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The Study of the Chemical and Biological Parameters that Affect Peel Separation in Palestinian Medjoul Date Palm Fruit

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Dedication

To the strong fighter and self-made lady, my mother, who helped me reach this point

To my partner, best friend, and wife Fathia

To my lovely children's, Mariam, Abdel Moiti, Ali Sadeen, Elien and Omar

To my supporter employer, Al Reef and PARC

To all my Colleagues and friends who were there for me and gave me a lot of support

I dedicate this Innovative Work

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In the name of God, the Most Gracious, the Most Merciful, and prayers and peace be upon our master Muhammad, the faithful prophet.

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الاقرار

أنا الموقع أدناه، مقدّم الرسالة التي تحمل العنوان:

The Study the Chemical and Biological Parameters that Affect Peel Separation in Palestinian Medjoul Date Palm Fruit

أقر بأن ما اشتملت عليه هذه الأطروحة إنما هو نتاج جهدي الخاص، باستثناء ما تمت الاشارة إليه حيثما ورد. وأن هذه الرسالة كاملة، أو اي جزء منها لم يقدم من قبل لنيل اي درجة او لقب علمي او بحثي لدى أي مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's Name: Mohammed Hmidat **اسم الطالب:**

Signature: **التوقيع:**

Date: 24.11.2021 **التاريخ:**

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List of Abbreviations and acronyms

Symbol	Full term
TSS	Total Soluble Solids
In Sug	Invert Sugars
pH	Hydrogen Ion Concentration
EC	Electrical Conductivity
WS	Salty Water
WF	Fresh Water
WT	Treated Water
FN	Nitrogen Fertilizer
FP	Phosphorous Fertilizer
FK	Potassium Fertilizer
WSi	WS= Salty Water, i= irrigation water quantity in m3 (50, 75, 100, 125, 150)
WFi	WF= Fresh Water, i= irrigation water quantity in m3 (50, 75, 100, 125, 150)
WTi	WT= Treated Water, i= irrigation water quantity in m3 (50, 75, 100, 125, 150)
FNwn	FN= Nitrogen Fertilizer, wn= quantity in kilogram of the applied nitrogen (0, 7.5, 15)
FPwn	FP= Phosphorus Fertilizer, wn= quantity in kilogram of the applied Phosphorus (0, 0.5, 1)
FKwn	FK= Potassium Fertilizer, wn= quantity in kilogram of the applied potassium (0, 2, 4)
PET	Polyethylene Terephthalate
Ew	Element in soil added with irrigation water (mg/kg)
Cw	Concentration of Element in irrigation water (mg/L)
W	Quantity of irrigation water (L)
Ws	Weight of sample
Vs	Soil volume in assumed cylinder (m3)
Ds	Soil bulk density (kg/m3)
D	Soil Circle diameter around date tree trunk (2m)
L	Soil Depth around date tree trunk (1 m)
Ef	Element in soil added as fertilizer (mg/kg)
Wf	Weigh of Added fertilizer complex (kg)
F%	Percent of Fertilizer element in its complex based on Molecular weights
Eca	Total element content accumulated is soil
Ei	Initial element content in soil
Ef	Element in soil added as fertilizer
Wd	Dry weight of sample

M	Moisture content in the sample (%)
Wf	Weight of the fiber in the sample
Wfa	Weight of the fat in the sample
TSSex	Total soluble solids quantity in the extract
TSSex%	Total soluble solids percentage in the extract
TWex	Total water quantity in the extract
TSSs	Total soluble solids in the date sample
INVSex	Invert sugars quantity in the extract
INVSex%	Invert sugar percentage in the extract
INVSs	Invert Sugars in the date sample
TDS	Total Dissolved Solids
NPK	Nitrogen Phosphorous and Potassium Fertilizer
R^2	Person Correlation Coefficient

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Abstract

The date palm (Phoenix dactylifera L.) was cultivated in the world as early as 4000 B.C. and became very important in the three religions, Judaism, Christianity and Islam by mentioning dates and date palms in the scriptures of these religions. The most probable area of origin of the date palm was in or near what is now the country of Iraq, but date cultivation spread to many countries starting in ancient times. Dates can survive in dry and very hot conditions, where it can tolerate relatively salty and alkaline soils, and can tolerate also to nearly salty water and it requires a long and hot summer with low humidity and few rains from pollination to harvest, but needs systemic irrigation because the evapotranspiration is high under hot and dry environment.

There are hundreds of date varieties in the world classified into three groups as: soft, semi-dry and dry varieties according to the moisture content in the fruit. Soft date varieties Medjoul which is classified as High-quality table date fruit, which is the most well-known for its unusually large size and its appealing flavor. Date fruits are high-energy food sources with 72% to 88% sugar content at maturity. The main sugar is sucrose which represents 80-85% during Khalal stage, a stage in which the date is

hard yellow or red in color with 50-85% moisture content. The main sugars after ripening are glucose and fructose, which are produced from sucrose during ripening by hydrolyses with the aid of invertase enzyme.

The hot arid regions of South West Asia and North Africa are the main producers and consumers of fruits, The Middle East and North Africa are also the major date producers in the world. There is a wide variation in the average export prices achieved by different countries. The high-quality varieties; like Medjoul reaches the highest export price. The crucial problem facing exporting and marketing Medjoul date is peel separation (skin separation) problem, which occurs during conversion from Khalal stage to Tamar stage in which, moisture content is normally below 25% and the texture is soft to firm with amber to dark brown color. Passing the Rutab stage, with moisture content of 30-45%. In the prior, the texture is soft and brown in color. Also, her the peel separates from the flesh when the date fruit lose part of its moisture content by evaporation. This problem leads to large loss that exceeds 40% of the production and huge commercial loss by lowering the sale price by roughly 50%.

In this study, different water qualities from different sources including treated waste water in Jericho were assessed chemically and analytically. The effect of water quantity and quality on the Medjoul date fruit peel separation and fruit quality and nutrition were studied to model the use of different water quality. The effect of fertilizer quantity and combinations, as well as the effect of other atmospheric elements such as soil and environmental parameters, on medjoul date peel separation and quality, was investigated.

Seventy-two Date palm trees selected from date farms in Jericho in Jordan Valley, where 57 trees were selected from Diek Farm in Al Maqtas street and 15 trees were selected from Al Raed Farm in Ketf Elwad where there are three different water qualities are available: fresh water, salty water and treated water with average EC of 2807.4, 6246 and 1274.4 µS/cm respectively.45 trees were selected and subjected to different water qualities and quantities, where 30 trees were selected from Diek farm, where 15 trees of them were identified by label WSi, where i=irrigation water quantity in m^3 (50, 75, 100, 125, 150) and subjected to salty water, where each three trees subjected to the same quantity of salty water, while the other 15 trees were identified by label WFi, where i=irrigation water quantity in m^3 (50, 75, 100, 125, 150) and subjected to fresh water, where each three trees subjected to the same quantity of fresh water. The remaining 15 trees were selected from al Raed farm and subjected to treated water and identified by labels of WTi, where i= irrigation water quantity (50, 75, 100, 125, 150), where each three trees subjected to the same quantity of treated water. The remaining 27 date palm trees selected from Diek farm and treated with different fertilizer types and quantity

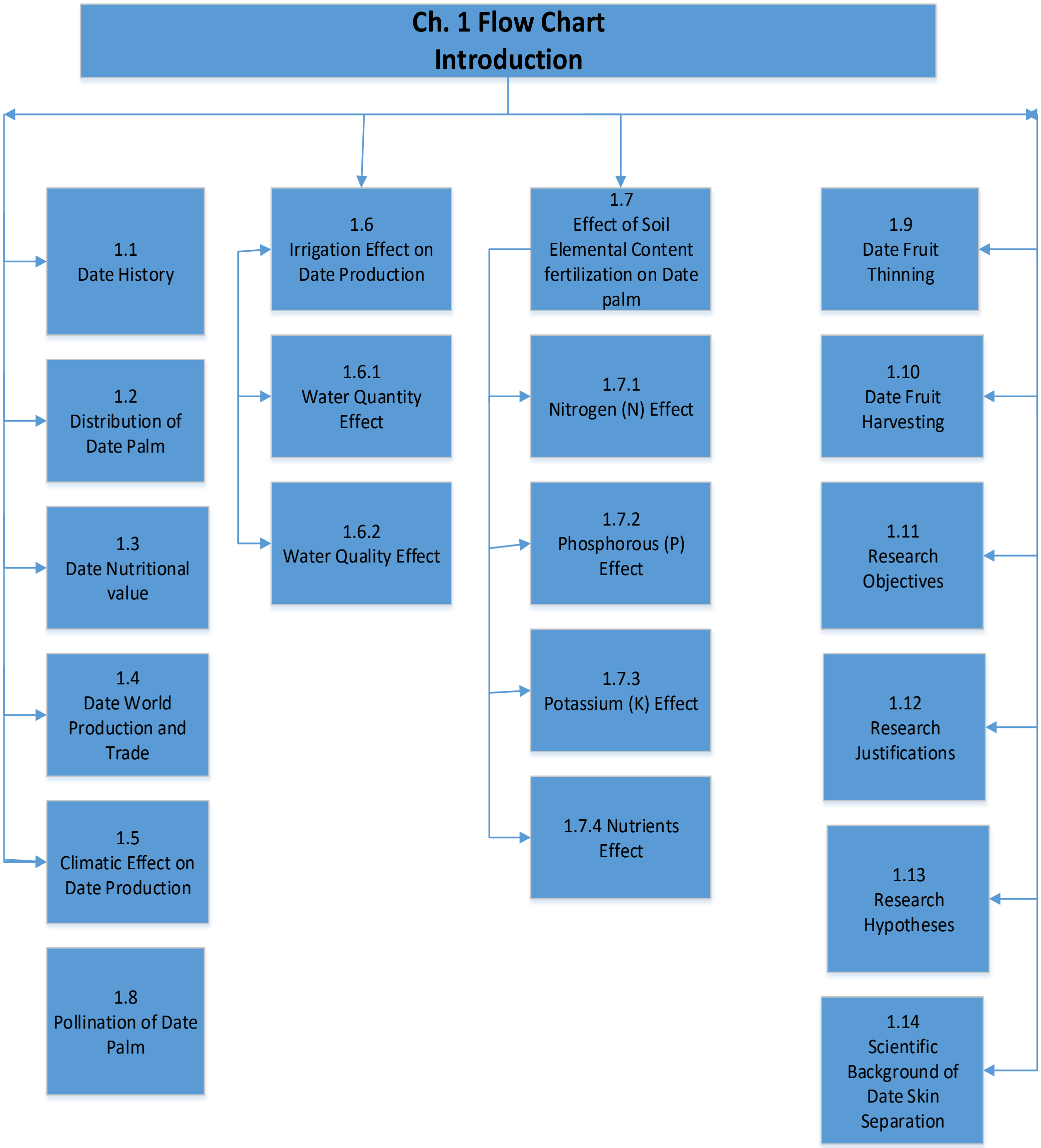
treatment below and above standard fertilization regime, where 9 trees subjected to different nitrogen quantities and labeled by FNwn, where wn= quantity in kilogram of the applied ammonium sulphate (0, 7.5, 15), 9 trees subjected to different phosphorous quantity and labeled by FPwp, where wp= quantity in kilogram of the applied phosphorous pentoxide (0, 0.5, 1), and 9 trees subjected to different potassium quantity and labeled by FKwk, where wk= quantity in kilogram of the applied potassium oxide (0, 2, 4) where all the 27 trees are irrigated with the same quantity of fresh water which was 100 m^3 for each tree annually, while each three trees subjected to the same treatment in each fertilizer type.

The results of this study show that date trees can tolerate basic and salty soil condition, where the average soil pH in all plots is 8.465, and the average EC is 4782.30 µS/cm, with high content of Na and N of 857.485 and 965.746 ppm respectively, while the lowest elemental content was Fe, Mn and P of 0.041, 0.055 and 1.717 ppm respectively. The ripen date fruit peel separation decrease with accumulated soil content of K, Na, Ca, Mg, Mn and P and. The date leaves nutrients content didn’t exhibit significant correlation with date peel separation. The increase of irrigation water shows a decrease in peel separation. On the other hand, added K and P fertilizer to soil were found to decrease date peel separation while, N fertilizer increase peel separation. The fiber content, TSS and invert sugars was found to decrease date peel separation, while fat content found to increase date peel separation. Finally, the meteorological parameters also notably affected date peel separation, where the date peel separation increase by increasing mean monthly maximum temperature, monthly heat summation units, monthly evaporation and mean monthly relative humidity during transition stage of date from khalal to rutab stage, while the peel separation decrease by increasing average monthly temperature during khalal, rutab and Tamar stages, mean monthly minimum temperature, monthly sunshine duration and mean monthly wind speed. On the other hand, the monthly total rain falls which happened in winter, before fruit formation didn't show any significant effect, where there was no registered rain fall during the period from blooming to harvesting of dates.

As conclusion, the date palm during cultivation should be treated with N and P fertilizer only at early stage and before Khalal stage, then the K fertilizer should be subjected before ripening stage, also the nutrients like Mg and Ca should be tested in the soil to be added if needed. In terms of irrigation water, the salty water is suitable to produce high quality date and should be sufficient to avoid water stress of date tree, but the irrigation water should be reduced more than 50% during ripening stage to reduce relative humidity around date fruits.

Chapter One

General Introduction



1.1 Date History

The date palm (Phoenix dactylifera L.) is one of the most abundant fruits in the world which is cultivated as early as 4000 B.C. since it was used for the construction of the temple of the moon god near Ur in Southern Iraq. In Egypt's Nile Valley it was used as the symbol for a year in Egyptian hieroglyphics and its frond as a symbol for a month (Zaid and Arias-Jiménez,2002).

It can be concluded that the date palm is probably the most ancient cultivated tree in the world and is one of religious significance to the three monotheistic religions of the world by mentioning dates and date palms in these religions. The Holy Koran mentioned date and date palm in 17 Chapters. Prophet Muhammad (peace be upon him) is reported to have said that the best property to own is date palm, that dates cure many disorders, and it has been reported that he urged Muslims to eat the date and tend the date palm (Zaid and Arias-Jiménez, 2002).

Date Palm cultivated across Northern Africa, the Middle East, the Horn of Africa and South Asia, and is naturalized in many tropical and subtropical regions worldwide, providing valuable food for people for the last 5000 years (Ghnimi et al., 2017). There are two distinct directions of spreading the date palm and its cultivation occurred during the past centuries as follows:

- One starting from Mesopotamia to Iran, reaching the Valley of the Indus and Pakistan.
- The other starting from Egypt towards Libya, the Maghreb and Sahel countries.

The most probable area of origin of the date palm was in or near what is now the country of Iraq, but date cultivation spread to many countries starting in ancient times as indicated by (Chao and Krueger, 2007). It is a major fruit crop in the Middle East and contribute 75-80 percent of the world production, which classified according to the stage of ripening into five main categories, Hababook or Jadal, Jamry, Bisir, Rutab and Tamr as published by (Eltayeb et al. ,1999). The export value of date palm from Palestine increased significantly between the years 2000 and 2019 from 22000 US Dollar to 28,830 Million, compared to neighbor countries like Jordan, which increase from 446000 US Dollar in the year 2000 to 223,333 Million US Dollar in 2019. In Israel, it increases from 6,055 Million US Dollar in the year 2000 to 203,380 Million US Dollar in 2019 (FAO, 2019).

Dates can survive and flourish in dry and very hot conditions, where it can tolerate relatively salty and alkaline soils, and can tolerate also to nearly salty water. Date palms require a long and hot summer with low humidity and a few rains falls from pollination to harvest, but needs constant irrigation because the evapotranspiration is relatively high under hot and dry environment. Chao and Krueger (2007), mentioned to an old saying about date palm growing which is ‘‘its feet in the water and its head in the fire’’. This means that the tree requires a lot of water to grow and high temperature to ripen.

The average temperature suitable to grow dates ranges from 12.7 to 27.5 °C, withstanding up to 50 °C, and can sustain at lower temperature up to -5 °C. On the other hand, the best and ideal temperature of date cultivation is from 21 to 27 °C(ChaoandKrueger,2007).

1.2 Distribution of date palm:

The geographical distribution of date palm can be observed from three aspects: (i) Distribution according to latitude, (ii) Distribution according to altitude, and (iii) Number of date palms in the world (Zaid and Arias-Jiménez,2002).

Firstly, the Distribution according to latitude for both northern and southern hemispheres, where in Asia, 32° north, the northern limit of date palm cultivation is located in the Indus Valley. The southern edge of the Perso-Afghan Mountain mass, till it reaches the 35° north in Iraq and turns south west to the Mediterranean Sea at the Gulf of Gaza. The distribution reaches the Atlantic Ocean by passing the Mediterranean coast as far as Tunisia and skirts the southern edge of Morocco. The southern limit of the date palm is located in the Sahara at 17° north parallel. From the 15° north in Sudan, it follows with the coast of the Red Sea and the Gulf of Aden, till it drops to 10° north to cover the northern part of Somalia. This southern line continues till it reaches the coasts of Arabia and Pakistan till the limit of Indus. In American continent, the date palm was newly introduced in Southern California at about 33° north, (Zaid and Arias-Jiménez, 2002).

Secondly, the distribution according to altitude imposes the availability of water and the temperature limits which largely determine the distribution of date palm in the world. The altitude range of date cultivation is about 1,892 m, which can grow from 392 m below sea level to 1500 m above sea level, (Zaid and Arias-Jiménez ,2002), but the high elevation characterized with low temperature and high relative humidity which can fit with different date cultivars rather than medjoul date which requires high temperature and low relative humidity.

Thirdly the distribution according to the number of date palms in the world was about 100 million of Date palm presented in the world distributed in 30 countries, and producing between 2.5 and 4 million tons of fruit per year. Asia comes first with 60 million date palms; while Africa occupies the second position with 32.5 million date palms, Mexico and the USA have 600,000 palms, followed by Europe with 32,000, and Australia with 30,000 (Zaid and Arias-Jiménez,2002). In Palestine, the area cultivated by date trees represents 676 “ha” with total date production of 7729 tons in 2019 (FAO, 2019).

There are hundreds of date varieties in the world, the priors are classified into three groups; soft, semi-dry and dry varieties according to the moisture content in the fruit. Soft date varieties like Medjoul, Abada, Amhat, Barhee, Bentaisha, Halawi, Hayany, Honey, Khadrawy and Halawi, in which almost all sucrose is converted into invert sugars (glucose and fructose) during ripening, with a moisture content >30%. Semi-dry date cultivars include cultivars such as Khalas Amry, Dayri, Zahidi, Deglet Noor, Sewy and with moisture content 20-30%. Dry date cultivars (<20% moisture) include cultivars such as Badrayah, Bartamoda, Deglet Beida, Horra, Sakoty and Thoory (Yahia and Kader,2011).

Medjoul date is one of the soft varieties, classified as High-quality table date fruit, which is the most well-known for its notably large size and its appealing delicious flavor. It can grow to about three inches long. The medjoul date is firmer and more resilient than most other soft dates and it is handled much better as well, making it a great choice for commercial production as indicated by (Yahia and Kader, 2011).

The medjoul date palm variety was first imported into the USA from the Bou Denib Oasis in Morocco in 1927. At the time, the infamous "bayoud disease" had infected or killed almost all of the medjoul date palms in Morocco. This shipment of eleven Medjool offshoots were the first and only Medjool date palm offshoots imported to the USA. These disease-free Medjool offshoots were eventually planted at the US Department of Agriculture station in Indio, California. This variety transferred to inside historical Palestine and planted in Jordan valley in the late of nineties in the nineteenth century (Crisosto and Costa ,2008).

1.3 Date’s nutritional value

The date fruit is the primary product of the date palm, which can be consumed fresh, dried, or processed. Most dates are harvested during the fully ripened Rutab and Tamar stages, while some of date varieties are harvested during Khalal stage with some stringency. The availability of date fruits can be in different forms, pitted and non-pitted, dehydrated, extruded, diced and macerated fruit. The uses of dates can be in many food industries like cereal, pressed cakes, pudding, bread, cookies, ice cream, candy bars, juice, vinegar, sugar syrup, wine, beer and many other processed foods (Zaid and Arias-Jiménez,2002).

Date fruits are high-energy food sources with 72% to 88% sugar content at maturity. The mainly-present sugar is sucrose which represents 80-85% during Khalal stage, but the main sugars after ripening are glucose and fructose, which are reduced from sucrose during ripening by hydrolyses with the aid of invertase enzyme. The invert sugar in dates is immediately absorbed by the human body without being subjected to the digestion that ordinary sugar undergoes. In this manner, dates give more than 3,000 calories per kilogram. Date fruits contain many nutrients and are a good source of iron, potassium, calcium, sulfur, magnesium, chlorine and copper, with minor nutrients such as phosphorus. Besides, dates contain around 16 amino acids plus some vitamins like A, B1, and B2 (Chao and Krueger,2007). The flesh of dates contains about 2.5 % fiber, 2 % protein and less than 2 % each of fat, total minerals, and pectin substances (Zaid and Arias-Jiménez ,2002).

Date contains around 600 mg of magnesium per kilo gram of dates, which might lead to the fact that date consumers in Saharan areas to have the lowest cancer diseases rate in the region. The Sodium content in date is only 1 mg per 100 g, which make dates a good option for those on a low-sodium diet. The iron content in dates represents a third of the Recommended Dietary Allowance for an adult male with3 mg per 100g of dates. The Vitamin content per kilogram of date is in average for all date varieties: vitamin A, 484 international units; B1, 0.77 milligram (mg); B2, 0.84 mg; and B7, 18.9 mg. The average protein content in date flesh is around 1.7% (Zaid and Arias-Jiménez, 2002).

1.4 Date World Production and Trade

The hot arid regions of South West Asia and North Africa are the world's lead producing and consuming of date fruits, which is a high-value confectionery and fruit crop and remains an extremely important subsistence crop in most of the desert regions.

Middle East and North Africa are the major date producers in the world. On average over the period 1999-2001, Iran, Saudi Arabia and Iraq had almost half of the date-grown area of the world. Trade figures indicate that about 93 percent of the date harvest is consumed locally and that by far the majority of these palms are not of the well-known export varieties. In recent years the date palm has been introduced as modern plantations in USA and in the southern hemisphere (Zaid and Arias-Jiménez,2002).

An average 500000 tons of dates were exported annually with a total value of about US$258 million in 1998-2000. This means that the bulk of the dates produced are consumed within the producing countries. From the 500000 tons exported, 225 000 tones were imported by India, 150 000 tones by the United Arab Emirates (UAE) and about 60 000 tones by the EC (Zaid and Arias-Jiménez,2002).

There is a wide variation in the average export prices achieved by different countries. Higher export prices are achieved by Israel, Tunisia, United States, Palestine and Algeria, which have developed a specific export strategy; to grow top quality varieties like Medjoul and target the higher priced European markets.

During conversion from Khalal stage to Tamar stage passing the Rutab stage, the problem of peel separation (skin separation) occurs; where the peel separates from the flesh when the date fruit lose part of its moisture content by evaporation. This problem inflects loss that exceed 40% of the production and huge commercial loss by lowering the sale price to lower than 50% in the same tree and in the same bunch, even in the same strand, both fruits with peel separation and without peel separation, which motivates putting an effort to study the chemical and biological characteristics of both fruits in order to be able to suggest solutions for this problem which threatens the medjoul date sector in Palestine.

1.5 Climatic Effect On date production

The climatic factors that may influence date growth and production are temperature, sun light, rain, relative humidity, and wind speed.

Arid and semi-arid regions which are characterized by long and hot summers, low rain fall, and very low relative humidity level during the ripening period are regarded convenient for date palm cultivation. The temperature of 7°C is the zero-vegetation point, where above this temperature, date growth is active to reach the optimum temperature of 32°C, while the date growth start decrease after reaches 38°C/40°C. On the other hand, the high temperature of 56°C and the low temperature below 0°C can be endured. Abul-Soadet al. (2013), found that the increase of air temperature above 40 was demolished the impact of high air relative humidity on the fruit. It was found that the soil nitrogen decreases with increase temperature, while it was increase with rain fall and humidity (Ibrahim and Zayed,2019). It was noted that the temperature increases during date maturation increased the activity of invertase enzyme to convert Sucrose to glucose, fructose and softness of fruits as found by (Ibrahim and Zayed,2019). The prior also found that, the fluctuation of temperature affects the expansion and contraction of the two tissues, thus, the peel is shed from the fruit which cause the *peel separation problem*. He also found that the peel separation of dates increase, if the drying temperature exceed 55 c and/or is below 40 c.

Flowering of date palm starts after the cold period when the temperature becomes high enough for flowering and named as zero flowering temperature which ranged from 17 to 22 °C depend on the local climatic conditions, where 18 °C is and average zero flowering temperature. The period length from flowering to ripening and maturation is around 120 to 200 days depends on variety and environmental conditions, where the flowering period occurs on average at March/April, while fruiting period from April/May to September/October (Zaid and Arias-Jiménez, 2002). The flowering and fruiting temperature during the flowering and fruiting periods are very important to calculate the heat units which are necessary for date production conditions. The heat units represent the sum of average daily temperature from flowering to maturation.

Rainfall in winter should not cause harm to the date fruits as fruits have not yet formed, but benefits the soils of the plantations by aestivating the deposited surface salt and avoiding the upward movement of salt from lower layers. Besides it plays a vital role in biochemical reactions, tradeoff of carbon dioxide by transpiration, and photosynthesis. There are some negative effects of rainfall on date palm pollination and fruit set where the rain occurs after pollination takes away most of applied pollen, also rainfall cause lower temperature which decrease the heat units required for fruit set (Al-Musawi, 2019).

The rotting of inflorescences results in increasing the relative air humidity which occurs by increased rainfall, also the high relative humidity might cause an infectious disease and lead pollen's explosion. As rain affects flowering, it is also affecting date fruits which causes severe checking and cracking in the Kimri stage, where fruits are basically green at late Khalal stage. The most sensitive date stages affected by rainfall are Rutab and Tamar stages where the associated humidity with rainfall causes severe damage including rotting and fall-off of the fruits and delayed ripening. High temperature and humidity during date ripening lead to the predisposition of the date to peel separation which increase date peel separation (Lobo et al., 2013). As temperature increases, fruit tissues elasticity decreases, fracture pressure, peel stiffness, turgor by transpiration and viscosity of the pectin which leads to an increase in peel separation (Brüggenwirth and Knoche ,2016).

