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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(11): 543-545 © 2021 TPI
www.thepharmajournal.com
Received: 03-08-2021
Accepted: 16-10-2021

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Biochemical response of teak (*Tectona grandis* Linn. f) under drip fertigation systems during early growth phase

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Abstract
Teak is considered as "King of timbers" and is one of the most prominent tropical hardwoods with huge demand. The experiment consists of 4 irrigation levels *viz*., I_1 – 50%, I_2 – 75%, I_3 – 100%, I_4 – 125% of calculated water requirement of tree (WRt) as main plots and 3 fertigation levels *viz*., F_1 – 75%, F_2 – 100%, F_3 - 125% of recommended dose of fertilizer (RDF) as sub plots. Surface application of irrigation and fertilization was kept as control. The experiment was laid out by split plot design with 3 replications. Biochemical responses were assessed in terms of Chloropyll (a, b and total) using standard scientific methodology. The statistical analysis of the result found significant differences at 0.05 level. The various irrigation and fertigation regimes had a significant difference on the biochemical traits of leaves, the interaction study between irrigation and fertigation had also significant impact over the chlorophyll content. The quantitative determination of biochemical estimates of leaf samples showed significantly higher under M_3 i.e., 100% PE and F_3 i.e, 125% RDF level. The drip system was observed to the higher than the conventional method in accumulation of chlorophyll.

Keywords: Teak, Drip system vs conventional, biochemical traits

Introduction

Teak (*Tectona grandis* Linn. f) known as "king of timber" and it is one of the most valuable timber species in the world predominately distributed in tropical or sub-tropical countries. It is a large, deciduous tree belonging to the family Lamiaceae that occurs in mixed hardwood forests. *Tectona grandis* grows well in deep, well drained alluvial soil (Kulkarni, 1951; Puri, 1951) [8] and is native to South and Southeast Asian countries, mainly Bangladesh, India, Indonesia, Malaysia, Myanmar, Laos, Thailand, and Sri Lanka.

Owing to its higher timber qualities, market demand, ease of domestication and cultivation, teak plantation have been widely established throughout the tropics since 1850s (FAO,1957) [3]. The total wood demand in India is estimated to be 199 M cu.m and Teak demand is almost half of the total round wood production (95 M cu.m) (FAO, 2019). Though teak is the most important and widely planted member of Lamiaceae family (Robertson and Reilly, 2004) [10], successful teak plantations are only found in discontinuous regions within the tropical climate zones (Kyaw *et al*., 2020) [6]. India alone consumes 70 to 100 per cent of teak logs from Africa and Latin America and 90,000 cu.m of Teak import annually (Shrivastava and Saxena, 2017) [12]. In order to meet the increased demand of timber in the global scenario, productive output should be supplied at a shorter rotation period. Resource inputs like irrigation and fertilizers coupled with the specific precision silvicultural operations will improve the productivity of the plantation tree species.

Fertigation is a one-such new approach in which fertilisers are delivered in combination with irrigation water via a drip system to enhance fertiliser use efficiency while also enhancing yields (Zafari *et al*, 2019) [18]. A properly installed drip fertigation system based on fertilizer schedule supplies resources at a precise rate, duration, and frequency that lead to the maximization of water and nutrient uptake with minimal rate of leaching loss from the root system (Gardenas *et al.*, 2005) [4]. The shrinking availability of land and water resources, increasing fertilizer prices, energy crisis, wide spread pollution and fast degradation of natural resources further emphasizes the need for improving water and fertilizer use efficiency (Solaimalai *et al*., 2005) [13].

Despite the fact that very minimal research has been done in India, the positive outcomes of these investigations have shown that this technique has enormous potential for use in a variety of species across the country (Yadav *et al*, 2016) [16]. Based on such synchronization the current study was carried out on teak productivity enhancement by assessing its biochemical traits particularly in early growth stage (up to 3 years) under drip fertigation technology.

Materials and Methods

Field experiment was carried out during 2020 – 2021 at Pachapalayam, Coimbatore district, Tamil Nadu to study the response biochemical attributes of different fertigation levels versus conventional method in four months old teak plantation. The experiment consists of four irrigation levels *viz*., I_1 – 50%, I_2 – 75%, I_3 – 100%, I_4 – 125% of calculated water requirement of tree (WRt) as main plots and three fertigation levels *viz*., F_1 – 75%, F_2 – 100%, F_3 - 125% of recommended dose of fertilizer (RDF) as sub plots. The recommended dose of fertilizer for teak has been taken as a baseline for the study was 150:100:100 Kg NPK ha^{-1} (Balagopalan, 1998). The conventional method of irrigation (surface application) and fertilization (soil application) was kept as control. The experiment was laid out by following split plot design with three replications.

