

Original Research Article

Performance of *Tecomella undulata* (Desert teak) stump planting over seedling for growth and straightness under arid condition.

Abstract

Tecomella undulata (Rohida) stump planting and seedlings had shown 100 percent survival during the study period. Stump plants exhibited enhance growth parameters over seedling originated plants. Treatment T₄ showed best growth performance in terms of plants' height, collar diameter, number of leaves and sprout density, with 44% and 54% higher growth in height and collar diameter than seedlings after two years of planting. As per the modified visual method of assessing straightness, higher stem straightness was obtained in T₄ (0.56m) and T₃ (0.40m) which had 77% and 66 % stem straightness, and score of 6 & 5 which plunge under A grade category. Whereas, T₂ and T₁ (0.33m & 0.23m) had 48 and 32% stem straightness percent with a score of 4, 3 and 2, which comes under B & C grades. From the study it was a clearly found that stump plantings treatment T₄-(>8-9mm thickness (pen/pencil-sized), with 20-25cm stump plants (2-5cm stem and 15-20cm tap root) was found to have achieved enhanced growth compared to seedling plants.

Keywords: *Tecomella undulata*, stump, seedling, stem straightness, sprout density.

Introduction

Tecomella undulata (Sm.) Seem (Rohida) is a medicinally and economically important plant that originated in India, Arabia (Randhawa and Mukhopadhyay, 1986), and now appears in the list of endangered plants of Punjab (Jerath *et al.*, 2012). *T. undulata* is a medium sized tree with height ranging from 8m to 15m. In India it is mostly distributed in the desert region of drier tract of Rajasthan, south-western parts of Punjab, Maharastra, Gujarat and Haryana. The plant grows under natural conditions in wild, unprotected and is highly exploited. It is very hardy and drought resistant plant, and has potential application for afforestation and landscaping of dry tracts. The tree is used for its high quality timber. Its wood is soft, durable and takes a good polish. Therefore, it is used in furniture, carving, and agricultural implements. The wood is prized equal to Teak and that's why it is also called as 'Marwar Teak of Rajasthan'. The Trees' parts like bark, wood chips, flowers etc are used

to cure syphilis and eczema. Bark possesses mild, relaxant, cardio tonic and chloretic activities. Hot water extract of the bark and wood is used to treat enlarged spleen, gonorrhoea, leucoderma and liver diseases (Saxena 2000 and Kumar 2020).

The main trunk of the Trees' branches very early, at lower level of the stem, in comparison to other timber yielding Trees. Young plantlets growing in wild or unprotected areas are usually grazed upon by Cattle, Goats and Sheep. Consistent grazing by animal makes the plant bushy if kept unprotected in the younger age. This makes most of its trunk part unsuitable for timber production if the branches are left unpruned. Additionally, two species of imperfect fungi (*Phoma* sp. and *Botryodiplodia theobromae*) are primarily responsible for canker-rot, which subsequently attract borers and heart rot pathogen (*Fomes* sp.) and damages the clear bole or death of trees leading this species to endangered status (Negi *et al.* 2011).

Overexploitation of trees for Agriculture and other commercial, scientific and educational purposes and other developmental activities of mankind have resulted in serious threat to plant species that have evolved over the course of millions of years (Khan, 1998). The regeneration rates of this tree in natural surroundings is quite low and natural regeneration of plants from seeds is very poor probably due to coincidence of seed maturity with onset of monsoon resulting in considerable damage to the seeds through fungal attack (Dhir and Shekhawat 2012, Kumar 2020).

The growth behavior of Rohida seedlings is of slow growing and branchy in nature and ascertains its superiority for its successful establishment either in any conservation, afforestation programmes or in agroforestry system with respect to its edaphic and climatic condition (Kumar 2020, Parton *et al.* 1987 and Joshi *et al.* 1989). For rapid early growth and development, adoptability and early establishment in the field, seedlings are either to be fertilized or new techniques are to be adopted to boost its growth and establishment. Among many planting techniques stump planting is one method that can enhance the growth of the plant in the early establishment stage and it is practiced in many species of plants and most commonly in teak and is successful (Ghising *et al.*, 2022). Keeping in view an attempt to standardize the stump planting technique and to evaluate the performance of stump plants over seedling was conducted in arid condition of Rajasthan, India.

