

Original Research Article

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Tree Growth, Litter Fall and Leaf Litter Decomposition of *Eucalyptus tereticornis* Base Agri-silviculture System

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ABSTRACT

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Tree growth, litter fall and leaf litter decomposition, nutrient return through leaf litter and litter decomposition were 7 year old *Eucalyptus tereticornis* plantation. The Tree growth under agri-silvicultural system at the beginning of experiment the observations recorded with respect to certain growth parameters of *Eucalyptus tereticornis* have been shown Table 1 in 2014–2015. The maximum tree height (21.80 m) found in tree no 5; Dbh (22.63 cm) and canopy width (5.82 m) were recorded in the same tree number 3. Whereas the maximum canopy length (6.32 m) was found in the tree number 3. In the next year 2015–2016 the observations recorded with respect to certain growth parameters at the end of experiment of *Eucalyptus tereticornis* have been shown in Table 2 and the maximum tree height (22.78 m) found in tree no 5; Dbh (24.48 cm) and canopy width (6.17 m) were recorded in the same tree number 3. Whereas the maximum canopy length (7.61 m) was found in the tree number 3. The maximum litter from litter trap was recorded in (59.94g) month of November during 2014–2015 and the minimum litter from litter traps was found in (6078 g) month of November during the year 2015–2016.

Introduction

Eucalyptus tereticornis renowned globally for its fast growth, high levels of drought tolerance and adaptability to diverse climatic conditions and soils, which makes it popular among eucalypt tree growers Bindumadhava *et al.*, (2011). Colonial propagation is an extensively used strategy to gain economic potential of eucalypt species/hybrids by multiplying desirable types. With moderate degree of sophistication in most forest

nurseries, it is performed to strategically improve the productivity Zobel *et al.*, (1995). To protect natural resources and the environment for the sustainable development, plantation has become the major source of timber supply for timber industry such as solid wood, plywood pulping and paper.

A good plantation species should produce not only high timber yield, but also the desired properties of wood for highly valued end products. Accelerating tree growth rate or

shortening the rotation could potentially affect wood quality Alterac *et al.*, (2005).

The total area of eucalypts planted in India is estimated to exceed 2,500,000 ha Midgley *et al.*, (2002). Several pulp and paper mills, forest departments and forest development corporations have substantial areas of plantations either directly under their control or in farmer's land from which wood is purchased. Most eucalypt plantations across India are of 'Mysore Gum', a land race considered to be a mixture of pure *Eucalyptus tereticornis* Smith and genetic segregates of inter specific hybrids, displaying high variability (Kaikini, 1961). The growth of Mysore Gum is quite slow; with mean annual increment of plantations averaging around 7 m³ ha⁻¹ (Chandra, 1992); and a number of trials have demonstrated superior performance of certain new eucalypt introductions or selected eucalypt clones. Eucalypts are the major raw material of the pulp and paper industries in India, so it is imperative that planting stock of high genetic quality be used to increase the yield from plantations mainly for Eucalypts. Due to the limited resources in arid and semi-arid regions, benefits from short rotation forests largely depend on the judicious management of soil and water resources. Improved selection of appropriate tree species and growth of trees at optimum densities are important management considerations to increase overall system productivity.

Tree stand density is a very important tool of silvicultural treatment and offer a means to affect the growing conditions of trees and thus, also the stem wood production. With the worldwide move towards intensive silviculture and shorter rotations, the quality of wood and end products from this changing resource has become a concern for the forest products industry.

Materials and Methods

Site description

The present study entitled "Tree growth, Litter fall and leaf litter decomposition of *Eucalyptus tereticornis* base agri-silviculture system" was carried out at Research Farm of the Department of Forestry, CCS Haryana Agricultural University, Hisar during the year 2014-15 and 2015-16.

The experimental site is situated at 29° 09' N latitude and 75° 43' E longitudes at an elevation of 215 m above mean sea level situated in semi-arid region of the Northwest India. The climate is subtropical-monsoonic with an average annual rainfall of 350-400 mm and 70-80% of which occurs during July to September. The summer months are very hot with maximum temperature ranging from 40 to 45°C in May and June, whereas, December and January are the coldest months (lowest January temperature as low as 0°C).

Experimental design planting

Seven year old *Eucalyptus tereticornis* were planted in 6×1.5 m under agri-silviculture system. The experiment was set up in Randomized Block Design. Under system agriculture crop was grown in Barley.

