

Germination Behavior and Seedlings Growth Performance of *Tamarindus indica* L. in Nursery and Field Condition of Bangladesh

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Abstract

Germination percentage of *Tamarindus indica* L. seeds were observed with 4 pre-sowing treatments viz, i) soaked in cow urine for 24 hours, ii) soaked in cow dung slurry for 24 hours, iii) soaked in tap water for 24 hours, iv) soaked in hot water (100 °C) for 30 seconds and followed by one hour in tap water and v) control, in the nursery of Bangladesh Forest Research Institute, Chattogram. Growth performances of seedlings were also determined in nursery and field conditions. The germination test was conducted in nursery bed filled with soil and decomposed cow dung at a ratio of 3:1. The growth performance of seedlings were determined by transferring the young seedling after 30-45 days of germination having 5-6 leaves from germination bed to polybags (15 cm × 23 cm) filled with soil mixed with cow dung. Growth performance in the field was observed by out planting one year old seedling at 1.5 m × 1.5 m, 2.0 m × 2.0 m and 2.5 m × 2.5 m spacing. Germination percentage was significantly ($p < 0.05$) influenced by pre-sowing treatments and highest germination percentage (86%) was obtained in cow urine treatment for 24 hours and lowest (44%) was found in hot water treatment. Growth performance of seedlings was also influenced by pre-sowing treatments in the nursery and highest vigor index was observed in cow urine treatment (3988) and lowest in hot water treatment (1629). Survival percentage of seedlings was highest 98% at 2.0 m × 2.0 m spacing in the field and average height was more than 68 cm after 12 months of out planting. Therefore, pre-sowing treatment of seed in cow-urine for 24 hours suggested for nursery raising and one old year seedlings may be planted at 2.0 m × 2.0 m spacing in the field for successful plantation of the species.

সারসংক্ষেপ

বাংলাদেশ বন গবেষণা ইনস্টিটিউট, চট্টগ্রামে নার্সারিতে তেঁতুল বীজের অংকুরোদগমের হারের উপর প্রি-ট্রিটমেন্টের প্রভাব নির্ণয়ের জন্য বীজ বপনের পূর্বে চার ধরনের প্রি-ট্রিটমেন্ট প্রয়োগ করা হয়। প্রি-ট্রিটমেন্টসমূহ হল: ১) বীজ ২৪ ঘন্টা গো-মূত্রে ভিজানো, ২) গরুর গোবর মিশ্রিত কাইতে (Cow dung slurry) ২৪ ঘন্টা ভিজানো, ৩) ট্যাপের পানিতে ২৪ ঘন্টা ভিজানো, ৪) গরম পানিতে ৩০ সেকেন্ড চুবানো এবং পরবর্তীতে এক ঘন্টা ট্যাপের পানিতে ভিজানো এবং ৫) কন্ট্রোল। নার্সারি ও মাঠ উভয় পর্যায়ে চারার বৃদ্ধির পরিমাপ করা হয়। বীজের অংকুরোদগম পরীক্ষাটি নার্সারি বেডে সম্পন্ন করা হয়, যেখানে মাটি ও গোবর ৩:১ অনুপাতে মিশ্রিত ছিল। বীজ অংকুরোদগমের ৩০-৪৫ দিন পরে ৫-৬ টি পাতাযুক্ত চারা পলিব্যাগে (১৫×২৩ সে.মি.) স্থানান্তর এবং এক বছর পরে মাঠপর্যায়ে চারা রোপণ করা হয়। বীজের অংকুরোদগমের