Materials and methods

Study site

The experiment was conducted at Agricultural Research Station, Keshwana, Jalore, Rajasthan. The site is located at latitude $25^{\circ}25'58.86''$ N and longitude of $72^{\circ}29'726''$ E, elevation 149.9 msl. Jalore comes under Transitional Plain of Luni Basin (Zone IIb) of Rajasthan (Fig.1.).

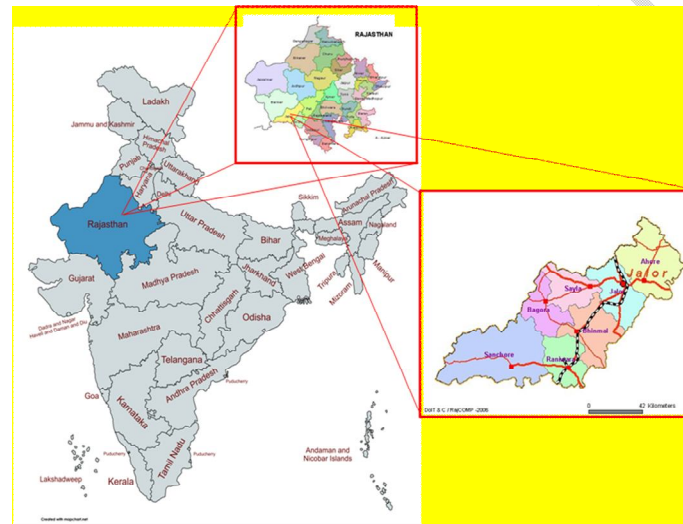


Fig.1. Map of study area

Climate

The climate of zone IIb is dry with large variation in temperature and rainfall (except some part of district Sirohi). During summer season highest temperature remains between 35° - 45° C and during winter season the lowest temperature go up to 10 - 50° C. Average annual rainfall varies from 330 mm in tehsils of district Jodhpur to 490 mm in pali district; however it is 421 mm in Jalore and 450 mm in tehsil of district

Sirohi, The rainfall is highly erratic and variable in space and time. Average number of rainy days varies from 19-26 days and relative humidity remains between 57-69% during rainy season.

Soil characters

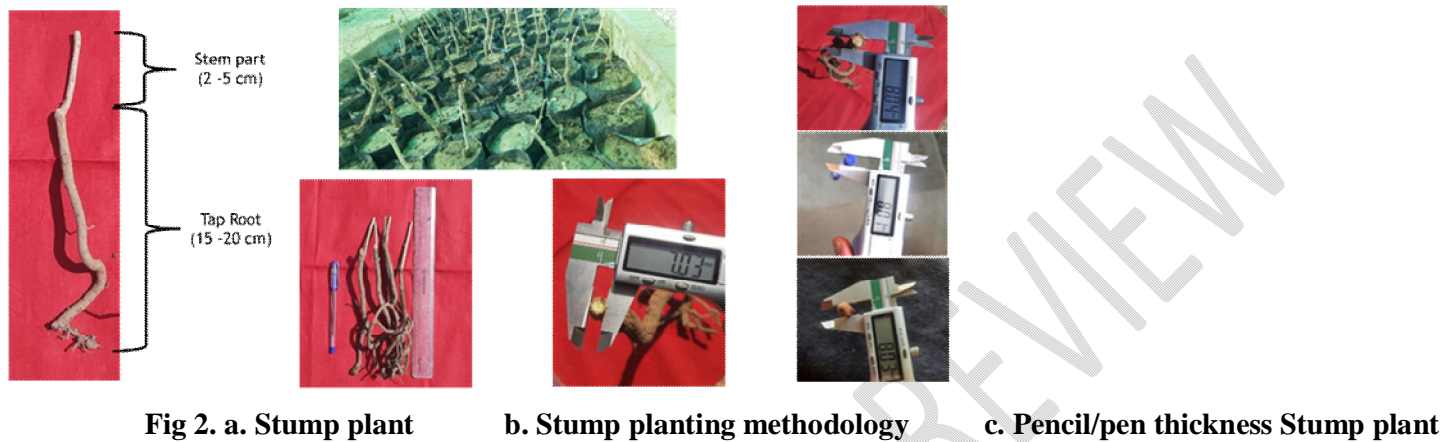
The soil of the experimental site has been classified as sandy loam. Soil information on pH, OC, N, P and K is given in Table 1. Data shows that surface soil is loamy in texture, overall, the pH 8.1 indicating that soil is slightly alkaline in nature, with 0.67 EC. Carbon content in the soil is poor having 0.52 %. Low in available nitrogen 156.3 kg ha⁻¹, medium in phosphorus (11.4 kg ha⁻¹) and low in potassium (30.29 kg ha⁻¹).

