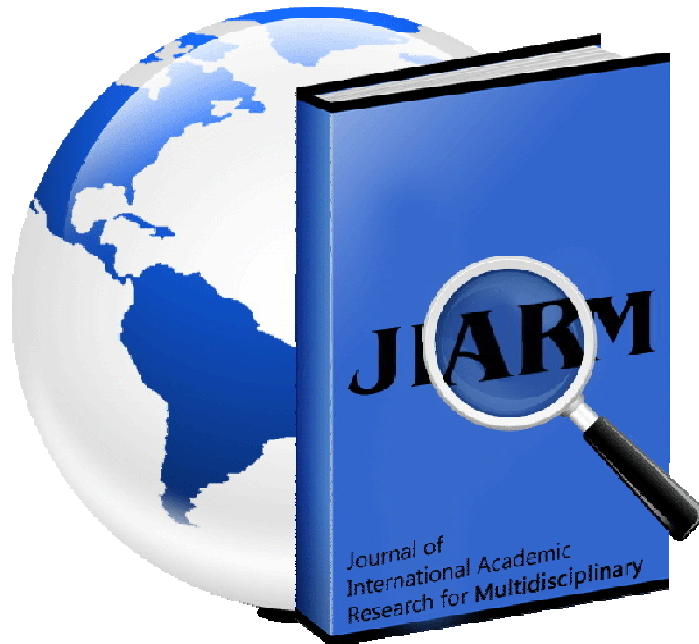


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**INFLUENCE OF INTEGRATED NUTRIENT MANAGEMENT PRACTICES FOR
GROWTH, BIOMASS PRODUCTION AND CARBON SEQUESTRATION
POTENTIAL OF DALBERGIA SISOO ROXB CLONES**

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ABSTRACT

A field experiment was carried out in 2012-13 to study the carbon sequestration rate and biomass carbon content of *Dalbergia sissoo* clones. The study area was located at TNPL, Karur (11°03'44.33" N latitude and 77°59'19.95" E longitude) Tamil Nadu, India. The experiment was conducted in randomized block design with four replications. Among the six different treatment combinations, 125% of Soil Test Value (STV) (138:98:65 NPK kg ha⁻¹) + VAM (100g plant⁻¹) + Azospirillum (50g plant⁻¹) + Phosphobacteria (50g plant⁻¹) + FYM (500g plant⁻¹) recorded the maximum values for growth parameters, carbon content and biomass carbon followed by 100 % of STV (110:78:52 NPK kg ha⁻¹) + VAM (100g plant⁻¹) + Azospirillum (50g plant⁻¹) + Phosphobacteria (50g plant⁻¹) + FYM (500g plant⁻¹). The results indicated that soil test value based integrated application of organics along with inorganic fertilizers positively influenced the growth, biomass and biomass carbon productivity in *Dalbergia sissoo* clones during the initial growth stages.

KEY WORDS: *Dalbergia Sissoo*, Clones, Nutrient, Biomass, Carbon Sequestration.

INTRODUCTION

Removal of greenhouse gases from the atmosphere into sinks (i.e. trees and soil) is one way of addressing climate change. In the wake of global efforts to address climate change, considerable interest has been generated about carbon sequestration potential of trees. Tree plantations are being considered as a mitigation option to reduce the increase in atmospheric CO₂ and climate change (Kraenzel et al., 2003). Soil organic carbon, being the largest terrestrial carbon pool plays a very significant role in global terrestrial ecosystem

carbon balance. Intergovernmental Panel on Climate Change (IPCC, 2007) estimated that the total soil carbon pool in top 1 m as 2011 Pg carbon.

The largest potential is in the subtropical and tropical regions (Watson et al., 2000). whereas differences in per cent C among different tree species and among wood types within a single tree (Lamlom and Savidge, 2003) indicated the need to estimate biomass and C content for each species and each tree component. Most published studies on this subject, however, have focused on total aboveground biomass and C, whereas discrimination among the different parts of the tree, wood types, and stocking densities by age is rarely done.