উপর প্রি-ট্রিটমেন্টের তাৎপর্যপূর্ণ প্রভাব ($p < 0.05$) পরিলক্ষিত হয়। গো-মূত্র দ্বারা (২৪ ঘণ্টা) ট্রিটমেন্টকৃত বীজের অংকুরোদগমের হার সবচেয়ে বেশী (৮৬%) এবং গরম পানি দ্বারা ট্রিটমেন্টকৃত বীজের অংকুরোদগমের হার সবচেয়ে কম (৪৪%) পাওয়া যায়। নার্সারিতে চারার বৃদ্ধির উপর প্রি-ট্রিটমেন্টের প্রভাব পরিলক্ষিত হয়, সবচাইতে বেশি ভিগর ইনডেকস পাওয়া যায় (৩৯৮৮) গো-মূত্র দ্বারা ট্রিটমেন্টকৃত বীজে এবং সবচাইতে কম ভিগর ইনডেকস পাওয়া যায় (১৬২৯) গরম পানি দ্বারা ট্রিটমেন্টকৃত বীজের ক্ষেত্রে। মাঠ পর্যায়ে ২ মি.×২ মি. দূরত্বে চারা লাগানোর এক বছর পর চারার বেঁচে থাকার হার ৯৮% পাওয়া যায় এবং চারার গড় উচ্চতা ছিল ৬৮ সে.মি.। সুতরাং নার্সারি উত্তোলনের জন্য বীজ গো-মূত্র দ্বারা ২৪ ঘণ্টা প্রি-ট্রিটমেন্ট করে বপন এবং সফল বনায়নের জন্য ২ মি.×২ মি. দূরত্বে এক বছর বয়সী চারা রোপণ উত্তম বলে প্রতীয়মান হয়।

Keywords: *Tamarindus indica*, Pre-sowing treatment, Dormancy breaking, Germination rate, growth performance.

Introduction

Tamarindus indica L. is a large evergreen tree species belongs to the family Caesalpinaceae. The plant attains up to 20 m height with 2 m diameter (Verheij and Coronel 1991). Leaves even-pinnate, leaflets 10-20 pairs, linear-oblong, slightly notched at the apex, glabrescent. Flowers small, pale yellow in terminal lax racemes. Fruit pod indehiscent, curved and flattened at two sides with very acidic pulp when ripen. Seeds rectangular, dark brown, smooth with hard testa.

T. indica is an indigenous plant to the drier Savannas of tropical Africa. Besides, the tree is growing wild in Sudan, Arabia, Oman (Rahim *et al.* 2011). However, it is cultivated in Cameroon, Nigeria and Tanzania etc. There is a long history for introduction of the *T. indica* into India at an early date and subsequently spread into other tropical Asian regions (Troup and Joshi 1983). Day by day this species was widely distributed throughout the tropical regions from Africa and South East Asia, Taiwan and as far as China (Rahim *et al.* 2011). *T. indica* is well adapted to semi-arid, arid and tropical climatic regions where maximum temperature is 33 to 37°C and minimum is 9.5 to 20°C (Rahim *et al.* 2011). The species is sensitive to frost. A mean rainfall of 500-1500 mm is required for its better growth. *T. indica* is grown on a wide range of soils from gravelly to deep alluvial and thrives in loamy, deep, alluvial soils which favor the development of a long taproot (Troup and Joshi 1983). It tolerates slightly alkaline or saline soils (Hocking 1993).

The species is valued mainly for its fruit pulp. Its acidic pulp is a favorite ingredient in culinary preparations such as curries, chutney, sauces, tamarind ball, sweetmeat, mixed with sugar and dessert (Purseglove 1987). Seeds are used in the jam, jelly and confectionary industries for making condiments. Seed are also eaten after removal of the testa by roasting and boiling. The leaves are eaten by cattle and goats.

