

the highest high tide on a new moon day¹⁷. Notably, the Fifth Assessment Report of the Intergovernmental Panel on Climate Change stated that in the North Indian Ocean region, frequency of tropical storms will remain unaltered in the coming decades, with increasingly extreme rainfall events occurring near storm centres¹⁸. Management plans for the LDWB, therefore, should prepare the region for embracing more storms like the *Amphan* in near future.

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Shortening seed germination time for *Borassus flabellifer* using compost pit seed pretreatment

Palmyra or the Asiatic palm (*Borassus flabellifer*) is a multipurpose palm belonging to the Arecaceae family. It is native to the tropical regions of Africa, Asia and New Guinea. Among the five species of *Borassus*, *B. aethiopum* (found in Africa), *B. flabellifer* (found distributed in the coastal areas of the Indian Ocean) and *B. sondaicus* (restricted to mainland Indonesia) are of livelihood and economic importance^{1–3}. All its plant parts find use in rural households, starting from its liquid endospermous fruit, neera (sap extracted from the inflorescence), tubers, culm, petiole to its leaf lamina^{4,5}. It is dioecious and flowering occurs from March to April. The sex of palm is identifiable after its first flowering, which occurs 12–20 years after sow-

ing. The female inflorescence has 6–12 bunches, and each bunch bears an average of 15–25 fruits. The fruits are smooth, having a leathery, brown outer covering that turns black at maturity⁶. Within the fruit is a fibrous mesocarp with a yellow or orange pulp⁷.

Palmyra is mainly propagated through seeds that are rectangular in shape, 4.5 in long, 4 in wide, and 1.75 in thick in the middle⁷. Palmyra fruits are difficult to dehusk as the fibres tightly adhere to the seeds. In palmyra, it is the hypocotyl that emerges first, growing deep into the ground (sometimes more than 1 m) before the roots and pseudo leaves appear. Germination in palmyra is of tubular type, where plumule emergence occurs from the proximal end of the growing

cotyledon away from the seed. This structure is known as the cotyledonary tube or apocolon. Herein, we refer to germination as the emergence of the hypocotyl.

In the nursery, palmyra seeds are either sown in seedbeds or in mounds of soil to facilitate easy transplantation. Palmyra seeds are hard to germinate; it takes around 60–90 days for germination. Pseudo leaves start emerging in 9–12 months from the date of sowing⁷.

India has nearly 102 million palmyra palms distributed across Tamil Nadu (TN), Maharashtra, Karnataka, Kerala, Odisha and West Bengal. About half of the palmyra population in the country is concentrated in TN, where it is the state tree⁸. On the other hand, reports have

indicated a steady decline in palm counts in India, especially in TN. The state ban on toddy tapping is one of the main reasons for its decline in TN. As the tappers and farmers have lost interest in growing this species, the existing palms also continue to be felled for other socio-economic purposes. Following this, NGOs, many agencies and institutions have started initiatives to conserve the species⁹⁻¹¹. Also, researchers have recounted their concern on the low genetic diversity in the existing palm populations^{12,13}. All these indicate the need for a pragmatic approach towards this palm species. A similar declining trend has also been reported for *Borassus aethiopicum* population in South Africa¹⁴.

Till date, direct seed sowing is the only known method of propagation in *B. flabellifer*. However, its establishment rate is low as it needs loose soil for the development of hypocotyl, which can be a limiting factor in the direct seed sowing method. The proper development of hypocotyl is imperative in ensuring establishment of the seedling. Therefore, nursery-raised palmyra seedlings could easily establish in the fields. Though attempts have been made to propagate *Borassus in vitro*¹⁵, seed-based propagation is the most widely adopted method.

Soaking the seeds in water for 24 h is recommended as a standardized practice for propagating *B. flabellifer*¹⁶. However, it takes a long time for the plumule to emerge. A search in the Web of Science, Scopus, J-Gate and other databases shows that there is a dearth of literature on the propagation of palmyra. Few dedicated theses have studied various aspects of palmyra germination, but conspicuously, there is no discussion on the pretreatment procedure^{17,18}. Though there have been studies at the nursery stage, most of them have focused on controlling tuber rot. Sankaralingam¹⁹ found that pretreating the palmyra seeds in 0.1% carbendazim could control root rot to a greater extent. In another trial, the combined application of *Trichoderma viride* (1% talc) and *Pseudomonas fluorescens* (1% talc) with 10 g of neem cake in soil was found to enhance germination and weight of the tubers²⁰. A pertinent study reported that treating palmyra seeds in 1% cow dung solution for 24 h could considerably reduce the time taken for its field emergence to around 100 days²¹. It is in this context that the present study explores the possibility of

shortening seed germination and plumule development using compost pit treatment.

