REVIEW ARTICLE Agricultural Reviews, Volume 46 Issue 2: 180-189 (April 2025)

Seed Dormancy and Germination Behaviour of Palmyrah: A Review

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10.18805/ag.R-2607

ABSTRACT

Palmyrah (*Borassus flabellifer* L.) is a slow growing, dioecious, drought resistant palm and considered to be native of Tropical Africa. It is cultivated as well as found growing in wild in the Indian subcontinent. It is distributed in India, Burma, Africa and Sri Lanka. Several problems are encountered in germination of seeds in palmyrah such as poor, protracted germination and prolonged nursery period. The main reasons for the failure of seeds to germinate in suitable conditions are either dead or dormant. The delayed germination of palmyrah might be due to the stony endocarp acting as a physical barrier to imbibition or imposing mechanical resistance to embryo enlargement. Against this backdrop, this review focuses on seed dormancy, pre-sowing seed treatment, nursery technology, and seed storage behaviour of palmyrah.

Key words: Germination, Nursery technology, Palmyrah, Seed dormancy, Seed storage, Seed structure.

Palmyrah is a dioecious palm and is considered to be a native of tropical Africa. It is distributed in Africa, India, Burma and Sri Lanka. The palm belongs to the family Arecaceae, subfamily Borassoideae and genus Borassus. The three most economically important species of Borassus are *Borassus aethiopum* Mart, *Borassus flabellifer* Linn and *Borassus sundaicus* Becc. (Mohanadas, 2002). The species *Borassus flabellifer* L. is abundant in the arid tropics of South America, West Africa, India, Sri Lanka and Southeast Asia (Mohandas, 2002; Morton, 1988). The palmyrah palms are slow-growing of the remotive tubular type and have no distinguishing features to identify the sex until flowering. The palm commences flowering only after 12-15 years of maturity (George and Karun, 2011). Palmyrah is an annual flowering type and usually flowers during November. The tender fruits appear from January to March. The fruits are three seeded and are seen in bunches. Seed embryo has very good nutritional and antioxidant properties and also utilized as food source for human consumption (Mehta *et al*., 2016). Palmyrah is a good source of carbohydrate, calcium, magnesium, iron and fibre but limited in fat and protein (Arunachalam *et al*., 2011). It is a multipurpose tree of great utility and occurs extensively in Tamil Nadu. It is exploited for juicy pulp from the fruit and tuberous seedling, beverage and sugar from the sap, fibre from the fruits and leaves from the branches, cordage weaving and plaiting and trunk wood for construction and fuel (Tahir *et al*., 2007; George *et al*., 2007). Due to multivarious uses, the government of Tamil Nadu has declared it as “State Tree” (Sankaralingam *et al*., 1999). The purpose of this review is to outline and discuss the various aspects of seed dormancy, pre-sowing seed treatment, nursery technology and storage behaviour of palmyrah seeds.

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How to cite this article: Masilamani, P., Rathika, S. Indurani, C. and Venkatesan, S. (2025). Seed Dormancy and Germination Behaviour of Palmyrah: A Review. Agricultural Reviews. 46(2): 180-189. doi: 10.18805/ag.R-2607.

Submitted: 10-11-2022 **Accepted:** 03-04-2023 **Online:** 25-05-2023

Seed structure

The mature embryo is situated in the endosperm below the “germ pore”, where the hard endocarp is thin. The distal end of the embryo forms a slight projection, covered by a thin conical cap formed by the endocarp which is easily detached, as in the ‘soft eye’ of the coconut. The embryo is more or less cylindrical in its distal region, while the proximal region is slightly compressed on two opposite sides, the two regions being separated by a shallow groove. The proximal region is made up entirely of the cotyledon, which constitutes the bulk of the embryo. The cotyledon consists of uniform thin-walled parenchymatous cells which are

closely packed together, and is traversed by procambial strands arranged longitudinally (Fig 1).

A longitudinal section of the embryo shows the plumule in the distal region, consisting of the apical meristem and a few leaf primordial, lying in a small cavity and enclosed by the sheathing portion of the cotyledon. The plumule and the radical are both situated in the axis of the embryo and the root primordium is not well differentiated at this stage. The tip of the radial appears as a minute projection at the distal end. The endosperm consists of cells with greatly thickened walls containing reserve material as in Phoenix dactylifera. The reserves are mostly of hemicelluloses and cellulose too appears to be present in these walls. The endosperm is hard and horny, and two regions may be distinguished: A central region consisting of larger cells and a harder peripheral region consisting of much narrower cells. The thickness of the cell walls is approximately the same in both regions (Dassanayake and Sivakadachchan, 1973).

Seed dormancy

Palmyrah is mainly propagated through seeds and there is no vegetative method available for its propagation (Masilamani *et al*., 2018). Several problems are encountered in germination of seeds in palmyrah such as poor, protracted germination and prolonged nursery period. The palmyrah seed takes 40-60 days to initiate germination and the eophyll (first leaf) emerge out after a period of 100 days from sowing (George and Karun, 2011; Masilamani *et al*., 2020). The main reasons for the failure of seeds to germinate in suitable conditions are either dead or dormant. Baskin and Baskin, (2014) reported that palm seeds are having various kinds of dormancy *viz.,* embryo is under developed, endocarp is water impermeable and seeds take a long time to germinate. The seeds of majority of palm species have morpho physiological dormancy due to the presence of underdeveloped embryos. The delayed germination of palmyrah might be due to the stony endocarp acting as a physical barrier to imbibition or imposing mechanical resistance to embryo enlargement (Masilamani *et al.,* 2018).