The sources of fertilizers used for supplying Nitrogen (N), Phosphorus (P) and Potassium (K) are Urea (46% N), Mono-ammonium phosphate (MAP) (61% P_2O_5), White potash (60% K_2O) for drip fertigation and conventional method of application. The different dosage of RDF levels was supplied once in fifteen days as per the fertilizer schedule through drip irrigation. The different irrigation treatments was carried out through drip system once in three days based on the climatological approach i.e., daily pan evaporation value taken from meteorology observatory of Tamil Nadu Agricultural University, Coimbatore.

Estimation of biochemical attributes

The chlorophyll (a, b and total) content in leaves were estimated by the method of (Yoshida *et al*., 1971), chlorophyll is extracted in 80% acetone and absorbance are read in a spectrophotometer. Using the absorption coefficients the amount of chlorophyll is calculated. The data was quantitatively expressed in mg/gm.

Weigh 0.25 grams of freshly collected leaf samples of different genotypes were grinded and extracted in 10 ml of 80% acetone with help of pestle and mortar in order to get fine paste. Then, the solution was about to centrifuged at 3000 rpm for 10 minutes. The collected supernatant was transferred to the 50 ml volumetric flask and volume was made to 25 ml with 80% acetone. Then, the absorbance was recorded at 480, 510, 645, 652 and 663 nm against the blank (80% acetone) in the spectrophotometer. The amount of chlorophyll present in the leaf extract was calculated with the absorbance of samples taken at different wavelengths using the following formulas:

$$\text{Chlorophyll a} = (12.7 \text{ X OD @663}) - (2.69 \text{ X OD @645}) \text{ X } \frac{V}{1000*W}$$

$$\text{Chlorophyll b} = (229 \text{ X OD @645}) - (4.68 \text{ X OD @663}) \text{ X } \frac{V}{1000*W}$$

$$\text{Total Chlorophyll} = (8.02 \text{ X OD @663}) + (20.2 \text{ X OD @ 645}) \text{ X } \frac{V}{1000*W}$$

Statistical analysis

The data were subjected to the standard method of analysis of variance (ANOVA) single factor, and the significance of difference between the genotypes was tested and tabulated (Mandel and Nambiar, 2002). Coefficients of variation (%) for each parameter was also computed and tabulated

Results and Discussion

Effect of fertigation on biochemical traits

Table 1 depicts the results of different treatments in terms of biochemical attributes. The various irrigation and fertigation regimes had a significant difference on the biochemical traits of leaves, the interaction study between irrigation and fertigation had also significant impact over the chlorophyll content. The surface irrigation and drip fertigation was found to statistically significant with their mean values.

In terms of chlorophyll ‘a’, the best irrigation treatment was M_3 (100% of WRt) with the values of 0.600 mg gm^{-1}. The poorest performer in terms of chlorophyll ‘a’ obtained value was M_1 (0.391 mg gm^{-1}). The best fertigation was found to be F_3 with the value of 0.610 mg gm^{-1} and the treatment F_1 seems to be the treatment with least value of chlorophyll ‘a’. Then, the interaction studies had showed to be statistically significant with the grouping of best treatment of M_3F_3 (0.619 mg gm^{-1}) and M_2F_3 (0.617 mg gm^{-1}) notified with the similar value. The conventional method was obtained chlorophyll ‘a’ value of 0.305 mg gm^{-1} which was found to be lower than the drip system (0.544 mg gm^{-1}).

The fertigation treatment of F_3 (0.377mg gm^{-1}) was identified to be the best performer in terms of chlorophyll ‘b’, whereas the least value was obtained in the treatment having F_1 (0.144 mg gm^{-1}). Then, the irrigation treatment with 100% WRt had observed with maximum content of 0.401 mg gm^{-}1 and the minimum content was noted in the treatment with 50% of WRt (0.179 mg gm^{-1}). The interaction effect had also significant impact on chlorophyll ‘b’ content, whereas the interactive treatment of M_3F_3 (0.542 mg gm^{-1}) i.e., the irrigation at 100% PE and fertigation at 100% RDF observed to be performed better. While comparing with the surface techniques (0.255 mg gm^{-}1) with drip system, the drip system was observed to be the best method of application of irrigation and fertigation with value of 0.155 mg gm^{-1}.

