Accelerationof Date Palm

(*Phoenix dactyliferaL*) Seeds Germination

تسريع إنبات بذور نخيل البلح

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Dedication

To my dear mother, the spirit of my father ,my teachers ,my sisters and brothers ,to all who assisted me during this study.

Acknowledgement

This study was accomplished as partial fulfillment for the degree of Master of Science in the Department of Horticulture Sudan University of Science and Technology.

There are many people whom I would like to thank and acknowledge their lively support and help in finishing this study.

First, I would like to thank my supervisor Prof. Abdel GaffarElhag Saidfor his continuous supervision, without which this work would have been difficult to finish with satisfaction. It would be very difficult for me to write the outcome of this research without his support and assistance.

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الخلاصة

اجريت هذه الدراسة تحت ظروف المشتل في ادارة القطاع البستاني بوزارة الزراعة والري بغرض دراسة اثر بعض المعاملات في انبات بذور نخيل البلح الصنف بركاوى وذلك خلال الفترة من نوفمبر 2015 حتى مارس 2016 م.

استخدم في هذه التجربة تصميم القطاعات العشوائية الكاملة والمعاملات التي استخدمت هي غمر البذور في الماء على فترات*صفر,2,4,6,8,10,12.وكذالك* تم استخدام خمسة انواع من اوساط الزراعةهي: رمل :طينيه (1:1)و رمل :طينيه (2:1)و رمل :طينيه (1:0)ورمل :طينيه (0:1)ورمل :طينيه (1:2).

اظهرت النتائج ان افضل نسبة انبات كانتفي معاملة الغمر في الماء لمدة 6 ايام. وكذالك تم الحصول على اقصر فتره للوصول إلى نسبة 50% إنبات عند الغمر في الماء لمدة 6ايام .

اما بالنسبة للا وساط الزراعية نجد ان الوسط الزراعي رمل :طمى1:2 و0:1 أعطت افضل النتائج لكل من نسبة الانبات واقصر فترة للوصول الى نسبة 50% انبات.

افضلطول للشتلات عند الغمر في الماء لمدة 6إيام اما في حالة الاوساط الافضل هو رمل :طمى 1:2.

ABSTRACT

This study was conducted in thenursery of the Horticultural Sector, Ministry of Agriculture and Irrigation, Khartoum, Sudan, to determine if pre-germination treatments could be an effective means to promote date palm (*Phoenix dactylifera L* .Cv.*Barakawei*) seed germination.

Seeds were pre-soaked in water for zero, 2, 4,6,8,10,12 days prior to sowing 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 design used in this experiment was the factorial completely randomized block design.

Best germination percentage of seeds was obtained with the 6day soaking time and progressively declined with increasing soaking time. The 6day soaking time also enhanced seed germination with fewest days to achieve 50% of final germination percentage. Regardless of soaking time, sowing of seeds in 2:1 sand: clay soil mix shortened the days for germination and resulted in a significant increase in germination percentage compared with other soil type mixes tested. The tallest seedlings were obtained with seeds soaked for 6days and planted inthe sand: clay 2: 1 soil mix.

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CHAPTER ONE

INTRODUCTION

Date palm, (*Phoenix dactylifera L.*) a member of the family Arecaceae (palmae), is a key plantation crop of many countries of arid regions of West Asia and North Africa. Almost every part of the plant is used for food or industrial products. It has an important role in rural communities of many developing countries. Dates are produced in the hot arid regions of the world and marketed world-wide as high value confectionary (Mahmoud *et al.*, 2008)

It is one of the oldest cultivated plants with history of more than 6000 years; and is believed to be the oldest food plant in the world. Dates play important social, environmental, economic roles for many people in arid and semi-arid regions of the world. It grows well under poor desert soils due to its hardy plant characteristics and deep root system (Chandra *et at.*, 1992; Sharma and Singh, 2013) and was distributed throughout the Middle East, North Africa and South Sahel areas, East and South Africa, South Western USA, Central and South America and South Western Europe. World date production is about 7.4 million tons in 2010 (FAOSTAT, 2011). About 70% of the total production of dates is from Arab world. Worldwide about 3000 named date palm cultivars exist, though some names are probably synonyms, the result of a local or national name given to one cultivar which also exists in another location under another name (Johnson, 2011).

Date is one of the oldest known fruit crops and is cultivated in North Africa and the Middle East and is introduced to new production areas in Australia, India/Pakistan, Mexico, South Africa, South America, and the United States. Commercial date palm growing countries of the world isNorth Africa and the Middle East, Southern Africa, Australia, India/Pakistan, Mexico South America, and the United States.(Zohary and Hopf, 2000)

The top 10 producing countries are Egypt, Saudi Arabia, Iran, United Arab Emirates, Pakistan, Algeria, Sudan, Oman, Libya, an Tunisia.There are thousands of date palm cultivars, including soft, semi-dry, and dry fruits (depending on their water and type of sugar content at harvest when fully-ripe), grown in these countries (Kader and Hussein, 2009).The Arab countries possess the majority of world's date palms and produce the majority of the world's total date crop (FAOSTAT, 2009).

The importance of date palm culture for its high nutritive, economic and social values is well recognized, especially in arid and semi-arid areas where it plays an important role in affecting microclimate in a way that enhances the production of other agricultural crops. Worldwide production, utilization and industrialization of dates are increasing continuously (Botes and Zaid, 2002)

In Sudan the date palm is the most important fruit tree in northern part of country. It has been cultivated there for more than 3000 years, contributing to the livelihoods of people in northern Sudan (Osman, 2001)

Date palm culture in Sudan is concentrated along the River Nile banks between latitudes 15.5° and 22° N in River Nile and Northern State, although some isolated date palm populations exist in oasis areas in north Kordofan, and Darfour and in the eastern region of the country (Elshibli and Korpelainen, 2009; Yousif, 1995).

Date palm production in Sudan is about 119.048 metric tons of fruits in 2010 (FAOSTAT).The date palm culture in Sudan depends on the cultivation of old traditional dry, soft, semisoft cultivars. The most important indigenous dry cultivars known include Barakawi, Gondaila, Tamoda and Abdel Rahim and soft ones includeMishrig Wad Khateeb, and Mishrig Wad Laggai. Moreover, a large number of trees, (farmer'varities), resulting from seeds are also locally grown by farmers are collectively named as Jaw indicating that they are seedling varieties (Osman and Boulos, 1978).

Date palms are propagated by three different methods as follows:

1. Seeds propagation: propagation by seeds is not desirable as it usually produces a differentiated population with no two palm seedlings are alike, and so decreasing the chances of producing quality fruit [Pieniążek and Pieniążek, 1981; Moustafa*et al*., 2010].
2. Offshoots propagation: this is the method most used in date palm propagation; whether male or female palm trees. Offshoots develop from axillary buds on the trunk of the palm tree. Separation of date palm offshoots from the mother palm requires a skilled and trained labourer. Offshoots are planted in their perminant site in the orchard [Pieniążek and Pieniążek, 1981; Alihouri and Dialami, 2010] to grow as new and separate individuals.
3. Tissue culture propagation: a new technique applied for mass propagation of date palm; three following methods of tissue culture are used: shoot tips and buds culture (organogenesis), embryo culture (embryogenesis), and highly differentiated somatic tissues culture which includes leaf, stem, inflorescence and root sections [Al-Sakran and Muneer, 2006].

Genetic variability and sex ratio are the main problems with seed propagation of date palm where a 50:50 male: female plants are usually produced and it is difficult to different between male and female trees before flowering. Seed trees often are delayed in their access to the flowering stage and the price of the fruits of seed propagated trees is often very low (www.moa.gov.jo/portals).

The seeds propagation of date palm advantages include ,to obtain trees stallion, purpose ofornamental and wind breaks ,obtain resistance to some diseases such as eggs cillnesstrees,purpose of special education such as pollination and hybridization .(www.paaf.gov.kw/paaf/ershad/jsp)

In this study an attempt was made to optimize germination of the seeds of “Barakawi” date palm cultivar by evaluating the effects of water soaking and type of planting medium on germination percentages and number of days required to achieve 50% final germination.

CHAPTER TWO

LITERATURE REVIEW

2.1. Origin, distribution and importance

Date palm is found in both the Old World (Near East, North Africa, Spain) and the New World (Australia and American continent) where dates are grown commercially in large quantities [Johnson, 2010].

The date belt stretches from the Indus valley in the east to the Atlantic in the west. In order to have a clear picture on the geographical distribution of date palm, it is worth looking at it from the following aspects: (A) distribution according to latitude, (B) distribution according to altitude and [Sawaya, 2000]

The distribution of date palm according to latitude for both northern and southern hemispheres is between 10°N (Somalia) and 39°N (Elche/Spain or Turkmenistan). Favorable areas are located between 24° and 34°N (Morocco, Algeria, Tunisia, Libya, Egypt, Iraq and Iran). In USA date palm is found between 33° and 35°N. [Zohary and Hopf, 2000]

Altitude is very important since it imposes the availability of water and the temperature limits which largely determine the distribution of date palm in the world. In fact, date palm grows well from 392 m below sea level to 1500 m above with an altitude range of 1892 m [Al-Bakr, 1972].

