Active and passive soil organic carbon pools as affected by different Land Use Patterns in red soils of Vikarabad district,Telangana

ABSTRACT

Carbon (C) fluxes are largely controlled by the small but highly bio-reactive, labile pools in terrestrial soils, while long-term C storage is determined by the long lived recalcitrant fractions.A survey was conducted in the year (2019-20 and 2020-21) in red soils of Vikarabad district covering eight *mandals* and soil samples were collected from four predominant land use patterns at two depths (0-15 and 15-30cm).Land use patterns studied included cultivated land with different cropping intensity *ie.,* 100% cropping intensity (redgram-fallow), 200% cropping intensity (rice-rice), and two from natural conditions *ie.,* forest land and fallow land to assess the impact of these land uses on various pools of SOC *viz.,* total organic carbon (TOC), oxidizable organic carbon and its pools.The SOC content of forest land recorded highest mean (7.07 g kg^{-1}) and that of fallow land recorded lowest (2.68 g kg^{-1}).The mean SOC stock was highest in forest land (13.92 Mg C ha^{-1}) and that fallow land was lowest (5.64 Mg C ha^{-1}). The highest accumulation of TOC mean was observed in forest (26.15 Mg ha^{-1}). About 60.00% and 53.16% of the TOC in forest land and 100% cropping intensity occurred as very active carbon pool suggesting that the accumulated C could easily be lost following the land use change.Contrarily, the majority of TOC of 200% cropping intensity (rice-rice) and fallow land (52.86% and 55.02% of TOC) was stabilized in the passive pool indicating more stable nature of the accumulated organic matter.

Keywords: *Land Use Patterns, Soil Organic Carbon, TOC, Active Pool, Passive Pool, Forest*

INTRODUCTION

Soil organic carbon (SOC) is reported as a sensitive indicator of soil quality and environmental sustainability [1].To sustain fertility and productivity of soil, SOC is considered essential which can improve physical, chemical and biological properties of a soil [2] as well as it can be used for predicting climate change and effects on crop production [3].The overall efficiency, resilience, adaptive capacity and mitigation potential of production or land use patterns towards the extremities of climate can be enhanced by increasing the quality as well as quantity of soil organic carbon pools in different land uses [4].Global SOC pool in the top 1 m soil is approximately 1200 to 1600 Pg (1 Pg = 101^5 g) and 695 to 930 Pg of inorganic carbon. The amount of carbon (C) stored in soil is two times of the global biotic C pool and three times of the global atmospheric C pool. The concentration of atmospheric carbon dioxide (CO_2) may be greatly impacted with a small change in SOC pool, thus affecting the global carbon cycle [5].It is therefore important to preserve, maintain and store SOC while addressing problems of climate change and food insecurity.

Land use/land cover change is one of the key factors which affect the soil organic carbon pool remarkably. The reason for this being the rate of input (e.g. plant litter) and rate of output (e.g. SOC mineralization) of soil organic matter (SOM) as a result of alterations in plant community and land management practice [6].Land use changes and management are widely recognized as the most important driving forces of global carbon cycles [7] contribute 6%–39% of the growth in CO_2 emissions and have profound impacts on SOC which are estimated to be one of the second largest source of human induced greenhouse gas emissions (1.5 Pg C/a) after fossil fuel combustion (5.3 Pg C/a) [8] because, soils may provide an immediate sink for atmospheric CO_2 with proper management. Tropical forests can act either as a carbon sink or source which contributes significantly in the modification of atmospheric C concentration.The conversion of tropical forests into other land uses such as plantations and croplands through anthropogenic activities may act as a carbon source leading to alterations of soil properties and processes.When natural forests are converted to croplands, the soil structure gets disrupted enhancing the mineralization of organic matter by microbes subsequently leading to SOC loss.

Many attempts have been made to differentiate SOC into various pools of varying lability and more labile pools have been used as sensitive indicators of changes in soil quality in response to land use management [9] because these fractions may precede future changes of SOC [10]. SOC stocks in soil consist of labile and non labile pool with varying residence time.Labile pool (active pool or light fraction pool) are the source of nutrients with most rapid turnover rates that influences the quality and productivity of soil, it is also available in a relatively small proportion because it is easily decomposed and extremely sensitive to environmental fluctuation. Another type is the stable, resistant/recalcitrant pools with varying residence time (passive pool) is slowly decomposed by microbial activity so, it is not considered as a good parameter for soil quality but contributes in total organic carbon (TOC) stocks [11].

Although many studies have focused on SOC dynamics as consequence of land use change for last 20 years, SOC dynamics was poorly understood as they include climate, time, vegetation, topography and parent material. Thus, we studied on single soil type that holds many of these interactive controls as constant allowing the evaluation of SOC dynamics with better understanding in different land use patterns.Therefore, the objective of this research was to quantify various SOC contents (very labile, labile, less labile and non-labile) and their relative proportions in total organic carbon (TOC) across different land use patters.

