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Germination and emergence of four rattan *Calamus* species of Western ghats in response to different pre-sowing seed treatments

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Abstract: The present investigation was carried out to study the effect of ten pre-sowing treatments on germination parameter of the four *Calamus* species in the nursery of College of Forestry, Vellanikkara. Most of the pre-sowing treatments of *Calamus* spp. gave better performance compared to the control. Complete removal of outer pericarp and sarcotesta of each seed manually (T_2), Sulphuric acid treatment for 3-5 minutes after removing sarcotesta (T_6) and Hot water treatment (50^0C) after removing sarcotesta for two minutes followed by soaking in water for 12 hours (T_7) were found promising in all the species. The higher germination percentage (83.82, 89.96), mean daily germination (0.020, 3.39), peak value of germination (0.026, 3.45) and germination value (0.00041, 11.56) and was recorded for *Calamus thwaitesii* and *C. metzianus* in treatment with GA_3 (T_9) respectively. The maximum germination percentage (27.74), MDG (0.41), PVG (0.46) and GV (0.20) for *C. hookerianus* in T_7 (Hot water treatment (50^0C) after removing sarcotesta for two minutes followed by soaking in water for 12 hours), and highest MDG (0.078), PVG (0.91) and GV (0.0065) for *C. travancoricus* in T_5 (Sulphuric acid treatment for 3-5 minutes without removing sarcotesta). The present study reiterated that the pre-sowing treatments hold major scope in the propagation of rattan seedlings which usually could not germinate well under ordinary conditions due to dormancy.

Keywords: Calamus, Pre-sowing treatment, Germination per cent, Germination value, Pericarp and Sarcotesta

INTRODUCTION

Rattan is the common name attributed to spiny old world climbing palms belonging to the family *Arecaceae* (*Palmae*) (Baker *et al.,* 2000). There are over 550 different species of rattan belonging to 12 genera distributed throughout the old world tropics (Dransfield *et al.,* 2002; Dransfield *et al.,* 2008). India has a good representation of rattans with 5 genera and 60 species mainly found in Western Ghats, Andaman and North-East India (Renuka, 1999) and widely used non-timber forest products (Siebert, 2012). Unlike most dicotyledonous lianas, rattans lack secondary growth, and thus have to maintain their primary-formed vascular system for the entire life of the stem; any mechanical damage to the vascular system might therefore be fatal for the plant. This is especially true for climbing palms which, for the most part, lack the capacity to root and branch. However, despite these apparent constraints, the abundance and species diversity of climbing rattans in many tropical forests suggest an ecological and evolutionary success of this growth form (Isnard and Rowe, 2008). Wood of rattans is strong, with medium density, yet much lighter than other hardwoods and extremely pliable. Because of these desirable characters, it is extensively used in the manufacture of a wide range of furniture and handicrafts items for low, medium and high end markets. The Indian cane furniture industries produced materials worth Rs.50 million with the value of exports standing at Rs. 5 million during early 20th century (Cibele *et al*., 2009).

Due to overexploitation and deforestation have led to unabated destruction of natural forest where the desired species thrives, soon there will be no more cane in Asia (Abasolo, 2015). Although rattans are still found in the natural forests in Kerala, they are restricted to less accessible areas in India. One among the major reasons for the depletion of resources appears to be the indiscriminate extraction of rattans because of the heavy demand for raw material. Even immature rattans are extracted before they could bear flowers or fruits, which have drastically affected the production of seeds. On the other hand, this is partially due to the non-adherence to the prescribed cutting cycles, and also due to inadequate information available on silviculture aspects of species for the purposes of developing sound management practices. As a result of such continuous and steady pressures on the natural habitat of rattans, the broad genetic base of rattan is being reduced rapidly. The increasing global demand for rattans and the severe depletion in the rattan resources resulted in an urgent need for effective conservation and propagation measures and necessitated the research on the propagation aspects of rattans species (Hong *et al.,* 2000; Hans Raj *et al.,* 2014).