The date itself is a high energy food item for both people and livestock. Since ancient times, the date palm has been an important source of food for the inhabitants of the Arab countries. Dates have proved to be the best resource to ensure food security during food shortages and crises [Pieniążek and Pieniążek, 1981].

The most commonly used parts of the date palm are its fruits; bark and leaves which have the many commercial and medicinal applications. Date fruits are high-energy food source with 72 to 88% sugar content at maturity (Ahmed *et al*., 1995).

2.2. Botanical description

Date palm (*Phoenix dactylifera L.*) is a multipurpose tree, with a long history of cultivation and utilization in North Africa and Middle East for at least 5000 years. Date palm is a diploid (2n=36), perennial, monocotyledonous plant. It is a dioecious species in character (has separate male and female individuals). Female trees are cultivated mainly for their nutritive fruits. Although the average economic life of a date palm tree is estimated to be up to 50 years, the tree may stay productive up to 150 years (Chao and Krueger, 2007).

2.2.1. Trunk

The trunk is, lignified, usually cylindrical with short internodes reaching up to 60m in length. It is un-branched and borne singly or in clumps by production of offshoots with a single terminal meristem protected by developing leaves and there is no cambium. The trunk is formed after the meristem has reached its full diameter after which there is no addition to the tissues of the columnar trunk or in the number of vascular bundles. Depending on the variety, environmental conditions and the cultural practices the diameter vary from 40 - 90 cm. As a result, the average circumference is about 1 to 1.10 m (Zaid, 2002).

2.2.2 Root

Date palm roots differ greatly in morphology from those of dicotyledonous trees in that all date roots are adventitious in origin and lack secondary thickening (Tomlinson, 1961). The radicle soon dies and the roots are adventitious without a cambium. Primary roots develop from the seed, secondary roots initiate from primary ones, and there are tertiary roots that take the previously mentioned growing manner and so on, until forming a huge cluster of fibrous roots. All these types of roots are cylindrical and have approximately the same diameter, throughout their length, which is about 1 - 1.5 cm (Zaid, 2002). They also lack root hairs; hence, absorbing rootlets supply the plant with the soil solution (Al-Bakr, 1972).The roots spread through 25m diameter from the palm, and 6m in depth or even deeper, but 85% of the root system distributed in 2m depth and 4m diameter around the palm in a deep loamy soil. The root system development and distribution depends on soil characteristics, type of culture, variety and depth of the underground water (Zaid, 2002). Date palm roots tolerate soil and water salinity, adverse soil temperature and water logging conditions for long periods of times.

2.2.3. Leaves

Depending on variety, age of a palm and environmental conditions, leaves of a date palm are 3 to 6 m long (4 m average) and have a normal life of 3 to 7 years an adult date palm has approximately 100 to 125 green leaves with an annual formation of 10 to 26 new leaves. The functional value of the leaf to the palm declines with age and no two leaves are the same age. Furthermore, leaves which are four years old are only about 65 percent as efficient in photosynthesis per unit area, compared to leaves of one year old (Nixon and Wedding, 1956)

A leaf (frond) consists of pinnae, spines, and midrib. Each individual leaf consists of 120 - 240 pinnae or leaflets on both sides, which occupy 60 - 80% of the midrib length. At the tip of the leaf, there may be one leaflet, or two forming V shape. The pinnae length varies from 15 - 104 cm, and width from 1- 6 cm. Depending on variety, the arrangement on the midrib on both sides could be in sets of 1, 2, 3, 4, or 5 leaflets .They are differentially arranged on the two outer edges of the fronds while their number varies from 10 to about 60. Spines can be single, in groups of two, or in groups of three. The spines are 1 - 24 cm in length and 0.5 - 1 cm in width (Dowson, 1982).

2.2.4. Inflorescence

All species of Phoenix are dioecious, i.e. individual palm trees carrying either staminate (male) or pistillate (female) flowers. The flowers are joint in an inflorescence and enclosed with an envelope called spathe, which is tough, leathery and green in color. The spathe becomes brown when the inflorescence matures and opens along-side, therefore, branched spikes appear containing 20 - 150 spikelets of 10 - 100 cm long, and fixed to a thick axis called rachis. Depending on tree age, sex and variety, the inflorescences vary in shape and quantity and the length differ from 25 to 100 cm. and the palm tree may possibly have alternate bearing; 0 - 25 spathes for female palm, on the other hand, male palms produce 10 - 30 spathes per year. Each spathe contains 8000 - 10000 female flowers, (Zaid, 2002).

Date palm has male, female and hermaphrodite flowers, but mature ones are functionally unisexual. The female flowers are sessile, small, rounded and waxy white, with six rudimentary stamens and threeseperate carpels, three stigmas surrounded with adhering perianth composed of three united sepals and three overlapping petals. The male flower contains six stamens within a larger petals and copular calyx, which formed from three chlamydeous sepals (Nixon, 1951).

2.2.5. Fruit

The fruit is botanically a berry consisting of an exocarp, a fleshy mesocarp and a papery endocarp enclosing a single elongated seed. The fruit result from the successful pollination and fertilization of one carpel out of the three carpels of the female flower. The shape of the fruit, its size, color, diameter, length, weight and taste are largely varietal characters but can easily be manipulated by cultural practices such as thinning and fertilization (Nixon and Carpenter, 1978). The texture of a date palm fruit is related to the moisture content and type of sugar in the mesocarp. The relationship between texture, moisture content and type of sugar in the mesocarp of fruits is a measure for the commercial classification of date fruits as dry, semi-dry or soft. Soft dates are dates with more than 30% moisture, low sucrose sugar, but with more than70% glucose and fructose. Semi-dry dates are dates with 20-30% moisture, 18-30% sucrose and 45-54% glucose and fructose. The dry date types contain less than 20% moisture with almost equal proportions of sucrose and reducing sugars (Hussein *et al*., 1976).

The developmental stages and maturity progression of the date fruit are important in relation to the amount and type of sugar (s) that accumulated. Fruit maturity is variety dependent, but in general it takes 7-9 months for the fruit to develop to a tree-ripe condition. There are five easily recognizable stages of fruit development known as the “Hababouk”, “Kimri”, “Khalal”, “Rutab” and “Tamar” stages.

These stages are distinguishable by their color, size and chemical composition. The Hababouck is the stage that follows fertilization, and last for 4 to 5 weeks to complete, and it is characterized by the loss of the two unfertilized carpels and a very slow growth rate. In addition, the fruit is immature and completely covered by the calyx, but only the sharp end of the ovary is visible, it is round in shape with an average weight of one gram. "Kimri" is the next stage, which lasts for about 17 weeks following pollination and is thus considered to be the longest stage. During this growth phase the fruit is hard and green in colour with high moisture content. The "Khalal" stage that follows the Kimri stage lasts for 4 to 6 weeks. During this phase the colour of the fruit changes completely from green to greenish yellow, yellow pink, or red depending on variety.

The fruit increases to its maximum size and weight during this phase and the colour of the seed changes from white to brown. A rapid accumulation of total sugars, mostly of the sucrose type occurs during this stage. The Rutab stage that follows the Khalal stage lasts for about 4 weeks. During this stage the fruit softens in texture and changes in color to light brown. Some of the sucrose accumulated in the previous stage may be inverted back to glucose and fructose resulting in a higher proportion of reducing sugars in comparison to sucrose. The apical portion of the fruit starts to ripen and changes its color to a dark color and becomes soft, and begins to lose its tangency and becomes sweet in taste.

In the final Tamar stage that last for 2 weeks, the fruit darkens in color to dark brown or black. Soft dates remain soft at this final stage and almost all the sugar, that is accumulated, is of the reducing type. In the semi-dry and dry dates, the process of drying starts at the Rutab stage. The fruits of these types of dates have approximately equal proportions of sucrose and glucose. When the date fruits are fully ripe, the texture of the flesh is soft; the skin in most varieties adheres to the flesh, and wrinkle, as the flesh shrinks. The color of the skin and underlying flesh darken with time. Yield of individual palm tree varies with varieties, cultural practices and population densities.

High quality date palm varieties grown under good cultural practices at population densities of 125 tree/ha yielded over 100 kg of fruits/tree/annum. An average potential yield of 14.21 tons/ha is common with “Deglet Noor” variety (Nixon and Carpenter, 1978).

2.2.6. Seed

The seed consist of a hard seed coat, endosperm and an embryo. It is oblong, ventrally grooved, with a small embryo embedded in a firm bony endosperm and covered by an operculum, (embryo cap), on the dorsal side. The seed represents about 5 to 15% of the fresh weight of the fruit. It ranges in weight from 0.5 to 4.0 gm, in length 12 - 36 mm, and in the width from 6 - 13 mm (Al-Bakr, 1972).