An experiment was conducted at the College of Forestry, Thrissur, Kerala from October 2016 to February 2017, to evaluate the potential seed pretreatments that could enhance germination percentage and help attain early plumule development in palmyra. Palm fruits were collected from the farmlands in Soman-kottai, Tirupur district, TN. The fruits were then dehusked to separate the seeds. Four sets of 90 palmyra seeds each were subjected to different pretreatments as follows: T1 – soaking in water for 48 h, T2 – maintaining the seeds deep inside compost pits filled with partly degraded organic waste for 5 days, T3 – soaking the seeds in 2% solution of potassium dihydrogen phosphate for 24 h, and T4 – control (untreated seeds).

The rationale behind the chosen seed pretreatments was that both T1 (water soaking will help in breaking seed dormancy) and T3 (potassium dihydrogen phosphate finds application in fertilizers and seed hardening of crops) are in the recommended package of practices. We hypothesized that maintaining the seeds deep inside the compost pits could provide sufficient heat to them, and will enhance their germination and plumule development.

Seeds subjected to water treatment were sun-dried for 2 h before sowing. At the end of 48 h, water used for soaking the seeds was dark yellow in colour with the smell of jaggery. Seeds subjected to compost pit treatment were watered daily for 5 min using a sprinkler. At the end of the fifth day, when the seeds were taken out of the compost pit, they were found covered with worms and were slightly warm. Next, 2% solution of potassium dihydrogen phosphate required for the treatment was prepared by mixing 400 g of the compound in 10 litre of water.

Each set of pretreated seeds was sown on separate seedbeds (10 m × 1.2 m × 0.6 m) in rows of three, taken along the length of the bed. Seeds were sown at a spacing of 10 cm between them and were covered by soil to form small mounds over them. At the end of the first month after sowing, all the seeds were checked to see whether hypocotyl had emerged or not. This was done using a small wooden stick by carefully removing the soil around the seeds without damaging them.

Later the seeds were again covered by soil to form small mounds. Seeds for which rooting did not begin were noted and the observations were continued (at the end of every month) till plumule development.

Hypocotyl growth was observed in all the three seedbeds by the end of the first month, except for the control. In control, rooting was observed only in 14 seeds at the end of the second month from the date of sowing. Pseudo leaves (first emergence) were first observed among the compost pit-treated seeds after 90 days from sowing. The percentage of germination was maximum (74.4) among the compost pit-treated seeds followed by water-treated and chemical-treated seeds (Table 1). Despite the high germination percentage observed in water-treated seeds, the time taken for emergence of plumule was more. Compost-treated seeds had an equally high percentage of germination and also showed early plumule development.

High incidence of tuber rot (43.33%) in seedlings raised using untreated seeds has been reported²². Tuber rot observed in the present study was also high; 63.6% in T1, 33.3% in T2, 43.8% in T3 and 71.4% in T4.

The mean germination rate observed in the control was low compared to the values reported in other studies. The average germination rate observed in untreated seeds raised in mound nursery was 30.4% (ref. 23).

Table 2 shows that both water and compost pit treatments are equally effective in enhancing seed germination in palmyra. However, early plumule development is observed if the seeds are kept inside the compost pit for a week or so before sowing. Bottom heat is recommended for most of the palms, and is adopted for raising palms in containerized nurseries. It has been documented that some villagers in Andhra Pradesh maintain the practice of keeping palmyra seeds in cow-dung pits²⁴. This is a way of providing bottom heat to the seeds. The results of this study also reiterate the fact that palmyra seeds require strong bottom heat for germination. However, using compost pits for increasing the rhizosphere temperature is cheaper and adaptable. The increased rhizosphere temperature inside compost pits provides sufficient warmth for the seeds, thereby helping in scarification. It might also help speed up enzymatic reactions in the

Table 1. Germination percentage and plumule development observed at the end of four months

Treatment	No. of seeds germinated	No. of days taken for plumule development	% Germination
Water treatment	66	103	73.3
Compost pit treatment	67	90	74.4
Chemical treatment	16	112	17.7
Control	14	115	15.5

Table 2. Comparison of mean germination rate for different treatments

Treatment	Mean germination rate
Water treatment	22 ^a
Compost pit treatment	22.33 ^a
Chemical treatment	5.33 ^b
Control	4.33 ^c
F value	75.25*

*Significant at 5% level.

Values with the same superscripts do not differ significantly within the column.

endosperm. We could, therefore, refute the claim that plumule emergence in *Borassus* is fast when seeds are treated with CaOCl₂ or 1% cow dung slurry²¹.

Compost pit treatment is a better option for producing palmyra seedlings in nurseries. Soaking the seeds in water for 24 h is not advisable as chances of tuber rot incidence were found to be high. Generally, hypocotyl growth would be poor in compact soils and therefore, we recommend proper soil preparation before sowing. Thus, compost pit pre-treatment of palmyra seeds could reduce the time for seed germination and plumule development. In nurseries, compost pit-treated seeds can be raised on elevated seedbeds (mounts of soil) and subsequently be transplanted to containers. The compost pit-treated seeds can also be sown in large polybags to avoid difficulties while transplanting.

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