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Effect of different treatments on the germination parameters and seedling quality index of *Tectona grandis* (Teak) under nursery condition

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Abstract
The study was conducted over a period of 5 months from March to July, 2017, to study the effect of varied pre-sowing treatments on seed germination of *Tectona grandis* (Teak) in the nursery area of College of Forestry, SHUATS, Allahabad. Seeds were subjected to 14 treatments including control i.e. T_0 (Control), T_1 (Soaked in normal water for 3 days), T_2 (Sunlight for 3 days), T_3 (Alternate wet 12hrs and drying 12hrs for 10 days), T_4 (Soaked in cow urine for 6 days), T_5 (Soaked in Cow dung slurry for 7 days), T_6 (Hammer treatment), T_7 (Sand paper), T_8 (Boiling 2 min), T_9 (Boiling 5 min), T_{10} (Conc. H_2SO_4 15 min), T_{11} (Conc. H_2SO_4 20 min), T_{12} (HNO_3 15 min), and T_{13} (HNO_3 20 min). Findings of the data revealed that pre-treatment of seed before sowing enhanced seed germination and seedling growth. The highest germination percentage (43.3%) was observed in T_3 (Alternate wet and drying) followed by T_5 (Cow dung slurry 40%) and T_{11} (H_2SO_4 20 min 33.3%). The lowest germination (13.3%) was recorded in T_2, T_4 and T_{12} (sunlight, cow urine and HNO_3 15 min) respectively. Seedling height, root length, collar diameter and number of leaves have resulted different performance trend and found as T_3, T_5, T_6, T_{10} and T_{11} respectively and as for fresh and dry shoot weight, fresh and dry root weight trend of higher value was observed in T_3 and T_5 respectively and the lowest in T_0. Observation for seedling quality parameter, it show difference in higher trend of value i.e. T_8 and T_9 for root shoot ratio-I, T_8 and T_{12} for root shoot ratio-II while for Sturdiness quotient, highest value was observed in T_4 (cow urine).Therefore, the effect of pre-sowing treatment T_3 (alternate wet and drying) and T_5 (cow dung slurry) was more effective in germination and production of quality seedling of *Tectona grandis* (Teak) in the nursery.

Keywords: Pretreatment, *Tectona grandis*, germination, soaked, sowing media

Introduction
Forests are necessary bond for economic and social progress. Forest contributes substantially to the economic development of the country by providing goods and services to the people and industry and also linked with our culture and civilization. Forest Plantations are an important resource of wood, fuel and a variety of other forest products in India. The earth plants have been playing an important role for human and seeds are one of the most important medium through which plant can survive their existence in this earth (Hossain *et al*., 2005) [1-14]. The seed is a key element in plant production that it exercises a very great influence on the success and failures of both natural and artificial regeneration (Nwoboshi, 1982). Seed germination and early seedling growth phases are considered critical for raising a successful crop as they directly determine the crop stand density and consequently the yield of the resultant crop (Hossain et. al., 2005) [1-14]. Seed size emerged as a governing characteristic for germination parameters and seedling establishment owing to best evolutionary traits of plant which also impart major contribution in genetic diversity (Kumar *et al*; 2017) [21]. It is indicated that seed germination and seedling growth are governed by many intrinsic and extrinsic factors and are species specific. . Numerous trees have been identified as fast growing, while many of tree species have seeds which possess hard seed coats that are impermeable to water; thus, they cannot germinate under normal condition (Imchen *et al*; 2015) [8]. Therefore, studies on factors that affect germination and seedling growth for a particular species are required. *Tectona grandis* commonly known as teak, is an important tropical hardwood trees species placed in the flowering plant family Lamiaceae. It is a large, deciduous tree that is dominant in mixed hardwood forests native to Southeast Asia (India, Myanmar, Thailand and Western Laos), where it grows up to 45 m high (Weaver, 1993) [38]. Teak, is the most important of the three