Fats are a major constituent of the stored food in the endosperm (DeMason*et al.*, 1983). The living cells of the endosperm of date palm seeds and the embryo respire aerobically at different rates after water imbibition, embryos at a more rapid rate than does the endosperm. The date palm endosperm consists of uniform living cells modified for storage purposes. Nuclei are present; however, it lacks large quantity of heterochromatin. Plastids and mitochondria are also present, but are rarely seen and they develop internal membranes. No endoplasmic reticulum is present before or after hydration. The cell wall is thick. In addition, major storage bodies occur in the cytoplasm, such as small lipid bodies and variably sized protein bodies that fill the cytoplasm. The living cells of the endosperm and the embryo respire aerobically after water imbibitions (DeMason*et al.*, 1983). The breakdown of the crude fat material in the endosperm into chemical compounds vital for growth and development requires oxygen (Sumainah et al., 1984). The importance of oxygen as a limiting factor in germination of date palm seeds has been documented (Olumekun and Remison 1985; Said, 1986).

2.3.Nutritional value

Date fruits are of high nutritional value with about 70% sugar in the form ofglucose, sucrose or fructose. Dates are also good sources of iron, potassium, calcium, magnesium, sulphur, copper and phosphorus, along with various vitamins, including thiamine, riboflavin, biotin, folic and ascorbic acid.

Components of date fruits (in %):

Water 22.5-24.5% ,Protein 2.3-5.6% ,Energy 274 calories ,Glucose 44-88%Fibres 6.5-11.5% ,Ash 1.9 gm ,Calcium 59 mg ,Phosphorus 63 mg ,Iron 3 mg, Sodium 1 mg Potassium 5.90% ,Fat 0.20-0.5% ,Vitamin A 50 IU ,Thiamine 0.09 mg,Riboflavin 0.10 mg,Niacin 2.2 mg(Mahmoudi*et al.*,2008).

2.4. Environmental conditions.

Date palm trees are hardy and drought resistant. They can be grown on a wide range of soil types and are adaptable over a wide range of climatic and soil conditions. Date is highly suited for large-scale cultivation under desert conditions. It thrive in a medium containing 10 to 15% salts, require high irradiance for maximal growth rates, produce highly valued fruits, have relatively few natural preditors and their cultivation requires large tracts of land which cannot be utilized competitively for other fruit or other crops.

Temperature, rain, relative humidity, and winds are the most important climatic factors that influence growth and development of the date palm tree. As mentioned previously, date palm can tolerate environmental conditions unsuitable for other fruit crops. Dates are cultivated in arid and semi-arid regions with long hot and dry summers. Date trees are thermophilic plants, adversely affected by long periods of low temperatures but can tolerate exceptionally high temperatures up to 50 ºC for several days with irrigation. The optimum temperature for growth is about 32 ºC - 40 ºC (Dowson, 1982).

Winter rainfalls are beneficial for leaching the salts but rains are harmful during periods of anthesis and fruit ripening, causing failure of pollination and severe fruit losses due to rot and fruit drop prior to and after maturity (Nixon and Carpenter, 1978). High relative humidity affects fruit quality; where the fruits become soft and sticky while at very low relative humidity they become dry and hard especially if these conditions of relative humidity are accompanied by hot and dry winds. Date palm trees can withstand strong, hot and dusty winds and can even protect and shelter other crops from the adverse effects of wind (Dowson, 1982). Dust and sand particles carried by winds affect the quality and reduce the quantity of the fruits. When dry, speedy and cool winds prevail at the time of pollination, they impose negative effects on pollen germination, receptivity of pistillate flowers, and fruit set.

2.5. Cultural practice

2.5.1. Irrigation

Irrigation in adequate amounts of water is important for good yield and vigorous growth. Once established they can tolerate short periods of drought. Depending on soil characteristics and weather conditions, irrigation frequencies vary from a location to another. A recommended practice of irrigation intervals of bearing palm trees is 7 - 14 days in summer, and 20 - 30 days in winter. Prolonged drought should never follow planting of newly transplanted offshoots. Nevertheless, decrease in irrigation water 15 – 30 days prior harvest is suitable. Various irrigation systems had been adopted in date growing areas. In Sudan, the traditional irrigation manner is flat basin, in which 4 - 6 palms are flooded together (Al-Bakr, 1972; Arar, 1980; Nixon, 1951; Jagirder, 1981; Reuveni, 1971).

2.5.2. Fertilization

Fertilization is found to be important to insure vigorous growth in young palms, and for enhanced fruit bearing capacity in adults. Animal manure had been used since ancient times as a source of nutrient elements. The recommended rate of its application was suggested as 55 - 75 kg/tree or 5 - 10 tones/feddan usually applied in winter of each year. Date growers did not adopt chemical fertilizers usage until recent time. The nutritional requirement was estimated at 45 kg/hectare for nitrogen, 13.5 kg/ha for phosphorus and 81 kg/ha for potassium (Djerbi, 1995).

2.5.3. Pollination

Date palms are dioecious(with the male and the female tree).The male flowers produce the pollen and the female flowers produce the fruits. Pollination is one of the essential agricultural practices for date fruit production and quality. The pollen from different male cultivar may have different effect on the production and quality of the fruits. The selection of certain male cultivar has effect on the set, quality, size, and color of the fruit [Moustafa*et al.*, 2010]. Some of the factors which play an important role in the pollination of date palm are the receptivity of the stigma for pollen grains and the suitable temperature for the germination of pollen grains which is 35°C. Rainfall and winds have negative effect on fruit set. There are many methods for pollination; manual and mechanical. Different devices and equipments are used for manual and mechanical pollination [Zirari, 2010].

2.5.4. Pruning

Pruning is an important agricultural practice to remove the dry leaves and leaf bases. Pruning also removes the fiber, spines, and high offshoots. This practice eliminates insect pests and the spread of diseases. Pruning also facilitates laborers when they maneuver to perform other basic agricultural practices such as pollination, thinning, pulling down bunches, and bagging.

Pruning, moreover, will enhance sun light penetration and aeration thus decreasing the percentage of the humidity around bunches. Pruning is carried out once a year after harvesting, along with pollination or when bunches are pulled down.

This operation can be done manually or mechanically using hydraulic lift and/or ladder. [Pieniążek and Pieniążek, 1981; Soliman*et al.*, 2010].

2.5.5. Propagation

There are three methods for the propagation of date palm; seed propagation, offshoot propagation, and tissue culture techniques.

2.5.5.1. Offshoots

Vegetative propagation by offshoot separation and planting had been the exclusive means of clonally reproducing desirable varieties. The relative slow growth rate of date palm has limited potential for vegetative propagation and the restricted supply of offshoots has further exacerbated the clonal propagation of date palm by offshoots. The availability of offshoots of desired cultivars has severely hindered large-scale date palm commercial production worldwide. Production of offshoots by a date palm tree during its life span is low, erratic, and difficult to control (Nixon and Carpenter, 1978).

In nature, date palms do not produce more than 3 to 8 offshoots during the whole life span and then only during the juvenile stage of growth (Veramendi and Navarro, 1997). This lengthy time period limits the supply of potential planting material which may delay the establishment of pure stand plantations in several semi-arid regions where date palm is an important food, industrial and export crop. Success of transplanted offshoots in the field is often poor. In some date growing areas, a transplantable offshoot must remain attached to its parent tree for 3 - 4 years until an adequate root system develops. The method proved to be slow, laborious, cumbersome, time consuming and ineffective for meeting date growers needs for desired known varieties in large numbers and short time for commercial plantations. The timing of transplanting, size, weight, length and age of transplantable offshoot are governed more by tradition and practical experience rather than by scientific studies. Nevertheless, some established date palm cultivars (e.g. “Barni” and “Agwat Al-Madeena” of Saudi Arabia and “Fard” of Sultanate of Oman) have been clonally propagated for centuries through the separation and planting of offshoots. However, propagation of date palm by offshoots has inadvertently led to detrimental spread of diseases and pests within and between date growing countries.

2.5.5.2. Tissue culture propagation

Clonal propagation by tissue culture techniques has been established as a valuable commercial method for propagation of several fruit trees (Debergh and Zimmerman, 1991).Tissue culture propagation of fruit tree species has increased in importance in recent years because it offers major production and marketing advantages over traditional propagation methods. It is often faster, promotes volume production and results in healthier plants. Development and feasibility of application of tissue culture methods for the propagation of date palm has been discussed by (Tisserat, 1983). Date palm is one of the plants that have defied clonal propagation by tissue culture. Progress has been slow because of many difficulties and limitations.

Success of date palm propagation by these techniques has been achieved only through callus induction and plantlets formation via embryogenesis (Bhaskaran and Smith, 1992). Plantlets produced are prone to somaclonal variation (Gurevich*et al*. 2005; Al-Khateeb, 2008). Each plantlet may be considered a potential cultivar due to the high degree of genetic variability and formation of off-type plants. It is highly desirable to avoid callus formation in propagation of known cultivars of any plant species to grantee the genetic fidelity of the regenerated plantlets.

