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Regeneration of *Canarium Strictum* Roxb.- A High Socio-Economically Important Tree Species of Northeast India

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Abstract: *Canarium strictum* Roxb., belonging to the family Burseraceae of flowering plants, is a medicinally and economically important tree species. It is highly demanded its aromatic resin, which is being used locally or commercially. The species is found in the northeastern region, southern states, and the Andaman Islands in India. It is distributed in the tropical moist mixed deciduous forests up to an altitude of 1600 m. In recent times, the natural population of the species is reduced drastically, and the species has become rare and vulnerable in the country. For promoting commercial cultivation and management, a regeneration study was undertaken. The paper deals with the germination behavior of *Canarium strictum* where seed germination, seedling growth, and seedling survival of the species were investigated. Different pre-seed germination treatments were applied where seed germination was highly effective in the treatments T_7: IBA 1000 ppm (48.61 $\pm$ 10.69%) followed by the treatment T_5: mechanical scarification (46.53 $\pm$ 4.81%) and treatment T_8 with IBA 2000 ppm (45.83 $\pm$ 3.21%) where late arrival of germination was recorded in T_1 (control) with 25.93% of germination. The earliest commencement of germination was found in T_8: IBA 2000 ppm followed by T_3: GA 1000 ppm. In the case of Mean Germination Time (MGT), it was lower for treatment T_7: IBA 1000 ppm and highest for treatment T_1 (control). In all treatments, seedling survival did not show a significant difference.

Keywords: *Canarium strictum, seed dormancy, seed treatment, germination percentage, seedling growth*

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I. INTRODUCTION

Canarium strictum Roxb. belongs to the family Burseraceae and is a highly valued socio-economically important evergreen tree species. The tree yields resins known as black dammar which is commercially harvested in South and Southeast Asian countries [1]. It is found in different parts of India as well as in Myanmar and China. In India, the plant is found in Western Ghat as well as in the Eastern Himalaya, particularly in moist deciduous to evergreen forests in tropical and subtropical zones, and used medicinally and spiritually [2]. It is an indigenous plant species of the country and is naturally distributed in the state of Sikkim, Arunachal Pradesh, Assam, Meghalaya, Orissa, Maharashtra, Karnataka, Kerala, and Tamil Nadu and in the Andaman Islands [3]. The resin exudates by *Canarium strictum* are known as 'Sambrani' or 'Dammar' which has much commercial as well as ethnomedicinal importance and also used in Siddha, an Indian system of medicine [4]. It is a common resource used in industrial products for incense and varnishing [5], [6].

Collection and utilization of Non-Timber Forest Products (NTFPs) is one of the common livelihood options

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for many of the communities all over the world. Due to their higher demand, many of these species are being harvested rapidly and overexploited from the forest floor. The demand of many NTFP yielding species is increasing day by day which causes severe threats to their population and are on the verge of their wild extinction. *Canarium strictum* is one of such types of species and already being placed in the IUCN Red list category, and is recognized as one of the vulnerable species in the southern Indian states [2]. Because of its increasing demand, overexploitation, and vulnerability from local extinction, the species deserves higher concern for its management and conservation [3], [7]. The continuous and unsustainable tapping of resins may lead whipped out of the natural population if proper measures are not taken in due time for its in situ conservation. Although the plant is socio-economically valuable, very limited study has been conducted on the ecology, phenology, and regeneration of the species. In this context, the present study was undertaken to understand the seed germination behavior and seedling survival of the species that may support in its large-scale management. As the seed is the main source for natural regeneration of many of the tree species, the study of its germination capacity in different conditions with seedling survival may pave the way for its easier management and cultivation.

II. MATERIALS AND METHOD

Ripe fruits of dhuna (*Canarium strictum*) were collected in January, 2015 from the natural stand in Pasighat Forest Division of Arunachal Pradesh. The fruits were collected from the field and carefully brought to the laboratory of Department of Forestry, NERIST (27.13° N latitude and 93.74° E longitude), Arunachal Pradesh for further processing. Nuts were cleaned in running water physically after fermenting the pulp by storing in polybag for one week. After proper washing, the seeds were allowed for proper drying in sunlight. The viability of seeds was determined by TZ (Tetrazolium) test, before testing them for germination. For germination experiments, the nuts were subjected to the following treatments:

1. Control, i.e., nuts without any treatments (T_1).
2. Nuts treated with sulfuric acid (40%) for 5 minutes (T_2).
3. Gibberellic acid with concentrations of 1000ppm (T_3) for 24 hours.
4. Gibberellic acid with concentrations of 2000ppm was used to treat the nuts for the duration of 24 hours (T_4).
5. Mechanical scarification (T_5).
6. Treating the nuts with fresh cow dung and keeping inside the oven at 40C for 48 hours (T_6).
7. Treatment with Indole Butyric acid (IBA) with concentrations of 1000ppm used for treating the nut for 24 hours (T_7).
8. Treatment with Indole Butyric acid with concentrations of 2000 ppm was used for treating the nut for 24 hours (T_8).

