Front. Agric. China 2011, 5(2): 241–246
DOI 10.1007/s11703-011-1086-2

RESEARCH ARTICLE

Seed germination techniques of *Phoenix dactylifera*: A new experience from Bangladesh

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Abstract **A new experiment on seed germination technique for *Phoenix dactylifera*, an exotic species was conducted in the nursery of Forestry and Wood Technology Discipline, Khulna University, Bangladesh. The seeds imported from Saudi Arabia were collected from Nirala Central Mosque, Khulna, Bangladesh, in September 2008 and treated with four presowing treatments (control, immersion in normal water at room temperature (20–22°C) for 12 h, immersion in sun-heated water (25–35°C) for 12 h, and immersion in hot water (50°C) for 10 h) before seed germination with different germination media (well dried loamy soil, coarse sand, mixture of coarse and fine sand at a ratio of 3:1, mixture of coarse and fine sand at a ratio of 3:2, and mixture of coarse and fine sand at a ratio of 1:1). The experiment showed that presowing treatments significantly increased the germination rates of seeds compared to those in control (68%) and hot water treatment (69%). The highest germination success (84%) was found in the immersion in normal water and sun-heated water for 12 h. Experiment also showed that seed germination with course sand and mixture of coarse and fine sand with a ratio of 3:1 performed better than the loamy soil. Germination started from 21 to 26 days and completed between 38–40 days of the germination period in all treatments. ANOVA showed a significant difference among the treatments in seed germination, but there was no significant difference among the media in seed germination. Normal water and sun-heated water for 12 h for pretreatment and coarse sand or mixture of coarse and fine sand at a ratio of 3:1 may be recommended for seed germination of the species in rural Bangladesh.**

Keywords seed dormancy, pericarp, presowing treatment, small-scale nursery owners, *Phoenix dactylifera*

Introduction

Phoenix dactylifera, a dioecious tree (rarely monoecious) that grows up to 30 m tall (Tackholm and Drar, 1973), is distributed throughout the desert regions at 15°–35° N latitude from the Canaries and Morocco in the west to India in the east. It grows very well in the inner and littoral parts of North Africa, southern parts of Balkan Peninsula, and Asia minor, from Syria, Palestine, Transjordan, Iraq, Arabia, Iran, to Baluchistan. It is cultivated as an ornamental plant in South Europe, but it seldom matures fruit except in the extreme southern parts of Italy and Spain. It is also cultivated in Arizona and California, USA, and Queensland, Australia (Knight, 1980). *Phoenix dactylifera* is mainly cultivated for fruits production. The Arabs cultivate it primarily for the daily consumption of fresh and dried fruits containing high energy, sugar, as well as a good source of iron and potassium. Date honey, date sugar, and date sap (fermented beverage) can be produced from the juice of *Phoenix dactylifera*. The pith of the tree (palm heart) can be used as vegetables and seed for producing oil. The leaves are used for producing mats, the fiber provides thread and rigging boats, the midribs for fencing and roofing, the seed oil for soap manufacturing, and the trunk for manufacturing doors, beams, and rafters (Tackholm and Drar, 1973). *Phoenix dactylifera* mainly propagates from seeds (Hilgeman, 1954), but it can also be propagated by offshoot propagation (traditional methods) (Nixon and Carpenter, 1978) and micropropagation (tissue culture) (Tisserat, 1979). Selected seeds should be stored after properly cleaning the pericarp and drying the seeds in the sun. Meerow (1990) mentioned some presowing treatments, for example, soaking in water for certain periods of time, scarification (cutting, filing, or soaking in acid), and removal

Received October 20, 2010; accepted December 15, 2010
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of seed from the fruit to eliminate natural germination inhibitors can enhance seed germination rate. Banks and Marcus (1999) discussed about the germination media for palm seed germination. They mentioned that palm seed germination media must be well-drained, yet it has some moisture-holding capacity. A pattern of alternate extremes of dryness and wetness is detrimental to palm seeds during germination. The particle size of the medium should not be excessively large or prone to separation with repeated irrigation. A mixture of peat moss and perlite (1∶1) is successfully used under a wide range of nursery conditions. They also mentioned that the mixture of germination medium should be adjusted depending on the conditions to which the seed will be exposed.

