed for total carbon by dichromate digestion of modified Walkley and Black`s rapid titration method as described by Nelson and Sommers[26].

2.2. Organic Nitrogen Fractions

Different nitrogen fractions viz. acid insoluble-N, hydrolysable NH_3-N, amino acid- N, amino sugar-N, hydrolysable unknown-N and total hydrolysable-N were determined as per fractionation procure given by Stevenson[39]. The details are given below:

2.2.1 Preparation of soil Hydrolyzate

Twenty gram of soil was taken in distillation flask, in which 2-3 drops of octyl alcohol and 20 ml of 6M HCl were added before refluxing it for 6 hours on constant low heat (80 ^{0}C) on a soxhlet extraction assembly. The hydrolyzed mixture was cooled and filtered and final volume was made to 100 ml without neutralizing and stored in freezer for determination of different forms of organic nitrogen. The neutralization of the hydrolyzate was done at the time of estimation of different organic nitrogen fractions on kjeldahl distillation unit.

2.2.2 Acid-Insoluble Nitrogen (Non-Hydrolyzable N)

This form of nitrogen is obtained by the difference between total soil N and total hydrolysable N.

2.2.3 Hydrolysable NH_3-N

After adding approximately 0.5 gm of MgO to 10 ml of hydrolysate and calculated amount of 5 M NaOH for neutralization, the kjeldahl flask was connected to the steam distillation apparatus and amount of ammonia-N was determined by absorbing in boric acid (%) mixed indicator and titrating with 0.05N H_2So_4.

2.2.4 Amino acid-N

In five ml of the hydrolysate, 1 ml of 0.5 M NaOH was added in 100 ml digestion flask and heated in boiling water bath until the volume was reduced to 2 to 3 ml. The contents of the flask were cooled, later added with citric acid and ninhydrin. This was followed by heating and cooling again and adding 1.25 g of the phosphate-borate buffer mixture. Immediately after adding 5m NaOH (neutralization), the flask was connected to the steam distillation apparatus and quantified as per kjeldahl method.

2.2.5 Amino sugar-N

This form of N was taken as the difference between the amounts of N recovered in ammonia + amino sugar-N and ammonia-N fractions.

2.2.6 Hydrolysable unknown-N

This form of N was taken as the difference between total hydrolysate N and the N accounted for as (NH_3 + amino acid + amino sugar-N).

2.2.7 Total hydrolysable-N

Five ml of hydrolyzate was placed in a 100 ml distillation flask. After adding 0.5 g of K_2SO_4 catalyst mixture and 2 ml of concentrated H_2SO_4, the flask was cautiously heated on a water bath until the mixture became clear. Total hydrolyzate N was determined by stream distillation after adding 10 ml of deionised water and 10 M NaOH by kjeldahl method.

Statistical Analysis

The data obtained under various studies was subjected to statistical analysis for significance using OPSTAT software. All data related to soil organic carbon, organic nitrogen fractions were subjected to randomized block design. Least square difference was used to compare the treatment effect at $P<0.05$.

RESULTS

3.1 Total organic carbon and its fraction

The data revealed that total organic carbon was higher under horticulture land use system within which it was found (9.72 g kg^{-1}) highest in guava orchard followed by citrus orchard and vegetable land use system with mean values 9.00 and 8.46 g kg^{-1}respectively. Among agriculture land use system mean total organic carbon was found highest in sugarcane-sugarcane (8.32 g kg^{-1}) cropping system. The TOC was found (7.29g kg^{-1}) significantly higher under cultivated soil than in uncultivated soil (5.22 g kg^{-1}).

3.2 Soil organic carbon fractions

3.2.1 Microbial biomass carbon (MBC)

The MBC fraction accounts very small portion of TOC but directly related to soil health. The horticulture land use system have significantly higher amount of MBC as compared to other land use systems. The mean value of MBC was lowest (113.2 mg kg^{-1}) in cultivated soil in pearl millet-wheat system and highest amount was observed in cultivated guava orchard (238.1 mg kg^{-1}). Microbial biomass carbon content (167.2 mg kg^{-1}) in cultivated soil was found significantly higher than uncultivated soil (73.5 mg kg^{-1}).

