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Short Communication

# Spatial Distribution of Soil Organic Carbon under Agroforestry and Traditional Cropping System in Hyper Arid Zone of Rajasthan

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Traditionally, the farmers of arid region are growing sole crops of moth bean and clusterbean under rainfed conditions. Sole cropping under traditional cropping system (TCS) is successful once in three years. Even in good cropping season, the land utilization does not exceed four months in a year. This practice of cultivation exposes the soil to extremes of climates such as high temperature and high wind velocity, which results in lowering of the soil fertility and land productivity levels. On these marginal soils, silvopasture/agroforestry systems not only contribute in preventing land degradation, but helps in improvement of soil fertility also. This improvement is considered in terms of organic C and other soil quality parameters. The soil organic carbon (SOC) is of critical importance as it increases infiltration rate, the ability of soil to store nutrients and the ease with which the roots can penetrate soil (Breman and Kressler, 1997). Hence a comparative study was undertaken to evaluate the status of SOC under agroforestry and TCS.

The study was carried out at the research farm of Central Arid Zone Research Institute, Regional Research Station located at Bikaner in northwestern Rajasthan. The region has an average annual rainfall of 247 mm with 40-60% coefficient of variation. Mean monthly air temperature ranges from 7.1°C (minimum temperature) and 23.7°C (maximum temperature) in January to a high of 29.3°C (minimum temperature) and 42.9°C (maximum temperature) in May. The soil of the experimental site was loamy sand in texture (85.7% sand, 10.8% silt and 3.8% clay) with 1.5 g $m^{-3}$ bulk density. Eighteen-year-old plantations of five tree species of arid zone viz., *Daschrystus nutan*, *Colophospermum mopane*, *Acacia nilotica*, *A. senegal* and *Prosopis juliflora* were planted in rows at a distance of 5 x 6 m. The inter row spacing of each tree species was tilled for the sowing of rainfed crops moth bean (*Vigna aconotifolia*) and clusterbean (*Cyamopsis tetragonoloba*) for the last three years while the intra row spacing was not tilled. Representative soil samples in three replications were collected from four different depths (0-5, 5-10, 10-15 and 15-30 cm) at three lateral distances (0.5, 1.0 and 1.5 m) from the tree trunk within the rows and between the rows to compare the organic carbon under cultivated and uncultivated soils. Replicated soil samples from same depth (0-5, 5-10, 10-15 and 15-30 cm) were also collected from surrounding fields, which were under cultivation of sole crops of moth bean and clusterbean under TCS. There were three sampling point's viz. (i) TCS, (ii) Agroforestry System (AFS) within rows and (iii) AFS between rows. The samples were air dried, passed through 2 mm sieve and analyzed for pH in 1:2 soil water suspension (Richards, 1954), organic-C and textural properties (Jackson, 1967).

The SOC was more under all the tree plantations as compared to TCS (Table 1). It was highest in surface layer and decreased gradually with depth. Keeping TCS as base, maximum increase in SOC was observed below *A. tortilis* and minimum under *D. nutan* at 0-5 cm soil depth at each lateral distance. The SOC under AFS was in the order *A. tortilis* followed by *A. senegal*, *C. mopane*, *P. juliflora* and *D. nutan*. The variation in SOC under different tree species was ascribed due to the variations in tree growth, litter fall and canopy size (Hosur

