CELL BIOLOGY & DEVELOPMENT
Volume 2, Number 2, December 2018
Pages: 63-68
E-ISSN: 2580-4499
DOI: 10.13057/cellbioldev/v020203

Date palm (*Phoenix dactylifera*) seeds germination

NAJWA MOHAMMED IDRISE MOHAMMED, ABDEL GAFFAR ELHAG SAID
Department of Horticulture, College of Agricultural Studies, Sudan University of Science and Technology. Shambat, Khartoum, Sudan.
Tel.: +249-18-379-6852

Manuscript received: 28 September 2018. Revision accepted: 24 December 2018.

Abstract. *Mohammed NMI, Said AGE. 2018. Date palm (*Phoenix dactylifera*) seeds germination. Cell Biol Dev 2: 63-68.* This study aimed to examine if pre-germination treatments could effectively promote date palm (*Phoenix dactylifera* L.) seed germination in the Nursery of the Horticultural Sector, Ministry of Agriculture and Irrigation, Khartoum, Sudan. Seeds were soaked in water for 0, 2, 4, 6, 8, 10, and 12 days before being planted in one of the following media: sand:clay (1:1), sand:clay (1:2), sand:clay (1:0), sand:clay (0:1), and sand:clay (2:1). The factorial completely randomized block design was employed in this investigation. The 6-day soaking time resulted in the highest percentage of seeds germinating; as the soaking time increased, the percentage of seeds germinating decreased. The 6-day soaking time also improved seed germination, allowing for a 50 % final germination percentage in the shortest time. Sowing seeds in a 2:1 soil mix decreased germination days, resulting in a substantial increase in germination percentage compared to other soil type mixes evaluated, regardless of soaking duration. In addition, seeds soaked for 6 days and planted in a 2:1 soil mix produced the tallest seedlings.

Keywords: Acceleration, date palm, *Phoenix dactylifera,* seeds germination

INTRODUCTION

The date palm (*Phoenix dactylifera* L.), a member of the Arecaceae (Palmae) family, is an important plantation crop in many desert countries in West Asia and North Africa. Almost every portion of the plant is used to produce food or industrial goods. In many developing countries, it plays a significant role in rural communities. Dates are grown in arid climates around the world and sold as a high-value confectionery all over the world (Mahmoudi et al. 2008)

It is one of the world's oldest cultivated plants, dating back over 6,000 years, and is said to be the world's oldest food plant. Many people in arid and semi-arid regions rely on dates for social, environmental, and economic reasons. Due to its hardy plant characteristics and deep root system, it grows well in poor desert soils (Chandra et al. 1992; Sharma and Singh 2013). It was found in the Middle East, North Africa, South Sahel areas, East and South Africa, the South Western United States, Central and South America, and South Western Europe. In 2010, global date production was estimated to be around 7.4 million tons (FAOSTAT 2011). The Arab world accounts for over 70% of total date production. Around 3,000 identified date palm varieties worldwide, while some names are likely synonyms, resulting from a local or national name given to one cultivar that also occurs in another region under a different name (Johnson 2011).

Dates are grown in North Africa and the Middle East and have recently been brought to new production locations in Australia, India/Pakistan, Mexico, South Africa, South America, and the United States. North Africa and the Middle East, Southern Africa, Australia, India/Pakistan, Palestine, Mexico, South America, and the United States are commercial date palm growing countries of the world (Zohary and Hopf 2000; Abd Rabou and Radwan 2017).

Egypt, Saudi Arabia, Iran, the United Arab Emirates, Pakistan, Algeria, Sudan, Oman, Libya, and Tunisia are the top 10 producing countries. Thousands of date palm cultivars are grown in these nations, including soft, semi-dry, and dry fruits (depending on their water and sugar content at harvest when completely ripe) (Kader and Hussein 2009). The Arab countries own most of the world's date palms and produce most of the total date harvest (FAOSTAT 2009). The importance of date palm culture for its high nutritional, economic, and social qualities is well known, particularly in arid and semi-arid environments where it plays a vital role in influencing microclimate and enhancing the production of other agricultural commodities. As a result, date production, use, and industrialization are all on the rise worldwide (Botes and Zaid 2002).