The irrigation treatment with 100 percent and 75 percent WRt yielded the highest total chlorophyll, with values of 1.259 mg gm-1 and 1.021 mg gm-1, respectively. In the treatment with 50 percent RDF, the minimal amount of 0.558 mg gm-1 was attained. In terms of fertigation treatment, F3 (1.370 mg gm-1) considered to be the highest, whereas F1 appeared to be the lowest (0.406 mg gm-1). The combination between irrigation and fertigation led to a substantial change in total chlorophyll content, with treatment M_3F_3 (1.253 mg gm-1) appearing to be the most effective.

Hence, in chlorophyll ‘a’, chlorophyll ‘b’ and total chlorophyll content tends to show positive effect with imposing of irrigation ad fertigation. All three content performed good at (M_3) 100% PE (optimum supply of water resources) and (F_3) 125% RDF level. From the study we can interpret that if the applied water resources lower than the evaporation rate then it leads to the drought stress. Drought stress is defined by decreased leaf water potential and turgor loss, depletion of cell water content, closing of stomata, and a reduction in cell expansion and growth. This shows concordance with Anjum *et al*., 2003 [1]; Bhatt and Rao 2005 [2]; Kusaka *et al*., 2005 [5]; Shao *et al*., 2008 [11]. They concluded that the main reason for the reduction of growth, development and photosynthetic pigments (chlorophyll content) is water deficit. The water applied at 125% PE also showed lesser amount of chlorophyll while comparing with 100% PE because in 125% PE the resources will move to lower depth which is beyond the active root zone. Hence, the resources will be effectively utilized under 100% PE. This shows similar with Ramah *et al*, (2011) [9]. The major nutrient nitrogen plays a significant role in chlorophyll synthesis. The increase in fertilizer dosage also leads to increase in the chlorophyll content. The result shows similar with the findings of Li *et al*, 2010 [7]; Uysal, 2018 [15]; Turan and Horuz, 2012 [14]. They reported that the nitrogen fertilisation and chlorophyll content in the leaves are tends to directly proportional with each other. When there is a scarcity of nitrogen, chlorophyll molecules starts disperse and resulted in the lack of photosynthesis. Hence, it leads to decrease in the growth and development. The drip system was observed to the higher than the conventional method in accumulation of chlorophyll due to evaporation and percolation losses of resources which was applied.

Table 1: Impact of fertigation on chlorophyll content (mg gm^{-1}) of leaves in teak plantation (4 months after fertigation)

Treatments	Chlorophyll 'a'					Chlorophyll 'b'					Total chlorophyll				
	M1	**M2**	**M3**	**M4**	**Mean**	**M1**	**M2**	**M3**	**M4**	**mean**	**M1**	**M2**	**M3**	**M4**	**Mean**
F1	0.088	0.439	0.490	0.451	0.455	0.079	0.174	0.232	0.089	0.144	0.467	0.493	0.684	0.481	0.406
F2	0.403	0.508	0.551	0.473	0.515	0.209	0.315	0.419	0.203	0.268	0.612	1.032	0.840	0.719	0.801
F3	0.515	0.617	0.619	0.591	0.610	0.214	0.404	0.542	0.246	0.377	0.615	1.239	1.253	0.794	1.370
Mean	0.391	0.553	0.600	0.501	0.544	0.179	0.236	0.401	0.200	0.255	0.558	1.021	1.259	0.598	0.859
		M	F	M at F	F at M		M	F	M at F	F at M		M	F	M at F	F at M
SEd		0.009	0.013	0.023	0.026		0.007	0.005	0.012	0.011		0.025	0.022	0.044	0.044
CD (p=0.05)		0.022**	0.027**	0.050	0.055		0.018**	0.012**	0.027	0.024		0.063**	0.046**	0.099	0.093
Conventional method	0.452		SEd		CD	0.155		SEd		CD	0.532		SEd		CD
Cm vs MF			0.028		0.071			0.0026		0.006			0.020		0.051

Conclusion

Hence, under drip system the irrigation applied at optimum level with evaporation i.e., 100% pan evaporation value (PE) value showed increase in chlorophyll content with effective utilization of resources. Also, the fertilizers which applied at higher dosage were observed with the maximum accumulation of chlorophyll content. In the treatment F_3 i.e., application of fertilizer at 125% RDF level was found to secure maximum amount of chlorophyll. Thus, in order to improve the photosynthetic pigment in teak is application of irrigation at 100% PE value and fertigation with 125% recommended dose of fertilizer level which will promotes the growth and development with higher yield accumulation. The drip technology serves better while comparing with the conventional method with evaporation losses.

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