2. METERIALS AND METHODS

2.1 Study area

The present study was carried out in Vikarabad district, Telangana, India.The geographical area of the district is 3,386 sq.km and is situated between 17°20'N to 11.15''N latitude and 77°54'N to 17.45''E longitude. The net cropped area in the district is about 20.4 lakh ha and has a forest cover of 44,548 ha and fallow land to an extent of 20,769 ha. The agro climate of this sub region is characterized as hot, semiarid moist with dry summers and cold winters.The mean annual temperature varies from 22°C to 32°C. The mean summer (April–June) temperature varies from 32°C to 46°C, rising to a maximum of 48°C in May, and the mean winter (December–February) temperature varies from 12°C to 26°C. The mean annual rainfall varies from 500 to 1000 mm covering 45–47% of the mean annual potential evapotranspiration (PET) ranging between 1500 and 1800 mm.To estimate the distribution of SOC stock and pools of different oxidisability among different land use patterns, we identified four land use patterns in Vikarabad ditrict, *viz.* 1) 100% cropping intensity (redgram-fallow) 2) 200% cropping intensity (Rice-rice) 3) Forest land 4) Fallow land. A total of 320 sites were selected for the present study.Details of the site characteristics including age of the land uses,dominant species and management practices of the land use studied were recorded with the help of the villagers and are presented in Table 1.

Table 1. Site characteristics of different land use patterns

Land use	Age (year)	Dominant species	Management practices
100% cropping intensity (Redgram-fallow)	10	*Cajanus cajan*	Deep summer ploughing and plough planting,regular weeding and fertilizer application with supplemental irrigation as and when required by the crop.
200% cropping intensity (Rice-rice)	10	*Oryza sativa*	Summer ploughing, plough planting and transplanting of the crop, application of fertilizers.
Forest land	40	*Tectona grandis, Eucalyptus, Acacia nilotica, Tamarindus indica, Leucaena leucocephala, Dalbergia sissoo, Ficus benghalensis, Pongamia pinnata*	Mild anthropogenic disturbances for occasional tree felling, frequent collection of fuel wood and other non-timber forest products
Fallow land	25	*Eulalia trispicata, Imperata cylindrica, Cyrondon dactylon, Cyperus rotondus*	Grazing by animals and erosional losses

2.2 Soil sampling and sample preparation

A survey was carried out in the year (2019-20 and 2020-21) and soil samples at two depths (0-15 and 15-30cm) were collected from eight *mandals* in Vikarabad district predominantly covered by red soils. Five villages in each *mandal* were selected and from each village, four land use pattern were selected out of which two were from agricultural land use with different cropping intensity *ie.,* 100% cropping intensity (redgram-fallow cropping system),200% cropping intensity (rice-rice cropping system) and two from natural conditions *ie.,* forest and fallow land. Within each land use plot soils were collected from five points (4 in the corners and 1 in the center) at two depth classes i.e. 0–15 and 15–30 respectively.The five sub-samples at each location and depth class were pooled to get one composite sample for each depth class per plot. A total of 320 soil samples were collected at two depths were obtained for analysis.The soils were mixed thoroughly and large plant debris, roots and stones were removed manually by hand. Soil samples from the same depths was collected from undisturbed plots separately for bulk density by using soil corer of known volume.In the laboratory, the soil samples were homogenized, air-dried, grounded and passed through 2 mm sieve for further analysis.

2.3 SOIL ANALYSIS

The soil samples were analysed for salient characteristics like pH, EC, bulk density, soil organic carbon following standard procedures. The soil organic carbon stock was calculated by multiplying OC content (g g^{-1}) with bulk density (Mg m^{-3}) and depth (m) of surface soil [12].

Soil organic carbon stock (Mg C ha^{-1}) = OC content (g g^{-1}) × bulk density (Mg m^{-3}) × depth (m)

2.3.1 Different Pools of soil organic carbon

They were determined as described by [11] and [13].One g of 0.5mm sieved soil was taken in 500mL Erlenmeyer flask in three sets. For each set 10mL of 1N potassium dichromate was pipetted out and transferred to Erlenmeyer flask. To the first set 5mL of concentrated H_2SO_4 was added, to the second set 10mL of concentrated H_2SO_4 and to the third set 20 mL of concentrated H_2SO_4. was added which corresponds to 12.0 *N*, 18.0 *N* and 24.0 *N* of H_2SO_4.All the Erlenmeyer flasks were kept aside for 30 min to complete the reaction. Then 200 mL distilled water, 10 mL of 85% orthophosphoric acid, a pinch of NaF and 1 ml of diphenylamine indicator were added and titrated with 0.5N ferrous ammonium sulphate till color changed from violet blue to green. A blank was also titrated in similar manner to determine the quantity of ferrous ammonium sulfate consumed. The values of different organic C pools were expressed in Mg ha^{-1}.

The different pools of oxidisable organic carbon were determined as given below

1.Very labile (VL)	Organic C oxidisable under 12.0 N H_2SO_4
2.Labile (L)	The difference in SOC extracted between 18.0 N and 12.0N H_2SO_4
3.Less labile (LL)	The difference in SOC extracted between 24.0 N and 18.0 N H_2SO_4
4.Non-labile (NL)	Obtained by subtraction of VL, L and LL from TOC

2.3.2 Total Organic Carbon (TOC): Since access to TOC analyzer was not possible, the TOC was calculated by the formula given by [14].

$$\log_{10}(TOC) = 0.725\times\log_{10}(WBC) + 0.198\times\log_{10}(SICL) - 0.0759\times\log_{10}(MAR) + 0.015$$

Where TOC is total soil organic C (%), WBC is the uncorrected Walkley and Black carbon (%) determined by wet digestion,SICL is the silt + clay content (%) and MAR is the main annual rainfall (mm) of the region.