Imbibition's studies

This study reveals that the water is not absorbed by the palmyrah nuts up to 120 hours of soaking (Fig 2). This may be due to the hard endocarp act as a physical barrier not allowing water entry in to the seed (Shelar *et al*., 2014).

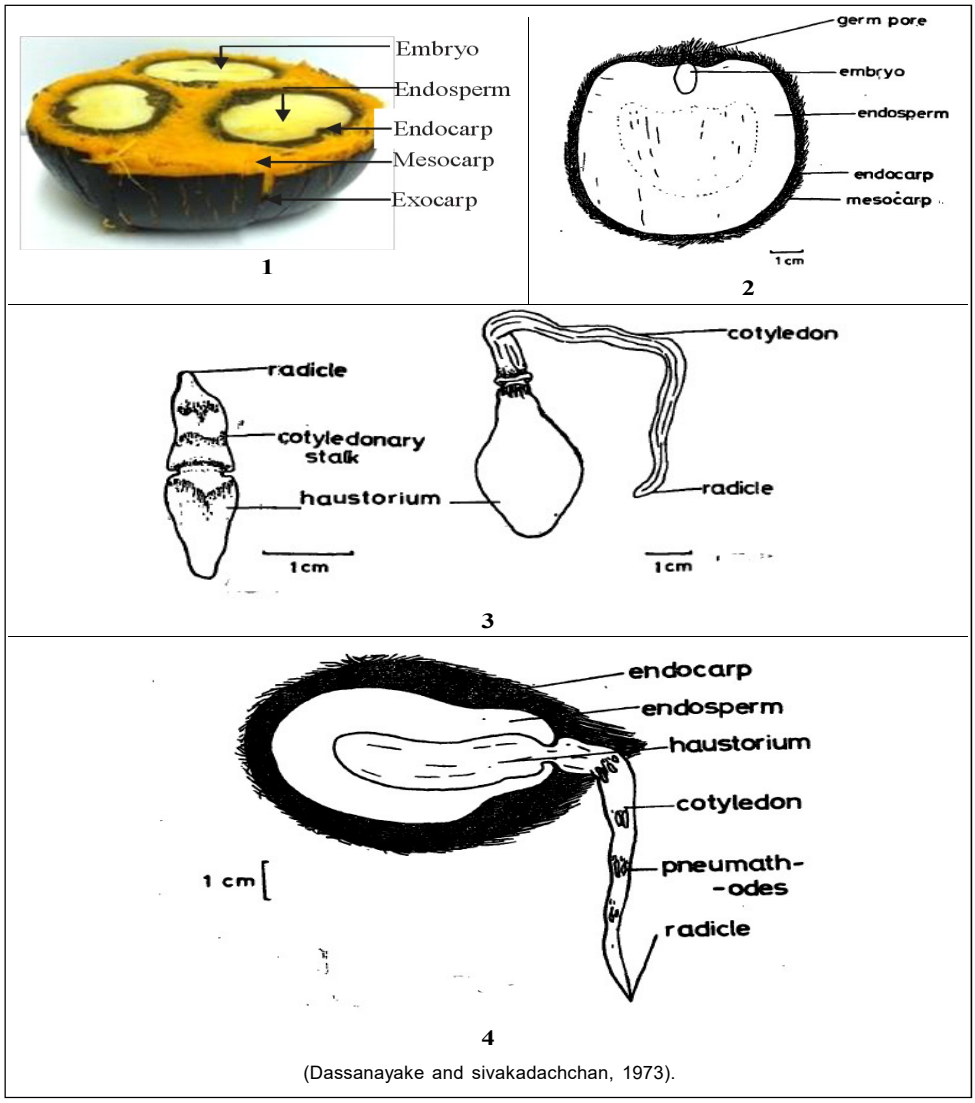
Seed germination

Dassanayake and Sivakadachchan studied the germination of palmyrah seeds in detail, while other authors such as Tennent (1960), Blatter (1926), and Gatin (1906) briefly discussed it (Fig 2). In palmyrah, the germination is tubular, the embryo is straight and the cotyledon extends so that the plumular portion of the seedling is carried away from the seed through the elongation of the proximal portion of the cotyledon, forming a structure widely termed as "Cotyledonary tube" or "apocolon" (Mahabale and Kulkarni, 1975). The expansion of the distal portion of the cotyledon inside the seed functions as a haustorium (Tomlinson, 1960). Dassanayake and Sivakadachchan, (1973) reported that palmyrah germination is of the remotive tubular type, the cotyledon elongating and burying the plumule and radical at a depth of 30-40 cm in the soil. The seedling produces a single scale leaf, which contains abundant storage starch. The remotive tubular mode of germination appears to occur in palm sub-families Borassoideae and Coryphoidcae and the genera Phoenix and phytelephas and to be related to the structure of the mature embryo.