Table 1. Soil physico-chemical characteristics of the study site.

Parameters	Value
pH	8.1
EC (mS/cm)	0.67
OC (%)	0.52
Available Nitrogen (kg ha ⁻¹)	156.3
Phosphorus (kg ha ⁻¹)	11.4
Potassium (kg ha ⁻¹)	30.29

Stump plant preparation

In this study *T. undulata* stump plant are prepared by the seedlings that are maintained in the nursery for about one year, seedlings were raised and harden for one year in a polybag with proper potting mixture (sand: soil: FYM in the ratio of 1:1:1, v/v). One year old hardy seedling with 4-9mm (pencil/pen thickness) collar diameter seedlings were selected and uprooted, all the leaves and secondary roots were trimmed or removed with a clean secateurs and stumps with 2cm to 5cm shoot height and 15cm to 20 cm tap root portion was retained. The stem portion received an oblique cut and the root portion a horizontal cut (Fig 2a, b & c).



Treatments

The experiment was laid in a randomized block design with five replication and four treatments (Table 2). A total of 20 stumps per treatment having four stumps in each replication were taken for study. Weeding and irrigation was done as and when required.

Table 2. Treatment details

Treatments	Details
T ₁	Seedling (1 yr).
T ₂	<6 mm Stump Planting
T ₃	7-8 mm Stump Planting
T ₄	>8-9 mm Stump Planting

Data on growth attributes of seedlings and stump plant i.e. survival percent, collar diameter, shoot height, number of branches, leaves, percent increase in growth, sprout density and stem straightness was documented using following procedure.

Survival Percentage, plant height (m), collar diameter (mm) and number of branches Plant⁻¹

Plant survival percentage was calculated as:

$$\text{Survival Percentage} = \frac{\text{Number of stumps planted} - \text{Number of stumps wilted}}{\text{Total number of stumps planted}} \times 100$$

Plant height data of randomly selected plants in each replication was recorded from ground level to the top of the plant with the help of measuring tape and then its averaged. Collar diameter was measured near the ground level with the help of digital caliper and expressed in mm. Number of branches and leaves were counted and then its average was worked out.

Percent increase in growth

Percent increase in growth of stump plant versus seedling parameter is calculated using following formula;

$$\text{Percent increase} = \frac{\text{Stump growth} - \text{Seedling growth}}{\text{Seedling growth}} \times 100$$

Sprout density

Sprout density (the number of sprouts per stump) was examined at the beginning and the end of growing season for two growing seasons. Sprouts were considered alive when at least one green tissue was present on the stump (Obrien *et al.* 2014).

Stem straightness.

Stem straightness for the Rohida plantation was done in the second year plantation and adopted visual assessment method. Data of randomly selected plants in each replication was recorded at the places where ever the stem exhibited the straightness with the help of meter scale and summed to get the total straightness of the plant and further used for calculation of straightness percentage (Fig. 2).

Visual assessment

The Forestry Commission's method for visual assessment of stem straightness was adopted and applied with some modification for Rohida seedlings (Fig. 2). Individual stem straightness is based on an estimate of straightness of sapling lengths and adopted scoring system from 0 (not straight) to 6 (straightest) and accordingly allotted the grade from A to E (Table 3) (Macdonald *et al.* 2009, Price *et al.* 2017).