species in the genus (*T. hamiltoniana, T.phillipensis*). It grows best in moist tropical climates with a pronounced dry season (3-6 months) (Kaosa-ard, 1981) [18-19]. It tolerates a pH range of 6.5 to 8.0 but good growth is attained on soils of pH 6.5 and an annual rainfall or 1500 mm. The world's first teak plantation was raised in Nilambur during the 1840s to ensure the steady supply of teak timber from North Kerala for the Britishers. Nilambur in kerala is renowned for the oldest teak plantation in the world. Nilambur is home to huge teak woods and plantations. Teak (*Tectona grandis*) is considered one of the most valuable woods for plantations. Teak wood is globally renowned for its strength, durability, dimensional stability, working quality and non-corrosive property when in contact with metal. The durability is attributable to the deposition of polyphenols in its heartwood. Teak can be left in its natural state and will survive without problems even if it is kept outside for most of the year. Its natural durability in extreme weather conditions means that some furniture will last for more than 50 years even if it is exposed to extreme weather. This also means teak is often more expensive than most of other woods and usually teaks furniture is not just an ordinary furniture, but it became something like a status symbol. A rare combination of durability, dimensional stability and strength properties make teak a paragon of timber and as of date faces no threat of being eclipsed by any other timber species. On account of these outstanding properties, Teak is sometimes hailed as the Queen of timbers. Valuable wood properties including high durability and resistance to chemical give the species highly estimated value (Sandermann and Dietrichs 1959). Today Teak is considered as one of the widely planted hardwood timber species in the world, covering 2.25 million ha (Ball *et al.,* 1999). Due to its high timber value, Teak is also considered as one of the promising timber species in Bangladesh which accounts for 60-70% of the annual plantation area (MOEF, 1993). Teakwood has been used in the manufacture of charcoal and as fuelwood, but nowadays it is usually considered too valuable for anything but pruning remnants and other rejects to be used in this way.

However, though it has a great economic value, people don't get interest in raising its seedling in nursery due to low germination percentage and more average time requirement for seed germination (Luna, 1996) [24]. In fact the drupes germinate slowly and irregularly if it is untreated (Jackson, 1994). This delayed and irregular germination of seeds in the nursery is a serious constraint for *T. grandis* for efficient nursery management and plantation establishment. Therefore it is essential to find out some pre-sowing treatments of their seeds for ensuring their earlier, successful germination. This will help people to minimize their production cost of seedlings on a broad scale. A considerable body of evidences suggest that pre-sowing treatments strongly enhance the germination process (Hossain *et al., 2005*; Palani *et al*., 1996; Azad *et al*., 2010a, b) [1-14, 28, 5-6]. However, research findings related to the pre-sowing seed treatments of T. grandis, are very scared. In addition, the studies are associated mainly with seedling growth performance of Teak but no detailed experiment to evaluate effects of fast and successful germination of Teak seeds (Chowdhury *et al.,* 2008; Kwame *et al.,* 2014) [22]. The viability of teak seeds varies from 40 to 85% depending on certain factors such as; seed size, seed source, collection year, weather conditions during flowering and fruiting (Kaosa-Ard, 1981) [18-19]. Although, since 1976 the International Seed Testing Association has defined this protocol of teak germination, some of the problems faced by the forest seed certification program are the large differences in germination results between laboratories. Keeping in mind above view, there is prime need to develop a suitable pre-treatment technique for the large-scale production of superior clonal stock for testing and plantation establishment. Consequently, under the present condition, the purpose of this research is to explore the best methods to break the seed dormancy of *T. grandis* using different treatments, describe the effects of treatments on the germination and finally to propose treatments that maximize seed germination of the specie value under a number of easily applicable low cost pre-sowing treatments.

2. Materials and Methods

2.1 Study Area

An experiment was conducted during 2017 in the nursery area of the College of Forestry, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, U.P. The experimental site is situated between the North latitude 28°52' and at the longitude 81° 55'E with an altitude of 98 m msl. The climate, in general, is temperate characterized by hot summers with maximum temperature 47°C during May and June and least being i.e. 1°C in January. On an average the area receives an annual rainfall of 850 to 1000 mm. Most of which is concentrated during monsoon season. It is located in the southeastern part of Uttar Pradesh and has tropical to subtropical climate with extremes of summer and winter.

