Madras Agric. J., 99 (7-9): 507-510, September 2012
https://doi.org/10.29321/MAJ.10.100126

Soil Humic and Fulvic Acid Fractions Under Different Land Use Systems

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Soil organic matter (SOM) in any agro-ecosystem is regulated by interaction of factors that determine its formation and promote decomposition, with a relative importance as: management > climate > biota > topography = parent material > time. Different land use practices under diverse climatic conditions in Hassan district (Karnataka) were selected for the study. Land use systems receiving frequent biomass additions through litter *viz*., Forest systems (both natural and manmade) and coffee plantations were observed with surface organic layer with higher SOC (10.6-13.2) content (g kg^{-1} soil). Agricultural systems mainly paddy, potato, vegetable, coconut and mulberry systems sparse OM additions were observed with reduced and lower SOC status (4.6-6.6). Humic acid (HA) and fulvic acid (FA) under these land use systems were dependent on land management i.e. source, form, amount, rate of organic materials added to soil. The HA fraction ranged from 0.2 g 100 g^{-1} soil in soils of coconut and paddy systems to 0.4 g 100 g^{-1} soil in natural forests. Quantitatively higher HA in forest and coffee systems was observed than agricultural systems. Proportionately to total SOM content (%), the HA was higher in agricultural soils (24.4-28.0) than coffee and forest soils (19.6-20.7). The systems with tree vegetations (forests and coffee) recorded higher proportions of FA (29.4-30.5) than agricultural systems like potato (26.5) and paddy (27.4). Forest systems with litter biomass additions (fresh organic materials) were with higher FA content while, agricultural systems receiving with almost decomposed OM (FYM) indicated higher HA than FA.

Key words*:* Land use system, soil organic matter, humic acid, fulvic acid.

Ample changes in both quantity and quality of soil organic matter (SOM) is mainly induced by the anthropogenic interventions like land use system and its management. Change in SOM composition and proportion by land use impact are reported earlier (Miglierina and Rosell, 1995). OM in any soil system depends on innumerable parameters like its addition through different sources and loss through decomposition. Major portion of SOM mainly composed of humic substances/ humus (stable organic matter compounds, consists of decayed organic matter of plant, animal and microbial origin) and almost termed synonym with SOM (Schnitzer, 2000). Soil humic fraction is classified as humic acid (HA): soluble in bases that precipitate in acid solution, Fulvic acid (FA): soluble in both acid and alkali solution and humin (HN): that is insoluble and inert part. Structural formation, chemical composition and stability of these humic substances are influenced by many variables like climate, parent material, altitude, vegetation type and soil management (Katyal, 2000). Hence, a study was conducted to know the impact of land use and its management on soil organic matter content and its fractions (HA and FA) in soils of different land use systems viz., forests (natural and manmade), coffee, coconut, mulberry, vegetable, potato and paddy systems in Hassan district (Karnataka).

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Materials and Methods

Study area

Hassan district is located on the eastern side of the Western Ghats, in the southern part of Karnataka state (Fig. 1). The district has a total geographical area of 6826.15 km^2 and lies between 12° 13' and 13° 33' North Latitudes and 75° 33' and 76º 38' East Longitude, is exposed for an equitable climate with average annual rainfall of 1031 mm. The western parts of the district receive high rainfall and it decreases significantly towards east. Of the total geographical area of 6.63 lakh ha, nearly 50 per cent of the area is under cultivation (Table 1).

Selection of land use systems

District represents four distinct agro climatic zones (Zone 4: Central dry zone, Zone 6: Southern dry zone, Zone 7: Southern transition zone, and Zone

9: Hilly zone) along the rainfall gradient in east-west direction. Selected major land use systems covering larger area such as coffee, rice, vegetable, potato, coconut, mulberry and forests (both natural-N and manmade-M) systems fall within the Southern Transition Zone (Zone-7). However, eastern parts of Sakleshpur, part of Hilly Zone (Zone 9), were chosen to collect soil samples from a few coffee plantations and natural forests. The sampling sites were chosen in narrow width of 35 x 20 km (Figure 2) for wider representation and to reduce sampling errors.

