



ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(8): 2103-2107
© 2023 TPI
www.thepharmajournal.com
Received: 22-05-2023
Accepted: 03-07-2023

Shreishtha Singh
Ph.D. Student, Department of
Tree Improvement and Genetic
Resources, College of Forestry,
Dr YS Parmar University of
Horticulture and Forestry,
Nauni, Solan, Himachal
Pradesh, India

Dr. HP Sankhyan
Professor and Head, Department
of Tree Improvement and
Genetic Resources, College of
Forestry, Dr YS Parmar
University of Horticulture and
Forestry, Nauni, Solan,
Himachal Pradesh, India

Altitudinal variation in seed and nursery growth parameters in *Dendrocalamus hamiltonii* Nees in Himachal Pradesh

Shreishtha Singh and Dr. HP Sankhyan

Abstract

The present investigation entitled “Altitudinal variation in seed and nursery growth parameters in *Dendrocalamus hamiltonii* Nees in Himachal Pradesh.” was carried out in the Department of Tree Improvement and Genetic Resources. Field survey was carried out across the populations of *Dendrocalamus hamiltonii* Nees in different altitudinal zones of Himachal Pradesh. Flowering and morphometric traits were taken as selection criteria to select well-represented twelve seed sources viz. S₁ (Jukhala), S₂ (Sujanpurtira) S₃ (Kallar), S₄ (Chabutra) S₅ (Sarkaghat) S₆ (Ghumariwn), S₇ (Toni Devi), S₈ (Kuthar) S₉ (Ratti) and S₁₀ (Awah Devi), S₁₁ (Giripul), S₁₂ (Sapri). The clumps having flowering were randomly selected and the seeds were collected from individual clumps was done for studying the seed traits viz. 100 seed weight, seed length (mm), seed width (mm), Seed germination (%), Germination energy, Germination index, Germination value. The data analyzed by RCBD revealed that there was small variation between seed sources was observed for nursery growth parameters. The variation observed for seed traits did not follow any particular trend with regard to different populations. It is visualized that on altitudinal basis seed and germination parameters can be used as an effective tool for selecting genotypes for good quality seeds and seedlings from natural populations.

Keywords: Variation, altitude, seed and germination parameters

Introduction

Bamboos are often giant, woody, evergreen, perennial, grasses belonging to the subfamily Bambusoideae of the family Poaceae. Bamboo is native to every continent except Europe and Antarctica and is found from sea level tropics to 4000 m in mountains, their genera and species are widely distributed. It is reported that over 77 genera and 1250 species occur globally, most of which are confined to Southeast Asia (Sharma 1987) [7].

In Himachal Pradesh only 8 species namely *Bambusa nutans*, *B. bambos*, *Dendrocalamus hamiltonii*, *D. parishii*, *D. strictus*, *Drepanostachyum talcatum* (syn *Arundinaria falcata*), *Thamnocalamus spathiflorus* (syn. *Arundinaria spathiflora*) and *Phyllostachys bambusoides* are reported. The latter one is the native species of China and was introduced in Himachal Pradesh (Chowdhery and Wadhwa. 1984) [3].

Bamboo's special biological and ecological characteristics and growth habits enable bamboo forests to serve ecological and environmental functions such as land rehabilitation, water conservation and control of soil erosion.

Dendrocalamus hamiltonii Nees is a large sized solid sympodial bamboo belongs to Family Poaceae, locally known as Maggar bans. It is culm grows at an angle and is greyish white when young and dull green at maturity. The diameter of culm and intermodal length ranges between 30-40 cm and 5-15 cm. Internodes are 30-50 cm long, culm sheath is glabrous, rough with brown hairs on outer side. It flowers sporadically or gregariously. It generally flowers sporadically, gregarious flowering occurs at an interval of 30-40 years. New culms arise from buds on the rhizome during July-August and attain their full length by November-December. New leaves production starts in summer.