2.3.3 Active and Passive Pools of Soil Organic Carbon

The very labile and labile pool may be summed up and it may be designated as active pool. Similarly, less labile and non-labile pool may be summed up and designated as passive pool

2.4 STATISTICAL ANALYSES

The data collected was statistically analyzed using SPSS statistical package version 18.0.All the soil parameters were analyzed by two-way ANOVA.The Duncan's multiple range test was used to segregate the significance of difference among the mean values obtained for soil parameters, in each land use pattern at *P*=0.05 which were considered to be statistically significant at 5% level of significance.

3. RESULTS AND DISCUSSION

The data on salient soil characteristics viz; bulk density, pH, EC, organic carbon and organic carbon stock are presented in (Table 2). The soil samples in general were sandy loam to sandy clay loam in texture with clay percent ranging from 35.96 to 40.28 %.

Bulk density (Mg m^{-3})

The data pertaining to soil bulk density is presented in (Table 2).The values on an average, indicated that 200% cropping intensity (rice-rice) recorded the highest bulk density (1.45 Mg m^{-3}) followed by 100% cropping intensity (1.41 Mg m^{-3}),fallow land (1.39 Mg m^{-3}) and forest land recorded the lowest bulk density (1.33 Mg m^{-3}).The interaction effect between depth and land use pattern for soil bulk density was significant. Across the depth at 15- 30cm the highest BD was obtained by 200% cropping intensity (1.48 Mg m^{-3}) this was followed by 100% cropping intensity (1.44 Mg m^{-3}),fallow land (1.42 Mg m^{-3}) and the lowest were recorded under forest land use (1.36 Mg m^{-3}). It was found that there was an increase in bulk density from 0- 15cm (1.37 Mg m^{-3}) to 15-30cm (1.43 Mg m^{-3}).The increase in bulk density with increase in depth in all the land use system may be attributed to lower organic matter content and soil compaction from the pressure of upper soil layer [15].

Soil pH and EC

The soil pH under different land use pattern on an average, indicated that the soils under forest land (Table 2) recorded the lowest soil pH (6.68) this was followed by fallow land (7.43), 100% cropping intensity (redgram-fallow) (7.59) and the highest was recorded in 200% cropping intensity (rice-rice) (7.72). Among the depths there was increase in soil pH from (7.27) to (7.43).Interaction effect between soil pH and land use pattern was significant with forest soils recording the lowest soil pH (6.56) followed by fallow land (7.38), 100% cropping intensity (7.50), 200% cropping intensity (7.64) at 0-15cm.At 15-30cm soil depth the pH of the soil increased and same trend was followed among all the land use pattern.

The highest soil electrical conductivity was recorded under 200% cropping intensity (ricerice) (0.28d Sm^{-1}) this was followed by 100% cropping intensity (redgram-fallow) cropping pattern (0.25 dSm^{-1}), fallow land (0.23 dSm-1) and the lowest was recorded under forest land use (0.18 dSm^{-1}).With increase in soil depth the EC of the soil decreased in all the land use pattern. The interaction between depths and land use pattern for soil EC was significant with highest EC being recorded by 200% cropping intensity (rice-rice)(0.30 dSm^{-1}) at 0-15 depth. A close perusal of the data on soil pH and EC indicates that the soils sites having lower pH shows lower EC values especially in forest and fallow lands. Similar results were obtained by [16] and [17].An increase in total soluble salt content has been reflected by an increase in EC under cultivated soils this could be due to the addition of fertilizers and other amendments.

Soil organic carbon (g kg^{-1})

The data pertaining to soil organic carbon is presented in (Table 2).Irrespective of soil depth on an average, the highest soil organic carbon content was recorded under forest land (7.05 g kg^{-1}) which was followed by 200% cropping intensity (rice-rice) (4.14 g kg^{-1}),100% cropping intensity (redgram-fallow)(3.42 g kg^{-1}) and lowest was seen in fallow land (2.68 g kg^{-1}).However with increase in depth the mean organic carbon decreased from (4.72 gkg^{-1}) to (3.87gkg^{-1}).Interaction effect between soil depth and land use pattern was significant and it varied from (7.30 g kg^{-1}) in forest soils at 0-15cm to (2.24 g kg^{-1}) in fallow land at 15-30cm. Higher amount of organic carbon under forest land could be attributed to leaf litter decomposition at the surface. It was observed that about 60-80% total carbon resources are in oxidisable form due to the presence of higher amount of soluble extractives like fat, waxes and alcohol soluble extractives in forest residues [18].Among the cropping systems, 200% cropping intensity (rice-rice) has shown significantly higher SOC. This might be due to continuous submergence of soils for 8-9 months in an year under rice-rice cropping system, prolonged water logging conditions may reduced the decomposing of added crop residues [11].However the lower values of SOC under fallow lands could be attributed to the very low amount of addition of residues in the form of leaf litter to the soil though the soil was not disturbed for longer period of time.

