

## Effect of The Tree Growth on Accumulation Organic Carbon And Nutrients Dynamics in Soil Under Multipurpose Tree Systems



### Agriculture

**KEYWORDS :** soil organic carbon; nitrogen; phosphorus; potassium

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### ABSTRACT

*Many environmental benefits have been attributed to agroforestry system in various ecosystems around the world. However, there is a limited amount of information to evaluate organic carbon and nitrogen, phosphorus and potassium amount in the soil under multipurpose tree system in Andhra Pradesh. The results revealed that the soil organic carbon and nitrogen content were higher in Pongamia pinnata tree systems due to accumulation of plant residue, its decomposition, high N fixation rate, increased the availability of nutrients in the soil through mineralization. Among the multipurpose tree system the phosphorus content under Dalbergia sissoo showed significantly higher over other land use system. Due to high plant residue and efficient nutrient recycling capacity the available potassium content under Acacia nilotica systems was high at three depths compared to the other systems. The organic carbon and major nutrient content decreased with increased depth significantly due to highest build-up of different nutrients on surface layers than other layers.*

### Introduction

Increasing industrial growth, change in land use patterns increase atmospheric pressure, deforestation and rise in fossil fuel emission have increased carbon dioxide concentration in the atmosphere which has led to global warming. Trees offer a significant potential to sequester substantial quantity of atmospheric carbon. Thus forming an important option for carbon mitigation in climate. An Agroforestry system is one of the main sinks of carbon on earth in comparison to other land use system. Density of soil organic carbon is different ecosystems varies as low as 3.7 kg m<sup>-3</sup> in arid to 24.0 kg m<sup>-3</sup> in boreal region (Lal, 2001). The tree residues (leaf, twigs and dead plant parts) affect the organic matter and nutrient dynamics of soils by their decomposition in soils. The quality and quantity of tree residue produced depends on tree species, its genetic nature (deciduous or evergreen), age and its existed climatic conditions. The magnitude of total leaf and litter fall in different types of forest tree species of India ranged between 1585-17578 kg ha<sup>-1</sup> ya<sup>-1</sup> in plantations situated in different parts of country (Shanmughavel and Francis, 1998). The mean annual litter fall (kg<sup>-1</sup> ha<sup>-1</sup>) for tropical dry deciduous, tropical, dry evergreen and temperate moist deciduous forest are reported as 4.33, 7.52, 6.44 and 8.39 respectively (Dadhwal et al., 1993). Temperate moist deciduous forest registered high while tropical dry deciduous forest lowest litter fall. Generally higher soil organic carbon and nutrient content under the trees have been observed than the adjacent sites without trees (Sharma and Pande, 1989). Major multipurpose agroforestry systems including Acacia nilotica, Azadirachta indica, Dalbergia sissoo, Eucalyptus tetranicus, Albizia lebeck, Pongamia pinnata and Tectona grandis. However, information on the effect of these species on soil properties is lacking. Therefore the present study was conducted on concentration of organic carbon and macronutrient and their accumulation in the soil profile in ANGRAU campus.

### Materials and Methods

The present investigation was carried out in university campus Acharya N G Ranga Agricultural University, Hyderabad (Andhra

