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Relation between morphological features & bio-ecological factors of date palm trees cultivars from sub-saharan region

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Abstract
This study aimed at suggesting and concluding the degrees of relationship between some morphological features of date palm trees cultivars from the Sub-Saharan region and some bio-ecological factors of this area. Four date palm varieties (Wad-Laggi, Wad-khateeb, Gondaila, and Barakawi) from Omdurman City were studied as representative samples of the most famous date palm types. Besides observing the morphological features of date palm trees, some bio-ecological data of this area were observed and reported from international literature and some interviews with expert peoples. Our results had been expressed as "degree of relationship" between the two study variants, estimated by comparing and weighting the differences in the morphology of date palm trees grow under bio-ecological conditions of the study area and other regions. We suggested that some morphological features of date palm trees such as the number of leaflets, the color of leaves, number of spines, and fruiting period (days), had strong relations with the bio-ecological system, ((expressed as (+++)), while some other feature such as the length of stem (tree height), length of leaves, fruit length and fruit width had some relations. Some morphological features i.e. stem diameter, spine length, and fruit weight seem to have no relations with the bio-ecological factors.

Keywords: date palm; morphological features, bio-ecological factors, Sub-Saharan region, relationships

1. Introduction
The date palm (*Phoenix dactylifera* L.) is a species of the genus *Phoenix*. Taxonomically classified as a member of the Phoeniceae tribe (Jain *et al.*, 2011b)[1]. The term *Phoenix dactylifera* means " red or purple finger" in Greek, due to the color and shape of the date palm fruit (Chao and Krueger, 2007)[2].
About 5,000 varieties of date palm were found around the world (Osman, 1984)[3], particularly distributed between latitudes 10º and 35º above and down the equator line in the map (Elshibli and Korpelainen, 2009; Yousif, 1995)[4,5]. About 22 date palm varieties were reported in the Sub-saharan region, this is less than about (400) varieties in the region of Iran and Iraq (Chao & Krueger, 2007)[6]. The exact history of date palm domestication in the Sub-saharan region was not clearly determined, but this region is considered as a diversity center of date palm (Kassem, 2012)[7]. Arid and semi-arid regions are rich with date palm cultivars, characterized by low rainfall and long and hot summer, with low relative humidity levels. The optimum temperature for date palm growth is about 32°C. High and low temperatures (± 56°C, 7°C) is well endured by a date palm for several days under irrigation (Zaid and de Wet, 2002a & 2002 b) [8, 9].
For example, in Sudan, a wide variation of the date palm is concentrated along the River Nile banks between latitudes 15.5° and 22° N and Northern states in the Sub-saharan region (Elshibli and Korpelainen, 2009; Yousif, 1995; Jaradat and Zaid, 2004)[4;5;10]. The best- known soft types of dates cultivars in Sudan, were namely, Wad Laggai, Wad Khateeb, Gondaila, Barakawi, and Medina (Elshibli and Korpelainen, 2009) [4]. Some date cultivars' genetic varieties may have the same name (Torres and Tisserat, 1980) [11].

1.1 Variety description
Date palm is a diploid (2n=36), perennial tree. Being dioecious, having separate female and male individuals. Female palm trees are cultivated for their nutritive fruits as they are pollinated by wind or insects, and are almost flower once a year in spring, while male trees produce pollens (Chao & Krueger, 2007; Jain *et al*., 2011b) [6, 1].
The use of morphological parameters is one of the common methods implemented - rather than the genetic features - to identify the date palm variation and level of diversity. (Elshibli and Korpelainen, 2009)[4]. The high genetic diversity among date palm cultivars from the Sub-saharan region was reported by many studies (Zehdi *et al*., 2004a) [12], this genetic diversity may be correlated with different bio-ecological factors. The taxonomy of the genus Phoenix has been under study for a long time, and it is well established in the literature only relatively recently (Jaradat, 2015)[13]. Categorizing and classifying date palm cultivars were somewhat confusing, it might be described based on fruit characteristics such as moisture or other features of the tree or leaves, or may be based on their respective countries or regions (Chao & Krueger, 2007)[6]. Some morphological markers such as fruit characteristics are significantly affected by the environment.