Method of soil sampling

The surface composite soil samples (0-15 cm) were pooled, from 3 soil sampling points, within a pre-identified representative site for the land use system. The composite soil sampling was adopted to reduce the sampling error and each such sample was considered as a replication for further analysis. Thus, each land use system (LUS) was represented by 15 soil samples. The soil samples were collected during February-April-2009 (summer) to lessen the seasonal effects on soil properties. In total, there were 120 samples (8 LUS x 15 samples). The soil samples were air dried, passed through 2 mm sieve and stored for analysis. From these samples, three samples representing each land use system were used for fractionation of soil organic matter into HA and FA.

Soil chemical analysis

Collected soil samples were analysed for pH and electrical conductivity (EC) by standard procedures outlined by Sarma *et al,* 1987. Further these samples were analysed for Soil Organic Carbon by following Chromic acid method (Jackson, 1973).

Soil organic matter studies

The soil organic matter was extracted and fractionated into different components. Each of the fractions were quantified and characterized. Detailed methodologies are furnished below. Three soil samples collected from different land use systems were acid (0.1 N HCl) treated to remove simple structural OM fractions for further fractionation into humic and fulvic acid.

***Extraction and fractionation*:** The soil residue was extracted with 50 mL of 0.1 M NaOH in 0.1 M sodium pyrophosphate and it was repeated thrice for complete extraction of humic fractions. The pooled alkali extract was acidified to pH 2 with 2 N HCl, stirred well and allowed to stand at room temperature for 24 hours. The soluble fulvic acid was separated from coagulate (humic acid fraction) by centrifugation. The process of precipitation and centrifugation were repeated to attain partial purification of humic acid fraction as described by Stevenson (1994).

Purification and quantification of soil organic matter fractions

Humic acid: Humic acid was further purified by treating the extracted humic acid fraction with HCl - HF mixture (5 mL. each of HCl and HF acids were dissolved in 990 mL of double distilled water) for 24 hours. The acid mixture was separated by centrifugation. This treatment was repeated three to four times in succession. Finally, the residue was thoroughly washed with distilled water and freeze dried. The sample weights were recorded before using it for further analysis.

Fulvic acid: The purification of fulvic acid was done as outlined by Wander and Traina (1996). The fulvic acid fraction was transferred to 100 mwco dialysis bags and dialysed against double distilled water for 24 hours. The dialyzed fraction was evaporated under low temperature and finally freeze dried. The dried sample was then weighed and stored for further analysis.

Results and Discussion

Soil Properties

pH and EC

The pH and electrical conductivity are the two important electrochemical properties of soils and the data pertaining to them are presented in Table 2. The soil pH of different land use systems ranged from slightly acidic (5.7 in paddy soils) to slightly alkaline conditions (7.8 in mulberry soils). Lower pH (5.8 to 5.9) in forest and natural systems can be attributed to leaching of exchangeable bases. In high rainfall areas, leaching of bases by percolating water would lead to soil acidity. Intensive cultivation of monocrops and use of acid forming fertilizers also might have contributed to soil acidity (Bouman *et al*, 1995). Interestingly, the pH was found neutral to alkaline in soils of vegetable system (6.4), coconut plantations (7.1) and mulberry fields (7.8). Application of calcium amendments might have altered the exchangeable cations in mulberry and vegetable systems and thus, resulted in slightly higher pH. The application of common salt (NaCl) in coconut plantations as a farmer's practice might have increased the soil pH. Qualitative and quantitative changes in exchangeable cations are known to

Table 1. Area under different land use systems in Hassan district

Land use system	Area ('000 ha)	Per cent area
Paddy	52.43	7.91
Other cereals and minor millets	126.68	19.12
Total pulses	34.72	5.24
Total oilseeds	25 .80	3.89
Potato	43.35	6.54
Other vegetables and fruits	6.00	0.91
Total fruits	7.13	1.08
Sugarcane	7.35	1.11
Non-food crops	139.57	21.06
Coffee	38.20	5.77
Coconut	61.80	9.33
Forest and forest plantations	58.78	8.87
Others	60.79	9.17

(Total geographical area 6.63 lakh ha) (Anonymous, 2009) influence soil pH (Bohn *et al,* 2001). The soil pH in forests (both natural and manmade) and potato system were found closer to that of paddy soils with