It has been cultivated in Himachal Pradesh and Nepal for a very long time for its culms and nutritive leaf fodder, particularly during winter when there is a keen shortage of green fodder in the winter season in hills. Being palatable and nutritious, it is especially suitable for milch cattle. It is lopped from October – February intensively for continuous winter fodder supplies. The yield is 50-125 kg of fresh leaves/ clump. It is ranked as the best fodder after *Grewia optiva* due to nutritional fodder characteristics, availability and distribution across Himalayas.

Corresponding Author:
Shreishtha Singh
Ph.D. Student, Department of
Tree Improvement and Genetic
Resources, College of Forestry,
Dr YS Parmar University of
Horticulture and Forestry,
Nauni, Solan, Himachal
Pradesh, India

Materials and Methods

Table 1: Description of different sites of study area

Site Names	Altitudinal range (above mean sea level)	Latitude	Longitude	District
A1 (300-601 amsl)				
S ₁ (Jukhala)	375 m	31° 29 N	76° 81 E	Bilaspur
S ₂ (Sujanpurtila)	515 m	31° 83 N	76° 51 E	Hamirpur
S ₃ (Kallar)	406 m			Kangra
A2 (601-901 amsl)				
S ₄ (Chabutra)	725 m	31° 68 N	76° 52 E	Hamirpur
S ₅ (Sarkaghat)	900 m	31.69°N	31° 69 ° E	Mandi
S ₆ (Ghumariwn)	700 m	31° 43 N	76° 71 E	Bilaspur
A3 900-1200 amsl				
S ₇ (Toni Devi)	982 m	31° 65N	76° 52 E	Hamirpur
S ₈ (Kuthar)	1125 m	30° 97 N	76° 96 E	Solan
S ₉ (Ratti)	1189 m	31° 70 N	76. ° 93 E	Kangra
A4 1200-1600 amsl				
S ₁₀ (Awah Devi)	1250 m	31°58'N	76° 51 E	Hamirpur
S ₁₁ (Giripul)	1453 m	30° 54 N	77° 54 E	Solan
S ₁₂ (Sapri)	1254 m	31° 89N	76.29 E	Kangra

Seed, germination and nursery growth parameters (one year) were assessed in natural populations of *Dendrocalamus hamiltonii* Nees in four altitudinal zones in low and mid hill of Himachal Pradesh. Before undertaking the actual study to accomplish the objectives of work, a detailed survey of the bamboo growing areas of Himachal Pradesh was carried out. After the detailed survey clumps showed flowering were selected. The study area was divided into four altitudinal ranges viz., 300-600 m (amsl), 600-900 m (amsl), 900-1200 m (amsl) and 1200-1500 m (amsl).

Seed and Germination Parameters recorded were Seed length (mm) was measured with the help of Digital Vernier Caliper, Seed width (mm) was measured with the help of Digital Vernier Caliper, Seed weight of 100 seeds (gm) was measured according to ISTA (1966). Germination parameters include Germination percentage (%) was calculated by the number of seeds germinated to the total number of seeds sown was counted and was expressed as germination percentage. Germination value was calculated by the following formula:

Germination value (GV) = Mean daily germination (MDG) x Peak value at mean daily germination (PV)

Germination index: It was calculated by the following formula.

Germination index (GI) = $\sum (G/T)$ where G is the percent of seed germinated per day and T is the germination period

Seed germination energy: It was calculated by the following formula

$$\text{Germination energy} = \frac{\text{No. of seeds germinated on four days after sowing}}{\text{Total no. seeds tested}} \times 100$$

Nursery growth parameters

Fifteen seeds per population were sown in nursery bed containing sand in higher proportion and FYM. Seedling

height (cm). The height of the culm was recorded from the ground level to the apex of the leading shoot by using measuring scale and was expressed in cm. Number of leaves per plant was manually observed and counted. Root length (cm): It was measured with the help of measuring tape and expressed in cm after one year of sowing. Number of roots per plant: It was manually observed and counted after one year of sowing. Survival percentage (%): It was calculated by the following formula:

$$\text{Survival percentag} = \frac{\text{Number of survived seedlings}}{\text{Total number of seeds sown}} \times 100$$

Collar diameter (mm): It was measured with the help of Digital Vernier Caliper near first node. Internodal length (cm): The internodal length was measured as distance between two nodes, at mid of the plant height and expressed in cm. Leaf length (cm): The petiole length was measured with the help of measuring scale and expressed in cm. Leaf width (cm): The petiole width was measured with the help of measuring scale and expressed in cm. Leaf area (cm²) was measured with the help of Leaf Area Meter. Number of leaves/seedling: The average number of leaves per plant was manually observed and counted.