Air humidity has various advantages and/or disadvantages on date plantation, where the high air humidity cause some leaf diseases, such as Graphiola leaf spot (Graphiola phoenicis), while other disease become rare or absent such as the Date mite (Bou-Faroua). On the other hand, the low air humidity causes pest and mite attacks, while fungal diseases are absent. The high temperature and relative humidity of air increase date peel separation as mentioned by Al-Hajaj et al., (2020).

The date quality during maturation process is also affected by air humidity. At high humidity, date fruits become sticky and soft, while the date fruits become very dry at low humidity especially when associated with hot and dry winds, which causes a rapid maturation that could leads to the appearance of yellowish or whitish rings at the fruit base. On the other hand, when air humidity is high during maturation, this causes cuts or breaks of the date fruit peel and some fruits fall to the ground. This phenomenon occurs mainly immediately before the Khalal stage. During rutab stage, when the air humidity is high, the fruit absorbs moisture and delays dehydration process to reach tamer stage, which leads peel separation of date fruits from pulp. Ibrahim and Zayed,(2019) found that the high humidity around the fruits during the transition of the fruits from the Kimri to the khalal stage can halt evaporation and may stop fruit peel from separating from pulp.

The wind speed affects date plantation from flowering through ripening stages, where light wind favors pollination, while high speed winds will blow away the pollen. Severe wind could lead to bunch death by blocking the movement of nutrients if the bunch is broken or torsion. Ibrahim and Zayed,(2019), mentioned that the wind increases the separation of date peel from pulp by increasing the process of free water loss from fruits, which causes the fruit crust to separate from the pulp of the date especially if the wind is combined with high air temperature.

Finally, the light spectrum is important for date palm plantation, where the growth of date palm is inhibited by light spectrum at the violet and yellow rays and is enhanced by red light by promoting photosynthesis. Ibrahim and Zayed (2019), indicate that the light increases photosynthesis and absorption of nutrients. It is also found by Kalaj (2016), that the light exposure of dates improves fruit size and TSS. According to other findings by Al-Qarni (2020), the direct sunlight of dates, increase date sugar content.

1.6 Irrigation Effect On date production

Water is the major input for agricultural production in Jordan Valley and plays an important role in food security. 20 percent of the total cultivated land is irrigated agriculture which contributes by40 percent of the total food produced worldwide (World Bank Group, 2021).Water shortages in arid and semi-arid zones like Palestine, as anticipated, led to the search for new sources for agricultural use such as tertiary treated wastewater (Shtayaet al. 2021). Productivity per unit of land in irrigated agriculture is, on average, at least twice as rain-irrigated agriculture, thereby allowing for more production intensification and crop diversification.

Due to population growth in the world, climate change and urbanization, competition for water resources is expected to increase, which will affect agriculture productivity. Population is expected to increase to over 10 billion by 2050, (World Bank Group, 2021), and whether urban or rural, this population will need food to meet its basic needs. Combined with the increased consumption of calories and more complex foods, which accompanies income growth in the developing world, it is estimated that agricultural production will need to expand by approximately 70% by 2050 (World Bank Group, 2021).

Supplementary irrigation is important for date palm trees grown in the Jordan Valley to survive and produce optimal yield, so the date palm trees require sufficient quantities of water with good quality, low salinity, and richness with nutrients and minerals. The irrigation water quantity is different from region to another depending on the availability of water and the climatic conditions, where the water quantity required for date palm trees increase with increased temperature and during fruit development; especially during summer months (July, August and September), where date tree consumes about 1/3 of the total annual consumption of water, while half of this quantity is required in winter months (December, January and February).The quantity of irrigation water required is dependent upon many factors like temperature, soil salinity, air humidity, wind speed and clouds, where the high temperature, the high soil salinity and high wind speed require more irrigation water, while the high air humidity and high cloud cover require less irrigation water (Zaid and Arias-Jiménez,2002).

The irrigation fittings and couplings must be placed near the roots of the date tree. The roots of the date palm are distributed as 40% in the top layer which represents 50 cm in average, 30% in the next layer of 100 cm, 20% in the third layer of 150 cm, while 10% in the deepest layer which is more than 150 cm depth. Accordingly, the best irrigation should be concentrated in a certain technique in the first two layers where the majority of the roots are present.

Jericho and Jordan valley has been the main source of banana and citrus, beside vegetables, but these crops need higher quantities of fresh water, which become almost depleted in the last 20 years. Fresh water in Jordan valley become more predominant for drinking, for that, farmers in this area convert to Medjoul date plantation which is an economically important crop and requires lower quantities of water, in addition to that, it’s more tolerant to salty water. Ibrahim and Zayed,(2019), reported that the increase of irrigation in summer increases the fracture of date peel which leads to fruit peel separation problem.

In Palestine, the agricultural sector is an important contributor to the Palestinian economy. It produces 11–20% of the country's GDP, accounts for25% of total exports and is the third largest employer, engaging15% of the total workforce (Sonneveld et al., 2018). Medjoul Date became the second economic crop after olive oil in Palestine, after the sharp expansion of area under cultivation in the last 10 years. Abu Qaoud (2015) predicts that date palm production will increase significantly and its contribution in the agricultural sector will rise tremendously. The medjoul date farms concentrated in Jericho and the Jordan Valley, put huge pressure on the water resources especially the underground water which is already very limited due to the Israeli policies and restrictions.

Medjoul date trees were first planted in Palestine in 1997, mainly in Jericho and northern Jordan Valley (Sonneveld et al. 2018). The plantation has been growing up fast and has become the second national economic crop in Palestine after olive oil. This sharp increase in the area of production places new pressure on securing sufficient water for irrigation for this expansion of medjoul plantation with minimizing the effect on fresh and drinking water.

One of the suggested factors of pre-harvest treatment that may affect peel separation problem of medjoul date is the irrigation water quality and quantity, the date trees can be irrigated by fresh water, low or medium salty water and treated wastewater or a combination of these waters.

It is very crucial point to find innovative solutions for the water scarcity and salinity in the Jordan Valley to meet the demand of the Medjoul date expansion in that area without affecting the fruit quality. Some of these solutions are the use of harvested water from rain and the treated water from municipality sewage treating water units.

The main and crucial quality problems in Medjoul date fruit is the peel separation problem, where the fruit peel separate from the pulp of the fruit during ripening, which cause huge loss that exceeds 50% of the price. In this research, the use of water quality (salty, fresh and treated) and water quantity from each water quality type will be studied to see the correlation between these parameters and the peel separation problem in Medjoul dates. There are numerous researches in literature that study the irrigation water effect on date growth and date quality in general which are discussed below.

1.6.1 Water quantity effect

The irrigation water quantity directly affects the quality of fruit and vegetables, in terms of shortage, excess of irrigation, irrigation frequency and irrigation fluctuations.

In terms of irrigation water shortage, Fallahi et al. (2010) found that the shortage in the irrigation water of apples, causes an increase in apple tree stress, enhances ethylene production, decrease yield and decrease apple fruit size. On the same manner, Zekri et al. (2018) found that, the deficit irrigation in citrus increases total sugars. Another researcher (Hassan and

Omran,2018) found that, the decrease in irrigation water decreases mean value of date fruit mass, flesh mass, fruit volume, length, diameter, moisture and peel thickness, while increases mean value of bulk density, firmness, solid density and rupture strain. On the other hand, Weston and Barth (1997) indicated that, in vegetables, as the irrigation water stress, the TSS and sugars increase. In peach production, Crisosto and Costa(2008) noted that, the decrease of irrigation water on peach trees reduces yield and fruit size, increases TSS, and decreases water loss from fruits, increase thickness of cuticle and increases density of trichomes in fruits. In the same direction, but in citrus production, Ritenour et al. (2002) noted that the decrease of citrus irrigation water decreases yield, fruit size and juice content, while increases peel thickness, soluble solids and acids. Kuzin et al. (2020) indicated that, the decrease of apple irrigation water decreases apple leaf K.

In terms of irrigation water increase, a wide research papers indicates many effects of this increase in irrigation water. Ibrahim and Zayed(2019) found that, when the irrigation water quantity increases especially in summer, this increases the percentage of peel separation in date fruit. In the same line, Gribaa et al. (2013) mentioned that, the increasing of water irrigation increases hydrophobic groups such as methyl ester and O-acetyl, this also decreases the degradation of hydrophilic groups such as galactan, arabinan and arabinogalactan in date fruits which leads to increase in the peel separation rate. For apricots, Francisco Pérez et al. (2016) found that, the date soluble sugars increase as the irrigation water increases. Sadik et al.

(2018) found that, the increase in irrigation water quantity in dates decreases TSS, while increases total sugars, fruit weight and evapo-transpiration. On the other hand, Al-Yahyai and Khan(2015) found that, increasing irrigation water increases water content, fruit juice volume and titratable acidity, while decreases TSS, total sugars, reduces sugars, pectin and dry matter. Sarker et al. (2016) also found that the increase of irrigation water delays ripening of mango fruits, decreases total sugars, decreases reducing sugars, decreases non-reducing sugars and decreases TSS.

The increase of apple irrigation was found to increase moisture content which reduces oxygen in root and decrease nitrogen leaching and availability, while decreases transpiration rate, proline leaf content, TSS, acidity and chlorophyll in leaf as indicated by Mohawesh and Al-Absi(2009). In date fruits, other authors found that, the increase of irrigation water was influence reducing sugars, fiber, pectin, tannins and vitamins and increase fruit water, titratable acidity and juice volume (Al-Yahyai and Manickavasagan, 2013). In his PhD dissertation, Kalaj (2016) found that, the increase of irrigation water was found to delay maturity, decrease fruit firmness and reduce soluble solids in tomato production. Wang and Xing(2017) indicate that, the irrigation of tomato increase yield and decreases organic acids, lycopene and vitamin C. Zekri et al. (2018) found that, the increase of irrigation water for citrus increases juice content, TSS/acid ratio, fruit size, fruit weight and green fruits, while decreases rind thickness of the fruit. It was found by Gribaa et al. (2013), that the increase of irrigation water in dates decrease the degree of methyl etherification of pectin, loss of galactose content, reduction of the branching of xylan by arabinose and increase weight and size of fruit. Abd El-Kader et al. (2010) found that, as the irrigation water increases, the yield and NPK uptake increases, but the excess in irrigation water led to an opposite trend of yield where the yield decreases. Mazahrih et al. (2018) noted that the increase of irrigation water led to increase fruit yield and fruit weight.

Regarding irrigation frequency, FAO proceeding report (2008), indicates that as the irrigation frequency increases, the date fruit size, fruit weight, moisture content and TSS increase while the fruit maturity period is reduced. In the same manner, Ibrahim and Zayed (2019) indicate that, the peel separation in date fruit decreases as the number of irrigation times per month decreases. Following the same direction, Alaouiet al. (2013) indicated that, as the irrigation frequency increases, this enhances fruit development, and increases yield and quality of peach. Zekri et al. (2018) argued that, the increase of irrigation frequency of citrus increases fruit water content, juice volume and titratable acidity. On the opposite direction, Baballahet al. (2016) indicated that tree yield increase by decreasing the irrigation frequency. Increasing the irrigation water of tomato increases acidity, color and tomato size, while decreases TSS (Weston and Barth,1997). On the other hand, Crisosto and Costa(2008) found that the fluctuation of irrigation water of peach did not affect the yield, flesh firmness, per cent red surface, acidity and pH. For citrus, in another research, Ritenour et al. (2002) noted that the increase of irrigation water increases rind thickness and decreases TSS.

1.6.2 Water quality effect

Like irrigation water quantity, irrigation water quality also affects fruit and vegetables quality and nutritional value. The main water quality types are fresh water, salty or brackish water and sewage treated water. The effects of these water types on plants come from their content of minerals and nutrients. The concentration of soil nutrients was increased significantly by irrigation with waste water treatment (Shtaya et al. 2021)

In terms of salty water, Ibrahim and Zayed (2019) indicate that the salinity of water or soil cause a decrease in water permeability in soil which lead to the use of more water to compensate the water deficit as a result of high salinity. The prior agrees with Robinson et al. (2018). Another foundation comes from Alkhateeb et al. (2015) who indicated that, as the salinity increases, the date growth decreases, the Na^+ contents in leaf and root of date palm increases, but the Na^+ concentration was higher in the roots than in the leaf. Al-Rawi and Al-Mohemdy (2012) agreed with previous findings and indicated that, as salty water irrigation increases, the Na concentration in fruits increases, while the tree growth rate, the yield, fruit quality and K concentration in fruits decreases. In the same regard, but for soil, Al-Rawi and Al-Mohemdy (2012) found that as the soil salinity increases, the Na content in date leaves increase, while the N, P and K contents in leaves decrease. Also, Yaish et al. (2015) agreed on the same findings, in terms of soil salinity, where they found that, as the soil salinity increases, the growth rate of the plant decrease. Also, FAO proceeding report (2008), indicate that, the yield of date fruit decreases as the water salinity increase. Also, the salty water reduced tree size and leaf area Al-Muaini et al (2017).

In terms of nutrients availability and uptake, Al-Qurashi et al. (2015) indicate that the salinity of soil and water prevents or slows down nutrient uptake by date palm plants. (Mazahrih et al. 2018) noted that, the increase of salty soil was restricting the mobility of P and K. Tripler et al. (2011) noted that, the increase of salinity in water leads to decrease tree growth, yield, fruit size, evapo-transpiration and delay maturity.

1.7 Effect of soil elemental content and Fertilization on Date Palm

For optimum growth of date trees, a fertilization program should be followed to provide nutrients needed for date trees to grow well and become productive tree, which needed at different rates by the date palm culture, where date palm trees need macronutrients like nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulfur (S), magnesium (Mg) and micronutrients like iron (Fe), boron (B), chlorine (Cl), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo), nickel (Ni).

Nitrogen is important for the plant in the photosynthesis process, maintenance of genetic identity and vegetative growth which results in high yield of date production. The availability of nitrogen in soil depends on the soil pH, where the best pH range to make nitrogen freely available to plants is below 5.5 or above 8.5 (Zaid and Arias-Jiménez,2002).

Phosphorus is an important nutrient for photosynthesis, vegetation growth, and respiration, maintenance of the genetic identity, reproduction, cell division, flowering and root development. The best bulk pH range of soil to make Phosphorus freely available to plants is within the range of 6.0 to 8.0 and above 8.5. Potassium is much needed to transport Nitrogen in the plant and promote photosynthesis within the plant’s cells. Potassium is the main osmo-regulator in the plant cell promotes plant resistance to drought cold and improves fruit quality by strengthen fiber and influence the opening and closing of the stoma. The best bulk pH range of soil to make Potassium freely available to plants is within the range of 5.5 to 7.5 and above 8.5. (Zaid and Arias-Jiménez,2002).

Boron is needed for the reproduction process of flowers and fruits and is also needed for pollination. Boron also helps the uptake of calcium, magnesium and potassium. It is important that the soil pH measurement needs to be adjusted to obtain the best benefits from the fertilizers.

Soil contains numerous organic matters and minerals which are essential for plant growth, but these nutrients will be depleted during cultivation as the plant naturally absorbs them. Consequently, the soil fertilization is important to compensate the nutrients loss and to enrich the soil with sufficient nutrients for the plants. These nutrients will come in the shapes of organic materials or chemical synthetics. The main fertilization nutrients needed by fate trees are Nitrogen N, Phosphorus P, Potassium K. there are also some other important nutrients like magnesium, calcium, manganese, and iron. The fertilization of date trees increase yield, TSS, total soluble tannins and total phenols (Qurashia et al. 2015, Elamin et al. 2017, Al-Yahyai, 2018). It was noted that, the increase of NPK fertilization increases the yield and TSS, while decreases the moisture content in the date fruit (Al-Yahyai, 2018).

1.7.1 Nitrogen (N) Effect

Nitrogen N is one of the important nutrients needed for plants; it increases crop production and improves quality of agricultural products. Plants absorb Nitrogen from soil with other micronutrients and it should be available in soil in sufficient quantity to enable the crop to achieve its maximum yield potential. The main problem of nitrogen is the leaking out from soil, so nitrogen application on soil needs some humates or chelator to hold onto nitrogen and make it more effective and more efficient. Nitrate form ($NO3^{–}$) is the main form of nitrogen absorbed by plant, and to a lesser extent ammonium ($NH4^{+}$) form.

Many researchers highlighted the importance of nitrogen application on plants and fruits or vegetables in terms of the nitrogen application quantity. Dialamiaand Mohebi, (2010) indicted that the application of minimum N, was found to increase yield and quality of dates. On the other hand, Ibrahim and Zayed (2019) found that the optimum nitrogen availability increases fruit weight, fruit size and proportion of pulp, but the use of excess nitrogen delays flowering, decrease number of flowers, delays ripening and reduces yield. While in terms of the effect of N on the other nutrients, the author found that the increase of N content in soil decreases the boron concentration in fruits. In the same manner, Ezz et al. (2010) indicate that, the increase in N fertilization increases yield, fruit tannins and leaf N, Ca and Mg content while decreases fruit TSS, total sugars, reducing sugars, leaf P, Fe and Zn. In terms of vegetation and fruit maturation, Kalaj (2016) noted that, the increase in N fertilization increases vegetative growth and delays maturation of fruits. For citrus fruits, the increase of nitrogen fertilization, increases juice content, TSS, acid concentration, peel thickness and fruit green, while the use of excess nitrogen lowers yield and TSS (Zekri et al., 2018). On the other hand, Salem and Ali (2020) found that, the application of N fertilization increases cell number in fruit, cell size and growth rate and produces chlorophyll, protein and nucleic acid. While in Avocado, HAAS (1949) indicated that, the application of N, with the presence of P and K increased P and K in leaves and fruits.

El-Merghany et al. (2018) found that the application of N increased fruit yield and bunch weight, while the excess of N increased fruit acidity, non-reducing sugars and decreased total sugars. On the other hand, the decrease in N fertilizer led to increase reducing sugars and total sugars. In vegetable production, (Weston and Barth, 1997) noted that increased soil nitrogen led to an increase of moisture content in vegetables, and decreased ascorbic acid and dietary fiber. On the other hand, the excess soil nitrogen led to a decrease of ascorbic acid in vegetables and increased weight loss. (Crisosto and Costa, 2008) investigated the application of N on Peach and noted that the increase of N application on peach trees stimulate vigorous vegetative growth, causing shading out and death of lower fruiting wood and increase fruit water loss rate, but the excess of N leads to delayed peach maturity. (Mazahrih et al.2018) found that the application of nitrogen contributed to building the protein and the cell of fruits. In the combination fertilization of NPK and their effect on date tree and date fruits, (Al-Kharusi et al. 2009) found that the NPK application increased dry matter content, nutrients uptake, crop yield, glucose and fructose content, and titratable acidity, while it decreased tannins. On the other hand, the increase in N application alone increased pectin and decreased dry matter. Ritenour et al. (2002) noted that in the citrus production, the increase of nitrogen application for citrus trees was increased yield, fruit peel thickness of young tree, TSS and acids, while it decreased fruit peel thickness of mature tree, solid content, juice content and it delayed ripening.

Another effect can be noted as fallout nitrogen shortage, where (Weston and Barth, 1997) noted that the nitrogen decreases in the soil of vegetables had a decrease of protein in harvested vegetables. On the other hand, (Crisosto and Costa, 2008) noted that the N deficiency leads to small fruit with poor flavor and unproductive trees. On the other hand, (Ritenour et al. 2002) indicated that the decrease of Nitrogen application led tp faster ripening and reduced yield.

1.7.2 Phosphorous (P) Effect

Phosphorus is required by plants in relatively large amounts; thus, it is classified as a macro-nutrient. Phosphorus is one of the four macronutrients required by plants: Nitrogen (N), Phosphorus (P), Potassium (K) and Calcium (Ca). It plays a major role in photosynthesis, nutrient transport, and energy transfer (Zaid and Arias-Jiménez,2002).

The optimum application of Phosphorus causes the plant to grow more vigorously and to mature earlier than a plant with inadequate Phosphorus intake. As the application of Phosphorus increases, bacterial growth on a plant's leaves decreases. While on the other hand, the Phosphorus deficiency lacks in fruit or flowers, stunted plant growth, wilting, and leaves that may have a purple cast.

There are many research papers and experiments that tackles the effect of increase or decrease in the Phosphorus nutrient on both plants and fruits.

In terms of increase. Al-Obeed et al. (2013) found that the increase of P fertilizer, on date trees, had increased fruit set, and yield, and improve physical and chemical characteristics. On the other hand, (Dialamia and Mohebi, 2010) indicate that the application of minimum P_2O_5, was found to increase yield and quality of dates. On contrast, (Ibrahim and Zayed, 2019) found that the excessive use of P decreases Zn and Cu. With regards of the effect of P on the availability of other nutrients, (Ibrahim and Zayed, 2019) indicated that the increase of P in soil leads to precipitate of Iron into Iron phosphate, also reduce the absorption on N.

For citrus fruits, (Zekri et al. 2018) noted that the increase of Phosphorus fertilization was increase TSS, number of green fruits, and yield, while it reduces acid concentration and peel thickness. In the same manner, (Ritenour et al. 2002) noted that the increase of P application for citrus hindered color development, acids, peel thickness, fruit size and TSS, while it increased sugars and juice content. On the other hand, and in terms of date leaf and fruit nutrient, (Kassem, 2012) found that the application of P was found to decrease Na and Cu concentrations in the leaves, decreased fruit Cu and NO3, decreased soil pH, increased fruit N, Fe, Zn, Mn, Cd and Pb, also favor the availability and uptake of elements. In Tomato production, Weston and Barth, (1997) found that the increase of Phosphorus in Soil lead to an increase in sugars and TSS in tomato.

In terms of Phosphorus deficit, Ibrahim and Zayed (2019), found that the deficit of P reduced plant growth, stunting of plants, and conferred lack of production and poor quality.

1.7.3 Potassium (K) Effect

Potassium is one of the vital elements required for plant growth and quality. It facilitates the transport of carbohydrates from leaves to other parts of the plant, including the fruit. Indeed, fruit contains large quantity of sugars, like dates, requires high quantity of Potassium.

The main processes of plant growth that require Potassium are: water use by plant, enzyme activation, photosynthesis, water and nutrient transport, sugar transport, starch synthesis and protein synthesis. Besides, Potassium helps to increases root growth and improves drought resistance which leads to improved crop quality through strong structure especially in date fruits (Zaid and Arias-Jiménez,2002).

In the literature, many research papers discuss the effect of potassium, whether increase or decrease of the element on the plant growth and crop quality.

(Ibrahim and Zayed, 2019) found that the increase of K fertilizer causes a decrease in peel separation of date fruit. In another research, (Al-Obeed et al. 2013) found that the increase of K fertilizer, increases fruit set, fruit yield, the content of N, P, K and Fe, and improves physical and chemical characteristics, while decreased Zn and Mn contents. In general, (Dialamia and Mohebi, 2010) found that the application of maximum K2O, was found to increase yield and quality of dates.

Another method of adding Potassium is spraying potassium solution on trees directly, in this manner, (Dialamia and Mohebi, 2010) indicate that spraying of Potassium silicate (K_2SiO_3) and Calcium Carbonate on date trees cause an improve in fruit physical characteristics, bunch weight, total sugars, non-reducing sugars, TSS and the level of Ca and Mg%. In the same way, (Al-Hajaj et al. 2020) study the foliar application of K on date tree and found that, it was improving fruit yield and fruit quality and increases bunch weight, fruit weight, fruit flesh weight and fruit moisture content. While the excess of foliar application of K increases leaf K content, but decreases Ca concentration, fruit yield, TSS, antioxidant activity and firmness.

In terms of the negative effect of the presence K in soil on the absorption of other elements, (Ibrahim and Zayed, 2019) noted that the increase of K in soil reduces the absorption of Ca and Mg. On the other hand, the combination of Potassium with Sulphur has a different effect on fruit nutrients, where (Kassem, 2012) found that the increase of potassium and Sulphur increases the fruit N, Fe, Mn, Cd, Pb and NO_3 contents, while increase K fertilizer found to increase Acidity of fruit and the nom-reducing sugars. In line with the previous study, with this combination effect of Potassium and Sulphur, (Kassem, 2012) found that the application of Potassium and Sulphur found to increase fruit N, Fe, Mn, Cd, Pb and NO3, also increase fruit yield, fruit weight and fruit length, while the application of K alone was found to increase fruit acidity, non-reducing sugars and to enhance nutrients uptake. In another research, (Ezz et al. 2010) found that the increase of K fertilizer increased yield, TSS, total sugars, reducing sugars and leaf N, K, Fe and Zn, while it decreased tannins and leaf Ca, Mg and Mn. On the other hand, (Kalaj, 2016) noted that the use of optimal K fertilization enhances leaf photosynthesis and reallocation of sugars and organic acids to fruits.

In citrus fruits production, (Zekri et al. 2018) indicate that the increase of Potassium fertilization was increased production, TSS, fruit size, fruit weight and lycopene, while it decreased acid concentration. In the same manner, (Ritenour et al.2002) noted that the increase of K in Citrus, decreases sugars, TSS, Juice content and delay maturity, while it increases acids, peel thickness, fruit size, fruit weight and vitamin C. On the other hand, the decrease of K in citrus increased fruit splitting and fruit drop, while it decreased color development. Agreed with the basic functions of K, (Salem and Ali, 2020) in their paper indicate that the application of K fertilization on date palm led to formation of proteins, fats, carbohydrates and chlorophyll, also maintaining the balance of salts and water. In another crop, (Abd El-Kader et al. 2010) noted that, the increase of Potassium in soil lead to increases titratable acidity and pH in tomatoes.