T. indica is used for many medicinal purposes. Phytochemical studies have revealed the presence of tannins, saponins, sesquiterpenes, alkaloids which are active against both gram positive and gram negative bacteria at 4-30°C temperature (Doughari 2006). Phytochemical has anti-diabetic, anti-microbial, anti-venomic, anti-malarial, anti-asthmatic, and anti-hyperlipidemic properties (Bhadoriya *et al.* 2011). It is used as an essential amino acid and aromatic acid (Adeola 2013). The ripe fruit is used as a refrigerant, digestive, carminative and laxative. Seeds cotyledons contain albuminoids, fat and carbohydrates. Leaves contain glycosides and bark contains tannins and resin

(Ghani 2003). Hordenine is isolated from leaves, barks and flowers (Rastogi & Mehrotra 1993). Wood contains charcoal which is valued for producing gunpowder (NAS 1979). Wood is hard to very hard and heavy, medium fine textured (Das and Mohiuddin 2001). The whole parts of *T. indica* is used in many ways. Because of its multipurpose uses it became an important economic crop and medicinal plants in the Indian subcontinent including Bangladesh. However, there is very little information about its propagation, cultivation in the country. Therefore, an attempt has been made to investigate the effects of pre-sowing treatment on seed germination and seedling growth performance of *T. indica* in the nursery and field levels.

Materials and Methods

The study area

The study was carried out in the nursery of Bangladesh Forest Research Institute (BFRI), Sholoshahar, Chattogram and Hinguli Research Station, Mirsari, Chattogram, Bangladesh over a period of two years from June 2017 to July 2019. Geographic position of the study area is situated between 22° 22' 27" and 22°29'0" North latitude and 91°46'30" and 91°46'30" East longitudes. The climate of the study area is tropical in nature and characterized by hot humid summer and cool dry winter. The maximum and minimum temperature in the area varies from 28.31 to 31.9 °C and from 15.2 to 25.2 °C respectively (Hossain and Arefin 2012). Mean annual rainfall is around 3000 mm mainly occurred from June to September.

Seed collection and growing media

The seeds were collected in the middle of March 2017 from 20-25 years old matured healthy trees from Kaptai National Park of Rangamati Hill district, Bangladesh. Then the seeds were dried in the sunlight for 2-3 days and stored in air tight polybag. Shrinked, discolored and damaged seeds were separated from collected seeds and only healthy seeds were used for the experiment. The number of seed per kilogram was 220 to 240. The germination trial was carried out by sowing seeds in bed filled with soil and decomposed cow dung at the proportion of 3:1 by volume. Seeds were sown in the seed bed at the depth of 0.5-1.0 cm.

Experimental design and different treatments

Experiments were conducted in Completely Randomized Design (CRD) with five replications. Four treatment were applied to determine their effect on seed germination and seedling growth attributes. The treatments were i) soaking in cow urine for 24 hours, ii) soaking in cow-dung slurry for 24 hours, iii) soaking in hot water (100°C) for 30 second followed by soaking in tap water for one hour, iv) soaking in tape water for 24 hours and v) control. In each replication 50 seeds were sown and in total 1250 seeds were used for germination trial in the seedbed of the nursery. Watering was carried out manually when necessary.

Assessment of seed germination and seedlings growth performance in seed bed

The effect of different treatments on seed germination and seedlings growth was explored periodically

through counting the germinated seeds and measuring initial growth performance of seedlings. Germination data was collected at two days intervals starting from sowing and continued till ending of germination. For assessing the growth performance, above ground height all seedlings were measured and number of leaves were counted when the seedlings were one month old. Besides these ten seedlings from each replicate (50 from each treatment) were randomly uprooted and measured their total length (root length and shoot length separately). Vigor index (VI) was calculated according to Baki & Anderson (1973).