Pradesh) which is located altitude of 542.6 m above MSL and 17o19'N latitude. The climate is mainly characterized by a very hot summer, a short rainy season and a very cold winter, it is arid which high variation between summer and winter temperature. The mean monthly maximum temperature varies from 31.5°C to 33.3°C in January to June. Rain fall is primarily from south west monsoon and mean rain fall (>75%) of the total 788.2 mm per annually received during July to September. The soils of region are light in colour and most of the soils are Alfisols some pocket of vertisols have salinity associated with brackish ground water. An experiment having 10-30 years old Acacia nilotica, Azadirachta indica, Dalbergia sissoo, Eucalyptus tetranicus, Albizia lebeck, Pongamia pinnata and Tectona grandis spacing 4x4 m was selected. The depth wise (0-30, 30-60 and 60-90 cm) soil samples were taken from 1 m<sup>3</sup> pit from each replication under tree species as well as from adjacent open area without trees (control) sampling taken during December 2012. The soil samples were air dried, grounded in a wooden pestle with mortar passed through a 2 mm stainless steel sieve and stored for organic carbon (OC) and available macronutrients (NPK). The organic carbon by walkley and black's method (Jackson, 1967), available N in the soil samples was determined by alkaline permanganate method (Subbiah and Asjia, 1956), available P<sub>2</sub>O<sub>5</sub> by Olsen's method using colorimeter (Olsen et al., 1954) and available K<sub>2</sub>O by neutral ammonium acetate method using flame photometer (Jackson, 1967). The accumulation of organic carbon (mg ha<sup>-1</sup>) and available nutrients (kg ha<sup>-1</sup>) in different soil layers was calculated by multiplied their concentration values with the weight of soil depth in ha. The data of different species were subjected to statistical analysis using ANOVA technique in randomized block design by taking six replications of locations and treatment as tree species mean separation was done with the CD value of 5% significance (Panse and Shuhatme, 1985).

### Results and Discussion

Soil organic carbon concentration decreased with increased in soil depth under tree species as well as control. The interaction effect that is varied significantly among tree species and soil depth. The

effect of plant residue addition were higher in the surface layer (0-30 cm) than the lower soil depths. The organic carbon content were 0.57% under *Pongamia pinnata* followed by *Albergia lebbeck* (0.47%), whereas under *Tectona grandis* (0.30%) and *Acacia nilotica* (0.26%) over control. The soil organic carbon accumulation in 60-90 cm on soil profile under the tree species varied from 0.29 % under *Pongamia pinnata* to 0.25% under *Albergia lebbeck* and this content was significantly higher than organic carbon in control treatment 0.08% and showed less variation (Table 1). Out of this, >42% of profile organic carbon was present in the surface (0-30cm) and >21% in 30-60cm soil depth under different tree species, indicating >40% in upper soil layers in a span of 20 years. The regular plant residue accumulation on soil surface layer, its decomposition and incorporation into the soil might have led to higher buildup of organic carbon on surface layers of soils than the lower layers. Increase in organic carbon status under tree species with addition of organic matter through litter fall has been reported by Patel and Singh (2000). Lower build up in organic carbon status under *Azadiracta indica* than the other tree species may due to poor litter quality than others. In addition to that, *Azadiracta indica* has thick and leathery bark and high alkaloid Nimbin content, thus, its decomposition by fungal and other fauna delayed.

The available nitrogen content under *Pongamia pinnata* (251.30 kg ha<sup>-1</sup>) land use system showed significantly higher over others and on par with *Dalbergia sissoo* (227.43 kg ha<sup>-1</sup>). High N fixation rate, increased availability of nutrients in the soil through mineralization of *Pongamia* leaf and improved soil properties could have resulted high nitrogen content under *Pongamia pinnata* soils. Among the different species the content of nitrogen in *Acacia nilotica*, *Eucalyptus tetricornis*, *Albergia lebbeck*, *Tectona grandis* and *Azadiracta indica* varied from (175.34 to 191.10 kg ha<sup>-1</sup>) and significantly higher over fallow land (105.50 kg ha<sup>-1</sup>). The nitrogen content of soil under the different tree component land use systems was increased to medium to high N content due to the N fixation nature of plant species, plant residue, root activity, microbial mineralization it was supported by Basvavraj et al. (2010). The result showing that nitrogen content

variation at lower depths was low compare to top layers it was due to poor organic carbon and microbial activity of deeper soil layer and variation of fixation nature of plant species and fallow land showed poor nitrogen content at all three depths due to poor vegetation and high nitrogen losses from the soil it was supported by Heim and Frey (2004).