(Crisosto and Costa, 2008) noted that the use of optimum Potassium on Peach trees leads to high photosynthetic rates, reallocation of sugars, reallocation of organic Acids and enhance fruit quality. For another crop, (Kuzin et al. 2020) indicate that the increase of K application in Apple was increase yield, sugar content, coloring and firmness, while it decreased leaf and fruit Ca, and reduced the availability of soil Ca. On the other hand, the excess K decreased Apple storability.

1.7.4 Other Nutrients Effect

Besides the preliminary nutrients required by plants, there are another macro or micronutrients which the plants need in order to grow will and sustain normal growth. Some of these nutrients are: Magnesium Mg, Calcium Ca, Iron Fe and Manganese Mn.

Magnesium (Mg) is classified as a secondary macronutrient that is necessary to both plant growth and health. It is involved in many biological activities in plants like photosynthesis where it works as a central atom in the chlorophyll molecule. Also, Mg is required in plants to perform properly regarding many cell enzymes. Finally, it contributes to protein synthesis by the activation of many enzymes. On the other hand, Magnesium deficiency results in the yellowing leaves with green veins, but it become more available for uptake as the pH of growing medium increase. Magnesium deficiency can be induced if there are high levels of calcium, potassium or sodium in the growing medium.

(Ibrahim and Zayed, 2019) found that the increase of Magnesium in soil was found to increase at pH from 7.0 to 8.8, while it was decrease at pH more than 8.5 and at pH less than 5.5. Generally speaking, Mg availability increase as the soil pH decrease, on the other hand, it reduces the absorbable Fe when Zn levels rise for instance. In the same manner, it was also found that the increase of Mg in soil reduces the absorption of soluble CU, N and Fe.

In citrus production, (Zekri et al. 2018) indicate that the increase of Mg fertilization for Citrus increases the TSS, fruit weight and fruit size, and decrease rind thickness of the citrus fruit. Also, in the same crop, (Ritenour et al. 2002) found that the increase in Mg application increases fruit weight, fruit size, TSS and total sugars, while it decreases peel thickness and acids.

Calcium (Ca) is one of the secondary macronutrients like Magnesium, which is essential for plant growth and plant health. Calcium, in the form of calcium pectate, is responsible for holding together the cell walls of plants. It is also used in activating certain enzymes and sending signals that coordinate certain cellular activities. In terms of calcium deficiency, it is not mobile within the plant, so the plant relies on transpiration process to take up the calcium, thus humidity or low temperature can induce Calcium deficiency. Calcium deficiency can arise if levels in the fertilizer solution are less than 40-60 ppm and/or potassium, magnesium, or sodium levels are too high (Zaid and Arias-Jiménez,2002).

(Aly and El Agamey 2018). found that, spraying of Potassium silicate (K_2SiO_3) and Calcium Carbonate on date trees causes an improvement in the fruit's physical characteristics, improve bunch weight, increase total sugars, non-reducing sugars, TSS and the level of Ca and Mg%. In the same manner, Crisosto and Costa, (2008) noted that the spraying of Ca on Peach Increases fruit flesh percentage and reduces peel russeting. (Ibrahim and Zayed, 2019) found that the increase of Ca concentration in soil was found to reduce Mg and K absorption. On the other hand, the same researcher noted that the Calcareous soils which are rich of Ca found to increase the peel separation of date fruit because the lime reacts with glucose and fructose sugars to form sugar crystals containing Ca++ in the form of calcium clocosite and calcium fructose, these sugary grains appear under the peel of the fruit, causing the peel to separate from the pulp, causing dryness and separation.

(Kalaj, 2016) found that The Ca application on date fruits was found to delay fruit senescence and develop cell wall structure. On the other hand, and particularly in tomato production, (Weston and Barth, 1997) noted that the increase of Calcium content in soil leads to increased firmness of tomato. In terms of Calcium effect on the mobility and uptake of other nutrients, (Al-Qurashi et al. 2015) found that, in calcareous soils, the mobility of Phosphorus decreased due to its strong retention by soil oxides and clay minerals because P ions rapidly undergo precipitation and adsorption due to its strong retention by soil oxides and clay minerals because P ions rapidly undergo precipitation and adsorption reactions in the soil. Also, under calcareous conditions, P is readily fixed. Also, (Mazahrih et al. 2018) noted that the calcareous soil restricts mobility of P and K and rapidly fix P. (Kuzin et al. 2020) noted that the clay soil absorbed K and made it unavailable for plants.

Iron (Fe) is classified as a micronutrient, which is required by plants less than macronutrients. It assists in energy production within the plants and assists in nitrate and sulfate reduction. It’s also essential for formation of chlorophyll. While on the other hand, the deficiency of iron results in the yellowing with green veins present leaves.

(Ibrahim and Zayed, 2019) noted that the soil pH affects the availability and activity of some nutrients, where the Fe activity decrease as the soil pH increases.

Manganese (Mn) is one micronutrient required by plants besides Iron. It is function is important in various biological activities in plants including photosynthesis, nitrogen assimilation, respiration and cell elongation. On the other hand, the deficiency of Mn causes yellow leaves with green veins like iron. Plant growth may also be reduced and stunted. The uptake of Mn holds back when the pH of growing medium exceeds 6.5 (Zaid and Arias-Jiménez,2002).

1.8 Pollination of date Palm

Date Palm sex characters are a dioecious species with separate individuals. The unisexual flowers of females are called distillates, which are present in an inflorescence of long and slender branchlets and responsible of producing fruits after pollinated by the male flowers which are called staminate and are responsible of producing pollen in an inflorescence of stout and short Branchlets which are born single and exhibit a waxy white color.

Pollination can be done naturally by wind or, artificially by hand or device in commercial date production to ensure good fruit set and good production. Commercial pollination used to mix the pollen powder with some fillers like wheat or starch with 1:4 ratio of Pollen: Filler to achieve high yielding of most date varieties, then spray the pollen mix on the date female inflorescence strands, and repeat the pollination process 2-3 times to increase fruit set (Zaid and Arias-Jiménez,2002).

The fruit set depends on the pollination efficiency which is affected by several factors like: The pollination time, the type of pollen, flowering period of male palm, viability and amount of pollen, and the female flowers receptivity are the main factors to take into account.

The normal time-line for Pollination is March and April, where it takes place within 2 or 4 days after the female spathe has opened. It is important that the flowering periods of male and female palms should be synchronized, where the male spathe is preferable to open 2 or 4 days earlier than the female spathe. The amount of pollen grains produced by spathe varied greatly from one male to another (0.02 - 82.29 g/spathe). Also, the size of the pollen grain was also found to vary among males, where Mean diameter of pollen varied from 16 to 30 microns. The viability of pollen is very important to be tested before use to be able, where it is identifying the capacity of pollen to germinate and grow normally. Different male palms have different viability to result in more fruit set and higher yield (Zaid and Arias-Jiménez,2002).

Receptivity of female flowers is an important factor that affects pollination efficiency, the female flowering period is different from place to another and from variety to another which is temperature dependent and that stays on for 30 days on average during February, March and April in the Middle East. In general, the period length of receptivity of the pistillate flowers varies according to date palm variety from few days like medjoul variety to more than one week in species like Deglet Nour and Zahidi. Iqbal et al. (2018), Reported that the delay of pollination was improved fruit quality and increase fruit drop, while it was decrease fruit set and fruit yield.

Finally, the environmental factors like temperature, Rain and wind affect the pollination efficiency. The high temperature delays the pollination by inhibiting spathes development, while low temperature negatively affects the fruit set, but fruit sets can be improved by placing papers bags over the female inflorescence at the time of pollination. When female flowers open earlier than the paper bag can be removed two to three weeks later. The optimum temperature of efficient pollination is about 35C where the pollen germination reaches its optimum (Zaid and Arias-Jiménez,2002).

The rain negatively affects date fruit set, where it indeed becomes a washing agent that takes away most of the applied pollen when the rain comes directly after pollination. Also, the rain will decrease temperature which indirectly decreases fruit set. Another negative effect of rain is the fact that it reduces the pistillate flowers when they come in contact with water. Finally, the rain increases relative air humidity which increase the possibility of some diseases caused by rotting of inflorescences

The dry wind after pollination cause drying out of out the stigmas of the female flowers and also leads to a faster drying of the styles before the pollen tube reaches the ovule. The velocity of wind has both, positive and negative effects, where light wind speeds can favor pollination, while the high-speed wind can take away the pollen, break the inflorescences fruit stalk, blocking the movement of sieve nutrients and finally causing the death of the bunch.

1.9 Date Fruit Thinning

There are many benefits that can be achieved from date fruit thinning like: avoid the phenomenon of alternative bearing, improve fruit size, improve fruit quality in terms of reduce mold growth and improve evapo-transpiration, faster fruit ripening, reduce weight of bunch for harvesting packing and good development of fruit with nutrients

The Date fruit thinning can be done via one of three ways:

- Decreasing the number of bunches by the removal of whole bunches
- Decreasing the number of strands per bunch
- Reducing the number of fruits per strand

After pollination, it is recommended to wait 6 or 8 weeks in order to apply the adequate thinning method. The removal of over bunches is important practice to keep the date palm healthy for next year's where the adult date palm tree can produce more than 20 bunches, but the number of bunches should be balanced with the number of date leaves which is recommended to keep one date fruit bunch for each 8-9 date leaves to avoid alternance phenomenon in the next years (Zaid and Arias-Jiménez,2002).

Reducing the number of strands per bunch is an important practice to increase fruit size and improve fruit quality, this practice can be done by following two systematic steps, where 1/3 of the bunch from the lower part is cut at the time of spathe opening, and the inside strands of the bunch will be cut and left only 30-35 spikelet per bunch. This will improve pollination efficiency, increase fruit size and improve fruit quality by ventilate the bunch from inside.

Finally, the thinning is continued by hand after few weeks of pollination, where fruits are removed from strands to reduce the number of fruits per strand to reach 8-10 date fruits per strand. This practice will increase the marketing competitiveness of date fruit by increase date fruit size. An adult palm bearing 10 to 12 bunches, will hence yield 60 to 72 kg of high-quality Medjool dates.

1.10 Date Fruit Harvesting

Physically speaking, Date Harvesting means detaching date fruits from date plant at different ripen stages depending on the date variety where there are some different visible observations of the harvesting time like color and degree of ripening. Besides, there are some invisible parameters such as sugar content, water content and enzyme activity. The date fruits are harvested at three stages depending on variety and market demand. The first variety is Khalal stage, with moisture content of 50-85%, which is hard and yellow, or red in color. The second stage is Rutab with moisture content of 30-45%, which is soft and brown color. The third stage is Tamar stage with moisture content below 25% and soft to firm hard with amber to dark brown color (Zaid and Arias-Jiménez,2002).

The date varieties that are harvested in the khalal stage are the varieties which have low amount of tannin at Khalal stage which results in low astringency. Also, these varieties are sweet rather than bitter at khalal stage. Some varieties that are harvested and marketed fresh at khalal stage are Barhee, Zaghlool, Hayany and Khalas.

Rutab stage is the shortest stage, where it is intermediate stage between khalal and Tamar stages, but fruits in this stage are appealing, the grower the highest rate of return. Because fruits in rutab stage are contains nearly high moisture content and too soft, they need high care during harvesting, transporting and storage. Major commercial date varieties harvested at Rutab stage are Deglet Nour and Medjool.

Date Fruits harvested at Tamar stage are classified as dried fruits, where moisture content is normally below 25% and goes down to 10% in some varieties, for that the dates at this stage is non-perishable and the microorganisms can't grow easily. Nonetheless, they can be stored for long periods of time because of the low moisture content and high concentration of total soluble solids. Most of these date varieties are: Dayri, Halawy, Khadrawy, Thoori, Zahidi and Sayer.

The softening of date fruit which especially occurs during the fruits goes from khalal stage to rutab stage is influenced by invertase enzymes which convert disaccharides to two monosaccharides, fructose and glucose by slow evaporation of water from date fruits. For that, the fructose and glucose monosaccharides contents in the date fruits is influenced by the evaporation speed and enzyme activity where these determine the shelf life based on the relationship between water activity and water content. (Ibrahim and Zayed,2019) reported that the date fruit development from khalal to rutab to tamer is associated with a decrease of water content in date fruits.

Regarding harvesting of Medjoul dates varieties, since it is soft and delicate fruit with a thin peel, the treatment should be carried out with special care, because if the date peel is harmed, the problem of peel separation and sugar crystallization under peel will appear, which affects the date appearance and then reduces the price and competitiveness of the dates in the markets. Harvesting of Medjoul variety starts when the date fruits transited from Khalal stage to Rutab stage and become Tamar with nearly high moisture content of 20-26% and part of them below 20% with water activity not more than 65%. Drying the Medjoul dates should be slow and deliberate because of the relationship between volume and outside surface to avoid peel separation problem. (Eltayeb et al. 1999) found that, as the date fruit develops toward ripening, the total soluble sugars increase. On the other hand, (Haider, et al. 2014) reported that the soluble protein decreases during date fruit development. This finding complies with the same finding by (Haider et al. 2014). Ragab et al. (2011) reported some quality effects of date fruit during development from Khalal to rutab stages, where this development increases the total sugars, reducing sugars, pH and Fe. Simultaneously, this development decreases fruit weight, flesh weight, pit weight, ash, fat content, fiber content, moisture content, protein content and non-reducing sugars, it also decreases some nutrients in fruits like K, P, Na, Mg and Cu. Other authors reported that the fruit development towards ripening actually decreased water content and Pectin, while it increased dry matter content (Gribaa et al. 2013). The date fruit TSS, titratable acidity, flesh darkening, proline amino acid and protein content increased while, phenolic compound andante-oxidant capacity decreased by fruit development. The priors are found by (Mohammad et al. 2015). Similar results are found by (Al-Qarni2020), where the fruit ripening was found to increase sugar content, enzyme activity and protein. In another publication by Haider et al. 2014), they found that the fruit ripening leads to decrease antiradical efficiency contents, antioxidant enzymes, total phenolic contents, soluble protein and non-reducing (sucrose) sugars, while it increases glucose and fructose. In the same manner, (Awad et al. 2011) found that the fruit ripening decreased antioxidant capacity, antioxidant compound concentrations, activities of the antioxidant enzymes, peroxidase, catalase, fruit weight, vitamin C, phenols and soluble tannins.

El Arem et al. 2012) reported that the as the fruit ripening increases, total phenolic content (TPC) and soluble tannins under peel decreases. The non-soluble tannins under peel also increased. On the other hand, (Awad2011) found that the fruit ripening increases TSS, flesh dry weight and acidity, while it decreased flesh weight, vitamin C, total phenols, soluble tannins and all nutrient elements (nitrogen, potassium, phosphorus, magnesium, calcium, sodium, zinc, iron, copper and manganese). In the same manner, Gribaa et al. (2013) reported that the ripening increased soluble sugars and cell expansion and growth, while it decreases water content, cell wall content of the pulp, loss of fruit firmness and turgor pressure.

To ensure that fruits will not fall down on the ground under trees when ripen, or be attacked by birds or insects, each bunch should be covered by shallow plastic bag. So, harvesting is done by shaking the bag of each bunch when more than 50% of the fruits are transited from Khalal to rutab stage and part of them have started to transit to Tamar stage, by this gentle shaking, most of the ripen date fruits fall down in the bag, then the bag is opened and the fallen fruits are collected in shallow plastic boxes in one layer of fruits. This procedure is repeated every 7 days.

The collected fruits should be sorted, firstly to remove any un-ripen fruits, damaged fruits and high moisture fruits (above 26%). So, the remaining fruits should be arranged in one layer in shallow plastic boxes for further treatments like fumigation by Aluminum phosphate gas to kill insects for non-organic dates, or by heat treatment for organic dates. Later on, the dates are graded according to size and peel separation, then are packed and stored. The high moisture fruits should be dried to moisture content of 20-26%, then they go for further treatment as above, while the un-ripen fruits should be treated in sun drier to ripen properly.

As any other crop, there are some quality limitations facing this sector, especially due to the fact that most of the crop is exported to the international markets with specific standards. The major quality problem facing marketing of Medjoul date is peel separation, where the peel of fruit separates from the pulp which significantly lowers the product's quality leading to market with loss of 50% in price. This problem appears well in the unripe fruits on tree and requires ripening by solar energy, which represent also more than 30% of the production, for that the loss caused by peel separation increase more and more.

The start of peel separation occurs before ripening is complete, as the fruit is still supplied with water and nutrients from the tree, but it can only be observed after ripening as the mesocarp losses water and softens. Peel separation is caused partly by high diurnal, cyclic stresses of turgor pressure fluctuations before the ripening stage of the fruit and also affected by the environmental conditions (Eltayeb et al. 1999). Hassan and Omran, (2018) reported the same characteristics of the date fruits during ripening stage from Khalal to Rutab and from rutab to tamer, they reported that during khalal to rutab stage, the rupture strain increases, while all elastic limits, firmness, bio-yield stress, bio-yield strain and rupture stress decrease. On the other hand, and during rutab to tamr stage, the elastic limit, bio-yield stress, rupture stress, and rupture strain notably increased, while firmness and bio-yield strain decreased. For strawberry, (Alvarez-Suarez et al. 2014) found that, as the strawberry ripening increases, vitamin C and anthocyanin increase, while the flavonoids content, the anti-oxidant capacity and tannins content decrease. In another publication, (Awad et al. 2011) found that the increase of maturity of dates increased the total sugars, reducing sugars and enzyme activity then sharply decrease, while decrease moisture content and protein content were observed. In the same manner, the ripening of date fruits was found to decrease tannins as reported by (Al-Kharusi et al. 2009).

1.11 Research Objectives

The main purpose of this study is to investigate the effect of different factors on date palm fruit peel separation characteristics in order to lower the peel separation rate of Medjoul dates. Commercially, the peel separation graded into three grades according to the percentage of peel separation in each fruit. Grade A, with peel separation that is less than 10% which is classified as a high-quality product, Grade B with peel separation between 10% and 35% which is classified as a medium quality product, finally, grade C which is classified as the lowest quality product with peel separation above 35%.

The main objectives of this research are:

- Studying the effect of the following parameters on date fruit peel separation:

1. Water quantity and quality
2. Fertilizer quantity and type
3. Meteorological parameters

- Studying the effect of soil and environmental parameters on the quality of medjoul date fruits and loose peel problem.
- Suggesting effective solutions to reduce loose peel separation problem in Palestinian medjoul date palm fruits.

In this study, different water qualities from different sources in Jericho were assessed chemically and analytically; including treated waste water. The effect of water quantity and quality on the medjoul date fruit peel separation and fruit quality were studied to model and compromise the use of different water qualities available. The effect of fertilizer quantity and combinations, the effect of other atmospheric parameters including soil and environmental parameters on medjoul date peel separation, and its quality were studied in an effort to suggest solutions to minimize the medjoul date peel separation problem.

1.12 Research Justifications

Medjoul date fruit in Palestine has become the second national agricultural crop after olive oil in terms of national income. In few years, it will become the first national crop where the area under growing of medjoul date is significantly increasing.

Like any agricultural product, Medjoul dates face real problems that affect its marketing. One of the quality problems is the peel separation of the date fruit which decreases the marketing price to around 50%. Besides, the side effects of this defect on nutritive quality like sugar crystal under the loose peel and the growth mold under the separated peel. Table (1.1) below summarize the average market prices of medjoul dates according to quality grades:

Table (1.1): Average market prices of medjoul dates according to quality grades

Quality Grade	Peel Separation (%)	Market Price according to size ($)
A	≤ 10	From 6 to 14
B	10 < > 35	From 4 to 8
C	35 ≤	From 2 to 4

There is a priority interest to study factors affecting the peel separation, including the effect of water, soil, fertilizer and environmental parameters and to suggest solutions to minimize this problem as a next step.

1.13 Research Hypotheses

During this study, there are some hypotheses that the research comprises to accomplish the above main objectives:

- Tuning water quantity and quality can directly affect the medjoul date peel separation problem.
- The soil type and composition can affect medjoul date peel separation.
- The fertilizers type and quantity used for date trees affect the Medjoul date peel separation.
- The meteorological parameters can affect the date peel separation.

1.14 Scientific Background of Date Peel Separation

Plantation of medjoul dates takes place by offshoot or by tissue culture, but in Palestine, the offshoot propagation method is the well-known method for date cultivation (Bitar et al. 2018). Each tree produces from 6 to 12 offshoots or more. The offshoot incubated on the mother tree for few months is then cut off and planted. The offshoot takes about four years to start production.

The production cycle starts from the pollinate bunches of female trees by pollen from male trees, then thinning process should be conducted to reduce the number of fruits in each bunch to produce large size and high-quality dates.

The date fruit takes about six months to fully ripen. There is a name for each of the four stages of date ripening; kimri, khalal, rutab, and finally tamar.

The kimri stage lasts about 5 months, and is basically the stage in which the dates are dominantly green. The next ripening stage is the khalal stage; when the dates have grown to their maximum size and have turn yellowish in medjoul dates or reddish depending on the specific date variety. Next comes the Rutab stage, when the dates begin to soften and lose their bright colors. The date becomes fully mature at the Tamar stage as appears in fig. (1:1) below:

Kimri Stage

Khalal Stage

Rutab Stage

Tamar Stage

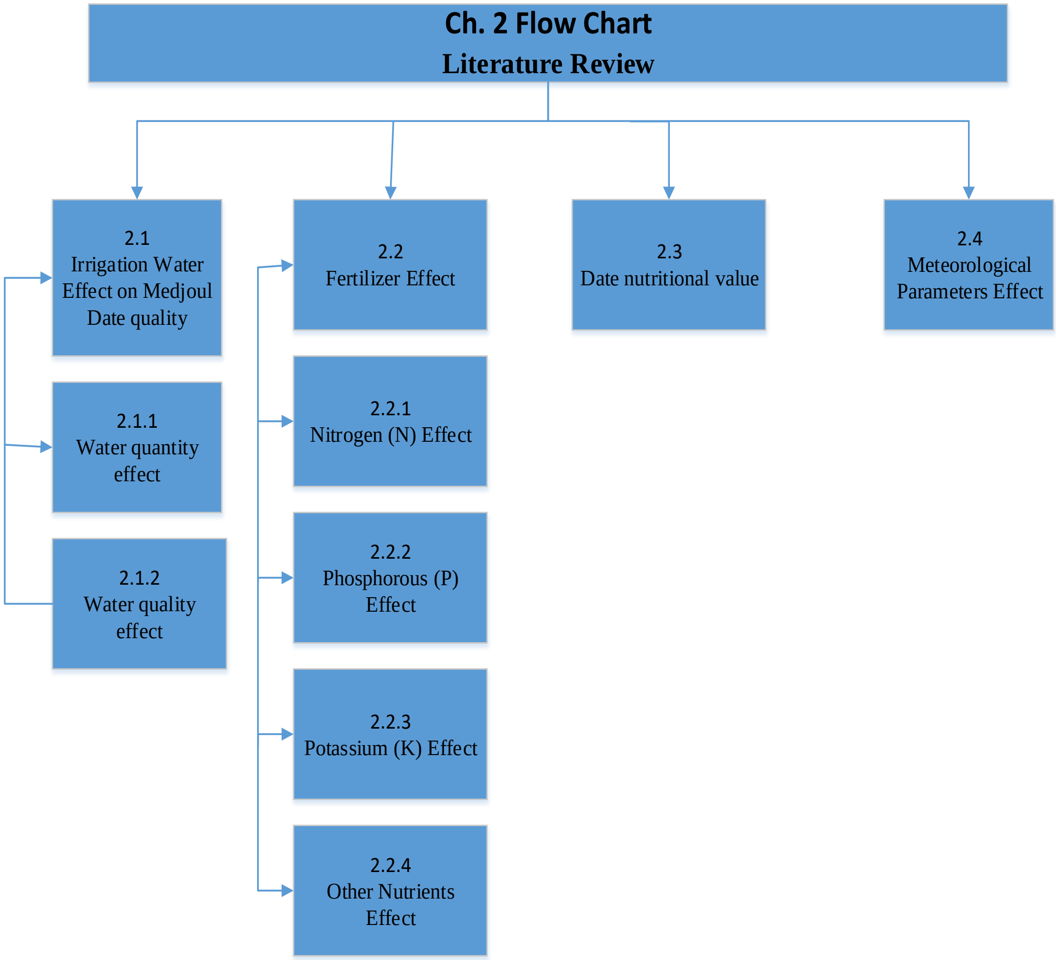
Medjoul Dates with Peel Separation

Medjoul dates without peel separation

Fig. (1.1): Medjoul date development stages.

Chapter Two

Literature Review



2.1 Irrigation Water Effect on Medjoul Date quality

Water is the most critical input for agricultural production. It also plays an important role in food security. 20 percent of the total cultivated land is irrigated agriculture which contributes 40 percent of the total food produced worldwide (World Bank Group, 2021). Productivity per unit of land in irrigated agriculture is, on average, at least twice as rain-irrigated agriculture, thereby allowing for more production intensification and crop diversification. In terms of Medjoul dates, all farms in Palestine are irrigated because these plantations are located in very hot area.

Agriculture is globally affected by climate change and population growth, where competition for water resources is expected to increase and availability of land for agriculture is expected to decrease. World Bank Group (2021) expected that, the global population to increase by over 10 billion by 2050. Due to this population growth, it is estimated that agricultural production will need to expand by approximately 70%.

Agricultural sector in Palestine is a major contributor to the Palestinian economy, which yields 11-20% of GDP and represents 25% of the total exports, engaging 15% of the total work force (Sonneveld et al. 2018). Medjoul date represents one of the major important crops in agricultural sector, especially in the last 10 years. Due to specialty of the Jordan valley area in terms of environmental characteristics, Medjoul date plantation concentrated in this area, which places a huge pressure on the water resources especially the underground water which is already very limited due to the Israeli policies and restrictions (Sonneveld et al., 2018). This pressure on water in Jordan Valley creates water scarcity problem for both drinking and irrigation of agricultural land, especially Medjoul date farms, which helps to find innovative solutions by harvesting water from rain and by using treated water for irrigation.