In India, attempts were made to assess carbon sequestration studies at macro level, mostly with the available data and not many attempts have been made so far to assess the biomass and soil carbon sequestration at micro level.

Dalbergia sissoo Roxb. is one of the tropical timber tree species with multiple uses such as fuelwood, fodder, pulp, shade, shelter and N-fixing ability (Sharma et al. 2007). It is one of the few indigenous leguminous tree species, growing naturally from Himalayan foot hills to the plains of Afghanistan, Malaysia and Pakistan. It is widely used in agroforestry, afforestation programmes and farm forestry in the Indian subcontinent (Huda et al. 2007). In dry deciduous forest, it has been reported to produce 15 tonnes ha⁻¹ year⁻¹ of woody biomass and a total biomass of 160 tonnes ha⁻¹ year⁻¹.

Systematic efforts to test selected clonal material of *Dalbergia sissoo* under location specific conditions for estimation of its carbon sequestration rate and biomass carbon content are meagre. Under location specific condition, the performance of clonal source of this species has to be tested for producing more utilizable biomass so as to fetch the highest carbon sequestration potential. This study was, therefore, undertaken to study carbon sequestration rate and biomass carbon content of *Dalbergia sissoo* clones.

MATERIALS AND METHODS

A field experiment was carried out at Tamil Nadu Newsprints and Papers Limited (TNPL), Karur (11°03'44.33" N latitude and 77°59'19.95" E longitude) Tamil Nadu, India. The mean annual rainfall of the site was 635 mm. The initial soil properties of the study area indicated that the soil was red sandy loam with pH 6.3 and EC 0.10 d Sm⁻¹. The soil available nitrogen, P₂O₅ and K₂O content were 220, 10.0 and 330 kg ha⁻¹ respectively. The design of the experiment was RBD and replicated four times. Six treatments were imposed and the details of them are as under

T₁ – Control

- T₂ – Recommended dose of fertilizer (RDF) alone - 110:65:65 NPK kg ha⁻¹,
 T₃ – Soil Test Value (STV) alone – 110:78:52 NPK kg ha⁻¹,
 T₄ – 75 % of STV – 83:59:39 NPK kg ha⁻¹ + VAM (100g plant⁻¹) + Azospirillum (50g plant⁻¹) + Phosphobacteria (50g plant⁻¹) + FYM (500g plant⁻¹),
 T₅ – 100 % of STV- 110:78:52 NPK kg ha⁻¹ + VAM (100g plant⁻¹) + Azospirillum (50g plant⁻¹) + Phosphobacteria (50g plant⁻¹) + FYM (500g plant⁻¹),
 T₆ – 125% of STV 138:98:65 NPK kg ha⁻¹ + VAM (100g plant⁻¹) + Azospirillum (50g plant⁻¹) + Phosphobacteria (50g plant⁻¹) + FYM (500g plant⁻¹).

New shoots were collected from *D. sissoo* clonal garden maintained by TNPL for clonal propagation. Two month old clones of *Dalbergia sissoo* was planted during November, 2012 in 40 cm³ size pit at 3 x 1.5m spacing. There were 24 plants per treatment; irrigation was given at weekly intervals.

Fertilizers and manures were applied 30 cm away from tree base to avoid the risk of loss over the surface. Biometric observations on plant height (cm), basal diameter (mm) and number of branches (no. plant⁻¹) were recorded at 3, 6 and 9 months after planting (MAP).

The above and below ground biomass estimation was done by destructive sampling method. Among the four replications, three trees were selected for each replication in all the treatments at 9 MAP. After recording the total height and basal diameter of the selected trees, they were felled at ground level using mechanical chain saw. The above ground portions were separated into stem, branches and leaves. Fresh weight of all the above ground tree components was recorded immediately after felling using appropriate spring scales.

