Indian Journal of Hill Farming 26(2):42-48 Available online at www.kiran.nic.in

Response of *Dalbergia sissoo* Roxb. Clones to Integrated Nutrient Management Practices

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Received 13.9.2013, Revised 24.9.2013, Accepted 24.9.2013.

ABSTRACT

A field experiment was carried out in 2012-13 to study the location specific nutrient requirement based on soil test value during the first year growth and development of *Dalbergia sissoo* raised from clonal source. The study area was located at TNPL, Karur (11º03´44.33" N latitude and 77º59´19.95" E longitude) Tamil Nadu, India. The experiment was conducted in randomized block design with four replications. There were six different treatment combinations of soil test value based organic and inorganic fertilizers. Among the treatments, 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}) recorded significantly maximum growth parameters, quality parameters and nutrient uptake 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 indicate that soil test value based integrated application of organics along with inorganic fertilizers could increase the growth as well as dry matter production in clonal plants of *Dalbergia sissoo* during the initial growth stages.

Key words: *Dalbergia sissoo*, clones, nutrient management, growth parameters, dry matter production.

INTRODUCTION

Increasing demand coupled with low productivity of tree plantations is one of the major concerns faced by wood based industries. One of the main reasons for low productivity of industrial plantations is non-availability of genetically improved planting stock and proper nutrient management practices. Improved planting material coupled with location specific silvicultural technologies will improve the productivity of the plantations (Lal 2000). Low soil fertility and moisture stress conditions of the field are important limitations causing transplanted seedlings difficult to establish. These limitations can be narrowed by use of inorganic fertilizers combined with organic fertilizers which are capable in increasing soil fertility and decreasing soil moisture loss. A large area is undertaken for transplantations each year but most plants either do not show satisfactory growth due to low soil fertility status or die during drought due to stress conditions.

Dalbergia sissoo Roxb. is one of the tropical timber tree species with multiple uses such as fuel wood, fodder, pulp, shade, shelter and N-fixing ability (Sharma et al. 2007). It is one of the few indigenous leguminous tree species of South Asia, growing naturally from Himalayan foot hills to the plains of Afghanistan, Malaysia, India and Pakistan. It is widely used in agroforestry and afforestation programmes in the Indian subcontinent (Chander et al. 1998, Huda et al. 2007). Nursery and field response of *D. sissoo* were also studied by Dabas and Kaushik (1998). In dry deciduous forest it has been reported to produce 15 tonnes ha^{-1} year^{-1} of woody biomass (Rajvanshi et al. 1985) and a total biomass of 160 tonnes ha^{-1} year^{-1} (Sharma et al. 1988).

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Systematic efforts to test the selected clonal material of *Dalbergia sissoo* under location specific conditions are meagre. Some trials comparing the performance of clones and seedlings have been conducted by different organizations and the results are mixed. Under location specific condition, the performance of clonal source of this species has to be tested for getting higher utilizable biomass so as to fetch the highest profit to the stakeholders. In order to solve the above mentioned problems and to bridge the gap between demand and supply of industrial wood and also to reduce the rotation period, new technologies have to be evolved through intensive location specific silvicultural management practices. The first year data on the growth of sissoo clones helps to assess the establishment in field condition besides the comparing differences in growth. The present study on location specific nutrient application based on soil test value for growth and development of *Dalbergia sissoo* raised from clonal source will help to arrive at the optimum nutrient requirement in the field condition in the initial period of establishment.

MATERIALS AND METHODS

Experiment Details

A field experiment was carried out at Tamil Nadu Newsprints and Papers Limited (TNPL), Karur (11º03′44.33" N latitude and 77º59′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 showed that the soil was red sandy loam with pH 6.3 and EC 0.10 d Sm^{-1}. The soil available nitrogen, P_2O_5 and K_2O content were 220, 10.0 and 330 kg ha^{-1} respectively. The design of the experiment was RBD and replicated four times. There were six treatments *viz.,* T_1 – Control, T_2 – Recommended dose of fertilizer (RDF) alone - 110:65:65 NPK kg ha^{-1}, T_3 – Soil Test Value (STV) alone – 110:78:52 NPK kg ha^{-1}, T_4 – 75 % of STV – 83:59:39 NPK kg ha^{-1} + VAM (100g $plant^{-1}$) + *Azospirillum* (50g $plant^{-1}$) + Phosphobacteria (50g $plant^{-1}$) + FYM (500g $plant^{-1}$), T_5 – 100 % of STV- 110:78:52 NPK kg ha^{-1} + VAM (100g $plant^{-1}$) + *Azospirillum* (50g $plant^{-1}$) + Phosphobacteria (50g $plant^{-1}$) + FYM (500g $plant^{-1}$), T_6 – 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 cm^3 size pit at 3 x 1.5m spacing. There were 24 plants per treatment; irrigation was given at weekly intervals.