2.5.5.3. Seed propagation

Subjective observations on germinating seeds revealed that germination in date palm seeds can be divided into five consecutive over- lapping steps: a) imbibition of water by the seed coat, leaching of chemical growth inhibitors and softening of the rigid cells of the operculum; b) embryo hydration and initiation of metabolic and physiological processes associated with germination; c) swelling and elongation of the cotyledonary sheath carrying the embryo from inside the seed through the micropyle opening, dislodging the operculum and burying it deep in the soil for completion of germination; d) elongation of the radical and e) emergence of the plumule through the cotyledonary sheath.

Seed dormancy is defined as nature's way of setting a time clock that allows seeds to initiate germination when conditions are normally favorable for germination and establishment of the seedlings (Baskin and Baskin, 2004). Most palms take 100 days or more to germinate, with an average germination rate of less than20%. There is great diversity in palm seed size. They range in size from 5 mm in length to the largest seed of the Lodoiceamaldivica weighing more than 20 kg (Jones, 1995).

Palm seeds ingeneral are difficult to germinate and propagation of most palm species is by seed (Kiem, 1968). In some instances germination may extent over several months to two years and may require elaborate seed treatments, with total germination for most palm species between 20% and 25% (Loomis, 1958; Basu and Mukhernice, 1972; Sento, 1976; Wagner, 1982; Clancy and Sullivan, 1988). Needle palm for instance, requires 6 months to 2 years to achieve 7% to 14% (Shuey and Wunderlin, 1977; Clancy and Sullivan, 1988). As reported by Wagner, (1982) 6.7% final germination percentage was obtained 195 days after sowing and that seed scarification did not increase final germination percentage or promote earlier germination. On the other hand Clancy and Sullivan, (1988) reported that seeds stratified and scarified required 435 days for first seed to germinate and 530 days from sowing to 14% final germination. Natural chemical germination inhibitors and physical dormancy imposed by the seed coat (Hodel, 1977; Carpenter *et al.* 1993) have been suggested as possible causes. Methods for enhancing germination of seeds of some members of the Arecaceae have been described in the literature including bottom heat (Yocum, 1961; Read, 1963; Nagao *et al*. 1980), pre-soaking in water (Loomis, 1958; Rees, 1963; Carpenter, 1987), growth regulators (Nagao and Sakai, 1979; Nagao *et al*. 1980), scarification (Loomis, 1958; Holmquist and Popenoe, 1967, Nagao *et al.*, 1980; Carpenter *et al*., 1993), maintaining relatively high germination medium temperature (Loomis,1958; Caulfield, 1976; Carpenter, 1988a); stratification, (Schopmeyer, 1974; Carpenter, 1988b) and tissue culture (Hodel, 1977). In these studies, the cause of low germinability of palm seeds is still not well understood. Research with other palm species indicate seed water soaking shortened the days required for germination (Loomis, 1958; Nagao and Sakai, 1979; Carpenter, 1987).

Meerow (1994) mentioned some pre-sowing treatments, for example, soaking in water for certain periods of time, scarification (cutting, filing, or soaking in acid), and removal of seeds from the fruit to eliminate natural germination inhibitors can enhance seed germination rate.

Water soaking involves exposing seeds to external water potential that permits partial seed hydration. Soaked seeds were pre-germinated seeds. Daily water changes helps in dissolving chemical germination inhibitors from the seed coat. The cells of the operculum imbibe water and soften and become liable to rupture. The cell walls of the micropyle opening and embryo expand as a result of water imbibitions, thus rupturing the operculum. Water and oxygen diffuse into the seed through the micropyle opening. Water is needed for cell softening and expanding whereas oxygen is needed with water for resumption of active growth of the embryo and protrusion of the cotyledon tube through the operculum.

The beneficial effects of pre-soaking of seeds in water, for varying time durations prior to sowing on seed germination is well recognized in seed germination of other plant species (Burns and Coggins, 1969; Perez, *etal.*1980; Nagao and Furutani, 1986; Sabota and Biedermann, 1987; Holloway, 1987; Catalan and Macchiavelli, 1991). In date palm rate of germination can be hastened and total germination percentage of date palm seeds can be increased simply and economically by pre-sowing soaks in tap water (Sento, 1972; Olumekun and Remison 1985; and Abdullah and Maroff, 2007). Soaking alone is adequate for the activation of the process of germination with no correlation with temperature (Olumeken and Remison, 1985; Abdullah and Maroff, 2007).

A common recommendation has been to soak palm seed in water for 1 to 7 days. It is advisable to change the water daily. Such a pre-treatment is useful only after dormancy requirements (if any) have been met, though few palm species have been tested for indications of seed dormancy. The seed must be planted immediately after the treatment, as storage following water imbibation may induce a secondary dormancy. Kitzke, (1958) reported the germination of seeds of fifteen species of the genus Copernicia in water.

It would appear possible that the softening of the cells of the operculum and the thickening of the cells of the micropyle region resulting from water imbibition during water soaks ruptured the operculum, allowing for entry of water and oxygen, needed for germination, through the micropyle opening. This speculation is in agreement with the findings of Al-Wasel and Warrag, (1998) who obtained significantly high germination percentage of date palm seeds by the mechanical removal of the operculum attributing that to alleviation of the physical resistance exerted by the operculum to the expansion and elongation of the germinating embryo as well as the entry of water and/or gases through the micropyle opening needed for germination. The rigid cells of the operculum become soft and liable to rupture by the enlarging embryo after water soaking. The mechanical removal of the operculum is a rather difficult operation. Caution and care should be exercised to avoid damaging the embryo (Al-Wasel and Warrag, 1998).

Banks and Marcus, (1999) advocated using well-drained, with 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.

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). 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 and no significant difference among the media in seed germination was obtained (Azad, *et al.*, 2011)

Many authors discussed about pre-sowing treatments of seed germinationto 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 overcome 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 (Catalan and Macchiavelli, 1991). Generally, untreated palm seed germinated slowly and irregularly, and the seeds with hard, solid, and inflexible seed coat were reported to recover germination with pre-sowing treatments (Meerow, 1990).Date seeds may remain viable for several years. In an unplanned experiment Nixon (1964) obtained 80 to 90% germination rate with 8 year old seeds, the rate of germination declining progressively with increasing seed age and failed completely with seeds 15-year-old.The absence of a prolonged dormancy in date palm seeds has been suggested (Sento, 1972; Olumekun and Remison, 1985). A problem associated with seed propagation of dates is poor germination. Delayed germination and reduced total germination percentage in date palm seeds has been attributed to naturally produced germination inhibiting substances (Ahmed, 1986), to the impermeability of the seed coat to water and/or gases (Al-Salih, 1984) or the mechanical resistance of the operculum to the elongation of the germinating embryo (Al-Wasel and Warrag, 1998).

CHAPTER THREE

MATERIALSAND METHODS

Experiments were conducted, using seeds of “Barakawi” date palm cultivar, in the lath houses of the Department of Horticulture, Ministry of Agriculture and Forestry, Al-Mogran, Khartoum (Latitude 35°- 15° N; Longitude 33°- 32 °E). Fruits of “Barakawi” were purchased from a whole saler, Central Market, Khartoum North, following harvesting. “Barakawi” cultivar was chosen in this study as a source of seeds on the basis of its economic importance and availability. Seeds were extracted, washed under running tap water and dried. The seeds were then visually selected for the study on the basis of size uniformity to minimize potential seed size effects and stored in plastic bags under ambient room temperature until use. The seeds were given no pre-treatment of any kind.

All selected seeds were soaked in tap water in a plastic bucket, 3 gallon size at room temperature for 0, 2, 4, 6, 8, 10 or 12-days prior to sowing; a total of 6 soaking times plus un-soaked seeds as control. Following the soaking treatments seeds were sown in sand: clay, (1:1), (2:1), (1:2) (0:1)and (1:0) mixture (v/v) planting medium. The soaking water was changed daily. For each treatment 20 seeds were counted out for testing. Lots of 5 soaked seeds at a time, were sown on the surface of each medium in perforated 27x24x7-cm black plastic bags, 15mm-deep, and 3 to 4 cm apart. In each treatment, 20 seeds were employed (5 seeds x four replications). The bags were placed in a lath house after seeding under natural daylight and day length. Watering was carried out manually with tap water once every other day and no fertilizer was applied.

A factorial randomized complete block design (RCBD) two ways was used with each treatment replicated 4 times, 5 seed per replication. In each treatment 20 seeds were employed (5 x four replications). A seed was considered to have germinated when the cotyledonary petiole emerged above soil level and was visible to the naked eye. Daily germination counts were made of seeds with visible cotyledonary petiole protrusion through the medium surface. Total germination percentage (G) and mean emergence time (days to 50% of total germination T50) were calculated from the daily germination counts. All observations were based on 20 seeds per treatment. The percentages refer to the proportion of the seeds that germinated. Data were subjected to analysis of variance procedure on Excel computer program. Duncan's multiple range test was used to separate treatments means at 5% level.