Estimation of soil physico-chemical properties

The soil sample was collected in before and after the experiment in both years under agri-silviculture system and open area. The soil was sampled using a 45mm diameter hand auger. Visible roots and organic residue were removed during sampling. Soil sample are dried, sieved and stored in cotton bags, before analysis. Available nitrogen was measured Micro-Kjendal (Piper, 1950) procedure. Total available phosphorus (P) was measured (calorimetrically) and total available

potassium (K) by flame photometer (Jackson, 1973).

Litter fall determination

Litter production was measured for 2 consecutive years continually from January 2014 till December 2016. Litter collection was made using wooden traps and 10 traps were randomly placed in under agri-silviculture system to represent an average of the total area.

Each trap was 50 cm × 50 cm depth to allow accumulation of falling litter. The randomly distributed litter traps was accordance with the method suggested by New-bould1967and Chapman1976.

The traps were fixed about 80–100 cm above ground level by pegs at the corners. The litter fall was collected at monthly interval over the annual cycle. After collection, the litter was separated into different categories viz., leaf litter, woody litter and miscellaneous litter and oven dried at 60°C constant weight.

Litter decomposition

Decomposition of *Eucalyptus tereticornis* litter was studied using the standard litter-bag techniques (Falconer *et al.*, 1933).

This study was carried out from June 2014 to May 2016. Freshly collection litter (only leaf) weighing 10g was placed in bags (20cm × 20 cm) made from nylon net (2.0 mm mesh size) and scattered at the agri-silviculture system. In total, there were 120 bags and three bags were removed randomly at monthly intervals. The bags were carefully tapered to remove adhering soil particles. The content was oven dried at 60°C and weighed rate of litter loss was determined based on remaining contents of bags.

Results and Discussion

Tree growth

The observations recorded with respect to certain growth parameters of *Eucalyptus tereticornis* have been shown in Table 1. The maximum tree height (21.80 m) found in tree no 5; Dbh (22.63 cm) and canopy width (5.82 m) were recorded in the same tree number 3. Whereas the maximum canopy length (6.32 m) was found in the tree number 3. In the next year 2015–2016 the observations showed in Table 2 at the end of experiment of maximum tree height (22.78 m) found in tree no 5; Dbh (24.48 cm) and canopy width (6.17 m) were recorded in the same tree number 3. Whereas the maximum canopy length (7.61 m) was found in the tree number 3. Results showed that the growth parameters of *Eucalyptus tereticornis* were significantly affected by the annual crops.

Total litter fall from litter trap

Litter fall in *Eucalyptus tereticornis* base agri-silviculture system the observation regarding Litterfall showed in table 3 and fig 1 and 2. It is evident from the table that the maximum litter from litter trap (59.94g) was found in month of November followed by (38.75) in January and the minimum leaf litter(17.39 g) recorded in month of July during 2014-2015. In the next year 2015-2016 the maximum litter from litter trap (60.78g) was found in month of November and the minimum leaf litter (18.85 g) recorded in month of July.

As evident from the results that the maximum leaf fall (50.32 g), wood fall (22.63 g) and miscellaneous fall (1.70 g) were found in month of November, September and may during and the minimum leaf fall (3.47 g), wood fall (2.18 g) and miscellaneous fall (0.002 g) were found in month of August, December and July during 2014-2015.

In the next year 2015-2016 the observation recorded maximum leaf fall (50.98 g), wood fall (23.88 g) and miscellaneous fall (2.10 g) were found in month of November, September and May and the minimum leaf

fall (3.78g), wood fall (2.78 g) and miscellaneous fall (0.030 g) were found in month of August, November and July (Table 4).

Table.1 Effect of litter fall and decomposition on tree growth at the beginning experiment in *Eucalyptus tereticornis* under agri-silviculture system during 2014-2015

Tree no	Growth at the beginning of experiment			
	Tree height (m)	Dbh (cm)	Canopy width (m)	Canopy length (m)
1	18.70	22.05	5.47	5.37
2	18.96	21.90	5.67	6.28
3	19.66	22.63	5.82	6.34
4	18.31	22.33	5.41	5.52
5	21.80	22.46	5.57	5.16
CD at 5%	1.68	1.06	0.64	0.253
SEm±	0.52	0.44	0.19	0.082

Table.2 Monthly estimation of litter from litter traps in 7 year old *Eucalyptus tereticornis* plantation under agrisilviculture system

