

Original Research Article

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Growth and Physiology of High Density *Dalbergia sissoo* Tree Plantations under Micro Fertigation System

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ABSTRACT

Keywords

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A field trial was conducted to standardize water and nutrient requirement for raising tree species in High Density Plantation and to study the impact of balanced fertilization on growth and physiology of tree species. The experiment was laid out in split plot design comprised of main plot with irrigation treatment and sub plot with fertilizer levels. Water requirement of the tree plantation was calculated using the pan evaporation (PE) data. Fertigation schedule consisted of humic acid (62.5 litre ha⁻¹), inorganic fertilizer level of 150:100:100 kg N, P and K ha⁻¹ (100% recommended dose) was applied in the form of urea, single super phosphate and muriate of potash and humic acid (62.5 litre ha⁻¹) + 75:50:50 kg N, P and K ha⁻¹ (75 % recommended dose). The maximum height increment of 5.28 m, maximum basal diameter increment of 51.19 mm and maximum volume index (1.19) was recorded in the treatment that received irrigation @125 % PE and fertigation with 150:100:100 kg of N, P, K ha⁻¹. The physiological parameters in terms of photosynthetic rate, transpiration rate, and stomatal conductance activities were found highest in treatment which received irrigation @125 % PE and fertigation with 150:100:100 kg of N, P, K ha⁻¹.

Introduction

Under Green India Mission 2014, more importance was given to agro-forestry aspects for achieving 33% green cover through planting of commercial tree species in farm lands. Increasing demand coupled with low productivity and long rotation period is one of the major concerns faced by wood based industries. Improved planting material coupled with location specific silvicultural technologies with the idea of “Precision

Silviculture” will improve the productivity of the plantations (Petronela, 2010).

In Tamil Nadu, the average annual rainfall of 961.8 mm is received in 40-45 rainy days and hence practically, it is not possible to meet the demand of irrigation by rainfall alone. Micro-irrigation system has the benefit of providing the highest water use efficiency of all forms of irrigation nearly 90 per cent (Jata *et al.*, 2013).

Dalbergia sissoo is also known as Indian Rosewood belongs to Fabaceae family and its heartwood is very hard with a specific gravity of 0.62 -0.82. *Dalbergia sissoo* is one of the indigenous species with short rotation. *Dalbergia sissoo* is a medium to large sized tree belonging to family –Leguminosae and subfamily *Papilionioideae*. It attains a height upto 30 m. This genus has about 300 species of tropical and sub-tropical timber tree species. It is having multiple uses such as fuel, wood, fodder, shade, and nitrogen fixing ability. The species occur throughout the Sub-Himalayan tract and outer Himalayan valleys from Indus to Assam, usually upto 900 m and occasionally ascending to 1500 m.

Sharma *et al.*, (1988) reported that annual uptake of nutrients, 63% N, 50% P, 48% K, 67% Ca and 57% of Mg are returned to the soil annually through litterfall in case of *Dalbergia sissoo* plantation and N was highest in leaf. The present research has been conducted to standardize water and nutrient requirement for raising this tree species in High Density Plantation and to study the impact of balanced fertilization on growth and physiology of tree species.

Materials and Methods

A field trial was conducted in Forest College and Research Institute, Mettupalayam. The soil of the experimental field was Illupanatham soil series. The soil was loamy sand in texture, well drained, slightly alkaline in reaction (pH of 7.87) and non saline (EC 0.20 dSm⁻¹). The initial soil fertility was low in available N (154 kg ha⁻¹), medium in available P (5.50 kg ha⁻¹) and high in available K (223 kg ha⁻¹). The surface soil was low in organic carbon content (0.45 per cent) (Table 1). The experiment was laid out in split plot design comprised of main plot with irrigation treatment and sub plot with fertilizer levels. Water requirement of the tree

plantation was calculated using the pan evaporation (PE) data. Fertigation schedule consisted of humic acid (62.5 litre ha⁻¹), inorganic fertilizer level of 150:100:100 kg N, P and K ha⁻¹ (100% recommended dose) was applied in the form of urea, single super phosphate and muriate of potash and humic acid (62.5 litre ha⁻¹) + 75: 50:50 kg N, P and K ha⁻¹ (75 % recommended dose). The biometric observations were recorded at 1 MAP, 4 MAP, 7 MAP and 9 MAP in seedlings per treatment per replication and the mean value for each parameter was calculated. The total height of the trees was measured from the ground level to the leading terminal tip using the standard scale and is expressed in metre. Basal diameter is measured with the help of digital vernier caliper in the ground level and expressed in mm. Volume index was calculated as per the formula given below. (Hatchell, 1985)