2.2 Materials

Tectona grandis seeds were collected from the Nursery, College of Forestry, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, U.P. Seeds of uniform size were selected to reduce non-treatment variation. The sowing mediums are prepared as the mixture of sand, soil and farm yard manure, in the ratio of 1:2:1 and it was filled into 4/6 size poly bags. After filling of polybags, the seeds were treated and sown in the nursery with uniform depth of 1cm.

2.4 Experimental Design

The experiments were laid out in a Complete Randomized Design (CRD) in green house. Seeds were subjected to fourteen (14) treatments viz. T_0 Control (Intact seeds without applying any treatment), T_1 (Soaking in normal water for three days), T_2 (Exposed to sunlight for three days), T_3 Alternate wet and drying(the seeds were soaked in water for 12 h and dried for 12 h at a temperature range of between 30 and 45°C for 8 days), T_4 (Soaked in Cow urine for six days followed by washing in tap water and sown in polybags), T_5 (Seeds were soaked in Cow dung slurry for 7 days followed by washing in tap water and sown in polybags), T_6 (Hammer treatment, making of crack on seed coat with the help of small hammer and sown in the polybags), T_7 (Sand paper treatment, it is allowed to rubbed the seed coat roughly and sown in the polybags), T_8 (Seed were treated with boiling water for 2 minutes), T_9 (Seed were treated with boiling water for 5 minutes), T_{10} (Seed treatment with Conc. Sulphuric acid (H_2SO_4) for 15 minutes followed by washing in running tap water and sown in polybags), T_{11} (Seed treatment with Conc. Sulphuric acid (H_2SO_4) for 20 minutes followed by washing in running tap water and sown in polybags), T_{12} (Seed treatment with Nitric Acid (HNO_3) for 15 minutes followed by washing in running tap water and sown in polybags), and T_{13} (Seed treatment with Nitric Acid (HNO_3) for 20 minutes followed by washing in running tap water and sown in

polybags) replicated three times. Ten (10) poly bags were used for each replication of each treatment. Therefore, a total of 420 seeds were subjected to 14 different pre-sowing treatments. The date of applying pre-treatment and sowing date were also recorded.

The experimental data recorded during the course of study were subjected to statistical analysis as per method of Variance, (ANOVA) as suggested by Fischer, 1950. Treatment effect would be determined by 'F' test by using the software OPSTAT. The significant and non-significant of the treatment effect were judged with the help of 'F' value (Variance ratio) and are compared with the tabulated value of 'F' at 5% level of significant, if calculated value exceeded the table value the effect was considered to be significant, otherwise the effect is considered non-significant.

3. Results

The results on the different seed treatment of *Tectona grandis* was tested on sowing in the poly-bags for germination parameters, growth parameters, biomass parameter, and seedling quality were measured for pre-treatments on Teak seeds after a 4 months planting period of time, (i.e. final reading) are presented separately.

3.1 Germination parameter

The number of days taken in initiation of seed germination was differ significantly in different treatment and earliest initiation of germination was observed in the treatment T_3 (24.33 days) and followed by T_5 (26.33 days) and T_6 (30.33 days) and T_{10} and T_9 which have similar initiation. The latest to initiate germination (39.67 days) was recorded in both T_0 and T_2 respectively followed by T_4 (36.67 days).The initial days of fastest completion of germination was recorded in T_5 (33.67 days) and T_3 (34.67 days) followed by T_6, T_9 and T_{10} which showed similar days to complete germination. And the latest to complete germination was recorded in T_0 (44.33 days) and T_2 (43.33 days). The germination percentage was differ significantly in different treatment and the maximum germination percentage was recorded by T_3 (43.33%) which is the highest shown among all the treatment and followed by T_5 (40%) and T_{11} (33.33). And the lowest (13.3%) was recorded in T_2, T_4 and T_{12} followed by (16.67%) in both T_0 and T_8 respectively. The highest germination speed among all the treatments was shown by T_3 (0.15) and followed by T_5 (0.13) and T_{11} (0.09) and T_6 and T_9 and T_{10} which have the similar value. The lowest or minimum (0.03) was shown by T_2 and T_4 respectively followed by T_0 and T_{12}.

