ISSN 1996-3351

Asian Journal of Biological Sciences

http://knowledgiascientific.com

Knowledgia SCIENTIFIC
A Place to Publish Outstanding Research

OPEN ACCESS Asian Journal of Biological Sciences

ISSN 1996-3351
DOI: 10.3923/ajbs.2018.120.129

Research Article
Pre-sowing Treatments for Improved Germination and Growth Performance of *Tamarindus indica* L. in Bangladesh

[1]S. Mozumder, [2]B.M. Khan and [2]M.R. Rahman

[1]Department of Geography and Environment, University of Dhaka, Dhaka, Bangladesh
[2]Institute of Forestry and Environmental Sciences, University of Chittagong, Chittagong, 4331, Bangladesh

Abstract

Background and Objective: Seed germination is the first step for the development of plant growth where some factor acts as a catalyst in this case. The study was conducted to assess the impact of different pre-sowing seed treatments on germination and seedling growth attributes of *Tamarindus indica* in the nursery. **Materials and Methods:** Performed treatments were control (T_1), socking seed in hot water treatment 100°C for 5 (T_2) and 10 min (T_3), soaking seeds in cold water for 48 h (T_4), soaking seeds in farm yard manure for 48 h (T_5), soaking seeds in concentrated H_2SO_4 for 3 min (T_6) and cracking of seeds (T_7). **Results:** The study revealed highest (84%) seed germination of *T. indica* was observed in socking seeds in conc. H_2SO_4 for 3 min. Maximum germination value (12.42), germination uniformity (7.64), germination index (7.05), mean germination time (26) was obtained in T_5 whereas highest germination energy (74.44) recorded in T_7. Seed germination began within 5 days and proceeded on normal 51 days. Shoot length, root length, collar diameter, leaf number, partial root number recorded maximum in T_5 followed by T_6. Similar trend of results were also observed in shoot, root, dry biomass production, vigor index, volume index and quality index. **Conclusion:** Therefore, the study recommended conc. H_2SO_4 treatment for 3 min for seed germination for experimental purposes only (considering the handling risk of that acid) while socking seeds with farm yard manure for 48 h can be used for large scale and quality seedling production in the nursery.

Key words: *Tamarindus indica*, germination energy, mean germination time, vigor index and germination uniformity

Citation: S. Mozumder, B.M. Khan and M.R. Rahman, 2018. Pre-sowing treatments for improved germination and growth performance of *Tamarindus indica* L. in Bangladesh. Asian J. Biol. Sci., 11: 120-129.

Corresponding Author: M.R. Rahman, Institute of Forestry and Environmental Sciences, University of Chittagong, Chittagong, 4331, Bangladesh
Tel: +88-01739048613

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Seed germination is the emergence and growth of embryo to young plants by rapture of seed coat[1]. It is an important and vulnerable stage in the life cycle of terrestrial angiosperm and determines seedling establishment and plant growth[2]. Sometimes the seeds can't germinate though they have a favourable condition which is called dormancy[3]. This delayed and irregular germination of seeds in the nursery is a serious constraint of efficient nursery management and plantation establishment[4]. Therefore, dormant seeds should be pre-treated before sowing to get good germination and desirable quantity of seedlings in the nursery[5].

Tamarindus indica L. is commonly known as Tamarind under Fabaceae family. It is assumed that the word tamarind derived from the Arabic "Tamar-u'l-Hind" (Tamere-Hind means date of India) as the pulp of this fruits is similar to dried dates[6]. Tamarind is a leguminous tree and indigenous to fertile areas throughout tropical Africa. Besides, it is widely distributed in northern Australia, Brazil, Mexico, the Philippines, the United States and Jamaica[7]. The species essentially a tree of tropical climate areas, thrives best under a maximum annual temperature ranging from 33-37°C to a minimum[8] 9.5-20°C. It is a large evergreen tree up to 20 m tall and with a diameter[9] up to 2 m. Flowers are bisexual and 2-2.5 cm in diameter, fertile stamens-3, ovary linear, about 7 mm long[6]. Seeds up to 18 mm long and glossy embedded in a thick, sticky, acid brown pulp adjacent to the seed cavities[10,11]. Besides, tapping pods with fingers can identify the maturity of fruits. The shells become easily broken at the time of tapping, if it is ready for harvesting[12,13].

Tamarind is a multipurpose tree species, with versatile uses. It is used for various household, medicinal and industrial purposes[6]. This species is considered as a component of agroforestry because of its potential nitrogen fixing ability, tolerance of infertile soil and erosion control[7]. The heartwood is very durable and used in furniture making and polishes well[9]. The wood can makes excellent charcoal which is valued for producing gunpowder and is also used for brick burning purposes due to its high calorific value[10,14] of 4850 kcal kg^{-1}. The fruit is used to cure intestinal ailments, reduce fever, malarial fever and is efficient against scurvy[15]. Tamarind pulp is a very good medicine for paralyzed people to restore sensation also used for treatment of painful and wounded throats[16]. Its pulp with lemon is used to treat diarrhea[17] and the root is used to treat dysentery. It can also used as shade tree, shelter belt and wind breaks due to its resistance to storms.

A lot of study has been suggested that germination of seeds with hard seed coat is enhanced by pre-sowing treatments[18-24]. However, there are a few literatures[25-27,9] of *T. indica* for growth and pre-showing treatments where, those are limited to compare with present study. Moreover, most of the treatments used in this study are now for the first time for *T. indica*. Therefore, in this study, the effects of different treatments were evaluated on seed germination and seedling growth performance of *T. indica* in the nursery.