Due to dormancy condition which prevents the easy germination of rattan seeds, like other members of the *Arecaceae* family, farmers and foresters are facing a major problem in the propagation of rattan species. But this situation can be altered by seed treatments, subjecting the seeds to favorable condition of moisture and temperature. This paper deals with the study of the pre-sowing treatments of four common rattan species of Kerala namely, *Calamus thwaitesii, C. metzianus, C. hookerianus,* and *C. travancoricus.*

MATERIALS AND METHODS

The present investigations were carried out at the tree nursery of College of Forestry, Kerala Agricultural University, Vellanikkara, Thrissur, Kerala. The experimental site has an elevation of 40.3 m above sea level and located at 10° 13'N latitude and 76° 13' E longitude. The study area experiences a warm humid climate, having mean annual rainfall of 2890 mm, most of which is received during the south west monsoon (June to August). The mean maximum temperature recorded at Vellanikkara varied from 20.9° C in June to 35.1° C in March. The mean minimum temperature varied from 20.9° C in July to 25.3° C in April.

Seeds of *Calamus thwaitesii* and *C. metzianus* were collected from KFRI sub centre at Palappilly, in Thrissur district and *C. hookerianus* and *C. travancoricus* from natural forests of Vazhachal forest division. The following pre sowing treatments were selected for the study.

T_1. Complete removal of outer pericarp of each seed manually.

T_2. Complete removal of outer pericarp and sarcotesta of each seed manually.

T_3. Scarification with sand and ash to remove the pericarp and sarcotesta completely: Seeds were rubbed with sand and ash to remove pericarp and sarcotesta.

T_4. Fermentation of the seed after removing pericarp: The seeds were soaked in water for 46 hours after removing pericarp.

T_5. Sulphuric acid treatment for 3-5 minutes without removing sarcotesta: Seeds were soaked in sulphuric acid for 3-5 minutes after removing pericarp followed by soaking in cold water for 24 hours.

T_6. Sulphuric acid treatment for 3-5 minutes after removing sarcotesta: Seeds were soaked in sulphuric acid for 3-5 minutes after removing pericarp and sarcotesta followed by soaking in cold water for 24 hours.

T_7. Hot water treatment (50^0C) after removing sarcotesta for two minutes followed by soaking in water for 12 hours:.

T_8. Cold water treatment after removing sarcotesta for 24 hours.

T_9. Treatment with GA_3 (100 ppm): The seeds were soaked in 100 ppm GA_3 solution for 24 hours after removing the sarcotesta and pericarp.

T_{10}. Control: Untreated seeds were sown as such, without removing the pericarp and sarcotesta.

Pre-treated seeds were sown in polybag (25 X 12 cm size *i.e* gauge, 250) within 3-4 days after collection since the viability of the seeds is very short. The ploybags were arranged in completely randomized design (CRD) with 3 replications with 20 seeds in each replication. The potting media used was a mixture of sand, soil, cow dung (1:1:1). Each seed was placed in the polybag filled with the media and uniformly covered with 2 cm layer of sawdust. Seedlings were kept under shade during the study period. Watering was done twice a day before germination and once a day after germination. Daily germination counts were recorded and from these observations, germination percentage, mean daily germination (MDG), peak value of germination (PV) and germination value (GV) were calculated (Czabator, 1962).

RESULTS

In general, the presowing treatments significantly influenced the various germination parameters and time for germination. The influence of pre-sowing treatments on different *Calamus* species are as follows

***C. thwaitesii* :** The influene of pre-sowing treatments on germination of *C. thwaitesii* differed significantly (Table 1). Comparing all the parameters, treatments viz. scarification with sand and ash (T_3), hot water treatment (T_7) and treatment with GA_3 (T_9) gave good germination per cent within a short time span. With regards to germination percentage, significant difference was observed among various treatments studied. A significantly higher germination per cent was obtained from treatment with GA_3 (T_9), scarification with sand and ash (T_3), T_8 (cold water treatment after removing sarcotesta), T_7 (Hot water treatment), and T_6 (Sulphuric acid treatment for 3-5 minutes after removing sarcotesta). T_{10} (Control) gave a lower germination per cent of 53.82.

