Seed Scarification Requirement in Doum (*Hyphaene thebaica* Mart.)

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Abstract:

Seed dormancy is a means to allow seeds to initiate germination when conditions are normally favorable for germination and survival of the seedlings. Dormancy can be regulated by the environment or by the seed itself. The seed dormancy may be due to unfavorable environmental conditions or sometimes, some seeds may not germinate because of some inhibitory factor of the seed itself. Dormancy of seed due to inhibitory factors, are either due to hard seed coat (external) or physical of physiological status of the interior of the seed. Seed dormancy in Doum palm (*H. thebaica Mart*) belongs to the first type. Tropical tree species that produces seeds with hard seed coat such as Doum which is a common component of flora of the southwestern Saudi Arabia are restricted in their distribution in the region because of the prolong dormancy and poor germination rate. The treatment methods for scarification proved effective to reduce dormancy in Doum seed. Seeds soaked in water showed much lower germination than the seed soaked in water after mechanical or chemical scarification. The highest germination percentage (93%) was recorded by mechanically scarified seed for 30 min and then soaked in water for 24 hours. The sulphuric acid treated seed resulted in a low germination percentage (32%). The results indicated that the impermeability of the seed coat of Doum seeds and the need to activate the growth of the embryo by soaking the seed in hot water are related to the environmental conditions which affect growth and distribution of Doum in southwestern Saudi Arabia.

Introduction :

Palms are extensively important to most of the world's population as providers of food and fiber, second only to the grasses that provide the grains (Ellison and Ellison, 2001). Palms not only provide aesthetic beauty, but play an important role in the urban environmental diversity of plant materials. They are an important part of the landscape nursery in warmer areas of the world and an important part of the interiorscaping industry in the Kingdom of Saudi Arabia. For many years, only a few palm species that were easily propagated were grown for both landscape and interior use.

Doum palm (*Hyphaene thebaica* Mart.) is a desert palm native to the Kingdom, sub-Saharan Africa and West India. It is known in the Kingdom which grow to 6 or 9 m and usually has forked stems with fan shaped leaves, 65-75 cm long. It is listed as one of the useful plants of the world (Fletcher, 1977). The trunks of the palm are used as part of construction, as well as for manufacture of various domestic utensils and the leaves are used to make mats, packing and writing paper. The oblong, yellow-orange apple sized fruit has a red outer skin, a thick, spongy and rather sweet fibrous fruit pulp (mesocarp) that tastes like gingerbread and a large kernel. Doum palm seeds have a hard seed coat under the fleshy fibrous pericarp.

In recent years, there has been a growing interest in palms, at commercial level, throughout the world. This has helped to stimulate interest in adding greater diversity in the palm species that are available for cultivation. Presently research in the Kingdom is oriented for the protection and propagation of endangered palms. There are over 2500 species of palms with more than 800 species in cultivation (Ellison and Ellison, 2001). More than 50 species have potential for cultivation in a desert climate and only 8 to 10 species are commonly propagated in the Kingdom of Saudi Arabia.

Palms are unique among woody ornamental plants since, with certain exceptions (date palm, oil palm), palm species can be propagated from seed. Delayed and uneven seed germination is common in nursery state. It has been estimated that over 25% of all palm species require over 100 days to germinate and they have less than 20% total germination (Banks and Marcus, 1999). The reasons for this remain obscure, as little research work has been accomplished on seed dormancy in palms.

Considering the slow and uneven seed germination factor of Doum treatments of seed before sowing that might enhance germination performance.

A fairly universal recommendation for enhancing germination been has to soak seed in water for 1 to 7 days. Such a pretreatment is useful only after dormancy requirements have been met, though few palm species have been tested for indications of seed dormancy (Broschat and Donselman, 1987). The seed must be planted immediately after the treatment. Storage may induce a secondary dormancy due to water imbibed during treatment. Not all species respond positively to a water soak treatment (Broschat and Donselman, 1987 and Rauch, 1998).

