KFRI Research Report No 303

ISSN 0970-8103

GROWTH ENHANCEMENT OF *DALBERGIA LATIFOLIA* THROUGH SOIL MANAGEMENT TECHNIQUES

M.P. Sujatha
Thomas P. Thomas
E.J. Maria Florence

Kerala Forest Research Institute
Peechi - 680 653, Thrissur, Kerala, India
Website : www.kfri.org

February 2008

KFRI Research Report No.303

GROWTH ENHANCEMENT OF *DALBERGIA LATIFOLIA* THROUGH SOIL MANAGEMENT TECHNIQUES

M.P. Sujatha
Thomas P. Thomas
E.J. Maria Florence

Kerala Forest Research Institute
Peechi – 690 653, Thrissur, Kerala, India

ABSTRACT OF PROJECT PROPOSAL

1	Project No.	:	KFRI 370/01
2	Title of project	:	Growth enhancement of *Dalbergia latifolia* through soil management techniques
3	Objectives	:	1. To study the influence of different soil management techniques on the growth of different types of planting material of *Dalbergia latifolia* through pot and field trials 2.To ascertain the association and variability of isolate of rhizobium with *Dalbergia latifolia* and to study the growth performance of this species by the innoculation of rhizobium 3. To study the clonal propagation of *Dalbergia latifolia* 4. To find out the best soil management technique and planting material giving maximum growth
4	Duration	:	3 years
5	Funding Agency	:	Kerala Forest Department
6	Project Team		
	Principal Investigator	:	M.P. Sujatha
	Associates	:	Thomas P. Thomas and E.J.Maria Florence

CONTENTS

List of Tables

List of Figures

ABSTRACT

Considering the drastic depletion, slow growing nature and long gestation period of *Dalbergia latifolia*, a nitrogen fixing as well as high valued timber yielding forest species, this study was conducted during 2001-2004 with the view of increasing its growth through various soil management practices using different types of planting materials such as root suckers, seedlings and rooted cuttings. The study also aimed at finding out the association and variability of isolate of rhizobium and the clonal propagation in this species. Growth response to various treatments such as lime, vermi compost, cow dung, chemical fertilizer, rhizobium and combinations of organic manures with chemical fertilizer were studied by conducting pot trial at Field Research Centre of KFRI in Velupadam and field trial at Sub Centre of KFRI in Nilambur. Changes in soil properties due to the application of various treatments were also studied. Results indicated that organic manures such as cow dung (1kg/plant) or compost (1kg/plant) either alone or in combination with chemical fertiliser (½ kg cow dung or ½ kg compost + potash-15g + amophos-50g) were effective in achieving a substantial increase in the growth of *Dalbergia latifolia* coupled with improvement in soil quality. All the three types of planting materials used in the study responded very well to the above treatments and the maximum growth responses were observed in root suckers followed by seedlings and cuttings. The best strain of rhizobia was isolated from those collected from Nilambur and all the cultures were capable of forming nodulation on *Dalbergia* seedlings. But the application of these rhizobia had no significant impact on the growth of *Dalbergia latifolia*. In order to produce rooted cuttings from suckers the best concentration of IBA was 5000 ppm .

1. INTRODUCTION

Dalbergia latifolia Roxb.(rose wood), belonging to the family Fabaceae is a nitrogen fixing as well as high valued timber yielding forest species. It is naturally distributed between 10 and 28 ^{0}N in India and grows more or less scattered in the deciduous forests with teak as one of its associates. It is also seen extended to moist tropical semi-evergreen forests as well as drier tropical dry deciduous forests. Outside India, it was grown in Java since 1875, and today it is found in SriLanka, Kenya, Nigeria, Tanzania and many parts of South East Asia. Rose wood is recognized internationally as one of the finest and most beautiful of Indian timbers due to its attractive brown colour, beautiful grains and superior wood qualities. The various uses of this wood include furniture, cabinetwork, decorative objects, musical instruments etc. It was shipped away by the Portugese and Dutch invaders and thus its foreign trade is centuries old.

It *grows* on a wide range of geological formations such as gneiss, trap, laterite, boulder deposits and alluvial formations and thrives best on well drained, deep, moist soil particularly near the perennial streams. It is an erect tree and one of the tallest mountain trees in India. The growth of the tree usually varies with locality and can attain up to a maximum of 45 m in height and over 5 m in girth. Under natural conditions it is very slow growing and most of the times seedlings are prone to fire. Taking into account the drastic depletion of this species in the natural forests, there is an urgent need to prioritize the establishment of large-scale plantations for which slow growing nature and long rotation period (more than 100 years) are the main barriers usually encountered. So the present study was framed with the view of achieving a sustainable and maximum increase in the growth of *Dalbergia latifolia* so that rotation period can be slashed considerably. The main objectives of the study are:

1. To study the influence of different soil management techniques on the growth of different types of saplings of *Dalbergia latifolia* through pot and field trials

2. To ascertain the association and variability of isolate of rhizobium with *Dalbergia latifolia* and to study the growth performance of this species by the innoculation of rhizobium

3. To study the clonal propagation of *Dalbergia latifolia*

4. To find out the best soil management technique and planting material giving maximum growth

2. REVIEW OF LITERATURE

The literature survey revealed that most of the studies so far conducted on the genus *Dalbergia* focused on *Dalbergia sissoo* and very few attempts were given to *Dalbergia latifolia* especially on the growth enhancement aspect.

