Effect of pre-sowing seed treatment, type of seed beds and time of sowing on *Terminalia chebula* in its natural forest

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ABSTRACT

Harar, *Terminalia chebula* Retz is an important medicinal tree species in the Asian countries. Large scale planting programme for the species is often difficult due to its poor seed germination and longer germination period in the natural forests. This study describes the effect of various pre-sowing treatments, bed types and sowing times on seed germination and seedling growth of Harar. Under various integration effects germination ranged from 9.17 to 40.00 per cent, germination energy from 5.00 to 20.33, time taken for germination from 26.83 to 31.50 days, shoot length from 4.60 to 6.77 cm, root length from 4.77 to 7.30 cm, number of leaves per seedling from 3.00 to 4.67, root-shoot ratio from 0.88 to 1.35 and total dry biomass per seedling from 1.27 to 2.03 g. However the combined interaction effect of pre-sowing treatments, bed types and sowing times treatments on these characters was found to be non-significant. At the same time the two factor combination of the treatments was found to significant in certain cases. Considering the early establishment and fast regeneration of Harar in natural forest, the best pre-treatment, bed type and sowing time in this study was scarification of hard seed coat, Raking + FYM @ 2 kg per square meter and July, respectivelywhich may be useful for further expansion of Harar plantations.

Keywords: *Terminalia chebula*; seed treatment, seed bed; sowing time; germination; seedlings

INTRODUCTION

Terminalia chebula is the native plant in India and Southeast Asia which is also grown extensively in Taiwan. *T chebula* belongs to the Combretaceae family and distributed in deciduous forests in India and areas of moderate or low rainfall (Naik et al 2004). *T chebula* in English is commonly known as black myrobalans and Harar in Hindi. The genera *Terminalia*, mainly consists of 250 species and is widespread in tropical regions around the world (Saleem et al 2002). The fruit of *T chebula* is considered as the king of medicines by Tibetans, second to none by Ayurvedic apothecaries and held in high regards by other folk medical practitioners (Karel et al 2004). The species is widely used in association with *T bellerica* and *Emblica officinalis* in Triphala, an important combination of three fruits and is extensively used in Indian subcontinent as an Ayurvedic medicine. Triphala has the presence of an antioxidant and is thought to expel toxins and other unwanted accumulations from the body. It also benefits underlying respiratory problems and conditions with elevated levels of cholesterol. *T chebula* is a medium to large deciduous tree with wide branches and a large disk-shaped crown which grows up to the height of 30 m (Chattopadhyay and Bhattacharyya 2007).

The population of these precious species is dwindling rapidly because of enormous population pressure, the hunger, lack of adequate governmental policies and the inefficient use of forest resources. Consequently a number of recent attempts have been made by the government, non-governmental organizations, private entities and individuals for plantation and management of medicinal plants species along with timber and fruit tree species by effective contribution by people across the country. The achievement of any plantation programme largely depends on germination of seeds and growth of

seedlings in the nursery. However poor germination capacity and longer germination period (up to 2-3 months) are the major drawbacks of raising seedlings and establishing plantations of the species of Harar (Luna 1996). It is believed that this delay and uneven germination of the seeds is due to the tough and hard seed coat and the thick fleshy pulp of the fruit. Pre-sowing treatments improve the germination of seeds with hard seed coat (Palani et al 1996, Hossain et al 2005, Anand et al 2012). Some experiments have tested the germination percentage of *T chebula* with various treatments such as depulping of fruit, hourly immersion in hot or cold water, scarification, treatments with H_2SO_4 etc. This research is an attempt to investigate the impact on germination and growth parameters of *T chebula* seedlings from pre-sowing treatments, type of seed beds and sowing times.

MATERIAL and METHODS

This study was conducted in the natural forest of Harar located in Naraina, Himachal Pradesh situated at the intersection of the 31°35'19" N latitude and 76°29'36" E longitude. Mean maximum temperature was 31.8°C while minimum was 20.8°C. Mean annual rainfall of the study area was about 122 cm that occurred mostly from July to September.