MATERIALS AND METHODS

Study site: The present study was conducted from April, 2016 to February, 2017 in the nursery of Institute of Forestry and Environmental Sciences, Chittagong University Bangladesh. It lies approximately at the interaction of 91°50 E longitude and 22°30' N latitude[4]. The altitude of this area is 14-87 m above from the mean sea level[28]. The nursery site enjoys a tropical monsoon climate characterized by hot, humid summer and cool, dry winter. The average annual rainfall of this area is about 2500-3000 mm which mostly takes place between June and September. The climate is tropical monsoon with a mean monthly maximum temperature of 29.75°C and a monthly minimum of 21.24°C. The highest temperature usually occurs on May as 32.60°C and minimum in January[29] as 14.10°C.

Seed collection and experimental design: Seeds of *T. indica* were collected from the plus tree of the seed orchard division of Bangladesh Forest Research Institute (BFRI). All the seeds of uniform size were selected in the lot to reduce non-treatment variation. The seeds were sown and grown in the soils collected from the forest areas of the Campus. The soils were well sieved (<3 mm) and mixed in the decomposed cowdung at a ratio of 3:1 and finally filled with polybags of size 12.5 cm×15.25 cm. A completely randomized block design (CRBD) was adopted for the study with three replications for each treatment. The treatments used in the experiment were as follows (Table 1).

After the pre-sowing treatments, two seeds were sown in each polybag directly. They were dibbed to 0.5 cm under the soil by pressing them with the thumb. Each replication consists of 30 seeds in 30 polybags. Thus each treatment consists of 90 seeds and a total of 630 seeds were subjected to 7 different pre-sowing treatments of the species. After germination, seedlings were allowed for growing to assess initial growth performance.

Table 1: Different treatment used for the experiment

Groups	Treatments
T_1	Control (no treatment)
T_2	Soaking the seeds in hot water (100°C) for 5 min followed by cold water washing
T_3	Soaking the seeds in hot water (100°C) for 10 min followed by cold water washing
T_4	Soaking the seeds in cold water for 48 h
T_5	Soaking the seeds in liquid farm yard manure for 48 h
T_6	Soaking the seeds in conc. H_2SO_4 for 3 min followed by cold water washing
T_7	Cracking the seeds with hammer

Assessment of physiological growth performance: The effects of pre-sowing treatments were assessed periodically through counting germinated seed and initial growth performance of the seedlings. The cumulative germination was recorded in every 5 days from the day of sowing and continued till ending of the germination (70 days after the seeds sown). For growth performance study; three seedlings from each replicate were randomly selected and uprooted very carefully to estimate the seedling biomass. The seedlings were then separated into the shoot, root and leaf and dried in an oven at 75°C for 48 h for recording dry weight.

Daily and cumulative germination counts: Germination counts were recorded in each assessment date until germination was completed. For each assessment date, daily germination was summed up to obtain cumulative germination number for each treatment.

Germination percentage, germination energy, germination index and mean germination time: Number of seeds germinated out of 100 seeds from the beginning to the end of germination trial and the Eq. used was[30]:

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds shown}} \times 100$$

Germination energy is the number of seeds in the percentage that have germinated up to the time when the rate of germination (number of seed germinating per day) reaches its peak[30].

Germination index (GI) was calculated as described in the AOSA[31] as the following Eq:

$$\text{Germination index} = \frac{\text{No. of germinated seeds}}{\text{Days of first count}} + ... + \frac{\text{No. of germinated seeds}}{\text{Days of final count}}$$

Mean germination time (MGT) measure of the rate and the time-spread of germination[32,33] where it ought to ascertain time to half of germination. The MGT was calculated according to the equation of Ellis and Roberts[34] and Afzal *et al.*[35]:

$$\text{MGT} = \frac{\sum \text{Dn}}{\sum \text{n}}$$

where, n is the number of seeds, which were germinated on day D and D is the number of days counted from the beginning of germination.

Germination uniformity, germination speed, germination value and imbibition period: Germination uniformity (GU) was calculated following modified Eq:

$$\text{GU} = \frac{\sum \text{n}}{\sum (\text{Fn} - \text{t})^2 \times \text{n}}$$

where, t is the time in days, starting from days 0, the day of germination and n is the number of seeds germinate at t and F are equal to MGT[36].

Speed of germination was calculated by the following formula used by Saeb *et al.*[2]:

$$S_G = \frac{n_1}{d_1} + \frac{n_2}{d_2} + ... + \frac{n_n}{d_n}$$

Where:

S_G = Speed of germination
n_n = Number of germinated seeds per each calculation
d_n = Number of day until calculation

The imbibition period (number of days from sowing to commencement of germination) was recorded. The germination value was calculated as per the method prescribed by Diavanshir and Pourbeik[37]. Germination value is a composite value that combined both germination speed and total germination, i.e.:

$$\text{Germination value (GV)} = \frac{\sum \text{DG's}}{\text{N}} \times \frac{\text{GP}}{10}$$

Where:

GV = Germination value
GP = Germination (%) at the end of the test

DG = Daily germination speed obtained by the dividing the cumulative germination (%) by the number of days since sowing

∑DG's = Total germination obtained by adding every DG's value obtained from the daily counts

N = Total number of daily counts, starting from the date of the first germination

10 = Constant

Root-shoot ratio and total dry biomass increment: Root-shoot ratio is the value obtained by dividing root with the shoot (leaf and stem). Total dry biomass increment (%) was also calculated by using the following Eq.[38]:

$$\text{Total dry biomass increment } (\%) = \frac{\text{Total dry weight of the treatment-Total dry weight of the control treatment}}{\text{Total dry weight of the control treatment}} \times 100$$