Pre-sowing seed treatments

Researchers have identified that more than a quarter of all palm species can take up to 100 days to germinate, with an overall germination rate of only 20% (Tomlinson, 1990). The reasons for this remain obscure, as very little investigation on seed dormancy condition in palms. Due to the often slow and uneven germination of palmyrah seeds, there has been a great deal of interest in any pre-sowing seed treatments that might increase the germination (Sathiya Narayanan *et al*., 2017; Singh and Kaur, 2021; Reshma and Simi, 2021). Soaking the seeds in water for 24 h is recommended as a standardized practice for propagating of palmyrah. 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 tubers (Ebenezar and Nainar, 2009). After removal of fleshy mesocarp from palmyrah fruits will increase the germination upto 15%, before sowing, palmyrah seeds were soaked in water for 3 h will increase the germination to 100%. But seeds soaked in hot water for 30 minutes had decrease the germination. Palmyrah seeds soaked in KH_2PO_4 solution for 24 hours will increase the germination. Before sowing, ripened fruits were shade dry for 4 weeks after that the fruits were soaked in 0.1% carbendazim for 24 h will reduce the pathogen infection during germination.

Masilamani *et al*., (2020) reported that Palmyrah seeds soaked in 1% $CaOcl_2$ recorded the highest field emergence of 56% with more number of leaves per seedling (2.1) when compared to control in seven months after sowing. This study also confirms the effect of pre-sowing treatments on field emergence and frond production of Palmyrah nut which has dormancy (Table 1). Enhanced germination with $CaOCl_2$ may be it counteracts the endogenous inhibitors or regulates the osmotic pressure gradient allowing just the required moisture activate enzymatic process and cell division warrant further elucidation. Soaking palmyrah seeds in 2% cow dung solution can improve field emergence after two years. Data collected one year after seeding showed different results from initial findings (Table 1; Fig 3 and Plate 1). This study shows that seed treatment has an effect on palmyrah germination for up to one year, after which the effect is no longer noticeable. Early stages of pre-sowing seed treatments can help increase the field emergence of untreated control seeds, which may be due to the hard



(Dassanayake and sivakadachchan, 1973).

Fig 1: Palmyrah fruit structure (1), Seed of palmyrah, cut longitudinally (2) Embryo from germinating seed, Constriction corresponds to the germ pore (3) and Germinating seed, cut longitudinally, showing entire embryo (4).

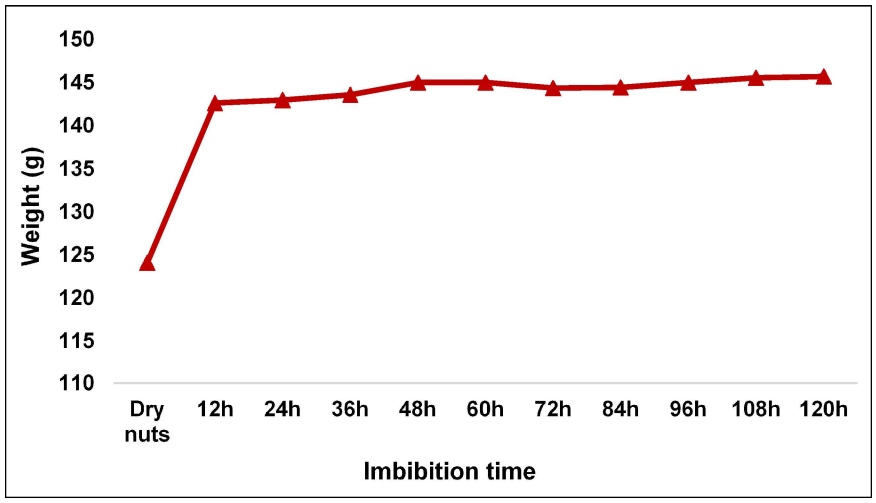


Fig 2: Effect of soaking duration on imbibition of palmyrah.

endocarp that impairs water imbibition and air diffusion. These positive responses have been seen up to seven months after sowing.

In a review, information on time of germination of palm seeds that included 1281 published records on 457 species; indicate that about 10% of the seeds germinated within 30 days, and for the other 90% time of germination ranged from between 40 to 1941 days. Seeds in about 53% of the 1241 observations germinated between days 31 and 40 to 121-130 days (Orozco-Segovia *et al.*, 2003). The seeds of most palms take longer than 30 days to germinate. The presences of underdeveloped embryos indicate that morphophysiological dormancy is the major dormancy class in the family. The 10% of the seeds that germinated in < 30 days would have morphological dormancy (Baskin and Baskin, 2014). From this study, it concluded that delayed seedling emergence in palmyrah is due to seed dormancy and get uniform initial growth and seedling establishment; pre-sowing treatment with 1% $CaOCl_2$ soaking for 24 hr is suggested. However, further investigation is necessary to ascertain the treatment effect on grown up palms beyond nursery stage.