Fruit collection and pre-sowing treatments: The Harar fruits were collected in the month of December from middle aged healthy trees bearing sufficient fruits. Fruits were depulped, dried in open sun, stored in gunny bags and later used for germination trials in natural forests and the nursery. The experiment was laid out in a randomized block design combination of three main factors [Seed bed preparation (B), pre-sowing seed treatment (P) and time of sowing (S)] each at three sub-factor levels viz seed bed preparation [B_1 (Raking of soil up to 4 to 5 inches depth), B_2 (Raking + FYM @ 2 kg per square meter) and B_3 (Pit of 1 cubic foot filled with soil and 2 kg FYM)], pre-sowing seed treatment [P_1 (Control), P_2 (Sulphuric acid @ 95% concentration) and P_3 (Mechanical breaking of seed coat)] and time of sowing [S_1 (March, S_2 (June) and S_3 (July)] in natural Harar forest.

Per cent germination: Germination percentage was calculated by counting the number of seeds germinated out of total number of seeds sown.

Germination energy: The number of seeds germinating daily in each treatment was recorded from the date of sowing until the completion of germination to compute germination energy.

Number of days to complete germination: The dates of commencement and completion of germination were recorded to calculate number of days taken to complete germination.

Shoot length: The shoot length of seedlings was measured from the collar region to the growing tip using the measuring scale and expressed in centimeters.

Root length: The length of taproot was measured from the collar region to the tip of the taproot using measuring scale and expressed in centimeters. In case of coiled root, a thread was run along the root and thread length was measured to determine the root length.

Number of leaves per plant: Number of leaves per plant was worked out by averaging total number of leaves counted in five randomly selected plants.

Root/shoot ratio: The root/shoot ratio was worked out on dry weight basis by dividing the weight of dry root by the weight of dry shoot of respective plant.

Biomass estimation: Total dry weight per plant was recorded for the biomass estimation. The seedlings were dried at 60°C for 48 hours for recording dry weight. The weight was taken using electronic balance and expressed in grams.

RESULTS and DISCUSSION

Germination parameters

Data on germination parameters as influenced by different treatments are given in Table 1.

Per cent germination: The highest germination was observed in bed type B_1 (26.94%) which was statistically at par with B_2 (26.67%) and higher than B_3 (22.96%). Pre-sowing treatment P_3 resulted in maximum germination (34.35%) which was significantly higher over P_2 (26.85%) and P_1 (15.37%). Sowing time S_3 was found the best with germination of 28.33 per cent which was superior to S_2 (25.19%) and S_1 (23.06%). Under two factor combination P*B, the highest germination (34.72%) was recorded in P_3B_1 and P_3B_2 which was at par with P_3B_3 (33.61%). Under interaction S*P, germination of 36.94 per cent in S_3P_3 was at par with S_2P_3 (34.72%). Under B*S treatment

Table 1. Effect of pre-sowing treatments, bed types and sowing times on per cent germination, germination energy and days taken for complete germination of *Terminalia chebula s*eedlings

Factor	Per cent germination				Germination energy				Days taken for complete germination			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
B_1	17.78	28.33	34.72	26.94	8.28	13.78	18.56	13.54	29.06	28.94	29.00	29.00
B_2	16.11	29.17	34.72	26.67	8.56	16.84	19.50	15.00	29.11	28.56	29.11	28.93
B_3	12.22	23.06	33.61	22.96	6.22	12.83	15.89	11.65	29.61	29.56	29.39	29.52
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
P_1	14.44	15.00	16.67	15.37	7.00	7.50	8.61	7.70	30.28	29.72	27.78	29.26
P_2	23.33	25.83	31.39	26.85	13.73	14.50	15.22	14.48	30.06	29.44	27.56	29.02
P_3	31.39	34.72	36.94	34.35	17.50	18.50	17.94	17.98	30.83	29.06	27.61	29.17
	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean
S_1	22.78	24.44	21.94	23.06	11.01	14.45	12.73	12.73	29.94	30.28	30.94	30.39
S_2	25.83	25.28	24.44	25.19	14.67	14.39	11.44	13.50	29.61	29.00	29.61	29.41
S_3	32.22	30.28	22.50	28.33	14.89	16.11	10.78	13.93	27.44	27.50	28.00	27.65