Seedlings volume, vigor and quality indices and sturdiness: Volume index is the value obtained by multiplying shoot height (cm) with the square of collar diameter (mm^2) of the seedling[39]. Vigor index was calculated according to Abdul-Baki and Anderson[40] as germination (%) × seedling total length, i.e., total shoot and root length (cm). The quality index (QI) as developed by Dickson *et al.*[41] to quantify seedling morphological quality was calculated as follows:

$$QI = \frac{\text{Total seedlings dry weight (g)}}{\frac{\text{Shoot height (cm)}}{\text{Collar diameter (mm)}} + \frac{\text{Shoot dry weight (g)}}{\text{Root dry weight (g)}}}$$

Sturdiness of seedling was calculated using the following Eq:

$$\text{Sturdiness} = \frac{\text{Shoot height (cm)}}{\text{Collar diameter (cm) of the seedling}}$$

Statistical analysis: Recorded data related to seed germination and seedling growth attributes were analyzed statistically by using computer software SPSS ver.20.00. The analysis of variance (ANOVA) and Duncan's Multiple Range test (DMRT) was tested for the analysis to explore the possible treatment variations.

RESULTS

Germination performance: The seed germination (%) of the seedlings significantly ($p<0.05$) varied in different treatments. The highest germination (%) (84.44%) was observed in treatment T_6 followed by T_5 (83.22%) and lowest (5.56%) in T_3. Besides, germination energy of the species was maximum (74.44%) in T_7 followed by T_5 and T_6 (63.33%). Moreover, highest germination index was recorded for T_5 (7.05) followed by T_7 (6.62) and least in T_3 (0.39) whereas the rate of germination of the species was significantly different from each other and highest (0.1835) value was found in T_6 (Table 2).

There was a significant difference ($p<0.05$) found for determining MGT of *T. indica*. Therefore, most note worthy mean germination time appeared in T_5 (soaking seeds with farm yard manure) which revealed in 26th day (Table 2) whereas least mean germination time appeared in T_4 in 8th day. However, MGT did not show the time from the start of imbibitions to a specific germination (%).

In T_1, the germination proceeded up to 38 days for the species. Besides, in T_5 of *T. indica* indicated most prolonged germination period up to 51 days.

Germination uniformity, germination speed, germination value, survival (%) and imbibitions period.

In case of germination uniformity the maximum value was recorded in T_5 (7.64) followed by T_6 (7.32) (Table 3). Besides, the study revealed germination speed was highest

Table 2: Influence of different treatment on germination (%), germination energy, germination index, germination period, mean germination time and germination rate of *T. indica* seeds

Treatments	Germination (%)	Germination energy (%)	Germination index	Germination period	Mean germination time	Germination rate
T_1	47.78^{b}	21.11^{b}	4.22^{bc}	38.00^{abc}	11.00^{a}	0.1015^{b}
T_2	48.89^{b}	43.33^{ab}	3.63^{c}	40.00^{abc}	23.00^{a}	0.0478^{b}
T_3	5.56^{c}	4.44^{c}	0.39^{d}	23.00^{bcd}	21.00^{a}	0.0467^{a}
T_4	15.57^{c}	13.33^{b}	2.09^{cd}	16.00^{cd}	8.00^{b}	0.1237^{a}
T_5	83.22^{a}	63.33^{a}	7.05^{a}	51.00^{a}	26.00^{a}	0.117^{b}
T_6	84.44^{a}	63.33^{a}	6.50^{ab}	45.00^{ab}	17.00^{a}	0.1835^{a}
T_7	82.05^{a}	74.44^{a}	6.62^{ab}	48.00^{ab}	23.00^{a}	0.0492^{b}
p-value	<0.001	<0.001	0.013	0.002	0.212	<0.001
F-value	42.744	51.825	3.782	5.584	1.578	99.242

$^{a-c}$Mean values with different lowercase superscripts in a column are significantly different at $p<0.05$, according to Duncan's multiple range test (DMRT)

Table 3: Influence of different treatment on germination uniformity, germination speed, germination rate, germination value, imbibitions period of *T. indica* seeds

Treatments	Germination uniformity	Germination Germination speed	Germination Germination value	Survival (%)	Imbibitions period
T_1	1.25	1.27	4.32	45	3
T_2	4.027	0.98	3.82	48	4
T_3	0.01	0.10	0.05	4	7
T_4	4.57	0.80	0.72	15	4
T_5	7.64	1.95	12.42	83	5
T_6	7.32	1.68	11.99	78	3
T_7	7.18	1.64	11.76	82	5

Table 4: Influence of different treatment on shoot and root lengths, collar diameter, leaf number and partial root number of *T. indica* seedlings in nursery

	Length (cm)			Collar diameter	Number	Number of
Treatments	Shoot	Root	Total	(mm)	of leaf	partial roots
T_1	33.33^{c}	8.67^{c}	44.00^{c}	5.59^{bc}	33.33^{b}	5.59^{bc}
T_2	44.00^{abc}	12.33^{bc}	56.33^{bc}	6.19^{ab}	40.67^{ab}	6.19^{ab}
T_3	40.00^{abc}	16.33^{abc}	56.33^{bc}	5.08^{c}	55.00^{a}	5.08^{c}
T_4	43.67^{abc}	17.00^{abc}	60.67^{ab}	5.25^{c}	45.67^{ab}	5.25^{c}
T_5	48.67^{a}	24.33^{a}	73.00^{a}	6.48^{a}	58.67^{a}	6.43^{a}
T_6	45.67^{ab}	18.66^{ab}	64.33^{ab}	6.24^{ab}	59.33^{a}	6.24^{ab}
T_7	37.00^{bc}	10.67^{bc}	47.67^{c}	5.34^{c}	40.33^{ab}	5.347^{c}
p-value	<0.001	<0.001	<.001	<.001	<.001	<.001
F-value	20.650	7.107	32.176	61.541	9.566	12.762