The available phosphorus content decreased with increasing the depth of soil under these land use systems among the plant species *Dalbergia sissoo* higher phosphorus content in three depth levels (Table 3). The P<sub>2</sub>O<sub>5</sub> content of the *Acacia nilotica*, *Azadiracta indica*, *Albergia lebbeck*, and *Pongamia pinnata* in the range of 15.1 to 16.1 kg ha<sup>-1</sup> and significantly on par with fallow land (15.5 kg ha<sup>-1</sup>) minimum P<sub>2</sub>O<sub>5</sub> was recorded under *Tectona grandis* (14.2 kg ha<sup>-1</sup>), *Eucalyptus tetranicus* (14.5 kg ha<sup>-1</sup>). Lower available P<sub>2</sub>O<sub>5</sub> content is attributed to phosphorus fixation by organic matter content, pH variation, mineralization of phosphoric nutrients under plant land use systems it was supported by Basvavraj et al. (2010).

The available Potassium (619.66 kg ha<sup>-1</sup>) content under *Acacia nilotica* land use systems was high at three depths. This might due to high k content in *Acacia* plant sps residue (1.1-1.6%), efficient nutrient recycling capacity and tapping of nutrients in deeper layers and accumulation at top layers increased k availability. Similar results were observed by Raddad et al. (2006) and Deans et al. (1999). Available Potassium content under *Azadiracta indica*, *Pongamia pinnata*, *Albergia lebbeck* land use systems showed variance from 521 to 550 kg ha<sup>-1</sup> and on par with *Acacia nilotica* soils. Among the land use systems lower k content observed in *Eucalyptus tetranicus*, *Dalbergia sissoo* and lowest Potassium content observed in *Tectona grandis* (Table 4). It was observed from the results that k content under all land use systems shows higher values over fallow land these results were in conformity with the findings of Nsabimana et al. (2008). Potassium content decreased with increased trend and Potassium content variation is significant at top layers and compare to lower depths.

**Table 1. Organic Carbon content (%) in multipurpose tree systems at different depths of different location in ANGRAU campus**

Depth (cm)	0-30cm						30-60cm						60-90cm					
	Locations						Locations						Locations					
	Student farm	College farm	ARI	Horti-culture college	Veteri-nary college	Mean	Student farm	College farm	ARI	Horti-culture college	Veteri-nary college	Mean	Student farm	College farm	ARI	Horti-culture college	Veteri-nary college	Mean
Multipurpose tree system																		
Fallow land	0.03	0.07	0.16	0.03	0.14	0.09	0.02	0.06	0.12	0.13	0.11	0.09	0.01	0.02	0.11	0.17	0.1	0.08
<i>Acacia nilotica</i>	0.28	0.21	0.25	0.26	0.28	0.26	0.19	0.17	0.18	0.21	0.23	0.20	0.14	0.15	0.13	0.19	0.17	0.16
<i>Azadiracta indica</i>	0.03	0.07	0.16	0.03	0.14	0.09	0.17	0.19	0.19	0.11	0.15	0.16	0.15	0.18	0.16	0.10	0.13	0.14
<i>Dalbergia sissoo</i>	0.22	0.25	0.19	0.18	0.18	0.20	0.24	0.26	0.23	0.21	0.28	0.24	0.18	0.16	0.17	0.19	0.16	0.17
<i>Eucalyptus tetranicus</i>	0.24	0.23	0.25	0.24	0.28	0.25	0.19	0.18	0.16	0.15	0.19	0.17	0.11	0.16	0.15	0.13	0.16	0.14
<i>Albergia lebbeck</i>	0.42	0.46	0.58	0.48	0.43	0.47	0.31	0.35	0.33	0.38	0.34	0.34	0.24	0.27	0.26	0.22	0.27	0.25
<i>Pongamia pinnata</i>	0.57	0.54	0.52	0.57	0.67	0.57	0.43	0.41	0.31	0.34	0.41	0.38	0.36	0.26	0.24	0.22	0.37	0.29
<i>Tectona grandis</i>	0.38	0.31	0.29	0.27	0.24	0.30	0.21	0.25	0.24	0.19	0.16	0.21	0.14	0.19	0.23	0.16	0.11	0.17
Mean	0.30	0.31	0.32	0.29	0.33	0.31	0.22	0.23	0.21	0.21	0.23	0.22	0.16	0.17	0.18	0.17	0.18	0.18
SEM ±	0.06						0.06						0.06					
CD(0.05)	15.89%						15.46%						25.23%					
CV%	0.03						0.07						0.16					