Assessment of seedling growth performance in the nursery (polybag) and in the field

When the seedlings were about 30-45 days old (with 5-6 leaves), they were transferred to the polybags (23 cm × 15 cm in size) filled with soil mixed with cow dung (3:1). The polybags were kept under full shade for one week and then placed under direct sunlight and allowed them to grow there. Data on shoot length, root length and leaf number of seedlings were also recorded at three months, six months, and twelve months after transferring them into polybags. When the seedlings were one year old, 225 seedlings were out planted in the field at the beginning of the monsoon (June- July). Equal number of seedlings (225), were allowed to grow in the nursery for one and half year more. Seedlings in the field were planted at 1.5 m × 1.5 m, 2.0 m × 2.0 m and 2.5 m × 2.5 m spacing at Hinguli Research Station, Chattogram, Bangladesh. The soil was sandy-loam with a pH 5.70-6.00. Average rainfall of the area was about 3200 mm and average maximum and minimum temperature was 34.7°C and 20.7°C respectively. Weeding was done every month in the nursery and water was added after planting. Data on the heights of each plant were recorded at six months and twelve months after planting. Survival percentage of the seedlings in the field was determined one year after planting the seedlings.

Data Analysis

All data were analyzed with computer software IBM SPSS var. 21 to conduct Analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) in order to determine the significant ($p \leq 0.05$) variations among the treatments.

Results

Seed germination and initial growth performance of seedlings in seed bed

Pre-sowing treatments influenced the germination period and germination percentage of *T. indica* seeds. Germination for all the treatments started 7 days after sowing (DAS) and continues up to 23 days with little variation among the treatments. The seeds soaked in cow urine for 24 h, showed highest germination (86%) and occurred within 7-19 DAS. Seeds soaked for 24 h in cow dung slurry showed 84% germination within 7-21 DAS. Seeds soaking in tap water for 24 h showed 80% germination within 7-23 DAS. Seeds soaked in hot water for 30 seconds showed 44% germination and 66% germination was recorded for control within 7-23 DAS (Fig. 1).

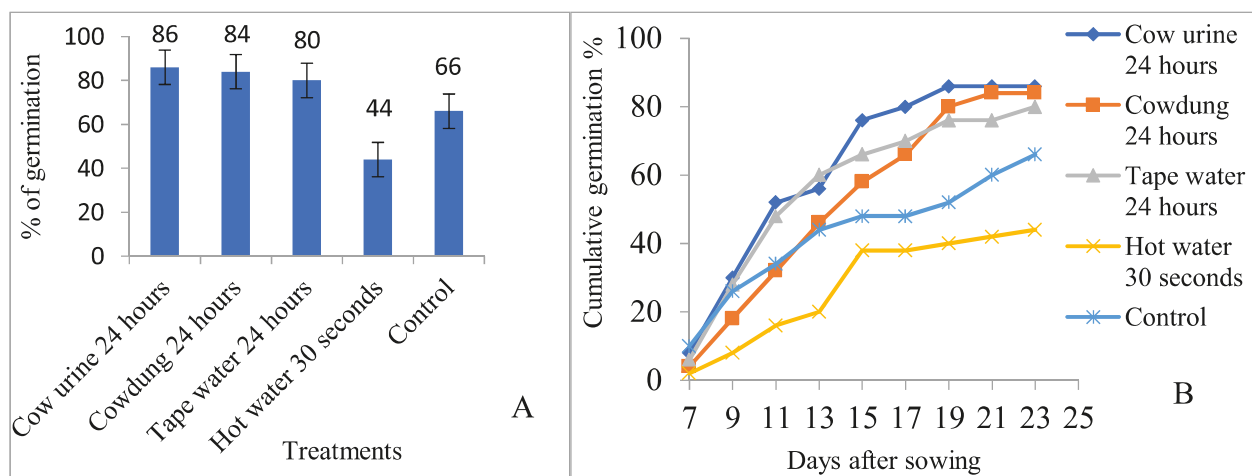


Figure 1. Germination percentage (A) and cumulative germination (B) of *T. indica* with different pre-sowing treatment

The initial growth performance of *T. indica* seedlings were influenced by pre-sowing treatment (Table 1). The highest root length (16.70 cm) and shoot length (29.67 cm) was recorded in seedlings from cow urine treated seeds. The second highest root length was recorded 15.67 cm whereas shoot length was 28.00 cm in the seeds soaked in cow dung slurry, followed by seeds soaked in tap water for 24 h and control. The lowest length (9.70 cm) of root was recorded in seeds treated with hot water. Average number of leaves varied from 8-10 among the treatments. Maximum number of leaf was recorded with seeds soaked in cow urine and lowest with the treatment soaked in hot water.