[a-c]Mean values with different lowercase superscripts in a column are significantly different at p<0.05, according to Duncan's multiple range test (DMRT)

Table 5: Influence of different treatment on fresh and dry weights of shoot and root, vigor index, volume index, total dry biomass increment and root:shoot of *T. indica* seedlings

	Fresh weight (g)			Dry weight (g)			Total dry biomass	Root:	Index	
Treatments	Shoot	Root	Total	Shoot	Root	Total	increment (%)	shoot	Vigor	Volume
T_1	5.18^{cd}	2.84^{c}	8.02^{cd}	2.80^{bc}	1.45^{c}	4.25^{bc}	00.00	0.26^{b}	1474.67^{d}	1040.91^{b}
T_2	9.64^{b}	2.76^{c}	12.41^{bc}	4.57^{ab}	1.69^{ab}	6.26^{ab}	+47.29412	0.28^{ab}	2532.33^{ab}	1760.62^{ab}
T_3	12.32^{abc}	5.72^{ab}	18.67^{ab}	5.64^{ab}	2.61^{abc}	8.24^{ab}	+93.88235	0.41^{ab}	2266.67^{bcd}	1036.18^{b}
T_4	9.91^{ab}	2.98^{bc}	13.78^{bc}	4.45^{ab}	2.11^{bc}	6.56^{ab}	+54.35294	0.40^{ab}	2970.67^{abc}	1207.68^{b}
T_5	17.62^{a}	7.52^{a}	25.15^{a}	8.00^{a}	3.94^{a}	11.94^{a}	+180.9412	0.52^{a}	3565.33^{a}	1944.02^{a}
T_6	13.95^{ab}	5.93^{ab}	19.25^{ab}	6.20^{ab}	3.24^{ab}	9.44^{ab}	+122.1176	0.44^{ab}	2532.33^{abcd}	1919.22^{a}
T_7	8.56^{bc}	2.98^{c}	11.54^{bc}	3.89^{abc}	1.91^{bc}	5.81^{b}	+36.70588	0.32^{ab}	1796.33^{cd}	1065.69^{a}
p-value	0.003	0.000	0.001	0.024	0.001	0.008	00.00	<0.001	<0.001	<0.001
F-value	5.134	9.332	6.730	3.239	6.274	4.294	00.00	23.347	10.770	8.315

[a-c]Mean values with different lowercase superscripts in a column are significantly different at p<0.05, according to Duncan's multiple range test (DMRT)

in T_5 (1.95) followed by T_6 (1.68). Germination value (12.42), survival percentage (83), imbibitions period (5) was also found maximum in T_5 (Table 3) whereas these values were different from the control treatment.

Seed germination began within 5 days after sowing and proceeded on and normal 52 days. Mean daily germination was observed highest in T_5 in 20 days followed by T_7 and lowest in T_3 (Fig. 1). Besides, cumulative germination was highest on 55 days after sowing in T_6 and T_7 (Fig. 2).

Morphological growth performance of the seedlings: For 3-month-old *T. indica* seedlings, shoot length was the highest (48.67 cm) and root length was the highest (24.33 cm) in treatment T_5 where the highest total length (73.00 cm) was found in same treatment. In addition the highest collar diameter (6.48 mm) and number of partial roots (6.43) were also recorded in T_5. Besides, second highest morphological growth performance were found in T_6 treatment (Table 4).

Fresh and dry matter production: Fresh and dry matter production, e.g., shoot and root fresh weight, total fresh weight, shoot and root dry weight and total dry weight of *T. indica* were shown in Table 5. In 3-month-old seedlings of *T. indica*, shoot fresh and dry weight were the highest (17.62 and 8.00 g, respectively) as well as total dry weight (11.94 g) were found in treatment T_5 and were significantly ($p<0.05$) different from those of control treatment (T_1). Besides root fresh weight and dry weight were the highest (7.52 and 3.94 g, respectively) in treatment T_5. Total fresh biomass was found to be the maximum also in T_5 (25.15 g). However, total