**Table 2. Available Nitrogen content (kg ha<sup>-1</sup>) in multipurpose tree systems at different depths of different location in ANGRAU Campus**

Depth (cm)	0-30cm						30-60cm						60-90cm					
	Student farm	College farm	ARI	Horti-culture college	Veteri-nary college	Mean	Student farm	College farm	ARI	Horti-culture college	Veteri-nary college	Mean	Student farm	College farm	ARI	Horti-culture college	Veteri-nary college	Mean
Multipurpose tree system																		
Fallow land	107.00	113.30	105.11	97.00	103.62	105.50	98.52	85.11	89.24	64.51	95.22	86.35	64.80	69.30	71.40	62.10	74.10	68.20
Acacia nilotica	178.91	175.63	181.93	180.60	181.41	179.61	153.61	155.84	175.25	174.10	170.50	165.80	140.20	148.9	160.40	156.70	169.80	155.20
Azadiracta indica	156.82	174.32	179.62	182.40	183.76	175.34	147.40	151.40	173.90	169.20	175.00	163.30	129.80	141.6	157.70	152.50	167.20	149.70
Dalbergia sisso	313.60	316.41	212.31	131.60	162.94	227.43	250.60	289.30	111.40	101.60	149.30	180.40	209.40	239.5	158.30	197.30	131.40	167.10
Eucalyptus tetranicus	187.51	189.10	201.93	189.50	187.22	191.10	176.20	177.50	197.80	163.00	176.20	178.10	157.20	163.7	186.00	142.50	163.20	162.05
Albergia lebbeck	161.43	171.01	186.40	178.40	180.35	175.57	159.40	159.40	176.20	169.50	173.10	167.50	129.00	143.4	163.10	153.30	170.30	151.80
Pongamia pinnata	376.52	317.52	221.62	152.10	189.06	251.30	239.00	301.70	114.00	139.4	150.80	189.00	201.70	227.9	196.10	101.20	129.10	171.20
Tectona grandis	173.10	179.11	184.10	177.60	176.37	178.00	165.40	164.90	169.10	168.20	168.10	167.10	161.50	166.30	158.0	159.80	156.00	160.30
Mean	211.60	204.50	184.14	161.13	170.50	185.42	173.73	185.61	150.86	143.62	157.24	162.24	149.20	162.50	156.32	140.40	145.10	131.71
SEM ±	19.21						18.3						11.9					
CD(0.05)	55.67						52.93						34.4					
CV%	23.17%						25.2%						17.6%					

**Table 3. Available Phosphorus content (kg ha<sup>-1</sup>) in multipurpose tree systems at different depths of different location in ANGRAU campus**