The vigor index of the seedlings was increased from 1629 in the treatment of seeds soaked in hot water to 3988 in the treatment of seeds soaked in cow urine for 24 hours (Table 1). The vigor index usually depends on the germination percentage and the seedling length. The study reveals that the seedling length was marginally different among the treatments. However, germination percentage in the treatment of seeds soaked in cow urine for 24 hours was almost doubled than that in the treatment of seeds soaked in hot water which led the vigor index substantially higher, seeds soaked in cow urine than of the other treatments.

Table 1. Initial growth performance of the seedlings germinated from various treatments one month after germination.

Treatments	Growth parameters			
	Ave. root length (cm)	Ave. shoot length (cm)	Ave. Leaf number (Nos.)	Vigor Index
Soaked in cow urine for 24 hours.	16.70±3.75	29.67±4.33	10.00±1.42	3988
Soaked in cow dung slurry for 24 hours	15.67±3.67	28.00±4.22	8.70±1.37	3668
Soaked in tap water for 24 hours	10.33±2.95	28.00±3.77	9.33±1.10	3066
Soaked in hot water (100 ⁰ C) for 30 seconds and followed by 1 hour in tap water	9.70±2.87	27.33±3.74	8.33±1.20	1629
Control	9.60±2.95	27.00±3.89	8.67±1.45	2416

Seedlings growth performance in nursery polybag

The study, revealed that similar to that of germination percentage the initial growth performance of *T. indica* seedlings from cow urine treatment was higher than that of other treatments (Table 1). Therefore, we sowed only the seeds treated in cow urine for 24 hours in seed beds for assessing the seedlings growth performances in the nursery and field. Seven hundred fifty (750) seeds were sown in five blocks considering as replication of the nursery bed for the purpose. One and half months old seedlings were transferred in the 15 cm × 23 cm sized polybags filled with soils mixed with cow dung (3:1) and allowed them to grow there. After 12 months of transferring the seedlings in the polybag, 225 seedlings were outplanted in the field. Rests of the seedlings were grown in the nursery for another year more. The seedlings mortality in the nursery was found very negligible (1-2%). Growth variation of seedlings was observed in the nursery in relation to age and the results are presented in the Table 2.

Table 2. Seedlings growth performance of *T. indica* at different ages in the nursery.

Age of seedlings (months)	Ave. length of root (cm)	Ave. length of shoot (cm)	Ave. number of leaves /seedlings
3	18.55±0.65	31.10±0.44	13.44 ±0.25
6	22.45±0.49	35.25±0.60	19.60 ±0.45
12	25.40±0.72	45.50±0.68	26.80 ±0.76
24	30.25±0.55	62.40±0.65	39.10 ± 0.89

The seedlings attained 31.10 cm height with average root length 18.55 cm and 13 leaves at three months age. The seedlings became hard and attained a height of 35.25 cm with 22.45 cm root and 19 leaves at six months. The average height 45.50 cm with 25.40 cm root and 26 leaves was recorded at 12 months. The seedlings reached 62.40 cm height with 30.25 cm root and 39 leaves at 24 months.

Survival and growth performance of seedlings in the field

One-year old seedlings of *T. indica* raised in polybags were out planted in the field with different spacing at Hinguli Research Station. Survival Percentage was recorded at 12 months and seedlings growth performance were recorded at 6 and 12 months after planting in the field as shown in Table 3. Survival percentage varied from 96-98% with an average of 97% among the treatments at 12 months after planting. The seedlings height varied from 49.76 cm to 57.20 cm at six months and 59.50 cm to 68.10 cm at one year in the field.