Significant variation was also observed in the mean daily germination (MDG) between the treatments and the values changed from 0.006 to 0.020 (Table 1). Significantly higher (0.020) MDG was recorded in T_9 (Treatment with GA_3) while, the minimum (0.006) was recorded by T_{10} (Control).The data pertaining to the peak value of germination (PVG) indicated that in most of the treatments, peak value of germination was same as MDG. The data range was also same as the highest being 0.020 in T_9 (Treatment with GA_3) and lowest being 0.006 on T_{10} (Control). The germination value (GV) varied as high as 0.0041 to as low as 0.00004. Treatment with GA_3 (T_9) recorded the highest (75.23) and Control (T_{10}) showed the lowest.

The days of commencement and end of the germination and the days required for half of the germination are depicted in the table 1. The days required for the commencement of germination was minimum in treatment with GA_3 (T_9) without significant difference. But in T_9 (Treatment with GA_3) and T_4 (Fermentation of the seed after removing pericarp), the germination came to an end faster than other treatments. The day

Table 1. Effect of pre-sowing treatments on germination of seeds of *C. thwaitesii.*

Tretments	Germination % ***	Mean daily germination	Peak value of germination	Germination value	Days required for 50% of the Germination	Days to start Germination	Days to end Germination
T_1	69.21^{b} (86.67)	0.011^{c}	0.013^{d}	0.00013^{d}	49.33^{c}	35.67^{cd}	77.33^{b}
T_2	67.38^{c} (85.00)	0.014^{bc}	0.017^{bc}	0.00022^{bc}	39.33^{c}	31.00^{d}	60.00^{c}
T_3	79.52^{a} (95.00)	0.016^{b}	0.021^{ab}	0.00026^{b}	39.33^{c}	29.67^{e}	60.67^{c}
T_4	71.92^{a} (90.00)	0.010^{c}	0.016^{bc}	0.00011^{d}	64.33^{ab}	39.33^{c}	77.33^{b}
T_5	68.64^{b} (86.67)	0.016^{b}	0.018^{bc}	0.00028^{b}	36.67^{cd}	28.00^{e}	55.67^{d}
T_6	71.92^{b} (90.00)	0.011^{c}	0.015^{c}	0.00014^{cd}	57.33^{b}	43.00^{b}	80.00^{a}
T_7	73.37^{b} (91.67)	0.016^{b}	0.022^{b}	0.00027^{b}	40.67^{bc}	32.00^{d}	57.67^{d}
T_8	75.21a^{b} 93.33)	0.012^{bc}	0.015^{c}	0.00015^{c}	57.33^{b}	38.33^{c}	77.00^{b}
T_9	83.82^{a} (96.67)	0.020^{a}	0.026^{a}	0.00041^{a}	34.33^{d}	28.00^{e}	48.67^{e}
T_{10}	53.82^{a} (65.00)	0.006^{d}	0.009^{e}	0.00004^{e}	86.67^{a}	68.00^{a}	82.35^{a}
F test	5.16**	23.27**	53.93**	31.13**	37.04**	44.82**	51.26**
SEm ±	15.76	0	0	0	11.98	7.97	11.17

The values with similar alphabets with in a column do not differ significantly *Significant at 1% level - ** Mean germination percentage is given in parenthesis

Table 2. Effect of pre-sowing treatments on germination of seeds of *C. metzianus.*