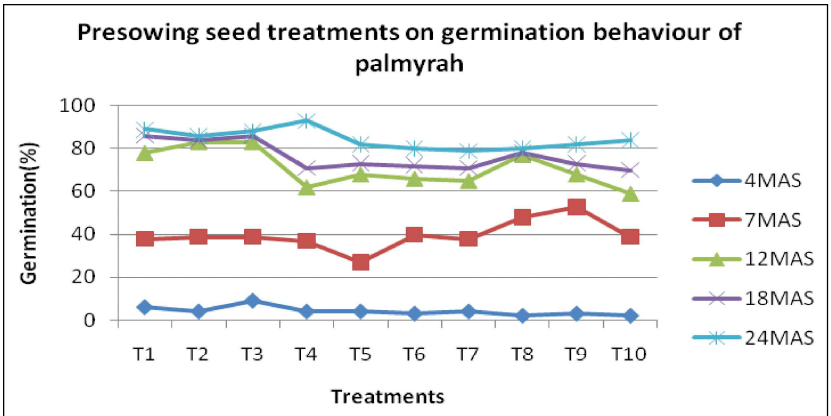
Das *et al*. (2020) reported that compost pit-treated seeds recorded highest germination of 74.4 per cent followed by water-treated and chemical-treated seeds. In both water and compost pit treatments are equally effective in enhancing seed germination in palmyra. However, early plumule development is observed if the seeds are kept inside the compost pit (Fig 4). Compost pit treatment is a better option for producing palmyra seedlings in nurseries.

Paulas (1988) reported that palmyrah seeds were pre-soaked in the nutrient solution like diammonium phosphate

Table 1: Effect of pre-sowing treatments on days taken for initial emergence and field emergence (%) of Palmyrah (4, 7, 12, 18 and 24 months after sowing).

Treatments	Days taken for	Field emergence (%)				
	initial emergence	(4 MAS)	(7 MAS)	(12 MAS)	(18 MAS)	(24 MAS)
T_1	108	6	38	78	86	89
T_2	108	4	39	83	84	86
T_3	102	9	39	83	86	88
T_4	108	4	37	62	71	93
T_5	108	4	27	68	73	82
T_6	110	3	40	66	72	80
T_7	110	4	38	65	71	79
T_8	110	2	48	77	78	80
T_9	103	3	53	68	73	82
T_{10}	110	2	39	59	70	84
Mean	108	4	40	70.9	76.4	84.3
SED	3.90	1.52	2.31	0.9221	1.140	1.289
CD (P=0.05)	NS	3.20	4.85	1.9235	2.379	2.690

Foot Note: T_1- Control; T_2- Soaking in water for 24 hrs; T_3- Soaking in 1% cow dung solution for 24 hrs; T_4- Soaking in 2% cow dung solution for 24 hrs; T_5- Soaking in 1%KNO_3 for 24 hrs; T_6- Soaking in 2% KNO_3 for 24 hrs; T_7- Soaking in 1% H_2O_2 for 24 hrs; T_8- Soaking in 2% H_2O_2 for 24 hrs; T_9- Soaking in 1% $CaOCl_2$ for 24 hrs; T_{10}- Soaking in 2% $CaOCl_2$ for 24 hrs.



Source: Masilamani *et al.*, 2020.

Fig 3: Effect of pre-sowing treatment on field emergence of palmyrah (4, 7, 12, 18 and 24 Months after sowing).

and potassium chloride at 2 per cent on each alone and in combination. The results showed that soaking seeds in water and DAP had higher germination (Fig 5). Seeds were treated with ethrel 200 ppm for 3 hours had highest germination of 55.1% and initial seedling vigour, which was followed by all other treatments (Fig 6). Thiourea solution at a concentration of 0.4% for 15 hours soaking had highest germination of 38.3% which was followed by all other treatments (Fig 7).

Nursery technology

Till date, direct seed sowing is the only known method of propagation in palmyrah. 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