Soil organic carbon stock (Mg C ha^{-1})

The values of soil organic carbon stock determined for different land use patterns are presented in (Table.2) and depicted in (Fig.1).The soil organic carbon stock varied across the land use patterns and soil depth. Among the land use patterns compared on an average, the highest soil organic carbon stock was recorded in forest land (13.92 Mg ha^{-1}) which was followed by 200% cropping intensity (9.00 Mg ha^{-1}),100% cropping intensity (7.28 Mg ha^{-1}) and lowest was seen in fallow land (5.64 Mg ha^{-1}).Soil organic carbon stock recorded a significant decrease in soil along the depth at lower layers from (9.68 Mg ha^{-1}) to (8.24 Mg ha^{-1}).While considering the land use patterns across the depth the interaction effect for soil organic carbon stock was significant and the forest land use recorded the highest mean (14.33 Mg ha^{-1})which was followed by 200% cropping intensity (9.71 Mg ha^{-1}) and lowest was recorded in fallow land (6.51 Mg ha^{-1}) at 0-15cm. At 15-30 cm soil depth the same trend was followed with the highest SOCS being recorded in forest land (13.50 Mg ha^{-1}),200% cropping intensity (8.29 Mg ha^{-1}),100% cropping intensity (6.39 Mg ha^{-1}) and lowest was recorded in fallow land (4.77 Mg ha^{-1}).

Among the land use patterns the highest SOCS in the forest could be related to the presence of complete land cover generating more litter fall which are returned to the soil as organic matter.Hence there is a possibility that forest land use system can be considered as a stabilized system with very little disturbance.The lower content of soil organic carbon stock under 100% cropping intensity could be mainly due to no organic manure application, fallow without adequate crop residues cover after completion of crop cycle combined with poor soil structure [19].The lowest values were obtained for soil organic carbon stock under fallow land could be due to the lack of shade under fallow land which facilitates the loss of carbon from soil [20].The higher soil organic carbon stock in the surface layer could be due to the addition of cropping system organic matter, more root biomass and root exudates.The difference between surface and sub surface stock which is higher in forest land followed by 200% cropping intensity,100% cropping intensity and lowest in fallow land could be due to the addition of fresh organic matter through leaf fall in forest soils and addition of FYM in cropping system in the surface horizons.

Among the cropping system 200% cropping intensity (rice - rice) recorded highest SOC stock which can be attributed to anerobiosis and the associated chemical and biochemical changes that take place in the submerged soils following the prolonged flooding under water. Further the decomposition of organic matter in the absence of oxygen is slow, incomplete and inefficient while under aerobic condition oxygen acts as electron acceptor hastening the decomposition process.In addition in submerged soils the formation of recalcitrant complexes with organic matter renders them less available for microbial attack.It was also noticed that higher productivity of wetlands and decreased humification of soil organic matter lead to the net accumulation of organic matter in wet lands soil.

Table 2. Effect of land use patterns on soil characteristics and soil organic carbon stock in Red soils of Vikarabad district

Depth	**Bulk density (Mg m^{-3})**	**pH**	**EC (dSm^{-1})**	**Organic carbon (g kg^{-1})**	**Soil organic carbon stock (Mg C ha^{-1})**
D_1 (0-15cm)	1.37^{A}	7.27^{B}	0.25^{A}	4.72^{A}	9.68^{A}
D_2 (15-30cm)	1.43^{B}	7.43^{A}	0.23^{B}	3.87^{B}	8.24^{B}
Land use pattern					
L_1:100% cropping intensity (redgram-fallow)	1.41^{b}	7.59^{b}	0.25^{ab}	3.42^{c}	7.28^{c}
L_2:200% cropping intensity (rice-rice)	1.45^{a}	7.72^{a}	0.28^{a}	4.14^{b}	9.00^{b}
L_3:Forest land	1.33^{d}	6.68^{d}	0.18^{b}	7.05^{a}	13.92^{a}
L_4:Fallow land	1.39^{c}	7.43^{c}	0.23^{c}	2.68^{d}	5.64^{d}
Interaction					
D_1L_1	1.39±0.01^{d}	7.50± 0.05^{c}	0.27± 0.04^{ab}	3.90± 0.21^{d}	8.16 ± 0.53^{d}
D_1L_2	1.43± 0.02^{bc}	7.64±0.07^{b}	0.30± 0.03^{a}	4.54± 0.18^{c}	9.71 ± 0.38^{c}
D_1L_3	1.30± 0.02^{f}	6.56± 0.09^{f}	0.19± 0.01^{de}	7.30± 0.14^{a}	14.33 ± 0.44^{a}
D_1L_4	1.36± 0.01^{e}	7.38±0.09^{d}	0.25± 0.02^{bc}	3.12± 0.16^{e}	6.51 ± 0.40^{e}
D_2L_1	1.44± 0.01^{b}	7.66±0.04^{b}	0.24± 0.04^{bc}	2.94± 0.26^{e}	6.39 ± 0.63^{e}
D_2L_2	1.48 ± 0.02^{a}	7.79±0.05^{a}	0.26± 0.03^{ab}	3.73 ± 0.24^{d}	8.29 ± 0.47^{d}
D_2L_3	1.36± 0.03^{ef}	6.80±0.06^{e}	0.17±0.01^{e}	6.80± 0.15^{b}	13.50 ± 0.36^{b}
D_2L_4	1.42 ± 0.01^{b}	7.48±0.03^{c}	0.22±0.02^{cd}	2.24 ± 0.16^{f}	4.77 ± 0.32^{f}

Mean values with different lower case superscript letters indicate significant difference between land use patterns for each soil depth and all land uses. Uppercase superscript letters indicate significant difference between depths for all land use system respectively at (P=0.05),± indicates standard deviation of mean