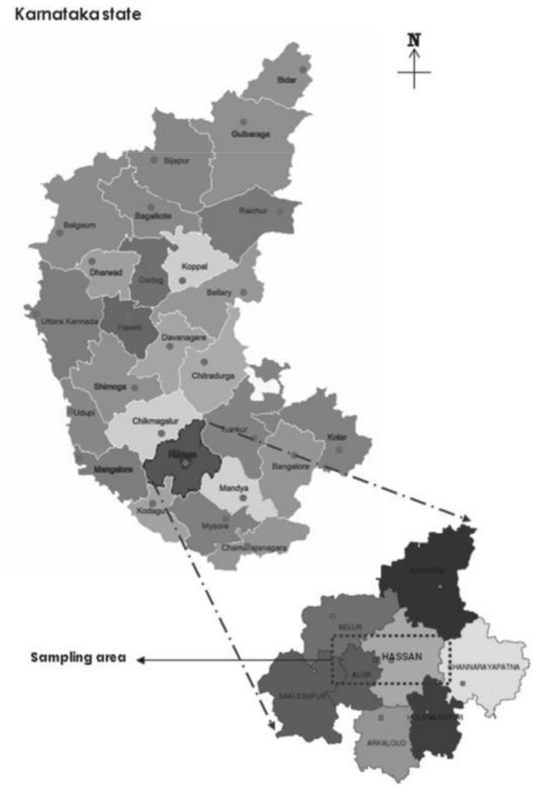

Fig. 1. Map depicting the study area in Hassan district

slight acidity. However, the variations were found on par with each other. The salt content of soils, measured in terms of electrical conductivity, ranged from 0.12 dS m^{-1} (in coffee, coconut, potato, natural forest systems) to 0.21 dS m^{-1} (in mulberry plots). Potato, coconut, forest and paddy systems recorded lower salinity and the variations among these systems were found to be non-significant. Continuous and excess application of fertilizer nutrients in mulberry might have led to greater salinity due to added salts through fertilization. Similar results on increased electrical conductivity with nutrient and manure application in Vertisols are reported by Patil *et al* (2003).

Soil organic carbon (SOC)

The SOC content (g kg^{-1}) ranged from 4.6 in potato plots to 13.2 natural forests (Table 2). The

Table 2. pH, Electrical Conductivity (EC) and Organic C in soils of different land use systems

Land use system	pH	EC (dS m^{-1})	Soil Organic-C (g kg^{-1})
Natural forests	5.8 ± 0.2	0.12 ± 0.05	13.2 ± 2.2
Manmade forests	5.8 ± 0.3	0.13 ± 0.07	10.6 ± 2.0
Coffee plantations	5.9 ± 0.3	0.12 ± 0.03	12.6 ± 2.0
Mulberry fields	7.8 ± 0.3	0.21 ± 0.07	6.6 ± 1.6
Coconut plantations	7.1 ± 0.4	0.12 ± 0.05	4.8 ± 1.1
Potato plots	5.8 ± 0.8	0.12 ± 0.07	4.6 ± 1.5
Paddy fields	5.7 ± 0.4	0.17 ± 0.06	6.0 ± 1.5
Vegetable fields	6.4 ± 0.6	0.16 ± 0.03	6.2 ± 1.9
S.Em ±	0.1	0.1	0.4
CD (at 0.05)	0.3	0.1	1.2

land use systems with tree type vegetation namely natural forests (13.2), coffee (12.6) and manmade forests (10.6) recorded higher amounts of SOC. Contrastingly, the soils of coconut plantations and potato fields recorded less SOC. Soils of mulberry, paddy and vegetables were recorded with the medium range of SOC. Addition of large amounts of litter biomass in the above systems might have contributed for higher SOC contents. Low addition of organic manures/litter biomass might have reduced SOC in agricultural systems. Intensive cultivation practices would also lead to soil organic matter decomposition (Doran, 2002) and thus, reduce SOC in agricultural soils (Tate, 1987; Katyal, 2000).

Soil organic matter

The quantities of soil organic matter and its fractions namely humic acid, fulvic acid fractions of different land use systems are presented in Table 3. The total soil organic matter content in samples used in the fractionation study ranged from 0.86 to 1.95 g 100 g^{-1} soil. Higher amounts of total soil organic matter were recorded in forests (natural and manmade) and coffee plantations with a range of 1.26 to 1.95 g 100 g^{-1} soil. Similar results on higher SOM in forests have been reported by Nagaraja (1997). Among agricultural systems, mulberry soils were observed with higher SOM (1.25 g 100 g^{-1}) than others. The total organic matter in agricultural systems was in the range of 0.86 to 1.25 g 100 g^{-1} soil. Similar relationships between cultivation and SOM status in agricultural soils are reported by Wander and Traina (1996).