Interaction P*B*S (per cent germination)

	P_1			P_2			P_3		
	B_1	B_2	B_3	B_1	B_2	B_3	B_1	B_2	B_3
S_1	15.83	14.17	13.33	22.50	26.67	20.83	30.00	32.50	31.67
S_2	15.83	15.00	14.17	27.50	26.67	23.33	34.17	34.17	35.83
S_3	21.67	19.17	9.17	35.00	34.17	25.00	40.00	37.50	33.33

Interaction P*B*S (germination energy)

	P_1			P_2			P_3		
	B_1	B_2	B_3	B_1	B_2	B_3	B_1	B_2	B_3
S_1	6.84	7.67	6.50	10.67	17.34	13.17	15.67	18.33	18.50
S_2	7.67	7.67	7.17	16.50	15.67	11.34	19.85	19.84	15.84
S_3	10.34	10.50	5.00	14.17	17.50	14.00	20.17	20.33	13.34

Interaction P*B*S (days taken for complete germination)

	P			P_2			P_3		
	B_1	B_2	B_3	B_1	B_2	B_3	B_1	B_2	B_3
S_1	29.17	30.50	31.17	30.67	28.83	30.67	30.00	31.50	31.00
S_2	30.17	29.17	29.83	29.33	29.17	29.83	29.33	28.67	29.17
S_3	27.83	27.67	27.83	26.83	27.67	28.17	27.67	27.17	28.00

$CD_{0.05}$

Per cent germination: P= 2.27, B= 2.27, S= 2.27, P*B= 3.93, S*P= 3.93, B*S= 3.93, P*B*S= NS

Germination energy: P= 0.36, B= 0.36, S= 0.36, P*B= NS, S*P= NS, B*S= 0.62, P*B*S= NS

Days taken for complete germination: P= NS, B= NS, S= 0.48, P*B= NS, S*P= NS, B*S= NS, P*B*S= NS

combination, B_1S_3 (32.22%) was found statistically at par with B_2S_3 (30.28%) and significantly better over all other combinations. In case of three factor interaction, no differences were recorded among various combinations.

Germination energy: Among bed types, B_2 exhibited the highest value of germination energy (15.00) which was significantly better over B_1 and B_3. The maximum germination energy (17.98) was recorded under pre-sowing treatment P_3. Sowing time S_3 gave the best germination energy (13.93) over S_1 and S_2. However under two or three factor combinations of P, B and S, the values were non-significant for all combinations.

Days taken for complete germination: The complete germination in the three bed types and three pre-treatments there were no statistical differences. Sowing time, S_3 took the minimum time (27.65 days) and was statistically better over S_1 and S_2. In this case also two or three factor combinations of P, B and S, the values were non-significant for all combinations.

Hossain et al (2013) recorded the fastest seed germination and highest germination percentage (73.8%) in depulped seeds soaked in cold water for 48 h followed by 72 h. Saleem et al (2013) reported the maximum germination (73.6%) by mechanical breaking of seed coat. Azad et al (2010) recorded the highest germination success (80%) in scarification with sand paper followed by 74 and 69 per cent in immersion in H_2SO_4 and hot water treatment respectively. Mathad et al (2014) rated mechanical puncturing of *Psorolea corylifolia* seed as the outstanding method that had the maximum germination (87%), mean daily germination (6.21) and germination value (7.69) whereas sulphuric acid treatment given for five minutes took less time for imbibition (17.67 h).

Seedling growth parameters

Data on seedling growth parameters as influenced by different treatments are given in Table 2.

Shoot length: The three bed types as well as pre-sowing treatments did not result in any difference in shoot length. The maximum shoot length (5.92 cm) was recorded under the sowing time S_1 in comparison to S_2 and S_3. The two factor combination P and S and three factor combination of P, B and S, the treatments had no statistical impact on shoot length.

Root length: The three bed types, pre-sowing treatments or sowing times and their two or three factor combinations did not result in statistically different root length.