The number of germinated seeds, (daily germination counts), was recorded daily after 40 days from sowing and continued for two months after germination. The total germination % was computed as the ratio of germinated seeds to the total number of seeds planted.

Total Germination % (G)

$$\% = \frac{ta}{a} * 100$$

Where:-

%: germination percent.

Ta: total number of germinated seedlings

A: total number of seeds

Days to achieve 50% of the germination percentage (T50)

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

Seedling length

Was determined by randomly selecting two seedlings from each treatment for measuring the length of each seedlings and the mean was calculated.The length was measured using a meter ruler in cm.

CHAPTER FOUR

RESULTS

Much variation in emergence percentages was observed among seeds for each treatment, reflecting the genetically heterozygous nature of date palm seeds. Response differences between treatments were evident for all parameters measured. The magnitude of response to water soaking varied with soaking duration and planting medium and the response competence of seeds to water soaking diminishes with increasing soaking time.

4.1. Final germination percentage

The effect of water soaking time and sowing medium type on total germination percentage of seeds of "Barakawi" date palm cultivar is portrayed in Table 1. The magnitude of the response to water soaking varied with treatment time. The 6day water pre-soaking resulted in a significant increase in total germination percentage (88%), over all other pre-water soaking tested. Germination percentage increased as water pre-soaking time increased from 0 to 6days. Extended water soaking time results in a progressive decrease in total germination percentage. Soaking seeds for 8days and longer resulted in significantly lower percentages of germination than for 6day treatment time. The least total germination percentage value, (69%), was recorded with seeds soaked for 12days. Differences between the 6days and 8 days water soaking treatments were non-significant. The average germination percentage showed a definite drop after the 8 day soaking time. Significantdifferences between sowing media was noted.

There were no significant differences between the1:0 and the 2:1sand: clay mix sowing media on total germination percentages, however, both sowing media resulted in a significant increase in total germination percentage compared to other sowing medium types. The highest germination percentage (86%) was recorded with seeds sown in1: 0 sand: clay sowing medium followed by seeds sowing in 2: 1 sand: clay sowing medium with an 83% germination percentage with no significant difference between the two types of media. The least germination percentage (72%) was obtained with seeds sown in 0: 1 sand: clay medium type. The 1: 2 and 0: 1 sand: clay soil mixes gave germination percentages of equivalent magnitude.

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)							Medium mean
	0	2	4	6	8	10	12	
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	

∗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

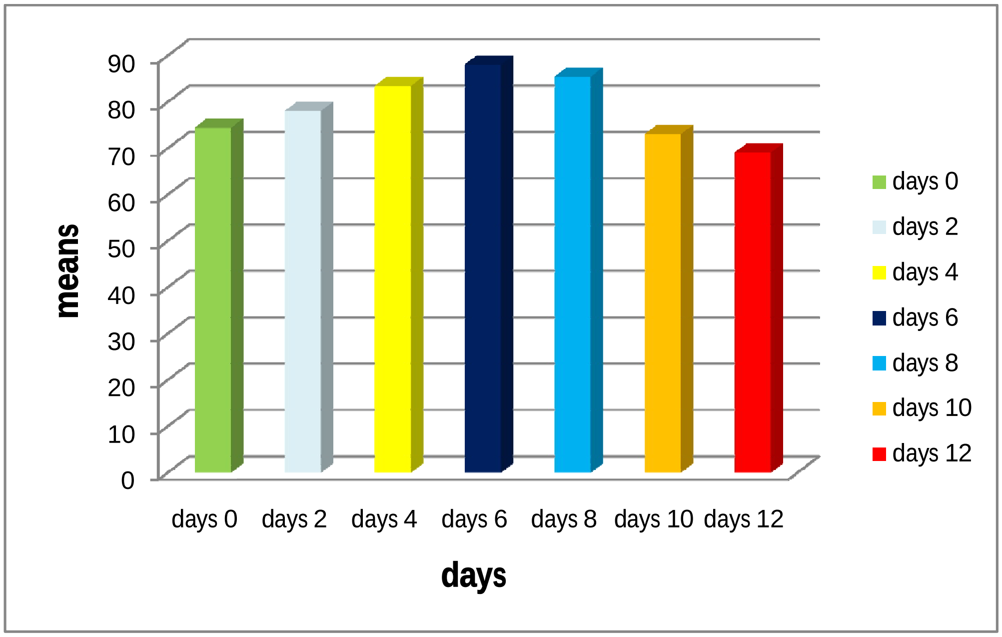
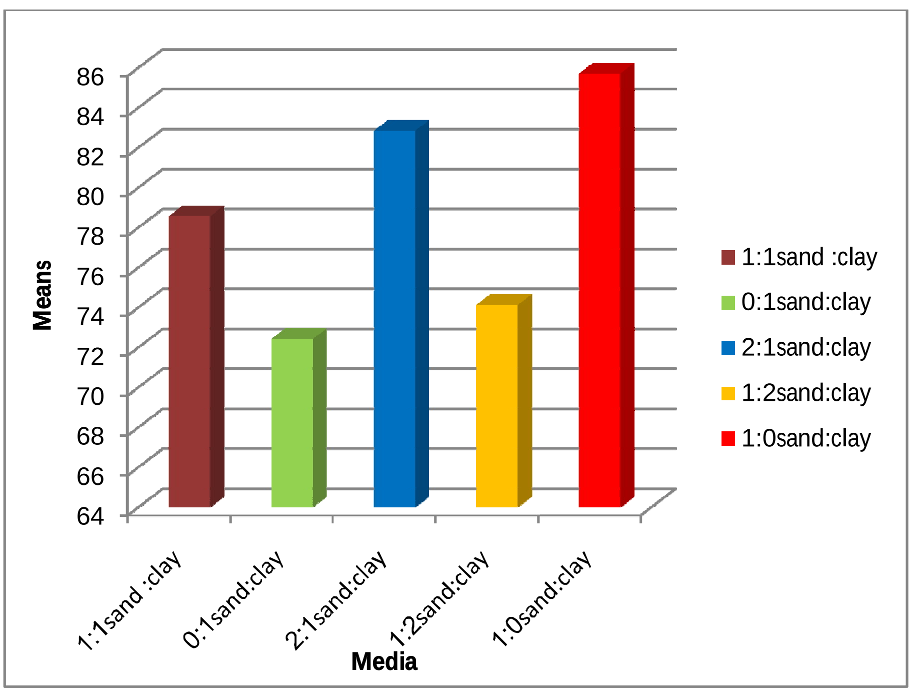


Figure (2). Effect of time of water soaking on total emergence percentage (%) of seeds of “Barakawi” date palm cultivar



4.2. Days to 50% germination

The data depicted in Table 2 showed that the results of the effects of the duration of soaking of seeds in water before seeds sowing in different soil media on days to achieve 50% (T50) of final germination percentage. The 6 day water soaking treatment gave the fewest days to achieve 50% germination of the final germination percentage (45 days), whereas the greatest number of days required by the germinating seeds to reach 50% germination of the final germination percentage (68 days) was obtained with the 8days soaking treatment. Extended soaking time delayed germination by lengthening T50 values with more days for seeds soaked for 8days. Mean days required for germination declined as soaking time in water was lengthened from 7days to 12days. Seeds soaked for more than 6day water soaking time required longer time to germinate than those soaked for times of 6days or less water soaking time. Differences among seeds soaked for 6days and less were no-significant. Irrespective of soaking duration, the1: 0 sand: clay soil mix significantly decreaced the number of days soaked seeds required to achieve T50 final germination relative to the other sowing media tested where as 44 days were required to achieve T50 of final germination percentage. Other soil mixes tested lengthened the periods to T50. The highest number of days required to achieve T50 of final germination percentage (62 days), was obtained for seeds planted in0: 1sand: clay than other soil mixes tested.