*Table 1. Depth wise and lateral distribution of SOC (g kg$^{-1}$) within rows and between rows under alternate land use systems with different tree components. Values are means ± 1 S.E.*

| Lateral spacing (cm) | Depth (cm) | *Daschrystus nutan* | *Colophospermum mopane* | *Acacia senegal* | *Acacia tortilis* | *Prosopis juliflora* |
|---|---|---|---|---|---|---|
| Within rows | | | | | | |
| 0-50 | 0-5 | 1.4±0.10 | 3.3±0.18 | 3.8±0.20 | 3.9±0.09 | 3.0±0.12 |
| | 5-10 | 1.4±0.05 | 1.7±0.06 | 1.7±0.06 | 3.0±0.12 | 1.2±0.06 |
| | 10-15 | 1.2±0.06 | 0.9±0.06 | 1.8±0.03 | 1.1±0.03 | 0.5±0.03 |
| | 15-30 | 1.2±0.09 | 0.9±0.03 | 1.1±0.09 | 0.9±0.03 | 0.6±0.06 |
| 50-100 | 0-5 | 1.3±0.09 | 1.9±0.06 | 3.3±0.11 | 3.8±0.12 | 2.3±0.11 |
| | 5-10 | 1.1±0.06 | 1.1±0.06 | 2.4±0.12 | 3.0±0.12 | 1.1±0.07 |
| | 10-15 | 1.0±0.06 | 0.9±0.03 | 1.3±0.07 | 0.6±0.09 | 0.6±0.09 |
| | 15-30 | 1.0±0.06 | 0.8±0.03 | 0.8±0.03 | 0.6±0.06 | 0.6±0.09 |
| Between rows | | | | | | |
| 0-50 | 0-5 | 1.4±0.07 | 2.7±0.09 | 3.2±0.15 | 3.4±0.12 | 2.9±0.07 |
| | 5-10 | 1.4±0.06 | 1.3±0.13 | 1.6±0.09 | 2.3±0.06 | 1.1±0.07 |
| | 10-15 | 1.3±0.09 | 1.1±0.09 | 0.8±0.03 | 1.0±0.09 | 0.6±0.03 |
| | 15-30 | 0.7±0.09 | 0.6±0.06 | 0.8±0.03 | 0.9±0.09 | 0.5±0.03 |
| 50-100 | 0-5 | 1.0±0.09 | 1.7±0.09 | 1.3±0.15 | 1.7±0.09 | 2.3±0.10 |
| | 5-10 | 0.9±0.07 | 1.1±0.06 | 1.1±0.09 | 1.4±0.09 | 1.1±0.09 |
| | 10-15 | 0.6±0.03 | 0.9±0.07 | 1.1±0.09 | 0.7±0.06 | 1.0±0.03 |
| | 15-30 | 0.6±0.03 | 0.9±0.07 | 0.8±0.03 | 0.7±0.06 | 0.8±0.06 |
| 100-150 | 0-5 | 0.9±0.07 | 1.8±0.10 | 1.3±0.12 | 1.7±0.09 | 1.8±0.09 |
| | 5-10 | 0.9±0.07 | 1.2±0.09 | 1.3±0.06 | 2.0±0.07 | 1.1±0.09 |
| | 10-15 | 0.6±0.09 | 1.1±0.07 | 0.9±0.03 | 1.7±0.03 | 0.8±0.03 |
| | 15-30 | 0.6±0.06 | 0.9±0.07 | 0.9±0.09 | 0.6±0.03 | 0.9±0.06 |

*Table 2. Mean values of SOC (g kg$^{-1}$) at different depths and lateral distances under TCS and AFS. Values are means±1 SE*

| | TCS | AFS (within rows) | AFS (between rows) |
|---|---|---|---|
| Depth (cm) | | | |
| 5 | 0.90±0.10 | 2.70±0.12 | 2.00±0.20 |
| 10 | 0.60±0.06 | 1.70±0.10 | 1.30±0.18 |
| 15 | 0.60±0.09 | 0.90±0.06 | 0.70±0.06 |
| Lateral distances (cm) | | | |
| 50 | 0.70±0.09 | 1.80±0.15 | 1.50±0.15 |
| 100 | 0.70±0.09 | 1.40±0.10 | 1.10±0.06 |
| 150 | 0.7±0.09 | 1.40±0.10 | 1.20±0.06 |

and Dasog, 1995). In the present study, *D. nutan* recorded minimum plant height (201.0±14.6 cm) and diameter at breast height (23.2±1.1 cm) as compared to other tree species viz. *C. mopane, A. senegal, A. tortilis* and *P. juliflora* with plant height 431.4±42.8, 372.4±21.6, 453.0±10.1, 433.4±44.8 cm and diameter at breast height 49.4±6.3, 39.6±3.5, 62.2±8.2 and 63.2±4.0 cm, respectively.