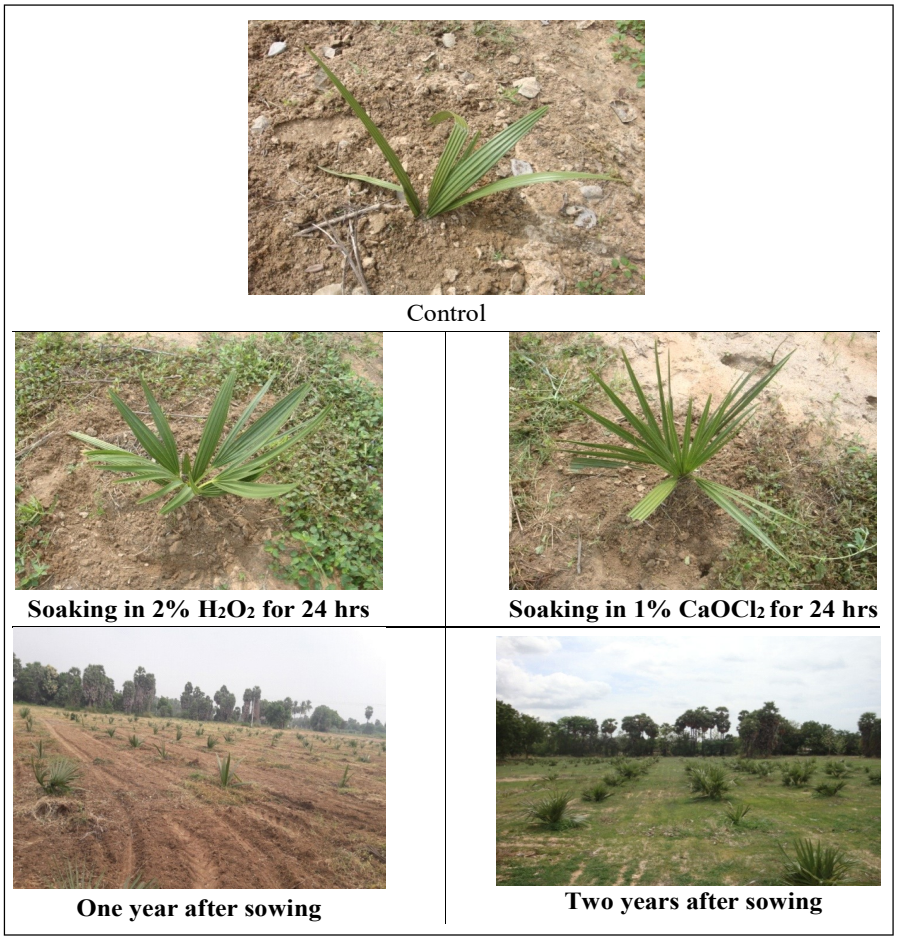
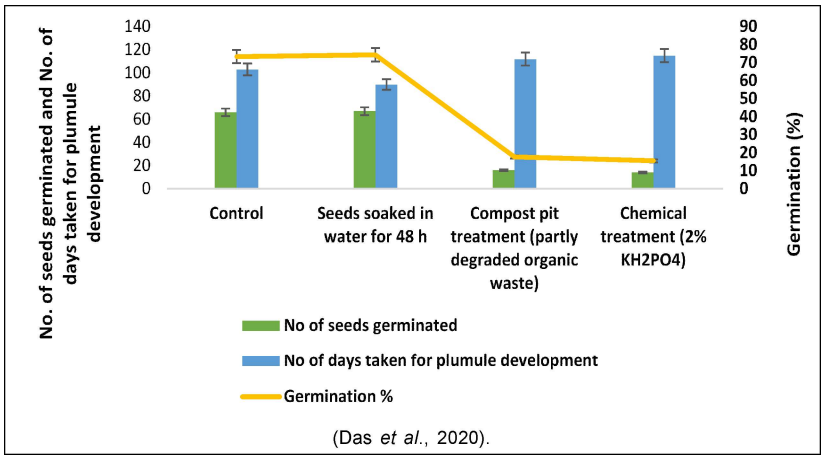


Plate 1: Palmyrah field emergence.



(Das *et al.*, 2020).

Fig 4: Germination percentage and plumule development observed at the end of four months.

sowing method. The proper development of hypocotyl is imperative in ensuring establishment of the seedling. Therefore, nursery-raised palmyra seedlings may be easily established in the fields.

The seeds were sown in sunken nursery bed (T_1), raised nursery bed (T_2) and direct sowing in the field (T_3) soil with sandy clay loam texture. The observations were recorded at monthly interval up to 24 months after sowing. The results reveled that seeds sown in nursery beds containing red earth, sand and farm yard manure (2:1:1 ratio) took 120 days for initial emergence whereas, seed sown in sunken bed containing sand and seed sown in the field has took 90 days for initial emergence (Fig 8). The highest field emergence of 77.30% was recorded after 11 months of sowing in nursery

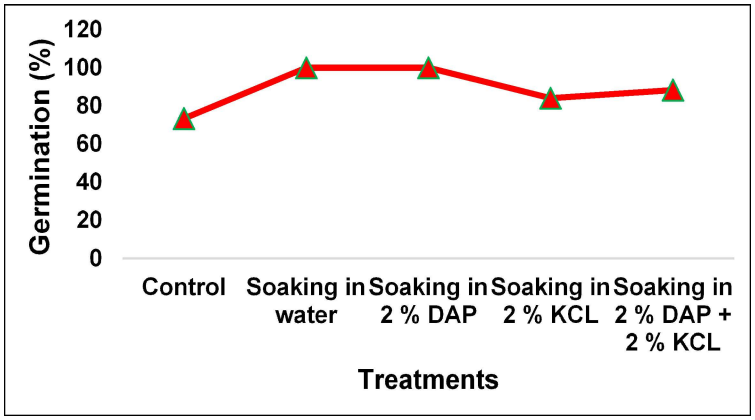


Fig 5: Effect of pre-sowing treatments on germination (%) in Palmyrah (Paulas, 1988).