It is often recommended to reduce the hardness of seed coat mechanically or chemically to facilitate hydration (Moussa et al., 1998). Scarification of seeds involves thinning the endocarp of the seed which may impede imbibition of water. It may be accomplished mechanically, by abrading the surface of the seed until the endosperm becomes visible, or by soaking the seed in different concentrations of sulfuric acid (H_2SO_4) for 10 to 30 minutes. It has been shown that scarification increases the germination percent of palm seeds with water-impermeable hard endocarp (Nagao et al., 1980, Murakami and Rauch, 1998 and Banks and Marcuss, 1999). This method is recommended only for those seeds that are very hard to germinate, as damage to the embryo during the process can be high (Meerow, 1990). Scarification has also increased the rate of germination of a number of palm species with hard and water-impermeable seed coats (Holmquist and Popenoe, 1967; Nagao et al., 1980 and Odetola, 1978). The effect of mechanical or acid scarification is the damage to the embryo during the process.

In the present investigation, seed germination of Doum from southwestern Saudi Arabia was studied under experimental conditions to ascertain the effects of different conditions of soaking, mechanical and sulphuric acid scarification on germination.

Materials and Methods :

Behavior of seed germination of Doum (*H. thebaica* Mart.) has been studied under controlled conditions. Mature fruits were collected in the first week of March 2006 from plants growing in western Saudi Arabia from the trees that showed highest fructification. Fruits were scarified using acid, hot water, or mechanical abrasion. Seeds were acid scarified using sulfuric acid for 30 and 60 min. To assure uniform coverage, the acid was stirred with a glass rod. The acid was decanted and seeds were rinsed under running tap water for 2 hr. Acid-scarified seeds were then immersed for 24 hr in tap water. Hot water scarification was accomplished by immersing seed in tap water 90°C and finally allowed to cool for 24 hr. Mechanical scarification was done for 20 or 30 min using 60 grit, D-weight, aluminum oxide sandpapers (Abrasive Leaders and Innovators, Fairborn, OH). Lining a tube with the sandpaper and moving back and forth in a horizontal motion until the scarified surfaces of the seeds were clearly visible. For control the seeds were soaked in tap water for 24 hr.

The seeds were placed in plastic boxes with sand (60% of humidity, placing water according to weight in each three days). Boxes were arranged in a completely randomized design (CRD) on a mist bench (mist interval of 5 sec every 30 min for 10 hrs.). Four replicates were considered for each treatment. The greenhouse temperature ranged from 26.7 to 29.4C during the day and 18.3 to 21.1C at night. The experiment was conducted under natural photoperiod and irradiance. A seed was considered to have germinated when the radicle could be seen. Data for germination were recorded at the interval of three days and the germinated seeds were removed for plantation. The percentage of germination and the germination rate were evaluated until no further seeds germinated.

Counts continued for 70 days to allow calculation of total germination percent and time to 50% germination (T_{50}). The effects of scarification treatments on both variables were tested by the analysis of variance (ANOVA). Differences between treatments after ANOVA were carried out through means comparison contrasts. Inspection of residuals was carried out to check for normality and homoscedasticity. Date for germination percentage and rate were transformed (arcsine of square root and log respectively) prior to analysis. Means were separated using Duncans multiple range test at $P<0.05$ (Steel and Torrie, 1996).

Results and Discussion:

Seeds of many desert and semidesert plants fail to germinate because of the impermeable seed coat. The method of scarification was found to artificially increasing the permeability of an impermeable seed coat have been used in the earlier investigations (Escudero et al., 1997, Baskin and Baskin, 1998, Bewley, 1997, Keeley, 1991, Corral et al., 1990 and Cavanagh, 1980). Doum seeds present physical dormancy, as described by Moussa and Margolis (1998) and Davies and Pritchard (1998) due to hard seed coat which is impermeable to water. When the cover was broken using a mechanical scarification method which resulted in quick germination. Permeability in hard-coated seeds can be increased through artificial techniques (Van Assche et al., 2003), such as subjecting the seeds to chemical, thermal, mechanical or pressure techniques. Some of these mechanisms occur with high frequency under natural conditions, for example during wildfires, mechanical abrasion, digestion by birds and mammals, or soil temperature changes (Baskin and Baskin 1998).

The scarification treatments had an effect on reducing the dormancy of the seed and subsequent germination (Table 1). Percentage of seed germination was recorded as 19% in the control (no scarification). The seeds germinate when conditions are adequate perhaps because their seed coat is permeable to water. The seeds which did not germinate were not considered as dormant. Of the three treatments applied, soaking in hot water, produced the lowest germination values. Germination of hot water scarified seeds was lower than that of mechanically scarified seeds and almost similar to control.