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)							Medium mean
	0	2	4	6	8	10	12	
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	

∗Means followed by the same letter (s) are not significantly different at P = 0.05, according to Duncan′s 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

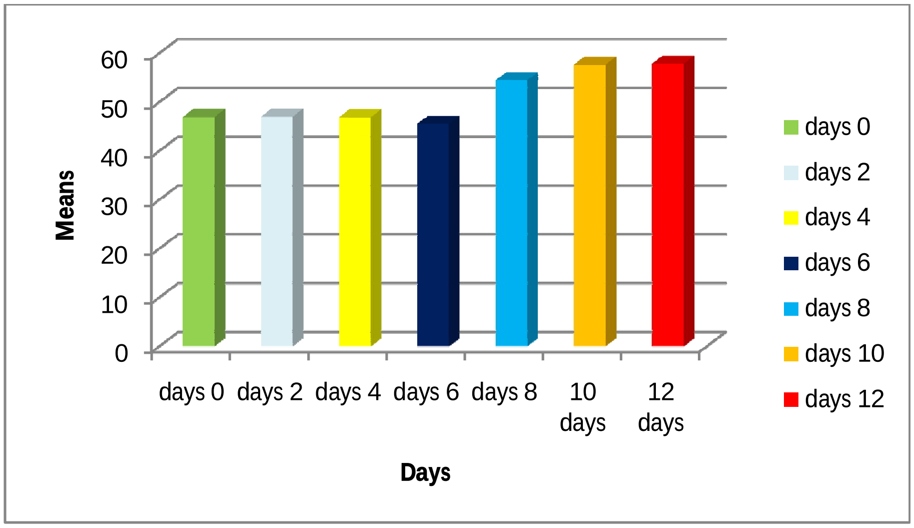
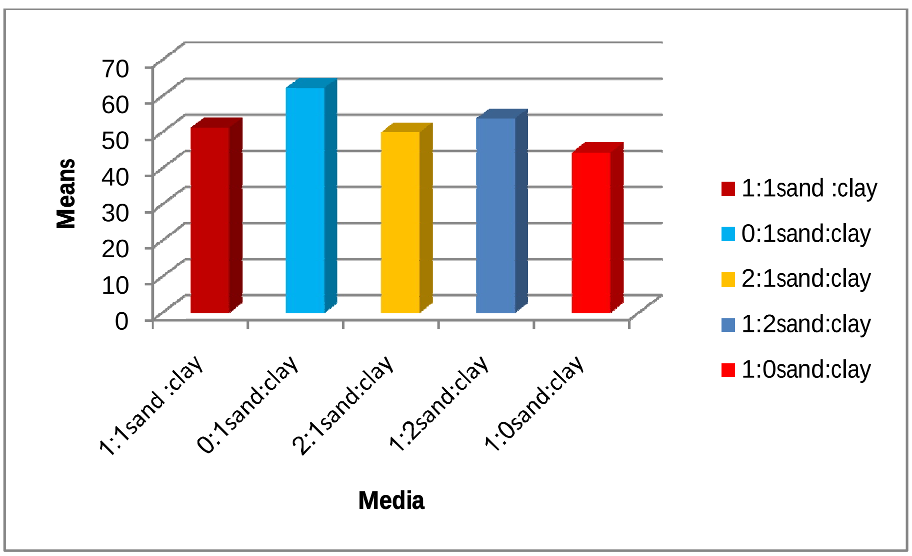


Figure (4). Effect of type of sowing medium on number of days required to achieve 50% final emergence percentage of seeds of "Barakawi" date palm cultivar



4.3. Seedling length (cm)

Seedling length was largely unresponsive to soaking time treatments. No significant difference on seedling length was obtained between the soaking times tested. Regardless of soaking time, the tallest seedlings (25 cm) were obtained with seeds sown in2:1 sand: clay sowing medium type with significant difference from the other media type tested. No significant difference was obtained among the values of seedling length recorded for the other media types tested table 3.

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	Soakingduration (in days)							Medium mean
	0	2	4	6	8	10	12	
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	

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

CHAPTER FIVE

DISCUSSION

Germination was the principal morphogenicresponseinvestigated in this study. Information on seed germination requirements and effective dormancy-breakingprocedures would benefit date palm seed propagation efforts. Several attempts (Holmquist and Popenoe, 1967; Said, 1986; Rees, 1963; Carpenter, 1987; Al-Wasel and Warrag, 1998) have been conducted to accelerate palm seed germination and to increase total germination percentage.

Pre-soaking in water prior to sowing has been recommended by Rees, (1963) for enhancing palm seeds germination because soaking is effective in enhancing germination and increasing germination percentage. Our results showed that date palm seeds soaked for 6days germinated significantly faster with high germination percentage. The day's water soaking time promoted highest total germination (88%) and fewer days (45) to 50% final germination than other water soaking treatments. Total germination percentage was higher, earlier and more uniform at 6days water soaking time than most other water soaking treatments tested. These results concur with previous reports with date palm seeds (Samarawira and Osuhor, 1981; Olumekun and Remison, 1985; Abdulla and Maroff, 2007) and with seeds of other palm species (Loomis, 1958; Rees, 1963; Nagao and Sakai, 1979; Carpenter, 1987) that soaking of seeds in water prior to sowing increased total germination percentage and reduced germination time.It would appear possible that at the 6day water soaking duration moisture imbibed by the seed coat was optimum to soften the tough cells of the operculum facilitating its subsequent rupture by the expanding embryo. Adequate water uptake and oxygen diffuse freely through the operculum and the micropyle opening into the seed for the resumption of germination. This contention is in line with what was reported by others (Al-Wasel and Warrag, 1998; Carpenter *etal.*, 1993) that indicate that mechanical removal of the operculum, (embryo cap), of seeds of palm species alleviated the physical dormancy imposed by the embryo cap substantially increased total germination and reduced germination time most probably through facilitation of water and oxygen diffusion into the seed. The replacement of the soaking water once every two days during seed preparation for sowing dilute and removes germination inhibitors from the seed coat and water imbibition by the micropyle opening softens the operculum which is then easily ruptured by the elongating embryo without the fears raised by Al-Wasel and Warrag (1998) of embryo damage by its mechanical removal.

The minimum time required by a seed to imbibe optimum moisture for germination varies among plant species and with the quantity of water present. In date palm seed germination, the optimum water soaking duration for maximum total germination varies from 2days (Abdulla and Maroff, 2007), 3days (Samarawira and Osuhor, 1981) or over 4days (Olumekun and Remison, 1985) water soaking duration. These inconsistencies could result from differences in cultivars, developmental stage of the source fruits, age of seeds and source, sowing media and environmental conditions at the experimental site. The most rapid and uniform germination occurred at 6day water soaking time.The 6day soaking duration seems to be the minimum time that “Barakawi” seeds required to achieve maximum moisture imbibition to hydrate the embryo and enabled it to mechanically dislodge the operculum. Lower soaking durations than 6days were sub-optimal for the water imbibition levels required for resumption of germination whereas, higher soaking durations than 6days were supra-optimal resulting in delayed, irregular and reduced total germination percentages. The sharp reduction in germination percentages with increased soaking time indicated that “Barakawi” seeds have a narrow water imbibition range for maximum moisture imbibition for germination. It is also possible that the effect of water soaking on date palm seed germination is due largely to physical structural weakening of the operculum rather than by biochemical changes in the embryo or the endosperm.

Response competence to soaking time generally diminishes with increasing soaking time. The progressive decline in germination percentage and delay in germination speed obtained when seeds were soaked for extended time above 7days in accord with a previous observation on seed germination (Carpenter and Maekawa, 1991) that indicates that increased free water in planting medium results in a progressive decline in total seed germination percentages and rates. This could possibly be attributed to the thickening and expansion of the micropyle wall with increasing soaking duration resulting in a progressive reduction in the micropyle opening, thus limiting the protrusion of the cotyledonary sheath through the micropyle opening. A similar view is maintained by Maekawa and Carpenter, (1991) that the gradual decrease in seed germination with increased free water content of the germination substrate is a consequence of thickening of micropyle walls and reduction in micropyle opening of the seeds. It is also possible that extended water soaking time could have affected germination negatively through the disruption of some physiological processes vital for germination.

The harmful effects with extended water soaking on seed germination may, however, be related to the destruction of the germ pore and/or the embryo of some of the seeds that failed to germinate by infection with rot causing soil microorganisms either before and/or after they started to germinate. However, the effects of water logging factors cannot be ruled out as reasons behind the negative effects of extended water soaking. Suffocation and formation of certain growth inhibitor (s) during extended water soaking could have been implicated in the gradual decline of germination percentage.

An important element contributing to the successful germination of seeds is the sowing medium. The selection of a suitable soil and its proper management are important in successful seed germination. Generally, sands or blends of sand and clay are utilized as sowing media for germination of seeds. The current results showed that germination of date palm seeds was best on sand: clay mix of 1:0. These results are parallel to those reported by Banks and Marcus (1999) who advocated using well-drained soil mixes with some moisture-holding capacity for germination of palm seeds. In response to sowing medium, total germination percentage was optimum with a medium of 1: 0 mixtures by volume of sand and clay than with the other media tested. The1: 0 sand: clay mix ensures rapid and uniform penetration of water throughout the medium; regulates moisture reserves and improve aeration. The capability of date palm seeds to germinate progressively decreases as the volume of clay, relative to sand, increases in the sowing medium. Deletion of sand from the sowing medium resulted in a significant negative effect suggesting that soil oxygen levels in high clay proportion sowing medium may be limiting or carbon dioxide or other gas level may be too high for germination. Adding sand to the sowing medium improved aeration and reduced water retention within the sowing medium. This would appear to be a result of a rapid and uniform penetration of water throughout this soil mix medium, and improved drainage and/or aeration relative to the other media tested. This speculation concurs with the recommendations of Hartmann *et al.* (2002) who suggested the use of well-drained media for various greenhouse propagation purposes. Similar results were obtained and similar conclusions were reached by Said, (1986). The results are also parallel to those reported by Bani (1988) and(Azad*et al.*, 2011) who obtained higher total rooting percentage; faster root emergence, longer roots and shoots and higher survival of rooted cuttings using sand as a rooting medium compared to a number of other horticultural substrates tested.