Table1: Effect of pre-treatment on Seeds germination on Number of days taken to initiate and complete germination, germination percentage and germination speed of *Tectona grandis*.

Treatment	No. of days taken to initiate Ger.	No. of days taken to complete Ger.	Germination Percentage	Germ. Speed
(T_0) Control	39.67	44.33	16.67	0.04
(T_1) Normal water (soak for 3 days)	36.00	42.67	20.00	0.05
(T_2) Sunlight for 3 days	39.67	43.33	13.33	0.03
(T_3) Alternate wet(12hrs) and drying (12 hrs) for 8 days	24.33	34.67	43.33	0.15
(T_4) Cow urine 6 days	36.67	38.33	13.33	0.03
(T_5) Cow dung slurry 7 days	26.33	33.67	40.00	0.13
(T_6) Hammer	30.33	35.00	233	0.07
(T_7) Sand paper	35.33	38.oo	20.00	0.05
(T_9) Boiling 2 min	35.67	37.33	16.67	0.05
(T_9) Boiling 5min	31.67	36.00	23.33	0.07
(T_{10}) H_2SO_4 15min	31.00	36.67	30.00	0.08
(T_{11}) H_2SO_4 20min	32.33	38.00	33.33	0.09
(T_{12}) HNO_3 15min	35.00	37.00	13.33	0.04
(T_{13}) HNO_3 20min	34.67	38.00	20.00	0.05
C.D.	3.003	4.418	11.888	0.030
SE(m)	1.031	1.517	4.082	0.010
SE(d)	1.458	2.146	5.774	0.015
C.V.	5.336	6.962	30.305	26.821
F-Test.	S	S	S	S

3.2 Growth Parameter

Seedling Height – The seedling height was differ significantly in different treatment and the maximum seedling height was observed in T_3 (16.48cm) followed by T_5 and T_6 showing 16.11cm and 15. 88cm respectively. The minimum value was showed by T_0 (13.6cm) followed by T_1 and T_7 and T_8 which shows similar height 14.28cm and 14.33cm and 14.15cm respectively.

Collar diameter – The collar was differ significantly in different treatment and the maximum collar diameter (5.03mm) was recorded in T_3 followed by T_5 (4.97mm) and followed by T_6 (4.88mm) and T_8, T_9, T_{10} and T_{11} showed similar value i.e. 4.77mm and 4.79mm and 4.84mm and 4.84 respectively. The minimum collar diameter was recorded in T_0 (4.23mm) and T_4 (4.17mm) and followed by T_2 (4.32mm).

No. of leaves per seedling – The Number of leaves was differ significantly in different treatment and the maximum no. of leaves per seedling was recorded in T_{11}) i.e. (7.67) followed up by T_5 (7.33) and T_9 (7.29). The minimum no. of leaves per seedling was recorded in T_1 (5.78) and T_8 (5.83) and followed by T_0 and T_7 and T_{12} which showed same no. of leaves per seedling i.e. 6.17 each.

Root length – The root lentgh was differ significantly in different treatment and the longest root length was recorded in T_5 (14.28cm) and followed by T_3 (14.09cm) and T_6 (13.98cm). The minimum root length was recorded in T_0 (11.07cm) followed by T_1 and T_4.

Table 2: Effect of pre-sowing seed treatment on growth parameter viz. seedling height, collar diameter, no. of leaves and root length on *Tectona grandis* seedling after 120 days.