Treatment/months	Monthly Litter from litter trap (g m ⁻² month ⁻¹)		Total
	Litter fall	Litter fall	
	2014-15	2015-16	
January	38.75	40.03	78.78
February	25.86	26.55	52.41
March	21.51	21.79	43.30
April	25.54	26.46	52.00
May	24.65	26.00	50.64
June	23.71	26.17	49.88
July	17.39	18.85	36.24
August	19.49	21.40	40.89
September	33.65	35.34	68.99
October	37.59	38.36	75.95
November	59.94	60.78	120.72
December	35.65	36.06	71.71
CD at 5%	6.24	6.05	
SEm±	0.41	0.46	

Table.3 Effect of litter fall and decomposition on tree growth at the end of experiment in *Eucalyptus tereticornis* under agri-silviculture system during 2015-2016

Tree no	Growth at the beginning of experiment			
	Tree height (m)	Dbh (cm)	Canopy width (m)	Canopy length (m)
1	19.49	24.10	5.67	6.59
2	19.29	23.54	6.04	7.31
3	20.39	24.48	5.96	7.61
4	19.65	24.42	5.58	6.84
5	22.78	24.35	6.17	5.75
CD at 5%	2.14	1.87	0.43	0.315
SEm±	0.64	0.55	0.13	0.851

Table.4 Monthly estimation of different categories of litter fall in 7 year old *Eucalyptus tereticornis* plantation under agri-silviculture system of sodic land

Treatment/months	Litter component (g m ⁻² month ⁻¹)						Total
	Leaf litter		Wood litter		Miscellaneous litter		
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	
January	35.037	35.680	3.083	3.533	0.400	0.480	78.213
February	19.108	19.717	6.483	6.417	0.040	0.076	51.841
March	8.867	8.528	12.000	12.417	0.408	0.508	42.728
April	18.217	18.762	6.467	6.683	0.628	0.676	51.433
May	14.432	14.925	8.283	8.633	1.700	2.100	50.073
June	6.642	7.507	16.533	17.867	0.307	0.454	49.31
July	4.840	4.520	12.317	13.950	0.002	0.040	35.669
August	3.477	3.783	15.733	17.250	0.050	0.030	40.323
September	10.733	11.087	22.633	23.883	0.050	0.030	68.416
October	29.877	29.987	7.417	8.000	0.070	0.030	75.381
November	50.322	50.982	9.350	9.417	0.040	0.040	120.151
December	32.895	32.680	2.183	2.583	0.342	0.456	71.139
CD at 5%	1.314	0.906	0.414	0.967	0.124	0.214	

SEm±	0.462	0.319	0.146	0.340	0.044	0.075	
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Fig.1 Relationship between month and remaining weight (%) of litter in *Eucalyptus tereticornis* base agri-silviculture system during 2014-2015