Peel separation (skin separation) problem in medjoul date is one of the main and crucial quality problems, where the fruit peel separates from the pulp of the fruit during ripening. The prior leads to a huge loss that exceeds 50% of the price. In this research, the use of water quality (salty, fresh and treated) and water quantity from each water quality type will be studied to investigate the correlation between these parameters and the peel separation problem in Medjoul dates. There are numerous researches in literature that study the irrigation water effect on date growth and date quality in general which are discussed below.

2.1.1 Water quantity effect

The irrigation water quantity directly affects the quality of fruits, and vegetables, especially Medjoul dates which is fully irrigated, where decrease or shortage, increase, excess irrigation, irrigation frequency and irrigation fluctuations, can affect directly the Medjoul date fruits.

In terms of irrigation water decrease or shortage, a group of researchers agreed on numerous effects of this irrigation water stress on the fruit and vegetable quality. Fallahi et al. (2010) found that the shortage in the irrigation water of Apple, cause an increase in apple stress, enhanced Ethylene production, decreased yield, and decreased apple fruit size (Fallahi et al. 2010). In the same context, (Zekri et al. 2018), found that, the deficit irrigation in citrus increases total sugars and reducing sugars. Another researcher, (Hassan and Omran,2018) found that the decrease of irrigation water decreased mean value of fruit mass, flesh mass, fruit volume, fruit length, fruit diameter, fruit moisture and fruit peel thickness, while it increased mean value of bulk density, firmness, solid density and rupture strain. On the other hand, (Weston and Barth,1997) indicated that in vegetables, as the irrigation water stress, the TSS and sugars increased. In Peach production, (Crisosto and Costa, 2008) noted that the decrease of irrigation water on Peach trees reduce yield, reduce fruit size, increase TSS, decreased water loss from fruits, increase thickness of cuticle and Increase density of trichomes than fruits. In the same direction, but in citrus production, (Ritenour et al. 2002) noted that the decrease of Citrus irrigation water resulted in decreased yield, fruit size and juice content, while it led to increased peel thickness, soluble solids and acids. Kuzin et al. (2020), indicated that the decrease of apple irrigation water, led to decreased apple leaf K.

In terms of irrigation water increase, a wide range research papers indicates many effects of this increase. Ibrahim and Zayed (2019) found that, when the irrigation water quantity increases, especially in summer, this increases the percentage of peel separation in date fruit. In the same direction, Gribaa et al. (2013) mentioned that, the increase of water irrigation in fact increased hydrophobic groups and decreased the degradation of hydrophilic groups in date fruits, which leads to a notable increase the peel separation percentage. For apricots, (Francisco Pérez et al. 2016), found that the date soluble sugars increase as the irrigation water increases. Sadik et al. (2018) contradicted this foundation and found that, the Increasing of irrigation water quantity in dates decreased TSS, while it increases total sugars, fruit weight, and evapo-transpiration. On the other hand, (Al-Yahyai and Khan, 2015) found also that increasing irrigation water increased water content, fruit juice volume and titratable Acidity, while it decreased TSS, total sugars, reducing sugars, pectin and dry matter. Sarker et al. (2016) also found that, the increase of irrigation water resulted in late ripening, decreased total sugars, reducing sugars, non-reducing sugars, and decrease TSS.

The increase of apple irrigation was found to increase moisture content which reduced oxygen in root and decreased N2 leaching and availability, while it decreases transpiration rate, proline leaf content, TSS, Acidity and chlorophyl in leaves (Mohawesh and Al-Absi, 2009). In date fruits, another authors (Al-Yahyai and Manickavasagan, 2013) found that the increase of irrigation water influenced reducing sugars, fiber, pectin, tannins and vitamins and it also increased fruit water, titratable acidity and juice volume. In his PhD dissertation, (Kalaj, 2016) found that the increase of irrigation water was found to delay maturity, decrease fruit firmness and reduce soluble solids. In tomato production, Wang and Xing, (2017) indicated that the irrigation of tomato increased yield and decreased organic acids, lycopene and vitamin C. (Zekri et al. 2018) on the other hand found that the increase of irrigation water for citrus did in fact increase juice content, TSS/Acid ratio, fruit size, fruit weight and green fruits, while it decreased rind thickness of the fruit. It was found by Gribaa et al. (2013) that, the increase of irrigation water in dates decreased the degree of methyl etherification of pectin, loss of galactose content, reduction of the branching of xylan by arabinose and an increase in weight and size of fruit. Abd El-Kader et al. (2010) in another research found that as the irrigation water increases, the yield and NPK uptake increases as well. But the excess irrigation water led to an opposite trend of yield where the yield decreased. Mazahrih et al. (2018) noted that the increase of irrigation water led to an increase in fruit yield and weight.

Regarding irrigation frequency, FAO proceeding report, (2008), indicates that as the irrigation frequency increase, the fruit size, weight, moisture content and TSS increase while the fruit maturity period reduced. In the same manner, (Ibrahim and Zayed, 2019) indicate that, the peel separation in date fruit decreases as the number of irrigation times per month decreases. Following the same pattern, (Alaoui et al. 2013) indicated that, as the irrigation frequency increases, this enhances fruit development, and increase yield and quality of peaches. Zekri et al. (2018) reported that the increase of irrigation frequency of citrus increased fruit water content, juice volume and titratable acidity. On the opposite direction, (Baballah et al. 2016) explored that tree yield increased by decreasing the irrigation frequency. Increasing the irrigation water of tomato has led to an increase in acidity, color and size, while it decreases TSS (Weston and Barth,1997). On the other hand, Crisostoand Costa, (2008) found that the fluctuation of irrigation water of Peaches did not affect the Yield, flesh firmness, percentage of red surface, acidity, and pH of Peaches. For citrus, in another research, (Ritenour et al. 2002), noted that the increase of irrigation water increased rind thickness and decreased TSS.

2.1.2 Water quality effect

The same as irrigation water quantity, the irrigation water quality also affects fruit and vegetables quality and nutrition, especially in Medjoul dates. The main water types used for irrigation in Jordan Valley are fresh water, salty water and treated sewage water. These water types contain different nutrient contents which can affect the fruit quality of the irrigated plants.

In terms of salty water, (Ibrahim and Zayed,2019) indicate that the salinity of water or soil causing decreased water permeability in soil, which lead to more water usage to compensate the water deficit as a result of high salinity. The prior is also confirmed also by Robinson et al. (2018). Another foundation comes from Alkhateeb et al. (2015) who indicated that, as the salinity increases, the dates growth simultaneously decreases, the Na^+ contents in leaves and roots of the date palm also rises, but the Na^+ concentration was higher in the roots than in the leaves. Al-Rawi and Al-Mohemdy (2012) agreed with previous findings and indicated that, as salty water irrigation increases, the Na concentration in fruits increases as well, while the tree growth rate, the yield, fruit quality and K concentration in fruits decrease. In the same line, but for soil, Al-Rawi and Al-Mohemdy (2012) found that as the soil salinity increases, the Na content in date leaves increase, while the N, P and K contents in leaves decrease. Also, Yaish et al (2015) agreed on the same finding, in terms of soil salinity, where they found that, as the soil salinity increases, the growth rate of the plant decreases. Also, FAO proceeding report (2008), indicated that the yield decreases as the water salinity increased. Also, the salty water was noted to reduce tree size and leaf area as indicated by (Al-Muaini et al.2017).

In terms of nutrients availability and uptake, Al-Qurashi et al. (2015) indicate that the salinity of soil and water prevent, or slow down nutrient uptake by plants. (Mazahrih et al. 2018) noted that, the increase of salty soil was restricting the mobility of P and K. (Tripler et al. 2011) noted that the increase of salinity in water led to decreased tree growth, yield, fruit size, evapo-transpiration and delayed maturity.

2.2 Fertilizer Effect

Soil is containing organic matters and minerals, which are essential for plant growth, but these nutrients will be depleted at some point during cultivation, which are absorbed by plants. Thus, soil fertilization is very important to compensate for the nutrient's loss, and to enrich soil with sufficient nutrients for the plants. These nutrients could be used as organic materials or chemical synthesis. The main fertilization nutrients needed by date trees are Nitrogen N, Phosphorus P, Potassium K. There are also some other important nutrients like Magnesium Mg, Calcium Ca, Manganese Mn, and Ferrous Fe. The fertilization of date trees increases yield, TSS, total soluble tannins and total phenols as indicated by (Qurashia et al. 2015), (Elamin et al. 2017), and (Al-Yahyai, 2018) who all agreed on the same findings, and noted that the increase of NPK fertilization increases the yield and TSS, while it decrease the moisture content in the date fruit.

2.2.1 Nitrogen (N) Effect

Nitrogen N, is one of the primary nutrients needed for the plants. It increases crop production, and improves quality of the products. Plants absorb Nitrogen from soil with other macronutrients and should be in sufficient quantities that are readily available in the soil in order for a crop to achieve its maximum yield potential. The main problem of Nitrogen is it loss from soil, so Nitrogen application on soil requires some humates or chelator to hold onto Nitrogen and make it more effective. Nitrate form (NO_3^-) is the main form of Nitrogen absorbed by plant, and to a lesser extent the ammonium (NH_4^+) form. numerous researchers highlighted the importance of Nitrogen Application on plants and fruits or vegetables in terms of increase or decrease in the nitrogen application quantity. Dialamiaand Mohebi, (2010) indicted that the application of minimum N, was found to increase yield and quality of dates. On the other hand, Ibrahim and Zayed, (2019) found that the optimum nitrogen availability increased fruit weight, fruit size and proportion of pulp, but the overly use nitrogen delayed flowering, decreased the number of flowers, delayed ripening and reduced yield, while in terms of the effect of N on the other nutrients, the author found that the increase of N content in soil decreased the boron concentration in fruits. In the same manner, (Ezz et al. 2010) indicated that the increase in N fertilization increased yield, fruit tannins and leaf N, Ca and Mg content while it decreases fruit TSS, total sugars, reducing sugars, leaf P, Fe and Zn. In terms of vegetation and fruit maturation, Kalaj, (2016) noted that the increase in N fertilization increased vegetative growth and delayed maturation of fruits. For citrus fruits, the increase of nitrogen fertilization increased juice content, TSS, acid concentration, peel thickness and fruit green, while the use of excess nitrogen was lower yield and lower TSS as indicated by (Zekri et al. 2018). On the other hand, Salem and Ali, (2020) found that the application of N fertilization increased cell number in fruit, cell size and growth rate, it also produced chlorophyll, protein and nucleic acid. While in Avocados, HAAS, (1949) indicated that the application of N, with presence of P and K increased P and K in leaves and fruits.

El-Merghany et al. (2018) found that the application of N increased fruit yield and bunch weight, while the excess of N increased fruit acidity, non-reducing sugars and decrease total sugars. On the other hand, the decrease in N fertilizer led to increased reducing sugars and total sugars. In vegetable production, (Weston and Barth, 1997) noted that the increase in soil Nitrogen has led to an increase in Moisture content in vegetables, decreased ascorbic acid and dietary fiber. On the other hand, the excess soil Nitrogen has caused a decrease of ascorbic acid in vegetables and increased weight loss. Crisosto and Costa, (2008) investigated the application of N on Peach and noted that the increase of N application on Peach trees stimulated vigorous vegetative growth, causing shading out and death of lower fruiting wood and increasing fruit water loss rate, but the excess of N lead to delayed peach maturity. Mazahrih et al. (2018) found that the application of Nitrogen built protein and cell of the fruits. In the combination fertilization of NPK and their effect on date tree and date fruits, (Al-Kharusi et al. 2009) found that the NPK application increased dry matter content, nutrients uptake, crop yield, glucose and fructose content, and titratable acidity, while it decreased tannins. On the other hand, the increase in N application alone, increased pectin and decreased dry matter. Ritenour et al. (2002) noted that in the Citrus production, the increase of Nitrogen application for citrus trees increased yield, fruit peel thickness of young tree, TSS and acids, while it decreased fruit peel thickness of mature tree, solid content, juice content and delay ripening.

Another effect can be exhibited as a result of from shortage of Nitrogen, where (Weston and Barth, 1997) noted that the Nitrogen decrease in the soil of vegetables had a decrease of protein in harvested vegetables. On the other hand, Crisosto and Costa, (2008) noted that the N deficiency led to small-sized fruit with poor flavor and unproductive trees. On the other hand, Ritenour et al. (2002) indicated that the decrease of Nitrogen application led to faster ripening and reduced yield.

2.2.2 Phosphorous (P) Effect

Phosphorus is classified as a macro-nutrient, which is required by plants in relatively large amounts. The major four macro-nutrients required by plants are: Nitrogen (N), Phosphorus (P), Potassium (K) and Calcium (Ca).

Phosphorus plays a major role in photosynthesis, nutrient transport, and energy transfer (Zaid and Arias-Jiménez,2002).

Phosphorus application leads to more vigorous growth of the plant and to mature earlier than a plant with inadequate Phosphorus. As the application of Phosphorus increases, this will decrease bacterial growth on a plant's leaves. While on the other hand, the Phosphorus deficiency of fruit or flowers leads to stunted plant growth, wilting, and leaves that may have a purple cast.

Al-Obeed et al. (2013) found that, the increase of P fertilization on date trees, increased fruit set, fruit yield, and improved physical and chemical characteristics. On the other hand, (Dialamia and Mohebi, 2010) indicate that the application of minimum P_2O_5, was found to increase yield and quality of dates. On contrast, (Ibrahim and Zayed, 2019) found that the overly use P decreased Zn and Cu. With regards of the effect of P on the availability of other nutrients, (Ibrahim and Zayed, 2019) indicated that the increase of P in soil leads to precipitate of Iron into Iron phosphate, it also reduces the absorption on N.

Zekri et al. (2018) noted that, the increase of Phosphorus fertilization in citrus increased TSS, number of green fruits and yield, while it reduced acid concentration and peel thickness. In the same manner, Ritenour et al. (2002) noted that the increase of P application for citrus decreased color development, acids, peel thickness, fruit size and TSS, while it increased sugars and juice content. On the other hand, and in terms of date leaf and fruit nutrient, Kassem, (2012) found that the application of P was found to decreased leaf Na and Cu, decrease fruit Cu and NO3, decrease soil pH, increased fruit N, Fe, Zn, Mn, Cd and Pb. It was also noted that it enhanced the availability and uptake of elements. In Tomato production, (Weston and Barth, 1997) found that the increase of Phosphorus in Soil has led an increase of sugars and TSS in tomatoes. In terms of Phosphorus deficit, (Ibrahim and Zayed, 2019) found that the deficit of P was reduced plant growth, stunting of plants, lack of production and poor quality.

2.2.3 Potassium (K) Effect

Potassium plays a major role in determining fruit quality. In this respect, it is one of the main elements required for plant growth as help and the transport of carbohydrates from leaves to other parts of the plant, including the fruit, so that, fruit containing large quantity of sugars, requires high quantity of Potassium, date fruits as an example.

Potassium is required by many processes of plant growth which are: water use by plant, enzyme activation, photosynthesis, water and nutrient transport, sugar transport, starch synthesis and protein synthesis. Also, Potassium helps to increases root growth and improves drought resistance, which leads to improved crop quality through maintaining turgor for strong structure, especially in date fruits.

In the literature, many research papers discuss the effect of potassium, even increase or decrease on the plant growth and crop quality.

Ibrahim and Zayed, (2019) found that the increase of K fertilizer causes a decrease in peel separation of date fruit. In another research, (Al-Obeed et al. 2013) found that the increase of K fertigation, increase fruit set, fruit yield, the content of N, P, K and Fe, and improves physical and chemical characteristics, while decrease Zn and Mn contents. In general, (Dialamia and Mohebi, 2010) found that the application of maximum K2O, was found to increase yield and quality of dates.

Potassium can also be added by spraying potassium solution on trees directly. Dialamia and Mohebi (2010) indicated that, spraying of Potassium silicate (K_2SiO_3) and Calcium Carbonate on date trees can lead to improvement of the fruit’s physical characteristics and bunch weight, increase in total sugars, non-reducing sugars, TSS and the level of Ca and Mg%. In the same way, (Al-Hajaj et al. 2020) studied the foliar application of K on date tree and found that it was improving fruit yield and quality and increase bunch weight, weight, flesh weight and moisture content. While the excess of foliar application of K increased leaf K content, but decreased Ca concentration, fruit yield, TSS, antioxidant activity and firmness.

Ibrahim and Zayed (2019) argue that, the increase of K in soil reduced the absorption of Ca and Mg. On the other hand, the combination of Potassium with Sulphur has a different effect on fruit nutrients, where (Kassem, 2012) found that the increase of potassium and Sulphur increased the fruit N, Fe, Mn, Cd, Pb and NO_3 contents. Besides, increase of K fertilizer was found to increase acidity of fruit and the nom-reducing sugars. In line with this combination effect of Potassium and Sulphur, Kassem, (2012) found that the application of Potassium and Sulphur was found to increase fruit N, Fe, Mn, Cd, Pb and NO3, it also increased fruit yield, weight and length, while the application of K alone was found to increase fruit acidity, non-reducing sugars and to enhance nutrients uptake. In another research, (Ezz et al. 2010) found that the increase of K fertilizer increased yield, TSS, total sugars, reducing sugars and leaf N, K, Fe and Zn, while it decreased tannins and leaf Ca, Mg and Mn. On the other hand, (Kalaj, 2016) noted that the use of optimal K fertilization enhanced leaf photosynthesis and reallocation of sugars and organic acids in the fruits.

In citrus fruits production, (Zekri et al. 2018) indicate that the increase of Potassium fertilization was increase production, TSS, fruit size, fruit weight and lycopene, while decrease acid concentration. In the same manner, (Ritenour et al.2002) noted that the increase of K in Citrus, this decreases sugars, TSS, Juice content and delays maturity, while it increases acids, peel thickness, fruit size, fruit weight and vitamin C. On the other hand, the decrease of K in citrus increased fruit splitting and fruit drop, while it decreased color development. Regarding with the basic functions of K, (Salem and Ali, 2020) in their paper indicated that the application of K fertilization on date palm led to formation of proteins, fats, carbohydrates and chlorophyll, also maintaining the balance of salts and water. In another crop, (Abd El-Kader et al. 2010) noted that, the increase of Potassium in soil led to increased titratable acidity and pH in tomato.

Crisosto and Costa (2008) noted that, the use of optimum Potassium on Peach trees led to high photosynthetic rates, reallocation of sugars, reallocation of organic Acids and enhanced fruit quality. For another crop, (Kuzin et al. 2020) indicate that the increase of K application in Apple increased yield, sugar content, coloring and firmness, while it actually decreased leaf and fruit Ca, and reduced the availability of soil Ca. Simultaneously, the excess K decreased apple storability.

2.2.4 Other Nutrients Effect

There are other macro or micronutrients in addition to preliminary nutrients, which are needed for plants in order to grow will and be sustainable, some of these nutrients are: Magnesium Mg, Calcium Ca, Iron Fe and Manganese Mn.

Magnesium (Mg) is necessary to both plant growth and health; it is classified as secondary macronutrient. It is involved in many biological activities in plants like photosynthesis where it works as central atom in the chlorophyll molecule. Also, Mg is required in plants to perform properly many cell enzymes. Finally, it contributes to protein synthesis by the activation of many enzymes. On the other hand, Magnesium deficiency results in yellow leaves with green veins, but it becomes more available for uptake as the pH of growing medium increases. Magnesium deficiency can be induced if there are high levels of calcium, potassium or sodium in the growing medium.

Ibrahim and Zayed (2019) found that, the increase of Magnesium in soil was found to increase at pH from 7.0 to 8.8, while it decreased at pH more than 8.5 and at pH less than 5.5. So in general, Mg availability increases as the soil pH decreases. In the same manner, it was also found that the increase of Mg in soil reduced the absorption of soluble CU, N and Fe.

The increase of Mg fertilization for Citrus increased the TSS, fruit weight and fruit size, decrease rind thickness of the citrus fruit (Zekri et al., 2018). Also, in the same crop, Ritenour et al. (2002) found that, the increase in Mg application was increase fruit weight, fruit size, TSS and total sugars, while decrease peel thickness and acids.

Calcium (Ca) is essential for plant growth and health. It is one of the secondary macronutrients like Magnesium. It is responsible for holding together the cell walls of plants. Ca is also used in activating certain enzymes and to send signals that coordinate certain cellular activities. In terms of calcium deficiency, it is not mobile within the plant, so the plant relies on transpiration process to take up the calcium, so humidity or low temperature can induce Calcium deficiency. Calcium deficiency can arise if levels in the fertilizer solution are less than 40-60 ppm and/or potassium, magnesium, or sodium levels are too high (Zaid and Arias-Jiménez,2002).

Aly and El Agamey (2018) found that, spraying of Potassium silicate (K_2SiO_3) and Calcium Carbonate on date trees causes an improvement of fruit physical characteristics, improves bunch weight, increases total sugars, non-reducing sugars, TSS and the level of Ca and Mg%. In the same manner, Crisosto and Costa, 2008) noted that the spray of Ca on Peach Increased fruit flesh percentage and reduced peel russeting. (Ibrahim and Zayed, 2019) was found that the increase of Ca concentration in soil was found to reduce Mg and K absorption. On the other hand, the same researcher noted that the Calcareous soils which are rich of Ca were found to increase the peel separation of date fruit because the lime reacts with glucose and fructose sugars to form sugar crystals containing Ca++ in the form of calcium clocosite and calcium fructose, these sugary grains appear under the peel of the fruit, causing the peel to separate from the pulp, causing dryness and separation.

Kalaj (2016) found that The Ca application on date fruits was found to delay fruit senescence and develop cell wall structure. On the other hand, and in tomato production, (Weston and Barth, 1997) noted that the increase of Calcium content in soil lead to increase firmness of tomato. In terms of Calcium effect on the mobility and uptake of other nutrients, (Al-Qurashi et al. 2015) found that, in calcareous soils, the mobility of Phosphorus decreased due to its strong retention by soil oxides and clay minerals because P ions rapidly undergo precipitation and adsorption due to its strong retention by soil oxides and clay minerals because P ions rapidly undergo precipitation and adsorption reactions in the soil. Also, under calcareous conditions, P is readily fixed. Also, (Mazahrih et al. 2018) noted that the calcareous soil restricts mobility of P and K and rapidly fix P. (Kuzin et al. 2020) noted that the clay soil was Absorb K and make it un available for plants.

Iron (Fe) is required by plants less than macronutrients and is classified as a micronutrient. It is assists in energy production within the plants and assists in nitrate and sulfate reduction. It’s also essential for formation of chlorophyll. On the other hand, the deficiency of iron results the yellow with green veins color of leaves.

Ibrahim and Zayed (2019) noted that the soil pH affects the availability and activity of some nutrients, where the Fe activity decreases as the soil pH increase.

Manganese (Mn) is one micronutrient required by plants after Iron. It is function is important in various biological activities in plants; including photosynthesis, nitrogen assimilation, respiration and cell elongation. On the other hand, the deficiency of Mn causes yellow leaves with green veins like in iron. Plant growth may also be reduced and stunted. The uptake of Mn is reduced when the pH of growing medium exceeds 6.5 (Zaid and Arias-Jiménez,2002).

2.3 Date nutritional value

Date fruits are rich in sugars, especially glucose and fructose at the tamar stage. The priors produced by hydrolysis of sucrose during ripening, these high levels of sugar content make Medjoul date a good source of energy.

Human body absorbs the date invert sugar immediately without being subjected to the digestion that ordinary sugar undergoes. Dates become a good source of energy providing more than 3,000 calories per kilogram.

Date fruits are containing numerous nutrients and are a good source of iron, potassium, calcium, sulfur, magnesium, chlorine and copper, with minor nutrients such as phosphorus. Also, dates are containing around 16 amino acids, plus some vitamins like A, B1, and B2 (Chao and Krueger ,2007). The flesh of dates contains about 2.5 % fiber, 2 % protein and less than 2 % of fat, minerals, and pectin substances (Zaid and Arias-Jiménez ,2002).

Date contains around 600 mg of magnesium per kilo gram of dates; which makes the date consumers in Saharan less suitable to cancer than other inhabitants if the region. The Sodium content in date is only 1 mg 100 g, which make dates a good food for those on a low sodium diet. The iron content in dates represents a third of the recommended Dietary Allowance for an adult male with 3 mg per 100g of dates. The Vitamin content per kilogram of date is in average for all date varieties as follows: vitamin A, 484 international units; B1, 0.77 milligram (mg); B2, 0.84 mg; and B7, 18.9 mg. The average protein content in date flesh is around 1.7% (Zaid and Arias-Jiménez,2002).

2.4 Meteorological Parameters Effect

Arid and semi-arid regions which are characterized by long and hot summers, low rainfall, and very low relative humidity level during the ripening period are the suitable for date palm cultivation. The temperature of 7°C is the zero-vegetation point, where above this temperature; date growth is active to reach the optimum temperature of 32°C, while the date growth starts decreasing after it reaches 38°C/40°C. On the other hand, the high temperature of 56°C and the low temperature below 0°C are normally endured. Abul-Soad et al. (2013), found that the increase of air temperature above 40 was demolished the impact of high air relative humidity on fruit. It was found that the soil nitrogen decreases with increased temperature, while it increased with rain fall and humidity (Ibrahim and Zayed,2019). The temperature increases during date maturation increased the activity of invertase enzyme to convert Sucrose to glucose, fructose and softness of fruits as found by (Ibrahim and Zayed,2019), who also found that, the fluctuation of temperature affects the expansion and contraction of the two tissues, thus, the peel is shed from the fruit which cause peel separation problem. He also found that the peel separation of dates increases if the drying temperature exceed 55 c and below 40 c.

The flowering of date palm starts after the cold period when the temperature become high enough for flowering and named as zero flowering temperature which ranges from 17 to 22 °C depending on the local climatic conditions, where 18 °C is and average zero flowering temperature. The period length from flowering to ripening and maturation is around 120 to 200 days depending on variety and environmental conditions, where the flowering period occurs on average at March/April, while fruiting period from April/May to September/October (Zaid and Arias-Jiménez,2002). The flowering and fruiting temperature during the flowering and fruiting periods are very important to calculate the heat units which are necessary for date production conditions. The heat units represent the sum of average daily temperature from flowering to maturation.