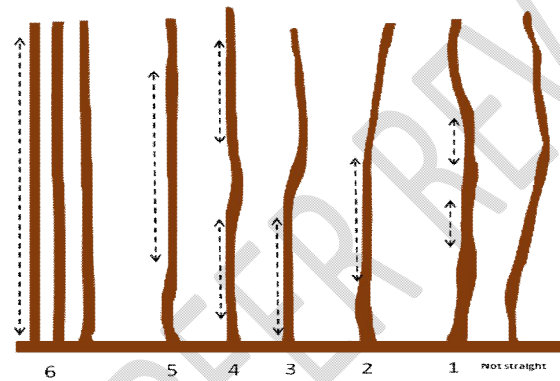


Fig 2. Pictorial representation of modified Forestry Commission's method for visual assessment of Rohida seedling adopted for stem straightness score and grading in the present study.

Table 3. Adopted stem straightness (%), grade and condition

Score	Straightness %	Grade	Condition
6	>75 % Straight	A	Excellent
5	>60 % & <75 %		
4	>50 % & <60 %	B	Very good
3	>40 % & <50 %		

2	>30 % & <40 %	C	Good
1	>20 % & <30 %	D	Moderate
0	<20 % Not straight	E	Poor

Stem straightness percentage

Stem straightness percentage was calculated using the following formula

$$\text{Stem straightness \%} = \frac{\text{Straight stem (m)}}{\text{Total height}} \times 100$$

Statistical analysis

The mean values of each replication were calculated and ANOVA was worked out for level of significance among different treatment combinations. Significant differences of treatment means were tested at $P \leq 0.05$ significance level.

Result and Discussion:

There is no information cited regarding preparation and development of stump planting technique and its performance evaluation in *Tecomella undulata*, stump planting are widely employed in raising teak plantations, but there are reports of stump planting in *Eucalyptus tereticornis*, *Grewia tiliifolia*, *Bombax ceiba*, *Pterocarpus marsupium* etc. (Joshi 1981, 1983, and Chacko *et al.* 1990).

Growth performance of *T. undulata* stump planting over seedling.

Survival (%) did not show marked variation between the plantations established by stump and seedling. The rohida stump and seedling had shown 100 percent survival during the study period. However, the success of stump planting varies considerably with species. Based on the

data presented in table 1 it can be inferred that the stump plants showed enhance growth parameters over seedling originated plants, growth data was significant among treatments throughout the study period. Mean tree height was higher in the stump grown plants than seedling grown plants. Treatment T₄ showed best growth performance in terms of plant height, collar diameter, number of leaves and sprout density followed by T₃, T₂ and T₁ for 2022 and for collar diameter, number of leaves and sprout density in the year 2021; Whereas, other parameters found to be non-significant i.e. height and number of branches in 2021 and number of branches during 2022 (Table.4). It also exhibited 44% and 54 % higher growth in height and collar diameter in T₄ fallowed by T₂ (26 & 39) and T₃ (14 & 24) as compare to seedling after two years of planting (Fig. 4). The results suggested that the differences in average height and collar diameter was more in stump than in seedling is due to marked adoptability which attributed for better root growth by utilization of stored food material and absorption of required nutrients from the soil. There is significant height increment in stump planted pine over regular planted pine was noted by Shaw et al. 1897 and height to diameter ratio was higher than those regular planted pine which indicates that trees are putting on height in order to get more light (Koot, 2005). In *Faraxinus angustifolia* it was advantageous that stumpling significantly increased the growth of highly damaged seedling by providing good survival of the species (Cieck and Tilki 2007). In another study it is found that there is lack of significant difference between height and collar diameter among stump and regular planted seedling of Douglas-fir (Koot, 2005). In contrary the root trainer grown stands showed good growth performance than stump plants in teak (Gorge et al. 2019). Similar findings were documented by many scientists in teak (Khedkar, 1999 and Rao *et al.*, 2001, Khedkar and Subramanian, 1997). Many reports suggest such variation in growth parameters owing due to differences in planting materials (Gyi *et al.*, 1983; Rao *et al.*, 2001).

Stem straightness (m), stem straightness percentage, score and grading stump and seedlings.