A small sample (500 g) of stem, branches and leaves were immediately transported to the laboratory in double sealed polythene bags. The samples were dried at 80°C till constant weight was obtained. From the oven dried weight, carbon content in the tree biomass was analysed through the appropriate laboratory technique.

$$TFW - \{TFW \cdot (SFW - SODW)\}$$

$$ODW(t) = \frac{\text{TFW} - \{TFW \cdot (SFW - SODW)\}}{SFW}$$

Lasco et al. (2005)

SFW

Where,

ODW = Total oven dry weight

TFW = Total fresh weight

SFW = Sample fresh weight

SODW = Sample oven dry weight

The samples for tree components viz., stem, branches, leaves and roots of the trees were collected separately, air dried and oven dried. Oven dried biomass samples were grounded in Willey Mill and carbon concentration in different tree components were determined based on ash per cent and determined by the procedure given by Allen et al. (1986). To estimate the ash per cent and biomass carbon, the following methods are used in tree species.

Porcelain crucibles were washed with 6 N hydrochloric acid and distilled water and dried in an oven at 65°C for one hour. One gram of powdered sample was taken in pre weighed crucibles. The crucibles were taken inside the cool furnace. After adjusting the furnace at 550°C, heating was increased slowly and after reaching 550°C, ignition was continued for 1 hour. Then, the crucibles were cooled slowly keeping them inside the furnace. After complete cooling, the crucible with ash was weighed and the percentage of ash was calculated as per the procedure with the following formula.

$$(W_3 - W_1)$$

$$\text{Ash \%} = \frac{\quad}{(W_2 - W_1)} \times 100$$

$$(W_2 - W_1)$$

Where,

W_1 = Weight of crucibles

W_2 = Weight of oven dried powdered samples + crucibles

W_3 = weight of ash + crucibles.

Carbon per cent in above ground biomass, below ground biomass, litter and dead organic matter was estimated by using the following formula given by Dhruw et al., (2009).

$$\text{Carbon \%} = 100 \% - \{ \text{Ash \%} + \text{Molecular weight of O}_2 (53.3 \%) \text{ in C}_6\text{H}_{12}\text{O}_6 \}$$

$$\text{Total biomass carbon stock (t C ha}^{-1}\text{)} = \text{AGB carbon} + \text{BGB carbon}$$

During 9 MAP, soil nutrient analysis was carried out following standard methods for soil pH and EC, available nitrogen, available phosphorus, available potassium and soil organic carbon content. Growth parameters and analytical data recorded in the study were analysed using suitable statistical tests.

RESULTS AND DISCUSSION

The nutrient management practices had a profound influence on growth parameters of the *D. sissoo*. However, the treatment comprising application of 125% of STV (138:98:65 NPK kg ha⁻¹) + VAM (100g plant⁻¹) + Azospirillum (50g plant⁻¹) + Phosphobacteria (50g plant⁻¹) + FYM (500g plant⁻¹) (T₆) recorded significantly higher plant height of 137.79, 229.33 and 315.25 cm respectively at 3, 6 and 9 MAP. The current findings are in tune with the findings

of many workers which revealed that increase in the fertilizer doses increased plant height (Velmurugan and Shanmugam 2011). The same treatment (T_6) recorded the maximum basal diameter of 9.73, 24.66 and 35.22 mm at all the three growth stages respectively compared to all the other treatments.

Nutrient management strategies significantly influenced the number of branches per plant. Higher number of branches per plant (19.00, 36.3 and 40.90) at 3, 6 and 9 MAP was recorded with application of 125% of STV (138:98:65 NPK kg ha^{-1}) + VAM (100g plant^{-1}) + Azospirillum (50g plant^{-1}) + Phosphobacteria (50g plant^{-1}) + FYM (500g plant^{-1}) (T_6). Increased availability of nutrients due to FYM+NPK application resulted in increased production of photosynthates and their translocation to branches could have led to more number of branches per plant. This is in line with the findings of Deswal et al. (2001). Increase in the number of branches per plant led to significant increase in total dry matter production (Table 1).