Results and Discussion

Seed and Germination parameters

Seed length (mm): The Seed length of *Dendrocalamus hamiltonii* Nees at different populations varied from 7.76 mm to 7.41 mm. The S₁ (Jukhala) population recorded the highest seed length which is followed by populations and S₅ (Sarkaghat) and S₆ (Ghumarwin) and; closely followed by S₄ (Chabutra). The minimum seed length was recorded at S₁₂ (Sapri). Elevation range A₁ (300-600 m) with mean value 7.58 was recorded best for Seed length whereas elevation range A₄ (1200-1500) recorded least for Seed length with mean value 7.48.

Table 2: Variation in seed and germination parameters among populations of *Dendrocalamus hamiltonii* Nees in Himachal Pradesh

Population Code	Seed length (mm)	Seed width (mm)	Seed germination (%)	100 Seed Weight (mg)	Germination energy	Germination index	Germination value
S ₁ (Jukhala)	7.76	4.53	79.98	3.80	21.83	2.52	13.55
S ₂ (Sujanpur tira)	7.59	4.45	75.34	3.8	20.90	2.51	12.51
S ₃ (Kallar)	7.41	4.35	78.56	3.53	21.23	2.43	13.46
S ₄ (Chabutra)	7.47	4.25	77.89	3.34	20.23	2.22	12.71
S ₅ (Sarkaghat)	7.72	4.54	75.62	3.40	20.23	2.31	12.21
S ₆ (Ghumariwn)	7.57	4.45	76.11	3.26	20.23	2.16	11.85
S ₇ (Toni Devi)	7.43	4.34	76.58	3.27	20.37	1.88	11.27
S ₈ (Kuthar)	7.46	4.25	75.23	3.22	20.17	1.72	11.45
S ₉ (Ratti)	7.72	4.53	73.94	3.21	19.17	1.73	11.74
S ₁₀ (Awah Devi)	7.59	4.45	72.25	3.12	18.17	1.74	11.90
S ₁₁ (Giripul)	7.42	4.34	74.56	3.19	19.57	1.65	11.78
S ₁₂ (Sapri)	7.44	4.25	72.51	3.16	17.37	2.49	12.59
C.D (0.05)	NS	0.01	0.17	0.17	2.54	0.58	0.78

Seed width (mm): The Seed width of *Dendrocalamus hamiltonii* Nees at different populations varied from 4.25 mm to 4.53 mm. The S₅ (Sarkaghat) population recorded the highest seed width which is followed by populations and S₉ (Ratti). The minimum seed width was recorded at S₁₂ (Sapri). Elevation range A₁ (300-600m) with mean value 4.44 was recorded best for Seed width whereas elevation range A₄ (1200-1500) recorded least for Seed width with mean value 4.34.

Seed germination (%): The Seed germination of *Dendrocalamus hamiltonii* Nees at different populations varied from 79.99 per cent to 72.25 per cent. S₁ (Jukhala) population recorded the highest seed germination which is followed by populations and S₃ (Kallar) and S₄ (Chabutra). The minimum seed germination was recorded at S₁₀ (Awah Devi). Elevation range A₁ (300-600m) with mean value 77.97 was recorded best for Seed germination whereas elevation range A₄ (1200-1500) recorded least for Seed germination with mean value 73.10.

Seed Weight (mg): The 100 seed weight of *Dendrocalamus hamiltonii* Nees at different populations varied from 3.13 to 3.81. The S₁ (Jukhala) population recorded the highest 100 seed weight which is followed by population S₂ (Sujanpur tira). The minimum 100 seed weight was recorded at S₁₀ (Awah Devi). Elevation range A₁ (300-600 m) with mean value 3.71 was recorded best for 100 seed weight whereas elevation range A₄ (1200-1500) recorded least for 100 seed weight with mean value 3.16.