After different treatments, the nuts were sown in polybags (8x5 cm) with three rows of small holes on polybags for control drainage of water. The polybags were filled with nursery soil and decomposed cow dung (3:2).

The mixed media were treated with fungicide Carbendazim solution (0.1 a.i.) and left for three days before sowing. Three replicates with 16 nuts each were taken. One nut was sown in each container in last week of January and kept under observation. The polybags were watered on alternative days. Seeds were considered germinated when radicle protrusion emerged.

The data were recorded at every alternate day for six months and weekly later on. The experiment was continued till the last germination was recorded. The study was conducted under the shade nursery condition. Randomized Complete Block Design (RCBD) was used for the experiment following the principles of replication and randomization, due to similarity in variation gradient. Regular weeding and watering were carried out at some intervals, in order to provide congenial conditions for seed germination and post- germination growth of seedlings. The following observations were recorded:

A. *Commencement of Germination*

It resembles the number of days for the first seed to have germinated from each treatment. Seeds respond to different treatments in different ways. So, the days taken for germination vary along with treatments.

B. *Germination Percentage*

It is a measure of number of germinated seeds against the total number of seeds sown, and is expressed in percentage.

Germination percentage (%) = (N/S) x 100%

Where N is the total number of germinated seeds and S is the total number of sown seeds.

C. *MGT*

$MGT_i(d) = \sum(t_j x n_{ij})/n_i$

Where MGT_i is the MGT of the treatment i; t_j is the j^{th} day from sowing; n_{ij} is the number of germinated seeds of the treatment i at the j^{th} day from sowing and n_i is the total number of germinated seeds of the treatment i.

D. Seedling Survival

The height of the seedling was measured from base to the growing tip and it was expressed in centimeters. The basal diameter in terms of collar diameter of the seedlings was measured at the basal region of the seedlings by using digital calipers and was expressed in millimeters. The numbers of leaves per seedling were counted and it was expressed in numbers. The experimental data were analyzed statistically by fitting the observed data in SPSS software.

III. RESULT AND DISCUSSION

A. Seed Germination Behavior

The data pertaining to commencement of germination of *Canarium strictum* (in Table 1), clearly indicate that the earliest commencement of germination was found in T_8 (IBA 2000 ppm) followed by T_3 (GA 1000 ppm) and late arrival of germination was recorded in T_1 (control) followed by T_2 (chemical scarification). Clear effects of the treatments with the two growth substances - IBA and GA- on quick germination have been observed

TABLE 1
GERMINATION STATUS OF *CANARIUM STRICTUM* SEEDS IN DIFFERENT TREATMENTS

Treatments	Commencement of Germination (days)	MGT (days)	Germination Percentage (%)
Control: T_1	50.33 ± 0.58	61.99 ± 1.42	25.93 ± 1.6
Chemical scarification: T_2	48.33 ± 2.08	60.30 ± 0.12	40.97 ± 6.37
GA 1000ppm: T_3	45.67 ± 3.06	58.51 ± 0.40	40.97 ± 7.32
GA 2000ppm: T_4	47.00 ± 1.00	59.14 ± 0.81	36.81 ± 9.85
Mechanical scarification: T_5	48.00 ± 3.61	58.36 ± 3.10	46.53 ± 4.81
Cow dung: T_6	48.00 ± 2.65	57.73 ± 4.80	39.58 ± 9.55
IBA 1000ppm: T_7	47.00 ± 1.73	57.67 ± 0.68	48.61 ± 10.69
IBA 2000ppm: T_8	44.67 ± 1.16	58.75 ± 3.21	45.83 ± 7.51
F values	1.82	1.08	2.56
p level	0.15	0.41	0.05*

The values are means ± *SD*. *F* values and *p* level are derived from one way analysis of variance (*significant value).