Rai and Sharma (1993) reported that annual dbh increment under Kerala condition as 0.34 cm and it would take 148 years to reach a dbh of 60 cm at this rate. Rachmawati *et al.* (1996) reported a significant increase in height and diameter of *Dalbergia latifolia* with the application of urea fertilizer @ 90 g per hole in a vertisol dominated soil in Indonesia. The efficient VAM fungi in increasing the growth of *Dalbergia latifolia* were *Glomus leptotichum* and *Glomus fasciculatum* (Sumana and Bagyaraj, 1998). Sonkar *et al.* (1999) confirmed the suitability of *Dalbergia latifolia* in loamy skeletal and murrumy types of degraded soil of Jabalpur, India. An increasing trend in N content in the litter of *D.latifolia* was found from summer to winter (Pandit *et al.*, 1998)

Pradhan *et al.* (1998) developed an efficient protocol for large scale in vitro propagation of *D. latifolia* using cotyledonary nodes. Sharma and Pandey (1999a) and Sharma and Pandey (1999b) found that IBA at 5000 ppm gave best positive effects on shoot and rooting behaviour respectively in *Dalbergia latifolia*. Gera *et al.* (2000) also reported a good response of root cuttings under low cost mist conditions.

3. INFLUENCE OF DIFFERENT SOIL MANAGEMENT TECHNIQUES ON THE GROWTH OF *DALBERGIA LATIFOLIA*

In order to boost the growth of *Dalbergia latifolia* especially during the initial growth stages, different soil management practices including chemical fertilisers, organic manures, lime and their combinations were experimented through both pot and field trials. Pot trial was included mainly to ascertain the impact of various treatments on small volume of soil, which will be an exact indication of long term impact on soil in the field. Influence of various soil treatments were tested on different types of planting materials such as seedlings, suckers and rooted cuttings through both pot and field trials.

3.1 STUDY AREA AND METHOD

Pot trial

Site for pot trial was selected at the Field Research Centre of KFRI at Velupadam, in Thrissur Forest Division. Soil for pot trial were collected from 0-20 cm layer, made free of gravel and the sieved soil samples were analysed for pH, organic carbon and exchangeable Al. Suckers were collected from *Dalbergia latifolia* growing areas at Nilambur and raised in poly bags for rooting. Similarly, seeds collected from Sholayur in Attappady were used to raise seedlings in the nursery. The technology for the production of rooted cuttings from juvenile suckers and its mass multiplication (as described under objective 2) was possible at the end of the first year of the study and hence the trial for boosting its growth was carried out in the following year separately.

For conducting pot culture experiment, one hundred earthen pots of 30 cm diameter and 30 cm height were arranged in 10 rows with 10 pots in each row. As described in Table 1, there were nine treatments and one control replicated ten times. Treatments were applied randomly to respective pots which were filled with about 12 kg gravel free soil. Uniform sized healthy suckers along with the bowl of earth underneath were planted in these pots, kept under 50% shade net and watered regularly. Similarly, in another set of 100 pots with same treatments, seedlings were

planted. Initial growth measurements, pest and disease incidence and the control measures adopted

Table 1. Treatment details

Treatment No.	Treatment details
T1	Lime- 10 g
T2	Vermi compost- 1 kg
T3	Chemical fertiliser (Potash-15 g+ Amophos-50 g)
T4	Cowdung-1 kg
T5	Vermi compost-500 g + T3
T6	Lime-500 g+ Cowdung-500 g
T7	Cowdung- 500 g + T3
T8	Cowdung-500 g + Lime- 10 g+ T3
T9	Rhizobium,
Control	-

were recorded. Due to the vigorous growth of the plants in some of the treatments, it was impossible to retain them in the pots after a period of six months. So these plants were harvested after recording the growth measurements. During the following year, similar trial with same treatments were carried out using rooted cuttings for a period of six months and the growth measurements before and after the experiment were recorded. Statistical analysis of data was done using SPSS package. At the end of all the experiments soil samples were collected from all the pots and analysed for important parameters for assessing the quality of lateritic soil such as pH, organic carbon, exchange acidity, exchangeable Al etc. using standard procedures (Black *et al* 1965.).

Field trial

A field experiment was conducted at Nilambur sub centre campus of KFRI during 2001-2004. The soil in the area was reddish brown to reddish yellow lateritic with coarse sandy loam texture and granular to massive structure. It was acidic (pH 5.0 to 5.4), low in

organic carbon (0.62 – 1.2 %), available N (0.05-0.1%), extractable P (0.001-0.002%) and exchangeable K (0.01-0.03%).

The experiment was laid out in randomized block design with 10 treatments and 5 replications. Care was taken to ensure least heterogeneity within blocks as well as planting material. Every plot representing a treatment had 25 plants each. Same treatments (except rhizobium) which were applied in the pot trial were also used for field trial. The treatments cow dung, compost and lime were applied on per plot basis @ 25 kg, 6 kg and 0.5 kg respectively.