1.2. Values of date palm
Date palm is a valuable plant as it grows in harshly dry environments providing the people with food (delicious fruit

called Balah or Tamar), raw materials used in house building, and some other local agro-food industries (Jain *et al*., 2011b)[1]. Its fruits had a high nutritional and energy-producing value particularly as a source of sugars (70% carbohydrates) (Jasim Ahmed *et al*., 2014)[14], the date is called a mine in itself because it is very rich in minerals and pectin substances, it has a high content of magnesium (±600 mg/1kg of dates) and phosphorous (Cook and Furr, 1953)[15], for that, date consumers in Saharan areas are known to have the lowest rate of cancer diseases. The date is also a good source vitamin A, B1, B2, and B7 (Zaid and de Wet, 2002 b)[9], its content of water reaches 30% depending on the variety and on the maturity stage of the fruit. for that, date palm is a good economical product, and it is truly an age-old multipurpose species (Jain *et al*., 2011b)[1], its economic life was estimated at 50 -150 years (Chao and Krueger, 2007) [6], this long generation times may reduce the impact of bio-ecological on the date palm tree and fruit characters including the morphological features (Loveless and Hamrick, 1984) [16].

1.3. Date palm propagation

There are three techniques to propagate date palm, seed propagation (sexual propagation), offshoot propagation (asexual, or vegetative traditional methods of propagation), and the recently developed tissue culture techniques (Zaid and de Wet, 2002)[17].

Seed propagation is not a proper method of date palm vegetative propagation, because it is a dioecious species and heterozygous, and thus there will be more variation within the progeny. But still, seed propagation is by far the easiest and quickest method of propagation, however, studies reported that the mixture of cultivars during sexual propagation by seeds results in new genotypes or forms of date palm (Elsafy *et al*., 2015) [18], therefore, considered as a main source of variation in the date palm (Zaid and de Wet, 2002)[17]. The offshoot propagation technique is difficult and expensive, but still, it offers some advantages, such as the shorter fruiting time (Elsafy *et al*., 2015) [18].

1.4. Bio-ecological factors

Some studies suggested that plant species diversity was positively correlated with multiple environmental factors, whereas it was negatively correlated with soil bulk density (Dov and Sax, 2002)[19]. Some studies suggested that the effects of soil and climatic factors were much stronger than those of geographical factors, while the integrated effects of geographical factors and meteorological conditions were contributed to the spatial heterogeneity of species biodiversity (Dov and Sax, 2002)[19]. Date palm fruit quality and quantity can be significantly altered by macro elements available in different soil types (Khayyat *et al*., 2007)[20]. The impact of macro elements (nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg2+), and calcium (Ca2+)) on date palm yields have been reported by many studies (Khayyat *et al*., 2007)[20]. Some soil-borne fungal diseases (such as Fusarium oxysporum) may cause the death of the tree, additionally, the unsuitable soil types have a large impact on date palm growth, and may impact the morphological features of the date palm tree (Jain *et al*., 2011b)[1]. Generally, soil moisture levels, drainage, and texture are environmental factors that may increase or lessen plant sensitivities to impacts (Fred Kuss, 1986) [21].

Many conditions cause physiological injury and may increase plant sensitivity to impacts, the habitat environments in which plants grow is one of these conditions (Fred Kuss, 1986)[21]. Climate change might impact the future distribution and characteristics of the date palm, it may cause about 55% of crop failure in agricultural regions in India (Farzin Shabani *et al*., 2013)[22]. Climate change may also alter some diseases of the date palm (Farzin Shabani *et al*., 2013)[22]. There is controversy concerning the effect of rain on the fruit set, some people consider a negative indirect effect of rain via low temperatures that accompany or follow rain (Elsafy *et al*., 2015)[18].

Moreover, very little rainfall and low stepwise irrigating can provide favorable conditions for date palm cultivation since it is adapted to arid desert conditions (Carrera *et al*., 2007; Farzin Shabani *et al*., 2016)[23;24]. High-speed dry wind storms will take away a great deal of the pollen during propagation, then wind affects the palm growth and date fruits characteristic, and even production (Elsafy *et al*., 2015) [18].

This study highlights relations between some morphological features of some date palm types (trees and fruits), and some bio-ecological factors including environmental and geographical conditions in Sub-saharan regions.