Table (1)
Effect of scarification treatments on germination % and time to reach 50% germination (days).

Scarification treatment	%	T_{50}
Control	19e	> 70a
Acid for 30 min + soak in water 24 hr.	77c	11.6b
Acid for 60 min + soak in water 24 hr	85b	9.4b
Abrasion for 10 min + soak in water 24 hr.	91a	7.1c
Abrasion for 30 min + soak in water 24 hr.	93a	5.4c
Hot water + soak in water for 24 hr.	46d	> 70a

Means follow by the same letter in each column are not significantly different using Duncan multiple range test at the 0.05 probability level.

In the present experiment the mechanical and chemical treatments showed higher germination values than the hot water soaking, thus indicating that mechanisms related to seed coat breakage and dissolution such as abrasion, animal predation or the action of soil acids could be connected to increased seed coat permeability. At present, however, the literature provides little information on their effects.

The germination percentages and germination rates differed significantly among treatments (Table 1). Al treatments analyzed, produced significant differences in the cumulative germination percentage in relation to germination of seeds soaked for 24 hr.

Soaking the seeds in water for 24 hr did not increase germination capability (Table 1), as the cumulative germination percentage was 15.4%. In contrast, scarification with sulphuric acid for 30 minutes showed significant difference in germination capability of Doum seed which reached a value of 77%.

The germinability of untreated seeds was generally low (15.4%) the germination rate of untreated seeds was considerably slower than that of mechanically scarified seeds. The mechanical scarification of the seed coat resulted in a pronounced increase of germinability, with final germination was recorded 91% and 93% (Table 1), and the T_{50} values decreased to 7.1 and 5.4 days (Table 1). Hot water scarification also increased the final germination level. The germination rate of hot water scarified seeds was similar to that recorded by mechanical scarification but slower to some extent.

Under natural conditions a number of factors are acting alone or in combination for producing the crack of the tegumentary barrier. Temperature oscillation and the alternance of dry and wet periods (Van Assche et al., 2003, Egley, 1995 and Ungar, 1988), bacteria and other soil microorganism action, and the chemical scarification suffered throughout the herbivore digestive system (Pereiras et al, 1987).

Mechanical scarification via abrasion for 20 minutes improved the seedling emergence. A longer period of abrasion would probably have made the seed coat permeable to water since nicking the seeds permitted imbibition. Manual mechanical scarification of individual seed of Doum significantly improved seedling emergence or germination compared to the control. Seed placed in water at 90°C that was allowed to cool for 24 hr increased the seedling emergency but was not as effective as acid or mechanical scarification (Table 1). It is not similar to that of the greenhouse where temperature plays a significant role in reducing seedling emergence.

Scarification with sulphuric acid resulted in reducing germination rates compared to the germination of mechanically scarified seeds (Fig. 1.). In these treatments the T_{50} values were 11.6 and 9.4 days.

These differences in germination rates have been interpreted as a result of the effect of mechanical and chemical scarification pretreatments on the seed coat structures in species with hard coat seeds (Thanos et al., 1992). The slow germination rate of softened seeds by soaking in hot water has been previously considered as an obvious ecological advantage in the summer-dry climatic conditions (Norman et al., 2002 and Thanos et al., 1992). It could be interpreted as a delaying the mechanism which prevents germination under conditions of occasional rainfall during the summer and early autumn which do not provide enough moisture for subsequent establishment and growth.