Root suckers were collected from natural *Dalbergia latifolia* area at Nellikkutha, Nilambur and planted in August 2001. Manuring was carried out during the North East monsoon of the same year and was repeated the following year and the next during South West monsoon. Measurements were recorded in March 2002, September 2002 and March 2003. Seedlings were raised at Nilambur from seeds collected from natural stands of Dalbergia at Sholayoor, Attappady. These seedlings were planted out in the experimental plots in June 2002 and manuring carried out during the North East monsoon of the same year, which was repeated in the next year during South West monsoon. Measurements were recorded in March 2003 and September 2003.

3.2. RESULTS AND DISCUSSION

3.2.1 Growth response

Pot trial

Growth of plants in response to various treatments in the pot culture experiment was studied by assessing the changes in the growth parameters such as height and girth at collar region (Table 2). Statistical analysis of data indicated that with the exception of lime and rhizobium, application of all other treatments resulted in significant increase in the height and girth of plants raised from suckers. The treatments cow dung + fertilizer, compost + fertiliser and chemical fertiliser alone yielded a maximum percentage increase of 483, 419 and 394 respectively over control while rhizobium and lime could contribute only 8 and 94 percentage respectively. Girth of plants also significantly increased in all

the treatments except lime and rhizobium. Maximum increase in girth was observed on application of cow dung + fertilizer followed by chemical fertilizer, compost + fertilizer, cow dung and compost. The above best treatments were effective in stimulating a significant increase in girth ranging from 152- 228%.

Table 2. Mean values of growth parameters in *Dalbergia latifolia* suckers as influenced by various soil treatments in pot trial

Treatment	Height(cm)				Girth at collar region (cm)			
	Initial	Final	Increment	% increase over control	Initial	Final	Increment	% increase over control
Lime	19.7	64.8	45.1^{a}	94	0.65	2.50	1.85^{ab}	55
Compost	17.9	115.2	97.3^{b}	319	0.71	3.67	3.0^{cd}	152
Chemical fertiliser	20.9	135.6	114.7^{b}	394	0.68	4.26	3.58^{cd}	200
Cow dung	22.6	132.9	110.3^{b}	375	0.61	3.96	3.35^{cd}	181
Compost+ fertiliser	28.0	148.5	120.5^{b}	419	0.69	4.12	3.43^{cd}	188
Cow dung + lime	21.7	128.3	106.6^{b}	359	0.75	3.43	2.68^{bc}	125
Cow dung + fertiliser	27.2	162.5	135.3^{b}	483	0.78	4.68	3.90^{d}	228
Cow dung +fertilizer + lime	16.0	117.5	101.5^{b}	337	0.78	3.69	2.90^{cd}	144
Rhizobium	21.5	46.7	25.2^{a}	8	0.69	1.92	1.03^{a}	-13
Control	21.5	42.7	23.2^{a}	-	0.71	1.95	1.19^{a}	-

n=10

Same superscripts denote non-significant difference.

The plants raised through seeds could attain a maximum increase in height in the treatments of compost, cow dung + fertiliser and cow dung + fertiliser + lime with a percentage increase varying from 177 to 239. Next to the above treatments, application of compost + fertilizer and cow dung were also effective in achieving a significant increase in height. As in the case of suckers, incorporation of lime and rhizobium into the

soil was not effective in increasing the height. The treatments which caused significant and maximum increase in height also resulted in maximum hike in the girth with 177-198% increase over control.

Table 3. Mean values of growth parameters in Dalbergia *latifolia* seedlings as influenced by various soil treatments in pot trial

Treatment	Height (cm)				Girth at collar region (cm)			
	Initial	Final	Increment	% increase over control	Initial	Final	Increment	% increase over control
Lime	14.6	64.8	50.3^{a}	54	0.65	2.26	1.61^{b}	43
Compost	13.3	120.4	107.1^{cde}	228	0.71	3.82	3.11^{ef}	177
Chemical fertiliser	13.2	142.4	129.3^{e}	297	0.68	2.96	2.28^{cd}	103
Cow dung	13.5	108.1	94.6^{cd}	190	0.61	3.08	2.47^{de}	120
Compost+ fertiliser	15.2	104.8	89.6^{cd}	175	0.69	3.16	2.47^{de}	120
Cow dung + lime	13.8	92.8	79.6^{bc}	144	0.75	2.72	1.97^{cd}	76
Cow dung + fertiliser	14.7	124.1	109.4^{de}	236	0.78	3.98	3.20^{ef}	186
Cow dung +fertilizer + lime	14.9	70.2	55.4^{ab}	70	0.78	4.12	3.34^{f}	198
Rhizobium	12.7	52.4	39.7^{a}	22	0.60	2.09	1.16^{ab}	3.6
Control	12.9	45.5	32.6^{a}	-	0.81	1.93	1.12^{a}	-

n=10

Same superscripts denote non-significant difference.