2. Materials and methods

Our samples were individual date palm trees collected from streets and from inside living houses in the area near Omdurman City (Sudan), Latitude in °N = 15°36', Altitude in meters above mean sea level is 380, this area had been taken for this study as a reprehensive example for the Sub-saharan region. Although the United Nations institutions did not classify Sudan as a Sub-saharan country, actually, the central area of Sudan is located directly within the area in the arid south of the great Sahara Desert of North Africa.

After a pilot survey, four well known and most famous Sudanese date palm cultivars (Wad Khateeb, Wad Laggai, Gondaila, and Barakawi) had been chosen for this study for investigating and observing their morphological characterization. A total of twenty date palm trees were included in our observational study (Five trees from each one of the four varieties). The studied morphological parts of date palm trees from the area of our study were stem, leaves, and fruits, most were quantitative and some were qualitative tree characteristics. For fruits, each observation being an average of three samples. The fruit weight was measured using a digital balance with an accuracy of 0.01 g, and the fruit size was measured using a regular ruler validated against a Vernier caliper. The study was based on 10-15 random date fruits of each variety. The length of the branched stem trees was calculated by summiting the lengths of all stem branches in addition to the length of the rest of the main stem. We faced some difficulties in measuring the height of some cultivars, because they were too long, or having too many spines. Date palm trees morphological parts in question were photographed individually. The observed bio-ecological factors were environmental parameters such a climate temperature, rainfalls, air humidity, and geographical parameters such as soil features. Besides our observations and practices, the data of bio-ecological factors had been collected from published researches done in this region and other regions and supported by practical real-time data gained from expert

persons from the study area. The relations had been suggested by comparing the observed bio-ecological factors of the region in question with the bio-ecological factors of other date palm regions, then observing and weighting (compare and contrast) the differences in morphology of date palm trees grow under both bio-ecological conditions. If the differences in bio-ecological factors are followed by notable differences in morphological features of the plant, then we suggest the presence of a relation. According to the degree of these differences, the suggested degree of the presence of a relationship was signed as one cross (+), or three crosses (+++) for strong relationships.

3. Results and Discussion

The most abundant date palm types observed in our study area (near Omdurman City (Sudan) were Barakawi, Gondaila, Wad-laggi, and Wad-khateeb varieties, these names are Arabic terms and there are no equivalent English words. Morphologically, these cultivars were closely related, except the Barkawi cultivar which had somewhat different characters such as stem length and dry fruit texture, these observations are similar to those reported by Al-Shahib &Marshall (2003) [25]. There is no information on how these trees have been individually domesticated. However, some other cultivars were also grown in this area. The distribution of soft or dry type of date palm culture in the Sub-saharan region seems to follow a geographic pattern (Osman, 1984) [3].

We screened some morphological features of these varieties for suggesting possible relations with the bio-ecological factors in the Sub-saharan region. (Table.1 summarizes some of these morphological features).

3.1. Morphological features

3.1.1. Stems and leaves

The average length of 20 trees (Stem or trunk length) of all types was 7.70 meters. Some studies done in other regions reported a date palm trunk height ranging between 15 and 25 meters (Al-Shahib and Marshall, 2003)[25]. The variations in the stem lengths of our samples and that of the other studies may be due to the abundant of specific varieties which were included in our study, however, the possibility of the presence of a relation between stem length feature and our geographical region factors seems as (+).

Three of the twenty date palm trees included in our observational study had branched stem, all of them were of Gondaila type, the average length of this branched stem trees (summation of lengths of all stem branches in addition to the length of the rest of the main stem) was 12.5 meters, while trees of the remaining types had a longer upright stem **(Fig.1).** The feature of stem shape, either upright or branched stem, seems like a genetic (hereditary) feature, our observations suggested no correlation between these feature with the bio-ecological system of the Sub-saharan region, this observation based on the fact of the presence of theses branched stem trees in other world date palm areas (Jaradat and Zaid, 2004)[10]. However, the branched stem phenomenon may be a result of either dichotomy, auxiliary bud development, or attack by a disease. Zaid's (2002)[8] study mentioned that the branched date palms are fertile and can produce the same amount of fruit as a single-headed palm.

Stems were brown in color, their outer circumference is about 1 to 1.10 m, and surrounded by rigid projections (old leaf scars).