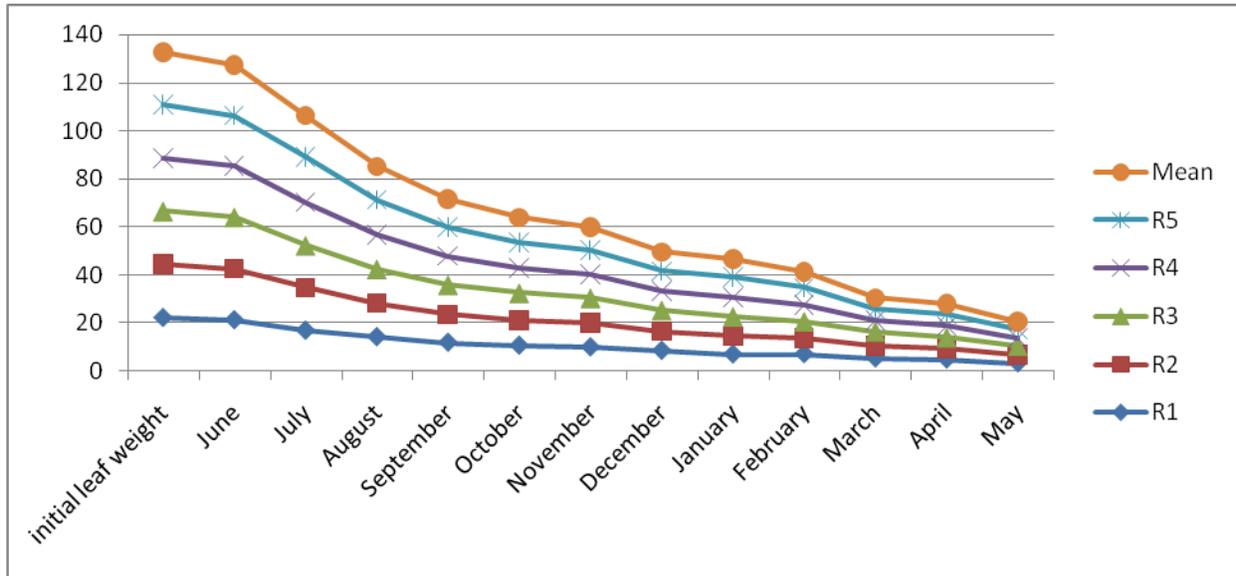
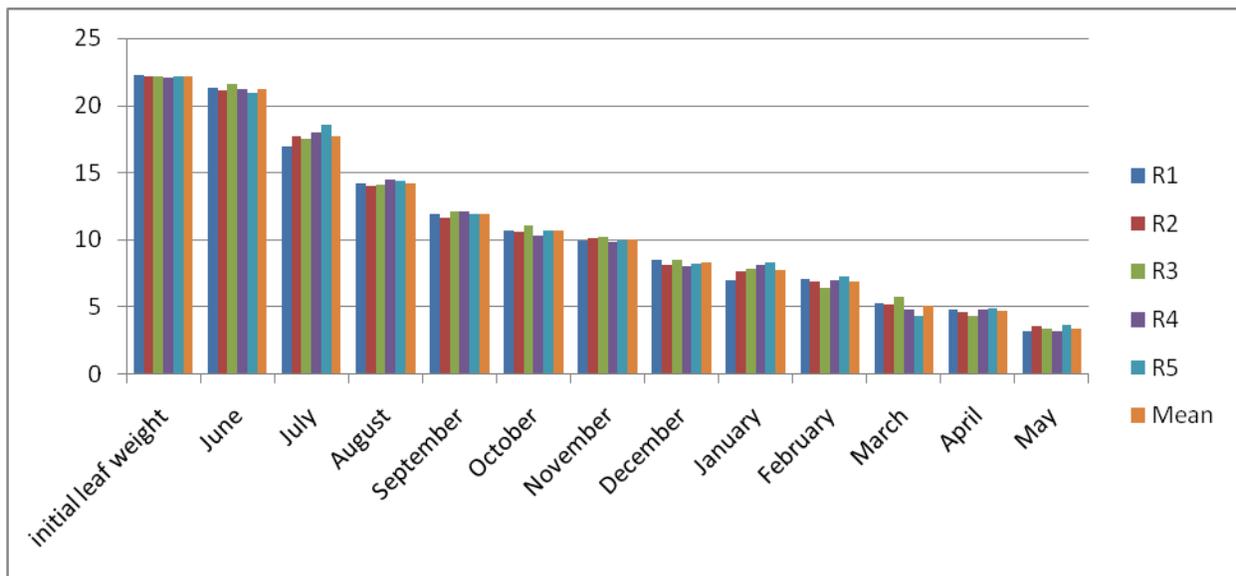


Fig.2 Relationship between month and remaining weight (%) of litter in *Eucalyptus tereticornis* base agri-silviculture system during 2015-2016



Tree growth

Results of the present study provide valuable information that supports the establishment

tree growth of *Eucalyptus tereticornis* base agri-silviculture system. The growth of *Eucalyptus tereticornis* increased with light, moisture and available nutrients. Therefore,

regular irrigation helps to make nutrient available in rhizosphere. Beneficial nutrient may be influenced by plant roots directly in tripartite association between Casuarina and Frankia and mycorrhiza Reddell 1990; Rajendran and Devaraj 2004. In our study 2014-2015, significant growth at the beginning of experiment was recorded in maximum tree (21.80 m), dbh (22.63 m) and canopy width, canopy length was found in (5.82 m), (6.34 m) of 7 year old plantation. The overall growth improvement may be attributed to improved genetic material available. Accumulation of biomass may be related to intensive silvicultural management such as superior genetic materials, appropriate distance, regular watering, weeding and manuring. However, growth of trees was markedly higher while adopting systematic cultivation method using suitable biofertilisers. In addition, excellent growth was observed in the height of *Eucalyptus tereticornis* which ranged from 9.87 to 11.90 m and girth at breast height which ranged from 16.8 to 23.2 cm after planting (Rajendran and Devaraj, 2004).

