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Economics of Teak (*Tectona grandis* L. F.) plantation with different spacing and organic inputs in Semi-arid region of Rajasthan

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Abstract
A field experiment was conducted during the July 2019 to April 2020, at the Herbal Garden, College of Horticulture and Forestry, Jhalarapatan, Jhalawar. The experiment consisted of 10 treatment of different organic inputs *viz*.; sand, FYM and Vermicompost in different combinations and was laid out in Randomized Block Design with three replications. The study aimed to find out best treatment combination and spacing for the initial establishment of the plantations with an appropriate idea to find out its cost of cultivation for ultimate success. Although treatment T_9 comprising [Vermicompost (2 kg + 1 kg + 1 kg) + FYM (2 kg + 1 kg + 1 kg)] was found significantly superior over all among treatments and then treatment T_8 [Vermicompost (1 kg + 1 kg + 1 kg) + FYM (1 kg + 1 kg + 1 kg)] exhibited at par results in most of the growth parameters in Teak (*Tectona grandis* L. F.) plantations but both the treatments are having maximum cost of cultivation. From the experiment, it may be concluded that T_9 and T_8 treatments being costlier, may be considered suitable for better growth and development of Teak (*Tectona grandis* L. F.) plants in the soil and climatic conditions similar to Jhalawar (Semi-arid) region with Spacing S_3 (5 m x 6 m) then S_2 (5 m x 5 m) for plant growth and development in the first year.

Keywords: Plantation, organic inputs, spacing and cost of cultivation

Introduction
Trees and forests are an integral part of the Indian culture. The best Indian culture was born in the forests. Forest plantations are defined as those forest stands established by planting or/and seeding in the process of afforestation or reforestation.

The annual planting target of teak in India is about 1.2 million ha. Planting stock production, empty fruits and a low germination rate by seed planting (Gupta and Kumar, 1976) [10]. The species is known to have a great genetic variability in India, with its natural distribution spreading over 8.9 m. ha of forests ranging from very dry to very moist conditions. In fact, the Indian subcontinent is considered as the center of diversity for teak because of the huge genetic variation for economically important traits such as bole form, timber quality, biochemical traits, etc. Anmol *et al*., 1997 [3].

Teak (*Tectona grandis* L. F.) is one of the most important timber yielding trees of Asian countries particularly India, Indonesia, Myanmar and Thailand. It is also the most popular, valuable and extremely durable wood of indigenous timber among all over the world. Schubert (1954) [19].

It is one of the most widely planted hard wood timber species in the world. The tree flowers between March and August and starts fruiting around September. The wood is dark golden yellow heartwood, which darkens with age Akinsami, (1985) [1]. Teak has a high tolerance for drought and it is both insect and disease resistant (Bhatt and Hwon, 2004) [5]. Where sprouts are able to grow into mature trees, sprouting may be a more effective means of re-establishment than the slow-growing seedlings (Harcombe and Marks 1983, Ohkubo, 1992) [11, 17].

Teak is usually planted by seed which can be planted directly in the field or using stumps made by uprooting the seedlings from the seedbed, pruning the root laterals, and cutting the main stem. It is a sun loving, deciduous tree, which thrives, in any well drained soil. It has a gestation period of 15-25 years Tiwari, (1992) [23]. It is one of the most valuable timber trees of the tropics which are characterized by a tall clear trunk with a rounded crown Tiwari *et al*., (2002) [24].

It is an important plantation species in tropical as well as subtropical regions of Southeast Asia including India (Goh and Monteuuis, 1997) [8]. It also holds the medicinal values; the bark is bitter tonic and has potential use in curing fever. It is also useful to cure headache and stomach problems, digestion may be enhanced by the teak wood or bark. Therapeutic uses have also reported in curing eye diseases and vomiting (Sreedevi and Damodharam, 2015) [21].

Teak wood is used in general construction, furniture as well as in bridges, flooring, cabinet work, vats and fixtures requiring high resistance to acids. It is also used as poles for building and communication purpose and furniture FAO, (2012). The products of teak have a long service life, making the timber a long- term prospects for carbon storage Bhatt *et al.*, (2003) [4]. Due to high timber value of teak, the participation of intended cultivators and farmers in plantation activities and agroforestry practices is increasing day- by - day in India.