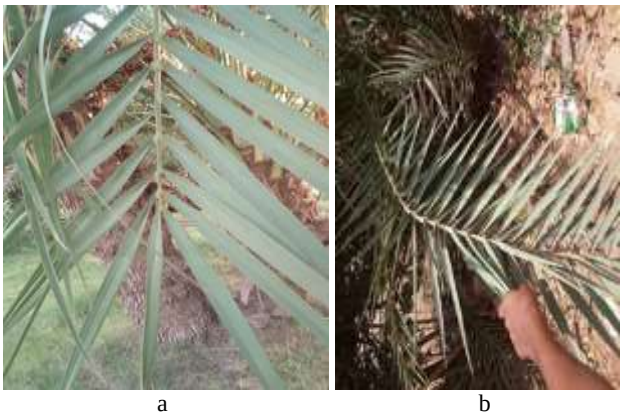
Date palm trees we observed had a feather-type sharp ended leave, with a length nearly ranged between 2 to 3 meters for the four cultivars in question. Leaves (also called fronds) length is depending on the variety and age of a palm, but the environmental conditions may also determine this feature (Jaradat, 2015) [13]. Leaflets of all palm types in question were shiny green colored, somewhat different from the dark green leaflets noted from other world date palm regions (Dehgan and Bijan, 1998) [26], this pale color may be due to the climatic conditions and soil's nature of the Sub-saharan region. It is necessary to notice that the date palm leaf is called a "branch" by natives of this area, which is realistic because the leaf is like a branch with many leaflets and thorns attached to the wood base of the leaf.

Each mature leaf contains an average of about 105 leaflets on both sides (Fig 2). Induplicate (V-shaped) leaflets were kept erect at all times because of the presence of a central fold on them (Jaradat, 2015) [13]. The shorter leaves and the different color of leaflets in our samples than date palms from other regions (leaf length 3.5-3.8m) (Dehgan, Bijan 1998) [26] lead us to suggest the presence of a strong relationship between soil characteristics and climatic conditions with these morphological features (we sign it as +++). The hot dry climate and low air humidity, besides the dry soil of this Sub-saharan region expected to have a strong inverse relationship with the darkness of leaflet color, and the leaves' length.

On average, about 15 spines (thorns) was arranged on the two outer edges of each leaf of our samples, with lengths ranging 7-8 cm, these spines were shorter than what reported for date palm from some other regions, which is about 24 cm (Ahmed Simozrag, 2016)[27]. The lower length and the more rigidity of thorns observed in our samples may also be due to the climatic and soil's nature of the Sub-saharan region, this suggestion is confirmed by comparing them with the ecosystems of other world date palm regions, which had a longer and much more number of thorns (30 to 35 thorn per leaf) (Ahmed Simozrag, 2016) [27]. Some studies had reported that basal leaflets were modified into spines (Elshibli and Korpelainen, 2009; Jaradat, 2015) [4, 13]. In this area, a well-known single character that differentiates the growth of Wad-laggi and Wad-khateeb cultivars is the orientation of spines along the base of the leaf (either alternate or opposite arrangement), but this character is not stable in other cultivars.

Fig 1: Long (Barakawi) date palm tree

Fig 2: Wad Laggi, & Gondila date palm trees are almost similar



a b

Fig 3: The leaf of Barakawi (a), and Wad Laggi date palm types (b)

3.1.2. Fruits

Barakawi cultivars possessed the highest fruit lengths, while Wad-laggi and Wad-khateeb showed lower fruit lengths. Barakawi fruits were elongated, while Wad-laggi and Wad-khateeb fruits were somewhat ovate **(Fig.3** shows fruits of the studied date palms**)**.

Studies of Jaradat (2015) [13] on date palm stated that fruit length varied between 2.92 and 5.40 cm. However, the same cultivars may significantly vary in their fruit size in different locations and seasons as a response to the environment and cultural practices (fertilization, pollination, thinning) (Elshibli and Korpelainen, 2009) [4].

The average fruit weight of all date palms in question was 8.07 g. The observed fruit weights of the Barakawi were the highest (average 9.70 grams).

The same date palm variety may produce fruits of somewhat different weight according to the geographical areas, it is somewhat difficult to differentiate Wad Laggi & Wad Khateeb date palm fruits.

The five distinct stages of fruit development were known as Hababouk, Kimri, Khalal, Rutab, and Tamar.