Rainfall in winter should be not cause harm to the date fruits, but benefits the soils of the plantations by aestivating the deposited surface salt and avoiding the upward movement of salt from lower layers. There are some negative effects of rainfall on date palm pollination and fruit set where the rain occurs after pollination takes away most of applied pollen, also rainfall cause lower temperature which decreases the heat units required for fruit set.

The rotting of inflorescences results of increasing the relative air humidity which occurs by increase rainfall, also the high relative humidity cause Khamedj disease and pollen's explosion. As rain affect flowering, it also affects date fruits which cause severe checking and cracking in the Kimri and late Khalal stages. The most sensitive date stages affected by rainfall are Rutab and Tamar stages where the associated humidity with rainfall causes severe damage including rotting and fall-off of the fruits and delay ripening. High temperature and humidity during date ripening lead to predisposing the date to peel separation (Lobo et al., 2013). The temperature increase decreases elasticity, fracture pressure, peel stiffness, turgor by transpiration and viscosity of the pectin which leads to increase peel separation (Brüggenwirth and Knoche ,2016).

Air humidity has various advantages and/or disadvantages on date plantation, where the high air humidity causes some leaf diseases, such as

“Graph Iola” leaf spot (Graphiola phoenicis Moug. Poit), while other disease become rare or absent such as the Date mite (Bou-Faroua). On the other hand, the low air humidity causes pest and mite attacks, while fungal diseases are absent. The high temperature and relative humidity of air increases date peel separation as mentioned by Al-Hajaj et al. , 2020.

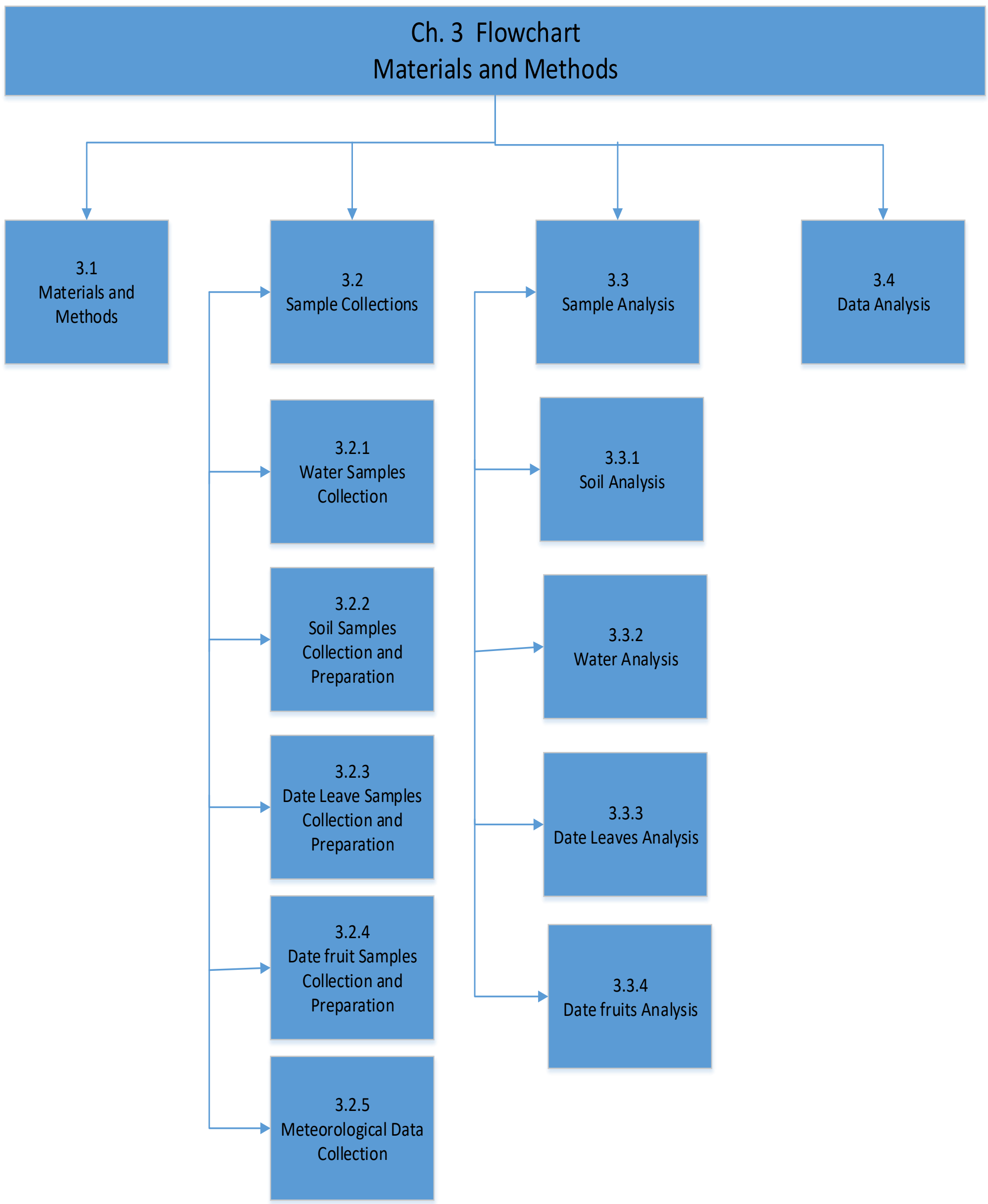
Air humidity affects the date quality during maturation process. At high humidity, date fruits become sticky and soft, while the date fruits become very dry at low humidity especially when associated with hot and dry winds which cause a rapid maturation which leads to appearance of yellowish or whitish rings at the fruit base. On the other hand, when air humidity is high during maturation, this causes cuts or breaks of the date fruit peel and some fruits fall to the ground. This phenomenon occurs mainly immediately before the Khalal stage. During rutab stage, when the air humidity is high, the fruit absorbs moisture and dehydration process to reach tamer stage become very slow which leads to separate the peel of date fruits from pulp. Ibrahim and Zayed,2019, found that, the high humidity around the fruits during the transition of the fruits from the Kimri to the khalal stage causes Evaporation stops and may enhance fruit peel to separate from pulp.

The wind affects date plantation from flowering to ripen stages, where light winds are in favor for pollination, high speed winds will blow away the pollen. Severe wind could lead to bunch death by blocking the movement of nutrients. Ibrahim and Zayed (2019), mentioned that the wind increases the separation of date peel from pulp by increasing the process of free water loss from fruits, which causes the crust to separate from the pulp of the date especially if the wind is combined with high temperature.

Finally, the light spectrum is important for date palm plantation, where the growth of date palm is inhibited by light spectrum at the violet and yellow rays and enhanced by red light by promoting photosynthesis. Ibrahim and Zayed (2019), indicate that the light increases photosynthesis and absorption of nutrients. It is also found by Kalaj (2016), that the light exposer of dates improves fruit size and TSS. In another study by Al-Qarni (2020), the author argues that the direct sunlight of dates, increases date sugar content.

Chapter Three

Materials and Methods



3.1 Experimental design

Seventy-two date palm trees were selected from date farms in Jericho city in the Jordan Valley, from which 57 trees were from Diek Farm in Al Maqtas street, and 15 trees were also selected from Al Raed Farm in Ketf Elwad where there are three different water quality are available: fresh water, which harvested from wadi Al Qilt and collected in ponds, salty water from underground and treated waste water from Jericho municipality waste water treated plant.

Experiment One: Irrigation Treatments

Effect of water on date peel separation (skin separation)

Forty-five trees were selected and subjected to different water qualities and quantities, where 30 trees were selected from Diek farm, where 15 trees of them were identified by the label WSi, where i=irrigation water quantity in m^3(50, 75, 100, 125 and150). They were also subjected to salty water, while the other 15 trees were identified by label WFi, where i=irrigation water quantity in m^3 (50, 75, 100, 125, 150), and subjected to fresh water. The remaining 15 trees were selected from al Raed farm and subjected to treated water and identified by labels of WTi, where i= irrigation water quantity (50, 75, 100, 125, and 150) as described in fig.3.1 below:

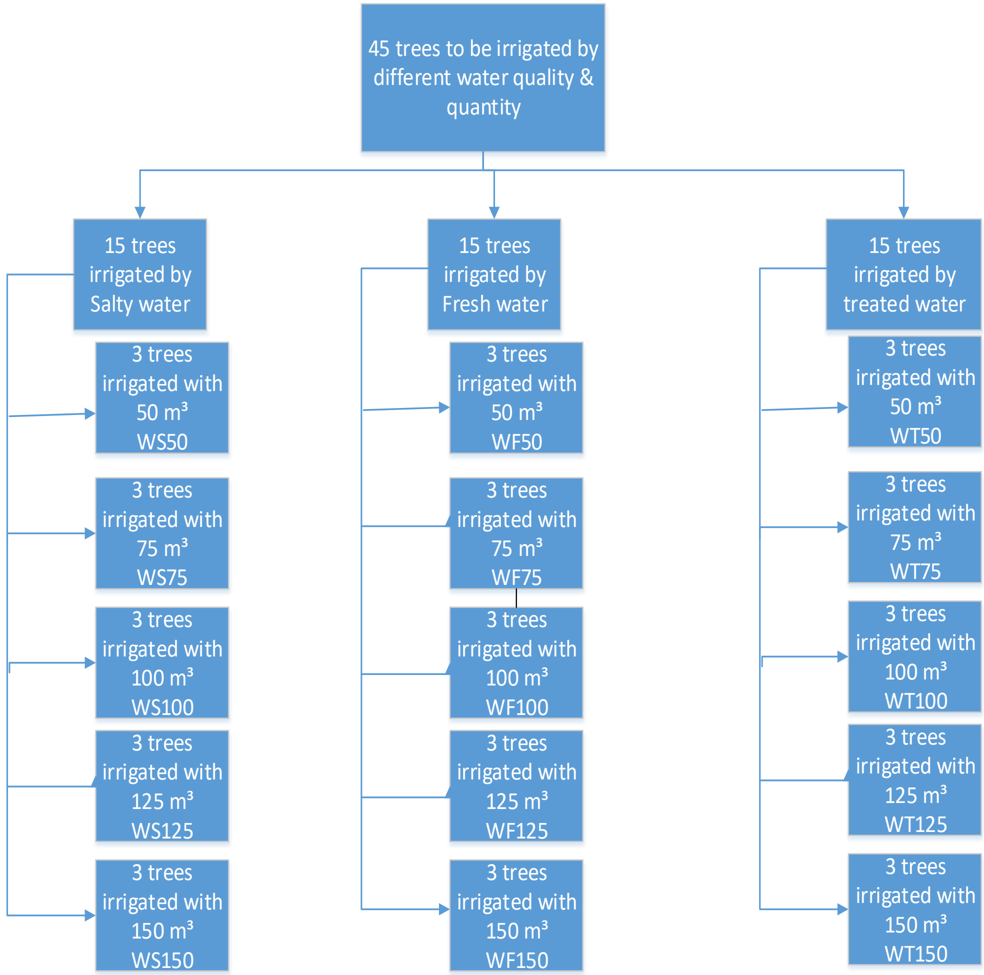


Fig.3.1: Date palm trees exposed to different water qualities and quantities

Fertilization Treatments

Effect of fertilizer on date peel separation (skin separation)

Twenty seven date palm trees were selected from Diek farm of the same age and size, and were treated with different fertilizer types and quantity, 9 trees were subjected to different nitrogen levels and labeled by FNwn, where wn= quantity in kilogram of the applied nitrogen (0, 7.5, 15), 9 trees were subjected to different phosphorous levels and labeled by FPwp, where wp= quantity in kilogram of the applied phosphorus (0, 0.5, 1), and 9 trees were subjected to different potassium levels and labeled by FKwk, where wk= quantity in kilogram of the applied potassium (0, 2, 4).All the 27 trees were irrigated by the same irrigation regime ($100m^3$) fresh water for each tree annually). Each three trees were subjected to the same treatment in each fertilizer as three replicates as described in fig.3.2 below:

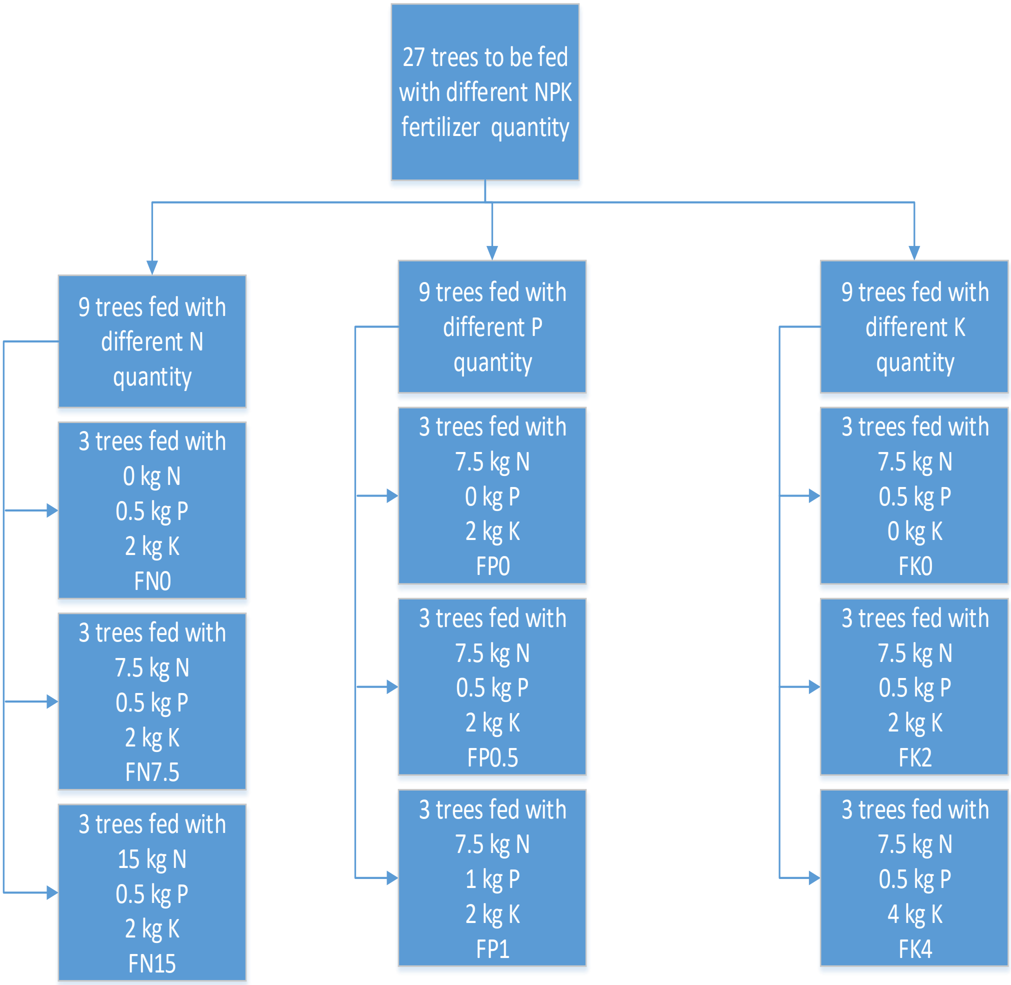


Fig.3.2: Date palm trees exposed to different Fertilizer type and quantity

3.2 Sample Collections

3.2.1 Water samples collection

Nine water samples from the three-irrigation water source (fresh water (WF), salty water (WS) and treated water (WT)) were collected at three times, end of December 2018, end of January 2019 and end of April 2019.

One liter of water sample was taken in PET-Acidified plastic bottles with 1M HCL, then kept in refrigerator until analysis.

3.2.2 Soil Samples Collection and preparation

Seventy-Two soil samples were collected from rhizosphere of the72 date trees under study before starting any treatment on December 2018, where the soil samples were collected by using Auger instrument from space of 50 cm to 75 cm from the tree trunk at a depth of 0 cm to 25 cm.

The collected soil samples we air dried in a sun dryer (greenhouse), then grinded by hard plastic hummer sieved using 2 mm stainless steel sieve and stored in a sealed polyethylene bag until analysis as shown in fig. (3.3) below:

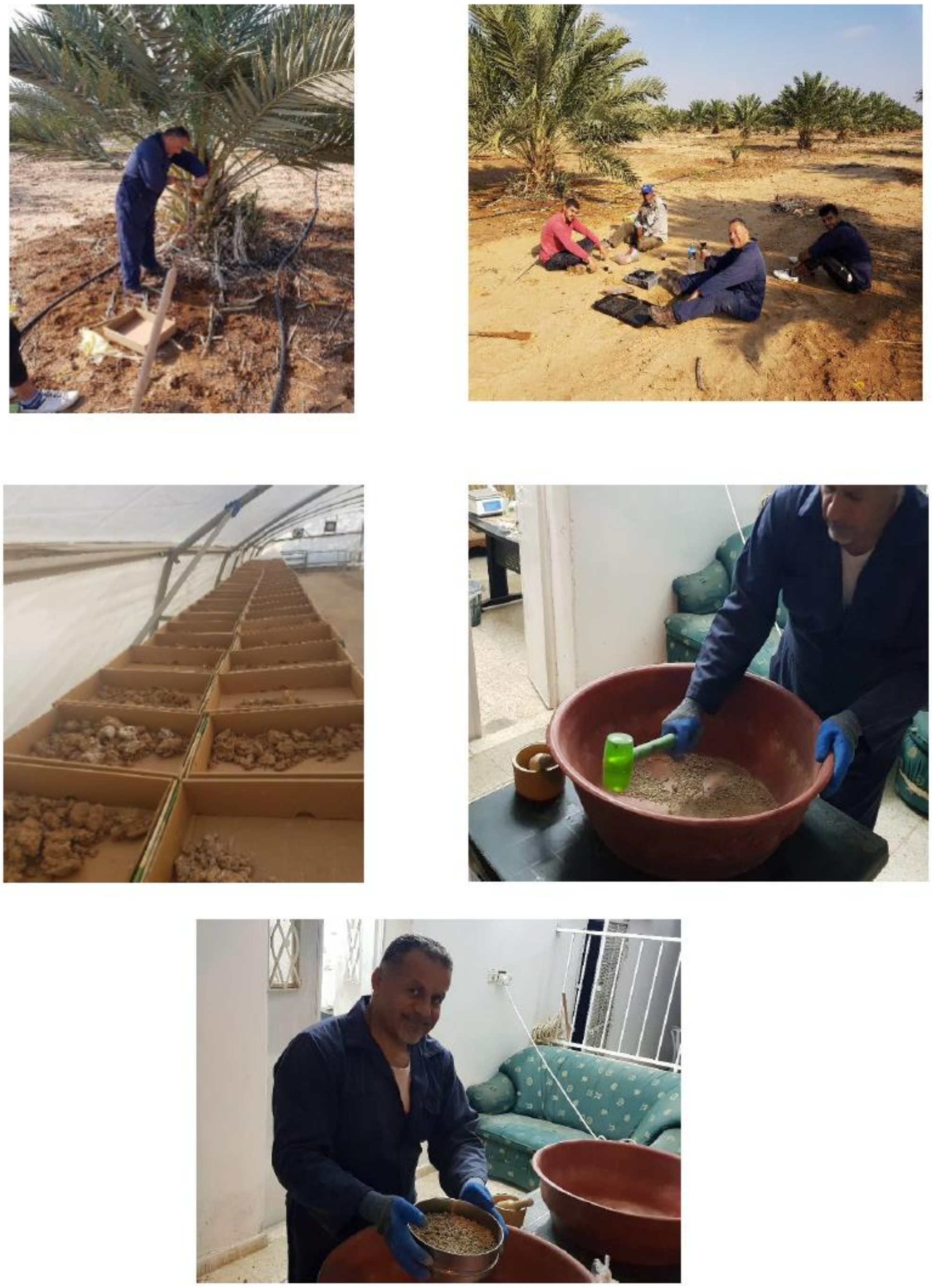


Fig.3.3: Soil sample collection and preparation

3.2.3 Date leaves Samples Collection and preparation

72 date leave samples were collected from the 72-date tree selected for this study, where two sets of new mature date leaves (each set contains 8-12

leaves) were taken from the top of the date branch from different positions on the tree.

The collected date leaf samples were identified and labeled, and then air dried in a sun dryer (greenhouse) to be completely dry. The dried date leaves were cut into small pieces by seizer, and then dipped into liquid nitrogen for few minutes to be brittle and grinded by coffee grinder into small particle size. Finally, the grinded samples kept in closed plastic tubes inside refrigerator until analysis as shown in fig. (3.4) below:

Fig.3.4: Date leaves sample collection and preparation

3.2.4 Date fruit samples collection and preparation

The date fruit samples were collected into two sets, one set at the end of April 2019 when fruit were green (early stage of Kimri), and the second set in September during ripening (Tamar Stage).

In the first fruit sample set, 72 date fruit samples were collected, where around 40 green date fruits from each tree from random selected bunch which then were identified by wrapping plastic stud on the bunch. The collected fruits were dried by using freeze dryer (Christ, Delta 1-24 LSC), then grinded by manual hummer and then by hummer mill (Retsch) then kept in Plastic tubes for analysis. Fig (3.5) describe briefly the green fruit sampling.

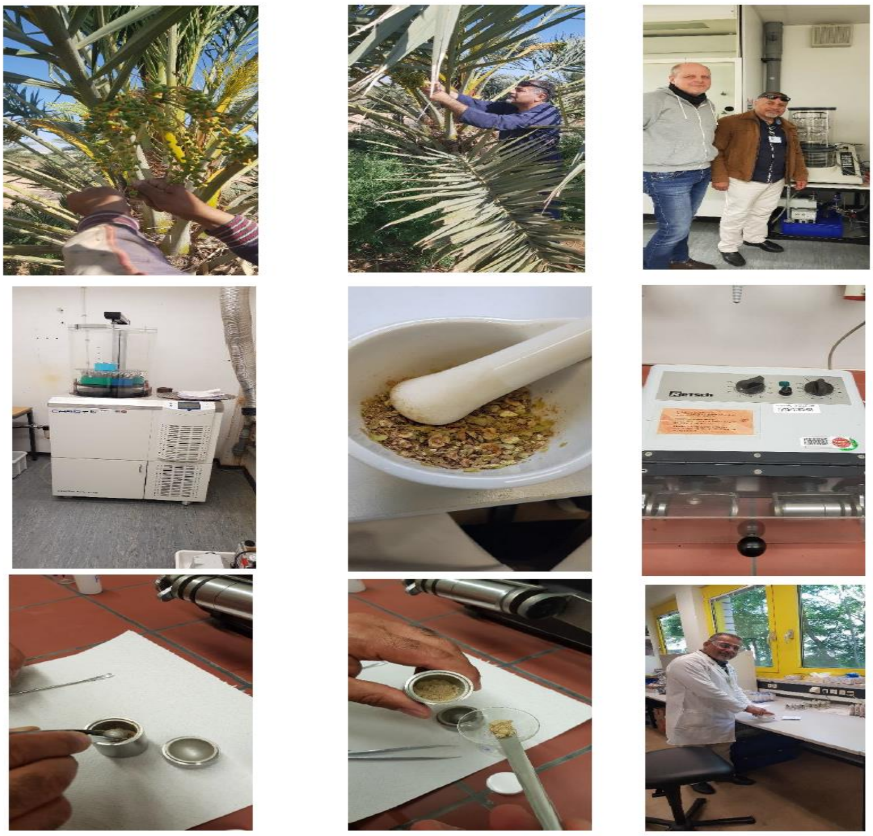


Fig.3.5: Green date fruit sample collection and preparation

In the second samples set, 72 date fruit samples were collected by collecting around 1 kg of ripen date fruit that were taken from the identified bunch on each tree, where this 1 kg sample contained both date grades, with and without peel separation. From this 1 kg fruit sample, 72 samples were selected to be without peel separation, also one date fruit sample from this 1 kg sample was taken also from each three replicates which contain peel separation with a total of 24 extra samples. In that the total fruit samples taken are 96 samples, 72 samples without peel separation and 24 samples with peel separation. Fig (3.6) shows the ripen fruit collection.

Fig.3.6: Ripen date fruit sample collection

The total production of each tree was calculated then graded visually into five grades: three grades in terms of fruit size (small, medium and large) and tow in terms of peel separation (without peel separation that is below 10% peel separation of the fruit surface, and with peel separation that is above 10% peel separation of the fruit surface). The fruit samples were stored in freezer at -18C until preparation and analysis. The ripen fruits prepared for analysis by dipping fruits in liquid nitrogen and grinded using coffee grinder, then stored in plastic bags in freezer to be ready for analysis.

The ripen date preparation described by pictures in fig. (3.7) below:

Fig.3.7: Ripen date fruit sample preparation

3.2.5 Meteorological Data Collection

The meteorological data was collected in cooperation with the Palestine Meteorological Department/ Jericho station where the data collected included monthly average temperature, mean monthly maximum temperature, mean monthly minimum temperature, monthly heat summation units, monthly total rain fall, mean monthly relative humidity, monthly sunshine duration, monthly evaporation and mean monthly wind speed.

3.3 Sample Analysis

3.3.1 Soil Analysis

There are two sets of analysis conducted on soil, one set elemental analysis was done in Julich institute in Germany, while the second set was carried out at An Najah National university which included pH and EC.

3.3.1.1 Soil Elemental Analysis

Briefly, 10.00g soil samples were mixed with 25mL H2O and were shaken overnight. The extracts were centrifuged and filtrated using 0.2µm filters. The ICP/OES was used for the measurement of P, Fe, Mn, Mg, Ca, Na and K.

Nitrogen of soil was analyzed by analyzing Nitrogen isotopes ^{15}N to find %N in the soil sample.

3.3.1.2 Soil pH and EC Analysis

50 gm of dry grinded soil samples were dissolved in 50 ml DW and mixed using electric shaker 15 min and let stand for 60 min and then filtrate by vacuum filtration (ICARDA 2013).

The filtrate liquid was tested for PH by using JENWAY 3510 pH meter, while the EC were tested by using JENWAY 4510 Conductivity meter.