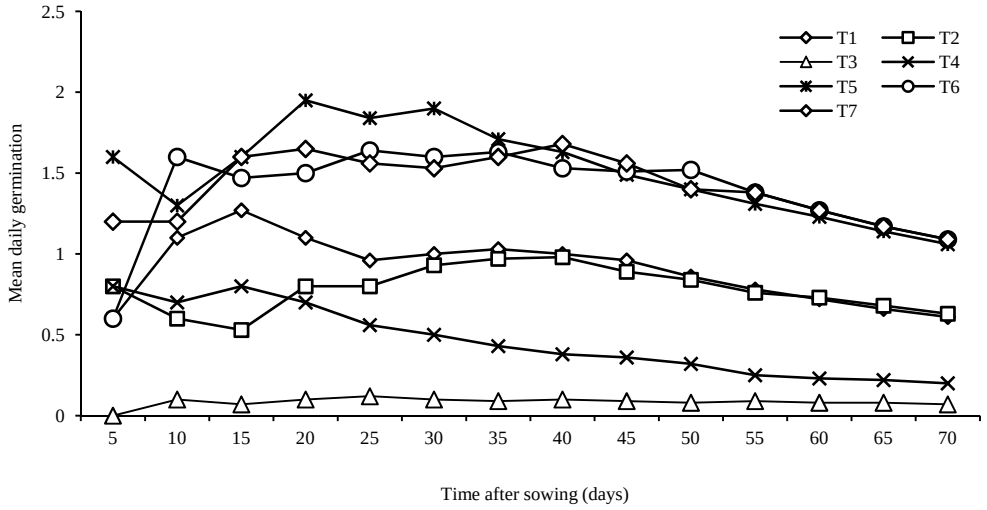

Fig. 1: Mean daily germination of *T. indica* seeds

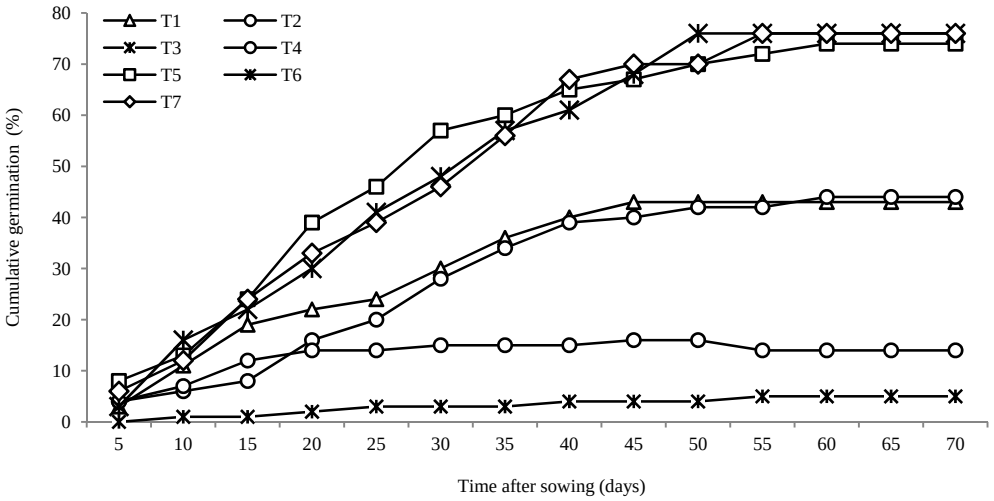

Fig. 2: Cumulative germination (%) of *T. indica* seeds

dry biomass increment (%) was highest in T_5 followed by T_6 and T_3 and was positive for all the treatments compared to T_1 treatment.

Root and shoot ratio, vigor index and volume index: Root and shoot ratio was significantly ($p<.001$) different for *T. indica* where one showed better ($T_5 = 0.52$) result followed by T_6 (0.44) and T_3 (0.41) (Table 5). Maximum vigor index and volume index (3565.33 and 1944.02, respectively) was found for the seedlings of *T. indica* in T_5 whereas those values were significantly different form control (T_1) (Table 5).

Quality index: Quality index of *T. indica* shown highest in T_5 (1.25) followed by T_3 (0.82) and least in T_1 (0.54) (Fig. 3).

As most of the parameters were highest in treatment T_5 and T_6, the sturdiness of Tamarind showed successful in T_4 (83.18) was followed by T_3 (78.74) and least shown by control treatment (59.62) (Fig. 4).

DISCUSSION

Under natural condition, *T. indica* takes much time, which creates dormancy and slows down germination process. Therefore, the results of the present study demonstrate that *T. indica* seeds, when treated with T_5 (soaking seeds with farm yard manure for 48 h) and T_6 (Soaking the seeds in conc. H_2SO_4 for 3 min followed by cold water washing) indicated better in germination execution,