Organic addition may accelerate decomposition of the native organic, although freshly added plant residues may have positive effect on indigenous organic matter Smith, (2000) [20]. Organic manure improved soil structure, seed germination, water holding capacity, drainage, base exchange capacity and checked soil erosion Gaur *et al*., (1978) [7].

Gopi, (2002) [9] reported that application of Vermicompost (1:1:1) as soil mixtures significantly increased the growth and biomass productivity of a few selected forest seedlings such as *Tectona grandis* L. F., *Casuarina equisetifolia*, *Simarouba glauca*, *Pongamia pinnata* and *Delonix regia*. Deciduous forest litter shift in organic input addition and more use of organics in intensive agriculture likely to make many changes in dynamics of organic carbon in soil in near future.

Vermicompost is eco-friendly natural manure prepared from biodegradable organic wastes. It is rich in beneficial micro flora such as N-fixers, P- solubilizers, cellulose decomposing micro-flora etc. which improve soil environment, by improving soil structure, texture, aeration are enhances the decomposition of organic matter, along with water holding capacity and prevents soil erosion. It promotes better root growth and nutrient absorption. In view of the increased availability of the above organic inputs and dwindling supply of FYM, investigations have thus become imperative to assess their combination and dosage levels of all possible with organic inputs.

Mehta *et al.*, (2013) [15] studied the effect of different soil mixtures on growth of teak (*Tectona grandis* L. F.*)* seedlings. They observed growth of nursery raised teak (*Tectona grandis* L. F.) seedlings by using varied proportion of soil, sand and farmyard manure in soil mixture under sodic soil condition. it was noticed that increase in proportion of sand in the soil mixture (1:1 to 1:2, soil and sand ratio) showed increase in seedling growth Seedling assumed rapid growth when FYM was added to the soil having greater amount of sand (1:3:2 soil: sand: FYM).

Chotchutimal *et al.*, (2013) studied the treatment consisted of six spacing (1 m × 0.25 m,1 m × 0.5 m, 1 m × 1 m, 1 m × 1.5 m, 2 m × 0.5 m and 2 m × 1 m). The results showed that spacing had a significant effect on plant height, diameter at breast height. Wider spacing resulted in greater plant height. The widest spacing (2 m × 1 m) exhibited the higher stem diameter and sprout number than the narrow spacing. The narrowest spacing of 1 m × 0.25 m spacing produced the highest total dry weight of leaf, woody stem and biomass yield.

Material and Methods

A field experiment was conducted during the July 2019 to April 2020 in the Jhalawar district of Rajasthan at Herbal garden, College of Horticulture and Forestry, Jhalawar (Agriculture University Kota). Jhalawar is bounded on the northwest by Kota district, on the northeast by Baran district, on the east by Guna district of Madhya Pradesh state, on the south by Rajgarh and Shajapur districts of Madhya Pradesh and on the west by Ratlam, Mandsaur and Nimach districts of Madhya Pradesh state. The district occupies an area of 6,928 km² and district lies in the south eastern corner of Rajasthan between Latitude 23°45'20" to 24°52'17" & Longitude 75°27'35" to 76°56'48". The district head quarter Jhalawar is situated on the National Highway No. 12 about 85 Km from Kota towards Bhopal. Total area under forest is 1, 27,328 ha and cultivated land is 3, 36,562 ha.