The date palm is the most important fruit tree in the northern region of Sudan. It has been cultivated there for 3,000 years, and it helps people in northern Sudan make a living (Osman 2001). Although some scattered date palm populations occur in oasis areas in North Kordofan and Darfour, as well as in the eastern section of the country, date palm culture in Sudan is centered along the River Nile banks between latitudes 15.5° and 22° N in River Nile and Northern State (Elshibli and Korpelainen 2008). Sudan produced approximately 119.048 metric tons of date palm fruits in 2010 (FAOSTAT 2011). The date palm industry of Sudan is based on the cultivation of old traditional dry, soft, and semi-soft varieties. Barakawi, Gondaila, Tamoda, and Abdel Rahim are the most important indigenous dry cultivars, while Mishrig Wad Khateeb and Mishrig Wad Laggai are the most important indigenous soft cultivars.

Furthermore, many trees (farmer's varieties) that grow from seeds are collectively called Jaw, signifying that they are seedling varieties (Osman and Boulos 1978).

The following are the three ways for propagating date palms: Seed propagation: seed propagation is undesirable since it results in a differentiated population in which no two palm seedlings are alike, reducing the likelihood of producing high-quality fruit (Pieniążek and Pieniążek 1981; Moustafa et al. 2010). Offshoot propagation is the most common way of propagating date palm trees, whether male or female. Axillary buds on the trunk of a palm tree produce offshoots. First, a professional and qualified laborer must separate date palm offshoots from the mother palm. Then, offshoots are planted in their permanent location in the orchard to grow as new and distinct individuals (Alihouim and Dialami 2010). Finally, tissue culture propagation is a new technique for mass propagation of date palms that uses three different types of tissue culture: shoot tips and buds culture (organogenesis), embryo culture (embryogenesis), and highly differentiated somatic tissues culture that includes leaf, stem, inflorescence, and root sections (Al-Sakran and Muneer 2006).

The main issues with date palm seed propagation are genetic variability and sex ratio, as 50:50 male:female plants are usually generated. It isn't easy to distinguish between male and female trees before flowering. As a result, seed trees are frequently delayed in reaching the flowering stage, and the price of seed propagated tree fruits is frequently low (www.moa.gov.jo/portals). The benefits of date palm seed propagation include obtaining tree stallion, ornamental and windbreaks, resistance to diseases such as eggs cillnesstreese, and specific education such as pollination and hybridization (www.paaf.gov.kw/paaf/ershad/jsp). This study evaluated the effects of water soaking and the planting medium on germination percentages and the days required to achieve 50% final germination on the seeds of the "Barakawi" date palm cultivar.

MATERIALS AND METHODS

Experiments were carried out in the Department of Horticulture, Ministry of Agriculture and Forestry, Al-Mogran, Khartoum, Sudan (Latitude 35°- 15° N; Longitude 33°- 32 °E) utilizing seeds of the "Barakawi" date palm cultivar. Following harvesting, the "Barakawi" fruits were acquired from Khartoum North's Central Market wholesaler. The "Barakawi" cultivar was chosen as a seed source in this research because of its economic value and availability. Seeds were removed, rinsed, and dried under running tap water. Next, the seeds were visually selected for the study based on size homogeneity to reduce potential seed size effects and stored in plastic bags at room temperature until use. There was no pre-treatment applied to the seedlings. Before sowing, all selected seeds were soaked for 0, 2, 4, 6, 8, 10, or 12-days in tap water in a 3-gallon plastic bucket at room temperature; a total of 6 soaking cycles plus unsoaked seeds as a control. Seeds were planted in sand:clay (1:1), (2:1), (1:2) (0:1), and (1:0) mixture (v/v) planting media after the soaking treatments. Every day, the soaking water was changed. Next, 20 seeds were counted out for testing for each treatment. In perforated 27x24x7-cm black plastic bags, 15mm-deep and 3 to 4 cm apart, the sums of 5 soaked seeds were sown on the surface of each medium. Twenty seeds were used in each treatment (5 seeds x four replications). After seeding, the bags were placed in a lath house with natural daylight and day length. Watering was done by hand with tap water every other day, and no fertilizer was used.