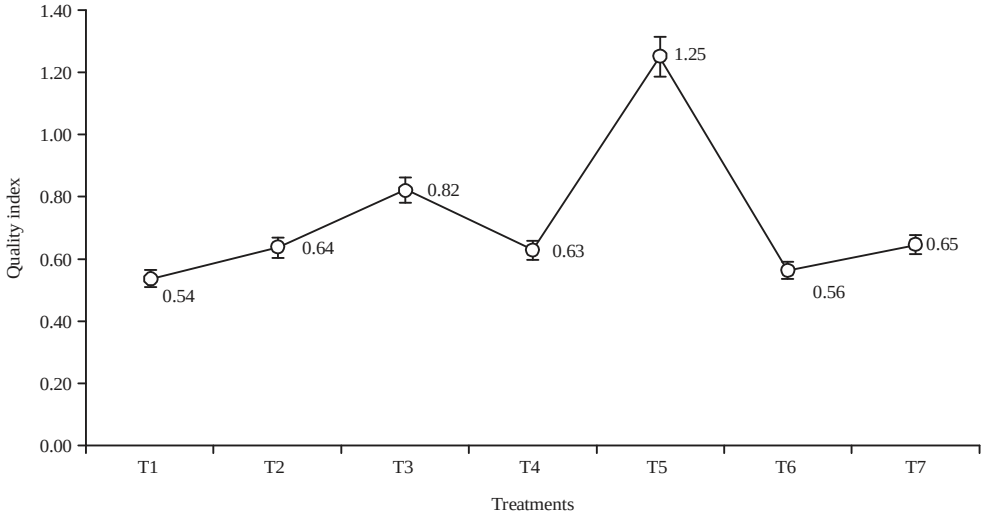

Fig. 3: Quality index of different treatment for *T. indica* seeds

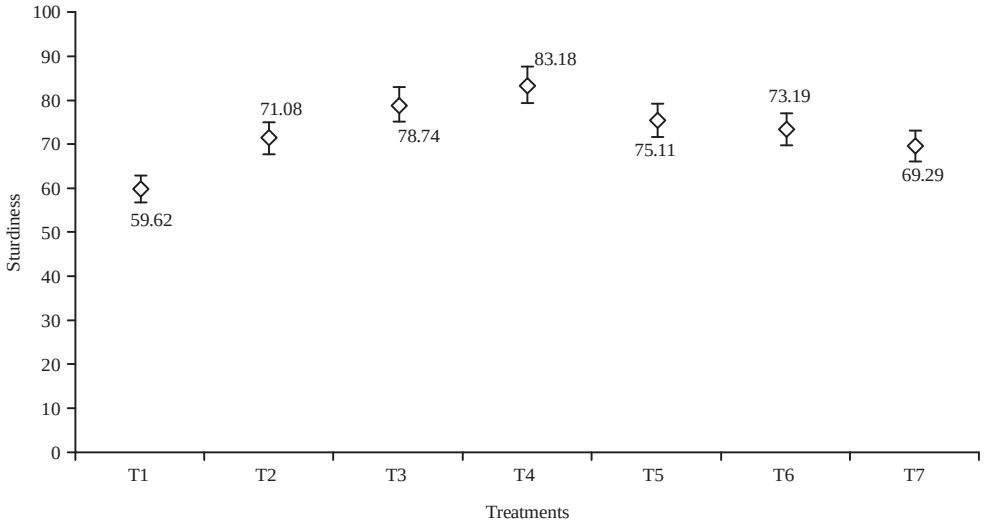

Fig. 4: Sturdiness of *T. indica* seedlings

growth parameter and biomass generation. In Bangladesh, the opportunity has already come and gone to survey and re-assess the undermining therapeutic and leguminous species like *T. indica*. However, it is possible to produce huge amount of quality seedlings within the nursery using farm yard manure whereas this work will beat the current state for example medicinal inefficiency, soil change, agri-business unsustainable condition and waterway bank degradation.

For the most part of the world, the legume seeds with hard seed coats are accounted to improve germination with pre-sowing treatments[42]. The effects of pre-sowing treatments on seed germination of some tropical forest tree species have been reported by some authors[43-49]. However, water treatment of seeds was suggested by Warrag and Eltigani[50] as an alternative for the sulfuric acid treatment. Hossain *et al.*[4] reported pre-sowing treatment (depulped seeds soaking in cold water for 48 h) was more effective for highest germination (66.7%) and production of quality seedling of *T. chebula* in the nursery.

Tamarind seed germination is influenced by different pre-sowing treatments as well[6]. The after effect of the present study was also different from various authors. Present study is not supported by the result of Azad *et al.*[25] where they revealed the pre-sowing treatments affected the germination process of seeds, which significantly increased the germination (%) (81.67%) with the cold water treatment.

According to Muhammad and Amusa[51] seeds of *T. indica* were placed on moistened filter papers in 28 cm diameter Petri dishes under laboratory condition for germination whereas the highest germination was recorded in seeds treated with 50% H_2SO_4 concentration with 60 min soaking period whereas present study recorded maximum germination after 3 min soaking with Sulphuric acid. However, Bello and Gada[52] indicated 68-95% germination of *T. indica* seeds within 3-19 days whereas conc. H_2SO_4 treatment gave the highest germination percentage of 95% and was closely supported by present study while exception was found for growth attributes of the species. In India, seed germination accelerated by soaking the seeds in 10% cow urine or cow dung solution[27] for 24 h where germination was increased from 37% untreated seeds to 73% with cow urine and 83% with cow dung solution and those findings are mismatch with present study. The study supported the treatment used by Kantharaju and Murthy[53], where they revealed successful germination occurred when healthy Tamarind seeds (one hundred) are soaked in cold 50% H_2SO_4. But the only exception occurs for duration of soaking the seeds with that acid. So a few writing support and differ above discoveries, consequences of this study may serve as valuable data in the generation and change of the tree species, as learning on seed germination necessities is a basic variable in seedlings creation.

CONCLUSION

Tamarind is often quoted as a dry ecosystem species but also suitable for less drought conditions. It has high nutritional, medicinal, industrial and cultural importance for rural communities. The abundance of the species is declining in our country whereas Juveniles' introduction into farmlands may be needed to ensure conservation. In such case, seed management and seedling development of *T. indica* should be must needed practice in the nursery. However, the study recommended socking seeds with farm yard manure for 48 h and conc. H_2SO_4 for 3 min and with can stimulates the germination percentage, seedling growth, biomass production, seedling quality indices when compared with other treatments. Therefore, acid treatment may be recommended for maximum seed germination and quality seedling production programs. But considering the commercial aspects, availability and risk of using conc. H_2SO_4 in general, seeds soaked in farm yard manure for 48 h are the better alternative for seed germination and profuse seedling production programs. However, farm yard manure is inexpensive, easy to apply and has no harmful effect on human body. Hence, large scale production is not possible due to inappropriate seed treatment with prolonged germination process; current experiment can be act as a remedy to disseminate the results among plant growers at public and private sectors.

SIGNIFICANCE STATEMENT

The study revealed acid treatment may be recommended for maximum seed germination and quality seedling production programs. But considering the commercial aspects, availability and risk of using conc. H_2SO_4 in general, seeds soaked in farm yard manure for 48 hours are the better alternative for seed germination and profuse seedling production programs. However, farmyard manure (organic manure) is inexpensive, easy to apply and has no harmful effect on human body. Therefore, current experiment can be act as a remedy to disseminate the results among plant growers at public and private sectors.

ACKNOWLEDGMENT

The authors are highly thankful to seed orchard division of Bangladesh Forest Research Institute (BFRI) for providing seeds and Institute of Forestry and Environmental Sciences, University of Chittagong for creating space the opportunity to do this research.