3.2.2 Dissolved organic carbon (DOC)

The effect of land use system in DOC was found significant and highest DOC content (386 mg kg^{-1}) was observed in cotton-wheat cropping system while lowest DOC content (150 mg kg^{-1}) was observed in citrus land use system. The effect of cultivation on mean value of DOC was non significant. DOC was found higher in agriculture land use system as compare to horticulture land use system.

3.2.2 Light fraction carbon (LFC)

Light fraction carbon constitutes the active pool of organic carbon. The LFC content of soil was found highest (1.76 g kg^{-1}) in guava land use system followed by citrus and vegetable land use system with mean value of 1.57 g kg^{-1} and 1.41 g kg^{-1} respectively. Overall LFC was observed significantly higher in cultivated soil as compared to uncultivated soil under all the land use systems with mean value of 1.06 g kg^{-1} and 0.39 g kg^{-1} respectively.

3.2.3 Heavy fraction carbon (HFC)

The heavy fraction constitutes the passive pool of organic carbon. The amount of heavy fraction was found significantly higher under horticulture land use system as compared to other land use systems although within horticulture land use system it was highest (7.51 g kg^{-1}) under guava orchard followed by citrus orchard with mean value of 7.11 g kg^{-1}. On comparing the cultivated soil with uncultivated then significantly higher value (5.81 g kg^{-1}) of HFC was observed in cultivated soil. Among agriculture land use systems, sugarcane-sugarcane cropping system was observed highest HFC content (7.02 g kg^{-1}) than other cropping systems.

3.3 Total nitrogen and fractions of organic nitrogen

Total Nitrogen was found higher in horticulture land use system as compared to other land use system and highest amount (1365.6 mg kg^{-1}) was observed under cultivated condition of guava orchard. Different nitrogen fractions viz. acid insoluble-N, hydrolysable NH_3-N, amino acid- N, amino sugar-N, hydrolysable unknown-N and total hydrolysable-N are estimated and it was found that the total hydrolysable nitrogen under different land use systems was found in range of 581.2 mg kg^{-1} (pearl millet-wheat) to 1003.2 mg kg^{-1}(guava orchard) under cultivated conditions with highest content observed in horticulture land use system. The soils under cultivation have significantly higher mean value of THN (725.6 mg kg-1) than uncultivated soils (452.3 mg kg-1). Significantly higher content of ammonia nitrogen (245.8 mg kg^{-1}) was found in sugarcane-sugarcane cropping system followed by guava (234.6 mg kg^{-1}) as compared to other land use system while comparing cultivated land with uncultivated, significantly higher content in former (221.6 mg kg^{-1}) was observed than latter (135.5 mg kg^{-1}). The amount of amino sugar nitrogen was found 165.6 mg kg^{-1} under guava land use system which was significantly higher than other land use systems. Overall, higher amount was found in horticulture land use system than field crop system under cultivated soil conditions. Significantly higher (118.3 mg kg^{-1}) content of amino sugar nitrogen was observed in cultivated condition than uncultivated accounting (75.5 mg kg^{-1}). The content of amino acid nitrogen was observed significantly higher in horticulture land use system as compared to agriculture land use system while within agriculture land use system higher amount was observed in sugarcane-sugarcane cropping system (224.4 mg kg^{-1}) followed by rice-wheat cropping system (220.0 mg kg^{-1}). The amino acid N was significantly higher under cultivated soils than uncultivated soils having mean value of 200.5 mg kg^{-1} and 106.4 mg kg^{-1}, respectively. The amount of hydrolysable unknown nitrogen was found significantly influenced by different land use system under cultivated and uncultivated soil. The range of HUN was observed significantly from 71.0 to 372.0 mg kg^{-1} under different land use system. The quantity of HUN was observed significantly higher under horticulture land use system as compared to other land use system. Within horticulture system, the order of HUN was guava > citrus > vegetable having 372.0, 249.0 and 139.0 mg kg^{-1} HUN, respectively. The mean value of HUN was observed 181.9 mg kg^{-1} in cultivated soil which was significantly than 134.3 mg kg^{-1} of uncultivated soil.