The required amounts of each fertilizer and manure 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), number of branches (no. $plant^{-1}$) and leaf area (cm^2 $plant^{-1}$) were recorded at 60, 120 and 180 days after planting (DAP). The total chlorophyll, chlorophyll a and b were estimated by adopting the method suggested by Yoshida et al. (1971) and expressed in mg g^{-1} of fresh weight. For root studies, one representative plant sample was removed at six months after planting from each plot and roots of the plant were excavated and the dry weight was recorded after oven drying the samples and expressed in g $plant^{-1}$. Quotient of sturdiness (SQ) was calculated following Thompson (1985). To quantify the morphological quality of seedlings, the quality index (QI) was calculated following Dickson et al. (1960) formula: QI = TW / (H/D) + (SW / RW), where, TW is the total seedling dry weight (g), H is the seedling height (cm), D is the collar diameter (mm), SW is the shoot dry weight (g) and RW is the root dry weight (g) of the plant. During 180 DAP, soil and plant nutrient analysis were carried out following standard methods for soil pH and EC (Jackson 1973), available nitrogen (Subbiah and Asija 1956), available phosphorus (Olsen et al. 1954), available potassium (Stanford and English 1949), soil organic carbon content (Walkley and Black 1934). The uptake of N, P and K was computed by multiplying total dry matter production with nutrient content and expressed in kg ha^{-1}. The data were subjected to analysis of variance using SPSS / PC+ (1986) statistical package to test the significance of difference in the studied parameters due to the treatments.

RESULTS AND DISCUSSION

Influence on growth characters

The nutrient management practices had a profound influence on growth parameters and quality parameters of the *D. sissoo* seedlings. 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 $plant^{-1}$) (T_6) recorded significantly higher plant height of 89.52, 182.27 and 229.33 cm respectively at 60, 120 and 180 DAP. Bumatay et al. (1988) supported that increased fertilizer application increased the height of the trees. The current findings are also in tune with many workers who revealed that increase in the fertilizer doses increased plant height (Kusumakumari 2002, Velmurugan and Shanmugam 2011). The same treatment (T_6) recorded the maximum basal diameter of 9.73, 16.83 and 24.66 mm at all the three growth stages respectively compared to all the other treatments. Singh (2001) reported that fertilizer (NPK) application significantly increased the collar diameter of *Populus deltoides.*

The nutrient management strategies significantly influenced the number of branches per plant. Higher number of branches per plant (16.00, 24.00 and 36.3) at 60, 120 and 180 DAP 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 and this could have led to the production of higher number of branches per plant. This is in line with the findings of Deswal et al. (2001). The increase in the height, basal diameter and number of branches of the treatment T_6 was recorded to be 28.60, 23.67 and 53.49 per cent respectively over the control at 180 DAP. This increase in number of branches per plant led to significant increase in total dry matter production (Table 1).

Influence on quality parameters

The analytical results on the chlorophyll content of *Dalbergia sissoo* clonal plants due to application of various nutrient management treatments showed that the highest chlorophyll a (1.300 mg g^{-1}), chlorophyll b (1.006 mg g^{-1}) and total chlorophyll (2.337 mg g^{-1}) at 180 DAP was observed in T_6 (Table 2) This was followed by T_5 (chlorophyll a 1.127 mg g^{-1}, chlorophyll b 0.817 mg g^{-1} and total chlorophyll 2.196 mg g^{-1}). The inoculation of biofertilizers to plant would have increased the chlorophyll content by the supply of higher amount of nitrogen to growing tissues (Singh et al. 1983) (Table 2).

Table 2: Effect of Nutrient Management Practices on Chlorophyll a, b and total Chlorophyll content (mg g^{-1}) of *Dalbergia sissoo* clones

Treatment	Chlorophyll a (mg g^{-1})	Chlorophyll b (mg g^{-1})	Total chlorophyll (mg g^{-1})
T_1	0.710	0.686	1.567
T_2	0.816	0.747	1.779
T_3	0.978	0.839	2.028
T_4	0.740	0.710	1.604
T_5	1.127	0.817	2.196
T_6	1.300	1.006	2.337
CD(P=0.05)	0.052	0.04	0.070