Treatments	Germination % ***	Mean Daily Germination	Peak Value of germination	Germination Value	Days required for 50% of the Germination	Days to start Germination	Days to end Germination
T_1	49.79^{e} (61.22)	2.29^{bc}	2.34^{d}	6.66^{a}	29.33^{cd}	25.67^{cd}	32.00^{cd}
T_2	55.51^{c}(63.17)	2.97^{b}	3.02^{b}	8.84^{b}	30.33^{c}	26.33^{c}	33.67^{c}
T_3	64.20^{d} (73.33)	2.17^{c}	2.26^{e}	5.18^{cd}	30.33^{c}	26.33^{c}	33.33^{c}
T_4	58.04^{de} (68.61)	2.15^{c}	2.23^{e}	4.88^{d}	34.00^{b}	29.33^{b}	37.33^{b}
T_5	62.54^{d}(80.00)	2.21^{de}	2.27^{de}	5.06^{c}	31.67^{bc}	29.00^{b}	36.00^{b}
T_6	71.51c (93.33)	2.72^{bc}	2.75^{c}	7.45^{bc}	31.33^{bc}	28.00^{b}	34.33^{c}
T_7	68.62^{cd} (100.00)	2.86^{b}	2.94^{b}	8.22^{b}	28.67^{d}	26.33^{c}	35.00^{bc}
T_8	80.1^{b} (100.00)	2.89^{b}	2.92^{b}	8.35^{b}	29.00^{cd}	26.00^{c}	34.67^{c}
T_9	89.96^{a} (100.00)	3.39^{a}	3.45^{a}	11.56^{a}	23.00^{e}	20.00^{d}	29.67^{d}
T_{10}	81.11^{b} (93.33)	2.04^{d}	2.09^{e}	4.20^{e}	42.00^{a}	40.00^{a}	45.67^{a}
F test	1.77NS	1.68*	1.68*	2.48*	28.84**	10.74**	22.26**
SEm ±	35.73	1.57	1.57	6.50	4.00	6.86	4.027

The values with similar alphabets with in a column do not differ significantly *Significant at 1% level - ** Mean germination percentage is given in parenthesis

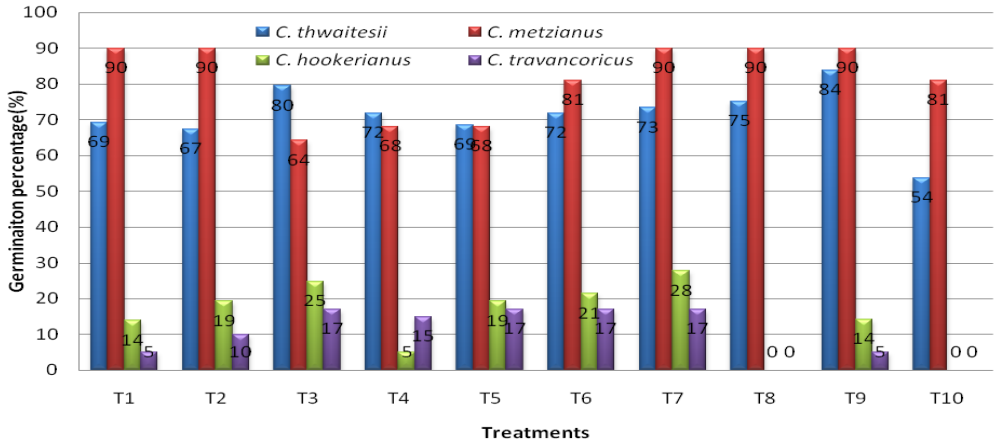

Fig. 1. *Effect of pre-sowing treatments on different Calamus species.*

taken for half of the germination was less in case of treatments like T_2, T_3, T_5, T_7 and T_9. Control took maximum days for half of the germination (86.67).

C. metzianus **:** The effect of pre-sowing treatment on germination of *C. metzianus* revealed relatively high germination percentage (89.96%) in treatment with GA_3 (T9) followed by control, cold water treatment after removing sarcotesta for 24 hours (T_8), sulphuric acid treatment for 3-5 minutes after removing sarcotesta (T_6) and lowest germination per cent was recorded in treatments viz., T_1 (49.79 %), T2 (55.51 %) and T_4 (58.04 %) (Table 2 and Fig. 1). The higher MDG observed in T_9 (Treatment with GA_3) and followed by T_2 (Complete removal of outer pericarp and sarcotesta manually, T_8 (cold water treatment after removing sarcotesta), T_7 (Hot water treatment) and least observed in control (T_{10}). The peak value of germination showed highest in T_9 and followed by T_2, T_7, T_8 and least was observed in T_4 (Fermentation of the seed after removing pericarp). The germination value ranged from 4.20 (T_{10}) to 11.56 (T_9) and the highest days to end germination was found in T_{10} (control) and least in T_9.