In Bangladesh, there is a very good demand of fruits of *Phoenix dactylifera* throughout the year. Bangladesh imports a large amount of fruits of *Phoenix dactylifera* every year. The present forest condition of Bangladesh is unable to meet the present demand of forest products specially foods and nutrients due to over exploitation of resources, destruction of forest, shortage of planting materials, higher plantation cost, and lack of research and technical knowledges although various kinds of exotic species are already introduced in our country and most of them are practiced only for fuel and timber production but not for the production of food for man and animal. Though *Phoenix dactylifera* is an exotic species in Bangladesh, it is able to produce foods that are essential for both men and other animals to survive. Now, the small-scale famers have the opportunity to cultivate it as an agroforestry component to the border of the farmland to produce fruits. Moreover, it can be practiced in the degraded land, fallow land, house-hold garden, railway station, roadside plantation, institutional areas, as well as urban and rural areas. If it is practiced and cultivated, Bangladesh needs not to import it. Furthermore, it can be exported to other countries in future. By this time, it is successfully practiced in some middle and northern part of the country, but there are scarcity of planting materials due to poor seed germination percentages. Intensive plantation in agroforestry, social forestry, and home garden is limited because of destitute seed germination and delayed nursery establishment (Azad et al., 2010a; 2010b). Germination success can be improved through adopting appropriate presowing techniques (Maguire, 1962; Koirala et al., 2000; Alamgir and Hossain, 2005a; 2005b; Azad et al., 2006a; 2006b). Therefore, the objectives of our study were to determine the best possible pretreatment methods and determine appropriate germination media that will maximize the germination percentage of *Phoenix dactylifera*.

Research method

Study area

The study was conducted in the nursery of Forestry and Wood Technology Discipline, Khulna University, Bangladesh. It is situated in the south-western part of Bangladesh, which is the part of the largest delta. The study area is located about 4 m above sea level. The geographic position of the study area is situated between 22°12′–23°59′ N and 89°14′–89°45′ E. The climate of the study area is known as subtropical in nature, like the other part of the country. Winter, summer, and monsoon are the three main seasons distinguish here. Relatively mild winter starts from November and ends in February, but the temperature fluctuation during the winter is very low. Temperature fluctuates at 7–12°C in winter and increases up to 25–32°C in summer, but very occasionally, it might rise up to 36–40°C. The mean monthly temperature is about 28°C. The summer is from March to June, and the monsoon is characterized by heavy rainfall starts from July and continues until October (BBS, 1993; Alam et al., 2005). The air temperature and relative humidity recorded were 18–27°C and 65%–85%, respectively, during the experiment.

Plant materials and experimental design

The seeds were collected from Nirala Central Mosque, Khulna, Bangladesh, in September 2008. The collected seeds were imported from Saudi Arabia to Bangladesh. The collected seeds were washed with fresh water three times to remove the thin layer of the seeds. The seeds were dried for 4 to 5 days in the open sun and 2–3 days under the shade to reduce the moisture after collection. The dried seeds were kept in dry and cool place for ten days. The dried seeds were checked to eliminate the stained, discolored, and damaged seeds. Healthy dried seeds were used for the experiment. The germination test was done by sowing the seeds in polybags (4 cm×6 cm). The experiment was conducted under four treatments with five different types of germination media. The treatments used are given as follows: Treatment 1 (T1): control, Treatment 2 (T2): immersion in normal water at room temperature (20–22°C) for 12 h, Treatment 3 (T3): immersion in sun-heated water (25–35°C) for 12 h, and Treatment 4 (T4): immersion in hot water (50°C) for 10 h. The germination media of the polybags used are given as follows:: Media 1 (M1): well dried loamy soil, Media 2 (M2): coarse sand, Media 3 (M3): mixture of coarse and fine sand at a ratio of 3∶1, Media 4 (M4): mixture of coarse and fine sand at a ratio of 3∶2, and Media 5 (M5): mixture of coarse and fine sand at a ratio of 1∶1. One seed was sown in each polybag. Polybags were kept in shade throughout the experiment. The seeds were sown at a depth of 0.5–1.5 cm, and watering was done manually once a day. Randomized Block Design (RBD) with three replications was used for the experiment. Four hundred and fifty (5×3×30) polybags were used for each treatment. Therefore, the total numbers of plants were 1800 (4×5×30×3).