At first maturing stages the fruits were Yellow-orange, at Tamar stage (ripe) it shrinks, being with a dark brown to black color, its flesh thickness being more or less 5 to 7 mm with little fiber. It has a sweet, but not concentrated taste**.** As characters of fruit morphology vary according to the palm type, some studies considered the fruit size as the most prominent differentiating feature of date palms (Jain, 2011 b) [28].

Fruits of the branched- stem date palm trees were shorter than those of the single long stem.

This feature of the fruit had no relation with the ecological system, it seems as a hereditary feature, these fruits are of variable size, depending on the species, with a single grooved seed (Elsafy, 2012) [29].

Depending on fruit characters, the four varieties in question were classified as soft types of dates (Elshibli and Korpelainen, 2009; Elhoumaizi and Saaidi, 2002) [4, 30].

Fig 4: Fruits of Barakawi date palm

Fig 4: Some types of Wad Laggi & Wad Khateeb date palm Fruits

The fruiting period of date palm (from fruit set to fruit maturation) in our study was reported as about 100 days, compared with 239 days in Cairo/Egypt, and 135 days in Mauritania (Abdelouahhab Zaid, 2002) [31]. These variations from one date variety to another depending on environmental conditions. Notifying that the Summer season is longer and more hot in this Sub-saharan region under this study. To that end, we suggest the presence of a strong relation (+++) between the fruiting period of the date palm and environmental conditions. Our study in the Sub-saharan region at northern central Sudan, near Omdurman City, showed that at low humidity the date fruits become very dry, but after the Tamar stage is reached, air humidity causes little damage to the fruit. The date palm regions' eco-system is mostly arid where air relative humidity has a large influence. At high humidity, fruits become soft and sticky, while at low humidity they become very dry (case of Northern Sudan and in-land plantations). However, date palm can withstand strong, hot, and dusty summer wind (Dowson, 1982) [32]. Many studies observed that date palm fruit quality and quantity can be significantly altered by macro elements available in different soil types, besides some impact of microelements on date palm yields (Khayyat *et al*., 2007; Dialami & Mohebi, 2010) [20, 33].

Table 1: Some observed morphological features of 4 date palm cultivars grown in the Sub-saharan region (Near Omdurman City, Sudan**).**

	Barakawi*	Gondaila*	Wad Laggai*	Wad Khateeb*	Average of all types
Tree height (m)	10.00	6.50	7.00	7.30	7.70
Stem diameter (m)	1.50	1.60	1.70	2.00	1.70
Length of leaves(m)	1.90	2.50	2.80	3.20	2.60
Number of leaflets per leaf	100	100	110	110	105.0
Number of spines per leaf	13.0	16.5	15.5	15.5	15.13
Fruit length (cm)	3.80	3.30	2.90	2.90	3.22
Fruit width (cm)	1.80	1.50	1.20	1.20	1.42
Fruit weight (g)	9.70	8.00	7.70	6.90	8.07

* The value for each variety were expressed as mean of five trees.

3.2. The impact of bio-ecological factors

Our observations on the average annual temperatures, the rainfall level per year, and the relative humidity for the area near Omdurman City was shown in Table 2. Date palm withstands large temperature fluctuations, below 7°C growth stops and this stage is called a resting period (Mason, 1925a; Nixon, 1978) [34, 35]. People in this area assume that date palms can survive the toughest conditions, so they neglect the usage of fertilizers and depend on the natural soil which may affect the growth of date palm trees and fruit production. In some other regions, the fertilization is done by about 45 kg of nitrogen, 13.5 kg of phosphate, and 81 kg of potassium, in order to produce 50 kg of date fruits per palm (Djerbi, 1995) [36]. The lack of some microelements such as manganese and boron may cause the death of palms within a period of five to seven years (called disease of broken leaves) (Djerbi, 1995) [36]. The Nile River composed of two branches, the White Nile and the Blue Nile, most sediments came from the Blue Nile, carrying high carbonate content which may lead to soil salinization in flooded depressions. Additionally, water stored in the soil is low or nil during the year in this Sub-saharan area. Our study area in this Sub-Saharan region although located near the Nile River, had a water deficit of about 1656 mm (Satakopan, 1965) [37]. Vegetation biomass was positively correlated with soil total nitrogen, organic carbon, and soil moisture, whereas it was negatively correlated with soil bulk density (Satakopan, 1965) [37]. Some other natural factors may be related to the fruiting features of the date palm, i.e. bird attacks are common in this area, by eating on the fruit during the Rutab and Tamar stages (Elshibli and Korpelainen, 2009) [4]. The importance of ventilation increases during the later stages of fruit growth. The bags retain the fruit and provide some protection from birds, but they do not hinder fruit-infesting insects (Carpenter, 1981) [38].