$$VI = \text{Basal diameter (mm)} \times \text{Height (m)}$$

The ecophysiological characters were measured using a Portable Photosynthesis System (PPS, model LCpro+ Photosynthesis System CO₂ gas analyzer, UK) to assess the impact on the physiology of the tree species. The measurements were made on fully matured leaves (5-6 leaves from the bud) at 4 MAP and 8 MAP on a sunny day between 10.00 AM to 11.00 AM. The photosynthetic rate of trees was measured using the Portable Photosynthesis System (PPS, Model LC pro+ Photosynthesis System CO₂ gas analyzer, UK). The PPS measures the uptake of CO₂ and estimates the photosynthetic productivity using Infra Red Gas analyzer (IRGA) and is expressed in $\mu \text{ mol. m}^{-2} \text{ s}^{-1}$. The stomatal conductance and transpiration rate were also measured by using the Portable Photosynthesis System (PPS, Model LC pro+ Photosynthesis System CO₂ gas analyzer, UK) and expressed in $\text{m mol. m}^{-2} \text{ s}^{-1}$.

Results and Discussion

Growth parameters

Among the various irrigation regimes, irrigation @125 % PE recorded the maximum height of 4.37 m and was on par with the irrigation @100 % PE. Fertigation of inorganic, conventional fertilizer level of 150:100:100 kg N, P and K ha⁻¹ recorded the highest value of height (5.10 m) at 9 MAP (Table 2).

Irrigation @ 125 % PE recorded the maximum basal diameter of 46.42 mm followed by Irrigation @ 100 % PE during the growth stage of 9 MAP (44.77 mm). Basal diameter varied significantly within the trees in the plantation. Fertigation of 150:100:100 kg N, P and K ha⁻¹ recorded the highest value of basal diameter (49.58 mm) at 9 MAP (Table 2).

The highest volume index of 0.99 was recorded in the treatment that received irrigation @100% PE followed by the volume indices of 0.96 and 0.86 in I₂ (125 % PE) and I₃ (150 % PE). Application of conventional water soluble fertilizer @ 150:100:100 kg N, P and K ha⁻¹ through fertigation registered the highest volume index of 1.09 followed by the treatment of humic acid (62.5 litre ha⁻¹) + 75: 50:50 kg N, P and K ha⁻¹ (0.88) and the lowest volume index of 0.83 was recorded in the treatment that received liquid organic fertilizer humic acid @ 62.5 litre ha⁻¹ (Table 2).

Irrigation @ 100% PE, 125% PE and fertigation with 150:100:100 kg N, P and K ha⁻¹ recorded the highest values of growth parameters. Similar observations were registered by Lisa *et al.*, (2009) in pine (*Pinus taeda* L.) plantations.

Physiological parameters

Physiological parameters viz., photosynthetic rate, transpiration rate and stomatal conductance were measured during 4 and 8 MAP. The highest photosynthetic rate of 7.66 $\mu\text{mol m}^{-2} \text{s}^{-1}$ was recorded in the fertigation treatment of 150:100:100 kg N, P and K ha⁻¹ followed by humic acid (62.5 litre ha⁻¹) + 75: 50:50 kg N, P and K ha⁻¹ (7.31 $\mu\text{mol m}^{-2} \text{s}^{-1}$). The minimum photosynthetic rate of 7.18 $\mu\text{mol m}^{-2} \text{s}^{-1}$ was registered by humic acid @ 62.5 litre ha⁻¹ (Table 3).

Fertigation treatment of 150:100:100 kg N, P and K ha⁻¹ recorded the highest value of transpiration (8.57 $\text{m mol m}^{-2} \text{s}^{-1}$) followed by humic acid (62.5 litre ha⁻¹) + 75: 50:50 kg N, P and K ha⁻¹ (6.87 $\text{m mol m}^{-2} \text{s}^{-1}$) and the least value of 5.75 $\text{m mol m}^{-2} \text{s}^{-1}$ was observed in the treatment of by humic acid @ 62.5 litre ha⁻¹ (Table 2).