Germination energy: The Germination energy of *Dendrocalamus hamiltonii* Nees at different populations varied from 17.37 to 21.84. The S₁ (Jukhala) population recorded the highest Germination energy which is followed by populations S₃ (Kallar) and S₂ (Sujanpur tira); closely followed by S₄ (Chabutra). The minimum Germination energy was recorded at S₁₂ (Sapri). Elevation range A₁ (300-600 m) with mean value was recorded best for Germination energy 21.32 with mean value whereas elevation range A₄ (1200-1500) recorded least for Germination energy with mean value 18.37.

Table 3: Altitudinal variation in seed and germination parameters (mean value) in natural populations of *Dendrocalamus hamiltonii* Nees in Himachal Pradesh

Altitude	Seed length (mm)	Seed width (mm)	Seed germination (%)	100 seed weight (mg)	Germination energy	Germination index	Germination value
A ₁	7.58	4.44	77.97	3.71	21.32	2.49	13.17
A ₂	7.58	4.41	76.54	3.33	20.24	2.23	12.26
A ₃	7.53	4.37	75.25	3.23	19.9	1.78	11.49
A ₄	7.48	4.34	73.1	3.16	18.37	1.96	12.1

Germination index

The Germination index of *Dendrocalamus hamiltonii* Nees at different populations varied from 17.37 cm to 21.84 cm. The S₁ (Jukhala) population recorded the highest Germination index which is followed by populations S₃ (Kallar) and S₂ (Sujanpur tira) closely followed by S₄ (Chabutra). The minimum Germination index was recorded at S₁₂ (Sapri). Elevation range A₁ (300-600 m) with mean value was recorded best for Germination index 21.32 with mean value whereas elevation range A₄ (1200-1500) recorded least for Germination index with mean value 18.37.

Damizade (2004) ^[10] planted seeds of *Capparis deciduas* in nursery for evaluating germination and survival rates of seedlings.

Zhao *et al.* (2006) ^[11] sorted seeds of *Nitraria sphaerocarpa* into three size-classes and buried at 2 cm depths in plastic pots filled with sand under controlled greenhouse condition.

Two weeks after seedling emergence, seedlings were buried in sand to various depths of 0, 33, 67, 100 and 133% of their mean height. Seedling height, mass and absolute height growth rate in partial burial treatments were higher than those of the unburied and completely buried treatments. In each seed size class, with increasing burial depth, or in each burial depth, with decreasing seed size, there was a tendency that both biomass allocation to root and biomass allocation to belowground stem increased, while biomass allocation to aboveground stem decreased.

First seed germination emerged 8 days after sowing and continued 8-14 days. Germination period of the species is expressed 8-28 days (Ahlawat *et al.*, 2002) ^[11].

Tinsae Bahru, *et al.* 2012 ^[8] studied the effect of germination site on germination energy and germination value of *O. abyssinica* seeds. The three various germinating sites, i.e., laboratory, greenhouse, and seedbed showed 70-83%, 25-69%

and 0-59% germination energy respectively. As a result, the germination energy of *O. abyssinica* seeds at three major germination sites indicated that laboratory recorded the highest germination energy of 83%, while the lowest percentage of 0% was observed at the seedbed. Nevertheless, the statistical test of ANOVA showed that no significant difference between germination energy of seeds and

germinating sites (at laboratory, green house and seedbed), respectively.

Azmy & Appanah (1998) [2] planted *Gigantochloa ligulata* at FRIM and results showed the seedlings developed in the second week after sowing. With 1:3 soils and rate and the germination was 76%.