A two-way factorial randomized complete block design (RCBD) was used, with each treatment replicated 4 times, with 5 seeds per replication. Twenty seeds were used in each treatment (5 x 4 replications). When the cotyledonary petiole emerged above soil level and was visible to the naked eye, the seed was considered to have germinated. Seeds with visible cotyledonary petiole protrusion through the medium surface were counted daily for germination. The daily germination counts were used to calculate the total germination percentage (G) and mean emergence time (days to 50% of total germination T50). All observations were made with a total of 20 seeds per treatment. The percentages represent the percentage of seeds that germinated. On the Excel computer program, data were subjected to an analysis of variance procedure. At the 5% level, Duncan's multiple range test was used to separate treatment means.

Forty days after seeding, the number of germinated seeds (daily germination counts) was recorded daily and continued for two months after germination. The ratio of germinated seeds to the total number of seeds planted was used to calculate the total germination percentage.

Total germination % (G)

% = ta/a x 100

Where,
%: germination percent.
Ta: total number of germinated seedlings
A: total number of seeds

Days to achieve 50% of the germination percentage.

The number of days required for the germination percentage to reach 50%.

Seedling length

The mean was derived by randomly picking two seedlings from each treatment to measure the length of each seedling. A meter ruler was used to measure the length in centimeters.

RESULTS AND DISCUSSION

Because date palm seeds are genetically heterozygous, there was a lot of diversity in emergence percentages across seeds for each treatment. However, there were clear disparities in response between the treatments for all measured measures. The amount of seed reaction to water soaking varied depending on soaking time and planting medium, and seed response competence to water soaking decreased as soaking time increased.

Final germination percentage

Table 1 depicts the effect of water soaking duration and sowing media type on the total germination percentage of seeds of the date palm cultivar "Barakawi." With increasing treatment time, the degree of the response to water soaking changed. Over all other pre-water soaking methods examined, the 6-day water pre-soaking led to a considerable increase in total germination percentage (88%). The percentage of germinated seeds increased as the water pre-soaking duration increased from 0 to 6 days. However, When you soak your seeds in water for an extended time, the percentage of seeds germinating decreases. Seeds soaked for 8 days or longer had significantly lower germination percentages than seeds for 6 days. With seeds treated for 12 days, the lowest total germination percentage figure (69%) was recorded. No significant differences existed between the 6-days and 8-days water soaking treatments. After an 8-days soak, the average germination percentage dropped significantly. There were significant variances between the sowing media.

There were no significant variations in total germination percentages between the 1:0 and 2:1 sand:clay mix sowing media, although both sowing media resulted in a considerable increase in total germination percentage compared to other sowing medium types. Seeds are sown in 1:0 sand:clay sowing medium had the highest germination rate (86%), followed by seeds sown in 2:1 sand:clay sowing medium with an 83 percent germination percentage, with no significant difference between the two types of media. Seeds grown in a 0:1 sand:clay medium type had the lowest germination percentage (72%). The germination percentages of the 1:2 and 0:1 sand:clay soil mixes were comparable.

Table 1. Effect of time of water soaking and type of sowing medium on total emergence percentage (%) of seeds of "Barakawi" date palm cultivar

Medium type	Soaking duration (days) 0	2	4	6	8	10	12	Medium mean
Sand: clay	50.20	50.20	52.20	52.00	69.25	75.00	86.25	62.18b
(0: 1)	B	b	b	b	b	b	b	
Sand: clay	52.00	52.50	46.70	51.20	52.00	54.50	67.25	53.75b
(1: 2)	B	b	b	b	b	b	b	
Sand: clay	39.00	38.20	44.20	39.00	42.00	51.25	56.50	44.32b
(1: 0)	B	b	b	b	b	b	b	
Sand: clay	47.70	46.20	48.00	44.00	57.50	51.00	64.00	51.21b
(1: 1)	b	b	b	b	b	b	b	
Sand: clay	45.50	47.50	43.00	41.20	51.25	56.25	65.00	49.96a
(2: 1)	a	a	a	A	a	a	a	
Soaking	46.90	46.95	46.80	45.50	54.40	57.60	57.80	
mean	a	a	a	A	a	a	a	

Note: Means followed by the same letter (s) are not significantly different at P = 0.05, according to Duncan's Multiple Range Test. Percent data were transformed to the square root of the arcsine of the proportion for analysis. All observations were based on 20 sown date palm seeds per treatment. The percentages refer to the proportion of the seeds that germinated