Seed germination

The number of seeds germinated in each treatment was recorded every alternate day. The starting and finishing dates of

germination were also recorded. At the end of the germination period, the germination percentage and germination rate (Maguire, 1962) were calculated using the following equations:

$$\text{Germination Percentage}(\%) = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds planted}} \times 100, \quad (1)$$

$$\text{Germination rate (G)} = \sum \frac{\text{Number of germinated seeds}}{\text{Day of count}}, \quad (2)$$

$$\text{i.e.G} = \frac{\text{Number of seedlings}}{\text{Day to first count}} + \cdots + \frac{\text{Number of seedlings}}{\text{Day to final count}} \quad (3)$$

Data analysis

Analysis of variance (ANOVA) and Duncan Multiple Range Test (DMRT) (Duncan, 1955) were carried out to analyze the data. Data were analyzed using MS Excel and STATISTICA software (ver.7.0.61.0 EN) to explore possible treatment media variation. Analysis of variance was carried out to determine the treatments effect on germination starting and closing date after seed sowing, length of germination period, seed germination percentage, and germination rate of *Phoenix dactylifera*. Analysis of variance was also carried out to determine the media effect on germination starting and closing date after seed sowing, length of germination period, seed germination percentage, and germination rate of *Phoenix dactylifera*. DMRT was conducted to compare mean germination starting and closing date after seed sowing, length of germination period, seed germination percentage, and germination rate of different presowing treatments effect and media of *Phoenix dactylifera*.

Results

Morphological characteristics of seeds

The seeds of *Phoenix dactylifera* are elliptical, hardy, and brown in color. There was a grove on the face side of the seed, but the back side is plain. The embryo is situated in the middle of the plain side from where taproot comes out first during germination. The average length, width, and thickness of the seeds are of 2.75±0.018, 0.82±0.009, and 0.68±0.079 cm, respectively.

Seed germination

Treatment effects

Germination started significantly earlier in immersion in normal water (T2) and in sun-treated water (T3) than in Control (T1) and in hot water treatment (T4). On the other hand, germination closed a little bit earlier in Control (T1) and in hot water treatment (T4) than in normal water (T2) and in sun water treatment (T3) (Table 1). Seed germination took place significantly longer in normal water (T2) and in sun-treated water (T3) than that of T1 and hot water treatment (T4) (Table 1). In all treatments, germination was completed within 38–40 days after sowing the seeds in polybag (Table 1). Analysis of variance showed significant difference ($P < 0.05$) in germination starting date, total germination period, total germination percentages, and germination rate among the treatments, but no significance difference was found in seed germination closing dates (Table 1 and Table 2).

Seed treated with normal water (T2) and sun-heated water (T3) germinated significantly higher (84%)) than that of T1 (68%) and in hot water treatment (69%). Germination rate was also significantly higher in normal water (T2) and in sun-treated water (T3) than that of T1 and hot water treatment (T4) (Table 1 and Fig. 1). Duncan Multiple Range Test (DMRT) showed significance difference on seed germination in T2 with T1, and T4; and in T3 with T1, and T4, but there was no significance difference in seed germination between T2 and T3, and between T1 and T4 (Table 1).

Germination media effects

Germination started a little earlier in coarse sand (M2), mixture of coarse and fine sand at a ratio of 3∶1 (M3), mixture of coarse and fine sand at a ratio of 3∶2(M4), and mixture of coarse and fine sand at a ratio of 1∶1 (M5). On the other hand, germination closed more or less in a similar pattern in all media (Table 3). Seed germination took a little longer time in M2 and M3 than that in M1, M4, and M5 (Table 3).

Table 1 Different presowing treatment effects on germination starting and closing day, seed germination period, germination percentage, and germination rate of *Phoenix dactylifera* at nursery stages

Particulars	Ttreatment 1 (T1)	Treatment 2 (T2)	Treatment 3 (T3)	Treatment 4 (T4)
Germination starting date (Days)	26±2.00a	21±1.22b	22±1.87b	27±1.00a
Germination closing date (Days)	38±1.04	40±1.22	40±1.22	38±1.17
Total germination period (Days)	12±2.00a	19±2.45b	18±3.00b	11±1.00a
Total germination (%)	68±3.09a	84.67±3.88b	84.52±3.43b	69.33±2.45a
Germination rate	0.62±0.03a	0.84±0.05b	0.85±0.05b	0.59±0.02a

Note: Same letter(s) in the same row indicates insignificant difference and±indicates standard error at $P < 0.05$. T1: control, T2: immersion in normal water at room temperature (20–22°C) for 12 h, T3: immersion in sun-heated water (25–35°C) for 12 h, and T4: immersion in hot water (50°C) for 10 h.