With regard to the plants raised from rooted cuttings, significant and maximum increment in height was brought out by the application of chemical fertilisers, cowdung + fertilisers and cowdung + fertiliser + lime. This was followed by the application of cowdung, compost and cowdung + lime. All other treatments were on par with the control. The percentage increase in height due to above treatments over control varied from 177-239. With the exception of lime, cow dung + lime and rhizobium all other treatments were on par and significantly increased the girth of plants compared to control. The percentage

increase in girth varied from 42-53 by the application of cowdung, compost and cowdung + lime.

Table 4. Mean values of growth parameters in rooted cuttings of *Dalbergia latifolia* as influenced by various soil treatments in pot trial

Treatment	Height (cm)				Girth at collar region (cm)			
	Initial	Final	Increment	% over control	Initial	Final	Increment	% over control
Lime	22.9	63.0	40.13^{a}	28	1.17	2.40	1.27^{ab}	-23
Compost	26.0	80.0	54.4^{ab}	74	1.0	3.12	2.12^{bc}	27
Chemical fertiliser	27.4	113.7	86.4^{bc}	177	0.92	3.29	2.37^{c}	43
Cow dung	25.6	83.9	58.3^{ab}	87	0.97	3.02	2.05^{abc}	23
Compost+ fertiliser	28.1	80.6	52.5^{a}	68	0.85	2.88	2.03^{abc}	22
Cow dung + lime	28.0	92.3	64.3^{ab}	106	1.0	2.80	1.80^{abc}	8
Cow dung + fertiliser	25.4	112.0	86.7^{bc}	178	0.87	3.23	2.36^{c}	42
Cow dung +fertiliser + lime	26.3	132.2	105.9^{c}	239	0.92	3.52	2.60^{c}	57
Rhizobium	29.4	62.8	33.5^{a}	7	0.89	2.31	1.42^{a}	-14
Control	27.6	58.8	31.2^{a}	-	0.73	2.39	1.66^{a}	-

n=10

Same superscripts denote non-significant difference.

Field trial

The following tables provide data on growth of seedlings as well as suckers under field trial at different growth stages.

Table 5. Mean values of height in Dalbergia *latifolia* seedlings as influenced by various soil treatments in field trial

Treatment	Mean height (cm)	
	6 months	12 months
Cow dung	33.15[b]	51.32[b]
Compost	32.8[b]	51.0[b]
Lime	31.75[c]	50.00[b]
Chemical fertiliser	40.57[a]	65.50[a]
Fertiliser + Cow dung	41.72[a]	66.49[a]
Fertiliser + Compost	33.31[b]	51.21[b]
Fertiliser + lime	31.75[c]	47.51[c]
Fertiliser + Cow dung + lime	44.08[a]	68.24[a]
Fertiliser+ Compost + lime	32.95[b]	50.50[b]
Control	27.72[d]	39.41[d]

Statistical analysis of data recorded six months after planting indicated that all treatments produced significant impact on height growth of seedlings. Fertiliser + cow dung + lime, fertilizer alone and cow dung + fertiliser exerted maximum influence on height growth of seedlings; their effects did not differ significantly. Other treatments in the descending order of influence were fertiliser + compost + lime, fertiliser + compost, cow dung, compost, fertiliser+lime and lime.

Chemical fertiliser application could bring about an increase of 46%, fertiliser + cow dung 51% and fertiliser + cow dung + lime 59% in the height growth of seedlings over that of control. Mean height of the best treatment was 44.08cm as compared to 27.72cm in control.

Statistical analysis of data recorded after one year revealed that all treatments were effective in improving the height of seedlings significantly. Treatments - fertiliser, fertiliser + cow dung and fertiliser + cow dung + lime brought about maximum increase in height of seedlings. These treatments did not differ among themselves. This was followed by cow dung, fertilizer + compost and fertiliser + compost + lime which also did not differ between themselves. Fertiliser + lime and compost came last in the order of influence.

Fertiliser applications could bring about an increase of 66%, fertiliser + cow dung 69% and fertiliser + cow dung + lime 73% in height of seedlings over that of control. Mean height of the best treatment was 68.24 cm as compared to 39.41cm of control.

Mean height of root suckers under each treatment at different periods depicted in Tables 6-7 is described below.

Table 6. Mean values of growth parameters in *Dalbergia latifolia* suckers as influenced by various soil treatments in field trial

Treatment	Mean Height			
	6 months	12 months	18 months	Gross Average of three periods
Cow dung	29.08^{cd}	45.33^{cd}	58.26^{cd}	42.50^{bcd}
Compost	28.80^{cd}	46.6^{cd}	59.2^{cd}	44.87^{bcd}
Lime	26.34^{de}	41.64^{de}	51.16^{de}	38.28^{cd}
Chemical fertiliser	49.01^{a}	78.96^{a}	98.99^{a}	72.61^{a}
Fertiliser + Cow dung	48.57^{a}	81.94^{a}	107.45^{a}	75.33^{a}
Fertiliser + Compost	33.78^{b}	54.87^{b}	78.02^{b}	52.49^{b}
Fertiliser + lime	30.30^{c}	48.52^{bc}	65.10^{c}	45.75^{bc}
Fertiliser + Cow dung + lime	52.72^{a}	80.48^{a}	106.06^{a}	76.62^{a}
Fertiliser+ Compost + lime	27.25^{cd}	42.39^{de}	58.79^{c}	40.80^{cd}
Control	22.35^{f}	38.05^{e}	46.39^{e}	34.04^{d}

Statistical analysis of data recorded 6 months after planting of suckers revealed that all treatments were significantly different from control. Highest increase in growth was obtained with the treatments fertilizer + cow dung + lime, fertiliser, fertiliser + cow dung and, there was no significant difference between these. This was followed by fertilizer + compost, fertiliser + lime, cow dung, compost, fertiliser + lime + compost and lime in the descending order of influence.