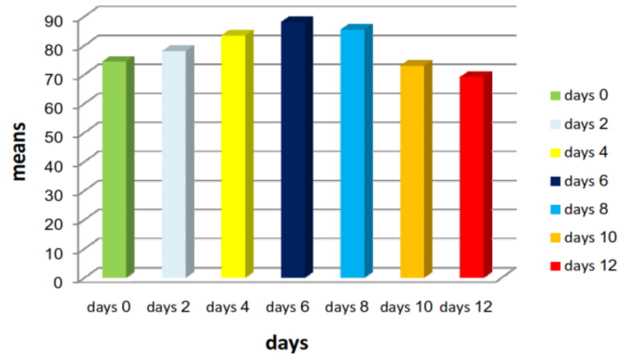

Figure 1. Effect of time of water soaking on total emergence percentage (%) of seeds of "Barakawi" date palm cultivar

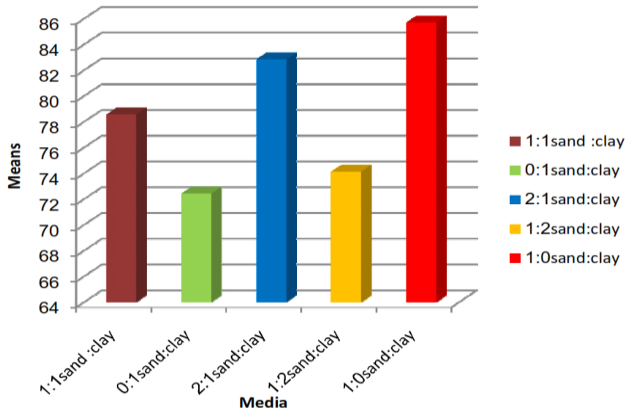

Figure 2. Effect of time of water soaking on total emergence percentage (%) of seeds of "Barakawi" date palm cultivar

Days to 50% germination

The results of the impacts of the period of seed soaking in water before sowing in different soil media on days to achieve 50% (T50) of final germination percentage were shown in Table 2. The 6-days water soaking treatment required the fewest days to accomplish 50% germination of the final germination percentage (45 days). In contrast, the 8-days water soaking treatment required the most days for the growing seeds to reach 50% germination of the final germination percentage (68 days). For seeds submerged for 8 days, a longer soaking duration delayed germination by prolonging T50 values with additional days. Mean days required for germination declined as soaking time in the water was lengthened from 7-days to 12-days. Seeds soaked for more than 6 days of water soaking time required a longer time to germinate than those soaked for 6 days or less water soaking time. Differences among seeds soaked for 6 days and less were no-significant. Irrespective of soaking duration, the1:0 sand: clay soil mix significantly decreased the number of soaking days required by seeds to achieve T50 final germination relative to the other sowing media tested, whereas 44 days were required to achieve T50 of final germination percentage. Other examined soil mixtures resulted in T50 durations. Seeds planted in 0:1 sand:clay required the most days (62 days) to achieve T50 of final germination percentage than seeds planted in other tested soil mixes.

Table 2. Effect of time of water soaking and type of sowing medium on number of days required to achieve 50% final emergence percentage of seeds of "Barakawi" date palm cultivar

Medium type	Soaking duration (days) 0	2	4	6	8	10	12	Medium mean
Sand: clay (0: 1)	50.20 b	50.20 b	52.20 b	52.00 b	69.25 b	75.00 b	86.25 B	62.18b
Sand: clay (1: 2)	52.00 b	52.50 b	46.70 b	51.20 b	52.00 b	54.50 b	67.25 B	53.75b
Sand: clay (1: 0)	39.00 b	38.20 b	44.20 b	39.00 b	42.00 b	51.25 b	56.50 B	44.32b
Sand: clay (1: 1)	47.70 b	46.20 b	48.00 b	44.00 b	57.50 b	51.00 b	64.00 B	51.21b
Sand: clay (2: 1)	45.50 a	47.50 a	43.00 a	41.20 a	51.25 a	56.25 a	65.00 A	49.96a
Soaking Mean	46.90 a	46.95 a	46.80 a	45.50 a	54.40 a	57.60 a	57.80 A	