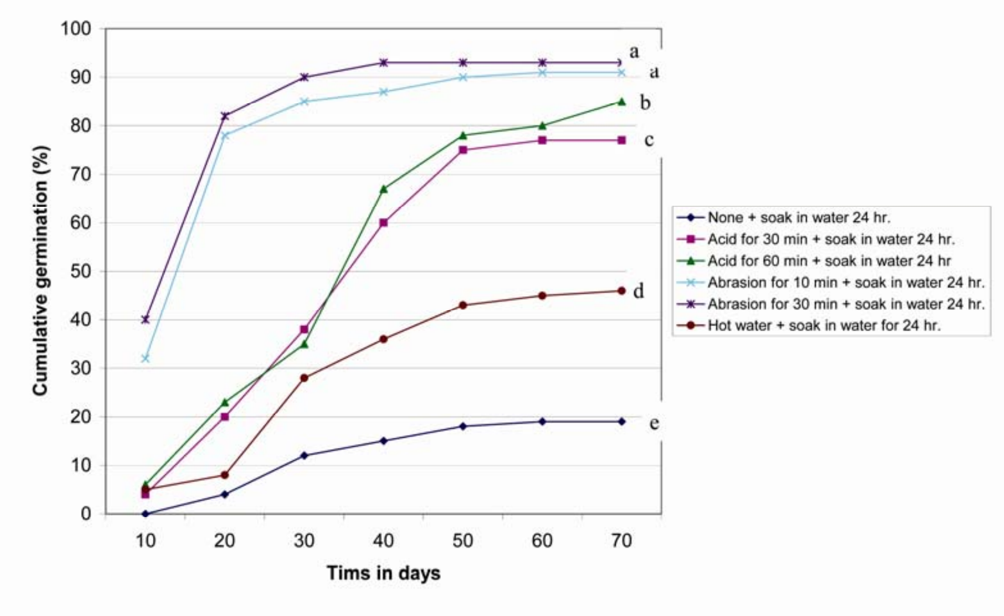

Fig. 1. Cumulative germination of Doum seeds. Germination is expressed as percentage of tested seeds. Different letters indicate significant difference ($P < 0.05$) between final germination after 70 days at the conditions in which seeds are germinated.

In conclusion, scarification treatments were one for the most effective methods for germinating Doum seeds. These treatments effectively overcome the dormancy and increased germination in Doum. Mechanical and acid scarifications were most effective for inducing germination are possibly a greater reflection of agents that stimulate germination in the soil. Thus scarification technique can be employed to propagate Doum for rehabilitation or horticulture programs and would be also effective in propagating congeneric rare species. Although, these treatments stimulated the germination of many seeds, those with physiological dormancy remained dormant. During storage these Doum seeds may not have received the environmental cues required to overcome dormancy and allow germination in response to the treatments tested.

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احتياجات بذور نخيل الدوم للخدش الميكانيكي

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الملخص :

يعد سكون البذور من العوامل التي لا تسمح بإنبات البذور إلا في حالة توفر الظروف البيئية الملائمة للإنبات ونمو البادرات. وقد يكون سكون البذور لأسباب بيئية أو لعوامل تتعلق بالبذور نفسها. حيث تدخل البذور في مرحلة السكون إذا كانت الظروف البيئية غير ملائمة أو في بعض الأحيان لا تنبت بعض البذور لوجود عوامل مثبطة للإنبات. هذا النوع من السكون يعود إلى سببين رئيسيين هما وجود الأغلفة الصلبة أو عوامل داخلية مثبطة للإنبات في مكونات البذرة. يعزى سكون بذور الدوم للسبب الأول. يتأثر توزيع النباتات التي لها بذور صلبة الأغلفة كنخيل الدوم والذي يعد أحد مكونات الفلورا النباتية الهامة في الجنوب الغربي للمملكة العربية السعودية، ويكون محدوداً بدرجة كبيرة نتيجة للتأثير السلبي للأغلفة الصلبة على امتصاص الماء ودخول الأوكسجين، كما أ نها تقاوم نمو الجنين. تحتاج مثل هذه البذور لمعاملة لرفع معدل الإنبات وانتظامه. هناك عدة طرق أثبتت فعاليتها لكسر سكون بذور الدوم. حيث أن نقع البذور التي لم يتم دخش أغلفتها، أعطى أدنى القيم مقارنة بالبذور التي تم نقعها بعد خدش البذور ميكانيكياً أو معاملة البذور كيميائياً. سجل أعلى معدلات الإنبات (٩٠٪) لبذور الدوم عند خدش البذور ميكانيكياً لمدة نصف ساعة ونقعها في الماء لمدة ٢٤ ساعة. أما معاملة بذور الدوم بحمض الكبريتيك فأعطت نسبة إنبات منخفضة (٣٢٪).

أشارت النتائج إلى ارتباط نفاذية بذور الدوم والحاجة إلى تشجيع وتسريع نمو جنين البذرة بنقع البذور في الماء الساخن بالظروف البيئية السائدة في الجنوب الغربي للمملكة العربية السعودية التي تحد من نمو وانتشار الدوم بهذه المنطقة.