Table 3. Total organic matter (OM), humic acid and fulvic acid contents and their proportion (to total SOM) in soils of different land use systems

Land use system	Total OM (g 100 g^{-1} soil)	Humic acid Quantity (g 100 g^{-1} soil)	Humic acid Proportion to total SOM (%)	Fulvic acid Quantity (g 100 g^{-1} soil)	Fulvic acid Proportion to total SOM (%)	HA: FA ratio
Natural forests	1.95	0.39	19.7	0.58	29.4	0.67
Manmade forests	1.26	0.26	20.7	0.39	30.5	0.68
Coffee plantations	1.62	0.32	19.6	0.49	29.6	0.66
Mulberry fields	1.25	0.31	24.8	0.37	29.5	0.84
Coconut plantations	0.86	0.24	28.0	0.25	29.2	0.96
Potato plots	1.00	0.25	24.4	0.27	26.5	0.92
Paddy fields	0.99	0.24	24.5	0.28	27.4	0.89
Vegetable fields	1.09	0.30	27.9	0.34	31.0	0.90

Humic and fulvic acid fractions

The humic acid fraction ranged from 0.24 g 100 g^{-1} soil in coconut and paddy systems to 0.39 g 100 g^{-1} soil in natural forests. In terms of quantities, the humic acid was found higher in forest soils compared to agricultural systems. In terms of its proportion to the total soil organic matter content, the humic acid was higher in agricultural soils (24.4 – 28.0 %) than coffee and forest soils (19.6 – 20.7 %). The fulvic acid fractions in terms of absolute values were found higher in vegetable, forests and coffee plantations compared to other land use systems. The systems with tree vegetations recorded higher proportions of fulvic acid with a range of 29.4 – 30.5 %. Narrower HA : FA ratios (0.66 to 0.68) in forests and coffee soils suggest that the fulvic acid was relatively more than humic acid (Fig. 2). Higher proportions of fulvic acid in forest soils

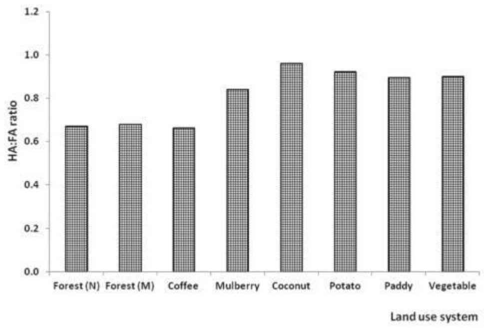

Figure 2. Ratio of humic acid to fulvic acid fractions in soils of different land systems

(receiving fresh biomass) are also reported by Stevenson (1994) and Schnitzer (2000). Among agricultural systems, the fulvic acid portions were lesser in potato (26.5 %) and paddy (27.4 %) while, it was higher in coconut (29.2 %), mulberry (29.5 %) and vegetable systems (31.0 %) . In case of agricultural soils, HA : FA ratios (0.84 to 0.96) indicate that the humic acid was relatively more (Stevenson, 1994). These results suggest that the HA : FA ratios are regulated by quality of organic matter added (Kumada, 1987; Stevenson, 1994; Schnitzer, 2000). Least variations in the proportional values were observed in all land use systems. This suggests that the proportional amount of each soil organic matter fraction is likely to be determined by the management practices adopted in the land use system and not the quantity of soil organic carbon (Martin *et al,* 1998; Slepetiene and Slepetys, 2005).

Conclusion

Humic substances are key fractions of soil organic matter, a major aspect controlling the flexibility of plant nutrition irrespective of land use system through different processes and mechanisms. Land use system practices and its management is a factor governing the quantity and quality of organic matter inturn humic substances. Present study revealed the status of these fractions in different land uses with forest soils as organic rich, whereas in cultivated systems it is determined by the management mainly including crop grown and its nutrient management. The lower status of agriculture systems indicates their potential to yield greater crop returns under better and superior organic matter management.

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Received: January 9, 2012; Accepted: April 10, 2012