All the treatments recorded significant variation for above and below ground biomass production. In the fractionated plant parts, the highest leaf (348.11 kg ha^{-1}), branch (185.36 kg ha^{-1}), stem (526.50 kg ha^{-1}) and root (296.03) biomass was registered in T_6 followed by T_5 and the lowest by T_1 (leaf - 287.24, branch - 144.15, stem - 452.89 and root - 261.29 kg ha^{-1}). The present study is in accordance with the results of Goel and Singh (2008) wherein it was observed that *Dalbergia sissoo* produced an above ground biomass of 13.52 mt ha^{-1} at the age of 5 years. Similarly, Ilyas Sadeli (2013) reported that stem portion contained the maximum biomass in *Acacia mangium*, when compared with branch and leaf at the age of 3 years.

The application of 125% of STV 138:98:65 NPK kg ha^{-1} + VAM (100g plant^{-1}) + Azospirillum (50g plant^{-1}) + Phosphobacteria (50g plant^{-1}) + FYM (500g plant^{-1}) (T_6) recorded the maximum carbon content in leaf, branch, stem and root (40.43 %, 41.68 %, 45% and 42.17 % respectively) while the lowest carbon content was recorded in T_1 for all the components (Table 2.). In all the treatments, branch and roots recorded almost similar percentage of carbon content. The results of Jana et al. (2009) indicated that stem biomass recorded in *Tectona grandis* maximum carbon content when compared to leaf.

T_6 recorded highest biomass carbon content in all fractionated tree components viz., leaf, branch, stem and root with the carbon value of 140.69 kg ha^{-1} , 77.31 kg ha^{-1} , 235.89 kg ha^{-1} and 124.83 kg ha^{-1} respectively. T_1 recorded the lowest biomass carbon content of 114.42 kg ha^{-1} , 200.92 kg ha^{-1} and 109.66 kg ha^{-1} in leaf, stem and root respectively. It is interesting to note that the amount of carbon present in stem was significantly high when compared to other plant parts in all the treatments subjected for investigation (Table 2). The results of Tagupa et

al. (2010) and Shrestha (2009) concluded that stem accounted for more biomass and the quantity of biomass was directly correlated to total carbon content in tree.

Different nutrient levels did not significantly influence the soil pH and electrical conductivity. The values ranged from 6.26 to 6.52 for pH and 0.10 to 0.15 d Sm⁻¹ for Ec respectively at 9 MAP. Reduction in soil pH might be due to the decomposition of litter addition and subsequent acid production coupled with residual effect of nitrogenous fertilizers. Similar findings were reported by Mohanraj (2008) in Eucalyptus. Maximum soluble salt concentration was recorded in T₆ which might be due to the different combinations of fertilizers and litter addition. (Table 3).

The results of the effect of various nutrient levels on soil available nutrients recorded significantly higher value (251.33 kg ha⁻¹) for available N under T₆ which was on par with T₅ (238.67 kg ha⁻¹). This might be due to the reason that the continuous addition of nitrogenous fertilizers led to build up in the available N status of the soil. Similar trend was also observed in soil available P and the highest value of 12.93 kg ha⁻¹ was recorded in T₆ which was on par with T₅ (11.57 kg ha⁻¹) and the lowest value of 8.67 kg ha⁻¹ was observed in T₁. Comparing the different doses of fertilizers, it was found that there was an increase in the soil available P which might be due to the fact that the application level of P fertilizers increased their residual effect in soil which thereby increased the available P. The results on the effect of various nutrient levels showed that highest value of available K (358.00 kg ha⁻¹) was under T₆ which was significantly superior in comparison with all other nutrient levels. The lowest value of 318.00 kg ha⁻¹ of soil available K was recorded in T₁. Similar results were also reported by Santhy and Kothandaraman (1988). Higher level of K fertilizers, higher biomass and more litter addition might have increased the available K content in soil (Table 3).

T₆ recorded higher organic carbon (0.46%) and the lowest organic carbon of 0.24 per cent was observed in control (T₁). Irrespective of fertilizer levels, the soil organic carbon content was significantly higher with increasing levels of fertilizers (Table 3). The increase in organic carbon content of the soil may be due to the application of P and its sources (Chellamuthu 1990).