Fertiliser application could bring about an increase of 120%, fertiliser + cow dung 117% and fertiliser + cow dung + lime 136% in height growth over control. Mean height of the best treatment was 52.72cm as compared to 22.35cm in control plants.

Statistical analysis of data collected after one year indicated that greatest influence on growth was produced by fertilizer + cow dung + lime, fertiliser, fertiliser + cow dung and these treatments did not differ between themselves. This was followed by fertilizer + compost, fertiliser + lime, cow dung, compost and fertiliser + lime + compost.

Application of fertiliser could bring about an increase of 108% in height, fertiliser + cow dung 115% and fertiliser + cow dung + lime 112% over and above the control plants. Mean height of the best treatment (fertiliser + cow dung) was 81.94 cm as compared to 38.05 cm of control plants.

All treatments except lime produced significant effect on height growth of plants after one and a half year of planting. Greatest effect was brought about by fertiliser + cow dung, fertilizer + cow dung + lime, and fertilizer; there was no significant difference between these. This was followed by fertiliser + compost, fertiliser+ lime, compost, cow dung and fertiliser + compost + lime. Fertiliser could cause an increase 113%, fertiliser + cow dung 132 % and fertilizer + cow dung + lime 129% in height growth over that of control. Mean height of the best treatment, fertiliser + cow dung, was 107.45cm compared to 46.39cm in control.

Gross average in height of the three periods also followed the same pattern as regards the treatments that yielded best results.

Cow dung, compost and lime in combination with other treatments were applied as soil improvers /ameliorants. They have shown their impact by making significant influence on height growth of seedlings. But maximum influence was shown by chemical fertiliser either alone or in combination with cow dung, compost and lime. This is natural considering the soil that is poor in NPK, which has responded fairly well to its application.

Data on growth response to various treatments in general indicated that *Dalbergia latifolia* is highly responsive to nutrient inputs irrespective of the nature of planting material. Whatever may be the source of nutrients, either organic, chemical or their combination, growth can be boosted considerably within a short period of time. Hence it

is assumed that lack of adequate nutrition might be a prime factor for the slow growing nature of *Dalbergia latifolia* under natural condition in addition to the ecological factors such as grazing, incidence of fire etc. The poor response of plants to rhizobium is thought to be due to the lack of nodule development during the study period. Even though the application of lime improved the soil pH (as described under 3.2.2) resulting in the enhanced availability of essential nutrients, it was not sufficient to have a significant hike in growth.

Thus the results of the present study indicated that growth of *Dalbergia latifolia*, which is naturally slow, can be boosted by the application of chemical fertiliser, compost or cow dung either alone or in combination irrespective of the planting material.

3.2.2 Soil characteristics

Important properties of lateritic soil such as pH, organic carbon, exchange acidity and exchangeable Al which have a pronounced influence on the quality of soil were determined to find out the impact of various treatments on soil. Soil analysis data (Table 7) revealed that application of lime caused a significant and maximum improvement of soil pH from 4.76 to 6.14. The order of other treatments which caused a significant hike in soil pH were compost > cow dung + lime > cow dung > compost + fertiliser. Application of cow dung + lime + fertiliser and rhizobium didn't produce any impact on soil pH compared to control while application of chemical fertilizer was found to lower the pH of soil.

Soil organic carbon content was greatly improved by the application of compost followed by cow dung + fertiliser, cow dung, cow dung + lime + fertiliser and compost + fertliser. Application of rhizobium, chemical fertilizers and lime were on par with control without causing any significant change in the organic carbon status. Soil treatment with fertiliser alone and cow dung + fertiliser were increasing the acidity and exch.Al status of the soil while other treatments caused a significant drop in these properties .

Table 7. Influence of various treatments on soil properties

Treatments	Soil characteristics			
	pH	Organic carbon (%)	Exchange acidity cmol(+)/kg	Exchangeable Al cmol(+)/kg
Initial	4.74 [d]	1.30[a]	1.20[c]	0.39[ab]
Lime	6.14 [a]	1.53[a]	0.26[a]	0.1[a]
Compost	5.86 [b]	2.01[c]	0.18[a]	0.02[a]
Chemical fertiliser	4.46 [e]	1.33[a]	1.57[cd]	1.35[c]
Cowdung	5.41 [c]	1.73[bc]	0.34[a]	0.22[a]
Compost + fertiliser	5.18 [c]	1.64[bc]	0.33[a]	0.19[a]
Cowdung + lime	5.73 [b]	1.49[a]	0.27[a]	0.12[a]
Cowdung + fertiliser	4.45 [e]	1.76[bc]	1.39[c]	0.26[ab]
Cowdung+lime+ fertiliser	4.77 [d]	1.70[bc]	1.21[c]	0.85[ab]
Rhizobium	4.83 [d]	1.35[a]	0.79[b]	0.64[ab]
Control	4.76 [d]	1.28[a]	1.22[c]	0.43[ab]

