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Short Communication

Influence of seed storage conditions and germination media on the germination of a priority bamboo species, *Dendrocalamus brandisii* (Munro) Kurz

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Abstract

The present investigation was formulated to determine the optimum storage condition and suitable germination media for enhancing the germination of *Dendrocalamus brandisii* seeds. Seed samples were stored at 4°C, 16°C and room temperature. The influence of four media on germination of the seeds was also estimated. Of the four media used, higher germination rates were observed in the vermiculite (60%), followed by quartz sand (55%), germination paper (55%) and soil (36%). Seeds with initial germination of 60 %, when stored for 36 months at 4°C and 45% relative humidity (RH) maintained their viability throughout the storage period. Whereas, in room temperature and 16°C, the seeds were viable only up to five and ten months respectively. The results indicated that seed viability of *D. brandisii* could be extended by reducing moisture content up to a critical level (8%) prior to storage, and fluctuations in moisture content play a significant role in seed deterioration and decrease in seed germination. It was also found that speed of germination was higher in vermiculite and germination paper (0.62) and lower in soil (0.22). Peak value was highest in germination paper (4.62), followed by vermiculite (3.76). Higher germination value was for vermiculite (0.27), followed by quartz sand and germination paper (0.16). The findings will contribute for successful storage of seeds, whenever flowering and seed set occurs and will help to establish plantations using seedlings.

Key words: *Dendrocalamus brandisii*, Germination paper, Quartz sand, Seed viability, Vermiculite

Propagation through seeds is the cheapest method of propagation in bamboo; however, seed propagation faces serious setbacks. Most of the bamboo species are monocarpic and most of the commercially exploited bamboo species belong to the gregarious flowering group, where the flowering starts synchronously in all the daughter clumps originating from one parent clump leading to the death of entire population after seed setting (Janzen, 1976). The major limitation of propagation of bamboos by seed is their short shelf life. So the development of appropriate storage methods and use of suitable germination medium will assure the use the large quantity of quality seeds produced during gregarious flowering to raise seedling nurseries in subsequent years.

Dendrocalamus brandisii (Munro) Kurz is a very large clump forming evergreen edible bamboo, commonly used for house building, basketry, handicrafts and furniture. It is mostly distributed in South and North-Eastern India and Myanmar, and was introduced to South East Asia. Its natural population in India is limited to tropical forests up to an altitude of 1300 m in Manipur and Andamans, but it is widely cultivated in Karnataka and Kerala.

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Its gregarious flowering was reported from Manipur during 1987-88 (Seethalakshmi and Kumar, 1998) and Coorg area of Karnataka during 2010-2012. The non-availability of the seeds coupled with short viability poses serious threats to its propagation. Hence the present study was carried out to standardize the optimum storage condition and to find out the best media for germination of *D. brandisii* seeds.

The flowering of *D. brandisii* occured during 2010-2012 in Coorg. Seed samples were collected in 2011 from Ponnampet (12° 08' 32.5" N 75°), Karnataka. The seeds were collected after spreading polythene sheets over the ground under the bamboo clumps. Processing of the seedlot was done by winnowing, sieving and handpicking of impurities.

Seed samples were divided into 15 lots, and five lots each were stored at 4°C, 16°C and room temperature. The samples were stored in sealed double polythene bags of thickness 0.05 mm, which in turn were placed in air tight plastic containers. Collected seeds were air dried to 8% moisture level prior to storage. During the storage 45 percent relative humidity was maintained at 16°C and 4°C. Germination percentage and moisture content of seeds from all the storage conditions were tested at monthly intervals for three years. Moisture content of seed samples was determined on fresh weight basis by placing the seeds in hot air oven at 103°C for 17 hours (ISTA, 2003).

Germination was evaluated in four media viz., vermiculite, quartz sand, germination paper and soil, with 100 seeds in four replications. Seed quality parameters such as germination percentage, speed of germination, germination value, and peak value were studied.