REFERENCES

1. Joshi, R., 2018. Role of enzymes in seed germination. Int. J. Creative Res. Thoughts, 6: 1481-1485.
2. Saeb, H., M. Khayyat, A. Zarezadeh, F. Moradinezhad, A. Samadzadeh and M. Safaee, 2013. Effects of Nacl stress on seed germination attributes of periwinkle (*Catharanthus roseus* L.) and corn poppy (*Papaver rhoeas* L.) plants. Plant Breed. Seed Sci., 67: 115-123.
3. Silveira, F.A.O., R.C. Ribeiro, S. Soares, D. Rocha and C. Oliveira, 2013. Physiological dormancy and seed germination inhibitors in *Miconia* (Melastomataceae). Plant Ecol. Evol., 146: 290-294.
4. Hossain, M.A., M.K. Arefin, B.M. Khan and M.A. Rahman, 2005. Effects of seed treatments on germination and seedling growth attributes of Horitaki (*Terminalia chebula* Retz.) in the nursery. Res. J. Agric. Biol. Sci., 1: 135-141.
5. Farhadi, M., M. Tigabu, A.G. Arian, M. Sharifani, A. Daneshvar and P.C. Oden, 2013. Pre-sowing treatment for breaking dormancy in *Acer velutinum* boiss. seed lots. J. For. Res., 24: 273-278.

6. Azad, M.S., 2018. Tamarindo-*Tamarindus indica*. In: Exotic Fruits Reference Guide, Rodrigues, S., E. de Oliveira Silva and E.S. de Brito (Eds.)., Academic Press, New York, pp: 403-412.
7. Das, D.K. and M.K. Alam, 2001. Trees of Bangladesh. Bangladesh Forest Research Institute, Chittagong, Bangladesh, Pages: 224.
8. Rahim, M.A., A.K.M.A. Alam, M.S. Alam and M.M. Anwar, 2011. Underutilized Fruits in Bangladesh. BAU-GPC., Bangladesh Agricultural University, Bangladesh, pp: 205.
9. Hossain, M.K., 2015. Silviculture of plantation trees of Bangladesh. Arannayak Foundation, Dhaka, Bangladesh.
10. Purseglove, J.W., 1987. Tropical Crops: Dicotyledons. Longman Science and Technology, New York, USA., pp: 204-206.
11. Coronel, R.E., 1991. *Tamarindus indica* L. In: Plant Resources of South-East Asia No. 2: Edible Fruits and Nuts, Verheij, E.W.M. and R.E. Coronel (Eds.). Pudoc, Wageningen, The Netherlands, pp: 298-301.
12. El-Siddig, K., H.P.M. Gunasena, B.A. Prasad, D.K.N.G. Pushpakumara, K.V.R. Ramana, P. Vijayanand and J.T. Williams, 2006. Tamarind, *Tamarindus indica*. Southampton Centre for Underutilized Crops, Southampton, pp: 188.
13. Hiwale, S., 2015. Tamarind (*Tamarindus indica* L.). In: Sustainable Horticulture in Semiarid Dry Lands, Hiwale, S. (Ed.)., Springer, India, pp: 197-212..
14. Gohil, D.I. and S.P. Singh, 2003. Studies on Some Multipurpose Tree Species as a Source of Rural Energy. In: Human Impact on Desert Environment, Narain P., S. Kathju, A. Kar, M.P. Singh and K. Praveen (Eds.). Arid Zone Research Association of India, Jodhpur, pp: 426-429..
15. Timyan, J., 1996. Bwa yo: Important trees of haiti. South East Consortium for International Development (SECID), Washington, DC.
16. Chaturvedi, A.N., 1985. Firewood farming on the degraded lands of gangetic plain. Uttar Pradesh Forest Bulletin No. 50, Government of India. Press, Lucknow, pp: 286.
17. Herhavo, J. and A. Bouquet, 1950. Plantes medicinales et toxiques de La Côte-d'Ivoire Haute-Velta. http://agris.fao.org/agris-search/search.do?recordID=US201300285138
18. Doran, J.C., J.W. Turnbull, D.J. Boland and B.V. Gunn, 1983. Handbook on Seeds of Dry Zone Acacias. FAO., Rome, pp: 59-63.
19. Napier, I., 1987. Pregermination treatment of *Cassia siamea* and *Leucaena leucocephala* seeds. Banko Janakari, 1: 5-6.
20. Palani, M., M.G. Dasthagir, K. Kumaran and R. Jerlin, 1996. Effect of pre-sowing treatment on growth attributes of *Albizia lebbeck* (L.) Benth. Ann. For., 4: 85-88.
21. Kushalappa, K.A., 1977. Teak plantations in Thailand. Indian Forester, 103: 323-328.
22. Muttiah, S., 1975. Some data on teak seed and further pregermination treatment trials. Ceylon Forester, 12: 25-36.
23. Koirala, B., M.K. Hossain and M.S. Hossain, 2000. Effect of presowing treatments on *Adenanthera pavonina* L. seeds and initial seedling development in the nursery. Malays. For., 63: 82-91.
24. Khan, B.M., M.K. Hossain and M.A.U. Mridha, 2014. Improving *Acacia auriculiformis* seedlings using microbial inoculant (beneficial microorganisms). J. For. Res., 25: 359-364.
25. Azad, M.S., N. Nahar and M.A. Matin, 2013. Effects of variation in seed sources and pre-sowing treatments on seed germination of *Tamarindus indica*: A multi-purpose tree species in Bangladesh. Forest Sci. Pract., 15: 121-129.
26. El-Siddig, K., G. Ebert and P. Ludders, 2001. A comparison of pretreatment methods for scarification and germination of *Tamarindus indica* L. seeds. Seed Sci. Technol., 29: 271-274.
27. Sankaranarayanan, R., M. Vijayakumar and P. Rangasamy, 1994. Cow urine for ideal seed germination in tamarind. Indian Hortic., Vol. 38, No. 4.
28. Mridha, M.U., B.M. Khan and M.K. Hossain, 2016. Microbial inoculant for seed germination and seedling growth of acacia mangium willd. J. Applied Environ. Biol. Sci., 6: 116-124.
29. Peel, M.C., B.L. Finlayson and T.A. McMahon, 2007. Updated world map of the Koppen-Geiger climate classification. Hydrol. Earth Syst. Sci., 11: 1633-1644.
30. Kumar, V., 1999. Nursery and Plantation Practices in Forestry. 2nd Edn., Scientific Publishers, Jodphur, India, Pages: 531.
31. AOSA., 1983. Seed vigor testing handbook. Contribution No. 32 to the Handbook on Seed Testing, 1983.
32. Bewley, J.D., K.J. Bradford, H.W.M. Hilhorst and H. Nonogaki, 2013. Seeds: Physiology of Development, Germination and Dormancy. 3rd Edn., Springer, New York.
33. Soltani, E., F. Ghaderi-Far, C.C. Baskin and J.M. Baskin, 2015. Problems with using mean germination time to calculate rate of seed germination. Aust. J. Bot., 63: 631-635.
34. Ellis, R.H. and E.H. Roberts, 1981. The quantification of ageing and survival in orthodox seeds. Seed Sci. Technol., 9: 373-409.
35. Afzal, I., S.M.A. Basra and A. Iqbal, 2005. The effects of seed soaking with plant growth regulators on seedling vigor of wheat under salinity stress. J. Stress Physiol. Biochem., 1: 6-14.
36. Abdolahi, M., B. Andelibi, E. Zangani, F. Shekari and S. Jamaati-e-Somarin, 2012. Effect of accelerated aging and priming on seed germination of rapeseed (*Brassica napus* L.) cultivars. Int. Res. J. Applied Basic Sci., 3: 499-508.
37. Djavanshir, K. and H. Pourbeik, 1976. Germination value: A new formula. Silvae Genet., 25: 79-83.
38. Iqbal, G.M.A., S.M.S. Huda, M. Sujauddin and M.K. Hossain, 2007. Effects of sludge on germination and initial growth performance of Leucaena leucocephala seedlings in the nursery. J. For. Res., 18: 226-230.
39. Manavalan, A., 1990. Seedling vigour and bioproductivity in woody biomass species. Ph.D. Thesis, Madurai: Madurai Kamarajar University.