DISCUSSION

Total soil organic carbon content in the soil has been increases with increasing the input of organic matter in the form of plant residue, leaf litter and with application of manure. Higher amount of organic carbon was found in the horticulture followed by vegetable and agriculture land use system. This may be because of continuous addition of organic waste through litter fall and FYM addition in the soil. Carter *et al.*[5] reported that the increased soil temperature due to the less shading, low vegetation cover and tillage practices subsequently made the soils susceptible to erosion and thereby reduction in TOC. Similarly, Somasundaram *et al.*[38] concluded higher TOC under grassed land use system and perennial tree plantation than cropped area. Similar results are also reported by Somasundaram *et al*., 2009; Liding *et al*., 2011; Sofi *et al*., 2012.

4.1 Organic Carbon Fractions

4.1.1 Microbial Biomass Carbon (MBC)

Microbial biomass carbon is most sensitive indicator of soil health. This fraction responds more quickly to the changes in crop management practices and type of cultivation than physical and chemical properties of soils[1,22,19]. In the present study the MBC constitutes 0.94- 1.86 % of TOC in uncultivated soil (Figure 2), whereas, it constituted 1.94 to 2.46 % in cultivated soil (Figure 3).

The microbial biomass carbon content was found higher in horticulture land use system than agriculture land use system as well as higher under cultivated conditions, due to higher amount of fresh organic matter addition which acts as substrate for microbes and enhances their population and activities and improved soil physical conditions due to cultivation. The mean increase in MBC content due to cultivation was about 127.5%. These results are in accordance with Pal *et al*. who concluded higher content of MBC under forest and horticulture LUS than agriculture and wasteland due to higher accumulation of organic matter by litter fall. The quantity and quality of soil C inputs as well as nutrient availability are important factors affecting the soil microbial biomass carbon content[21].

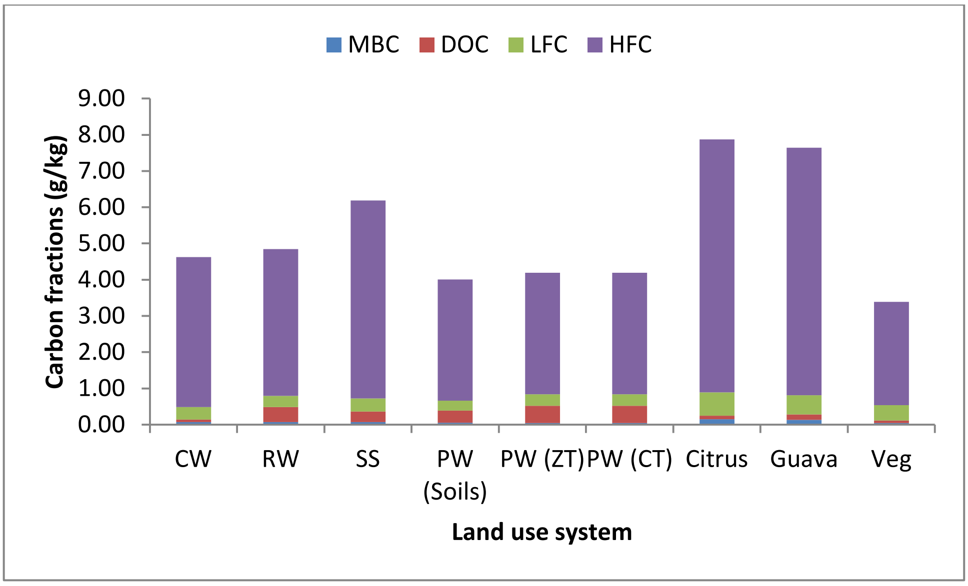

Fig. 1: Distribution of carbon fractions under different land use systems under uncultivated conditions