C. hookerianus**:** Various pre-sowing treatments significantly influence the germination of *C. hookerianus* seeds and the results indicated that maximum germination was found in hot water treatment (T_7), followed by scarification with sand and ash (T_3) , H_2SO_4 treatment after removing sarcotesta (T_6) and least observed in control (T_{10}) (Table 3 and Fig. 1) respectively. All the other treatments were found promising with an increase in germination except control.

With regards to MDG, the lowest value (zero) was recorded in control and maximum MDG was recorded in T_7 (Hot water treatment), T_8 (cold water treatment after removing sarcotesta), (T_3) Scarification with sand and ash, H_2SO_4 treatment after removing sarcotesta (T_6) respectively. It was evident from the table 3 that the data pertaining to the peak value of germination was same as mean daily germination in all the treatments. Fermentation of the seed after removing pericarp has given low germination percentage, though the seeds germinated early than that of the other treatments. Days required for half of the germination was lowest in T_{10} and followed by T_9. All the other treatments had no significant difference in effects.

C. travancoricus**:** Germination of *C. travancoricus* seeds was very poor with all the treatments (Table 4). The best treatments which gave faster and maximum germination percentage were T_2 (complete removal of outer pericarp and sarcotesta) followed by T_5 (Sulphuric acid treatment without removing sarcotesta). The germination percentage varied from 0.00 per cent to 27.25 per cent. No germination was observed in control (T_{10}) and cold water treatment after removing sarcotesta (T_8). The MDG ranged varied from 0.00- 0.087. The maximum peak value of germination was observed in T_5 and followed by T_3, T_6, T_4, T_7, and T_2 respectively. The germination value ranged from 0.00-0.0065. The days to end germination was recorded maximum in hot water treatment (T_7) and followed by T_6, T_3, T_5, T_4 and T_2 respectively.

A comparison of influence of pre-sowing treatments on germination of the four species of *Calamus* is depicted in Fig. 1. Treatment with GA_3 gave a relatively higher germination per cent in all the species except *C. hookerianus*, *C. travancoricus*. Complete removal of outer pericarp and sarcotesta of each seed manually (T_2), Sulphuric acid treatment for 3-5 minutes after removing sarcotesta (T_6) and Hot water treatment (50^0C) after removing sarcotesta for two minutes followed by soaking in water for 12 hours (T_7) were found promising in all the species (Fig. 1) and it is evident that the seeds sown without any treatment gave poor germination in all the species.

DISCUSSION

A rattan produce seeds in bulk, but their germination percentage is very low in most of the species if sown as such. According to Odetola (1987), several species of the family *Arecaceae* have mysterious physical numbness in varying degrees, demanding pre-sowing treatment in water or growth regulatory chemicals, chemical or mechanical stratification or even degrees

Table 3. Effect of pre-sowing treatments on germination of seeds of *C. hookerianus.*

Treatments	Germination % ***	Mean Daily Germination	Peak Value of germination	Germination Value	Days required for 50% of the germination	Days to start germination	Days to end germination
T1	13.84^{d} (8.89)	0.13^{d}	0.19^{d}	0.03^{de}	43.67^{d}	40.00^{c}	45.00^{cd}
T2	19.26^{c} (11.11)	0.18^{c}	0.24^{c}	0.03^{de}	60.67^{b}	52.33^{ab}	60.67^{ab}
T3	24.84^{b} (17.78)	0.25^{bc}	0.29^{b}	0.06^{c}	67.00^{a}	51.67^{ab}	71.33^{c}
T4	4.99^{e} (2.22)	0.04^{e}	0.07^{e}	0.01^{e}	17.33^{e}	17.33^{d}	17.33^{e}
T5	19.26^{c} (11.11)	0.19^{c}	0.23^{c}	0.04^{d}	58.00^{bc}	52.67^{a}	58.00^{b}
T6	21.41^{bc} (13.33)	0.22^{b}	0.29^{b}	0.05^{cd}	59.33^{b}	52.67^{a}	59.33^{ab}
T7	27.74^{a} (22.22)	0.41^{a}	0.46^{a}	0.20^{a}	52.33^{c}	49.33^{b}	54.00^{bc}
T8	20. 97^{bc} (13.33)	0.26^{bc}	0.35ab	0.08^{b}	51.00^{c}	50.00^{b}	51.67^{c}
T9	14.27^{d} (8.89)	0.15^{d}	0.23^{c}	0.04^{d}	39.00^{c}	34.33^{cd}	39.00^{d}
T10	0.00^{f} (0.00)	0.00^{f}	0.00^{f}	0.00^{e}	0.00^{f}	0.00^{e}	0.00^{f}
F test	4.275**	3.726**	3.726**	2.359**	3.70**	3.22**	3.85**
SEm ±	18.68	0.27	0.27	0.10	49.16	45.05	49.59