Note: Means followed by the same letter (s) are not significantly different at P = 0.05, according to Duncan׳s Multiple Range Test

Table 3. Effect duration of water soaking and type of sowing medium on lengths of date palm "Barakawi" seedlings (week's cm) after sowing

Medium type	Soaking duration (in days) 0	2	4	6	8	10	12	Medium mean
Sand: clay (0: 1)	21.25 b	21.40 b	22.36 b	22.72 b	22.64 b	22.56 b	22.34 b	22.18b
Sand: clay (1: 2)	22.10 b	22.43 b	22.17 b	22.15 b	22.26 b	21.93 b	22.51 b	22.22b
Sand: clay (1: 0)	22.84 b	23.10 b	21.66 b	22.66 b	22.34 b	22.15 b	20.44 b	22.17b
Sand: clay (1: 1)	22.80 b	22.26 b	22.35 b	22.48 b	23.10 b	22.70 b	21.10 b	22.40b
Sand: clay (2: 1)	24.76 a	25.59 a	26.01 a	26.03 a	24.15 a	24.53 a	25.90 a	25.28a
Soaking Mean	22.75 a	22.95 a	22.91 a	23.20 a	22.90 a	22.77 a	22.46 a	

Note: Means followed by the same letter are not significantly different at P = 0.05, according to Duncan Multiple Range Test

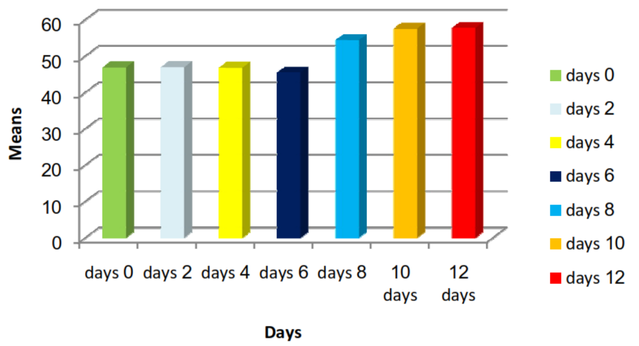

Figure 3. Effect of time of water soaking on number of days required to achieve 50% final emergence percentage of seeds of "Barakawi" date palm cultivar

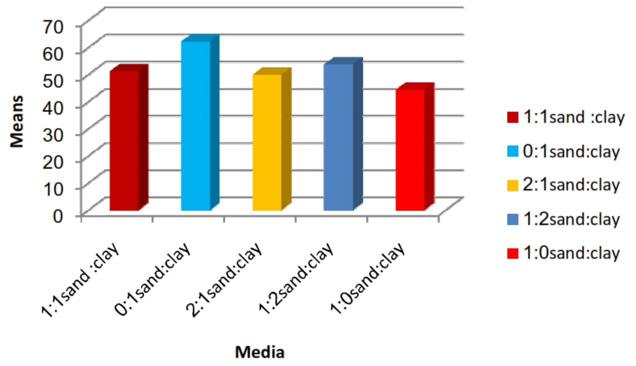

Figure 4. Effect of type of sowing medium on number of days required to achieve 50% final emergence percentage of seeds of "Barakawi" date palm cultivar

Seedling length (cm)

Soaking time treatments had little effect on seedling length. There was no discernible variation in seedling length between the soaking times investigated. With substantial differences from the other media types studied, seeds were sown in 2: 1 sand: clay sowing medium produced the tallest seedlings (25 cm) regardless of soaking time. Table 3 shows no significant difference in seedling length recorded for the other tested media types.