Table 4: Variation in nursery raised (12 months old) seedlings for growth parameters in *Dendrocalamus hamiltonii* Nees in Himachal Pradesh

Population code	Seedling height (m)	Collar diameter (mm)	Number of roots	Root Length (cm)	Leaf Length (cm)	Leaf Width (cm)	Leaf area (m ²)	No. of Leaves	Internodal Length (cm)
S ₁ (Jukhala)	16.70	1.27	12.81	9.80	7.89	2.16	13.72	10.12	2.78
S ₂ (Sujanpurtira)	12.71	1.04	12.56	9.21	6.82	1.82	13.60	9.39	2.83
S ₃ (Kallar)	11.30	0.81	11.99	8.82	4.69	1.62	12.33	9.30	2.68
S ₄ (Chabutra)	17.62	0.83	9.687	8.98	4.69	1.85	11.50	9.54	2.53
S ₅ (Sarkaghat)	16.79	1.22	12.23	9.80	7.88	2.11	13.57	10.20	2.85
S ₆ (Ghumariwn)	13.29	0.97	12.34	8.85	6.88	1.71	13.02	9.43	2.80
S ₇ (Toni Devi)	11.24	0.80	12.00	9.35	4.66	1.62	12.44	9.39	2.67
S ₈ (Kuthar)	17.69	0.83	11.10	9.44	4.71	1.87	11.20	8.29	2.53
S ₉ (Ratti)	16.51	1.22	12.19	9.72	7.80	1.96	13.70	10.22	2.82
S ₁₀ (Awah Devi)	13.21	0.93	12.67	9.52	6.81	1.73	13.00	9.43	2.84
S ₁₁ (Giripul)	11.48	0.79	11.77	9.43	4.81	1.64	12.40	9.34	2.66
S ₁₂ (Sapri)	11.31	0.82	11.73	9.06	4.69	1.84	11.07	8.35	2.54
CD(0.05)	0.21	*0.29	NS	NS	0.37	NS	0.73	NS	0.06

Table 5: Altitudinal variation in nursery raised (12 months old) seedlings for growth parameters (mean value) in *Dendrocalamus hamiltonii* Nees in Himachal Pradesh

Altitude	Seedling height (m)	No. of Roots	Collar diameter (mm)	Root length (cm)	Leaf length (cm)	Leaf width (cm)	Leaf area (m ²)	No. of leaves	Internodal length (cm)
A ₁	13.57	12.45	1.04	9.28	6.47	1.87	13.21	9.60	2.76
A ₂	15.90	11.41	1.00	9.21	6.48	1.89	12.7	9.73	2.79
A ₃	15.15	11.76	0.95	9.51	5.41	1.82	12.45	9.30	2.67
A ₄	12.0	12.05	0.85	9.33	5.72	1.74	12.15	9.04	2.68

Variation in nursery raised (12 months old) seedlings for growth parameters

Seedling height (cm): The Seedling height of (12 months old) seedlings of *Dendrocalamus hamiltonii* Nees in different populations varied from 17.69 to 11.24. The S₈ (Kuthar) population recorded the highest seedling height which is followed by population S₄ (Chabutra) and S₁ (Jukhala). The minimum seedling height was recorded at S₇ (Toni Devi). Elevation range A₂ (600-900m) with mean value 15.90 was recorded best for Seedling height whereas elevation range A₄ (900-1200) was recorded least for Seedling height with a mean value of 12.0.

Number of Roots: The Number of roots of (12 months old) seedlings of *Dendrocalamus hamiltonii* Nees in different populations varied from 11.10 to 12.81. The S₁ (Jukhala) population recorded the highest Number of roots which is followed by populations S₂ (Sujanpurtira) and S₃ (Kallar). The minimum Number of roots was recorded at S₈ (Kuthar). Elevation range A₁ (300-600m) with mean value 12.45 was recorded best for No of roots whereas elevation range A₄ (1200-1500) recorded least for Number of roots with mean value 12.05.

Collar diameter (mm): The Collar diameter of (12 months old) seedlings of *Dendrocalamus hamiltonii* Nees in different populations varied from 0.79 to 1.27. The S₁ (Jukhala) population recorded the highest collar diameter which is followed by populations and S₂ (Sujanpurtira) and S₉ (Ratti). The minimum collar diameter was recorded at S₁₁ (Giripul).

Elevation range A₁ (300-600m) with mean value 1.04 was recorded best for collar diameter whereas elevation range A₄ (1200-1500) recorded least for No of roots with mean value 0.85.