Germination percentage of the seeds was calculated as suggested by ISTA (2003).
The speed of germination was calculated as suggested by Maguire (1962).

$$\text{Speed of germination} = \frac{n1}{1} + \frac{n2}{2} + \cdots + \frac{nx}{x}$$

Germination value was calculated by the following formula (Czabator, 1962):

$GV = PV \times MDG$, where

MDG = Mean daily germination, calculated as the cumulative percentage of full seed germination at the end of the test, divided by the number of days from the sowing to the end of the test; PV (Peak value) = Speed of germination which is the maximum mean daily germination reached at any time during the period of the test.

Three factor analysis of variance was conducted with storage condition, duration and germination medium as factors and the mean data were compared by DMRT.

Effect of germination media and duration of storage on seed germination is depicted in Table 1. The highest germination per cent was observed in the seeds sown in vermiculite, followed by quartz sand, germination paper and soil. Under 4°C storage, the germination of seeds in vermiculite, quartz sand, germination paper and soil were 60, 55, 55 and 36 percent respectively. Similar pattern of germination was observed for 36 months in all media. Hence, storage under 4°C is the best method for enhancing the viability of *D. brandisii*. Under 16°C storage, the germination of seeds was 60, 55, 55 and 36 percent up to the tenth month in vermiculite, quartz sand, germination paper and soil, respectively. Thereafter germination declined and in the 12thmonth of the storage, germination was 54, 48, 49 and 30 percent respectively. In the 18th month, germination drastically reduced to 15, 11, 11 and 4 percent respectively. From the 24th month onwards seeds failed to germinate. At room temperature, the germination of *D. brandisii* seeds was 60, 55, 55 and 36 percent up to the fifth month in vermiculite, quartz sand, germination paper and soil, respectively. Thereafter, a gradual decrease in the germination percentages was observed. In the sixth month, germination percentages were 55, 49, 49 and

Table 1. Effect of storage conditions, germination media and duration of storage on germination of *D. brandisii* seeds

Storage duration (Monthly intervals)	4°C				16°C				Room temperature			
	Vermiculite	Quartz sand	Germination paper	Soil	Vermiculite	Quartz sand	Germination paper	Soil	Vermiculite	Quartz sand	Germination paper	Soil
1	59.95± 0.24	54.55± 0.15	54.80± 0.31	36.15± 0.24	60.25± 0.21	54.65± 0.20	55.35± 0.19	35.95± 0.41	60.05± 0.53	54.70± 0.22	55.40± 0.36	35.25± 0.22
3	60.25± 0.16	55.00± 0.44	55.35± 0.19	36.20± 0.30	59.95± 0.12	54.75± 0.14	55.65± 0.17	36.25± 0.27	60.90± 0.17	54.50± 0.29	55.20± 0.32	35.75± 0.41
6	60.00± 0.11	55.25± 0.18	55.05± 0.22	35.50± 0.21	60.25± 0.33	54.80± 0.15	54.75± 0.33	35.80± 0.30	54.85± 0.26	48.85± 0.19	48.65± 0.41	30.05± 0.35
9	60.00± 0.19	55.10± 0.26	55.65± 0.36	35.05± 0.44	60.65± 0.39	55.00± 0.90	55.10± 0.19	37.60± 0.13	19.80± 0.29	18.60± 0.54	17.50± 0.43	11.00± 0.08
12	61.00± 0.33	55.80± 0.22	54.90± 0.30	35.60± 0.36	54.15± 0.17	48.25± 1.08	49.85± 0.23	29.55± 0.29	00.00	00.00	00.00	00.00
18	60.00± 0.27	54.55± 0.25	54.85± 0.48	34.60± 0.26	14.9± 0.29	10.60± 0.19	10.90± 0.20	4.25± 0.11	00.00	00.00	00.00	00.00
24	60.05± 0.20	54.75± 0.27	54.55± 0.22	34.45± 0.12	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00
30	60.30± 0.29	54.90± 0.17	54.95± 0.23	34.70± 0.31	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00
36	60.65± 0.26	52.90± 1.45	55.10± 0.23	35.30± 0.12	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00

Note: Values given are mean and standard deviation

30 respectively. In the ninth month germination declined to 20, 18, 18 and 11 percent respectively. In the twelth month, germination was completely absent (Table 1).