Litter production

The litter fall of *Eucalyptus tereticornis* studied indifferent component at monthly interval. However, the rate of leaf fall on seasonal basis was greatest in winter (November to February) followed by summer (March to June) and Rainy season (July to October). A similar Pattern was also observed for total above ground tree litter fall under agri-silviculture system (Saravanan *et al.*, 2012). Litter production is directly related to the availability to nutrient and fast growth of species. There is more pressure on soil nutrient as more number of trees is present in under agri-silviculture system. However, some amount of nutrient is returned to the soil through leaf litter. In the present estimation the maximum litter fall (52.45 g) to (68.23 g)

was found during November to February. Total litter fall 545 g m² observed in the present study is lower than that of the reported value for nearby only tree plantation. Malaya and Nisanka (1997) was reported the data on cumulative litter fall for 24 months ranged between 5784 g m⁻² (12-13 years) tree plantation.

In addition to evergreen nature of the species, litter fall in *Eucalyptus tereticornis* plantation under agri-silviculture system throughout the year may be attributes to the growth pattern of the species coupled with favourable environmental factors, especially atmospheric and wind velocity. Maximum litter fall during winter (November to February) was due to heavy spike shedding. Besides, maximum litter fall during winter might also be light intensity, temperature and moisture Rana *et al.*, 2007; Bray and Gorham 1964. This pattern of leaf fall is comparable with other plantations of this region. The leaf fall accounted for 64.3% (*Eucalyptus* hybrid) to 90.8% (*D. sissoo*) of the total annual litter fall which is within the range of 37.7–96.3% reported for different other plantations Meentemeyer *et al.*, 1982 calculated 70% leaf litter in the total litter fall in forests around the world. The annual woody litter fall estimated in this study ranging between 16.6 and 131.8 g m⁻² year⁻¹ is comparable with other plantations of similar age. The total litter fall for *C. Equisetifolia* in this study (664.77 g m⁻² year⁻¹) is similar to that produced by a *C. equisetifolia* (455-824 g m⁻² year⁻¹) plantation on the sandy coast of Orissa and by a *E. oblique* (388–537 g m⁻² year⁻¹) plantation in New Zealand. However, the present value in this study was lower than the values reported for the coastal hills of Africa and for *Eucalyptus* hybrid in Uttaranchal Tarai, *Casuarina* spp. in Kerela, India but litter fall peak winter followed by summer higher reported by Baker 1983; Pande and Sharma 1986. Total litter production by *C.*

equisetifolia, in the present study was lower than the plantations of the same species raised in coastal Orissa, Uttaranchal Tarai and Kurukshetra regions respectively. Overall comparison, in general, indicated that the litter production on the present sites was lower than the stands at other sites. The relatively lower values of litter production in the present study may be due to the slow growth of trees on sodic land and subsequent slow turnover of biomass.

Litter decomposition

The higher rate of litter production and its subsequent decomposition under agri-silviculture system turnover of nutrients and affected nutrient cycling. Litter quality has been considered as an important factor controlling decomposition Ribeiro *et al.*, (2002); Tatenno *et al.*, (2007). The processes of leaf decay are largely controlled by soil microorganisms and are, therefore, influenced by temperature, moisture, pH and soil microorganisms (Jenkinson 1981). Maximum decomposition was recorded during 2014-2015 (3.52 g m⁻²) and 2015-2016 (3.45 g m⁻²) in month of July during the rainy season followed by summer and winter. This is obvious from the positive rate of weight loss and soil moisture and rainfall (Austin and Vitousek, 2000; Dasselar and Latinga, 2000). The high rate of decomposition (rainy season) attributable to suitable temperature and moisture was due to regular irrigation, rainfall, fungal population and soil aeration. Similar observations were observed for *Eucalyptus*, *Dipterocarpus tuberculatus* and oak-conifer forest (Wedderburn and Carter 1999; Sarjubala and Yadava 2007).

In conclusion, the amount of above ground tree litter production was lower than present agri-silviculture system on sodic soil than other plantation located on normal site may be because of slower growth rate of the former.

Under system maximum litter fall in *Eucalyptus tereticornis* and fast decomposition. Present study clearly indicates the scope of using the leaf litters of *Eucalyptus tereticornis* as green. Under adverse soil and different climatic conditions *Eucalyptus tereticornis* (a species of coastal origin) reflected indifference and assumed greater potential of biomass and productivity than other species Rana *et al.*, (1998). By inclusion of *Eucalyptus tereticornis* in agroforestry, satisfactory improvement in wheat and paddy crop yield on sodic soil occurred within few year of intensive cultivation in the same locality Parihar and Rana (1999).

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