Root length (cm): The Root length of (12 months old) seedlings of *Dendrocalamus hamiltonii* Nees in different populations varied from 7.32 to 9.47. The S₁ (Jukhala) population recorded the highest Root length which is followed by populations and S₅ (Sarkaghat) and S₉ (Ratti). The minimum Root length was recorded at S₆ (Ghumarwin). Elevation range A₁ (300-600m) with mean value 9.28 was recorded best for Root length whereas elevation range A₄ (1200-1500) recorded least for Root length with mean value 9.33.

Leaf length (cm): The Leaf length of (12 months old) seedlings of *Dendrocalamus hamiltonii* Nees in different populations varied from 6.54 to 2.72. The S₁ (Jukhala) population recorded the highest leaf length which is followed by populations S₅ (Sarkaghat) and S₉ (Ratti). The minimum leaf length was recorded at S₇ (Toni Devi). Elevation range A₁ (300-600m) with mean value 6.47 was recorded best for leaf length whereas elevation range A₄ (1200-1500) recorded least for leaf length with mean value 5.72.

Leaf width (cm): The Leaf width of (12 months old) seedlings of *Dendrocalamus hamiltonii* Nees in different populations varied from 1.71 to 2.16. The S₁ (Jukhala) population recorded the highest Leaf width which is followed

by populations S₅ (Sarkaghat) and S₉ (Ratti). The minimum Leaf width was recorded at S₃ (Kallar) and S₇ (Toni Devi). Elevation range A₁ (600-900 m) with mean value 1.89 was recorded best for Leaf width whereas elevation range A₄ (1200-1500) recorded least for Leaf width with mean value 1.74.

Leaf area (cm²): The Leaf area of (12 months old) seedlings of *Dendrocalamus hamiltonii* Nees in different populations varied from 11.07 to 13.72. The S₉ (Ratti) population recorded the highest Leaf area which is followed by populations S₁ (Jukhala) and S₂ (Sujanpur tira). The minimum Leaf area was recorded at S₁₂ (Sapri). Elevation range A₁ (300-600m) with mean value of 13.21 was recorded best for Leaf area whereas elevation range A₄ (1200-1500) recorded least for Leaf area with mean value of 12.15.

Number of leaves

The Number of leaves of (12 months old) seedlings of *Dendrocalamus hamiltonii* Nees in different populations varied from 8.35 to 10.22. The S₅ (Sujanpur tira) population recorded the highest Number of leaves which is followed by populations S₉ (Ratti) and S₄ (Chabutra). The minimum No of leaves was recorded at S₁₂ (Sapri). Elevation range A₁ (300-600 m) with mean value 9.60 was recorded best for Number of leaves whereas elevation range A₄ (1200-1500) recorded least for Number of leaves with mean value of 9.04.

Internodal length (cm)

The Internodal length of (12 months old) seedlings of *Dendrocalamus hamiltonii* Nees in different populations varied from 2.53 to 2.78. The S₅ (Sarkaghat) population recorded the highest internodal length which is followed by populations S₁₀ (Awah Devi) and S₉ (Ratti). The minimum Internodal length was recorded at S₄ (Chabutra). Elevation range A₁ (300-600m) with mean value 2.76 was recorded best for leaf area whereas elevation range A₄ (1200-1500) recorded least for Internodal length with mean value 2.68. Low variability was observed in seed and germination parameters as revealed in Table 2.

Similar studies were conducted by Ratan Lal Banik (1980) ^[6] observed that in 1-year-old seedlings of *B. Tulda* and *B. Glaucescens* culms emerge more or less throughout the year irrespective of seasonal variations. But in the second year there are some months when no culms emerge. This periodicity indicates that rhizome buds in the seedlings remain active throughout the year up to age 1 year and that, if the seedlings were planted within this time, success in field establishment could be much improved. Kindeya Gebrehiwot, et al. (2016) ^[5] seeds sown without treatment revealed better performance in seedling survival, seedling height and leaf number of seedlings. Direct sowing was the preferred method of propagation from seeding treatments. The performances of mean seedling height and number of leaves per seedling of *O. abyssinica* was 9.02 cm and 4.22 respectively. However, Kassahun (2003) ^[4] reported that the mean seedling height and number of leaves per seedling were 20.38 cm and 6.69 respectively.