4.1.2 Dissolved Organic Carbon (DOC)

Dissolved organic carbon is most active and mobile form of organic matter in soils. It is believed to be derived from plant roots, litter and soil humus and is known as labile substrate for microbial activity. It decomposes within few weeks or months.[40].

The DOC constitutes 1.27 % to 11.16 % of total organic carbon in uncultivated soil (Figure 2) and 1.67 to 6.56 % in cultivated soil (figure 3). The DOC content was found higher in rice-wheat cropping system than horticulture land use system and sugarcane-sugarcane and pearl millet-wheat cropping system. This may be attributed to compaction of soil under rice cultivation during puddling operation which reduces the leaching losses of DOC and therefore DOC remain more on the surface in rice-wheat cropping system as compared to other land use system. Chaudhary *et* al.[9] observed higher DOC in compact sodic soil. . The DOC content was higher under cultivated soils as compared to uncultivated soil due to more addition of organic matter during cultivation of crops.

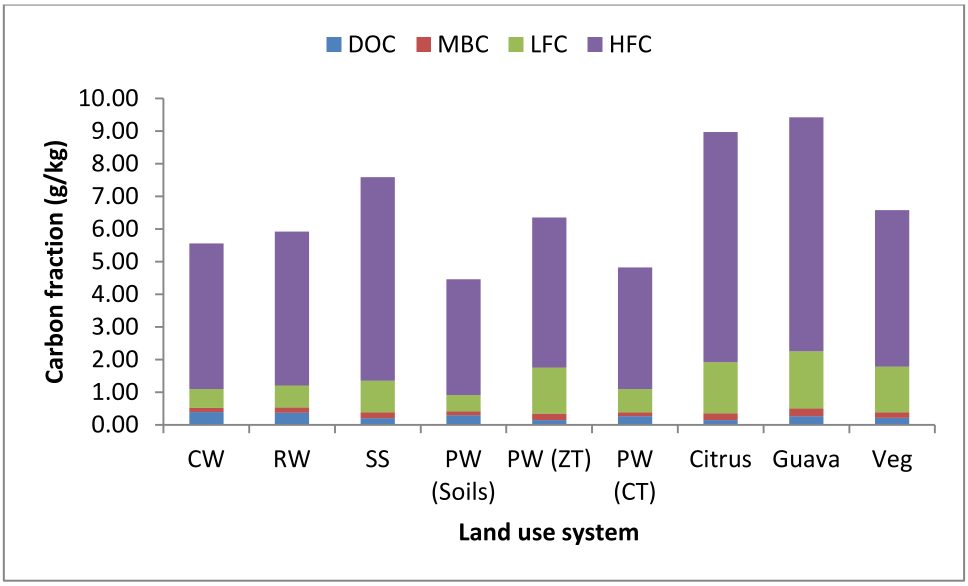

Fig. 2: Distribution of carbon fractions under different land use systems under cultivated conditions

4.1.3 Light Fraction Carbon (LFC)

Light fraction consists largely of plant residues in varying stages of decomposition and that exist within soil. The chemical composition of light fraction has been found to be comparable to that of plant litter and it is under slow decomposition stage. The quantity of light fraction carbon was observed higher under horticulture land use system followed by vegetable and agriculture land use system. The probable reason for such results may be larger addition of plant residue as well as higher moisture and shadow under horticulture land use system which slowed down the rate of decomposition. Also regular application of FYM and continuous litter fall increases the LFC content in horticulture land use system. For the similar reasons the LFC content was higher under cultivated condition than uncultivated ones. These results are in accordance with the results reported by[13,45].