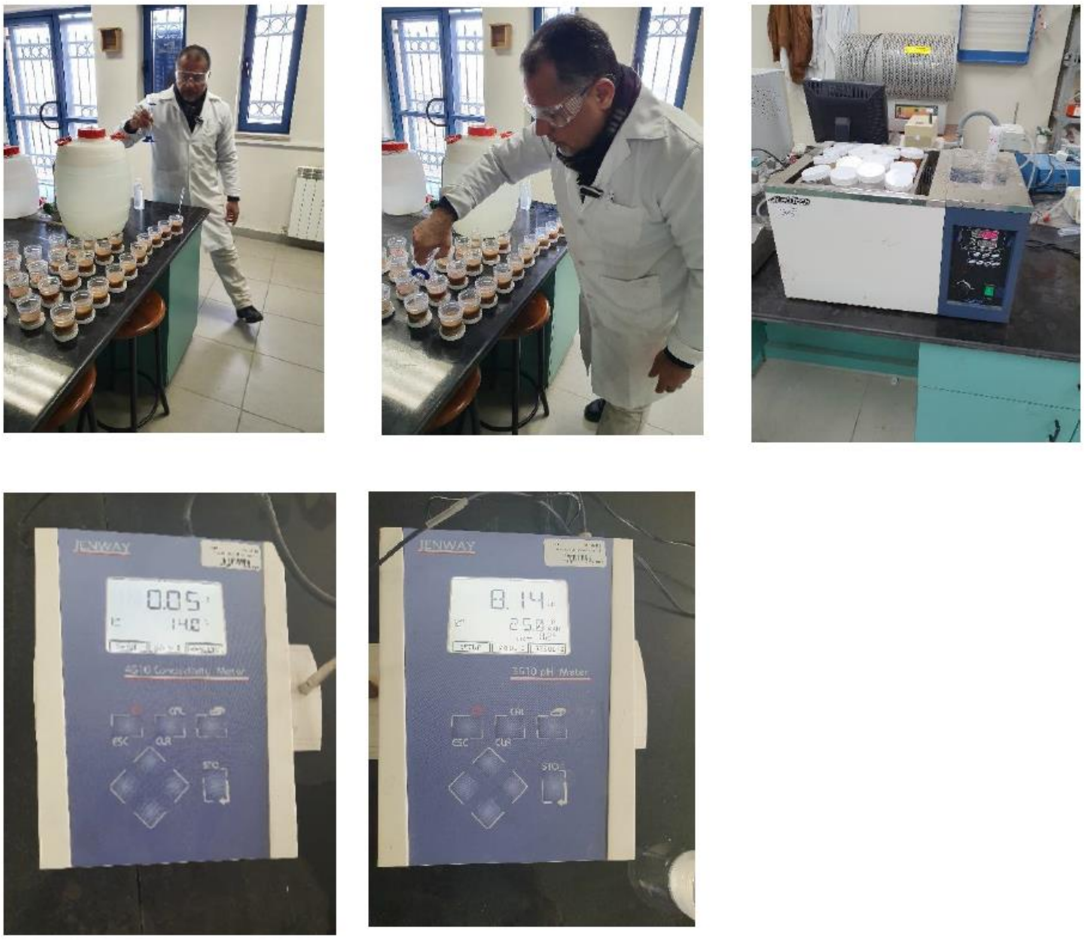


Fig.3.8: Soil EC and pH analysis

3.3.2 Water Analysis

There are two sets of analysis conducted on water, one set elemental analysis which was done at Julich institute in Germany, while the second set was done at An Najah National University, which includes pH, EC and Total nitrogen.

3.3.2.1 Water Elemental Analysis

The elemental analysis of water was done by using ICP/OES which at Julich institute in Germany for measurements of P, Fe, Mn, Mg, Ca, Na and K.

3.3.2.2 Water pH and EC Analysis

Water samples were directly tested for PH by using JENWAY 3510 pH meter, while the EC were tested by using JENWAY 4510 Conductivity meter.

3.3.2.3 Water Nitrogen Analysis

Water samples where first Analyzed for Nitrate using Genesys 10 S UV-VIS Spectrophotometer, then the N concentration was calculated from nitrate analysis after checking the ammonia in samples which found negligible.

3.3.3 Date Leaves Analysis

Date leaves analysis was done at Julich institute in Germany for elemental analysis where, briefly, 0.1500g-0.2500g samples were weighed. A mixture of HCl: HNO3=2mL: 8mL were added to the samples and digested by microwave at 180 degree for 1h. Finally, the digested solution was diluted to 50 mL and measured using ICP/OES. All concentrations were calculated using dry-equivalent weighs as mg/kg.

3.3.4 Date Fruit Analysis

There are two sets of fruit samples, the green fruit set and the ripen fruit set.

3.3.4.1 Green fruit analysis

The green and grinded fruit samples were analyzed in Julich institute in Germany for elemental analysis where briefly, 0.1500g-0.2500g samples were weighed. A mixture of HCl: HNO3=2mL: 8mL were added to the samples and digested by microwave at 180 degree for 1h. Finally, the digested solution was diluted to 50 mL and measured using ICP/OES. All concentrations were calculated using dry-equivalent weighs.

3.3.4.2 Ripen fruit analysis

The ripen fruit samples were graded visually into six grades as discussed in section (3.2.4), where the samples are graded into three grades according to size as follows:

- Large Grade: with fruit weight of 20 gm and above
- Medium Grade: with fruit weight of 15-20 gm
- Small Grade: with fruit weight of below 15 gm

Then, each grade above was classified into two grades according to peel separation, one grade “below 10% peel separation” and was named “without peel separation”, whereas the second grade of above was of a higher percentage and was named “with peel separation.”

The analyses done on ripen date fruit, represents moisture content, TSS and invert sugars which were done at “Al Reef for investment and agricultural marketing company labs”, while the fiber and fat content were done at “Al

Quds university”. The remaining analysis of pH, and EC were done at An Najah National University.

3.3.4.2.1 Ripen fruit analysis of moisture content analysis

Moisture content was analyzed by taking about 2 gm of the grinded date fruits and tested for moisture content by using infrared moisture analyzer (PMB ADAM moisture analyzer) at 120 c temperature for 15 min. The moisture content appears on the device screen as percentage of water content in the date fruit sample.

3.3.4.2.2 Fiber content analysis of ripen fruit

The fiber content analysis of grinded ripen date fruit were conducted in the “Agricultural Research and analysis Laboratory” at Al Quds university by using FIA-6-V2 fiber analyzer and FA-46 fat analyzer as the below procedure where the fiber analyzer shown in fig. (3.9) below:

0.5-3 gm of grinded ripen fruit were taken in where this weight considered as Ws, then dried crucible (40-100 µm) is weighed, and this weight considered as W1, the crucible with sample inserts into the FIA-6-V2 fiber analyzer and lifting the assembly to press the crucible title, then the cooling water was switched on. The instrument was turned on and let to preheat till temperature almost was 88C. Following the prior, diluted sulphuric acid (0.127 mol/l) was added through FIA-6-V2 device and was kept between 120 ml and 170 ml and then it was let to heat until the solution reached slightly boiling state, at that stage, it was kept to the end of the heating cycle. The waste was discharged and the crucible was washed automatically by distilled water and discharged.

The instrument was again heated as above and the diluted sodium hydroxide (0.313 mol/l) was added, then the same procedure was repeated for sodium solution as for sulphuric acid solution including heating, draining, adding water, draining. The crucibles were put into the oven to dry and then weighed, where this weight was considered W2.

The fiber quantity in the sample is calculated as described in equation (3.1) below:

Fiber quantity (sample) = W2 – W1 (3.1).

Fig.3.9: Fiber content of ripen date fruit analysis

3.3.4.2.3 Fat content analysis of ripen fruit

The fat content analysis of ripen fruits was done in the Agricultural Research and analysis Laboratory at Al Quds university by using FA-46 fat analyzer as the below procedure where the fat analyzer shown in fig. (3.10) below:

2 – 5 gm of grinded ripen fruit were taken and placed into thimble filter and this weight is considered as Ws, then the thimble filter is put in the holder attached to the device by magnet. Dry extraction cup is weighed and this weight is considered as W1, then 60 ml of petroleum ether were added into the extraction cup. The device is heated and the boiling petroleum ether starts extracting the fat from the sample, where this process passes for 60 min until the solvent ran out and the extraction cup become dry, then it was let to cool and was placed inside a drying oven over night, then cooled in desiccator and weighed where this weight considered as W2. The fat quantity in the sample is calculated as described in equation (3.2) below:

$$\text{Fat quantity (sample)} = W2 - W1 \qquad (3.2)$$

Fig.3.10: Fat content of ripen date fruit analysis.

3.3.4.2.4 Ripen fruit extract analysis of pH, EC, TSS and invert sugars

10 gm of grinded date fruit were dissolved in 30 ml DW, shaken and left for two hours in a water path, and then filtrate by cloth and the extract filtrate again by filter paper. The filtrate was stored in closed plastic tubes in a refrigerator until analysis. The pictures in figure (3.11) show the date extract preparation.

Date fruit extracts were directly tested for PH by using JENWAY 3510 pH meter, while the EC were tested by using JENWAY 4510 Conductivity meter as shown in fig. (3.12).

The TSS and reduced sugars of the date fruit extracts were analyzed by using PRO 101 digital refractometer, while the invert sugars were analyzed by using HI 96804 invert sugar refractometer as shown in fig. (3.13).

Fig.3.11: Ripen date fruit extract preparation

Fig.3.12: Ripen date fruit extract analysis of pH and Ec.

Fig.3.13: Ripen date fruit extract analysis of TSS and invert sugars.

3.4 Data Analysis

Statistical analysis

All statistical analyses were carried out using SAS (SAS Institute Inc., Cary, USA, Release 8.02, 2001). Mean comparisons were carried out using the GLM procedure, treating main factors separately using one-way analysis of variance (ANOVA). Differences were considered significant if P values were lower than 0.05. The Bonferroni procedure was employed with multiple t-tests in order to maintain an experiment-wise of 5%.

The data were analyzed by using Excel program for calculations and drawing charts, on the other hands, the SAS program was used for statistical analysis to compare means by one-way anova and to find correlations between parameters.

To make the data suitable for analysis, there are calculations and preparation that were conducted on the data by using excel program as below:

3.4.1 Element content added to soil by irrigation water

The added contents of each element to the soil by irrigation water were calculated by using the following equation (3.3):

$$E_w = (C_w \text{ x } W)/W_s \qquad (3.3)$$

Where:

E_w: Element in soil added with irrigation water (mg/kg)

C_w: Concentration of Element in irrigation water (mg/L) which is analyzed in section (3.3.2.1).

W: Quantity of irrigation water (L)

W_s: Weight of soil which accepts the irrigation water (kg). This can be calculated by assuming that we have a circle of 2 m diameter around the date tree trunk with 1 m depth, so W_s can be calculated from the following equation (3.4):

$$W_s = V_s \times D_s \qquad (3.4)$$

Where:

Vs: Soil volume in assumed cylinder (m^3)

Ds: Soil bulk density (kg/m_3)

The soil volume can be calculated from equation (3.5) below:

$$Vs = (\pi/4) \times D^2 \times L \qquad (3.5)$$

Where:

D: Soil Circle diameter around date tree trunk (2m)

L: Soil Depth around date tree trunk (1 m)

The Soil bulk density is calculated by taking different soil samples in a-500-ml volumetric flask, and taking its weight to have the soil bulk density of each sample in (kg/m^3), and then take average of all samples to be:

$D_s = 1331\ kg/m^3$

So, the soil volume V_s will be:

$V_s = 3.143\ m^3$

Then the soil weight W_s will be:

Ws = 4183.143 kg

3.4.2 Element content added to soil as fertilizer

The fertilizers added to the date trees in this experiment was nitrogen N, phosphorus P and potassium k.

The fertilizer content in soil added as fertilizer was calculated from equation (3.6) below:

E_f: (Wf x $F_{\%}$ x 1000000)/ W_s (3.6)

Where:

E_f: Element in soil added as fertilizer (mg/kg)

Wf: Weigh of Added fertilizer complex (kg)

$F_{\%}$: Percentage of Fertilizer element in its complex based on Molecular weights

W_s: Weight of soil which accepts the fertilizer (kg). This can be calculated by assuming that we have a circle of 2 m diameter around the date tree trunk with 1 m depth as calculated in section (3.4.1) above (Ws=4183.143 kg).

The Nitrogen N was Added as ammonium sulphate ($(NH_4)_2SO_4$))

The Phosphorus P was added as Phosphorus pentoxide (P_2O_5)

The Potassium was added as Potassium Oxide (K_2O)

The $F_{\%}$ tabulated in table (3.1) below:

Table (3.1): Percentage of fertilizer element in its complex

Fertilizer Complex	**Element**	**$F_{\%}$**
$(NH_4)_2SO_4$)	N	0.212
P_2O_5	P	0.436
K_2O	K	0.830

3.4.3 Element content accumulated in soil

The total element content accumulated is soil around date tree trunk was calculated from equation (3.7) below:

$$E_{ac} = E_i + E_w + E_f \qquad (3.7)$$

Where:

E_{ac}: Total element content accumulated is soil

E_i: Initial element content in soil which was analyzed in section (3.3.1.1)

E_w: Element in soil added with irrigation water which was calculated in section (3.4.1)

E_f: Element in soil added as fertilizer which was calculated in section (3.4.2).

3.4.4 Fiber content in ripen date fruits

The moisture content of each date fruit sample was analyzed in section (3.3.4.2.1) and the dry weight of sample calculated as described in equation (3.8):

$$Wd = Ws-(M*Ws) \quad (3.8)$$

Where:

Wd = dry wight of sample

M = moisture content in the sample (%)

Ws= weight of sample

The fiber content in the date sample was calculated based on dry weight of the sample as shown in equation (3.9):

$$\text{Fiber content (dry)} = (Wf / Wd) * 100\% \quad (3.9)$$

Where:

Wf = weight of the fiber in sample (as calculated in section 3.3.4.2.2)

Wd = wight of dry sample as calculated in equation (3.8)

3.4.5 Fat content in ripen date fruits

The moisture content in the sample and the weight of dry sample was calculated as described in section (3.4.4) above.

The fat content in the date sample was calculated based on dry wight of the sample as shown in equation (3.10):

Fat content (dry) = (Wfa / Wd) * 100% (3.10)

Where:

Wfa = weight of the fat in the sample (calculated in section 3.3.4.2.3)

Wd = wight of dry sample as calculated in equation (3.8)

3.4.6 TSS content in ripen date fruits

The TSS (Brix) results of ripen date fruit extract as in section (3.3.4.2.4) was used to calculate the TSS in the date sample as described below:

$TSS_{ex} = ((TSS_{ex}\%) * TW_{ex})/(100 - TSS_{ex})$ (3.11)

Where:

TSS_{ex}=Total soluble solids quantity in the extract

$TSS_{ex}\%$ = Total soluble solids percentage in the extract (calculated in section (3.3.4.2.4)

TW_{ex}= Total water quantity in the extract as calculated in equation (3.12)

TW_{ex} = (moisture content*sample weight) + Distilled water added (3.12)

Finally, the TSS content in the date fruit sample was calculated as described in equation (3.13)

$TSS_s = (TSS_{ex}/W_s) *100\%$ (3.13)

Where:

TSS_s = Total soluble solids in the date sample

TSS_{ex} = Total soluble solids quantity in the extract

W_s = Wight of date sample

3.4.7 Invert sugars content in ripen date fruits

The invert sugar results of ripen date fruit extract which get from section (3.3.4.2.4) was used to calculate the invert sugars in the date sample as described below:

$INVS_{ex} = ((INVS_{ex}\%) *TW_{ex})/(100-INVS_{ex})$ (3.14)

Where:

$INVS_{ex}$ =Invert sugars quantity in the extract

$INVS_{ex}\%$ = Invert sugar percentage in the extract (calculated in section (3.3.4.2.4)

TW_{ex}= Total water quantity in the extract where is calculated in equation (3.12)

TW_{ex} = (moisture content*sample weight) + Distilled water added (3.15)

Finally, the invert sugar content in the date fruit sample was calculated as described in equation (3.16)

$INVS_s = (INVS_{ex}/W_s) *100\%$ (3.16)

Where:

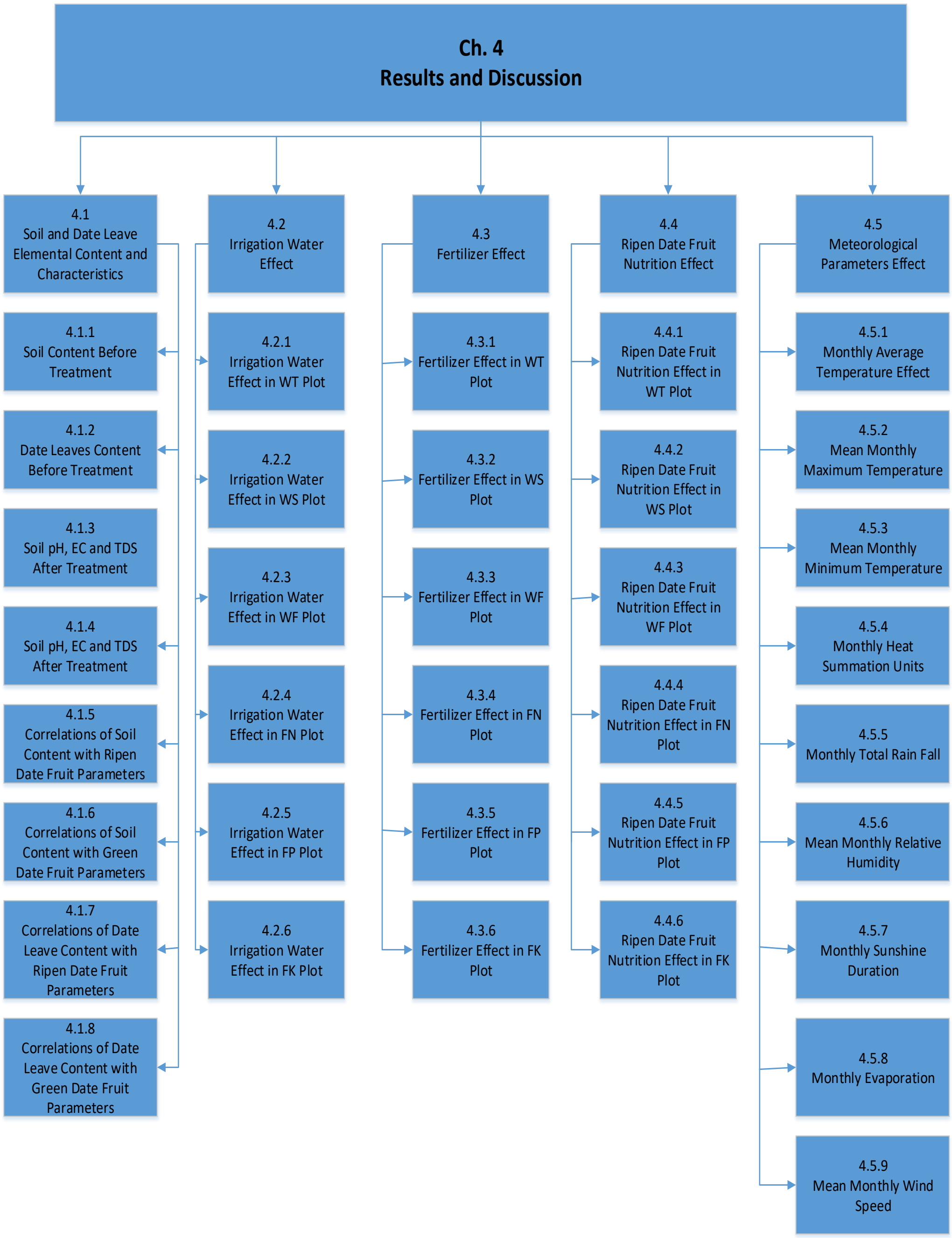
$INVS_s$ = Invert Sugars in the date sample

$INVS_{ex}$ = Invert sugars quantity in the extract

W_s = Wight of date sample

Chapter Four

Results and Discussion



The results of this study were discussed into five sections, starting firstly with characterization of the soil and leaves of all studied date palm trees which includes elemental content of soil and date leaves of phosphorus, ferrous, manganese, magnesium, calcium, sodium, potassium and nitrogen, and some chemical parameters of soil includes pH, EC and TDS. After treatment, the chemical soil parameters and the accumulated soil elemental content were discussed in terms of their effect on the nutrition of green date fruits and the nutrition and peel separation of the ripen date fruits.

In the second section of this chapter, the irrigation water quality and quantity were discussed in terms of their effect on the nutrition of green date fruits and the nutrition and peel separation of the ripen date fruits.

During the third section of this chapter, the fertilizer quantity and type of NPK added fertilizers were discussed in terms of their effect on the nutrition of green date fruits and the nutrition and peel separation of the ripen date fruits.

The fourth section of this chapter, some of the ripen date parameters like fiber, fat, TSS, invert sugars, pH and EC were discussed in terms of their effect on the ripen date fruit peel separation.

Finally, the meteorological data from 2017, 2018 and 2019 collected of monthly average temperature, mean monthly maximum temperature, mean monthly minimum temperature, monthly heat summation units, monthly total rain fall, mean monthly relative humidity, monthly sunshine duration, monthly evaporation and mean monthly wind speed, were correlated with the packing data of peel separation in the above three years and discussed.

Section One: Soil and Date Leaves Elemental Content Effect

4.1 Soil and date leaves elemental content and characteristics

The soil characteristics and before treatment, the soil accumulated in soil during treatment and date leave characteristics were studied then correlated with both green date fruit parameters and ripen date fruit parameters in the below sections.

4.1.1 Soil Elemental content and other parameters characteristics before experiment

The soil elemental results like Phosphorus (P), ferrous (Fe), Manganese (Mn), Magnesium (Mg), Calcium (Ca), Sodium (Na), Potassium (K) and Nitrogen (N), also some chemical parameters of soil like pH, Electrical Conductivity (EC) and total dissolved Solids (TDS) before treatment are tabulated in tables (4.1), (4.3), (4.5), (4.7), (4.9) and (4.11) which was labeled as soil characterization tables in the six plots: treated water plot (table 4.1), salty water plot (table 4.3), fresh water plot (table 4.5), nitrogen fertilizer plot (table 4.7), phosphorus fertilizer plot (table 4.9) and potassium fertilizer plot (table 4.11) as below:

Table (4.1): Soil characterization in treated waste water plot (WT) before experiment

Sample ID	pH	EC (µS/cm)	TDS (mg/L)	Soil Element content (mg/kg)							
				P	Fe	Mn	Mg	Ca	Na	K	N
WT50	8.68	16320.00	10444.80	0.81	0.00	0.05	322.56	866.03	3422.60	525.31	1267.04
WT50	8.46	2960.00	1894.40	0.69	0.00	0.02	132.87	386.47	313.87	184.30	1385.37
WT50	8.50	922.00	590.08	2.92	0.02	0.01	31.82	65.19	145.97	39.90	1234.81
WT75	8.34	3530.00	2259.20	0.93	0.00	0.04	240.78	767.13	348.79	142.76	734.15
WT75	8.34	6340.00	4057.60	0.55	0.00	0.06	336.11	724.23	959.72	241.84	808.96
WT75	8.65	1150.00	736.00	1.35	0.00	0.01	42.89	79.57	166.13	50.09	1265.36
WT100	8.68	721.00	461.44	1.25	0.18	0.00	21.05	47.22	127.62	32.68	1130.97
WT100	8.40	3350.00	2144.00	0.46	0.00	0.02	187.44	761.45	423.88	191.23	842.71
WT100	8.56	5850.00	3744.00	0.41	0.00	0.03	266.37	784.95	892.90	345.38	866.94
WT125	8.40	10470.00	6700.80	0.61	0.00	0.09	420.09	1012.20	1641.54	384.66	1295.52
WT125	8.52	8330.00	5331.20	0.41	0.00	0.04	358.80	850.47	1400.55	310.75	628.15
WT125	8.40	5770.00	3692.80	0.63	0.00	0.05	242.69	680.20	791.55	153.67	667.64
WT150	8.72	7690.00	4921.60	0.40	0.00	0.02	178.68	792.54	1695.37	403.70	1013.54
WT150	8.63	7830.00	5011.20	0.39	0.00	0.10	248.44	873.98	1517.51	431.09	887.08
WT150	8.96	10050.00	6432.00	0.45	0.00	0.01	336.02	758.30	2110.71	773.78	1343.58
Maximum	**8.96**	**16320.00**	**10444.80**	**2.92**	**0.18**	**0.10**	**420.09**	**1012.20**	**3422.60**	**773.78**	**1385.37**
Minimum	**8.34**	**721.00**	**461.44**	**0.39**	**0.00**	**0.00**	**21.05**	**47.22**	**127.62**	**32.68**	**628.15**
Average	**8.55**	**6085.53**	**3894.74**	**0.82**	**0.01**	**0.04**	**224.44**	**630.00**	**1063.91**	**280.74**	**1024.79**

By analyzing the results with one-way Anova using SAS statistical program in terms of means and significantly in each treatment groups in treated water plot, it revealed that, all means of each parameter in each treated water group are not significantly difference which indicates that the base line of chemical parameters and elemental contents are nearly the same before treatment as summarized in Table (4.2) below:

Table (4.2): Soil characteristics in treated waste water plot (WT) of each treatment of WT50, WT75, WT100, WT125 and WT150 before experiment

Treatment / Parameter		WT50	WT75	WT100	WT125	WT150
pH	Mean	8.55	8.44	8.55	8.44	8.77
	Grouping	A	A	A	A	A
EC	Mean (µS/cm)	6734.00	3673.00	3307.00	8190.00	8523.00
	Grouping	A	A	A	A	A
TDS	Mean (mg/L)	4310.00	2351.00	2116.00	5242.00	5455.00
	Grouping	A	A	A	A	A
P	Mean (mg/kg)	1.47	0.94	0.71	0.55	0.41
	Grouping	A	A	A	A	A
Fe	Mean (mg/kg)	0.01	0.00	0.06	0.00	0.00
	Grouping	A	A	A	A	A
Mn	Mean (mg/kg)	0.03	0.04	0.02	0.06	0.04
	Grouping	A	A	A	A	A
Mg	Mean (mg/kg)	162.42	206.59	158.29	340.53	254.38
	Grouping	A	A	A	A	A
Ca	Mean (mg/kg)	439.20	523.60	531.20	847.60	808.30
	Grouping	A	A	A	A	A
Na	Mean (mg/kg)	1294.10	491.50	481.50	1277.90	1774.50
	Grouping	A	A	A	A	A
K	Mean (mg/kg)	249.80	144.90	189.80	283.00	536.20
	Grouping	A	A	A	A	A
N	Mean (mg/kg)	1295.70	936.20	946.90	863.80	1081.40
	Grouping	A	A	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

Table (4.2) shows that, the soil is basic from its pH in all plots, and the elemental content of Fe and Mn were very small while the N and Na had the highest levels in the soil of treated water plot, where this appears also in the EC and TDS of the soil which high at high Na.