Table 1: Soil parameters and methods used at the experimental site

Sr. No.	Chemical properties	Avg. Values	Methods used
1.	Organic carbon (%)	0.49	Walkley and Black (1934) [25]
2.	Available Nitrogen (kg ha^{-1})	312.62	Alkali Permanganate method (Subbiah and Asija, 1956) [22]
3.	Available phosphorus (P_2O_5 kg ha^{-1})	21.14	Olsen's method (Olsen *et al.*, 1954) [18]
4.	Available Potassium (K_2O kg ha^{-1})	278.32	Flame photometer method (Metson, 1956)
5.	EC (dSm^{-1} at 25^0C)	0.45	Using solubridge (Jackson, 1973) [12]
6.	pH (1: 2: Soil: water suspension)	7.75	Potentiometric method using pH meter (Jackson, 1973) [12]

The climate of the zone is sub-humid and sub-tropical characterized by mild winter and warm summer with relatively high humidity during the month of July to September. The region has mean annual rainfall 943 mm received from South-West monsoon during last week of June to September and sometimes scantly showers during winter season. The experimental field had black soil of the clay loam type in texture (Black cotton), low in reaction and medium in respect to nitrogen, phosphorus and potassium content.

The initial expenditure in terms of rupees per plant was worked out on the basis of cost of cultivation of each treatment per plant.

Result and Discussion

It is evident from the data (Table 2 and Figure 1) that maximum cost of cultivation per plant 147.5 Rs (for study period) and 161.38 Rs (for whole year) was observed in T_9 [Vermicompost (2 kg + 1 kg + 1 kg) + FYM (2 kg + 1 kg + 1 kg)]. The significantly minimum cost of cultivation per plant 107.5 Rs (for study period) and 121.38 Rs (for whole year) was observed in T_0 [as control (soil only)]. It is apparent from Table 2 that maximum cost of cultivation per plant observed lowest in T_0 [as control (soil only)] a value of 107.5 Rs (for study period) and 121.38 Rs (for whole year) but it performed poorly in other growth parameters while highest cost of cultivation per plant was observed with T_9 [Vermicompost (2 kg + 1 kg + 1 kg) + FYM (2 kg + 1 kg + 1 kg)] a value of 147.5 Rs (for study period) and 161.38 Rs (for whole year) and then in T_8 [Vermicompost (1 kg + 1 kg + 1 kg) + FYM (1 kg + 1 kg + 1 kg)] a value of 137.5 Rs (for study period) and 151.38 Rs (for whole year). Though the highest cost of cultivation per plant incurred in treatment T_9 [Vermicompost

(2 kg + 1 kg + 1 kg) + FYM (2 kg + 1 kg + 1 kg)] but it performed very well in other growth parameters. Similar findings were reported by Mishra *et al.*, (2017) [16] in Influence of GA_3 and Growing Media on Growth and Seedling Establishment of Papaya (*Carica papaya* L.) cv. Pusa Nanha, Labarta *et al.* in Economic Analysis Approaches to potato-based integrated crop systems: Michigan State University, East Lansing, Michigan, (2002) [13], Lu *et al.* in Partial budget analysis of effects of crop management intensity on profitability of three water melon cultivars., (2003), Alimi *et al* in Partial Budget Analysis for On-Farm Research, Nigeria., (2000) [2].

Table 2: Economics - Cost of cultivation of Teak (Tectona grandis L.F.) plantations.

Name of Treatment	Cost of growing media per plant (sand, FYM and vermicompost) (Rs)				Labour cost (Rs)		Seedling cost (Rs)	Tractor + pit digging cost (Rs)	Total cost of cultivation (Rs)		Cost of cultivation per plant (Rs)	
Quantity kg per Treatment	S_1 (5x4 m)	S_2 (5x5 m)	S_3 (5x6 m)	Total	For study period	For whole year			For study period	For whole year	For study period	For whole year
T_0 [Control]	0	0	0	0	2250	2750	540	1080	3870	4370	107.5	121.38
T_1 [1 kg sand as basal application only]	60	60	60	180	2250	2750	540	1080	4050	4550	112.5	126.38
T_2 [2 kg FYM as basal application only]	96	96	96	288	2250	2750	540	1080	4158	4658	115.5	129.38
T_3 [1 kg Vermicompost as basal application only]	72	72	72	216	2250	2750	540	1080	4086	4586	113.5	127.38
T_4 [1 kg. sand + FYM (1+1+1) kg]	204	204	204	612	2250	2750	540	1080	4482	4982	124.5	138.38
T_5 [1 kg. sand + FYM (2+1+1) kg]	252	252	252	756	2250	2750	540	1080	4626	5126	128.5	142.38
T_6 [1 kg. sand + Vermicompost (1+1+1) kg]	276	276	276	828	2250	2750	540	1080	4698	5198	130.5	144.38
T_7 [1 kg. sand + Vermicompost (2+1+1) kg]	348	348	348	1044	2250	2750	540	1080	4914	5414	136.5	150.38
T_8 [Vermicompost (1+1+1) kg + FYM (1+1+1) kg]	360	360	360	1080	2250	2750	540	1080	4950	5450	137.5	151.38
T_9 [Vermicompost (2+1+1) kg + FYM (2+1+1) kg]	480	480	480	1440	2250	2750	540	1080	5310	5810	147.5	161.38