4.1.4 Heavy Fraction Carbon (HFC)

Heavy fraction carbon composed of more processed decomposition products which turnover more slowly and has high specific gravity because of their association with soil minerals. Heavy fraction carbon content of uncultivated soil was found between 78.52 to 97.26 % of TOC (Figure 1), whereas, in cultivated soil it varied between 77.09 to 84.68 % (Figure 2) under different land use systems. Matos *et al.*[23] found similar results and reported HFC content as 82% of TOC and represented the highest carbon fraction in soil.

Guava orchard found to have higher content of HFC when compared to all other LUS. This is may be due to larger addition of plant residue in the soil by litter fall since long time and their stabilization by the humification process. These results are in agreement with Datta *et al.*[10] who stated higher amount of HFC under guava plantation and its content increases with increasing depth due to more stabilization of organic carbon at lower depth. On comparing to different agro-climatic regions higher HFC content was observed under rice-wheat and sugarcane-sugarcane cropping systems as compared to cotton-wheat and pearl millet-wheat cropping system. This may be attributed to higher organic carbon in the slightly lower temperature conditions which decreases the rate of decomposition and favours the accumulation of humus.

4.2 Organic Nitrogen Fractions

4.2.1 Total Hydrolysable Nitrogen (THN)

Hydrolysable N is more vulnerable to mineralization and could be considered as a major source of potentially available N for plants than non hydrolysable N. This fraction constitutes the 32.87 to 58.38 % and 53.9 to 79.2% of total nitrogen under cultivated and uncultivated soils. The main identifiable organic N groups included in it is amino acid-N, amino sugar N, ammonia N and unidentifiable hydrolysable unknown N (Figure 3).

The amount of THN found higher under horticulture land use system than agriculture land use system. Guava LUS was found with highest amount of THN followed by citrus. Rice-wheat and sugarcane-sugarcane cropping system observed higher content of THN as compared to cotton-wheat and pearl millet-wheat cropping system. The probable reasons for such finding are positive correlation of THN with content of total organic carbon. The LUS possessing higher content of TOC also reported to have higher content of THN. Sekhon *et al*.[31] also reported increase in THN with combined application of inorganic and organic fertilizers.

4.2.2 Ammonia Nitrogen (AN)

Ammonia N constitutes the major portion of hydrolysable N. 7 to 25.1% and 18.5 to 36.7% and 18.5 to 36.7 % of total nitrogen was found as ammonia nitrogen in uncultivated and cultivated soil, respectively.

Ammonia content was found higher under agriculture land use system than horticulture land use system, because this fraction is more correlated to added fertilizers and manures than organic matter added through litter fall. For the similar reasons its amount also found to be decrease in uncultivated than cultivated soils. These results are in accordance to findings of Dominguez *et al*. [11] who stated that dynamic of soil organic N was profoundly affected by continuous cropping with a contrasting tillage system.