The values with similar alphabets with in a column do not differ significantly *Significant at 1% level - ** Mean germination percentage is given in parenthesis

Table 4. Effect of pre-sowing treatments on germination of seeds of *C. travancoricus.*

Treatments	Germination % ***	Mean daily Germination	Peak value of germination	Germination Value	Days required for 50% of the germination	Days to start germination	Days to End germination
T1	24.99^{b} (2.22)	0.023^{d}	0.029^{d}	0.0016^{d}	32.73^{d}	62.75^{c}	32.33^{d}
T2	29.87^{a} (4.44)	0.039^{d}	0.046^{c}	0.0023^{d}	76.00^{c}	76.27^{bc}	76.00^{c}
T3	15.67^{c} (8.89)	0.074^{b}	0.083^{ab}	0.0060^{ab}	119.67^{ab}	111.55^{b}	119.67^{b}
T4	14.96^{c} (6.67)	0.062^{c}	0.068^{b}	0.0039^{c}	107.67^{b}	107.50^{b}	107.67^{bc}
T5	27.25^{b} (8.89)	0.078^{a}	0.091^{a}	0.0065^{a}	112.33^{b}	115.84^{ab}	112.33^{bc}
T6	17.11^{c} (8.89)	0.073^{bc}	0.082^{ab}	0.0055^{b}	120.33^{ab}	114.48^{ab}	120.33^{ab}
T7	10.91^{d} (8.89)	0.058^{c}	0.063^{bc}	0.0059^{b}	120.67^{a}	118.67^{a}	120.67^{a}
T8	0.00^{e} (0.00)	0.000^{e}	0.000^{e}	0.0000^{e}	e0.00^{A}	0.00^{e}	0.00^{e}
T9	4.99^{d} (2.22)	0.023^{d}	0.029^{d}	0.0016^{d}	32.33^{d}	38.92^{d}	32.33^{d}
T10	0.00^{e} (0.00)	0.00^{e}	0.00^{e}	0.00^{e}	0.00^{A}	0.00^{e}	0.00^{e}
F test	5.68**	3.92**	3.92**	1.91*	7.10**	6.67**	7.10**
SEm ±	13.64	0.07	0.07	0.80	85.62	85.75	85.62

The values with similar alphabets with in a column do not differ significantly *Significant at 1% level - ** Mean germination percentage is given in parenthesis

of exposure to brightness. The present study investigates the effects of pre-sowing treatments on four *Calamus* species and comparison with various works researchers.

Pre-sowing treatments increased germination percentage in all the *Calamus spp.* except for *C. metzianus* (Fig.1), in which relatively high germination percentage was observed in un-treated seeds also. *C. thwaitesii* also exhibited better germination percentage in untreated seeds. This indicates the scope of *C. thwaitesii* and *C. metzianus* in its fast establishment and perpetuation. Different physiological, anatomical or morphological factors can be drawn as the reason for poor germination results in *C. hookerianus* and *C. travancoricus* in comparision with *C. metzianus* and *C. thwaitesii* (Fig. 1). In general, seeds without seed treatments gave low germination. The effect of pre-sowing treatments on germination varied with species. In the present study *C. thwaitesii* and *C. metzianus* gave better results with control along with other pre-treatments (Tables 1 and 2). In contradiction, germination results were not encouraging with respect to *C. hookerianus* and *C. travancoricus*. Seeds sown with the pericarp and sarcotesta intact have shown poor germination rates (Generalao, 1977; Manokaran, 1978; Bowen and Eusebio, 1982; Ahmad, 1983; Sunderland, 1999).