It is interesting to note that the build up of SOC by different tree species in present study was not exceeding 0.39% (maximum under *A. tortilis*). Contrary to our findings, the researchers like Singh *et al.* (1995) and Gupta *et al.* (1991) observed a maximum of 3.85 and 6.44% SOC, respectively, under the soils of 15 to 20-year-old plantations. The lower SOC build up in our study was due to harsh climatic conditions such as low rainfall and high temperature. Due to these unfavorable conditions, rapid loss of soil organic matter takes place and therefore build up of SOC is less in arid region. Our findings support the earlier results of Sharma and Gupta (1989) who reported a maximum of 0.34% SOC under silviculture system in arid zone. Beniwal (1999) also reported higher increase in SOC under semi-arid climate (2.5 to 4.2 g kg$^{-1}$) as compared to arid ecosystem (1.2 to 2.5 g kg$^{-1}$) under silvopasture system.

It is evident that SOC decreased with increasing soil depth in both TCS and AFS (Table 2). The values were significantly higher in AFS as compared to TCS at each depth because of increased incorporation and decomposition of leaf litter and root biomass particularly up to 10 cm soil depth. Improvement in SOC by tree plantation and its negative relation with soil depth was also observed by other workers (Gupta *et al.*, 1991). The low SOC under TCS was due to long fallow with no vegetation for most part of the year and tillage that increased the oxidation of SOC and decomposition. Kumar *et al.* (1994) have also reported similar findings.

Significantly higher SOC was recorded within the tree rows in upper soil layers of 0-5 and 5-10 cm soil depth. Below 10 cm soil depth, SOC in between the rows and within the rows were at par. Soil samples collected from representative depth within the rows show distribution of SOC under uncultivated state and therefore show higher accumulation of SOC in top layers as compared to samples collected from between the rows which was tilled for sowing the crops and represent a cultivated state in AFS. Thus it seems that cultivation for growing crops in between the rows lowers SOC.

Significantly higher SOC was observed at 50 cm lateral distance over 100 and 150 cm distances in AFS within and between the rows (Table 2). SOC at 100 and 150 cm distance was at par under both management practices (AFS within the rows and AFS between the rows). If we compare the effect of management practices within AFS systems, significantly higher SOC at 100 and 150 cm lateral distances was observed within the rows as compared to between the rows. No significant difference in SOC at 50 cm distance was observed within and between the rows as under natural conditions, equilibrium of nutrient cycle exists between soil and tree species in which most nutrients are stored in biomass and top soil. When this nutrient cycle is broken by lopping the trees in between the tree rows and ploughing the soil for cultivation, significant changes in soil properties take place due to organic matter decomposition and its loss in environment and limiting litter fall in between the rows which results in lowering the SOC at 100 and 150 cm lateral distances in between the rows as compared to within the rows. Moreover, root growth is also apparently checked under cultivated field (between the rows of AFS) as compared to uncultivated field (within the rows of AFS). At 50 cm lateral distance, virtually there was no soil manipulation under both AFS systems (i.e. AFS within the rows and AFS between the rows) and hence no significant variation in SOC was observed. Gupta *et al.* (1991) observed the variations in SOC under different management practices in alternate land use systems. They observed the lower SOC in cultivated forest area as compared to protected site. Sanchez (1976) observed the decreased annual addition of organic matter due to cultivation. Due to absence of tree component in traditional cropping system, no such lateral distances are marked and therefore the same values for SOC has been shown.

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