Treatment	Seedling height (cm)	Collar diameter (mm)	No. of leaves per seedling	Root length (cm)
(T_0) Control	13.57	4.23	6.17	11.07
(T_1) Normal water (soak for 3 days)	14.28	4.67	5.78	12.49
(T_2) Sunlight for 3 days	14.40	4.32	4.83	12.68
(T_3) Alternate wet(12hrs) and drying (12 hrs) for 8 days	16.48	5.03	7.17	14.09
(T_4) Cow urine 6 days	14.42	4.17	5.67	12.50
(T_5) Cow dung slurry 7 days	16.11	4.97	7.33	14.22
(T_6) Hammer	15.88	4.88	7.17	13.97
(T_7) Sand paper	14.33	4.52	6.17	13.12
(T_8) Boiling 2 min	14.15	4.77	5.83	13.43
(T_9) Boiling 5min	14.68	4.79	7.28	13.62
(T_{10}) H_2SO_4 15min	15.22	4.84	6.61	13.83
(T_{11}) H_2SO_4 20min	15.21	4.83	7.67	13.51
(T_{12}) HNO_3 15min	14.55	4.48	6.17	12.90
(T_{13}) HNO_3 20min	14.94	4.51	6.67	13.04
CD	0.514	0.252	1.116	0.501
SE(m)	0.177	0.086	0.383	0.172
SE(d)	0.250	0.122	0.542	0.243
C.V.	2.063	3.226	10.267	0.260
F-Test	S	S	S	S

3.3 Biomass parameter

Fresh shoot weight (g) – Fresh shoot was weighed using an electronic weighing balance. The average shoot weight was calculated for each treatment selecting 5 plants from each replication. It was differ significantly in different treatment and the maximum fresh shoot weight was shown by T_5 (4.04gm) followed by T_3 (4.02gm) and T_6 (3.96gm) and T_{11} (3.92gm) while the minimum fresh shoot weight was shown by T_0 (3.08gm) and followed by T_2 (3.15gm).

Fresh root weight – The same method was performed like the previous where weighing was done after separating of the roots from the shoot. The maximum fresh root weight was observed in T_3 (2.18gm) and followed by T_5 (1.97gm) and T_1 and T_{10} which showed same weight 1.81gm and T_{11} (1.78gm). And the minimum fresh root was observed in T_0 and T_{12} and T_{13} which showed similar weight 1.53gm and 1.58gm and 1.55gm respectively and followed by T_2 and T_8 which showed almost similar weight 1.65gm and 1.63gm respectively.

Dry shoot weight – 5 plants were selected randomly from the three replication and left in the hot air oven at 60˚C for 48hrs which were further weighed by using electronic weighing balance. The average dry shoot matter was calculated for each treatment. The maximum dry shoot weight was observed in T_5 (1.07gm) followed by T_3 (1.01gm) and T_4 and T_9 and T_{11} which showed almost weight 0.93gm and 0.92gm and 0.95gm respectively. And the minimum dry shoot weight was observed in T_{12} (0.72gm) and followed by T_0 (0.073gm).

Dry root weight – The maximum dry root weight was observed in both T_3 and T_5 which showed 0.43gm and followed by T_1 (0.40gm). And the minimum dry root weight was observed in T_0 and T_{13} which showed 0.33gm.

Table 3: Effect of pre-sowing seeds treatment on Biomass traits viz. Fresh shoot and dry weight and Dry shoot and root weight of *Tectona grandis* seedling.