Treatment with GA_3 (T_9) was successful in both *C. thwaitesii* and *C. metzianus*. The positive effect of GA_3 was established in the studies of Upreti and Dhar (1997). It was found that soaking in 500 ppm GA_3 solution for 12 hours significantly enhanced seed germination percentage to 91.73 per cent. The use of growth regulators as gibberellins (Bevilaqua *et al.,* 1993) and cytokinins (Cunha and Casali, 1989) during the germination can improve performance of various species, mainly under adverse conditions. Frazao and Pinheiro (1981) and Frazao *et al*. (1981), noticed increase in germination of palm with GA_3 application.

A number of investigators have reported a hastening affect on germination by soaking seed in 10-2000 ppm concentration of GA_3 for 1-3 days (Nagao and Sakai, 1979; Nagao *et al.,* 1980; Doughty *et al.,* 1986). Odetola (1987) reported 10-25 ppm GA_3 worked well for a wide variety of species. Apart from treatment with GA_3, a significantly higher germination percentage was also obtained from, T3 (Scarification with sand and ash) T8 (cold water treatment after removing sarcotesta) and T7 (Hot water treatment after removing sarcotesta) in *C. thwaitesii* (Table 1 and Fig. 1).

An overall better performance was exhibited by *C. metzianus* towards all the subjected pre-sowing treatments (Table 2 and Fig. 1) and showed relatively higher germination percentage (90%). Different treatments found to have influenced the germination percent, but they do not differ significantly from each other (Table 2). This indicated that *C. metzianus* germinates well without any pre-sowing treatments. This may be because of the better physiological and morphological make-up of the seeds. Better adaptability of the seeds to the nursery conditions may also have played a significant role for their successful germination results.

The removal of sarcotesta and pericarp (T2) gave an increase in germination percentage in *C. hookerianus* and *C. travancoricus* (Tables 3 and 4). Swapon and Baruah (1994) also got 90 per cent germination after removal of scale and mesocarp, 8 per cent after removing only scale and 7 per cent germination without any treatment in *C. tenuis*. In general all the pre sowing treatments are found to be useful in the germination of *C. hookerianus* and *C. travancoricus*, were the present study reveals the difficulty in germination of untreated seeds. *C. thwaitesii* comparatively showed a low germination percentage with removal of pericarp and sarcotesta with respect to other treatments. Sumanthakul (l989) has reported a low germination rate of 16 per cent for *C. latifolius* when the pericarp and sarcotesta were removed completely. Sowing the whole fruit as well as fruit with pericarp removed, surprisingly gave 54.5 and 32.0 per cent germination rates respectively. The unusual low germination rate for clean removal of pericarp and sarcotesta probably confirmed the reservation expressed by Darus and Aminah (1985) that the embryos can be damaged during the cleaning process.

Hot water treatment after removing sarcotesta and pericarp (T_7) gave higher germination value in *C. hookerianus* (Table 3 and Fig. 1). Emerson *et al.* (2003) got a higher germination speed index (GSI), when the *Phoenix roebelenii* was germinated at a temperature of 30^0C. In case of *C. travancoricus*, germination value was lower, which do not statistically differ from zero in all the treatments except T5 (H_2SO_4 treatment without removing sarcotesta). Kitze (1958) also got promising results for germination in palm seeds of *Copernicia* while using sulphuric acid, but lower when compared to the value obtained with mechanical scarification. Bovi and Buchanan (1976a), studied effect of treatments which include immersion in cold water, hot water (± 80° C) and sulphuric acid (75 per cent) for 5 or 10 minutes on seeds of *Euterpe oleracea* and concluded that both the use of sulphuric acid and the hot water were not found satisfactory.

Flach (1997) noted that germination in sago palm *Metroxylon sagu* can be speeded up by removing the seed husk and by loosening the covering over the embryo (operculum). Removal of flesh, accelerates the germination of seeds in many palm species. (Bovi and Buchanan 1976a; Bovi and Buchanan, 1976b; Maeda, 1987; Meerow, 1991; Broschat, 1994; Lorenzi *et al.,* 2004; Ferreira and Gentle, 2006; Penariol, 2007; da Luz *et al.,* 2008). Elias *et al*. (2006) researching in the same species, found the germinal pore depth in the substrate could decrease the percentage of dormancy in seeds. In the present study it was observed from table 1 that, the initiation of germination and its ceasing came to an end more rapidly than any other treatment for *C. thwaitesii,* with respect to T_9 (Treatment with GA_3) and T_5 (H_2SO_4 treatment without removing sarcotesta).