Seedling length was not influenced by soaking treatments. However, the 6day soaking treatment gave non-significantly high value over all other soaking treatments tested. The reason why seedling length was not affected by soaking treatments may be attributed to competition between the new formed apical meristem of the shoot and the leaf blades for assimilates (source-sink relationship). Growth, immediately after germination, may be controlled separately from germination with an increasing shift in assimilate translocation germination to the meristematic region. Soaking initiated metabolic and physiological processes essential for resumption of active growth of the embryo. It would appear possible that no carry-over effect of the water soaking treatments on germination of seeds to growth and development of established seedlings.

In response to sowing medium, seedlings were longest with a medium of 2: l mixture by volume of sand and clay than with the other media tested. The increased seedling length with this medium might be due to rapid and uniform penetration of water throughout the medium, high moisture reserves, improved drainage and/or aeration and high organic matter relative to the other media tested.

CHAPTER SIX

CONCLUSION

It could, therefore, be concluded, that soaking of seeds in water did ameliorate complex dormancy operative in date palm seeds. Soaking of date palm seeds for a week as a pre-sowing treatment, appears promising as a technique for hastening and increasing total germination of date palm seeds. The method may provide a foundation for development of generalizable seed germination procedure for other plant species. It proved to be simple, rapid, efficient, inexpensive, easy, repeatable, and can be carried out on year-round basis. However, additional research is warranted to optimize total germination percentages and to further reduce the number of days required for germination so that a system for commercial application can be developed.

REFERENC

- **Arar, P. (1980).** Soil, Irrigation and Drainage of the Date Palm. Training course in Date Production andProtection.Islam Abad Pakistan. Part1. Regional Project for Palm and Date Research Centre in Near East and North Africa.
- **Ahmed, H.S. (1986).** Endogenous growth substances of date palm and their relation to germination. Proceeding of the Second Symposium on Date Palm, Saudi Arabia, Volume1. Pp. 173-178.
- **Ahmed, I.A., Ahmed, A.W.K., Robinson, R.K.(1995)** Chemical composition of date varieties as influenced by the stage of ripening. Food Chem. 54:305–309.
- **Abdullah, G. and 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. Pp. 204-215
- **Alihouim.,Dialami H.(2010).**Effect of Offshoot Wright on Establishment and VegetativeGrowth in ‘Sayar’ Date Palm. Acta Hort., 882, 755−759.
- **Al-Bakr, A.J., (1972).** The Date Palm: A review of its past, present status and the recent advances in its culture industry and trade. Iraq. Pp: 1085. (In Arabic).
- **Al-Bakr A., (1972).** The Date Palm. It's Past and Present Status. Alania Press, Baghdad.
- **Al-Salih, A.A. (1984).** Influence of position of scarification and type of seed planting on date palm seed germination. Date Palm Journal, 3: 23-31.

- **Al-Wasel, A.S. and Warrag, M.O.A. (1998).** Effect of fruit developmental stage, seed scarification and operculum removal on seed germination of date palm. Journal of King Saud University, Agricultural Science, 10 (2): 153-161.
- **Al-Shisha W, Marshall RJ (2003) .**The fruit of the date palm: its possible use as the best food for the future. International Journal of Food Science and Nutrition 54: 247-259.
- **Al-Sakran M.S., Muneer S.E.,(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, pp. 1−20.
- **Al-Khteeb, A. A. (2008).** The problems facing the use of tissue culture technique in date palm (*Phoenix dactylifera L.)*. Scientific Journal of King Fiasal University (Basic and Applied Sciences), 9: 85-104.
- **Burns, R.M. and Coggins, Jr. C.W. (1969).** Sweet orange germination aided by water and gibberellin seed soaks. California Agriculture 23:18-19.
- **Basu, S.k. and Mukhernice, D.P. (1972).** Studies on the germination of palm seeds. Principles, 16: 136-137.
- **Bani, Y.A. (1988).** Vegetative Propagation of Some Horticultural Plants. M.Sc. thesis, University of Khartoum, Shambat, Sudan.
- **Bhaskaran, S. and Smith, R.H. (1992).** Somatic embryogenesis from shoot tip and immature inflorescence of *Phoenix dactylifera L*. cv. "Barhee". Plant Cell Reports, 12: 22-25.
- **Banks K, Marcus J (1999).** A practical guide to germinating palm seeds. Palms, Journal of the International Palm Society, 56–59.
- **Botes A, Zaid A (2002).** The economic importance of date production and international trade In: Zaid A, ed. Date palm cultivation. FAO Plant

Production and Protection Paper No. 156. Rome: Food and Agriculture Organization of the United Nations, pp. 45-56.

- **Baskin J. M. and Baskin, C. C. (2004).** Classification system for seed dormancy. Seed Science Research 14, 1-16.
- **Black, M. H. and Halmer, P. (2006).** The Encyclopedia of Seedscience, Technology and uses Wallingford, Ukcabi p. 224. ISBN 978-0-05199-7230.
- **Caulfield, N.W. (1976).** Pointers for successful germination of palm seed. International Plant Propagation Society Proceeding, 26: 402-405.
- **Carpenter, W.J. (1987).**Temperature and imbibition effects on seed germination of Sabal palmetto and Serenoa ripen. HortScience, 22:660.
- **Carpenter, W.J. (1988a).** Temperature affects seed germination of four Florida palm species. Hort Science, 23: 336-337.
- **Carpenter, W.J. (1988b).** Seed after-ripening and temperature influence Butiacapitata germination. HortScience, 23: 702-703.
- **Clancy, K.E. and Sullivan, M.J. (1988).** Some observations on seed germination and polyembryonic in the needle palm Rhapidophyllumhystrix. Principles, 32: 18-25.
- **Catalan L A, Macchiavelli R E (1991).** Improving germination in flexuosa D.C. and P. AlbaGriseb. With hot water treatments and scarification. Seed Science and Technology, 19: 253–262.
- **Chandra, A., Chandra, Anjou and Gupta, I.C. (1992).** Date Palm Research in that. Desert scientific publisers, Jodhpur p.116.
- **Carpenter, W.J.; Ostmark, E.R. and Cornell, J.A. (1993)**. Embryo cap removal and high temperature exposure stimulate rapid germination of needle palm seeds. HortScience, 28: 904-907.
- **Chao CT, Krueger RR (2007)** .The date palm (*Phoenix dactylifera L.*): overview ofbiology, uses and cultivation. HortScience 42: 1077–1082.

- **Dowson, V.H.W. (1982).** Date production and protection. FAO. Plant production and protection, No. 35.
- **DeMason D. A.; R. Sexton and J.S. Grant Raid, (1983).** Structure, composition and physiological state of the endosperm of *Phoenix dactylifera L.* Annals of Botany 52: 71-80.
- **Debergh, B.C. and R.H. Zimmerman (1991).** Micro propagation: Technology and Application. Kluwer Academic Publishers, Dordrecht, the Netherlands, Pp. 1-484.
- **Djerbi, M. (1995).**Precis de phone inculture. FAO. 192 pp.
- **Elshibli, S., and H. Korpelainen. (2008a).** Microsatellite markers reveal high genetic diversity indate palm (*Phoenix dactylifera L.*) germplasm from Sudan. Genetica 134:251-260.
- **FAOSTAT, (2009)**. Crop Production 2008, Statistics Division, Food and Agriculture Organization of theUnited Nations.
- **FAOSTAT. (2011).** Crop production 2011, Statistics division, Food and Agricultureorganization of United Nations.
- **Gurevich, V.; Lavi, U. and Cohen, Y. (2005).**Genetic variation in date palms propagated from offshoots and tissue culture. Journal of the American Society for Horticultural Science, 130:46-53.
- **Homquist, J. de D, and Popenoe, J. (1967).** Germination experiments: The effect of scarification on the germination of seeds of Acrocomiacrispa and Arengengleri. Principes, 11:23-25.
- **Hussein, F.; Mustafa, S.; El-Samiraea, F. and EL-Zeid, A. (1976).** Studies on physical and chemical characteristics of eighteen date cultivars grown in Saudi Arabia. Indian J. Hort. 33:107-113.
- **Hodel, D. (1977).** Note on embryo culture of palms. Principles. 21: 103-108.
- **Holloway, P.S. (1987).** Seed germination of Alaska iris, Iris setosa spp. interior. HortScience, 22:898-899.