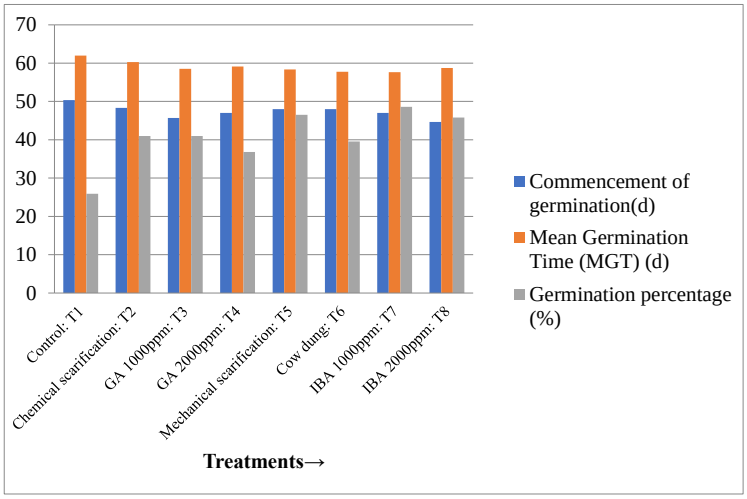

Fig. 1. Germination behavior of *Canarium strictum* seeds in different treatments

The calculation of mean germination time revealed that the highest MGT was found in treatment T_1 (control). On the other hand, it was found lowest in the treatment T_7 (IBA 1000 ppm) followed by T_6 (Cow dung treatment). The result signifies that although the untreated control seeds have slow initiation of germination, the overall time taken for the germination is very good.

Germination percentage is the parameter to determine the percentage of seeds being germinated from the total sown seeds. Seed germination was highly effective in the treatments T_7: IBA 1000 ppm (48.61 ± 10.69%) followed by the treatment T_5: mechanical scarification (46.53 ± 4.81%) and treatment with IBA 2000 ppm: T_8 (45.83 ± 3.21%) where lowest germination percentage

was recorded in T_1 (control) with 25.93% of seed germination.

B. Seedling Survival

The success of germination is correlated with the seedling survival. In many species, it has been found that even after good germination percentage of the seeds, the mortality of seedlings is seen in the growth period and hence, the seedling survival percentage becomes very low. The seedlings that are capable of establishment can show better growth that can be measured through the height, collar diameter, and leaves formation.

The data of seedling survival, i.e., seedling height, collar diameter, and leaf number per seedling, were recorded at regular intervals for 18 seedlings of each treatments. The data to measure seedling height of *Canarium strictum* were recorded after 90 days of germination. The data revealed that the results were statistically significant for all the treatments. The result showed that highest seedling height was recorded in the treatment T_4 (GA 2000ppm) (18.94 $\pm$ 0.91 cm) followed by T_3 (GA 1000ppm) (18.22 $\pm$ 0.91 cm). However, lowest seedling height was recorded in T_2 (Chemical scarification) (15.85 $\pm$ 1.10 cm) followed by T_5 (Mechanical scarification) (16.57 $\pm$ 2.13 cm). It has been found that after 90 days of the commencement of the germination, the seedling attains a minimum height of 16 cm.

The highest collar diameter was recorded in treatment T_8 (IBA 2000ppm) (2.61 $\pm$ 0.10) followed by T_4 (GA 2000ppm) (2.60 $\pm$ 0.13). The lowest collar diameter was recorded in T_3 (GA 1000ppm) (2.45 $\pm$ 0.16) followed by T_1 (control) (2.47 $\pm$ 0.13). The highest number of leaves was recorded in treatment T_4 (GA 2000ppm) (8.61 $\pm$ 0.50) followed by T_2 (Chemical scarification) (8.50 $\pm$ 0.99) and the lowest number of leaves was recorded in treatment T_5 (Mechanical scarification) (7.06 $\pm$ 1.26) followed by T_6 (Cow dung treatment) (7.61 $\pm$ 0.78).

TABLE 2
GROWTH PERFORMANCE OF *CANARIUM STRICTUM* IN DIFFERENT TREATMENTS

Treatments	Height (cm)	Collar Diameter (mm)	No. of Leaves/Seedling
Control: T_1	17.52 $\pm$ 2.17	2.47 $\pm$ 2.17	7.39 $\pm$ 1.20
Chemical scarification: T_2	15.85 $\pm$ 1.10	2.52 $\pm$ 0.13	8.50 $\pm$ 0.99
GA 1000 ppm: T_3	18.22 $\pm$ 0.91	2.45 $\pm$ 0.16	7.89 $\pm$ 0.76
GA 2000ppm: T_4	18.94 $\pm$ 0.91	2.60 $\pm$ 0.13	8.61 $\pm$ 0.50
Mechanical scarification: T_5	16.57 $\pm$ 2.13	2.58 $\pm$ 0.16	7.06 $\pm$ 1.26
Cow dung: T_6	16.82 $\pm$ 2.02	2.56 $\pm$ 0.14	7.61 $\pm$ 0.78
IBA 1000ppm: T_7	17.23 $\pm$ 1.76	2.59 $\pm$ 0.11	8.22 $\pm$ 0.94
IBA 2000ppm: T_8	17.62 $\pm$ 2.06	2.61 $\pm$ 0.10	8.39 $\pm$ 1.15
F - value	5.72	3.86	6.05
p - level	0.00*	0.00*	0.00*