The trend of leaf area revealed steep increases from 60 to 180 DAP. A highly significant individual effect on improving leaf area of 45.54, 83.11 and 141.90 cm^2 $plant^{-1}$ at all the growth stages *viz*., 60, 120 and 180 DAP was noticed in the treatment T_6 which received 125% of STV 138:98:65 NPK kg

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

Treatment	60 DAP			120 DAP			180 DAP		
	Height (cm)	Basal dia. (mm)	Branches (nos)	Height (cm)	Basal dia. (mm)	Branches (nos)	Height (cm)	Basal dia.(mm)	Branches (nos)
T_1	70.96	5.30	9.00	132.57	11.00	15.67	178.33	19.94	23.67
T_2	77.04	6.36	9.33	153.13	13.11	20.33	202.33	21.82	25.33
T_3	74.24	6.47	10.33	135.01	11.68	20.33	201.00	21.87	24.67
T_4	75.80	5.96	8.33	149.00	12.00	19.33	202.67	21.16	27.67
T_5	77.91	7.15	14.67	158.88	13.13	22.67	211.67	22.86	34.67
T_6	89.52	9.73	16.00	182.27	16.83	24.00	229.33	24.66	36.33
CD(P=0.05)	7.62	0.75	2.15	6.81	1.12	3.25	7.40	1.63	4.85

ha^{-1} + VAM (100g plant^{-1}) + *Azospirillum* (50g plant^{-1}) + Phosphobacteria (50g plant^{-1}) + FYM (500g plant^{-1}). This was followed by T_5 (43.08, 77.02 and 134.05 cm^2 plant^{-1}) in all three stages. An increment in leaf area of 25.44 per cent was recorded in T_6 over the control at 180 DAP. Similar to other parameters the leaf area also increased due to the integration of inorganic, organic and biofertilizers. This observation is in agreement with the findings of Das et al. (1994) in *Morus alba* (Table. 3).

Table 3: Effect of Nutrient Management Practices on Leaf area (cm^{2}plant^{-1}) of *Dalbergia sissoo* clones

Treatment	Leaf area (cm^{2}plant^{-1})		
	60 DAP	120 DAP	180 DAP
T_1	21.50	55.82	113.12
T_2	39.12	68.94	126.36
T_3	33.37	73.75	121.61
T_4	36.50	70.02	120.65
T_5	43.08	77.02	134.05
T_6	45.54	83.11	141.90
CD(P=0.05)	3.87	5.10	5.69

The total dry matter production at 180 DAP was recorded to be significantly higher in T_6 (52.27 g plant^{-1}) followed by T_5 (45.66 g plant^{-1}). The dry matter production was recorded to be lowest in T_1 (33.45 g plant^{-1}). The increase in the DMP of the treatment T_6 over the control was recorded to be 56.26 per cent. The combined application of urea and SSP to *Dalbergia sissoo* might have resulted in the production of vigorous seedlings with high survival and maximum dry matter production which is concomitant with the results of Tiwari and Saxena (2003).

The sturdiness quotient ranged from 8.97 to 9.60 and it was found to be non significant whereas the Dickson quality index (QI) ranged from 2.58 to 3.76. Among the various treatments, T_6 recorded the maximum value for Dickson quality index followed by T_5. Higher values for QI indicated the positive impact of the treatments on the growth and development of the seedlings at 180 days after planting. This was in consonance with the findings of Bayala et al. 2009 who reported that QI appeared to be the most appropriate indicator to predict out planting performance in Acacia, Gliricidia and Leucaena species (Table. 4).

Table 4 : Effect of Nutrient Management Practices on Total Dry matter production (g plant^{-1}), Sturdiness quotient and Dickson quality index of *Dalbergia sissoo* at 180 DAP

Treatment	Total Dry matter production (g plant^{-1})	Sturdiness quotient	Dickson quality index
T_1	33.45	8.97	2.58
T_2	43.34	9.26	3.16
T_3	42.50	9.21	3.11
T_4	40.41	9.60	2.94
T_5	45.66	9.31	3.41
T_6	52.27	9.32	3.76
CD(P=0.05)	0.98	NS	0.20

Influence on soil properties

The different nutrient levels did not significantly influence the soil pH and electrical conductivity of the soil. However, the values ranged from 6.26 to 6.52 pH and 0.10 to 0.15 d Sm^{-1} respectively at 180 DAP. The 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*, Chakraborthy and Chakraborthy (1989) in *Acacia auriculiformis*. The maximum soluble salt concentration was recorded in T_6 which might be due to the different combinations of fertilizer application and litter addition. Totey et al. (1992) reported that EC increased with the age of Teak plantations, Chakraborthy and Chakraborthy (1989) reported that four year old *Acacia auriculiformis* plantation enhanced the soil EC (Table 5).