From the study it could be concluded that application of 125% of STV (138:98:65 NPK kg ha⁻¹) + VAM (100g plant⁻¹) + Azospirillum (50g plant⁻¹) + Phosphobacteria (50g plant⁻¹) + FYM (500g plant⁻¹) will improve the growth, dry matter production as well as the biomass carbon productivity in clonal plants of Dalbergia sissoo during the initial growth stages.

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Table 1. Effect of Nutrient Management Practices on growth parameters of *Dalbergia sissoo*

Treatments	3 MAP			6MAP			9MAP			
	Height (cm)	Basal diameter (mm)	Branches (Numbers)	Height (cm)	Basal diameter (mm)	Branches (Numbers)	Height (cm)	Basal diameter (mm)	Branches (Numbers)	Root length (cm)
T1	114.06	9.89	11.55	178.33	19.94	23.67	203.00	22.74	26.03	100.68
T2	117.32	10.40	14.89	202.33	21.82	25.33	256.75	28.43	36.33	120.46
T3	120.16	10.79	15.43	201.00	21.87	24.67	254.75	28.21	34.28	120.04
T4	131.49	11.17	15.11	202.67	21.16	27.67	264.25	25.97	34.43	120.16
T5	133.73	11.60	16.10	211.67	22.86	34.67	290.75	29.37	37.90	125.65
T6	137.79	12.94	19.00	229.33	24.66	36.33	315.25	35.22	40.90	129.61
SEd	2.46	0.24	0.53	7.46	1.02	3.67	15.66	1.52	1.43	1.68
CD(P=0.05)	5.24	0.51	1.12	16.63	2.28	8.18	33.37	3.22	3.05	3.59

Table 2. Effect of Nutrient Management Practices on above and below ground biomass (kg ha^{-1}), Carbon concentration (%) and biomass carbon (kg ha^{-1}) of *Dalbergia sissoo*

Treatments	Biomass (kg ha^{-1})				Carbon per cent				Biomass carbon (kg ha^{-1})			
	Leaf	Branch	Stem	Root	Leaf	Branch	Stem	Root	Leaf	Branch	Stem	Root
T ₁	287.24	144.15	452.89	261.29	39.82	40.95	44.37	41.97	114.42	59.04	200.92	109.66
T ₂	317.04	158.65	508.35	290.42	40.11	40.86	44.65	41.00	127.27	64.83	227.04	119.05
T ₃	300.27	157.11	495.09	289.74	40.02	41.42	44.65	41.55	120.14	65.04	221.09	120.39
T ₄	313.75	158.76	496.53	283.29	40.16	41.34	43.83	41.39	126.05	65.65	217.74	117.28
T ₅	324.51	173.36	504.74	288.66	40.04	40.74	44.79	41.65	129.93	70.60	227.15	120.21
T ₆	348.11	185.36	526.50	296.03	40.43	41.68	45.00	42.17	140.69	77.31	235.89	124.83
SEd	8.66	6.58	9.93	3.77	0.36	0.22	0.37	0.21	4.21	2.83	6.30	1.75
CD(P=0.05)	18.44	14.01	21.16	8.03	0.76	0.46	0.79	0.45	8.97	6.02	13.43	3.73

Table 3. Effect of Nutrient Management Practices on soil physicochemical and fertility properties of Dalbergia sissoo at 9 MAP

Treatment	pH	Electrical conductivity (dS m ⁻¹)	Organic carbon %	Available N (kg ha ⁻¹)	Available P (kg ha ⁻¹)	Available K (kg ha ⁻¹)
T ₁	6.36	0.11	0.24	210.00	8.67	318.00
T ₂	6.34	0.13	0.30	226.00	11.03	325.68
T ₃	6.31	0.14	0.30	232.33	11.13	333.66
T ₄	6.33	0.12	0.32	236.67	11.10	332.65
T ₅	6.52	0.14	0.37	238.67	11.57	340.69
T ₆	6.26	0.15	0.46	251.33	12.93	358.00
SEd	0.14	0.02	0.04	4.44	0.44	3.58
CD(P=0.05)	NS	NS	0.08	9.47	0.94	7.63