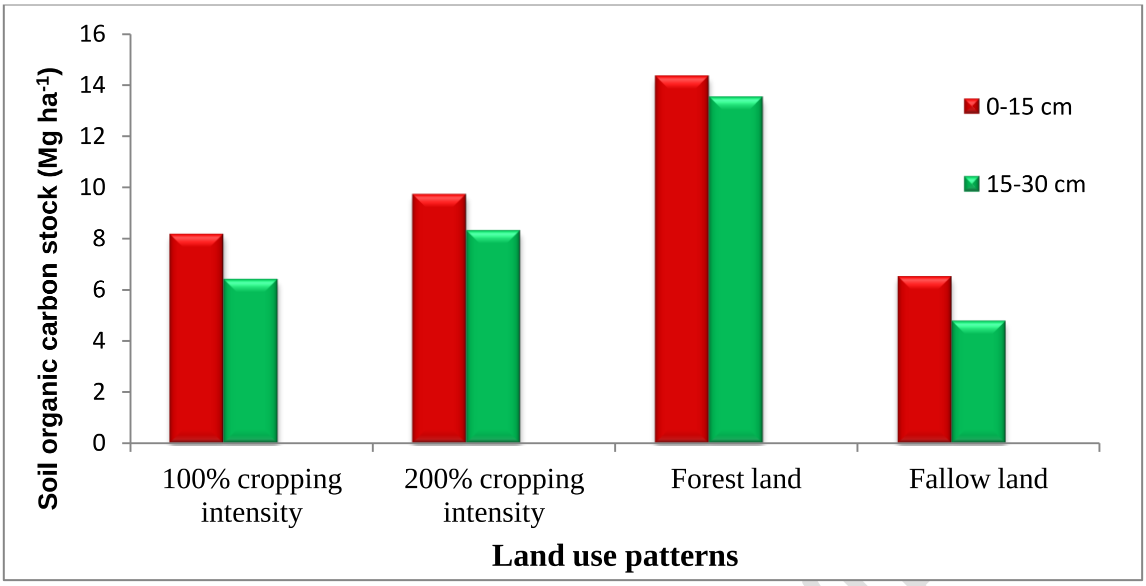

Fig 1. Soil organic carbon stock (Mg C ha^{-1}) at two soil depths under different land use patterns in red soils

Active and Passive Soil Organic Carbon Pools

Very labile (VL) carbon pools varied across the land use patterns and soil depth and is present in (Table 3).It varied significantly among the land use patterns and soil depths.Among land use patterns compared on an average, the forest land recorded the highest content of very labile carbon (9.05 Mg ha^{-1}) which was followed by 200% cropping intensity (4.95Mg ha^{-1}),100% cropping intensity (3.80 Mg ha^{-1}) and the lowest was observed in fallow land irrespective of depths (2.40 Mg ha^{-1}).

A decrease in the content of this pool of SOC was noticed between 0-15 to 15-30 cm depth in all the land use patterns from (5.05 Mg ha^{-1}) to (4.50 Mg ha^{-1}). Interaction effect between depth and land use patterns was significant and among the land use patterns highest was recorded in forest land at 0-15cm (9.60 Mg ha^{-1}) and lowest VL pool of carbon was recorded in fallow land at 15-30cm soil depth (1.80 Mg ha^{-1}).The decrease in very labile pools of soil carbon can be attributed to the lack of carbon supply from the top layers. Similar results were obtained by [20].[21] reported higher content of very labile pool under forest land suggesting higher input of organic matter through plant residues. This increase is mainly related to free light fraction of soil organic carbon. Further the higher levels of very labile pool in forest land can be attributed to no turning of soil and constant supply of plant residues [22] and [4].In addition the higher amounts of very labile fraction which is sensitive to management practices [23] depends on largely the amount of organic residue added to the [10] and [13].This explains the reason for higher amounts of accumulation of very labile pool in surface layer as compared to subsurface layer. Percent contribution of VL pool to that of TOC (Fig2) was found to be highest in forest land (34.53 %) followed by 100% cropping intensity (28.75 %), 200% cropping intensity (26.97%) and lowest was recorded in fallow land (25.88 %).

Labile pools of soil carbon under different land use patterns are presented in (Table 3).The amount of labile pool of SOC significantly varied among the land use patterns. On an average, its amount was highest in forest land (5.25 Mg ha^{-1}) followed by 200% cropping intensity (3.70 Mg ha^{-1})

and 100% cropping intensity (3.22Mg ha^{-1}) both were onpar with each other and lowest was recorded in fallow land (1.77Mg ha^{-1}).There were variations in the content of these pools of SOC along depth under different land forms. Decreasing trend in the content of labile pool of SOC with increasing depth was seen in all land use patterns from (3.48 Mg ha^{-1}) to (3.08 Mg ha^{-1}). Interaction effect between depth and land use pattern was significant with forest land recording the highest labile pool at 0-15cm (5.76 Mg ha^{-1}) and lowest was recorded by fallow land at 15-30cm soil depth (1.44 Mg ha^{-1}).