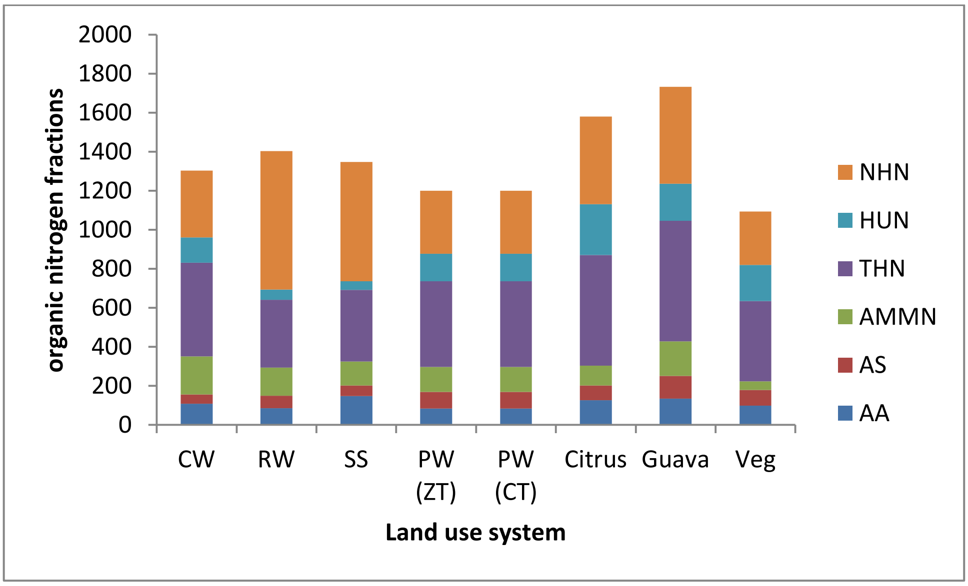

Fig. 3: Distribution of organic nitrogen fractions under different land use systems under cultivated conditions

4.2.3 Amino Sugar Nitrogen (ASN)

It is the easily hydrolysable fraction of organic nitrogen and considered to be largely in the form of high molecular weight compounds and serves as the available nitrogen source for the plants uptake thereby in their growth. The lowest content of N is represented by this group of N and it constitutes 5.54 to 13.4 % of total N (Figure 3). Amino sugar N was found to highly positively correlated to LFC and TOC thereby any addition of organic matter could increases the amino sugar N. Higher amount of amino sugar nitrogen was found in cultivated soil rather than uncultivated soil. Similar results are reported by Kaur and Singh[18] who stated that incorporation of FYM, Press mud and Green manure incorporation along with inorganic fertilizers increased the ASN by 45.9, 67.6, 21.6 % respectively over inorganic fertilizer treatment.

4.2.4 Amino Acid Nitrogen (AAN)

The main identifiable organic N compounds in soil hydrolysate are the amino acid and amino sugars. The amount of amino acid N was found higher under horticulture land use system than vegetable and agriculture land use system. The amino acid N content significantly increased in cultivated soil as compared to uncultivated soil. This may be attributed to more addition of FYM and fertilizers under cultivation than uncultivated soils which add up organic nitrogen in the form of proteins, protein-humic complexes and peptides. These results are found to be in agreement with Trumbore,[41] who reported that under cultivation of different vegetable cropping system for 20 years along with FYM application, the soil found to store more organic matter and after decomposition of native organic matter will lead to increased availability of free and peptide bound amino acids.

4.2.5 Hydrolysable Unknown Nitrogen (HUN)

The fraction of total hydrolysable nitrogen which remains after extraction of other known fractions (aimno acid N, amino sugar N, ammonia N) is accounted as hydrolysable unknown nitrogen. Hydrolysable unknown nitrogen constitutes 4.5 to 28.77 % of total nitrogen and 6.85 to 28.9% of total nitrogen under cultivated and uncultivated soil conditons.

Hydrolysable unknown nitrogen (HUN) was found higher under horticulture land use system than agriculture land use system. Increase (35.44 %) content of HUN was observed in cultivated soil as compared to uncultivated soil. The probable reason for such results is higher association of HUN with organic matter and organic carbon. Soil richer in TOC possesses higher content of HUN. Similar results have also been reported by Santhy *et al*., 1998; Sihag *et al*., 2005; Sekhon *et al*., 2011 and Kaur and Singh[18].

4.2.6 Non Hydrolysable Nitrogen (NHN)

The nitrogen which is not solubilised by acid hydrolysis is referred to as acid insoluble N. This fraction constitutes the 36.6 to 67.14% of total nitrogen under uncultivated conditions and 20.78 to 46.1 % of total nitrogen under cultivated soils. Climatic conditions play an important role in governing the availability of acid insoluble N content. Lower temperature and moderate rainfall conditions favour accumulation of acid insoluble N in soil due to reduction in the rate of decomposition.