Discussion

The primary morphogenic response evaluated in this study was germination. Date palm seed propagation efforts might benefit from information on seed germination requirements and effective dormancy-breaking procedures. Several attempts have been made to expedite palm seed germination and enhance total germination percentage (Rees 1963; Homquist and Popenoe 1967; Said 1986; Carpenter 1987; Al-Wasel and Warrag 1998). Because soaking is excellent in promoting germination and raising germination percentage, Rees (1963) recommends pre-soaking in water before sowing to enhance palm seed germination. According to our findings, date palm seeds treated for 6 days sprouted substantially faster and with a higher germination rate. Compared to other water-soaking treatments, the day's duration promoted the highest overall germination (88%) and fewer days (45) to 50% of final germination. In addition, at 6 days of water soaking time, the total germination percentage was higher, earlier, and more uniform than most other studied water soaking treatments. Previous studies with date palm seeds (Samarawira and Osuhor 1981; Olumekun and Remison 1985; Abdullah and Maroff 2007) and seeds from other palm species (Loomis 1958; Rees 1963; Nagao and Sakai 1979; Carpenter 1987) have shown that soaking seeds in water before sowing increased total germination percentage and shortened germination time. For resumption of germination, sufficient water and oxygen permeate freely via the operculum and the micropyle opening into the seed. Others have reported (Al-Wasel and Warrag 1998; Carpenter et al. 1993) that mechanical removal of the operculum (embryo cap) of palm seeds alleviated the physical dormancy imposed by the embryo cap, resulting in a significant increase in total germination and a reduction in germination time, most likely by facilitating water and oxygen diffusion. Replacement of the soaking water once every two days during seed preparation for sowing dilutes and removes germination inhibitors from the seed coat. Water imbibition through the micropyle opening softens the operculum, which is then easily ruptured by the elongating embryo without the risk of embryo damage raised by Al-Wasel and Warrag (1998).

The amount of time a seed takes to absorb enough moisture for germination varies depending on the plant species and the amount of water available. The ideal water soaking length for maximal total germination in date palm seeds ranges from 2 days (Abdullah and Maroff 2007), 3 days (Samarawira and Osuhor 1981), and over 4 days (Olumekun and Remison 1985). Differences in cultivars, developmental stage of source fruits, age of seeds and source, sowing media, and ambient variables at the study site could all contribute to inconsistencies. The most uniform and quick germination happened after 6 days of water soaking. The 6-day soaking period appears to be the bare minimum for "Barakawi" seeds to achieve optimum moisture imbibition, allowing the embryo to remove the operculum mechanically. Increased soaking time resulted in a significant decrease in germination percentages, indicating that "Barakawi" seeds have a narrow water imbibition range for maximum moisture for germination. It's also possible that the effect of water soaking on date palm seed germination is primarily related to the operculum's physical, structural weakening rather than biochemical changes in the embryo or endosperm.

The ability to respond to soaking time decreases as the soaking time increases. The progressive decline in germination percentage and delay in germination speed found when seeds were soaked for longer than 7 days is consistent with a previous observation on seed germination (Maekawa and Carpenter 1991), which shows that increased free water in the planting medium causes a progressive decline in total seed germination percentages and rates. That could be due to the thickening of the micropyle wall and expanding with increased soaking time, resulting in a progressive reduction in the micropyle opening and limiting cotyledonary sheath protrusion via the micropyle opening. Maekawa and Carpenter (1991) hold a similar viewpoint, claiming that when the free water content of the germination substrate increases, seed germination decreases as the micropyle walls thicken and the micropyle opening of the seeds decreases. It's also likely that the prolonged water soaking time had a negative impact on germination by disrupting several physiological processes required for germination. The negative effects of prolonged water soaking on seed germination could, however, be connected to the destruction of the germ pore and/or embryo of some seeds that failed to germinate due to infection with rot-causing soil bacteria before and/or after they began to germinate. Water logging causes, on the other hand, cannot be ruled out as a cause of the harmful effects of prolonged water soaking. The progressive drop in germination percentage could have been caused by suffocation and specific growth inhibitors (s) production during extended water soaking.

The sowing medium is an important factor in the proper germination of seeds. Successful seed germination depends on selecting suitable soil and its proper care. Sands or sand and clay mixtures are commonly used as sowing media for seed germination. According to the current findings, date palm seeds germinate best on a 1:0 sand: clay combination. These findings are similar to those of Banks and Marcus (1999), who recommended utilizing well-drained soil mixes with some moisture-holding capability for palm seed germination. Total germination percentage was higher with a medium of 1: 0 mixtures by volume of sand and clay than the other media evaluated in response to the sowing medium. The 1:0 sand:clay mixture allows rapid and equal water penetration throughout the medium while also regulating moisture reserves and improving aeration. The capacity of date palm seeds to germinate reduces as the clay volume in the sowing media increases compared to sand. The removal of sand from the sowing medium had a substantial negative effect, implying that soil oxygen levels in high clay percentage sowing mediums are restricting or that carbon dioxide or other gas levels are too high for germination. Adding sand to the sowing medium enhanced aeration and decreased water retention, which appears to be due to enhanced drainage and/or aeration compared to the other media evaluated and rapid and uniform water penetration throughout this soil mix medium. This hypothesis is consistent with Hartmann et al. (2002) 's suggestions for using well-drained media for various greenhouse growth goals. Said (1986) arrived at identical findings and had similar results. The findings are consistent with Bani (1988) and Azad et al. (2011), which found that using sand as a rooting medium resulted in a higher total rooting percentage, faster root emergence, longer roots and shoots, and higher survival of rooted cuttings compared to a variety of other horticultural substrates tested.