Percent contribution of labile pool to that of TOC (Fig.2) was found highest in 100% cropping intensity (24.40%) followed by 200% cropping intensity (20.16%),forest land (22.67 %) and lowest was recorded fallow land (19.09%). Less labile pool of carbon under different land use patterns are presented in (Table 2).It varied significantly among the land use patterns and depth. Among the land use patterns on an average, fallow land recorded the lowest less labile pool (2.20 Mg ha^{-1}) which was onpar with 100% cropping intensity (2.46 Mg ha^{-1}) followed by 200% cropping intensity (3.30 Mg ha^{-1}) and highest was recorded in forest land (3.50 Mg ha^{-1}).Whereas when the percent contribution of less labile pool to that of TOC was calculated (Fig.2) it was found that less labile pool percent was found highest in fallow land (23.73%)followed by 100% cropping intensity(18.61%),200% cropping intensity (17.98 %) and lowest was recorded under forest land (13.35%).

The less labile carbon pools decreased with increase in soil depth.The clay content of soil could affect the changes and stabilization of carbon pools. Due to natural and undisturbed conditions in forest land and in absence of tillage practices might have contributed to higher amount of less labile carbon.On the other hand lower values of less labile pool under the agriculture land use system could be attributed to lesser accumulation of organic carbon in conventional agricultural systems involving ploughing and other intercultural operations [24].Similar results of less labile pools were also reported by [25] and [26]..

The higher amount of less labile pool of carbon in 200% cropping intensity could be attributed to retarded rate of carbon oxidation in the soil that are flooded for almost 3 to $3_{1/2}$ years during rainy season [27].This must have resulted in slower decomposition of carbon substances in soil as compared to upland conditions and the molecules like lignins, waxes may gradually accumulate in soil contributing to less labile pool.Further slower decomposition of submerged soils as compared to uplands soils lead to incorporation of phenolic substances in the soils organic matter fractions making them recalcitrant to decomposition [28].Similar results were also reported by [29].

Land use patterns have significantly influenced the non labile pool of SOC and are presented in (Table.3).On an average, its amount was highest with forest land (8.40 Mg ha^{-1}) followed by 200% cropping intensity (6.40 Mg ha^{-1}), 100% cropping intensity (3.73 Mg ha^{-1}) and lowest was recorded in fallow land (2.90 Mg ha^{-1}). With increase in depth the non labile pool on an average decreased from (5.35 Mg ha^{-1}) to (5.25 Mg ha^{-1}).Interaction effect between depth and land use patterns was significant and forest land recorded the highest non labile pool at both the soil depths.

Percent contribution of non labile pool of SOC to TOC (Fig.2) under different land use forms was opposite to that of very labile and labile pools, the trend was followed as 200% cropping intensity (34.87%) followed by forest land (32.05 %),fallow land (31.28%)and lowest was recorded under 100% cropping intensity (28.22%).With increase in depth of soil the non labile pool of soil carbon decreased in all the land use patterns expect 200% cropping intensity in which it showed an increase. Higher values of non labile pool under 200% cropping intensity can be attributed to fairly stable and more recalcitrant carbon content in soil which increases with increase in soil depth. As almost 7-8 months the soil remains under submergence and this prolonged submergence might retard the oxidation and enhance the contribution of recalcitrant carbon to soil organic carbon.[30] also reported higher proportions of passive non labile pool in forest and it could be due to high input of plant litter in forest as compared to other land use patterns. They suggested that organic carbon in forest soils is more stable than the other land use type studied. The results of the present study indicate appropriate management practices are needed to prevent the losses of soil organic carbon through decomposition in land use patterns further the land use system affect both active and passive carbon pools. Our results are in accordance with findings of [31].

The amount of different pools of SOC at surface soil was as follows: very labile pool followed by non labile pool, labile pool and less labile pool constituting about 27.77%, 29.46%, 19.18% and 15.57% of the TOC, respectively. At 15-30cm depth, the amount of different pools of SOC followed the trend as follows: non labile followed by very labile, labile, less labile pool constituting about 34.25%,29.33%, 20.11% and 16.29 % of the TOC respectively.

Total organic carbon

Total organic carbon (TOC) content ranged from 7.64 to 27.86 Mg ha^{-1} under different land use patterns and depths (Table.3).On an average, the forest land had maintained significantly higher amount of mean TOC (26.15 Mg ha^{-1}) followed by 200% cropping intensity (18.35 Mg ha^{-1}),100% cropping intensity (13.21 Mg ha^{-1}) and lowest was recorded under fallow land (9.27 Mg ha^{-1}).With increase soil depth the total organic carbon decreased from (18.18 Mg ha^{-1}) to (15.31 Mg ha^{-1}). Interaction effect between depth and land use pattern for TOC was significant with forest soils recording the highest TOC at 0-15cm (27.86 Mg ha^{-1}) and lowest was recorded at 15-30cm by fallow land (7.64 Mg ha^{-1}).

In our study TOC content varied across different land use patterns and forest land had the highest TOC concentration. Total organic carbon content build up under any land use type is the balance between C inputs (litter fall deposits, crop residues, root exudates, root biomass and manure) and C losses (respiration by soil organisms) determined by the residue turnover, their quality and decomposition rate. A near-equilibrium between C inputs and C losses was found in undisturbed ecosystems. Higher SOC content in forest land use types in our present study could be due to high level of inputs (leaf litter and root biomass) from the forest trees and its recalcitrant nature thus preventing microbial decomposition which in turn increased the TOC content in soil [29].