4.3 Total Nitrogen

Total nitrogen in different land use system found to vary from 837.6 (pearl millet-wheat cropping system) to 1365.6 kg ha^{-1}(guava orchard). The content of total nitrogen was found higher under horticulture land use system than agriculture land use system because of higher amount of return of litter in soil. Similar results were founded by Liding *et al*.[20] who reported higher content of Total nitrogen in orchard and vegetable field than cropland.

Correlation between total organic carbon and its fractions, total nitrogen and its fractions

Relationship between soil total organic carbon and its pool with total nitrogen and its fraction were found to be positive. Study of correlation matrix revealed the existence of highly positive significant correlation between TOC and its fractions MBC, LFC and HFC. However, DOC was negatively non significantly correlated with TOC, MBC, LFC and HFC. The TOC was highly significantly positively correlated with HFC (r=0.98**) and MBC (r= 0.91**), THN (r=0.79**), amino sugar (r=0.55*), amino acid (r=0.80**), HUN(r=0.72**), TN (r = 0.79**). Microbial biomass carbon was showed highly positively correlated with all the carbon fractions except DOC and nitrogen fractions and total nitrogen, total nitrogen (r= 0.82**) and highest positive correlation existed with THN (r= 0.93**).

positive significant correlation between TOC and its fractions MBC, LFC and HFC. However, DOC was negatively non significantly correlated with TOC, MBC, LFC and HFC. The TOC was highly significantly positively correlated with HFC (r=0.98**) and MBC (r= 0.91**), THN (r=0.79**), amino sugar (r=0.55*), amino acid (r=0.80**), HUN(r=0.72**), TN (r = 0.79**). Microbial biomass carbon was showed highly positively correlated with all the carbon fractions except DOC and nitrogen fractions and total nitrogen, total nitrogen (r= 0.82**) and highest positive correlation existed with THN (r= 0.93**).

A strong positive correlation existed between LFC with HFC (r= 0.75**) and with MBC (r= 0.90**), THN (r=0.85**), ammonia nitrogen (r=0.52**), amino sugar (r=0.73**), amino acid (r=0.82**), total nitrogen (r=0.84**). Heavy fraction carbon showed positive correlation with other organic carbon fractions and THN(r=0.72**), ammonia acid nitrogen (r= 0.74**), HUN (r=0.65**), TN(r=0.77**). All the organic nitrogen fractions revealed positive correlation with TOC and highest positive correlation obtained with amino acid (r= 0.80**). THN revealed highly positive correlation with total nitrogen and other organic nitrogen fractions and strongest positive correlation existed with MBC (r= 0.93**), ammonia nitrogen (r=0.60**), amino sugar (r=0.60**), ammonia nitrogen (r=0.81**), HUN (r=0.81**), TN (r=0.73**). Ammonia nitrogen revealed highly positive correlation with THN (r= 0.70**) while amino acid showed strongest positive correlation with LFC (r= 0.73**). HUN fraction of organic nitrogen was observed positively correlated with LFC (r= 0.84**) and THN fraction of organic nitrogen (r= 0.81**).Total nitrogen was observed highly positively correlated with MBC (r= 0.82**) followed by THN (r= 0.77**). NHN showed non significant negatively correlated to various fractions of carbon as well as remaining nitrogen fractions.