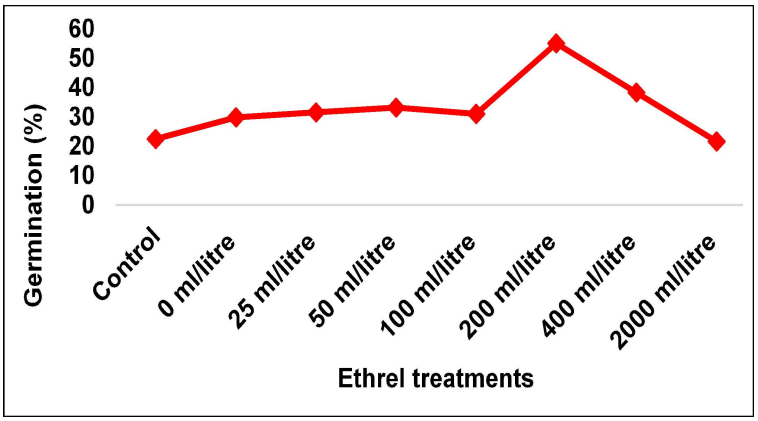


Fig 6: Effect of ethrel treatments on germination (%) in Palmyrah (Paulas, 1988).

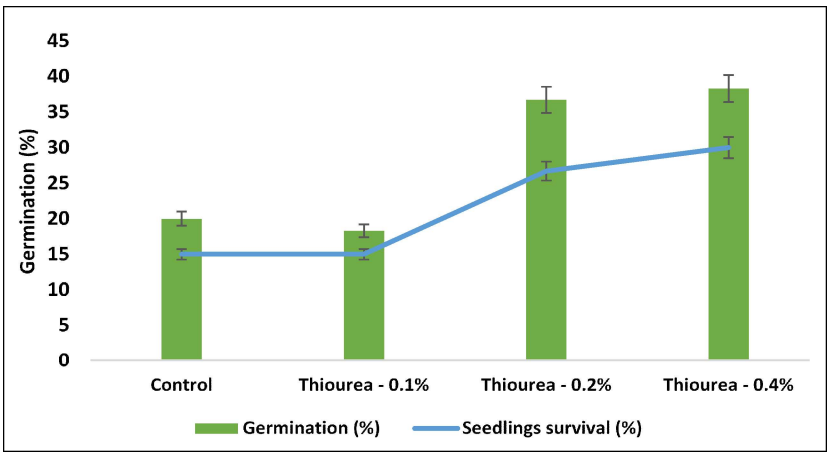


Fig 7: Effect of thiourea treatments on germination (%) in Palmyrah (Paulas, 1988).

medium containing red earth, sand and farmyard manure 2:1:1 ratio after that there was no increase in the field emergence upto 24 months after sowing (Table 2 and Fig 9). Where as in field sowing, months taken for initial emergence (0.67 per cent) was 3 months after sowing, it increasing trend up to 12 months after sowing (52 per cent) after that there was no increasing in the field emergence upto 24 months.

The seed placed for germination in the normal nursery mixture of red earth + sand + farm yard manure at 2:1:1 ratio showed a stimulatory effect on germination. Since the imbibing seeds involve enzymatic activities, the presence of the extra available nutrients in red earth: sand: farm yard manure solution might have promoted the various enzymatic process leading to faster cell division, radical elongation besides improving germination. Besides that, red earth has having available nitrate and presence of NPK in the farm yard manure, these nitrate and NPK ameliorate the nursery media and giving nourishment of the growing radical and plumule of the palmyrah seedling, From this experiment, it could be concluded that palmyrah seed sown in nursery media containing red earth + sand + farmyard manure 2:1:1 registered maximum field emergence (77.30%) when compared seed sown in sand media (62.67%) and field sowing (52.0%) for 24 months after sowing.

Ricard Kennady *et al*. (2021) studied that the germination behavior of one, two, three and four seeded fruit. The results revealed that maximum germination (86.22%), length of apocolun (32.42 cm), girth of apocolun (114.14 cm) and weight of apocolun (128.20 g) were recorded in three seeded fruits. Ravindran *et al*. (2021) studied that the media and containers for palmyrah palm seedling production. seedlings were produced in six kinds of media and in experiment 2 seedlings were produced in four kinds of containers. Results revealed that the media significantly influenced the days taken for sprouting, percentage of germination, number of leaves per seedling and seedling height (cm). Potting mixture, such as soil, sand and vermicompost mixed in 2:1:1 + Imida 6 g/kg + GA3 1000 mg/l (T4) took less number of days for sprouting (90 days) compared to other treatments and media. In case of containers, black polythene bag (12.5 × 50 cm) gave the highest germination rate (78%) followed by PVC tube (12.5 × 50 cm) as 42%, banana pseudo stem sheath (12.5 × 50 cm) as 38% and Bamboo tube (12.5 × 50 cm) as 33%. Similarly, black polythene bag (12.5 × 50 cm) recorded

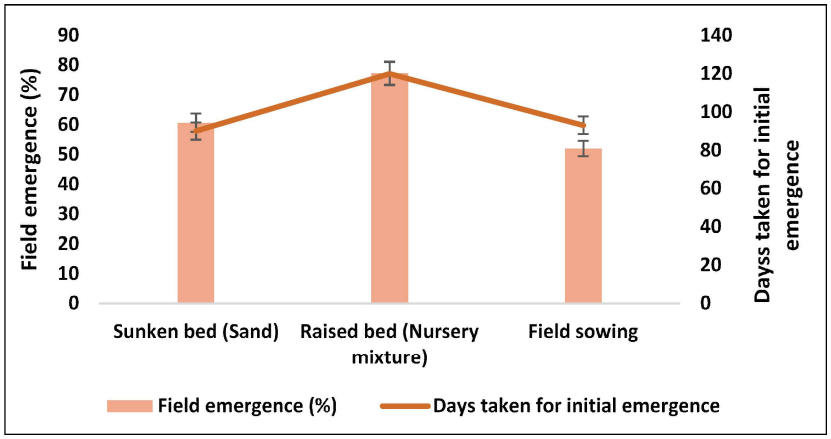


Fig 8: Effect of sowing condition and media on days taken for initial emergence and field emergence (%) of palmyrah seeds*.