Table (4.3): Soil characterization in Salty water plot (WS) before experiment

Sample ID	pH	EC (µS/cm)	TDS (mg/L)	Soil Element content (mg/kg)							
				P	Fe	Mn	Mg	Ca	Na	K	N
WS50	8.15	14990.00	9593.60	0.99	0.18	0.16	592.49	493.68	2803.63	356.15	1066.37
WS50	8.22	15340.00	9817.60	0.78	0.00	0.86	611.52	766.00	2779.92	448.08	840.65
WS50	8.24	16280.00	10419.20	0.75	0.01	0.04	558.52	660.88	2984.93	511.08	1006.90
WS75	8.30	7340.00	4697.60	0.87	0.01	0.03	193.20	181.62	1400.07	241.74	890.78
WS75	8.38	3160.00	2022.40	1.45	0.11	0.01	49.72	45.22	752.93	135.53	766.84
WS75	8.56	3830.00	2451.20	1.17	0.02	0.03	139.30	122.77	659.47	194.16	1271.15
WS100	8.35	7800.00	4992.00	0.76	0.01	0.01	227.68	178.32	1497.35	277.69	818.58
WS100	8.38	6880.00	4403.20	0.92	0.01	0.03	229.42	213.51	1193.14	240.03	874.82
WS100	8.25	12970.00	8300.80	3.48	0.04	0.26	672.80	691.80	2063.91	501.44	2473.17
WS125	8.58	1717.00	1098.88	12.22	0.55	0.02	30.24	23.81	345.82	63.78	1016.74
WS125	8.30	8630.00	5523.20	2.37	0.02	0.06	339.91	295.20	1324.94	239.60	1396.69
WS125	8.65	8480.00	5427.20	0.92	0.01	0.01	134.98	81.22	1217.42	238.35	626.04
WS150	8.59	3100.00	1984.00	1.25	0.02	0.01	74.81	76.32	556.74	142.96	720.07
WS150	8.63	2920.00	1868.80	0.53	0.03	0.01	81.66	61.80	552.12	130.45	548.63
WS150	8.38	8470.00	5420.80	0.43	0.01	0.02	480.13	892.04	1400.46	368.91	553.57
Maximum	**8.65**	**16280.00**	**10419.20**	**12.22**	**0.55**	**0.86**	**672.80**	**892.04**	**2984.93**	**511.08**	**2473.17**
Minimum	**8.15**	**1717.00**	**1098.88**	**0.43**	**0.00**	**0.01**	**30.24**	**23.81**	**345.82**	**63.78**	**548.63**
Average	**8.40**	**8127.13**	**5201.37**	**1.93**	**0.07**	**0.10**	**294.43**	**318.95**	**1435.52**	**272.66**	**991.40**

In salty water plot, it is also basic soil and the elemental content of Na and N are the highest while the content of Fe and Mn are the lowest similar to treated water plot.

Table (4.4) reveals that there is no significant difference between salty water treatment groups in all elements except Na where WS50 is significantly different from the other four salty water treatments, this trend is also identical in EC and TDS.

Table (4.4): Soil characteristics in salty water plot (WS) of each treatment of WS50, WS75, WS100, WS125 and WS150 before experiment.

Treatment / Parameter		WS50	WS75	WS100	WS125	WS150
pH	Mean	8.20	8.41	8.33	8.51	8.53
	Grouping	A	A	A	A	A
EC	Mean (µS/cm)	15537.00	4777.00	9217.00	6276.00	4830.00
	Grouping	A	B	A, B	B	B
TDS	Mean (mg/L)	9943.00	3057.00	5899.00	4016.00	3091.00
	Grouping	A	B	A, B	B	B
P	Mean (mg/kg)	0.84	1.16	1.72	5.17	0.74
	Grouping	A	A	A	A	A
Fe	Mean (mg/kg)	0.06	0.05	0.02	0.19	0.02
	Grouping	A	A	A	A	A
Mn	Mean (mg/kg)	0.35	0.02	0.10	0.03	0.01
	Grouping	A	A	A	A	A
Mg	Mean (mg/kg)	587.50	127.40	376.60	168.40	212.20
	Grouping	A	A	A	A	A
Ca	Mean (mg/kg)	640.20	116.50	361.20	133.40	343.40
	Grouping	A	A	A	A	A
Na	Mean (mg/kg)	2856.20	937.50	1584.80	962.70	836.40
	Grouping	A	B	B	B	B
K	Mean (mg/kg)	438.44	190.48	339.72	180.58	214.11
	Grouping	A	A	A	A	A
N	Mean (mg/kg)	971.30	976.30	1388.90	1013.20	607.40
	Grouping	A	A	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

Table (4.5): Soil characterization in Fresh water plot (WF) before experiment

Sample ID	pH	EC (µS/cm)	TDS (mg/L)	Soil Element content (mg/kg)							
				P	Fe	Mn	Mg	Ca	Na	K	N
WF50	8.40	3380.00	2163.20	5.33	0.01	0.04	161.60	195.84	412.47	127.77	1105.73
WF50	8.57	1123.00	718.72	2.59	0.04	0.01	59.03	60.15	160.31	79.95	794.84
WF50	8.39	8270.00	5292.80	0.81	0.01	0.03	373.38	575.97	1648.57	324.64	797.21
WF75	8.44	6960.00	4454.40	0.31	0.01	0.02	294.28	424.75	1120.12	283.50	391.60
WF75	8.16	4110.00	2630.40	0.32	0.00	0.02	234.40	837.83	436.46	213.75	490.29
WF75	8.50	3210.00	2054.40	1.35	0.00	0.02	174.21	226.38	547.56	144.75	699.79
WF100	8.53	2000.00	1280.00	4.26	0.10	0.01	71.03	64.56	344.85	104.55	728.49
WF100	8.43	3840.00	2457.60	0.29	0.00	0.01	230.72	347.08	500.89	200.58	396.95
WF100	8.27	2640.00	1689.60	0.70	0.00	0.03	249.07	757.97	257.43	192.97	753.00
WF125	8.33	2680.00	1715.20	0.79	0.01	0.02	213.01	476.48	187.09	201.63	935.60
WF125	8.74	647.00	414.08	1.76	0.24	0.01	22.16	19.99	99.39	62.23	529.43
WF125	8.62	623.00	398.72	2.76	0.20	0.01	22.89	21.97	103.30	54.31	580.92
WF150	8.47	1619.00	1036.16	1.50	0.03	0.02	79.48	103.28	209.85	97.36	600.85
WF150	8.34	3440.00	2201.60	1.13	0.00	0.05	263.80	549.28	404.57	183.77	715.10
WF150	8.48	907.00	580.48	5.59	0.05	0.02	59.84	66.64	123.73	84.29	1820.54
Maximum	**8.74**	**8270.00**	**5292.80**	**5.59**	**0.24**	**0.05**	**373.38**	**837.83**	**1648.57**	**324.64**	**1820.54**
Minimum	**8.16**	**623.00**	**398.72**	**0.29**	**0.00**	**0.01**	**22.16**	**19.99**	**99.39**	**54.31**	**391.60**
Average	**8.44**	**3029.93**	**1939.16**	**1.97**	**0.05**	**0.02**	**167.26**	**315.21**	**437.11**	**157.07**	**756.02**

Table (4.5) characterizes the soil in fresh water plot and reflects that the same analytical parameter of the soil in treated water and salty water described above by basic soil characteristics of pH above 8.00 and has the minimum content of Fe and Mn, while highest content of Na and N, but with lower contents than WT and WS.

By analyzing the data of the fresh water plot (WF), it is apparent that there is no significant difference between means of all fresh water treatment groups as described on table (4.6) below.

Table (4.6): Soil characteristics in Fresh water plot (WF) of each treatment of WF50, Wf75, WF100, WF125 and WF150 before experiment.

Treatment / Parameter		WF50	WF75	WF100	WF125	WF150
pH	Mean	8.45	8.37	8.41	8.56	8.43
	Grouping	A	A	A	A	A
EC	Mean (µS/cm)	4258.00	4760.00	2827.00	1317.00	1989.00
	Grouping	A	A	A	A	A
TDS	Mean (mg/L)	2725.00	3046.00	1809.00	843.00	1273.00
	Grouping	A	A	A	A	A
P	Mean (mg/kg)	2.91	0.66	1.75	1.77	2.74
	Grouping	A	A	A	A	A
Fe	Mean (mg/kg)	0.02	0.00	0.03	0.15	0.03
	Grouping	A	A	A	A	A
Mn	Mean (mg/kg)	0.03	0.02	0.02	0.01	0.03
	Grouping	A	A	A	A	A
Mg	Mean (mg/kg)	198.00	234.30	183.61	86.02	134.37
	Grouping	A	A	A	A	A
Ca	Mean (mg/kg)	277.30	496.30	389.90	172.80	239.70
	Grouping	A	A	A	A	A
Na	Mean (mg/kg)	740.50	701.04	367.70	129.90	246.10
	Grouping	A	A	A	A	A
K	Mean (mg/kg)	177.45	214.00	166.03	106.06	121.81
	Grouping	A	A	A	A	A
N	Mean (mg/kg)	899.30	527.20	626.10	682.00	1045.50
	Grouping	A	A	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

Table (4.7): Soil characterization in Nitrogen plot (FN) before experiment

Sample ID	pH	EC (µS/cm)	TDS (mg/L)	Soil Element content (mg/kg)							
				P	Fe	Mn	Mg	Ca	Na	K	N
FN0	8.60	1688.00	1080.32	0.45	0.10	0.01	33.28	31.96	294.72	96.16	672.13
FN0	8.37	6530.00	4179.20	3.71	0.01	0.09	329.96	382.00	1036.30	221.82	1275.91
FN0	8.49	5790.00	3705.60	2.28	0.01	0.07	401.64	762.03	828.31	230.13	743.88
FN7.5	8.51	2060.00	1318.40	5.97	0.03	0.03	79.87	83.70	274.35	85.77	1061.66
FN7.5	8.62	1699.00	1087.36	0.65	0.03	0.01	85.43	90.94	303.62	107.34	660.38
FN7.5	8.84	2320.00	1484.80	0.41	0.02	0.01	56.61	44.71	449.55	131.13	618.21
FN15	8.47	1224.00	783.36	4.79	0.02	0.03	81.40	89.86	146.75	80.16	1067.96
FN15	8.51	2780.00	1779.20	1.43	0.00	0.05	312.45	691.84	397.60	183.84	643.61
FN15	8.63	4510.00	2886.40	0.37	0.01	0.01	192.26	890.04	880.84	239.03	625.21
Maximum	**8.84**	**6530.00**	**4179.20**	**5.97**	**0.10**	**0.09**	**401.64**	**890.04**	**1036.30**	**239.03**	**1275.91**
Minimum	**8.37**	**1224.00**	**783.36**	**0.37**	**0.00**	**0.01**	**33.28**	**31.96**	**146.75**	**80.16**	**618.21**
Average	**8.56**	**3177.89**	**2033.85**	**2.23**	**0.02**	**0.03**	**174.77**	**340.79**	**512.45**	**152.82**	**818.77**

In nitrogen plot, we can notice that the same characteristics of soil with basic soil, low content of Mn and Fe, while high content of Na and N.

Table (4.8) below shows that there is no significant difference between means in all groups in the nitrogen plot.

Table (4.8): Soil characteristics in nitrogen plot (FN) of each treatment of FN0, FN7.5 and FN 15 before experiment

Treatment / Parameter		FN0	FN7.5	FN15
pH	Mean	8.49	8.66	8.54
	Grouping	A	A	A
EC	Mean (µS/cm)	4669.00	2026.00	2838.00
	Grouping	A	A	A
TDS	Mean (mg/L)	2988.40	1296.90	1816.30
	Grouping	A	A	A
P	Mean (mg/kg)	2.15	2.34	2.20
	Grouping	A	A	A
Fe	Mean (mg/kg)	0.04	0.026	0.01
	Grouping	A	A	A
Mn	Mean (mg/kg)	0.06	0.02	0.03
	Grouping	A	A	A
Mg	Mean (mg/kg)	255.00	74.00	195.40
	Grouping	A	A	A
Ca	Mean (mg/kg)	392.00	73.10	557.20
	Grouping	A	A	A
Na	Mean (mg/kg)	719.80	342.50	475.10
	Grouping	A	A	A
K	Mean (mg/kg)	182.70	108.08	167.68
	Grouping	A	A	A
N	Mean (mg/kg)	897.30	780.10	778.90
	Grouping	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

Table (4.9): Soil characterization in Phosphorus plot (FP) before experiment

Sample ID	pH	EC (µS/cm)	TDS (mg/L)	Soil Element content (mg/kg)							
				P	Fe	Mn	Mg	Ca	Na	K	N
FP0	8.41	4590.00	2937.60	0.76	0.02	0.02	242.96	916.76	719.97	229.61	826.05
FP0	8.39	4440.00	2841.60	4.76	0.01	0.12	302.32	413.95	663.34	159.31	2002.45
FP0	8.29	3040.00	1945.60	0.52	0.12	0.03	200.05	910.27	303.62	191.71	665.20
FP0.5	8.31	3250.00	2080.00	0.27	0.01	0.02	226.84	890.79	290.86	262.50	633.62
FP0.5	8.37	6110.00	3910.40	0.47	0.01	0.02	245.33	942.28	1068.23	297.50	523.48
FP0.5	8.37	9200.00	5888.00	0.63	0.00	0.06	376.95	933.04	1641.16	326.49	829.84
FP1	8.35	9410.00	6022.40	0.75	0.00	0.06	262.20	966.79	1675.55	380.26	1038.46
FP1	8.39	3140.00	2009.60	1.10	0.00	0.04	251.26	509.23	436.90	196.99	798.76
FP1	8.42	4810.00	3078.40	2.37	0.00	0.07	220.86	330.55	710.27	219.02	2035.19
Maximum	**8.42**	**9410.00**	**6022.40**	**4.76**	**0.12**	**0.12**	**376.95**	**966.79**	**1675.55**	**380.26**	**2035.19**
Minimum	**8.29**	**3040.00**	**1945.60**	**0.27**	**0.00**	**0.02**	**200.05**	**330.55**	**290.86**	**159.31**	**523.48**
Average	**8.37**	**5332.22**	**3412.62**	**1.29**	**0.02**	**0.05**	**258.75**	**757.07**	**834.43**	**251.49**	**1039.23**

The characteristics of soil before treatment in the remaining plots of phosphorus plot (FP) and potassium plot (FK) which are summarized in tables (4.9) and (4.11) respectively show the same trend of the other plots with basic soil and low content of Fe and Mn, while higher content of Na and N.

The one-way Anova analysis of the characteristics of soil in phosphorus plot and potassium plot shows that there is no significant difference of means between parameters in all groups as described in tables (4.10) and (4.12)

Table (4.10): Soil characteristics in phosphorus plot (FP) of each treatment of FP0, FP0.5 and FP1 before experiment

Treatment / Parameter		FP0	FP0.5	FP1
pH	Mean	8.36	8.35	8.39
	Grouping	A	A	A
EC	Mean (µS/cm)	4023.00	6187.00	5787.00
	Grouping	A	A	A
TDS	Mean (mg/L)	2575.00	3959.00	3703.00
	Grouping	A	A	A
P	Mean (mg/kg)	2.01	0.46	1.41
	Grouping	A	A	A
Fe	Mean (mg/kg)	0.05	0.01	0.00
	Grouping	A	A	A
Mn	Mean (mg/kg)	0.06	0.03	0.06
	Grouping	A	A	A
Mg	Mean (mg/kg)	248.44	283.04	244.77
	Grouping	A	A	A
Ca	Mean (mg/kg)	747.00	922.00	602.20
	Grouping	A	A	A
Na	Mean (mg/kg)	562.30	1000.10	940.90
	Grouping	A	A	A
K	Mean (mg/kg)	193.54	295.50	265.42
	Grouping	A	A	A
N	Mean (mg/kg)	1164.60	662.30	1290.80
	Grouping	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

Table (4.11): Soil characterization in Potassium plot (FK) before experiment

Sample ID	pH	EC (µS/cm)	TDS (mg/L)	Soil Element content (mg/kg)							
				P	Fe	Mn	Mg	Ca	Na	K	N
FK0	8.46	2480.00	1587.20	0.22	0.00	0.01	174.63	853.88	211.14	202.08	509.10
FK0	8.50	2040.00	1305.60	2.46	0.00	0.05	200.54	355.60	235.80	135.41	1375.24
FK0	8.43	3030.00	1939.20	0.63	0.00	0.03	283.90	722.11	352.11	186.81	802.15
FK2	8.51	2880.00	1843.20	0.48	0.00	0.03	199.50	790.21	324.05	190.15	1223.07
FK2	8.37	2750.00	1760.00	1.19	0.00	0.06	297.22	733.04	298.47	173.73	1611.97
FK2	8.39	2720.00	1740.80	0.37	0.00	0.02	194.07	803.68	294.55	160.34	692.85
FK4	8.70	3820.00	2444.80	0.31	0.00	0.01	158.80	745.06	838.41	372.92	1141.81
FK4	8.38	4110.00	2630.40	1.26	0.00	0.04	223.73	802.77	649.51	275.94	1043.08
FK4	8.46	2640.00	1689.60	0.45	0.00	0.02	206.73	825.97	298.91	176.44	745.17
Maximum	**8.70**	**4110.00**	**2630.40**	**2.46**	**0.00**	**0.06**	**297.22**	**853.88**	**838.41**	**372.92**	**1611.97**
Minimum	**8.37**	**2040.00**	**1305.60**	**0.22**	**0.00**	**0.01**	**158.80**	**355.60**	**211.14**	**135.41**	**509.10**
Average	**8.47**	**2941.11**	**1882.31**	**0.82**	**0.00**	**0.03**	**215.46**	**736.92**	**389.22**	**208.20**	**1016.05**

Table (4.12): Soil characteristics in potassium plot (FK) of each treatment of FK0, FK2 and FK4 before experiment

Treatment / Parameter		FK0	FK2	FK4
pH	Mean	8.46	8.42	8.51
	Grouping	A	A	A
EC	Mean (µS/cm)	2516.70	2783.30	3523.30
	Grouping	A	A	A
TDS	Mean (mg/L)	1610.70	1781.30	2554.90
	Grouping	A	A	A
P	Mean (mg/kg)	1.10	0.68	0.67
	Grouping	A	A	A
Fe	Mean (mg/kg)	0.00	0.00	0.00
	Grouping	A	A	A
Mn	Mean (mg/kg)	0.03	0.04	0.02
	Grouping	A	A	A
Mg	Mean (mg/kg)	219.69	230.26	196.42
	Grouping	A	A	A
Ca	Mean (mg/kg)	643.90	775.60	791.30
	Grouping	A	A	A
Na	Mean (mg/kg)	266.40	305.70	595.60
	Grouping	A	A	A
K	Mean (mg/kg)	174.77	174.74	275.10
	Grouping	A	A	A
N	Mean (mg/kg)	895.50	1176.00	976.70
	Grouping	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

As summary of soil parameters in all plots before treatment, table (4.13) below summarize the mean of all parameters in all treatment plots.

The pH of soil is nearly the same in all plots which indicates that all soil plots are basic soil. But the soil EC and TDS are different in the treatment plots which are the highest in salty water plot (WS) followed by Treated water plot (WT), while the lowest in Potassium plot (FK).

Table (4.13) and fig. (4.1) show the elemental content of soil in each plot. It is shown that the highest content was observed in Na in salty water plot, while the lowest element content was observed in Fe in in Potassium plot, also in general, the elements P, Mn and Fe are observed in very low contents in all plots.

Table (4.13): Means of soil characteristics in all plots before experiment

Parameter	Means in Each Plot					
	WT	WS	WF	FN	FP	FK
pH	8.55	8.40	8.44	8.56	8.37	8.47
EC (µS/cm)	6085.53	8127.13	3029.93	3177.89	5332.22	2941.11
TDS (mg/L)	3894.74	5201.37	1939.16	2033.85	3412.62	1882.31
P (mg/kg)	0.82	1.93	1.97	2.23	1.29	0.82
Fe (mg/kg)	0.01	0.07	0.05	0.02	0.02	0.00
Mn (mg/kg)	0.04	0.10	0.02	0.03	0.05	0.03
Mg (mg/kg)	224.44	294.43	167.26	174.77	258.75	215.46
Ca (mg/kg)	630.00	318.95	315.21	340.79	757.07	736.92
Na (mg/kg)	1063.91	1435.52	437.11	512.45	834.43	389.22
K (mg/kg)	280.74	272.66	157.07	152.82	251.49	208.20
N (mg/kg)	1024.79	991.40	756.02	818.77	10.39.23	1016.05

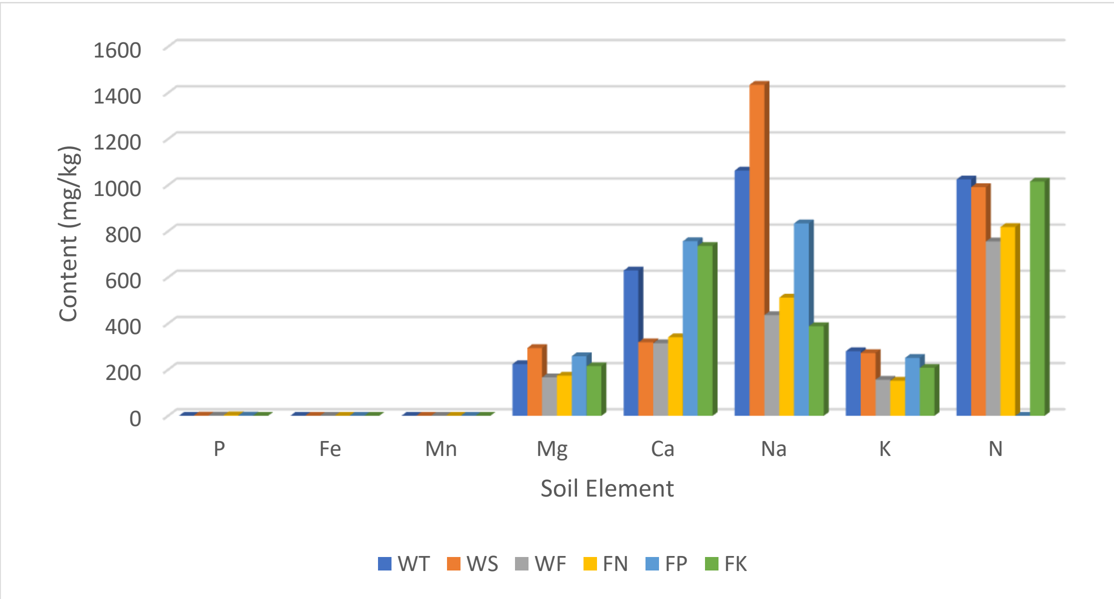


Fig. (4.1): Soil elemental content before experiment in all treatment plots

4.1.2 Date Leaves Elemental characteristics before treatment

Date leaves characteristics in terms of elemental content before treatment are summarized in tables 4.14 to 4.19 in the six plots under study: treated water, salty water, fresh water, nitrogen fertilizer, phosphorus fertilizer and potassium fertilizer respectively.