Table 3. Effect of land use patterns on soil carbon pools (Mg ha^{-1}) in red soils of Vikarabad district

	Very labile (Mg ha^{-1})	Labile (Mg ha^{-1})	Lesslabile (Mg ha^{-1})	Nonlabile (Mg ha^{-1})	Active pool (Mg ha^{-1})	Passive pool (Mg ha^{-1})	TOC (Mg ha^{-1})
Depth							
D_1 (0-15cm)	5.05^{A}	3.48^{A}	2.85^{A}	5.35^{A}	9.49^{A}	8.69^{A}	18.18^{A}
D_2 (15-30cm)	4.50^{B}	3.08^{B}	2.47^{B}	5.25^{B}	7.58^{B}	7.73^{B}	15.31^{B}
Land use patterns							
L_1: 100% cropping intensity (redgram-fallow)	3.80^{b}	3.22^{b}	2.46^{c}	3.73^{c}	7.02^{c}	6.19^{bc}	13.21^{c}
L_2:200% cropping intensity (rice-rice)	4.95^{c}	3.70^{b}	3.30^{b}	6.40^{b}	8.65^{b}	9.70^{b}	18.35^{b}
L_3:Forest land	9.05^{a}	5.25^{a}	3.50^{a}	8.40^{a}	14.30^{a}	11.85^{a}	26.15^{a}
L_4:Fallow land	2.40^{d}	1.77^{c}	2.20^{c}	2.90^{d}	4.17^{d}	5.10^{d}	9.27^{d}
Interaction							
D_1L_1	4.50 ± 0.32^{d}	3.70 ± 0.16^{cd}	2.82 ± 0.18^{c}	4.04 ± 0.29^{d}	8.20 ± 0.43^{d}	6.86 ± 1.51^{d}	15.06 ± 1.75^{e}
D_1L_2	5.30 ± 0.35^{c}	4.00 ± 0.32^{c}	3.06 ± 0.17^{b}	6.00 ± 0.35^{c}	9.30 ± 0.59^{c}	9.60 ± 0.47^{c}	18.90 ± 0.40^{c}
D_1L_3	9.60 ± 0.19^{a}	5.76 ± 0.36^{a}	3.90 ± 0.20^{a}	8.60 ± 0.69^{a}	15.36 ± 0.49^{a}	12.50 ± 0.43^{a}	27.86 ± 0.49^{a}
D_1L_4	3.00 ± 0.49^{e}	2.10 ± 0.20^{f}	2.60 ± 0.30^{cd}	3.20 ± 0.30^{de}	5.10 ± 0.50^{f}	5.80 ± 0.52^{e}	10.90 ± 0.82^{g}
D_2L_1	3.10 ± 0.37^{e}	2.75 ± 0.29^{e}	2.10 ± 0.33^{d}	3.42 ± 0.22^{de}	5.85 ± 0.45^{e}	5.52 ± 0.46^{e}	11.37 ± 0.81^{f}
D_2L_2	4.60 ± 0.31^{d}	3.40 ± 0.26^{d}	3.00 ± 0.21^{b}	6.80 ± 0.41^{b}	8.00 ± 0.35^{d}	9.80 ± 0.39^{c}	17.80 ± 0.49^{d}
D_2L_3	8.50 ± 0.18^{b}	4.75 ± 0.26^{b}	3.10 ± 0.23^{b}	8.20 ± 0.80^{a}	13.25 ± 0.39^{b}	11.20 ± 0.65^{b}	24.55 ± 0.62^{b}
D_2L_4	1.80 ± 0.36^{f}	1.44 ± 0.20^{g}	1.80 ± 0.27^{e}	2.60 ± 0.26^{f}	3.24 ± 0.35^{g}	4.40 ± 0.61^{f}	7.64 ± 0.60^{h}

Mean values with different lower case superscript letters indicate significant difference between land use patterns for each soil depth and all land uses. Uppercase superscript letters indicate significant difference between depths for all land use system respectively at ($P<0.05$).± indicates standard deviation of mean.

The content of active pool of SOC on an average (Table 3) was significantly higher under forest land (14.30 Mg ha^{-1}) which was followed by 200% cropping intensity (8.65 Mg ha^{-1}),100% cropping intensity (7.02 Mg ha^{-1}) and lowest was recorded in fallow land (4.17 Mg ha^{-1}).Interaction effect between land use patterns and soil depth for active pool was significant. With increase in depth active pool (AP) of soil organic carbon declined in all the land use patterns from (9.49 Mg ha^{-1}) to (7.58 Mg ha^{-1}). Interaction effect between depth and land use pattern was significant with forest soils having the highest active carbon pool at 0-15cm (12.50 Mg ha^{-1}).

The percent contribution of AP to TOC (Fig.3) was found highest in forest land (60.00%) followed by 100% cropping intensity (53.15 %),200% cropping intensity cropping (47.13%) and lowest in fallow land (44.98%).

Passive pool (PP) of SOC was also significantly influenced by land use patterns and is presented in (Table 3).On an average, the content of passive pool of SOC was significantly higher under forest land (11.85 Mg ha^{-1}) which was followed by 200% cropping intensity (9.70 Mg ha^{-1}),100% cropping intensity (6.19 Mg ha^{-1}),fallow land (5.10 Mg ha^{-1}).With increase in depth on an average passive carbon pools decreased from (8.69 Mg ha^{-1}) at 0-15cm to (7.73 Mg ha^{-1}) at 15-30cm soil depth. The percent contribution of passive pool to TOC (Fig.3) followed different trend where, fallow land contributed the highest percent (55.01%) which was followed by 200% cropping intensity (52.86%),forest land (41.00%) and lowest was reported by 100% cropping intensity (46.84%).The interaction effect between land use patterns and depth was significant with active and passive carbon pool decreasing with soil depth in all the land use patterns except in 200% cropping intensity where passive carbon pool increased with increase in depth of soil from 0-15 to15-30cm.