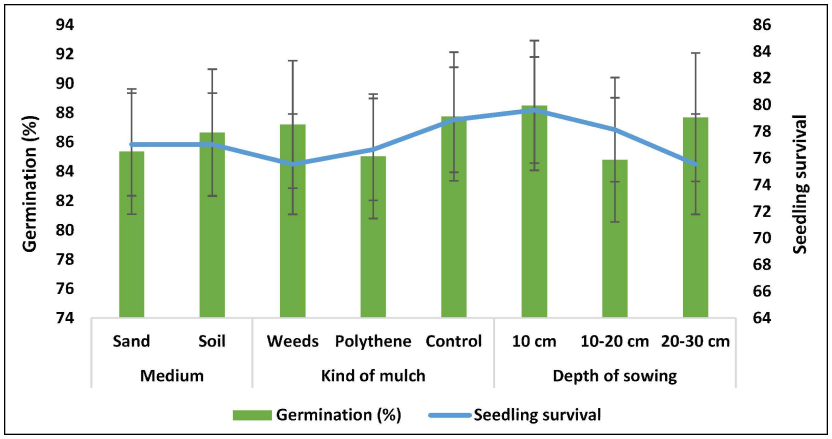


Fig 9: Effect of medium of nursery, kind of mulch and depth of sowing on seedling performance (Anonymous, 1985).

highest seedling height of 54 cm which was on par with bamboo tube (12.5 × 50 cm) as 42 cm.

A germination study was conducted using five soil types as sprouting media, including red, black, sandy, theri and alluvial soils. Among the different soil types, germination percentage (86.2%), tuber length (40.32 cm), girth (12.40 cm), weight (110.20 g) and starch content (98.5%) were recorded maximum in tubers, which sprouted in *theri* soil. *Theri* soil also gave low moisture content (48%) with moderate fiber (92%) (Ricard Kennady *et al*. (2021).

Anonymous (1985) studied the effect of nursery bed medium, mulching type and sowing depth on palmyrah. Observations on germination and survival of seedling were recorded over a period of 7 months. Sandy soil was found

Table 2: Effect of sowing condition and media on no of leaves/seedling and shoot length (cm) of palmyrah (24 months after sowing)*.

	No of leaves/ seedling	Shoot length (cm)	No of leaves/ seedling	Shoot length (cm)
T_1- Seed sowing in sunken bed containing sand	3.8	24.2	2.1	50.4
T_2- Seed sowing in raised bed containing red earth, sand and farmyard manure (2:1:1 ratio)	4.1	22.1	5.2	63.75
T_3- Seed sowing in field	3.2	23.5	9.6	62.3

*Mean of eight replications.

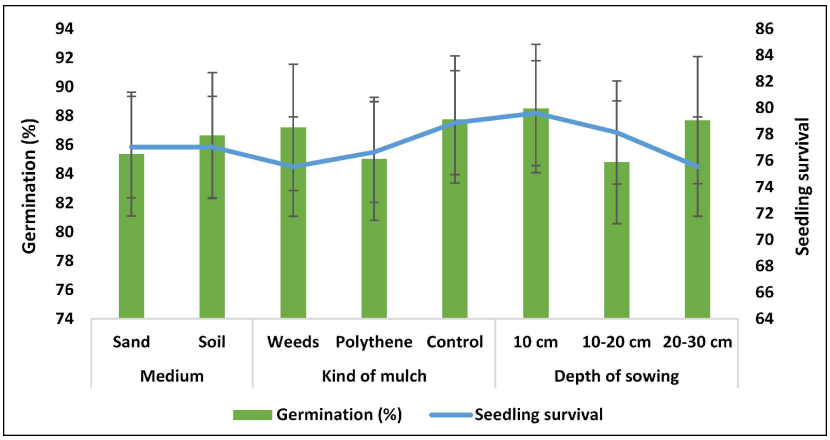


Fig 10: Effect of medium of nursery, kind of mulch and depth of sowing on seedling performance (Anonymous, 1985) of palmyrah.