Soils of Kerala in general are acid in reaction and hence any nutrient management practice which will have a significant impact in decreasing the soil acidity assume great importance. Results of the present study give an indication that application of cow dung, compost and compost + fertiliser improves soil pH by lowering exchange acidity and exchangeable Al. Similarly, organic manures either alone or in combination with fertiliser enrich the organic matter pool thereby improving the overall health of soil. But the application of chemical fertiliser increased the exchange acidity and exchangeable Al and hence no improvement in soil pH was observed. Also its contribution to enrich the organic matter pool of the soil was negligible. Even though, application of lime improves the soil pH and ameliorates exchangeable Al to a great extent, it fails to improve the soil organic carbon status due to its inorganic nature. Thus the study suggests that applications of organic manures either alone or in combination with chemical fertilisers are advisable to improve the quality of soil since they add much to the organic pool as well as lower soil acidity and exchangeable Al.

4. ASSOCIATION AND VARIABILITY OF *RHIZOBIUM* AND ITS EFFECT ON THE GROWTH OF *DALBERGIA LATIFOLIA*

Nitrogen fixing trees are able to establish and thrive in nitrogen deficient degraded soil. The low pH, which is the inherent character of degraded tropical soils, is one of the most serious impediments for nitrogen fixation. With a few exceptions, most of the leguminous plants can fix atmospheric nitrogen through the root nodules developed by the bacterium, *Rhizobium*. *Dalbergia latifolia* Roxb. is a leguminous tree, which fixes nitrogen in their root nodules. The present study was conducted to study the association of *Rhizobium* and its effect on growth of *D. latifolia*

4.1 ISOLATION OF *RHIZOBIUM* FROM ROOT NODULES

Root nodules were collected from the roots of trees of *D. latifolia* growing in three localities such as Peechi, Veluppadam and Nilambur. *Rhizobium* was isolated in pure culture as described by Vincent (1970). Healthy nodules from the roots were washed free of surface soil. These were first surface sterilized in 95 % ethyl alcohol for 10 seconds and then 0.1 % acidified mercuric chloride solution for three minutes. The nodules were further washed in 5 changes of sterile distilled water in Petri dishes. These sterile nodules were transferred to a test tube containing one ml of sterile distilled water and crushed with a sterile glass rod to prepare nodule suspension. A loopful of the nodule suspension was streaked on yeast mannitol Congo red agar (Appendix 1) for isolation of colonies. The plates were incubated at $26 \pm 2\ ^{0}C$ for five days

4.2 SCREENING OF DIFFERENT *RHIZOBIUM* ISOLATES FOR TESTING THE EFFICACY

The rhizobial isolates were tested for their efficacy in poly pots using sterilized sand-soil mixture. Good seeds collected from healthy trees of *D. latifolia* from Nilambur were used for this study. Pods were surface sterilized with 0.1 % mercuric chloride for 25 seconds and using a sterile scalpel, the seeds were separated from the pods and sown in poly bags

containing sterilized sand-soil mixture. The poly bags were kept in glass house and watered regularly with sterile water.

A loopful of Rhizobial cultures isolated from Nilambur (RN), Peechi (RP) and Veluppadam (RV) was inoculated into 25 ml of the yeast mannitol broth in 100 ml conical flask and incubated for 5 days under aerobic condition. Two ml of inoculum containing 35 x 10^7 colony forming unit/ml was added to the 7-day-old *Dalbergia* seedlings growing in polybags in glass house. Ten replications were maintained for each isolate. The plants were watered with sterilized water. After 45 days, the seedlings were removed carefully with their root system intact. Fresh weight and dry weight of shoot and root, number of nodules and fresh and dry weight of nodules were recorded. The best strain of *Rhizobium* was selected based on the above observations and later used for the field studies.

4..3 FIELD TESTING WITH EFFECTIVE *RHIZOBIUM* CULTURE

Based on the biomass of shoot and root and number and weight of nodules, *Rhizobium* isolated from Nilambur (RN) was selected for the field study. A loopful of *Rhizobium* culture was inoculated into 25 ml of the yeast mannitol broth in 100 ml conical flask and incubated for 5 days under aerobic condition.

Site for pot trial was selected at Velupadam. Pots for pot trial were purchased and they were kept in the shed constructed for that purpose. Soil collected for pot trial was made free of gravel and the sieved soil samples were analyzed for pH, organic carbon and exchangeable Al.. Based on the status of these soil properties, the amount of lime, compost, cow dung and chemical fertilisers to be applied were found out. Pots were filled with soil and the treatments were applied to respective pots. There were 9 treatments with 10 replications. Seedlings were planted in these pots. Similarly in another set of 90 pots suckers were planted.

Ten milliliter of the inoculum containing 35 x 10^7 colony forming unit/ml was added to the plants growing in pots. Watering was done regularly. Growth measurements were taken at the end of the experiment.