3.3. Suggested Degree of Relationship between bio-ecological factors and morphological features of date palm

3.3.1. Our observations

Beside our results of the morphological features of date palm, Table 2 shows bio-ecological factors of the Sub-saharan region (Near Omdurman City).

Table 2: Some bio-ecological factors and morphological features of date palm from Sub-saharan region (Near Omdurman City, Sudan).

Bio-ecological factors Region	Average annual temperatures (°C)	Average of relative humidity	Soil characteristics	Rainfall level m/m per year	Observed values of morphological features *
Our results	30.7 (max 48, min 10)	30%	High salinization Low stored water	25	**Stem length** = 6.83 m
					Leaves & Leaflets Features
					Length of Leaves = 2.60 m
					No. of Leaflets/ leave = 105
					Color: shiny green
					Fruits' features
					Length = 3.22 cm
					Width = 1.42 cm
					Weight = 8.07 g
					Number of spines per Leaf = 15.13
					Fruiting period = 100 days

3.3.2. Some bio-ecological features of other regions

Some bio-ecological variables from other geographical date palm regions were as follows:

- For North African region: Values average of annual temperatures (ºC) were taken from Cairo/Egypt = 30 (max 33.7, min 7.6) (Al Bakr, 1972; Maged Hussein and Ebtisam Mohamed, 2016) [39, 40], and Tunisia = 21.3 (max 49, min 5) (Dowson, 1982) [32]. The overall average for these regions max 41.35, min 5.85, average annual temperatures = 25.65. In Mauritania (Western North Africa) the rainfall level m/m per year = 110 (Djerbi, 1995) [37].
- For Middle East (Asian) region: Values were taken from Iraq. Averages of relative humidity = about 40% (Dowson, 1982) [32].
- For Tropical & subtropical region: Values average was taken from Namibia, relative humidity = about 50% (Dowson, 1982) [32]; and from Niger, rainfall level = 146 m/m per year (Djerbi, 1995) [37].

3.3.3. Suggested Degree of Relationship

By weighting and comparing the variables observed in our study with variables from other geographical regions, the number of leaves, the color of leaves, the number of spines, and the fruiting period (days) suggested being highly related to the bio-ecological system of the Sub-saharan region, while stem length (tree height), length of leaves, fruit length and fruit width (cm) seems at a low degree of relation.

By observation, and this evidence-based weighting, the non-mentioned morphological features suggested having no direct relation with the bio-ecological systems, i.e. stem diameter, spine length, and fruit weight. The suggested degrees of the presence of relationship were expressed by one cross (+) for low positive relation; and three crosses (+++) for high positive relation, shown in Table 3.

Table 3: Suggested Degrees of Relationship between bio-ecological factors and morphological date palm features

Morphological Features	Suggested Degree of Relationship
Stem length (tree height)	(+)
Length of leaves	(+)
Number of leaflets Per leaf	(+++)
Color of leaves	(+++)
Fruit length (cm	(+)
Fruit width (cm)	(+)
Number of spines Per leaf	(+++)
Fruiting period (days)	(+++)

(+) for low positive relationship; and three crosses (+++) for high positive relationship

4. Conclusion

This study suggested the possibility of the presence of a relationship between some morphological features of date palm varieties chosen from a Sub-saharan region, and the bio-ecological factors of that area. The presence and degree of the relationship were suggested by comparing and weighting the differences in date palm morphology and the bio-ecological factors in the region under study versus those in some other areas. Features as the number of leaflets, the color of leaves, the number of spines, and the fruiting period of date palm seem to be affected by the Sub-saharan bio-ecological nature which is characterized by a hot long summer season, and a dry, high salinity soil. These impacts lead us to suggest a presence of a relation between the morphology of date palm cultivars, and the bio-ecological system, expressed in this study as “Degree of Relationship”.