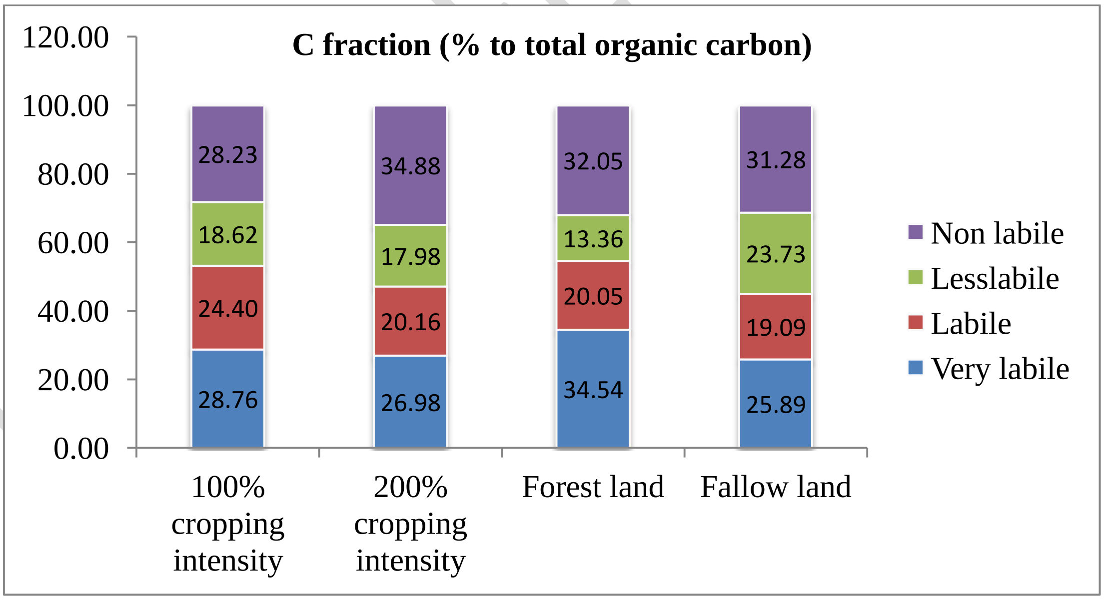

Fig 2. Percent contribution of various pools of carbon of varying labillity (0-30cm) towards total organic carbon (TOC) in different land use patterns

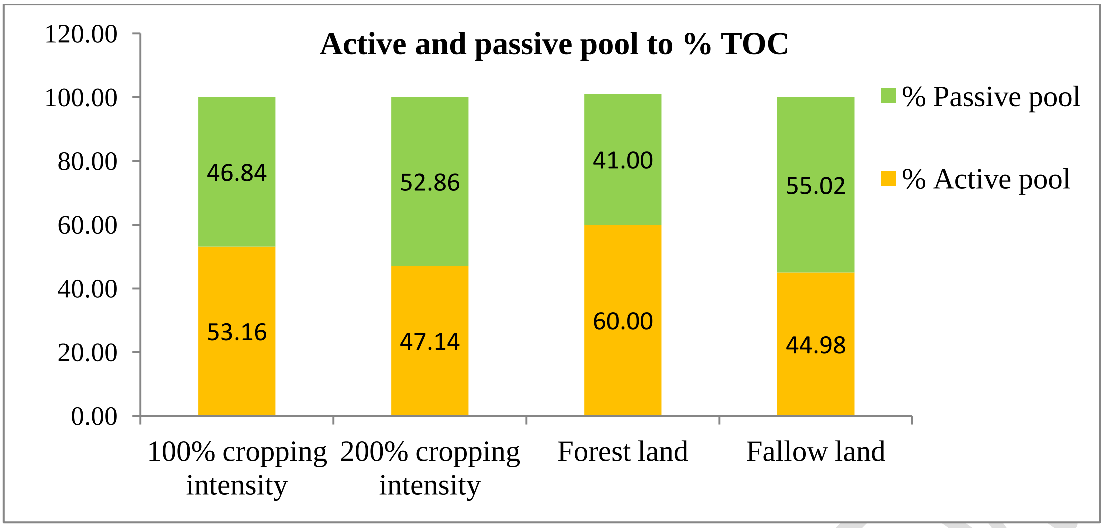

Fig 3. Distribution of active and passive pools up to 0-30cm depth (as % of TOC) under different land usepatters.

4. CONCLUSIONS

Within the 0–30 cm soil profile, TOC content and SOC stocks were higher in forest land than the other land use patterns indicating the depletion of TOC with land use changes.The majority of soil organic carbon of forest land and 100% cropping intensity (redgram-fallow) was in an easily oxidisable active form, suggesting that the accumulated carbon could be easily lost following the land use change. Conversely, preponderance of passive carbon pools in fallow land and 200% cropping intensity (rice-rice system) indicated more stable nature of the accumulated soil organic carbon.The data acquired revealed that the applied soil management regimes had significant effects of varying magnitude on TOC and its fractions.Thus, size and distribution of active and passive carbon pools can be used as indicators for change in soil quality.

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