Table 2 *P*-values among treatment and media effects of *Phoenix dactylifera* at 95% level of confidence

Sources	Particulars	*P*- value
Treatment effects		
	Germination starting date (Days)	0.0411*
	Germination closing date (Days)	0.1918
	Total germination period (Days)	0.0461*
	Total germination (%)	0.0016**
	Germination rate	0.0004**
Media effects		
	Germination starting date (Days)	0.2632
	Germination closing date (Days)	0.1122
	Total germination period (Days)	0.2464
	Total germination (%)	0.1712
	Germination rate	0.3551

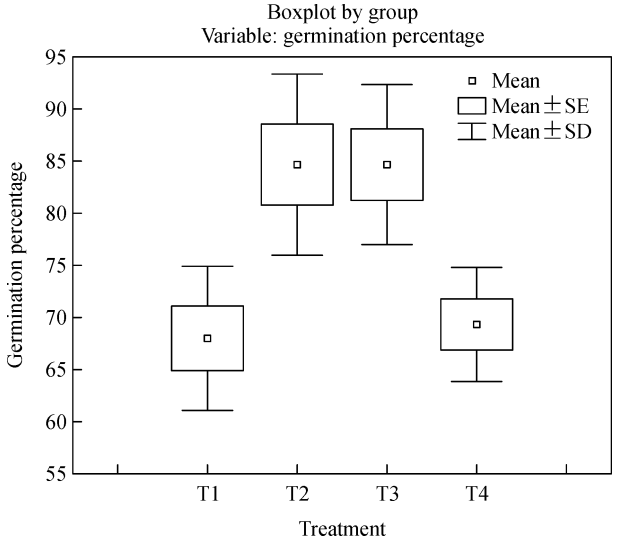

Figure 1 Different treatment effects on germination percentage of *Phoenix dactylifera* at nursery stages.

In all media, germination started within 21–28 days and completed within 38–40 days after sowing the seeds in polybag (Table 3). Analysis of variance showed no significance difference ($P > 0.05$) in germination starting date, closing date, total germination period, total germination percentages, and germination rate among the media effect (Table 2). The highest germination success (84%) took place in M3, whereas the lowest germination (68%) took place in M1, followed by the second (81%), third (77%), and fourth (71%) highest germination in M2, M4, and M5, respectively (Table 3 and Fig. 2).

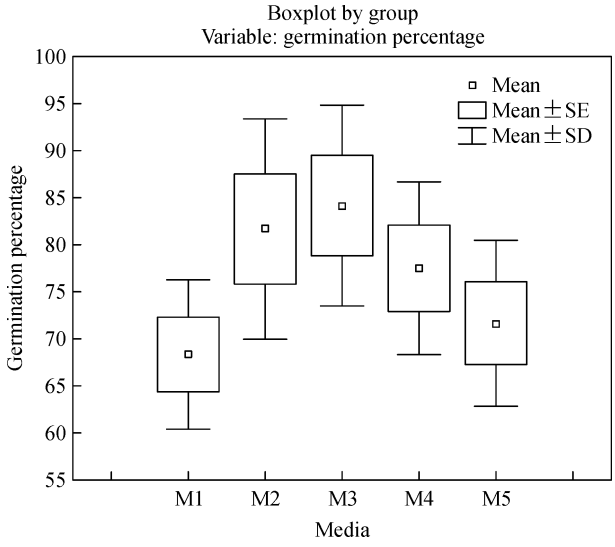

Figure 2 Different media effects on germination percentage of *Phoenix dactylifera* at nursery stages.

Discussion

Many authors discussed about presowing treatments of seed germination to break down the seed dormancy and thereby increase the germination rate and speed up the germination process. Seed dormancy can vary species to species, stage of maturity of seed, degree of drought, etc. Therefore, pretreatment should be adjusted accordingly. Physical seed dormancy may be defeated either by physical scarification of seed coat by clipping, nicking, piercing, flaming, or filing with the aid of needle, knife, hot wire burner, abrasion paper, etc. (Catalan and Macchiavelli, 1991). Equally acid treatment (Kobmoo and Hellum, 1984) or hot water treatment (Kobmoo and Hellum, 1984; Khasa, 1992; Airi et al., 2009) can also conquer physical seed dormancy. Generally, the untreated palm germinated slowly and irregularly, and the seeds with

Table 3 Effects of different media on seed germination starting and closing day, seed germination period, germination percentage, and germination rate of *Phoenix dactylifera* at nursery stages

Particulars	Media 1 (M1)	Media 2 (M2)	Media 3 (M3)	Media 4 (M4)	Media 5 (M5)
Germination starting date*	28±2.04	21.75±2.39	23±2.88	23±2.02	24.25±1.25
Germination closing date*	38±1.39	40.5±1.44	40.5±1.45	38±1.27	38±1.61
Total germination period*	10±2.04	18.75±3.75	17.5±4.33	15±2.83	13.75±1.25
Total germination (%)	68.33±3.96	81.67±5.85	84.17±5.33	77.5±4.58	71.67±4.40
Germination rate	0.60±0.06	0.80±0.09	0.77±0.09	0.74±0.05	0.70±0.04