Among the fertigation levels 150:100:100 kg N, P and K ha⁻¹ recorded significantly highest value of stomatal conductance (0.15 $\text{m mol m}^{-2} \text{s}^{-1}$) followed by humic acid (62.5 litre ha⁻¹) + 75: 50:50 kg N, P and K ha⁻¹ (0.12 $\text{m mol m}^{-2} \text{s}^{-1}$) and the least value of stomatal conductance (0.10 $\text{m mol m}^{-2} \text{s}^{-1}$) was observed in the treatment of by humic acid @ 62.5 litre ha⁻¹ (Table 2).

Fertigation with 150:100:100 kg N, P and K ha⁻¹ recorded the highest values of photosynthetic rate, transpiration rate and stomatal conductance. Increased water use in irrigated stands was associated with higher sapwood area, stomatal conductance and transpiration per unit leaf area (Robert *et al.*, 2010).

Micro irrigation and fertigation treatments were found to improve the physiological trait which in turn has positive significant effect on the growth of the tree plantation.

Table.1 Initial Soil characteristics of experimental soil

Parameter	Value
Texture	Loamy sand
Soil series	Illupanatham
Soil reaction	7.87
Electrical conductivity (dSm^{-1})	0.20
$\text{KMNO}_4\text{-N}$ (kg ha^{-1})	154.0
Olsen-P (kg ha^{-1})	5.50
$\text{NNNH}_4\text{OAC-K}$ (kg ha^{-1})	223.0
Organic carbon (g kg^{-1})	4.50

Table.2 Effect of fertigation on growth parameters of *Dalbergia sissoo* tree plantation

(Mean of 3 replications)

Irrigation Fertigation regimes	Height (m)				Basal diameter (mm)				Volume index			
	1 MAP	4 MAP	7MAP	9 MAP	1 MAP	4 MAP	7MAP	9 MAP	1 MAP	4 MAP	7MAP	9 MAP
I1	1.32	2.54	3.23	4.27	12.52	22.19	31.57	44.77	0.02	0.12	0.27	0.99
I2	1.13	2.24	3.00	4.37	9.93	17.94	27.35	46.42	0.01	0.07	0.26	0.96
I3	1.12	2.07	2.81	4.08	9.09	17.04	26.57	42.71	0.01	0.07	0.23	0.86
CD ($p=0.05$)	0.16*	0.46*	0.23*	0.30*	1.81**	2.94**	3.56*	2.65*	0.005**	0.03**	0.13*	0.14*
F1	1.23	2.21	2.93	3.76	10.79	19.64	27.53	41.38	0.02	0.09	0.23	0.83
F2	1.27	2.57	3.35	5.10	11.23	19.90	31.51	49.58	0.02	0.09	0.36	1.09
F3	1.07	2.08	2.75	3.85	9.52	17.63	26.45	42.94	0.01	0.07	0.17	0.88
CD ($p=0.05$)	0.13**	0.18**	0.14**	0.34**	1.43*	1.84**	1.21**	2.59**	0.005*	0.02*	0.08**	0.13**

Table.3 Effect of fertigation on physiology of *Dalbergia sissoo* tree plantation

(Mean of 3 replications)

Irrigation / Fertigation regimes	Photosynthetic rate ($\mu \text{ mol m}^{-2} \text{ s}^{-1}$)		Transpiration rate ($\text{m mol m}^{-2} \text{ s}^{-1}$)		Stomatal conductance ($\text{m mol m}^{-2} \text{ s}^{-1}$)	
	4 MAP	8 MAP	4 MAP	8 MAP	4 MAP	8 MAP
I1	7.53	8.17	5.12	7.11	0.12	0.12
I2	7.42	8.18	5.44	7.53	0.12	0.12
I3	7.20	8.16	4.82	6.54	0.12	0.12
CD ($p=0.05$)	NS.	NS.	0.18**	0.20**	NS	NS
F1	7.18	8.13	4.09	5.75	0.10	0.10
F2	7.66	8.25	6.57	8.57	0.14	0.15
F3	7.31	8.13	4.73	6.87	0.12	0.12
CD ($p=0.05$)	0.22**	0.24*	0.17**	0.21**	0.003**	0.003**

The maximum height increment of 5.28 m, maximum basal diameter increment of 51.19 mm and maximum volume index (1.19) was recorded in the treatment that received irrigation @125 % PE and fertigation with 150:100:100 kg of N, P, K ha⁻¹. The physiological parameters in terms of photosynthetic rate, transpiration rate, and stomatal conductance activities were found highest in treatment which received irrigation @125 % PE and fertigation with 150:100:100 kg of N, P, K ha⁻¹.

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