4. 4 RESULTS AND DISCUSSION

4.4.1 Culture characters

After incubation for five days, typical transparent water clear or white colonies growing on the media appeared. The growth of *Rhizobium* was confirmed by growing the colonies in yeast mannitol agar medium with 2.5 ml of 1.0 per cent Congo red per plate. In each Petri dish 15-20 ml of the medium was poured and allowed to solidify. The isolated young (3-day –old) cultures were streaked on the agar medium and the inoculated plates were incubated for seven days at 26 ± 2 ^{0}C. None of the isolate absorbed Congo red. It is confirmatory that the isolates were *Rhizobium* because little or no absorption of Congo red by colonies was confirmatory to *Rhizobium* (Fig. I). The rhizobial colonies were selected and purified and maintained in yeast mannitol agar slants for further studies. All the isolates were fast growers and took 5-7 days to grow into a large mucoid colony.

4.4.2 Screening of different isolates for testing the efficacy

From the inoculation studies on the seedlings, it was found that all the cultures were capable of forming nodulation on *Dalbergia* seedlings (Figs. 6a, 6b and 6c). From the

result it was found that the seedlings inoculated with *Rhizobium* from Nilambur (RN) had more shoot and root biomass and root nodules than Veluppadam (RV) and Peechi (RP).

Field testing with effective *Rhizobium* culture is explained under objective 1.

5. CLONAL PROPAGATION OF *DALBERGIA LATIFOLIA*

The usual method followed for raising planting stock begins with collection of seeds from seed stands. The seeds are used to raise nurseries of quality seedlings. But, in this practice all the desired characters of the parent trees will not be transferred to their progenies because of recombination and segregation of genes responsible for the characters. However, if propagules are produced through vegetative multiplication, it is possible to retain the genotype of the parent plants and transfer all the characters to its young ones. Clonal propagation is an important component of tree improvement programme. Uniformity among individuals in population is achieved by cloning.

5.1 Rooting of *D. latifolia*

For rooting *Dalbergia latifolia,* juvenile shoots are produced by planting root suckers. Healthy root suckers were uprooted from Nilambur, where *D. latifolia* is growing naturally. The root suckers were planted in clay pots and watered every day. New shoots are developed after two months. The apical bud portion of the shoot was taken for rooting. The length of the shoot was 12-15 cm and with at least 4-5 leaves. For prophylactic treatment, the prepared shoots were immersed in fungicidal (Bavistin) solution (1 gm/l water) for 10-15 min.

For standardizing the dosage of rooting hormone, juvenile shoots of 45 days old were treated with different concentrations of Indole Butyric Acid (IBA) such as 4000, 5000 and 6000 ppm. Different concentration of hormone was prepared by mixing the required

quantity of IBA with 100 g of inert talcum. The hormone is mixed thoroughly with talcum using a blender. The apical shoots are dipped in the hormone for 1 cm deep and the excess hormone sticking on the stem was removed by tapping off gently and planted in reddish soil in iron trays.

5.2 Effect of rooting medium and concentration of rooting hormone on rooting and sprouting of *D. latifolia*

To find out the best medium and ideal concentration of hormone for rooting and sprouting, 100 shoots each were treated with different concentration of IBA such as 4000, 5000 and 6000 ppm and planted in vermiculite as well as red soil in iron trays and kept in mist chamber (Fig. 8). The temperature and relative humidity inside the chamber was maintained at 32 ^{0}C and 65-80% respectively.

5.3 RESULTS

5.3.1 Rooting of *D. latifolia*

Rooting initiated after 15 days (Fig 9a). New shoots were developed from the cuttings after 30 days (Fig. 9b). The sprouted cuttings were retained in mist chamber for a further period of 15 days and then transferred to hardening shed and retained for 2 weeks. Later they were transferred to another hardening shed for 15 days and transplanted

individually in poly bags and kept in open space for hardening (Fig. 9). The transplanted ramets were maintained for two months before planting in the field. The root and shoot systems of the cutting was well developed and healthy.

5.3.2 Effect of rooting medium and concentration of rooting hormone on rooting and sprouting of *D. latifolia*

The percentage of shooting and rooting in different medium and different concentration of rooting hormone is given in Table 8.

Table 8. Effect of rooting medium and concentration of rooting hormone on rooting and sprouting of *D. latifolia*

Concentration of the hormone	Rooting percentage	
	Vermiculite	Red soil
4000 ppm	10	12
5000 ppm	25	85
6000 ppm	25	30

The table shows that the best concentration for higher rooting and shooting was found to be 5000 ppm of IBA. Between the two different rooting media red soil was good for higher rooting.

6. SELECTION OF BEST TREATMENT AND PLANTING MATERIAL

Based on the results of pot and field trials it was seen that application of chemical fertiliser, cow dung and compost either alone or in combination with chemical fertiliser caused remarkable increase in the growth of *Dalbergia latifolia* compared to control. Among the above treatments, application of chemical fertiliser was found to decrease the quality of soil by increasing acidity coupled with no improvement in organic matter content and Al chelation. Therefore, application of chemical fertiliser is not advisable even though it is boosting the growth of plants. On the other hand, application of cow dung or compost either alone or in combination with fertiliser was found to improve the soil along with the growth of plants. So these treatments are suggested for sustainable growth of *Dalbergia latifolia* under plantation programme.