Soaking treatments had little effect on seedling length. The 6-days soaking treatment, on the other hand, had a non-significantly higher value than the other soaking treatments examined. The lack of effect of soaking treatments on seedling length may be due to competition for assimilates between the newly developed apical meristem of the shoot and the leaf blades (source-sink relationship). With a growing shift in assimilating translocation germination to the meristematic area, growth can be controlled separately from germination right after germination. Soaking triggered metabolic and physiological mechanisms that allowed the embryo to resume active development. The water-soaking treatments have no carry-over effect from seed germination to seedling growth and development.

Seedlings grew the longest in a medium containing a 2:1 ratio of sand and clay by volume compared to the other media examined. Compared to the other media examined, the enhanced seedling duration with this medium could be attributable to rapid and consistent water penetration throughout the medium, high moisture reserves, improved drainage and/or aeration, and high organic matter.

As a result, it is possible to assume that soaking seeds in water helped date palm seeds overcome their intricate dormancy. Soaking date palm seeds for a week as a presowing treatment seems to be a potential method for speeding up and improving total germination. The technique could be used to design a generalizable seed germination approach for additional plant species. It proved simple, quick, efficient, economical, straightforward, repeatable, and can be practiced year-round. However, more study is needed to maximize total germination percentages and reduce the days required for germination to build a commercially viable system.

REFERENCES

Abd Rabou AN, Radwan ES. 2017. The current status of the date palm (*Phoenix dactylifera*) and its uses in the Gaza Strip, Palestine. Biodiversitas 18: 1047-1061. DOI: 10.13057/biodiv/d180324.

Abdullah G, Maroff A. 2007. The influence of a few gibberellins levels on the seed germination and the growth of seedlings of three varieties of date palm (*Phoenix dactylifera* L.) Proceedings of the International Conference on the Technology of Horticultural Productivity for Sustainable Development and Biodiversity, Alepo, Syria.

Alihouim, Dialami H. 2010. Effect of offshoot wright on establishment and vegetativegrowth in 'Sayar' Date Palm. Acta Hort 882: 755-759. DOI: 10.17660/ActaHortic.2010.882.83.

Al-Sakran MS, Muneer SE. 2006. Adoption of date palm tissue culture technology among date palm producers in the Central Region of Saudi Arabia. Research Bulletin No. 145. Agricultural Research Center, Faculty of Food Sciences and Agriculture, King Saud University, Riyadh.

Al-Wasel AS, Warrag MOA. 1998. Effect of fruit developmental stage, seed scarification and operculum removal on seed germination of date palm. J King Saud Univ Agric Sci 10 (2): 153-161.

Azad MS, Rahman MT, Matin MA. 2011. Seed germination techniques of *Phoenix dactylifera L*: A new experience from Bangladesh. Front Agric Chin 5 (2): 241-246. DOI: 10.1007/s11703-011-1086-2.

Bani YA. 1988. Vegetative Propagation of Some Horticultural Plants. [M.Sc. thesis]. University of Khartoum, Shambat, Sudan.

Banks K, Marcus J. 1999. A practical guide to germinating palm seeds. Palms J Intl Palm Soc 43 (2): 56-59.

Botes A, Zaid A. 2002. The economic importance of date production and international trade In: Zaid A (eds). Date Palm Cultivation. FAO Plant Production and Protection Paper No. 156. Food and Agriculture Organization of the United Nations, Rome.

Carpenter WJ, Ostmark ER, Cornell JA. 1993. Embryo cap removal and high temperature exposure stimulate rapid germination of needle palm seeds. HortScience 28: 904-907. DOI: 10.21273/HORTSCI.28.9.904.