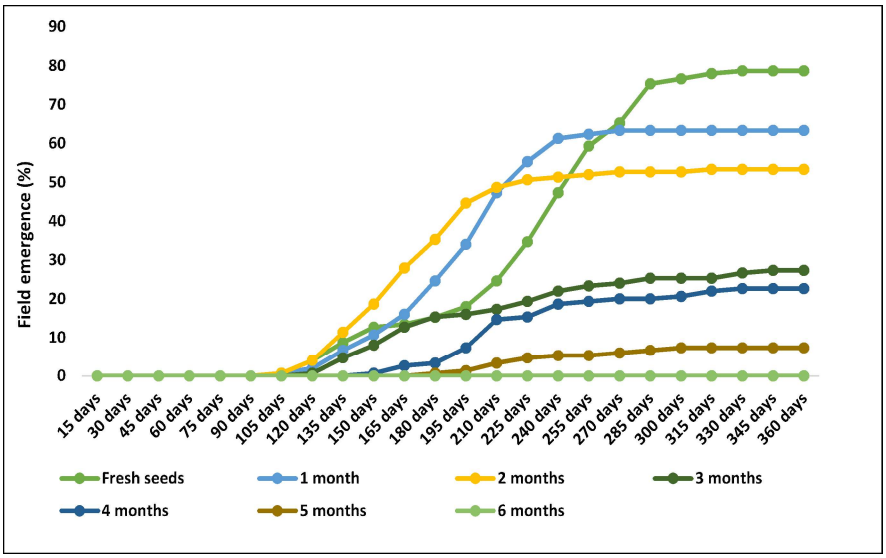


Fig 11: Effect of seed longevity period on field emergence (%) of palmyrah seeds (Masilamani *et al*., 2021).

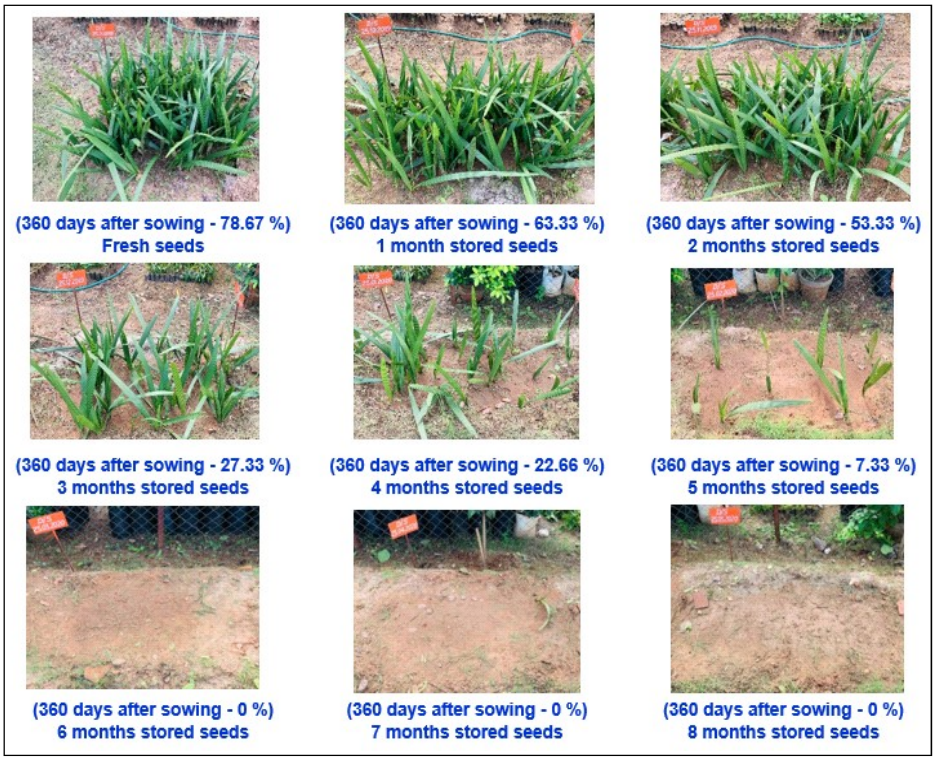


Plate 2: Palmyrah seeds monthly sowing in raised bed for one year.

to have a higher success rate of germinating seeds than pure sand, at 86.6% and 85.37% respectively. Seed germination was not significantly increased by mulching nursery beds with weeds or polythene sheets, with the control showing 87.8% germination. Sowing at 10 cm depth yielded 88.52% germination, outperforming other treatments (Fig 10).

Seed storage

Palmyrah seeds are slow to germinate due to the stony endocarp and it is unknown how long they can be stored without losing viability. Against the stalemate, Masilamani *et al*. (2021) discovered that fresh seed had the highest field emergence of 78.67%, followed by 1 month stored seed (63.33%) and 2 months stored seed (53.33%). Beyond 6 months, no emergence was observed. Seeds stored for one and two months took 105 days to germinate, whereas all other treatments had shorter emergence times. This results clearly indicated that fresh, one and two months stored seeds recorded significant effect on germination and it can be used for taking up sowing (Fig 11; Plate 2).

Conclusion

It is concluded that Palmyrah germination is of the remotive tubular type, the cotyledon elongating and burying the plumule and radical at a depth of 30-40 cm in the soil. It took 90-100 days for seedling emerging above the soil and its continued more than a year. The seeds can be stored for two months only without deterioration of viability. Highest field emergence was recorded in seeds sown in raised bed containing red earth, sand and farmyard manure (2:1:1) when compare to sand and field sowing in two year after sowing. Pre-sowing seed treatment with water or soaking in 1% cow dung solution for 24 hrs will increase the germination and field emergence of palmyrah.

Conflict of interest

All authors declare that they have no conflict of interest.

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