Seed germination commenced from 3rd day after sowing (DAS) and was completed by 18-20 DAS in vermiculite, quartz sand and germination paper. However, germination of seeds in the soil medium started from 7th DAS and was completed by 23-26 DAS. In general the germination media had good effect on the percentage of seed germination.

The speed of germination, peak value and germination decreased significantly with duration of storage ($P< 0.001$). Speed of germination decreased from 0.651 to 0.226 whereas, peak value and germination value decreased from 3.49 to 1.38 and 0.23 to 0.08 respectively (Table 2).

With regard to storage temperature, there was a significant decrease in the speed of germination and peak value with increase in temperature. Speed of germination was the highest at 4°C (0.67) and lowest at room temperature (0.33). Peak value was higher

Table 2. Germination parameters of *D. brandisii* as influenced by duration of storage

Monthly intervals	Speed of germination	Peak value	Germination value
1	0.651 ± 0.028^{a}	3.49 ± 0.166^{cd}	0.23 ± 0.016^{ab}
3	0.648 ± 0.027^{a}	3.49 ± 0.157^{cd}	0.18 ± 0.011^{def}
6	0.653 ± 0.03^{a}	4.16 ± 0.264^{ab}	0.22 ± 0.02^{abc}
9	0.54 ± 0.037^{b}	3.69 ± 0.265^{bcd}	0.18 ± 0.021^{cdef}
12	0.447 ± 0.048^{c}	2.85 ± 0.35^{e}	0.13 ± 0.017^{gh}
18	0.266 ± 0.043^{d}	1.65 ± 0.289^{f}	0.1 ± 0.021^{hi}
24	0.232 ± 0.046^{d}	1.73 ± 0.373^{f}	0.08 ± 0.02^{i}
30	0.226 ± 0.046^{d}	1.53 ± 0.322^{f}	0.07 ± 0.016^{i}
36	0.226 ± 0.045^{d}	1.38 ± 0.299^{f}	0.08 ± 0.019^{i}

Significant at 0.01 level

Means bearing same letter as superscript are homogeneous within a column

Table 3. Germination parameters of *D. brandisii* seeds as influenced by storage temperature

Temperature	Speed of germination	Peak value	Germination value
4°C	0.67 ± 0.013[a]	4.06 ± 0.109[a]	0.23 ± 0.009[a]
16°C	0.51 ± 0.019[b]	3.11 ± 0.133[b]	0.15 ± 0.007[b]
Room temperature	0.33 ± 0.019[c]	2.09 ± 0.127[c]	0.09 ± 0.007[c]

Significant at 0.01 level

Means bearing same letter as superscript are homogeneous within a column

Table 4. Germination parameters of *D. brandisii* seeds as influenced by germination media

Medium	Speed of germination	Peak value	Germination value
Vermiculite	0.62 ± 0.022[a]	3.76 ± 0.141[b]	0.27 ± 0.012[a]
Quartz sand	0.55 ± 0.02[b]	2.8 ± 0.104[c]	0.16 ± 0.007[b]
Germination paper	0.62 ± 0.022[a]	4.62 ± 0.179[a]	0.16 ± 0.007[b]
Soil	0.22 ± 0.008[c]	1.16 ± 0.044[d]	0.05 ± 0.002[c]

Significant at 0.01 level

Means bearing same letter as superscript are homogeneous within a column

in 4°C storage, followed by 16°C and room temperature. Similarly, with increasing temperature, there were significant differences in the germination value at one per cent level. Germination values of *D. brandisii* seeds were 0.23, 0.15 and 0.09 in 4°C, 16°C and room temperature respectively (Table 3).