Number of leaves per seedling: Pertaining to bed types the maximum number of leaves per seedling (4.00) was recorded in B_3 which was at par with B_1 (3.78). Pre-sowing treatment P_3 revealed the highest number of leaves per seedling (4.22) which was statistically better over P_1 and P_2. With respect to sowing time, no difference was recorded under the three sowing times. Under two factor P*B interaction, P_3B_3, P_3B_1, P_3B_2, P_2B_3 and P_2B_1 were superior over all other treatment. In case of B*S factor interaction, B_3S_1, B_3S_3, B_1S_3 and B_1S_2 were at par and were superior over other treatments. The two factor combination P and S and three factor combination P, B and S the treatments were statistically at par.

Root-shoot ratio: Like root length, there was no statistical difference in effect of various treatments on the root-shoot ratio except the sowing time wherein S_3 and S_2 were found superior with root-shoot ratio of 1.19 and 1.12 respectively over S_1 (1.04).

Karaguzel et al (2004) reported that mechanical scarifying of *Lupinus varius* increased seedling characteristics such as shoot length, root length, number of leaves and root-shoot ratio. Soliman and Abbas (2013) observed more number of leaves (37.40 and 40.20) under hot water treatment of *Cassia fistula* L seeds for 3 min and 6 min resepctively. Dhupper (2013) also found the maximum shoot growth and number of leaves in *Acacia nilotica* under hot water treatment of seed for 15 min.

Biomass estimation

Total dry biomass per seedling: The highest dry biomass per seedling (1.70 g) was observed in S_1 in comparison to S_2 and S_3. The bed types, pre-sowing treatments and the two or three factor combinations of P, B and S had no significant effect on the total dry biomass per seedling.

CONCLUSION

Harar takes a longer time to germinate naturally because of hard seed coat. It is vital that the seed coat should be softened and broken to make it easy and convenient for the embryo to come out. The key issue with recommending pre-seeding treatment is that

Table 2. Effect of pre-sowing treatments, bed types and sowing time on shoot length, root length, number of leaves per seedling and root-shoot ratio of *Terminalia chebula* seedlings

Factor	Shoot length				Root length			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
B_1	5.29	5.56	5.66	5.50	5.58	6.32	6.34	6.08
B_2	5.30	5.16	5.73	5.40	5.79	5.91	6.61	6.10
B_3	5.10	5.89	5.56	5.51	5.50	5.99	5.99	5.83
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
P_1	5.54	4.86	5.29	5.23	5.44	5.39	6.03	5.62
P_2	6.16	5.13	5.31	5.53	6.26	5.72	6.24	6.07
P_3	6.07	5.68	5.53	5.65	6.51	6.24	6.19	6.31
	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean
S_1	5.74	5.87	6.16	5.92	5.89	6.13	6.19	6.07
S_2	5.26	5.24	5.17	5.22	5.68	6.08	5.60	5.79
S_3	5.50	5.08	5.22	5.27	6.68	6.10	5.69	6.16
	Number of leaves per seedling				Root-shoot ratio			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
B_1	3.22	3.89	4.22	3.78	1.05	1.15	1.11	1.11
B_2	3.33	3.33	4.11	3.59	1.09	1.20	1.18	1.16
B_3	3.56	4.11	4.33	4.00	1.14	1.04	1.10	1.09
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
P_1	3.33	3.11	3.67	3.37	1.01	1.11	1.16	1.09
P_2	3.67	3.67	4.00	3.78	1.04	1.14	1.22	1.13
P_3	4.22	4.22	4.22	4.22	1.07	1.11	1.21	1.13
	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean
S_1	3.56	3.44	4.22	3.74	1.04	1.05	1.04	1.04
S_2	3.78	3.67	3.56	3.67	1.08	1.16	1.11	1.12
S_3	4.00	3.67	4.22	3.96	1.20	1.26	1.13	1.19

Interaction P*B*S (shoot length)