Carpenter WJ. 1987. Temperature and imbibition effects on seed germination of Sabal palmetto and Serenoa ripen. HortScience 22: 660.

Chandra A, Chandra A, Gupta IC. 1992. Date Palm Research in That. Desert Scientific Publisers, Jodhpur.

Elshibli S, Korpelainen H. 2008. Microsatellite markers reveal high genetic diversity indate palm (*Phoenix dactylifera L.*) germplasm from Sudan. Genetica 134: 251-260. DOI: 10.1007/s10709-007-9232-8.

FAOSTAT. 2009. Crop Production 2008. Statistics Division, Food and Agriculture Organization of theUnited Nations, Rome.

FAOSTAT. 2011. Crop production 2011, Statistics Division, Food and Agricultureorganization of United Nations.

Hartmann HT, Kester DE, Jr Davies FT, Geneve RL. 2002. Plant Propagation Principles and Practices. 7th Edition. Prentice Hall, Inc., Upper Saddle River, New Jersey.

Homquist J de D, Popenoe J. 1967. Germination experiments: The effect of scarification on the germination of seeds of *Acrocomia crispa* and *Arengengleri*. Principes 11: 23-25.

Johnson DV. 2011. Introduction: Date palm biotechnology from theory to practice. In: Jain SM, Johnson DV, Alkhayri JM (eds). Date Palm Biotechnology. Springer, The Nederlands. DOI: 10.1007/978-94-007-1318-5_1.

Kader AA, Hussein AM. 2009. Harvesting and Post-Harvest Handling of Dates. International Centerfor Agricultural Research in the Dry Areas (ICARDA), Nairobi.

Loomis HF. 1958. The preparation and germination of palm seeds. Principles 2: 98-103.

Maekawa S, Carpenter WJ. 1991. Verbena seed hilum morphology contributes to irregular germination. HortScience 26: 129- 132. DOI: 10.21273/HORTSCI.26.2.129.

Mahmoudi H, Hosseininia G, Azadi H, Fatemi M. 2008. Enhancing date palm processing, marketing and pset control throughorganic culture. J Orag Syst 3 (2): 29-39.

Moustafa AA, Ibrahim ZA, El-Yazel SAS, El-Anver MA. 2010. Evaluation and selection of some seedling date palm males grown in Fayoum Governorate, Egypt. Acta Hort 882: 69-79. DOI: 10.17660/ActaHortic.2010.882.7.

Nagao MA, Sakai WS. 1979. Effect of growth regulators on seed germination of *Archonlophoenix alexandrea*. HortScience 14: 182-183.

Olumekun VO, Remison SU. 1985. The effects of soaking, heat treatment and growth regulators on the germination of date palm (*Phoenix dactylifera* L.). J Nigerian Inst Oil Palm Res 7 (1): 107-119.

Osman AMA, Boulos NN. 1978. Evaluation of some Sudanese date cultivars. ActaHortic 84: 185-190. DOI: 10.17660/ActaHortic.1978.84.21.

Osman AMA. 2001. Development of date palm culture in Republic of Sudan. Paperpresented at a workshop on date palm culture and dates production in Republic of Sudan. Date Palm Research and Development Network. 17 August, Khartoum, Sudan.

Pieniążek J, Pieniążek SZ. 1981. Owocekraindalekich (Fruits of distant countries). PWRIL, Warszawa. [Polish].

Rees RW. 1963. Germination of palm seeds using a method developed for the oil palm. Principles 7: 27-29. DOI: 10.1093/oxfordjournals.aob.a083848.

Said AE. 1986. The effect of seed orientation on the in vitro germination of date palm (*Phoenix dactylifera L.*) seeds. Proceeding of the Second Symposium on Date Palm, Saudi Arabia.

Samarawira I, Osuhor E. 1981. Samarugermplasm Repository of Nigerian Population of the Date Palm. Mimeograph, Faculty of Agriculture, Ahmedu Bello University, Zaria, Nigeria.

Sharma SK, Singh RS. 2013. Date Palm in Fruit Production Technology. Narendra publishing House, New Delhi.

Zohary D, M. Hopf. 2000. Domestication of Plants in the Old World (3rd Ed.). Oxford University Press, Oxford, UK.