Stem straightness is important for timber, pole and pulpwood species. It is better to assess the stem straightness in the early stage that can be helpful for proper management and also to determining tree and log value. This measurement makes a forest or plantation manager to effectively assess the production before harvesting and is useful to improve forecasting, planning, marketing and resource use. Very less or no information is available on the stem straightness characteristics of stumpling and seedling of rohida. However, available reports on different species suggest

considerable differences in seedling grown plant as compared to clonal or vegetative origin (Mitarini and Harahap, 1994). For *T. undulata* it is important to study the stem straightness in the early stage because the main trunk of the plant branches very early at lower level of the stem and results in bushy habit of the plant which makes most of its trunk part unsuitable for timber production if the branches are left un-pruned. Stem straightness was significantly differed among treatments, higher stem straightness was obtained in T₄ (0.56 m) and T₃ (0.40 m) which had 77 and 66 % stem straightness percent , scored 6 & 5 considered A grade. Whereas, T₂ and T₁ (0.33 m & 0.23 m) had 48 and 32 % stem straightness percent with a score of 4, 3 and 2 which comes under B & C grade (Table 5 & Fig 4) as per the modified visual method of assessing straightness (Price et al. 2017).

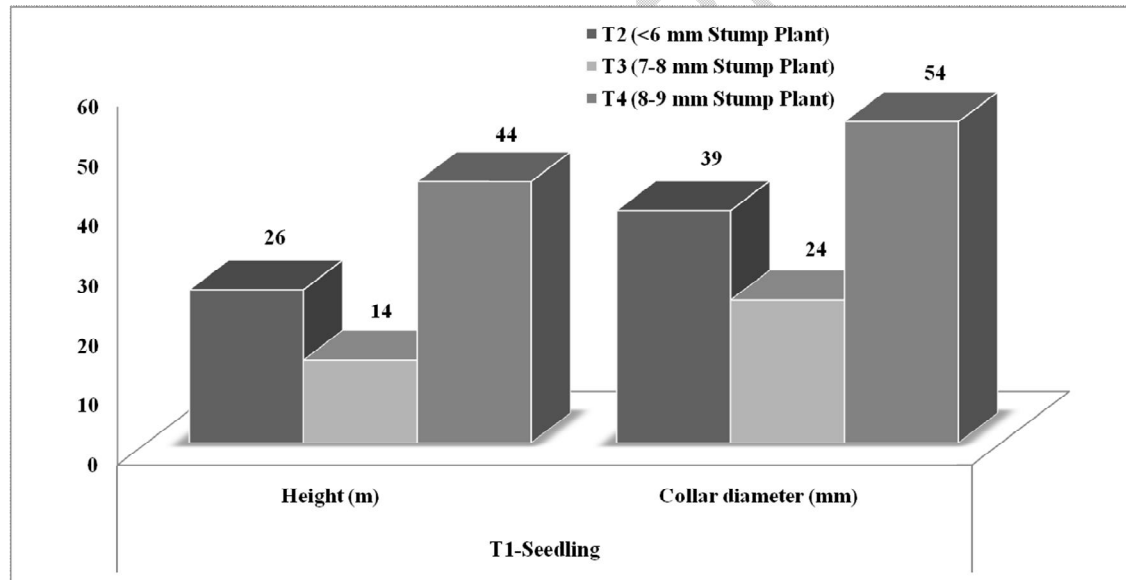
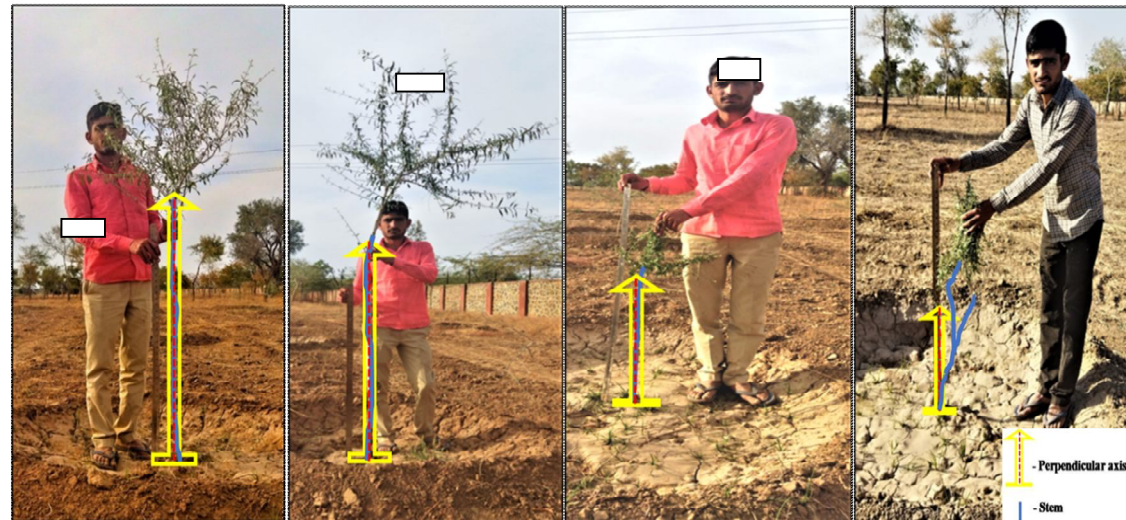