Treatment	Fresh shoot weight	Fresh root weight	Dry shoot weight	Dry root weight
(T_0) Control	3.08	1.53	0.73	0.33
(T_1) Normal water (soak for 3 days)	3.77	1.81	0.83	0.40
(T_2) Sunlight for 3 days	3.15	1.65	0.81	0.36
(T_3) Alternate wet(12hrs) and drying (12 hrs) for 8 days	4.02	2.18	1.01	0.43
(T_4) Cow urine 6 days	3.45	1.75	0.93	0.33
(T_5) Cow dung slurry 7 days	4.04	1.97	1.07	0.43
(T_6) Hammer	3.96	1.73	0.88	0.37
(T_7) Sand paper	3.48	1.70	0.73	0.35
(T_8) Boiling 2 min	3.40	1.63	0.73	0.35
(T_9) Boiling 5min	3.63	1.72	0.92	0.37
(T_{10}) H_2SO_4 15min	3.75	1.81	0.89	0.36
(T_{11}) H_2SO_4 20min	3.92	1.78	0.96	0.38
(T_{12}) HNO_3 15min	3.45	1.57	0.72	0.35
(T_{13}) HNO_3 20min	3.48	1.55	0.84	0.33
C.D.	0.322	0.153	0.178	N/A
SE(m)	0.110	0.053	0.061	0.025
SE(d)	0.156	0.074	0.086	0.035
C.V.	5.292	5.225	12.246	11.649
F-Test	S	S	S	S

3.4 Seedling quality parameter

Root shoot ratio – I: The maximum Root shoot ratio-I was obtained in T_3 (0.54) and significantly followed up by T_2 (0.53) and T_0 (0.50). And the minimum Root shoot ratio –I was obtained in T_6 and T_{13} i.e. 0.44 each and followed by both T_{11} and T_{12} (HNO_3) which showed same value i.e. 0.45.

Root shoot ratio – II: The maximum root shoot ratio – II was observed in T_{12} (0.49) followed up by T_8 and T_7 which showed same value i.e. 0.48 while, the minimum root shoot ratio – II was observed in T_4 (0.36) and followed by T_{13} (0.39) and T_5 and T_9 and T_{11} which showed same value i.e. 0.40.

Sturdiness Quotient: The maximum value was obtained from T_4 (3.47) and followed by T_2 (3.34) and T_{13} (3.32). And the minimum value was obtained from T_8 (2.97) and followed up by T_1 (3.06) and T_9 (3.07).

Table 4: Effect of pre-sowing seeds treatment Seedling quality traits viz. Root shoot ratio – I, Root shoot ratio – II and Sturdiness Quotient of *Tectona grandis* seedling.

Treatment	Root shoot ratio - I	Root shoot ratio - II	Sturdiness Quotient
(T_0) Control	0.50	0.46	3.21
(T_1) Normal water (soak for 3 days)	0.48	0.48	3.06
(T_2) Sunlight for 3 days	0.53	0.45	3.34
(T_3) Alternate wet(12hrs) and drying (12 hrs) for 8 days	0.54	0.43	3.28
(T_4) Cow urine 6 days	0.51	0.36	3.47
(T_5) Cow dung slurry 7 days	0.49	0.41	3.24
(T_6) Hammer	0.44	0.42	3.25
(T_7) Sand paper	0.49	0.48	3.17
(T_8) Boiling 2 min	0.48	0.48	2.97
(T_9) Boiling 5min	0.47	0.40	3.07
(T_{10}) H_2SO_4 15min	0.48	0.41	3.15
(T_{11}) H_2SO_4 20min	0.45	0.40	3.15
(T_{12}) HNO_3 15min	0.45	0.49	3.25
(T_{13}) HNO_3 20min	0.44	0.39	3.32
C.D.	0.052	N/A	0.170
SE(m)	0.018	0.034	0.058
SE(d)	0.025	0.047	0.083
C.V.	6.424	13.440	3.158
F-Test	S	S	S

4. Discussion

Several authors have argued that different methods of presowing treatments enhance the germination rate and speed up the germination process (Teketay, 1996; Alamgir and Hossain, 2005 and Azad *et al.*, 2010a, b) [35, 1, 5-6]. Similarly findings of the present study revealed that seeds of *Tectona grandis* under different treatments ensured better results in the varied parameters viz., germination parameter, growth parameter, biomass parameter and seedling quality parameter.