Germination within short time span will be helpful in generating seedlings of uniform growth pattern. Figliolia *et al*. (1987), while comparing the germination of seeds of *Euterpa edulis* fruit found that scarification of seeds gave faster and uniform germination than the control.

In general the treatments in which the pericarp and sarcotesta were removed gave earlier germination in all the species. The seeds sown without any pre-treatments showed very slow germination. According to Goel (1992), removal of sarcotesta in canes is necessary as a pre-sowing treatment, in order to shorten the germination period. Removal of the hilar cover gave the best germination results for *C. merrillii*, where its germination time was drastically shortened from the usual range of 90 - 120 days to only two days (Bagaloyos, 1988). Likewise, the reduction was from 240 - 365 days to only 8-14 days for *C. ornatus* var. *philippinensis*.

Germination was a faster process in *C. metzianus* (Table 2). In all the treatments germination started early, within 20th to 28th days except for T10 (Control). This observation supports the necessity of pre sowing treatment in *C. metzianus,* when the requirement is for faster production of seedlings. The period of germination was 6-10 days only. Even though germination started late in T10 (Control) (40th day), the germination finished within 6 days (46th day). This ensured a more uniformity with respect to the morphology of the seedlings. Cumulative germination of *C. manan* was 74 per cent over 4-11 weeks, and 43 per cent over 6-31 weeks for *C. tumidus* (Aminuddin and Zollpatah, 1990). Viable seeds of peach palm (*Euterpe edulis*) started germinating on an average of 170 days after sowing (Oak, 1994). Germination percentage varied with respect to the period of germination in peach palm (Martins-Cordor *et al.,* 2006). The magnitude of variation was from 0-4 per cent (60 days), 0-15 per cent (90 days), 3-25 per cent (120 days) and 14-56 per cent (150 days) respectively. In the present study, the values obtained from the germination percentage were similar to those cited for the peach palm. As per different studies, the germination rate was found to be 44 per cent in 160 days (Negreiros and Perez, 2004); 73 per cent in 100 days (Nodari, 1998). Variation in germination was observed among the progenies of *E. edulis* (Martins-Cordor *et al.,* 2006). Similar work carried out with Palm trees also noted variations between genotypes for the germination percentage (Cunha and Garden, 1995).Mature seeds of *C. tenuis* and *C. rotang* were used to study the germination frequency in nursery soil by Singh *et al*. (1999) at Assam Agricultural University. There was no germination from the intact seeds or from the seeds after removal of outer scaly pericarp. The germination percentage increased (45 and 65 per cent for *C. tenuis* and *C. rotang*, respectively) and corresponding days for germination were 32 and 35 per cent respectively, when the outer scaly pericarp, fleshy sarcotesta and hilum were removed mechanically by rubbing with sand and ash. Removal of the micropyle gave 100 per cent germination for both species and reduced the time for germination to 11-12 days *in vivo*.

Conclusion

The present investigation revealed that the pre-sowing treatments increased germination percentage in all the *Calamus spp.* except for *C. metzianus*, in which relatively high germination percentage was observed in un-treated seeds also. The treatments in which the pericarp and sarcotesta were removed gave earlier germination in all the species. Various pre-sowing treatments significantly influence on the germination of *C. hookerianus* seeds and the results indicated that maximum germination was found in hot water treatment. Germination of *C. travancoricus* seeds was very poor with all the treatments. However, the best treatment which gave faster and maximum germination percentage was for complete removal of outer pericarp and sarcotesta. Among the species, *Calamus thwaitesii* and *C. metzianus* gave better results with control along with other pre-treatments. In contradiction, germination results were not encouraging with respect to *C. hookerianus* and *C. travancoricus.* However, further investigation is needed to confirm the higher germination of the seeds and to know whether this enhanced performance is continued under field conditions.

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