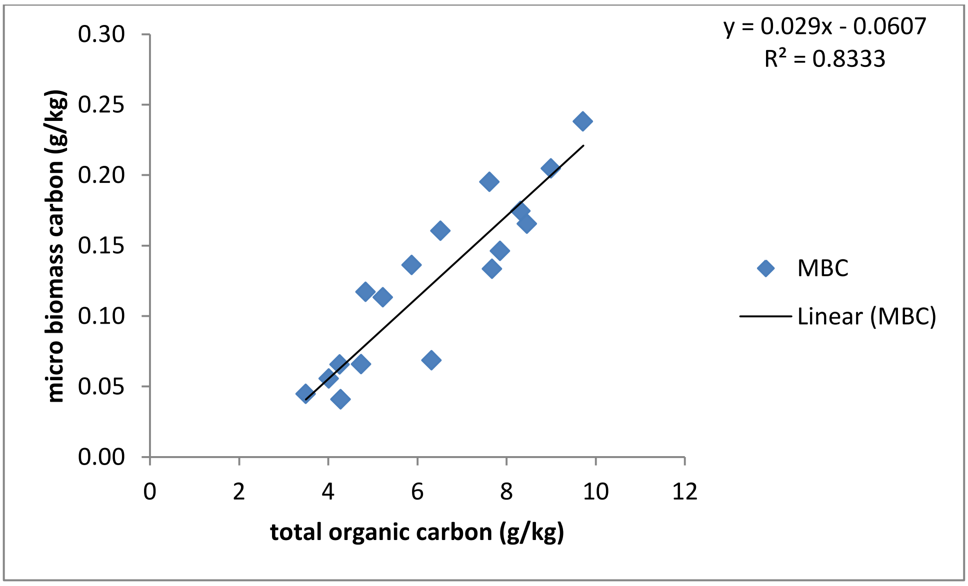

Fig. 4: Regression analysis of MBC with TOC

Table 1: Soil organic carbon and its fraction under different land use systems

Land use systems	Organic carbon fractions				
	Soil organi Carbon (g kg $^{-1}$)	Microbial biomas Carbon (mg kg^{-1})	Dissolved organic carbon (mg kg^{-1})	Light fractio Carbon (g kg $^{-1}$)	Heavy fractio Carbon (g kg $^{-1}$)
Agriculture					
Cotton-Wheat	5.88	136.2	386.0	0.57	4.79
Rice-Wheat	6.52	160.5	370.0	0.67	5.38
Sugarcane-sugarcane	8.32	174.5	208.0	0.97	7.02
Pearl millet-Wheat (Soil farm)	4.84	117.2	294.0	0.50	3.76
Horticulture					
Citrus	9.00	204.7	150.0	1.57	7.11
Guava	9.72	238.1	260.0	1.76	7.51
Vegetables					
Tomato/potato/ cauliflower/brinjal	8.46	165.4	212.0	1.41	6.72

Table 2: Total nitrogen and organic nitrogen fraction under different land use systems

Land use systems	Organic nitrogen fractions						
	Total nitrogen (mg kg^{-1})	**Total hydrolysable nitrogen (mg kg^{-1})**	**Ammonia nitrogen (mg kg^{-1})**	**Aminoacid nitrogen (mg kg^{-1})**	**Amino sugar nitrogen (mg kg^{-1})**	**Non hydrolysable Nitrogen (mg kg^{-1})**	**Hydrolysable Unknown Nitrogen (mg kg^{-1})**
Agriculture							
Cotton-Wheat	945.0	704.6	223.6	133.2	74.6	240.4	273.1
Rice-Wheat	1207.5	736.4	231.3	220.0	106.0	471.1	178.0
Sugarcane-sugarcane	1051.1	681.4	245.8	224.4	138.8	369.7	71.0
Pearlmillet-Wheat (Soil farm)	837.6	581.2	224.2	153.0	99.2	255.6	103.0
Horticulture							
Citrus	1276.5	869.2	217.4	273.0	129.5	407.3	249.0
Guava	1365.6	1003.2	234.6	230.8	165.6	362.4	372.0
Vegetables							
Tomato/potato/ cauliflower/brinjal	822.5	651.6	175.8	225.0	110.2	170.9	139.0

CONCLUSIONS

It can be concluded from the present study that the organic carbon and organic nitrogen fractions were found higher in horticulture land use system as compared to agricultural and vegetable land use system. Similarly, higher organic carbon and organic nitrogen fractions were observed under cultivated soils than uncultivated soil except dissolved organic carbon in all land use systems.

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