Table 3. Growth performance of *T. indica* seedlings at different spacing in Hinguli Research Station.

Age of seedling Spacing	Survival % at 12 months	Average Height (cm)	
		6 months (cm)	12 months (cm)
1.50 m x 1.50 m	96	52.4±0.59 ^b	65.95±1.11 ^b
2.00 m x 2.00 m	98	57.20±0.78 ^a	68.10±1.21 ^a
2.50 m x 2.50 m	97	49.76±0.54 ^c	59.50± 1.32 ^c

Discussion

Pre-sowing treatments overwhelmingly affected the germination period and germination percentage of *T. indica* seeds. The germination percentage in the seeds treated by cow urine for 24 hours is significantly ($p < 0.05$) higher (86%) than control (66%) and seeds treated in hot water (100°C) for the 30 seconds followed by one hour soaking in tap water is the lowest (44%). However, there was no significant variation between seeds treated cow dung slurry for 24 hours (84%) and treated in tap water for 24 hours (80%). Hartman *et al.* (2007) showed that soaking the seeds in tap water at room temperature helps in softening the seed coats, removal of inhibitors and reduces the time required for germination and increases germination percentage. (Ajiboye (2010) also showed that imbibition of water by seed helps to enlarge the embryo which leads to increase the seed germination. The above result was supported by some experiments i.e. Muhammad and Amusa (2003), Abubakar and Muhammad (2013). Haider *et al.* (2014b) showed that better germination (80%) by soaking the seeds in tap water for 24 hours against control (62%) in *Acacia catechu*. Naidu (2001) reported that better germination (79-81%) was observed when seeds were soaked in water or placed in running water against control (17%) in *Pterocarpus santalinus* seeds. Gupta (2003) mentioned that overnight soaking of *Rauwolfia serpentina* seeds in cold water gave better germination (86%) against control (40%). The findings of the present study is similar to the findings of the above mentioned study.

Growth performance of the seedlings was influenced by pre-sowing treatments of seeds. However, there was no significant variation in growth performance among the treatments at $p \leq 0.05$. Similar results were reported by several authors. It was also mentioned that seedling growth including root length, shoot length, total length and vigor index in *Terminalia chebula* was increased by pre-sowing treatment in tap water (Hossain *et al.* 2013). In another experiment, (Hossain *et al.* 2005b) showed maximum growth including shoot length, root length, total length and vigor index in *Terminalia belerica* seedlings when fruits were depulped and soaked in cold water. However, similar to the present study, there was no remarkable difference in average number of leaves per seedlings of *T. belerica* seedlings (Hossain *et al.* 2005a).

The height growth of the seedlings was higher (68.10 cm) in 2.0 m × 2.0 m spacing at twelve months from plantation and lowest (59.50 cm) in 2.5 m × 2.5 m spacing (Table 3). The variation of the growth in the seedling may be due to the microclimatic condition between the spacing. The survival percentage of the seedlings in the field was satisfactory (98%) in 2.0 m × 2.0 m spacing. Considering the above-mentioned facts and comparatively less land requirement, 2.0 m × 2.0 m spacing may be considered for planting of one-year old seedlings in the field. Abubakar and Muhammad (2013) also reported that one-year old seedlings of *T. indica* may be out planted in the field.

Conclusion

Pre-sowing treatment of *Tamarindus indica* seed plays vibrant role to enhance the seed germination under nursery conditions. Among the pre-sowing treatments, the best germination percentage and growth performance of *T. indica* was found in cow urine treatment. Pricking of seedlings at the age of 30-45 days after sowing of seeds from nursery bed to polybags ensures least mortality of seedlings. Therefore, pre-sowing treatments of *T. indica* seeds in cow urine for 24 hours is suitable for seedlings raising in the nursery and one year old seedlings may be planted at 2.0 m × 2.0 m spacing in the plantation program.

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