The germination parameters were also significantly influenced by germination media. The speed of germination was the highest in vermiculite and was at par with germination paper. In soil, the speed of germination was the least. The speed of germination in vermiculite and germination paper was 0.62, and that of quartz sand and soil was 0.55 and 0.22 respectively. Similarly, peak value of germination was the highest in germination paper (4.62) followed by vermiculite (3.76), quartz sand (2.8) and soil (1.16). Germination value was higher for seeds sown in vermiculite and lower in those sown in soil. Germination value was similar in quartz sand and germination paper (Table 4).

Germination demarcates the transition from the seed being depend-ent on food sources from the mother plant to an independent plant capable of taking up nutrients and growing independently (Schmidt, 2000). In the present study, seeds of *D. brandisii* were able to maintain their viability up to 36 months in cold storage (4°C). Earlier report (Boonarutee and Somboon, 1990) on seed viability of *D. brandisii* showed that it could be stored for 18 months under cold room temperature (2-4°C). According to Vashisth and Nagarajan (2009), seed deteriorative reactions occur in seeds at higher moisture content and high temperature, resulting in reduced seed vigour and viability. Control of relative humidity is the most important factor in maintaining the viability because it directly influences the moisture content of seeds in storage as they come to equilibrium with the amount of moisture surrounding them; a concept known as equilibrium moisture content (Shelar et al., 2008). In the present experiment relative humidity of 45% was maintained in the seeds stored at 4°C and 16°C. In room temperature storage *D. brandisii* seeds remained viable for five months. The rapid decrease in viability of seeds stored at room temperature might be due to the fluctuations in the moisture content.

The time for commencement and completion of germination varied with medium. Banik (1987) observed that bamboo seeds germinate within 3-7 days and germination will be completed within 15-25 days. The days taken for germination in soil medium were similar to that in our study, but it was also observed that germination medium exerts profound influence on seed germination. Seeds of *D. brandisii* initiated germination from the third day after sowing and germination was completed within

18-20 days in vermiculite, quartz sand and germination paper. But the performance of seeds in soil medium was entirely different with, the germination starting from seventh day of sowing and completed within 26 days. The highest germination rate was noticed in the vermiculite medium, followed by quartz sand and germination paper, and the lowest germination was observed in soil. This may be due to the ability of vermiculite, quartz sand and germination paper to retain only sufficient moisture and air compared to soil medium in which aeration may be less and there is a possibility of retention of excess moisture. There are no previous studies on the influence of germination media on seed germination of bamboo seeds. Results of the present study indicated that germination media has significant effect on seed germination and on the growth of seedlings.

In the present study, all the germination associated parameters decreased with the increase in the storage period. The germination value, speed of germination and peak value were higher for seeds stored at 4°C. Biochemical processes are generally slowed down at low temperature; the lower the temperature, the slower the process. Further, low tempera-ture (< 8-10°C) inactivates most seed insects and storage fungi (Schmidt, 2000). According to Walters et al. (2010), seed deterioration is a catabolic process consisting of a sequence of events beginning with a chain of biochemical events, predominantly membrane damage and impairment of biosynthetic reactions, and then losses of various seed performance attributes, starting with reduced germination rate, reduced field emergence, increased numbers of abnormal seedlings and finally seed death. In the present study, increase in seed moisture content might have occurred in the seeds stored at 16°C and room temperature. High relative humidity and high temperature resulted in increased hydrolytic enzyme activity, enhanced respiration, increase in free fatty acids and eventually, a rapid rate of deterioration. This indicated that storage under low temperature is essential for maintaining the viability and vigour of seeds.

From the results it is concluded that seed viability of *D. brandisii* was significantly influenced by storage temperature and storage period. Maintaining the critical level of seed moisture was influenced by storage temperature. Seeds were able to maintain their lowest safe moisture level for 36 months in cold storage (4°C and 45% relative humidity) condition. Therefore, storage of seeds under low temperature (4°C) is essential for maintaining the viability of seeds. Similarly vermiculite is the best medium for germination of *D.brandisii* seeds.

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