Conclusion

The Seed length of *Dendrocalamus hamiltonii* Nees at different populations varied from 7.76 mm to 7.41 mm. The Seed width of *Dendrocalamus hamiltonii* Nees at different populations varied from 4.25 mm to 4.53 mm. The Seed germination of *Dendrocalamus hamiltonii* Nees. At different

populations varied from 79.99 per cent to 72.25 per cent. The 100 seed weight of *Dendrocalamus hamiltonii* Nees at different populations varied from 3.13 mg to 3.81 mg. The seedling height of *Dendrocalamus hamiltonii* Nees at different populations varied from 17.62 cm to 11.31 cm. The Collar diameter (mm) of *Dendrocalamus hamiltonii* Nees at different populations varied from 0.82 mm to 1.27 mm. The Leaf length of *Dendrocalamus hamiltonii* Nees at different populations varied from 4.66 cm to 7.89 cm. Leaf area (cm²) weight of *Dendrocalamus hamiltonii* Nees at different populations varied from 11.07 cm² to 13.72 cm². Seed and nursery growth parameters show low variability between seed sources however on the basis of altitude Seed and nursery growth parameters show distinctiveness in all studied parameters.

References

- Ahlawat SP, Haridasan K, Hegde SN. Field Manual for Propagation of bamboo in North East India. State Forest Research Institute, Department of Environment & Forests, Government of Arunachal Pradesh. Itanagar. SFRI Information Bulletin. 2002;14:1-18.
- Azmy HM, Appanah S. Bamboo resources conservation and utilization in Malaysia. FRIM, Kepong, Kuala Lumpur, Malaysia. In: Rao AN, V Ramanatha Rao (Editions), The work on Bamboo and Rattan Genetic Resources is supported by Japanese Government. Proceedings of training course cum workshop, Kunming and Xishuanbanna, Yunnan, China; c1998 May. p. 10-17. http://www2.bioversityinternational.org/publications/We_b_version/572/ch27.html
- Chowdhery HJ, Wadhwa BM. Flora of Himachal Pradesh-Analysis, Botanical Survey of India, Howrah; c1984. p. 1-3.
- Kassahun E, Christersson L, Ledin S, Weih M. Bamboo as bio resource in Ethiopia: Management strategy to improve seedling performance (*Oxytenanthera abyssinica*). Bio resource technology. 2003;88:33-39.
- Kindeya Gebrehiwot, Teklay Woldetensae, Emiru Birhane, Sarah Tewolde-Berhan. Propagation method of the lowland bamboo through seed and culm cuttings. Journal of the Drylands. 2016;6(2):513-518.
- Ratan Lal Banik. Bamboo research in Asia: Proceedings of a workshop held in Singapore. Ottawa, Ont., IDRC; c1980. p. 139-150.
- Sharma YML. Inventory and resource of bamboos. In: Rao AN, Dhanarajan G, Sastry CB. (Editions.). Recent Research on Bamboos. Proceedings of the International Bamboo Workshop. Hangzhou, China, IDRC; c1987. p. 117.
- Tinsae Bahru, Berhane Kidane, et al. Effects of Germination Sites on Germination Percentage, germination energy and germination value of lowland bamboo seeds forestry and forest products: technologies and Issues. Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia; c2012.
- Tewari DN. A Monograph on Bamboo. International Book Distributors, Dehra Dun; c1992. p. 498.
- Damizade GH. Effect of environmental condition on seedlings survival rate of *Capparis decidua* (Forssk.) Edgew. Poplar and Forest Research of Iran. 2004;12(4):509-531. (In Persian, English summary).
- Zhao WZ, Qy Li, Fang HY. Effects of sand burial disturbance on seedling growth of *Nitraria sphaerocarpa*. Plant and Soil. 2006;295(1-2):95-102.