Note: * indicates Days, M1–M5 indicate well dried loamy soil, coarse sand, mixture of coarse and fine sand at a ratio of 3:1, mixture of coarse and fine sand at a ratio of 3:2, and mixture of coarse and fine sand at a ratio of 1:1, respectively. ±indicates standard error at $P < 0.05$.

hard, solid, and inflexible seed coat were reported to recover germination with presowing treatments (Meerow, 1990). Furthermore, the findings of the present study showed that the seeds of *Phoenix dactylifera* under different treatments improved seed germination success significantly ($P < 0.05$) higher than the Control. The germination of seeds treated with immersion in normal water for 12 h and sun-heated water for 12 h (84%) was significantly higher than that of Control and hot water soaking. Duncan Multiple Range Test (DMRT) showed no significance difference on seed germination between normal water and sun-treated water, and between control and hot water treatment but significance difference on seed germination in normal water with Control and hot water treatment, and in sun-treated water with Control and hot water treatment. It may be because the outer coat of the seeds were more or less equally soften in immersion in normal water and in sun-treated water, thus germination took place at a similar pattern in normal water treatment and sun-treated water, but immersion in hot water (50°C) for 10 h treatment may not thin and soften the seed coat equally with immersion in normal water and in sun-treated water due to the difference of time. The experiment revealed that germination period of T2 and T3 were significantly higher than that of T1 and T4 because germination started significantly early in T2 and T3 and continued for a long time. On the other hand, in case T1 and T4 germination start lately and stop faster than T2 and T3. It may be because of the longer soaking time in T2 and T3, which helps soften the outer coat of the seeds and, thereby, increase the germination success. Kitzke (1958) discussed that presoaking of seeds can improve the germination success of palm, but not all the species will respond positively in the same pattern. He also mentioned that experiments documented in the literature rarely tried varying the duration of the presoak period on seeds of the same species. Meerow (1990) mentioned presowing treatment palm seeds under immersion of water can also improve the germination success. He also mentioned temperature of the water for seed treatments can also play an important role for seed germination percentages. He also argued that 30–35°C temperature of water for presoaking will enhance the germination process. Hore and Sen (1996) found 91.8% germination after storage of one month reduced to 55.2 percent after the nine month.

In the present study, effect of seed germination media on seed germination was also determined, and we found no significant effect of germination media on seed germination. The interaction of pretreatment and potting media effects were not analyzed here as the pretreatment effect and medium effect were from different interactions and replications of the experiment; aside from this, the germination media has a very poor effect on seed germination. The present experiment also revealed that there was no significant difference of seed germination success due to use of different combination of germination media. The experiment showed very good germination success in the mixture of coarse and fine sand other than loamy soil. This is may be due to the water drainage capacity of sandy soil than loamy soil. Banks and Marcus (1999) argued that palm seed germination should take place in well-drained germination media with some moisture-holding capacity. They also discussed that a pattern of alternate extremes of dryness and wetness is detrimental to palm seeds during germination. Doijode (2001) mentioned that moisture-holding capacity of germination media will reduce the germination percentages.

Concluding comments

Phoenix dactylifera is an important tree species for agroforestry, social forestry, and home garden, for its rapid growth, and tolerance of infertile and moderate dry seasons make it a very useful species for rehabilitation of degraded lands. Thus, the species is very interesting to the researchers to determine appropriate seed germination techniques. Among the presowing treatments, normal water immersion for 12 h and sun-heated water immersion for 12 h performed very well for the species, and there was no significant difference of seed germination in normal water immersion and sun-heated water treatment. Nevertheless, the use of water for presoaking treatments of *Phoenix dactylifera* is quite simple and inexpensive for the small scale farmers. On the other hand, the effect of germination media on *Phoenix dactylifera* seed germination performed better in sandy soil especially in the mixture of coarse and fine sand in a ratio of 3∶1. Therefore, it is suggested to apply normal water and sun-heated water immersion for 12 h as presowing treatments and mixture of coarse and fine sand as a seed germination media of *Phoenix dactylifera* in Bangladesh for social forestry, agroforestry program, and home garden plantation.

Acknowledgements

We acknowledge the Forestry and Wood Technology (FWT) Discipline, Khulna University, Bangladesh, for providing logistics support during the experiment. We also thank the support stuff of the nursery of FWT Discipline, Khulna University, Bangladesh, for their help and cooperation during the experiment.

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