Depth (cm)	0-30cm						30-60cm						60-90cm					
	Student farm	College farm	ARI	Horti-culture college	Veteri-nary college	Mean	Student farm	College farm	ARI	Horti-culture college	Veteri-nary college	Mean	Student farm	College farm	ARI	Horti-culture college	Veteri-nary college	Mean
Multipurpose tree system																		
Fallow land	15.4	11.3	14.1	15.3	21.4	15.5	11.9	9.5	12.8	13.1	18.5	13.1	10.8	8.1	11.1	11.5	11.7	10.6
Acacia nilotica	13.1	13.5	17.4	13.4	19.1	15.3	10.2	14.7	16.5	10.0	16.7	13.6	7.4	12.3	13.2	9.6	11.0	10.7
Azadiracta indica	18.9	17.5	12.6	15.3	14.1	15.6	17.5	15.8	10.9	12.5	12.8	13.9	10.7	11.4	9.6	10.1	10.2	10.4
Dalbergia sisso	20.5	18.9	22.5	21.0	25.5	21.6	15.6	15.1	17.1	17.1	17.6	16.5	11.4	14.3	10.5	12.5	15.2	12.7
Eucalyptus tetranicus	13.4	14.6	11.6	18.1	15.1	14.5	10.2	13.7	9.7	11.3	13.5	11.6	9.8	10.1	7.8	8.4	12.7	9.7
Albergia lebbeck	15.4	13.5	14.1	15.1	17.8	15.1	12.5	11.5	10.9	14.1	16.7	13.1	12.0	10.1	9.8	12.1	11.3	11.0
Pongamia pinnata	20.0	15.6	18.5	12.1	14.3	16.1	17.3	14.3	16.3	11.4	12.6	14.3	14.6	10.6	11.7	9.8	10.9	11.5
Tectona grandis	15.2	15.2	13.4	14.2	13.2	14.2	12.7	12.5	11.2	11.6	11.8	11.9	9.87	8.3	9.6	11.9	10.0	9.9
Mean	16.49	15.01	15.53	15.56	17.56		13.49	13.39	13.18	12.64	15.03		10.82	10.65	10.42	10.74	11.63	
SEM ±	3.29						3.06						2.04					
CD(0.05)	15.86%						17.46%						15.48%					
CV%	15.4						11.3						14.1					

**Table 4. Available Potassium content (kg ha<sup>-1</sup>) in multipurpose tree systems at different depths of different location in ANGRAU campus**

Depth (cm)	0-30cm						30-60cm						60-90cm					
	Student farm	College farm	ARI	Horti-culture college	Veteri-nary college	Mean	Student farm	College farm	ARI	Horti-culture college	Veteri-nary college	Mean	Student farm	College farm	ARI	Horti-culture college	Veteri-nary college	Mean
Multipurpose tree system																		
Fallow land	112.70	176.31	164.10	186.31	114.16	150.54	112.6	176.0	152.0	165.0	185.0	158.12	103.20	189.11	104.21	156.31	153.02	141.04
<i>Acacia nilotica</i>	698.2	414.72	402.88	646.2	936.32	619.66	568.09	358.43	382.4	595.2	508.32	482.49	484.72	434.85	514.12	492.68	446.12	474.50
<i>Azadiracta indica</i>	546.94	555.36	539.2	528.4	580.21	550.02	499.84	408.48	475.52	453.76	471.1	461.74	318.08	400.48	420.71	440.96	467.29	409.50
<i>Dalbergia sisso</i>	470.24	494.43	412.32	452.95	435.91	453.17	340.0	480.0	394.16	431.93	218.03	372.82	365.76	312.48	348.96	389.3	386.52	360.60
<i>Eucalyptus tetranicus</i>	402.08	400.32	415.2	455.68	443.91	423.44	390.24	480.36	394.24	431.09	328.98	404.98	270.24	282.43	202.88	306.43	289.98	270.39
<i>Albergia lebeck</i>	596.64	501.28	492.71	504.96	509.64	521.05	521.6	437.44	402.01	462.13	496.71	463.98	450.88	402.04	398.3	359.52	437.02	409.55
<i>Pongamia pinnata</i>	564.48	571.63	458.24	539.04	489.34	524.55	459.2	532.01	408.64	417.31	446.89	452.81	318.56	391.05	365.44	380	326.24	356.26
<i>Tectona grandis</i>	333.76	338.08	358.24	314.08	372.96	343.42	317.28	334.24	246.4	251.64	314.31	292.77	239.84	290.24	228.72	276	218.42	250.64
Mean	465.63	431.47	405.34	453.41	485.28	448.23	401.10	400.87	356.92	401.00	371.16	386.21	318.91	337.82	322.89	350.11	340.57	334.06
SEM ±	37.5						29.4						17.1					
CD(0.05)	108.7						84.1						49.53					
CV%	18.7%						16.8%						11.5%					

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