Fig. 3. Percent increase in growth of stump plant over seedling of *T. undulata*.

□



A grade

B grade

C grade

D grade

Fig. 4. Photograph showing grades (A,B,C & D) of stem straightness in *T. undulata* under field condition of ARS Keshwana, Jalore, Rajasthan (Lat 25^o23' 14.22'' N and Long 73^o30' 43.08'' E).

Conclusion

The present study showed that growth and productivity can be enhanced by stump planting technique. Hence stump plantings of 8-9 mm thickness (pen/pencil-sized), with 20-25 cm stump plant (2- 5 cm stem and 15-20 cm tap root) is found to achieving enhanced growth and stem straightness in *T. undulata*. This finding is helpful in producing quality planting stock of *T. undulata* for establishment of plantation and afforestation programmes. Further as a future line of work long-term studies on its growth and management practices should be undertaken to judge the duration for field establishment of stumps plants over seedlings of *T. Undulata*.

Acknowledgement:

Authors are thankful to Zonal Director Research, Agricultural Research Station (Agriculture University Jodhpur) for providing necessary facility to conduct this experiment.

Conflict of interest.

Authors declare there is no conflict of interests.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

- 1.
- 2.
- 3.

Table 4: Growth performance *T. undulata* stumpling and seedling.

Treatments	2021					2022				
	Height (m)	Collar diameter (mm)	No. of branches	No. of leaves	Sprout density	Height (m)	Collar diameter (mm)	No. of branches	No. of leaves	Sprout density
T ₁	0.28	9.12	5.98	37.00	6.17	0.91	18.01	7.20	42.90	7.15
T ₂	0.29	9.44	5.51	32.40	5.40	1.11	22.16	8.20	49.30	8.22
T ₃	0.32	9.48	5.58	32.3	5.38	1.14	20.881	9.30	51.90	8.65
T ₄	0.34	11.06	5.97	42.00	7.00	1.44	27.563	10.30	64.50	10.75
Mean	0.31	9.78	5.76	35.93	5.99	1.19	20.48	8.75	52.15	8.69
CD	NS	0.939	NS	4.908	0.799	0.242	5.846	NS	12.473	2.082
SE(m)	0.018	0.301	0.339	1.575	0.257	0.078	1.876	0.721	4.004	0.668

Table 5: Stem straightness (m), stem straightness percentage, score and grade for *T. undulata*.

Treatments	Height (m)	Stem straightness (m)	Stem straightness %	Score	Grade
T ₁	0.91	0.23	32	2	C
T ₂	1.11	0.33	48	3 & 4	B
T ₃	1.14	0.40	66	5 & 6	A
T ₄	1.44	0.56	77	6	A
Mean	1.19	0.37	56		
CD	0.242	0.231	12.075		
SE(m)	0.078	0.074	3.876		

Reference:

- Chacko KC, Sudheendra kumar VV, Mohanan C, Surendran T, and Muhammad E (1990) Studies on stump as planting material for *Eucalyptus tereticornis* plantations. KFRI Research Report 63. p 29.
- Cieck E and Tilki F (2007) The effect of stumpling back on survival and growth of planted *Fraxinus angustifolia* Vahl. Asian Journal of Plant Science, 6(3): 546-549.
- Dhir R and Shekhawat G S (2012) Critical review on *Tecomella undulata*: A medicinally potent endangered plant species of Indian Thar desert. *International Journal of Current Research* 4(6): 36-44.
- George E, Kunhamu TK, Jamaludheen V, Santhoshkumar AV and Gopakumar (2019) Comparative performance of stump and root trainer raised teak plantations in humid Kerala. *Indian Journal of Agroforestry*, 21 (2) : 18-21.
- Ghising K, Dey AN, Chakravarty S, Panda MR , Bhowmick N and Mukhopadhyay D (2022). Growth Performance of Teak (*Tectona grandis* Linn.) Stump under different Growing Media in Nursery. *Biological Forum – An International Journal*, 14(3): 322-330.
- Gyi, MKK, Khin UA and Win UZ (1983) Studies on Planting Technique for Teak. Forest Research Institute, Burma, pp. 25.
- Jerath N, Singh G and Sehgal D (2012). *Bioresources based industry in Punjab: A treatise*. Punjab Biodiversity Board and State Council for Science and Technology, Chandigarh. 157 pp.
- Joshi DC, Arora BR, Aggarwal RK, Ruhel DC and Shama BK. 1989, Forms and content of nutrient elements. In Review of research on sand soils in India, pp. 85-112. Central Arid Zone research Institute Jodhpur
- Joshi HB (1981). (Ed.) Troup's the Silviculture of Indian trees. Vol. 3, 311 p.
- Joshi HB (1983). (Ed.) Troup's the Silviculture of Indian trees. Vol. 4, 344p.
- Khan TI (1998) Biodiversity: concepts and need of conservation, In: Biodiversity conservation and sustainable development, edited by Khan TI and Shishodia YS (Pointer Publishers, Jaipur, India) 124-139.
- Khedkar MH (1999) Advantages of raising teak (*Tectona grandis*) plantations by using root trainer plants. *Indian Forester*, 125(2):133-136.
- Khedkar MH and Subramanian K (1997) Trails on raising teak (*Tectona grandis*) planting stock in root trainers. *Indian Forester*, 123(2): 95-99.
- Koot C (2005) A comparison of stump-versus regularly planted conifer seedling growth and performance. Technical report. Forest Investment Account Land Base Investment Program. P17.
- Kumar, S S. (2020) *Tecomella undulata* (Rohira): A Valuable Endangered Tree of Indian Thar Desert, Agrospheres: e-Newsletter. 1(2): 17-19.
- Macdonald E, Mochan S and Connolly T (2009) Validation of a stem straightness scoring system for Sitka spruce (*Picea sitchensis* (Bong.) Carr.). *Forestry*, Vol. 82, No. 4, 2009. doi:10.1093/forestry/cpp011.
- Negi RS, Sharma MK, Sharma KC, Kshetrapal S, Kothari SL and Trivedi PC (2011) Genetic diversity and variations in the endangered tree (*Tecomella undulata*) in Rajasthan. *Indian Journal of Fundamental and Applied Life Sciences* ISSN: 2231-6345 (Online)
- Obrien MJ, Leuzinger S, Philipson CD, Tay J and Hector A (2014) Drought survival of tropical tree seedlings enhanced by non-structural carbohydrate levels. *National Climate Change* 4:710–714. <https://doi.org/10.1038/nclimate2281>.

- Parton WJ, Schimel, DS, Cole CD and Ojima DS (1987) Analysis of factor controlling soil organic matter levels in great plains grasslands. *Soil Science Society of America Journal* 1173-1179.
- Price A, Hapca A, Gardiner Barry, Macdonald E and Mclean P (2017) Assessing the stem straightness of trees. Forestry Commission Technical Note 021. P6. ISBN: 978-0-85538-958-1. www.forestry.gov.uk/forestresearch.
- Randhawa GS and Mukhopadhyay A (1986). Floriculture in India. Allied Publishers Private Limited Mumbai, India, pp- 225.
- Rao PS, Venkaiah K, Murti SSN and Sattar, SA (2001) Root trainer vs. stump planting of teak a comparative study. *Indian Forester*, 127(11): 1289-1293.
- Saxena VS (2000) Forest Plants: Forest types and Forest wealth, In: Encyclopaedia Botanica, edited by Trivedi PC (Pointer Publishers, Jaipur, India) 84.
- Shaw CG Sidle RC and Harris AS (1987) Evaluation of planting sites common to a southeast Alaska clear-cut. III. Effect of microsite type and ectomycorrhizal inoculation on growth and survival of Sitka spruce seedling. *Canadian Journal of Forest Research*. 17: 334-339.

UNDER PEER REVIEW