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6. References

1. Jain S, Al-Khayri J, Johnson D. Date palm biotechnology. Available at: http://www. springer.com/gp/book/9789400713178, Accessed: March 2013, 1st edn. Springer, University of Helsinki, Finland, 2011.
2. Chao CT, Krueger RR. The Date Palm (Phoenix dactylifera L.): Overview of Biology, Uses, and Cultivation. HortScience, 2007; 42: 1077-1082.
3. Osman AMA. The performance of date palms in the Sudan. Acta Horticulturae, 1984; 143:231+-237.
4. Elshibli S, aKorpelainen H. “Biodiversity of date palms (*Phoenix dactylifera* L.) in Sudan: chemical, morphological and DNA polymorphisms of selected cultivars,”. *Plant Genetic Resources: Characterisation and Utilisation*. 2009; 7(2):194-203.
5. Yousif AA. *The Date Palm.* Khartoum University Press, Khartoum, Sudan, 1995, 1.
6. Chao CCT, Krueger RR. “The date palm (*Phoenix dactylifera* L.): overview of biology, uses, and cultivation”. *HortScience*, 2007; 42 (5):1077-1082.
7. Kassem HA. The response of date palm to calcareous soil fertilisation. Journal of Soil Science and Plant Nutrition. 2012; 12:45-58.
8. Zaid A, de Wet PF. Botanical and systematic description of the date palm. In: Zaid A (ed.) Date Palm Cultivation. FAO Plant Production and Protection Paper no. 156. Rome: Food and Agriculture Organisation of the United Nations, 2002, 1-28.
9. Zaid A, de Wet PF. Origin, geographical distribution and nutritional values of date palm. In: Zaid A (ed.) Date Palm Cultivation. FAO Plant Production and Protection Paper no. 156. Rome: Food and Agricuture Organisation of the United Nations, 2002, 29-44.
10. Jaradat AA, Zaid A. Quality traits of date palm fruits in a center of origin and center of diversity. Food, Agriculture and Environment. 2004; 2:208-217.
11. Torres AM, Tisserat B. Leaf isozymes as genetic markers in date palms. Am J Bot. 1980; 67(2):162-167.
12. Zehdi S, Trifi M, Billotte N, Marrakchi M and Pintaud JC. Genetic diversity of Tunisian date palms (Phoenix dactylifera L.) revealed by nuclear microsatellite polymorphism. Hereditas, 2004a; 141:278-287.