(The values are means $\pm$ *SD*. F values and p level are derived from ANOVA; *significant value).

It has been found that no significant difference was recorded in seedling growth performance, and almost the values are similar and close to each other. So, the seedling survival status was found almost similar in all treatments. A general observation of all the seedlings after six months clearly indicated that the different treatments used do not have any effect on seedling survival in a given environmental condition.

Although the pre-treatment of seeds with growth substances (hormones), like Gibberellic Acid and Indole Butyric Acid (IBA), is found more effective in the present study, the study of [8] revealed that the species shows good results of germination even under controlled conditions. Hence proper nursery management may be a better option for easier seed germination. Pre-treatments of seed with potassium di-hydrogen phosphate and GA3 separately help in breaking seed dormancy in the species [4]. To improve the germination percentage, the mechanical scarification and treatment with cow dung provide almost equal results to the use of growth substance. Hence, for minimizing the cost and easy pre-treatment, the mechanical scarification and use of cow dung can be promoted.

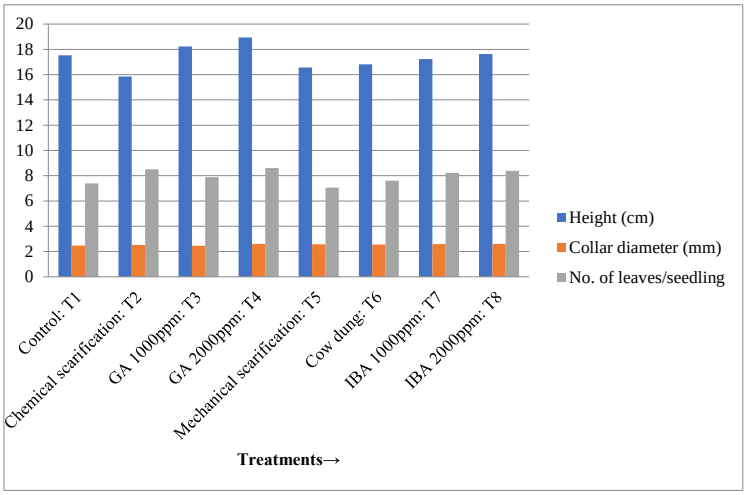

Fig. 2. Growth performance of the seedlings of *Canarium strictum* in different treatments

It is also viewed that the decreases in regeneration potential and the population size of *C. strictum* may affect the different pollinators and frugivores that are dependent on the species [1]. Cultivation is the best option to increase quantities when populations are low having higher demand and competition among harvesters [9]. Instead of having vast medicinal and economic properties, it is now rarely available as no specific strategy has been adopted for its conservation. Management and cultivation through adopting suitable seed germination techniques of *C. strictum* are required as the population of the species is declining gradually. The cultivation of the species should be promoted for better economic gain and in support to livelihood of the tribal peoples [3], [10]. It is suggested by different workers to develop a suitable sustainable model for harvesting of resin combining both indigenous systems and modern science which can make the species available to the nature and mankind.

IV. CONCLUSION

Seed germination is an easier and cheaper way of plant regeneration. Proper cultivation, management, and conservation of valuable plant species is highly beneficial for the human being. Our research study on germination of this seed using various pre-sowing treatments reveals that the species performed well in different aspects, such as germination percentage, MGT, commencement of germination, seedling height, collar diameter, and number of leaves per seedling. According to the recorded data, IBA (1000ppm) treatment with germination percentage (48.61%), outperformed all other treatments. Therefore, pre-showing treatments prove to be indispensable for carrying out germination of such endangered species for increasing the population status, and farmers can apply such type of methodology. Some awareness cum training programme should be undertaken by Government organization, like Forest Departments and other relevant institutions and NGO's to disseminate the knowledge for propagation, cultivation, and sustainable harvesting of the species so that the species, can save from its extinction as well as for good revenue generation.

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