Present study showed possible treatment variations in Teak seeds and find that there is no significant different among the presowing treatments of Alternate wet and drying and soaking in cowdung slurry 7 days though most treatment are significantly differ from control that showed poor results.. The experiment have high influence in the seed pre-treatment for initiation and completion of germination of *Tectona grandis* seeds as T_3 (Alternate wet and drying) resulted into early initiation and followed by T_5 (Cow dung slurry). While, for completion of germination T_3 and T_5 showed a statistically similar days. Thus, alternate wet and drying (T_3) and Cow dung slurry (T_5) showed a better germination percentage and also was statistically at par. But T_3 showed the highest germination percentage at 43.33%. This may be attributed to instant entry of water into the seed coat facilitating fast imbibition of water to the seed tissue which is a prerequisite for seed germination. Germination energy is an indicator of speed of germination and it is believed that the seeds which germinate rapidly and vigorously under favorable conditions in nursery are likely to be capable of producing vigorous seedlings in the field condition where weak and delayed germination often fatal (Hedge *et al.*, 2009 and FAO 1985). In this regard, T_3 performed the best of all, followed up by T_5 which give similar value with T_3.

In most of the growth, biomass and quality parameter though not highly, significant variation was also observed due to the effect of pre-sowing treatments methods applied on the seeds. This variation may be attributed to differences in number of days taken to initiate and complete germination in different sowing treatments. The seedling height and collar diameter and root length shows similar advantages where T_3 (Alternate wet and drying) and T_5 (Cow dung slurry) respectively shows maximum and second maximum seedling height also shows maximum collar diameter and maximum root length. While T_{11} (Conc. H_2SO_4 20min) which showed lesser in the three respect (i.e. seedling height, collar diameter, root length) than T_3 and T_5 shows maximum number of leaves.

Differences in growth and biomass parameter on account of pre-sowing treatment have also been reported by Tewari *et al.*, (2008) in *Gweria optiva*, Thakur *et al.*, (2011) in *Sapindus mukorossi*, Venkatesh *et al.*, (1997) in *Pongamia pinnata*, Jerlin and Vadivela (1994) in *Acacia millifera*. Biomass parameter shows that T_5 (Cow dung slurry) and T_3 (alternate wet drying treatment) both with almost similar weight i.e. 4.04gm and 4.02gm dominate the fresh shoot weight and T_3 (alternate wet drying treatment) (2.18gm) dominate the fresh root weight.

The root and shoot ratio – I was worked out on the basis of fresh root and shoot weight of the seedling as per the following formula adopted by (Handa *et. al.*, 2005) [13]. While the root and shoot ratio – II was worked out on the basis root and shoot dry weight as per the following formula adopted by Raj *et. al.*, (2010) [30] Luna and Channoli (2006) [26]. The

maximum Root shoot ratio-I was obtained in T_3 (Alternate wet and drying) (0.54) and significantly followed up by T_2 (Sunlight treatment) (0.53) and T_0 (Control) (0.50). The maximum root shoot ratio – II was observed in T_{12} (HNO_3 15min) (0.49) followed up by T_8 (Boiling 2min) and T_7 (Sand paper) which showed same value i.e. 0.48. The sturdiness quotient reflects the stock and spindly nature of seedling (Vikatish *et al.*, 2009) [37]. Sturdiness quotient was calculated by dividing the seedling height (cm) by collar diameter (mm) according to the Roller (1977) [32] and Luna & Chamoli (2006) [26]. The maximum value was being obtained from T_4 (Cow urine) (3.47) and followed by T_2 (Sunlight treatment) (3.34) and T_{13} (HNO_3 20min) (3.32).

5. Conclusion

The findings of present study concludes that germinability and seedling vigour of *Tectona grandis* emerged better in treatment T_3 (Alternate wet and drying) which is at par with T_5 (Cow dung slurry) than other treatments though, T_5 (Cow dung slurry) performed slightly lower in the germination parameter than T_3. Since, seed germination under Alternate wet and drying and Cow dung slurry treatment is quite simple and inexpensive, hence recommended for *Tectona grandis* on a broad scale in developing quality planting stock and afforestation program.

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7. References

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