40. Abdul-Baki, A.A. and J.D. Anderson, 1973. Vigor determination in soybean seed by multiple criteria. Crop Sci., 13: 630-633.
41. Dickson, A., A.L. Leaf and J.F. Hosner, 1960. Quality appraisal of white spruce and white pine seedling stock in nurseries. For. Chron., 36: 10-13.
42. Palani, M., M.G. Dasthagir and K. Kalayanasundaram, 1995. Effect of presowing chemical treatment on germination and seedling growth in *Acacia nilotica*. Int. Tree Crops J., 8: 189-192.
43. Matin, M.A. and M.H. Rashid, 1992. Seed morphology, germination and seedling survival of *Albizia* trees in the nursery. Bangladesh J. For. Sci., 21: 40-45.
44. Ali, M.A., S. Akhter and M. Kamaluddin, 1997. Study on the bearing of hot water treatment on seed germination and seedling growth of *Albizia procera* benth. Indian Forester, 123: 764-768.
45. Khan, B.M., B. Koirala and M.K. Hossian, 2001. Effect of different pre-sowing treatments on germination and seedling growth attributes in ghora neem (*Melia azedarach* L.). Malays. Forester, 64: 14-21.
46. Alamgir, M. and M.K. Hossain, 2005. Effect of pre-sowing treatments on *Albizia procera* (Roxb.) Benth seeds and initials development of seedlings in the nursery. J. For. Environ., 3: 53-60.
47. Matin, M.A., M.S. Islam and M.S. Azad, 2006. Seed germination, seedling growth and rooting of branch cuttings of *Dalbergia sissoo* Roxb. Khulna University Studies, Special Issue (1st Research Cell Conference), pp: 83-87.
48. Azad, M.S., R.K. Biswas and M.A. Matin, 2012. Seed germination of *Albizia procera* (Roxb.) Benth. in Bangladesh: A basis for seed source variation and pre-sowing treatment effect. For. Study China., 12: 124-130.
49. Haider, M.R., M.S. Alam and M.A. Hossain, 2014. Effect of pre-sowing treatment on seed germination and seedlings growth attributes of *Acacia catechu* willd. in nursery and field conditions. Int. J. Latest Res. Sci. Technol., 3: 214-219.
50. Warrag, E.I. and M.A. Eltigani, 2005. Breaking seed coat dormancy of *Acacia nilotica* seeds under simulated natural habitat conditions in Sudan. Trop. Ecol., 46: 127-132.
51. Muhammad, S. and N.A. Amusa, 2003. Effects of sulphuric acid and hot water treatments on seed germination of tamarind (*Tamarindus indica* L.). Afr. J. Biotechnol., 2: 267-279.
52. Bello, A.G. and Z.Y. Gada, 2015. Germination and early growth assessment of *Tamarindus indica* L. in Sokoto State, Nigeria. Int. J. For. Res. 10.1155/2015/634108.
53. Kantharaju, S. and K.R.S. Murthy, 2014. Characterization of esterases of *Tamarindus indica* seeds. J. Biosci. Med., 2: 54-62.