Note: - (This cost is calculated for 9 months by (July' 2019 to March' 2020)

1. Cost of sand = Rs 5 per kg
2. Cost of FYM = Rs 4 per kg
3. Cost of Vermicompost = Rs 6 per kg
4. Labour charges = Rs 250 per mandays (mixture preparation, irrigation, weeding)
5. Seedling purchase cost = Rs 15/ plant
6. Tractor + pit digging cost = Rs 30 / plant (diesel cost + driver cost + ploughing cost)

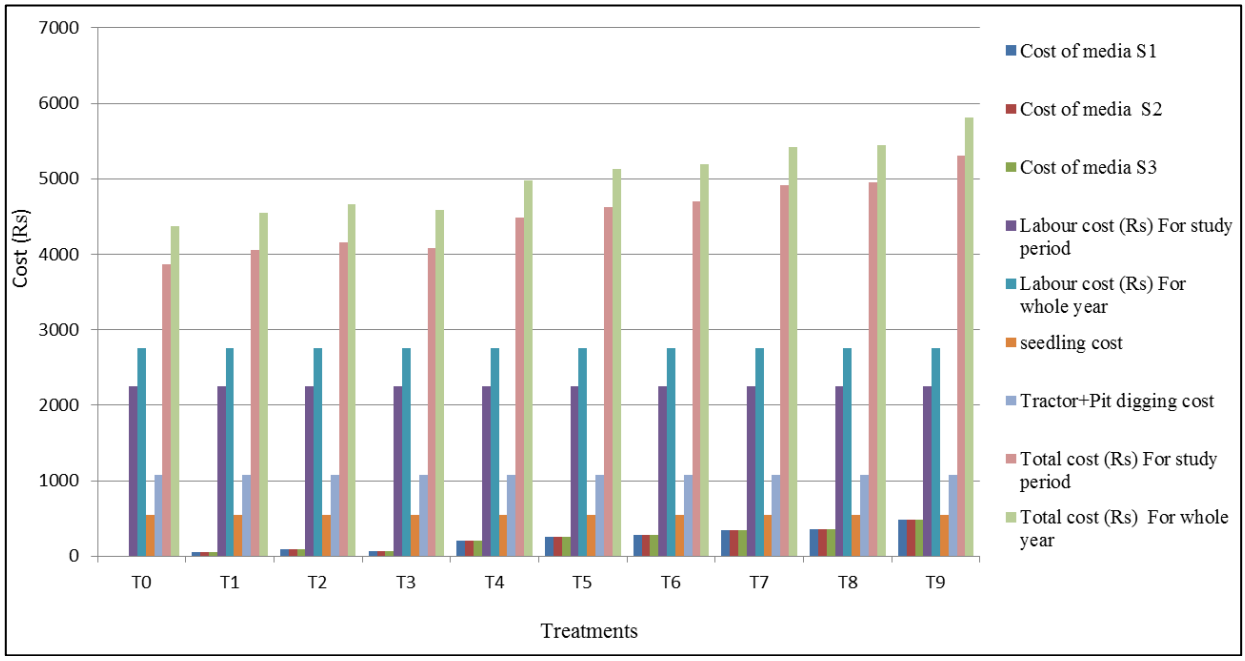

Fig 1: Economics - Cost of cultivation of Teak (*Tectona grandis* L.F.) plantations

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