The results of the effect of various nutrient levels on soil available nutrients showed that significantly higher value (251.33 kg ha^{-1}) for available N under T_6 and it was on par with T_5 (238.67 kg ha^{-1}). The lowest value (210 kg ha^{-1}) was recorded under T_1. This might be due to the reason that the continuous addition of nitrogenous fertilizers leads to build up in the available N status of the soil. Sharma and Meelu (1975) reported that application of phosphorus continuously over a period enhanced the available N content. Similar trend was also observed in soil available P and the highest value of 12.93 kg ha^{-1} was recorded in T_6 which was on par with T_5 (11.57 kg ha^{-1}) and the lowest value of 8.67 kg ha^{-1} was observed in T_1. Comparing the different doses of fertilizers, it was found that there

Table 5 : Effect of Nutrient Management Practices on soil physicochemical and fertility properties of *Dalbergia sissoo* at 180 DAP

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
CD(P=0.05)	NS	NS	0.08	9.47	0.94	7.63

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. Similar results were also reported by Santhy and Kothandaraman (1988). The results on the effect of various nutrient levels showed that highest value of soil available K (358.00 kg ha^{-1}) under T_6 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 T_1. The higher level of K fertilizers, higher biomass and more litter addition might have increased the available K content in soil. The result of this study is in line with Santhy (1995) (Table 5).

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) was associated with relatively higher organic carbon (0.46%) and the lowest organic carbon of 0.24 per cent was observed in control (T_1). Irrespective of fertilizer levels, the soil organic carbon content was significantly higher with increasing levels of fertilizers in *Dalbergia sissoo* clonal plantation (Table 5). The increase in organic carbon content of the soil may be due to the application of P and its sources (Chellamuthu 1990).

Influence on nutrient uptake

There was a significant effect of nutrient management practices on nitrogen, phosphorus and potassium uptake of *D. sissoo* plants. 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 highest N, P and K uptake of 86.13, 23.96 and 72.74 kg ha^{-1} respectively at 180 DAP followed by T_5. The control (T_1) registered the lowest N, P and K uptake 23.60, 10.81 and 28.72 kg ha^{-1} respectively at 180 DAP. The higher value of nutrient uptake recorded in the treatment T_6 might be due to the fact that application of 125 per cent of soil test value NPK along with organic and biofertilizers must have enhanced mineralization of organic nitrogen, phosphorus and potassium, thus making more NPK available to the plant. Hulikatti and Madiwalar (2011) also reported that application of FYM+NPK increased the N and P uptake in *Acacia auriculiformis* plants. The present finding is also in agreement with the findings of Mishra (1995) who stated that in *Dendrocalamus strictus*, the maximum value of K uptake was registered by the application of *Azospirillum* along with FYM and NPK fertilization (Table. 6).

Table 6 : Effect of Nutrient Management Practices on N, P and K uptake (kg ha^{-1}) of *Dalbergia sissoo* at 180 DAP

Treatment	N Uptake kg ha^{-1}	P Uptake kg ha^{-1}	K Uptake kg ha^{-1}
T_1	23.60	10.81	28.72
T_2	33.57	16.33	44.88
T_3	38.13	14.78	45.82
T_4	37.50	15.63	47.49
T_5	65.28	19.59	48.44
T_6	86.13	23.96	72.74
CD(P=0.05)	12.22	1.91	12.41

CONCLUSION

The study conducted on the nutrient management practices of *Dalbergia sissoo* revealed that all the growth parameters, quality parameters and nutrient uptake were found to be higher with the treatment T_6 which received 125% of STV 138:98:65 NPK kg ha^{-1} + VAM (100g $plant^{-1}$) + *Azospirillum* (50g $plant^{-1}$) + Phosphobacteria (50g $plant^{-1}$) + FYM (500g $plant^{-1}$). Soil test value based integrated application of organics along with inorganic fertilizers could increase the growth as well as dry matter production in clonal plants of *Dalbergia sissoo* during the initial growth stages especially during the first year of growth. The present study will help in arriving at possible juvenile adult correlations, if any in sissoo clones besides aiding in precision application of a mix of inorganic, organic and bio fertilizers through INM mode.

ACKNOWLEDGEMENTS

The authors thank the Indian Council for Agricultural Research, New Delhi, The Dean, Forest College and Research Institute for financial support and the Tamil Nadu Newsprint and Papers Limited, Karur for providing the necessary facilities for conducting the research.

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