	P_1			P_2			P_3		
	B_1	B_2	B_3	B_1	B_2	B_3	B_1	B_2	B_3
S_1	5.30	5.43	5.90	6.10	5.60	6.77	5.83	6.57	5.80
S_2	4.90	5.07	4.60	4.97	4.97	5.47	5.90	5.70	5.43
S_3	5.67	5.40	4.80	5.60	4.90	5.43	5.23	4.93	5.43

Interaction P*B*S (root length)

	P_1			P_2			P_3		
	B_1	B_2	B_3	B_1	B_2	B_3	B_1	B_2	B_3
S_1	4.80	5.00	6.53	6.77	6.10	5.90	6.10	7.30	6.13
S_2	4.87	6.10	5.20	5.67	5.63	5.87	6.50	6.50	5.73
S_3	7.07	6.27	4.77	6.53	6.00	6.20	6.43	6.03	6.10

Interaction P*B*S (number of leaves per seedling)

	P_1			P_2			P_3		
	B_1	B_2	B_3	B_1	B_2	B_3	B_1	B_2	B_3
S_1	3.00	3.33	3.67	3.67	3.00	4.33	4.00	4.00	4.67
S_2	3.00	3.33	3.00	4.00	3.33	3.67	4.33	4.33	4.00
S_3	3.67	3.33	4.00	4.00	3.67	4.33	4.33	4.00	4.33

Interaction P*B*S (root-shoot ratio)

	P_1			P_2			P_3		
	B_1	B_2	B_3	B_1	B_2	B_3	B_1	B_2	B_3
S_1	0.93	0.93	1.18	1.15	1.09	0.88	1.03	1.14	1.05
S_2	1.00	1.20	1.13	1.17	1.15	1.09	1.08	1.13	1.12
S_3	1.23	1.13	1.10	1.15	1.35	1.15	1.22	1.28	1.13

$CD_{0.05}$
Shoot length: P= NS, B= NS, S= 0.20, P*B= NS, S*P= NS, B*S= NS, P*B*S= NS
Root length: P= NS, B= NS, S= NS, P*B= NS, S*P= NS, B*S= NS, P*B*S= NS
Number of leaves/seedling: P= 0.31, B= 0.31, S= NS, P*B= 0.54, S*P = NS, B*S= 0.54, P*B*S= NS
Root-shoot ratio: P= NS, B= NS, S= 0.07, P*B= NS, S*P= NS, B*S= NS, P*B*S= NS

Table 3. Effects of pre-sowing treatments, bed types and sowing time on total dry biomass per seedling of *Terminalia chebula* seedlings

Factor — Total dry biomass per seedling

	P_1	P_2	P_3	Mean
B_1	1.40	1.60	1.60	1.53
B_2	1.70	1.56	1.69	1.65
B_3	1.44	1.53	1.54	1.51
	S_1	S_2	S_3	Mean
P_1	1.63	1.30	1.61	1.51
P_2	1.77	1.43	1.49	1.56
P_3	1.71	1.52	1.60	1.61
	B_1	B_2	B_3	Mean
S_1	1.58	1.69	1.84	1.70
S_2	1.40	1.58	1.28	1.42
S_3	1.62	1.68	1.40	1.57

Interaction P*B*S

	P_1			P_2			P_3		
	B_1	B_2	B_3	B_1	B_2	B_3	B_1	B_2	B_3
S_1	1.33	1.70	1.87	1.93	1.63	1.73	1.47	1.73	1.93
S_2	1.27	1.37	1.27	1.37	1.63	1.30	1.57	1.73	1.27
S_3	1.60	2.03	1.20	1.50	1.40	1.57	1.77	1.60	1.43

$CD_{0.05}$
P= NS, B= NS, S= 0.18, P*B= NS, S*P= NS, B*S= NS, P*B*S= NS

farmers should be able to produce good quality seedlings with minimal costs and labour. Among pre-sowing treatments mechanical breaking of seed coat outperform all other pre-treatments whereas B_2 raking + FYM @ 2 kg per square meter proved the best among seed bed preparations with respect to germination of Harar. July proved to be the best time for sowing of Harar. Therefore sowing of kernels directly in a seed bed in the Harar natural forest following extraction from endocarp during July led to the highest germination which can improve maintaining eroding genetic base of natural Harar populations.

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