13. Jaradat AA. Biodiversity, Genetic Diversity, and Genetic Resources of Date Palm. In: Al-Khayri J., Jain S., Johnson D. (eds) Date Palm Genetic Resources and Utilization. Springer, Dordrecht, 2015. https://doi.org/10.1007/978-94-017-9694-12
14. Jasim Ahmed, Fahad Aljasass, Muhammad Siddiq. Date Fruit Composition and Nutrition, In book: Dates: Postharvest Science, Processing Technology and Health Benefits (pp.261-284). Edition: 1st, Chapter: Date Fruit composition and nutrition Publisher: John Wiley & Sons, Ltd. Editors: Muhammad Siddiq, Salah M. Aleid, Adel A. Kader, 2014. DOI: 10.1002/9781118292419
15. Cook JA, Furr JR. Sugars in the fruit of soft, semi-dry and dry commercial date varieties. Date Growers' Institute, 1952, 29.
16. Loveless MD, Hamrick JL. Ecological determinants of genetic structure in plant populations. Annual Review of Ecology and Systematics. 1984; 15:65-95.
17. Zaid A, de Wet P. "Climatic requirements of date palm," in *Date Palm Cultivation. FAO Plant Production and Protection*, FAO, Rome, Italy, 2002, 57-72.
18. Elsafy M, Zborowska A, Bryngelsson T, Fatih M, Mujaju C, Garkava-Gustavsson L. "Elucidating the genetic diversity of farmer cultivars of female date palms (*Phoenix dactylifera* L.) from Sudan by microsatellite markers". Genetic Resources and Crop Evolution, 2015, 1-12.
19. Dov F, Sax D. Native and naturalized plant diversity are positively correlated in scrub communities of California and Chile, Diversity and Distributions. 2002; 8:193-210.
20. Khayyat M, Tafazoli E, Eshghi S, Rajaee S. Effect of Nitrogen, Boron, Potassium and Zinc on Yield and Fruit Quality of Date Palm. American-Eurasian J. Agric. & Environ. Sci. 2007; 2(3):289-296. ISSN: 1818-6769.
21. Fred R, Kuss A. A review of major factors influencing plant responses to recreation impacts. Environmental Management. 1986; 10:637-650.
22. Farzin Shabani, Lalit Kumar, Subhashni Taylor. Suitable regions for date palm cultivation in Iran are predicted to increase substantially under future climate change scenarios. The Journal of Agricultural Science, 2013, 152(4). DOI: 10.1017/S0021859613000816
23. Carrera LM, Buyer JS, Vinyard B, Abdul-Baki AA, Sikora LJ, Teasdale JR. Effects of cover crops, compost, and manure amendments on soil microbial community structure in tomato production systems, applied soil ecology. 2007; 37:247-255.
24. Farzin Shabani, Oscar Cacho & Lalit Kumar. Effects of climate change on economic feasibility of future date palm production: An integrated assessment in Iran, Human and Ecological Risk Assessment: An International Journal, 2016 ; 22, (5). https://doi.org/10.1080/10807039.2016.1162089
25. Al-Shahib W, Marshall RJ. "The fruit of the date palm: it's possible use as the best food for the future?". International Journal of Food Sciences and Nutrition. 2003; 54(4):247-259.
26. Dehgan Bijan. Landscape Plants for Subtropical Climates. Gainesville, FL: University Press of Florida, 1998.
27. Ahmed Simozrag, Adel Chala, Aissa Djerouni & Mouhamad Elmoncef BENTCHIKOU. Phenotypic diversity of date palm cultivars (Phoenix dactylifera L.) from Algeria. Gayana Bot. 2016; 73(1):42-53, ISSN 0016-5301
28. Jain SM. Date palm genetic diversity conservation for sustainable production. Acta Hort. 2011; 882:785-791.
29. Elsafy M. Study on the on-farm diversity of local date palm (Phoenix dactylifera L.) genetic resources in Northern region of Sudan [M.S. thesis], Department of Plant Breeding and Biotechnology, Swedish University of Agricultural Sciences, Alnarp, Sweden, 2012.
30. Elhoumaizi MA, Saaidi M, Oihabi A, and Cilas C. "Phenotypic diversity of date-palm cultivars (*Phoenix dactylifera* L.) from Morocco". Genetic Resources and Crop Evolution. 2002; 49(5):483-490.
31. Abdelouahhab Zaid. Date Palm Cultivation, Fao, Plant Production and Protection Paper 156 Rev. 1. Rome, 2002. ISSN 0259-2517. ISBN 92-5-104863-0
32. Dowson VHW. Date production and protection with special reference to North Africa and the Near East. FAO Technical Bulletin. 1982; 35:294.
33. Dialami H. Effect of nitrogen, phosphorus and potassium fertilizers on date palm, cultivar 'Sayer'. Final report of research project, Agricultural Research, Education and Extension Organization, Iran, 2009.
34. Mason SC. The minimum temperature for growth of the date palm and the absence of a resting period. J. Agric. Res. 1925; 31:401-414.
35. Nixon RW, Carpenter JB. Growing Dates in the United States. U.S. Dept. of Agriculture, Agric. Information Bulletin No. 207: USDA. Technical Document, 1978, 63.
36. Djerbi M. Précis de Phoeniciculture. FAO, 1995, 192.
37. Satakopan V. Water balance in the Sudan. Memoir 5. Sudan Met. Service, Khartoum, 1965.
38. Carpenter JB. Improvement of traditional date culture. Date Plam J. 1981; 1(1):1-16.
39. AL-Bekr AJ. The Date Palm: A review of its past, present status and the recent advances in its culture industry and trade. Iraq (Arabic), 1972, 1085.
40. Maged MA Hussein, Ebtisam EE Mohamed. Temperature Trend over Nile Delta, Egypt in 20th Century. Advances in Research. 2016; 7(2):1-14, Article no.AIR.25466 ISSN: 2348-0394, NLM ID: 101666096 SCIENCEDOMAIN international www.sciencedomain.org