- **Hartmann, H. T.; Kester, D. E.; Davies, F.T., Jr., and Geneve R. L. (2002).** Plant Propagation Principles and Practices. 7th edition. Prentice Hall, Inc. Upper Saddle River, New Jersey.
- **Kitzke, E. D. (1958).** A method for germinating Copernicia palm seeds. Principles 2: 5-8.
- **Kiem, S.C. (1968).** Propagation of palms. Principles, 2: 138-142.
- **Kader, A.A. and A.M. Hussein, (2009)**. Harvesting and Post-harvest handling of dates, International Centerfor Agricultural Research in the Dry Areas (ICARDA).
- **Jagirder, S.A.P. (1981).** Establishment of date palm orchards and tending palm. Training course on date palm production and protection. Islam Abad, Pakistan. FAO. Part 1.
- **Jones, David L. (1995).** Palms throughout the world. 264-266.
- **Johnson D. V., (2010).**World Wide Dispersal of the Date Palm from its Homeland. Acta Hort., 882,369−375.
- **Johnson, D.V. (2011).** Introduction: date palm biotechnology from theory to practice.In: Jain, S.M., Johnson, D.V. and Alkhayri, J.M. (Eds). Springer Science +Business media B.
- **Loomis H.F. (1958).** The preparation and germination of palm seeds. Principles, 2: 98-103.
- **Meerow A. W. (1990).** Palm seed germination. IFAS Cooperative Extension Bulletin, 274: 1–10.
- **Maekawa, S. and Carpenter, W.J. (1991).** Verbena seed hilum morphology contributes to irregular germination. HortScience, 26: 129-132.
- **Meerow, A. W. (1994).** Fungicide treatment of pygmy date palm seeds affects seedling emergence. Hort Science 29:1201.

- **Mahmoudi, H., G. Hosseininia, H. Azadi and M. Fatemi(2008)**Enhancing date palm processing, marketing and pset control throughorganic culture. J. Organic Systems. 3(2): 29-39.
- **MoustafaA. A., Ibrahim Z. A., El-YazelS. A. S., El-Anver M.A., (2010).** Evaluation and Selection ofSome Seedling Date Palm Males Grown in Fayoum Governorate, Egypt. Acta Hort., 882, 69−79.
- **Nixon, R.W. (1951).**The date palm- “Tree of life” in the subtropical deserts. Economic Botany, 5: 274-301.
- **Nixon, R.W. and R.T. Wedding. (1956).** Age of date palm leaves in relation to efficiency of photosynthesis. Proc. Amer. Soc. Hort. Sci. 67:266-269.
- **Nixon, R.W. (1964).** Viability of date seeds in relation to age. Date Grower’s Institute Report, 41: 3-4.
- **Nixon, R.W. and Carpenter, J. B. (1978).** Growing Dates in the United States. USDA Agric. Inf. Bulletin. 207, Washington, DC.
- **Nagoa, M.A. and Sakai, W.S. (1979).** Effect of growth regulators on seed germination of Archonlophoenixalexandrea. HortScience, 14: 182-183.
- **Nagao, M.A.; K. Kanegawa, and S. Sakai. (1980).** Accelerating palm seeds germination with gibberellic acid, scarification, and bottom heat. HortScience 15(2): 200-201.
- **Nagoa, M.A. and Furutani, S.C. (1986).** Improving germination of papaya seed by density separation, potassium nitrate, and gibberellic acid. HortScience, 21: 1439-1440.
- **Olumekun, V.O. and S.U. Remison. (1985).**The effects of soaking, heat treatment and growth regulators on the germination of date palm (*Phoenix dactylifera L.*). Journal of the Nigerian Institute for Oil Palm Research. 7(1): 107-119.

- **Osman, A.M.A., and N.N. Boulos. (1978).** Evaluation of some Sudanese date cultivars. ActaHortic: 185-190.
- **Olumekun, V.O. and S.U. Remison. (1985).**The effects of soaking, heat treatment and growth regulators on the germination of date palm (Phoenix dactylifera L.). Journal of the Nigerian Institute for Oil Palm Research. 7(1): 107-119.
- **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. 22-17 August, Khartoum, Sudan: Date Palm Research and Development Network.
- **Perez, A.; Reyes, M.N. and Cuevas, J. (1980).** Germination of two papaya varieties: effect of seed aeration, K-treatment, removing of the sarcotesta, high temperature, soaking in distilled water and age of seeds. Journal of Agriculture, University of Puerto Rico, 64: 164- 172.
- **Pieniążek J., PieniążekSz., (1981).** Owocekraindalekich (Fruits of distant countries). PWRIL, Warszawa, 278–285 (in Polish).
- **Read, A.R. (1963).** Culture of palm seedlings after germination. Principles, 6: 126-133.
- **Rees, R.W. (1963).** Germination of palm seeds using a method developed for the oil palm. Principles, 7: 27-29.
- **Reuveni, O. (1971).** Trickle irrigation of date palms. Date grower's Institute Report, 48: 16-18.
- **Sento, T. (1972).** Studies on seed germination of Palmae V: Chrysalidocarpuslutescens. Mascarenareschaffeltii and *Phoenix dactylifera L*. Journal of Japanese Society of Horticultural Science, 47: 76-82.
- **Schopmeyer, C.S, (1974).** Seeds of woody plants of the United States. Forest Series USDA, Agriculture Handbook, 450. p. 883.

- **Sento, T. (1976).** Studies on the germination of palm seeds. Memoirs of the College of Agriculture, Ehime University, 21: 1-78.
- **Shuey, A. and Wunderlin, R.P. (1977).** The needle palm. Rhapidophyllum. Principes, 21:47-57.
- **Samarawira, I. and Osuhor, E. (1981).**Samarugermplasm repository of Nigerian population of the date palm. Mimeograph, Faculty of Agriculture, Ahmedu Bello University, Zaria, Nigeria.
- **Sumainah, Gh.M;Makki, Y.M. and Rumney, T.G. (1984**). Changes in chemical composition of three cultivars of date palm seeds during germination. Date Palm Journal, 3: 395-407.
- **Said, A.E. (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. Volume1. Pp. 239-246.
- **Sabota, C.; Beyl, C. and Biederman, J.A. (1987).** Acceleration of sweet corn germination at low temperatures with Terra-Sorb or water presoaks. HortScience, 22: 431-434.
- **Sawaya W. N., (2000).** Proposal for the Establishment of a Regional Network for Date-Palm in theNear East and North Africa. A draft for discussion, FAO/RNE.
- **Soliman S.S., Al-Obeed R.S., Harhash M.M., (2010).** The Effect of Bunch Thinning on Yield of Fruit Quality of ‘Khalas’ Date Palm. Acta Hort., 882, 726−731.
- **SalimAzad, TabiurRahman, Abdul Matin, (2011).**Seed germination techniques of *Phoenix dactylifera L*:A new experience from Bangladesh
- **Sharma S.K and Singh, R.S(2013).** Date Palm in fruit production technology(ed.Dhillon,WS)Narendra publishing House, New Delhi.pp.213-225.

- **Tomlinson, P.B. (1961).**Palmae, p. 47-52. In: C.R. Metcalfe (Ed,). Anatomy of the Monocotyledons. Vol.11. Clarendon Press, Oxford, U.K.
- **Tisserat, B. (1983).**Tissue culture of date palm. A new method to propagate an ancient tree. Principles, 27: 105-117.
- **Veramendi, J. and Navarro, L. (1997).**Influence of explant source of adult date palm (*Phoenix dactylifera L.*) on embryo genic callus formation. Journal of Horticultural Science. 72: 655-671.
- **Wagner, R.I. (1982).** Raising ornamental palms. principles, 26: 86-101.
- **Zohary, D. and M. Hopf, (2000).**Domestication of Plants in the Old World (3rd Ed.), Oxford UniversityPress, Oxford, UK.
- **Yocum, H.G. (1961).** A method for germinating palm seeds. principles, 5:31-32.
- **Yousif, A.A. (1995).** The date palm. Khartoum University press vol 1:273-280, Khartoum, Sudan.
- **Zaid, A. (2002).**Date palm cultivation. FAO Plant Production and Protection Paper No. 156. Rome: Food and Agriculture Organization of the United Nations.
- **Zaid, A., de Wet, P.F. (2002b).** In Date palm cultivation, Date palm propagation, edZaid A. (Food and Agriculture Organization Plant Production and Protection Paper no. 156. Food and Agriculture Organization of the United Nations, Rome, Italy), pp 73–105.
- **Zirari A., (2010).**Effects of Time of Pollination and of Pollen Source on Yield and Fruit Quality of‘Najda’ Date Palm Cultivar (*Phoenix dactylifera L.*) under DraaValey Conditions in Morocco .Acta Hort., 882, 89−94.

APPENDICES

Appendix (1)

Ministry of enviroment, forestry and physical development meteorological authority weather –climate data

Station:-

Khartoum

Period:-2015 to 2016

ELEMENT /Month	Mean Temperature c° MAX.	Mean Temperature c° MIN.
November	36.0	21.6
December	29.5	15.6
January	28.5	14.9
February	33.0	17.5
March	39.5	24.3

Note: - Max = Maximum

Min = Minimum

Appendix (2)

Appendix (3)

Appendix (4)