In the present study, root suckers were collected from natural stands of *Dalbergia latifolia* and hence the age of suckers is not known. As described under the objective 3,

rooted cutting were developed from above suckers. Thus the age of planting materials is not known except those of seedlings. Statistical comparison is possible only between the plants of same age. However, all the three types of planting materials used in the study responded very well to the above treatments and the maximum growth response were observed in root suckers followed by seedlings and cuttings.

7. CONCLUSION

Based on the above study it is concluded that application of organic manures such as cow dung (1kg/plant) or compost (1kg/plant) either alone or in combination with chemical fertiliser (½ kg cow dung or ½ kg compost + potash-15g + amophos-50g) was effective in achieving a sustainable increase in the growth of *Dalbergia latifolia* coupled with improvement in soil quality. All the three types of planting materials used in the study responded very well to the above treatments and the maximum growth response was observed in root suckers followed by seedlings and cuttings. The best strain of rhizobia was isolated from those collected from Nilambur and all the cultures were capable of forming nodulation on *Dalbergia* seedlings. But the application of these rhizobia had no significant impact on the growth of *Dalbergia latifolia*. In order to produce rooted cuttings from suckers the best concentration of IBA was 5000 ppm .

.

8. ACKNOWLEDGEMENTS

We express our sincere gratitude to Dr. J.K. Sharma former Director, KFRI and Dr. R. Gnanaharan, Director, KFRI for their kind support and constant encouragements, Dr. U.M. Chandrashekara and Mr. K.K. Unni for support in the field and pot trials, Smt. K. Remadevi, for laboratory assistance and Mr. Sajeev Kumar for assistance in pot trial.

Financial assistance given by the Kerala Forest Department under Forest Development Fund is also gratefully acknowledged.

9. REFERENCES

Black, C.A., Evans, D.D., Ensminger, L.E., White, J.L. and Clark, F.E.,1965, Methods of soil anlysis . Part I , American Society of Agronomy . Inc, Madison, Wisconsin, USA.

Gera, M., Gera, N. and Singh,V.K. 2000, Rooting response of root cuttings of some MPT species under low cost mist conditions. *Indian Forester*, 126: 2, 171-174.

Pradhan,C., Pattnaik, S. and Chand, P.K.1998, Rapid invitro propagation of east Indian rose wood (*Dalbergia latifolia* Roxb.) through high frequency shoot proliferation from cotyledonary nodes. *Journal of Plant Biochemistry and Biotechnology*, 7: 1.61-64.

Pandit , B.R., Prasannakumar, P.G., and Jana, C.K. 1997. Seasonal variations in lead content in Dangs forest Gujrat, *Advances in Plant sciences*, 10:2, pp.145-148.

Rachmawati , I., Effendi, M., and Sinaga, M.,1996, Growth and development performance of multipurpose tree species under the effects of fertilizer. *Buletin-penelitian Kehutanan- Kupang*. 1:2.. 43-51.

Rai, S.N., and Sharma, C.R.,1993, Diameter increment in *Artocarpus hirsuta* , *Dalbergia latifolia* and *Grewia tilaefolia* in the mixed deciduous forests of Wayanad Kerala. *India Forester*, 119: 1. 11-16.

Sharma, L.K., and Pandey, O.N.,1999a, Plant growth regulators and shoot behaviour of Dalbergia cuttings. *Journal of Research- Birsa Agricultural University*, 11:1, 109-112.

Sharma, L.K., and Pandey, O.N., 1999b,.Effect of plant growth regulators on rooting behaviour of cuttings of *Dalbergia latifolia* Roxb. and *Dalbergia sisso* Roxb, *Indian Forester*, 125: 4. 421- 426.

Sonkar, S.D., Sigh, A.K., Nath, V., and Bannerjee, S.K.,1999, Performance and suitability of some nitrogen and non-nitrogen fixing tree species in loamy skeletal soil of Jabalpur (M.P). *Environment and Ecology*, 17: 4,pp. 818-822.

Sumana , D.J., D.A., and Bagyaraj, 1998 Selection of efficient VA mycorrhizal fungi for *Dalbergia latifolia* Roxb *Annals of Forestry*, 6:2, pp.186- 190.

Ingredients	Quantity
Mannitol	10.0g
K_2HPO_4	0.5 g
$MgSO_47H_2O$	0.2 g
NaCl	0.1 g
Yeast extract	0.5 g
Agar	20.0 g
Distilled water	1000 ml
pH	7.0-7.2

Vincent, J.M., 1970,. A manual for the practical study of the root nodule bacteria. International Biological Programme Handbook, 15 Blackwell Science Publications, Oxford, 164 .

Appendix 1

Yeast Mannitol Agar (Vincent 1970)

Appendix 1

Yeast Mannitol Agar (Vincent 1970)

Ingredients	Quantity
Mannitol	10.0g
K_2HPO_4	0.5 g
$MgSO_47H_2O$	0.2 g
NaCl	0.1 g
Yeast extract	0.5 g
Agar	20.0 g
Distilled water	1000 ml
pH	7.0-7.2