Table (4.14): Date leaves characterization in treated waste water plot (WT) before experiment

Sample ID	Date Leaves Element Content (mg/kg)							
	P	Fe	Mn	Mg	Ca	Na	K	N
WT50	1498.00	135.88	55.11	1948.00	7108.00	148.27	7780.00	17408.53
WT50	1288.00	175.70	40.26	1458.00	5885.00	120.25	8206.00	17101.56
WT50	1181.00	240.98	29.43	1526.00	5349.00	92.15	8114.00	15813.55
WT75	1367.00	125.80	65.08	2476.00	6748.00	112.28	8586.00	19680.76
WT75	1245.00	199.11	25.55	1471.00	5274.00	89.55	8741.00	16939.90
WT75	1174.00	204.05	37.92	1482.00	5630.00	181.10	9329.00	16495.35
WT100	1101.00	244.95	47.95	1413.00	6694.00	158.88	7650.00	16250.45
WT100	1203.00	161.10	33.76	1447.00	5208.00	107.48	8979.00	17055.68
WT100	1217.00	161.56	32.75	1983.00	5561.00	154.17	8390.00	17201.91
WT125	1259.00	106.57	30.44	1397.00	4834.00	135.74	9368.00	18074.39
WT125	1302.00	127.62	66.69	1868.00	6141.00	152.01	8364.00	18406.01
WT125	1343.00	180.99	48.69	1654.00	5834.00	130.16	7739.00	19066.29
WT150	1297.00	160.02	44.08	1908.00	6197.00	122.78	7147.00	17985.24
WT150	1417.00	150.63	39.09	1979.00	6919.00	72.19	8269.00	20495.77
WT150	1277.00	96.13	44.79	2260.00	6680.00	179.17	8518.00	18014.87
Maximum	1498.00	244.95	66.69	2476.00	7108.00	181.10	9368.00	20495.77
Minimum	1101.00	96.13	25.55	1397.00	4834.00	72.19	7147.00	15813.55
Average	1277.93	164.74	42.77	1751.33	6004.13	130.41	8345.33	17732.68

Table (4.15): Date leaves characterization in Salty water plot (WS) before experiment

Sample ID	Date Leaves Element Contents (mg/kg)							
	P	Fe	Mn	Mg	Ca	Na	K	N
WS50	1191.00	195.63	35.97	1941.00	4780.00	105.24	9079.00	16983.63
WS50	954.00	153.78	10.01	1410.00	3532.00	77.17	7775.00	16912.30
WS50	1205.00	175.75	30.89	1868.00	3889.00	96.33	9736.00	17197.73
WS75	1326.00	124.27	32.90	1801.00	3824.00	97.76	9741.00	17420.79
WS75	1151.00	159.34	19.29	1902.00	4583.00	99.37	7983.00	15998.84
WS75	1151.00	186.54	33.70	2023.00	4983.00	116.75	8125.00	16672.92
WS100	1242.00	140.72	25.14	1742.00	3634.00	82.15	10223.00	17459.41
WS100	1280.00	157.25	20.23	1877.00	3825.00	94.09	9904.00	17202.34
WS100	1052.00	193.17	25.57	1861.00	4000.00	141.02	8366.00	16917.03
WS125	1146.00	209.74	32.32	1902.00	3621.00	102.96	9278.00	15718.43
WS125	1227.00	195.18	38.06	2116.00	4214.00	123.33	10514.00	15988.83
WS125	986.00	145.22	26.42	1879.00	3331.00	214.79	12549.00	12267.74
WS150	1284.00	139.63	33.59	1881.00	4039.00	80.41	9578.00	18990.00
WS150	1233.00	139.28	29.81	2415.00	3701.00	99.08	9018.00	17289.10
WS150	1111.00	133.26	21.09	2089.00	3497.00	114.19	7897.00	15443.66
Maximum	1326.00	209.74	38.06	2415.00	4983.00	214.79	12549.00	18990.00
Minimum	954.00	124.27	10.01	1410.00	3331.00	77.17	7775.00	12267.74
Average	1169.27	163.25	27.67	1913.80	3963.53	109.64	9317.73	16564.18

Table (4.16): Date leaves characterization in Fresh water plot (WF) before experiment

Sample ID	Date Leaves Element content (mg/kg)							
	P	Fe	Mn	Mg	Ca	Na	K	N
WF50	1309.00	174.00	29.80	1626.00	4366.00	121.04	9867.00	19003.55
WF50	1150.00	160.29	52.58	2154.00	3990.00	96.63	7412.00	15702.00
WF50	1206.00	187.99	38.97	2030.00	4830.00	93.46	9121.00	18748.81
WF75	1144.00	134.90	22.11	1967.00	3849.00	104.90	7938.00	16833.80
WF75	1251.00	194.20	26.17	1691.00	4199.00	96.95	9433.00	18607.73
WF75	1149.00	109.41	22.88	1836.00	3801.00	98.92	8367.00	17793.98
WF100	1268.00	159.40	24.80	1667.00	4566.00	116.44	8204.00	17442.58
WF100	1171.00	147.48	35.88	1858.00	4593.00	93.50	7968.00	16230.52
WF100	1225.00	193.12	52.56	1913.00	4292.00	94.60	8403.00	16834.81
WF125	1184.00	233.88	34.66	1611.00	4797.00	90.23	9193.00	16691.73
WF125	1154.00	127.16	26.79	1781.00	3437.00	97.29	7982.00	15929.08
WF125	1164.00	205.86	22.60	1995.00	4177.00	105.44	8023.00	17415.53
WF150	1162.00	187.06	33.15	2018.00	3826.00	96.83	7626.00	16035.06
WF150	1136.00	102.80	25.05	1969.00	3571.00	77.80	7897.00	17058.89
WF150	1157.00	184.52	27.69	1495.00	5049.00	65.71	7301.00	14759.00
Maximum	1309.00	233.88	52.58	2154.00	5049.00	121.04	9867.00	19003.55
Minimum	1136.00	102.80	22.11	1495.00	3437.00	65.71	7301.00	14759.00
Average	1188.67	166.80	31.71	1840.73	4222.87	96.65	8315.67	17005.80

Table (4.17): Date leaves characterization in nitrogen plot (FN) before experiment

Sample ID	Date Leaves Element content (mg/kg)							
	P	Fe	Mn	Mg	Ca	Na	K	N
FN0	1284.00	192.23	23.21	1703.00	5078.00	97.47	9187.00	18332.05
FN0	1063.00	183.09	30.54	2005.00	4950.00	127.73	7454.00	16099.54
FN0	1164.00	178.74	34.70	1748.00	4329.00	115.59	8434.00	16157.55
FN7.5	1111.00	157.59	30.15	1626.00	4030.00	75.07	8104.00	16730.77
FN7.5	1176.00	92.54	29.87	2153.00	3952.00	78.54	8948.00	14905.83
FN7.5	1134.00	146.24	20.53	1943.00	4672.00	80.67	7995.00	15778.02
FN15	1073.00	198.62	41.95	1690.00	5715.00	131.96	6660.00	16865.44
FN15	1112.00	132.09	35.50	1828.00	4039.00	92.55	8257.00	17116.92
FN15	1152.00	187.76	32.69	1494.00	4583.00	88.25	8691.00	17957.12
Maximum	1284.00	198.62	41.95	2153.00	5715.00	131.96	9187.00	18332.05
Minimum	1063.00	92.54	20.53	1494.00	3952.00	75.07	6660.00	14905.83
Average	1141.00	163.21	31.02	1798.89	4594.22	98.65	8192.22	16660.36

Table (4.18): Date leaves characterization in phosphorus plot (FP) before experiment

Sample ID	Date Leaves Element content (mg/kg)							
	P	Fe	Mn	Mg	Ca	Na	K	N
FP0	1253.00	160.08	20.78	1896.00	4658.00	61.50	8695.00	16654.30
FP0	1391.00	142.34	35.08	1879.00	4184.00	76.54	8817.00	18978.36
FP0	1103.00	148.44	52.04	2170.00	5045.00	77.54	8715.00	16170.20
FP0.5	1185.00	180.07	44.04	1814.00	4309.00	91.30	9310.00	17821.41
FP0.5	1159.00	145.48	30.93	1701.00	3824.00	77.81	7959.00	17457.96
FP0.5	977.00	280.47	39.59	1553.00	3861.00	171.08	8053.00	15482.64
FP1	1114.00	201.47	37.71	1553.00	4769.00	98.06	8085.00	16363.57
FP1	1149.00	204.42	37.84	1564.00	4871.00	100.70	8249.00	17842.51
FP1	1069.00	184.62	35.75	1450.00	4697.00	114.63	9074.00	15008.01
Maximum	1391.00	280.47	52.04	2170.00	5045.00	171.08	9310.00	18978.36
Minimum	977.00	142.34	20.78	1450.00	3824.00	61.50	7959.00	15008.01
Average	1155.56	183.04	37.08	1731.11	4468.67	96.57	8550.78	16864.33

Table (4.19): Date leaves characterization in potassium plot (FK) before experiment

Sample ID	Date Leaves Element content (mg/kg)							
	P	Fe	Mn	Mg	Ca	Na	K	N
FK0	1102.00	162.51	24.44	1903.00	4510.00	91.25	8139.00	15810.12
FK0	1238.00	201.62	51.49	1684.00	4694.00	96.79	8333.00	16268.05
FK0	1172.00	193.95	60.65	1668.00	5243.00	78.10	7944.00	16220.55
FK2	1252.00	138.29	9.93	1529.00	4828.00	69.33	8041.00	17154.30
FK2	1182.00	162.62	48.24	1653.00	4507.00	54.90	8756.00	17478.34
FK2	1146.00	109.17	26.63	1677.00	3998.00	55.65	9217.00	15509.10
FK4	1032.00	122.69	29.96	2045.00	3215.00	105.61	9597.00	16529.10
FK4	1184.00	172.50	31.06	1837.00	4944.00	125.79	9067.00	16125.29
FK4	999.00	160.48	36.26	1786.00	3899.00	118.24	8008.00	15111.76
Maximum	1252.00	201.62	60.65	2045.00	5243.00	125.79	9597.00	17478.34
Minimum	999.00	109.17	9.93	1529.00	3215.00	54.90	7944.00	15111.76
Average	1145.22	158.20	35.41	1753.56	4426.44	88.41	8566.89	16245.18

As a summary of date leaves characteristics, in all plots, it is apparent that the lowest elemental content is Manganese (Mn) content, which is noticed in salty water plot with content of 27.67 mg/kg, while the highest elemental content is nitrogen (N) with content of 17732.68 mg/kg which is found in treated water plot. The next highest elemental content is potassium (K) with a content of 9317.73 mg/kg appearing in salty water plot as described in table (4.20) below and fig. (4.2):

Table (4.20): Means of date leaves characteristics in all plots before experiment

Parameter	Means in Each Plot					
	WT	WS	WF	FN	FP	FK
P (mg/kg)	1277.93	1169.27	1188.67	1141.00	1155.56	1145.22
Fe (mg/kg)	164.74	163.25	166.80	163.21	183.04	158.20
Mn (mg/kg)	42.77	27.67	31.71	31.02	37.08	35.41
Mg (mg/kg)	1751.33	1913.80	1840.73	1798.89	1731.11	1753.56
Ca (mg/kg)	6004.13	3963.53	4222.87	4594.22	4468.67	4426.44
Na (mg/kg)	130.41	109.64	96.65	98.65	96.57	88.41
K (mg/kg)	8345.33	9317.73	8315.67	8192.22	8550.78	8566.89
N (mg/kg)	17732.68	16564.18	17005.50	16660.36	16864.33	16245.18

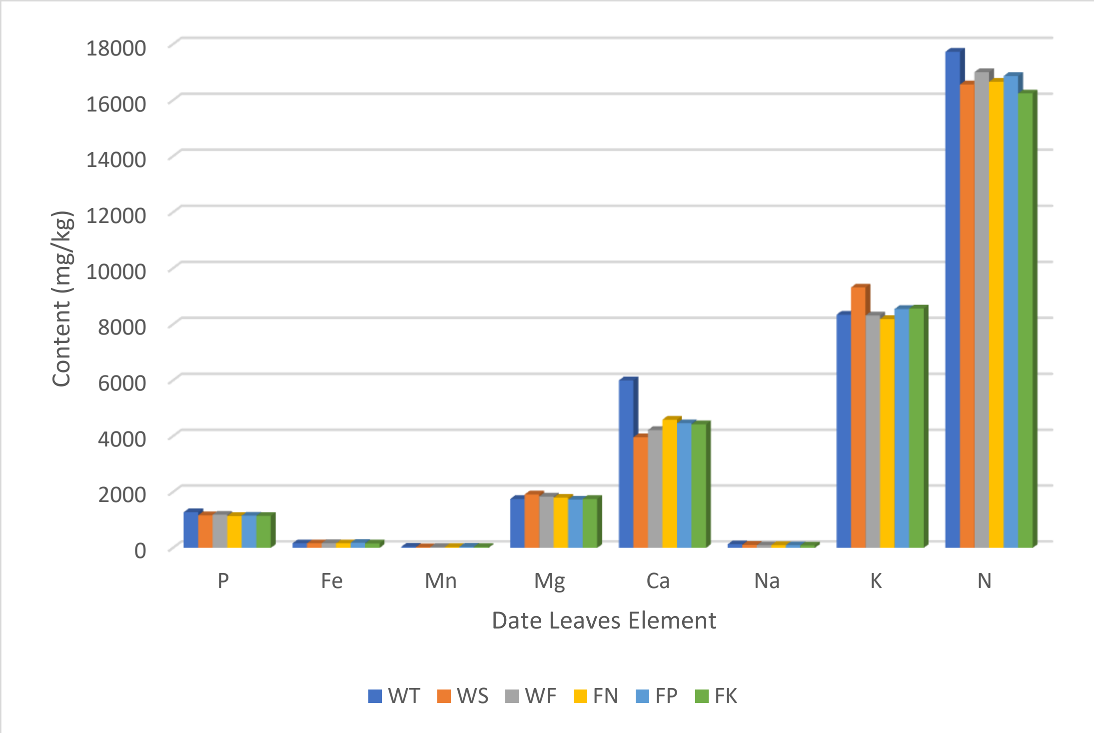


Fig. (4.2): Date leaves elemental content before experiment in all treatment plots

The one-way anova statistical analysis of date leaves parameters in all plots also discussed in treated water plot (WT), salty water plot (WS), fresh water plot (WF), nitrogen plot (FN), phosphorus plot (FP) and potassium plot (FK) in tables (4.21) to (4.26) respectively.

It is obvious from the statistical analysis of the elemental characteristics of date laves as shown in tables from (4.21) to (4.26) that there is no significant difference of means of each parameter group in all plots except the Magnesium (Mg) content in phosphorus fertilizer plot (FP), where the mean of Mg content in FP group is significantly difference from the other groups, FP0 and FP0.5. Another exception stands out in potassium fertilizer plot (FK) where the means of sodium (Na) content are significantly different in all potassium fertilizer plot groups: FK0, FK2 and FK4 as shown in table 4.26.

Table (4.21): Date leaves characteristics in treated waste water plot (WT) of each treatment of WT50, WT75, WT100, WT125 and WT150 before experiment

Treatment / Parameter		WT50	WT75	WT100	WT125	WT150
P	Mean (mg/kg)	1322.22	1262.00	1173.67	1301.33	1330.33
	Grouping	A	A	A	A	A
Fe	Mean (mg/kg)	184.19	176.32	189.20	138.39	135.59
	Grouping	A	A	A	A	A
Mn	Mean (mg/kg)	41.60	82.85	38.15	48.61	42.65
	Grouping	A	A	A	A	A
Mg	Mean (mg/kg)	1644.00	1809.70	1614.30	1639.70	2049.00
	Grouping	A	A	A	A	A
Ca	Mean (mg/kg)	6114.00	5884.00	5821.00	5603.00	6598.70
	Grouping	A	A	A	A	A
Na	Mean (mg/kg)	120.22	127.64	140.18	139.30	124.71
	Grouping	A	A	A	A	A
K	Mean (mg/kg)	8033.30	8885.30	8339.70	8490.30	7979.00
	Grouping	A	A	A	A	A
N	Mean (mg/kg)	16774.50	17705.30	16836.00	18515.60	18832.00
	Grouping	A	A	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

Table (4.22): Date leaves characteristics in salty water plot (WS) of each treatment of WS50, WS75, WS100, WS125 and WS150 before experiment

Treatment / Parameter		WS50	WS75	WS100	WS125	WS150
P	Mean (mg/kg)	1116.67	1209.33	1191.33	1119.67	1209.33
	Grouping	A	A	A	A	A
Fe	Mean (mg/kg)	175.05	156.72	163.71	183.38	137.39
	Grouping	A	A	A	A	A
Mn	Mean (mg/kg)	25.62	28.63	23.65	32.27	28.16
	Grouping	A	A	A	A	A
Mg	Mean (mg/kg)	1739.70	1908.70	1826.70	1965.70	2128.30
	Grouping	A	A	A	A	A
Ca	Mean (mg/kg)	4067.00	4463.30	3819.70	3722.00	3745.70
	Grouping	A	A	A	A	A
Na	Mean (mg/kg)	92.91	104.63	105.75	147.03	97.89
	Grouping	A	A	A	A	A
K	Mean (mg/kg)	8863.30	8616.30	9497.70	10780.30	8831.00
	Grouping	A	A	A	A	A
N	Mean (mg/kg)	17031.00	16698.00	17193.00	14658.00	17241.00
	Grouping	A	A	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

Table (4.23): Date Leaves characteristics in Fresh water plot (WF) of each treatment of WF50, WF75, WF100, WF125 and WF150 before experiment.

Treatment / Parameter		WF50	WF75	WF100	WF125	WF150
P	Mean (mg/kg)	1221.67	1181.33	1221.33	1167.33	1151.67
	Grouping	A	A	A	A	A
Fe	Mean (mg/kg)	174.09	146.17	166.67	188.97	158.13
	Grouping	A	A	A	A	A
Mn	Mean (mg/kg)	40.45	23.72	37.75	28.02	28.63
	Grouping	A	A	A	A	A
Mg	Mean (mg/kg)	1936.70	1831.30	1812.70	1795.70	1827.30
	Grouping	A	A	A	A	A
Ca	Mean (mg/kg)	4395.30	3949.70	4483.70	4137.00	4148.70
	Grouping	A	A	A	A	A
Na	Mean (mg/kg)	103.71	100.26	101.51	97.65	80.13
	Grouping	A	A	A	A	A
K	Mean (mg/kg)	8800.00	8579.30	8191.70	8399.30	7608.00
	Grouping	A	A	A	A	A
N	Mean (mg/kg)	17818.1	17745.20	16836.00	16678.80	15951.00
	Grouping	A	A	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

Table (4.24): Date leaves characteristics in nitrogen plot (FN) of each treatment of FN0, FN7.5 and FN15 before experiment

Treatment / Parameter		FN0	FN7.5	FN15
P	Mean (mg/kg)	1170.33	1140.33	1112.33
	Grouping	A	A	A
Fe	Mean (mg/kg)	184.69	132.12	172.82
	Grouping	A	A	A
Mn	Mean (mg/kg)	29.48	26.85	36.71
	Grouping	A	A	A
Mg	Mean (mg/kg)	1818.70	1907.30	1670.70
	Grouping	A	A	A
Ca	Mean (mg/kg)	4785.70	4218.00	4779.00
	Grouping	A	A	A
Na	Mean (mg/kg)	113.60	78.09	104.25
	Grouping	A	A	A
K	Mean (mg/kg)	8358.30	8349.00	7869.30
	Grouping	A	A	A
N	Mean (mg/kg)	16863.00	15804.90	17313.20
	Grouping	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

Table (4.25): Date leaves characteristics in phosphorus plot (FP) of each treatment of FP0, FP0.5 and FP1 before experiment

Treatment / Parameter		FP0	FP0.5	FP1
P	Mean (mg/kg)	1249.00	1107.00	1110.67
	Grouping	A	A	A
Fe	Mean (mg/kg)	150.29	202.01	196.84
	Grouping	A	A	A
Mn	Mean (mg/kg)	35.97	38.19	37.10
	Grouping	A	A	A
Mg	Mean (mg/kg)	1981.70	1689.30	1522.30
	Grouping	A	B, A	B
Ca	Mean (mg/kg)	4629.00	3998.00	4779.00
	Grouping	A	A	A
Na	Mean (mg/kg)	71.86	113.40	104.46
	Grouping	A	A	A
K	Mean (mg/kg)	8742.30	8440.70	8469.30
	Grouping	A	A	A
N	Mean (mg/kg)	16099.60	16713.90	15922.10
	Grouping	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

Table (4.26): Date leaves characteristics in potassium plot (FK) of each treatment of FK0, FK2 and FK4 before experiment

Treatment / Parameter		FK0	FK2	FK4
P	Mean (mg/kg)	1170.67	1193.33	1071.67
	Grouping	A	A	A
Fe	Mean (mg/kg)	186.03	136.69	151.89
	Grouping	A	A	A
Mn	Mean (mg/kg)	45.53	28.27	32.43
	Grouping	A	A	A
Mg	Mean (mg/kg)	1751.67	1619.67	1889.33
	Grouping	A	A	A
Ca	Mean (mg/kg)	4815.70	4444.30	4019.30
	Grouping	A	A	A
Na	Mean (mg/kg)	88.71	59.96	116.55
	Grouping	B	C	A
K	Mean (mg/kg)	8138.70	8671.30	8890.70
	Grouping	A	A	A
N	Mean (mg/kg)	17268.00	16921.00	16405.00
	Grouping	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

4.1.3 pH, EC and TDS of soil after treatment

The analysis of soil parameters after treatment was done only on pH, EC and TDS where tables (4.27) and (4.28) below summarize there means in soil after treatment and show the significance of means in each group of treatment.

Table (4.27): Soil parameters of pH, EC and TDS in water plots (WT, WS, and WF) after Experiment

Treatment / Parameter		WT50	WT75	WT100	WT125	WT150
pH	Mean	8.79	8.64	8.69	8.74	8.94
	Grouping	A	A	A	A	A
EC	Mean (µS/cm)	7115.00	5033.00	4613.00	4611.00	5070.00
	Grouping	A	A	A	A	A
TDS	Mean (mg/L)	4554.00	3221.00	2953.00	2951.00	3245.00
	Grouping	A	A	A	A	A
Treatment / Parameter		WS50	WS75	WS100	WS125	WS150
pH	Mean	8.47	8.49	8.31	8.48	8.24
	Grouping	A	A	A	A	A
EC	Mean (µS/cm)	15513.00	11907.00	17970.00	14917.00	16017.00
	Grouping	A	A	A	A	A
TDS	Mean (mg/L)	9929.00	7620.00	11501.00	9547.00	10251.00
	Grouping	A	A	A	A	A
Treatment / Parameter		WF50	WF75	WF100	WF125	WF150
pH	Mean	8.31	8.35	8.59	8.38	8.61
	Grouping	A	A	A	A	A
EC	Mean (µS/cm)	14133.00	12933.00	15410.00	7570.00	6073.00
	Grouping	A	A	A	A	A
TDS	Mean (mg/L)	9045.00	8277.00	9862.00	4845.00	3887.00
	Grouping	A	A	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

Table (4.28): Soil parameters of pH, EC and TDS in fertilizer plots (FN, FP, and FK) after Experiment

Treatment / Parameter		FN0	FN7.5	FN15
pH	Mean	8.32	8.35	8.11
	Grouping	A	A	A
EC	Mean (µS/cm)	11357.00	13147.00	8963.00
	Grouping	A	A	A
TDS	Mean (mg/L)	7268.00	8414.00	5737.00
	Grouping	A	A	A
Treatment / Parameter		FP0	FP0.5	FP1
pH	Mean	8.30	8.34	8.35
	Grouping	A	A	A
EC	Mean (µS/cm)	8423.00	20190.00	11133.00
	Grouping	B	A	B
TDS	Mean (mg/L)	5391.00	12922.00	7125.00
	Grouping	B	A	B
Treatment / Parameter		FK0	FK2	FK4
pH	Mean	8.22	8.28	8.35
	Grouping	A	A	A
EC	Mean (µS/cm)	13457.00	13777.00	13343.00
	Grouping	A	A	A
TDS	Mean (mg/L)	8612.00	8817.00	8540.00
	Grouping	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, n=3.

From the above tables, it can be inferred that there is no significance difference in means of pH, EC and TDS in all treatment groups in the water and fertilizer plots except the TDS in the phosphorus plot, where the treatment group of FP0.5 requires takes 0.5 kg of phosphorus fertilizer is different from both FP0 and FP1 which requires zero and 1 kg of phosphorus fertilizer respectively.

Fig. (4.3) below compare the means of the above three parameters in all plots before and after treatment, where it can be concluded from this chart that the pH of soil before and after treatment was has changed significantly and the values are close to each other in the basic soil region. It is apparent from this figure that the three parameters are not highly-affected in water treatment plot before and after treatment. On the other hand, there are significant difference in the mean of the three soil EC and TDS before and after treatment where both parameters increase after treatment with the highest difference in the salty water plot.

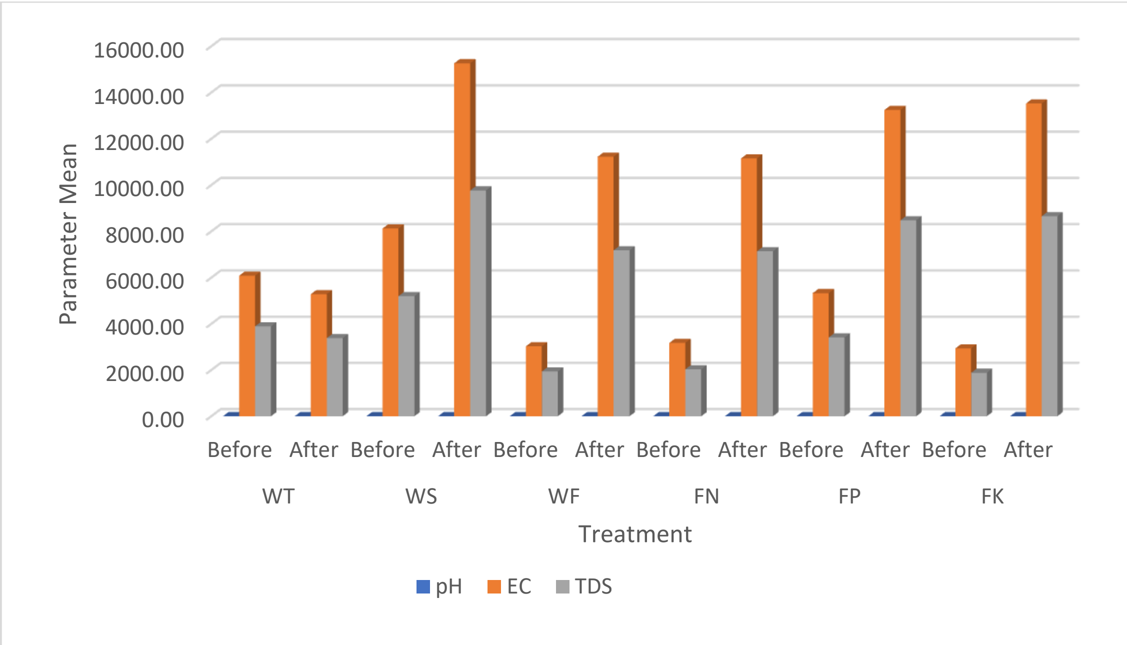


Fig. (4.3): means of three soil parameters (pH, EC and TDS) before and after experiment.

4.1.4 Accumulated Elements in Soil

The accumulation of the six analyzed elements in soil (P, Fe, Mn, Mg, Ca, Na, K and N) was calculated by the summation of elements content of each analysis initially in the soil before treatment, the element content in irrigation water were added to soil and the element content in the fertilizer added to soil.

The Accumulated element content in soil during treatment that, Mn and Fe have the lowest content in all plots, while Na has the highest content in soil especially in salty water plot as shown in fig. (4.4) below. The high content of Na in salty water plot is *logically true* where the salty irrigation water contains high amount of Na and other elements like Mg, Ca and K.

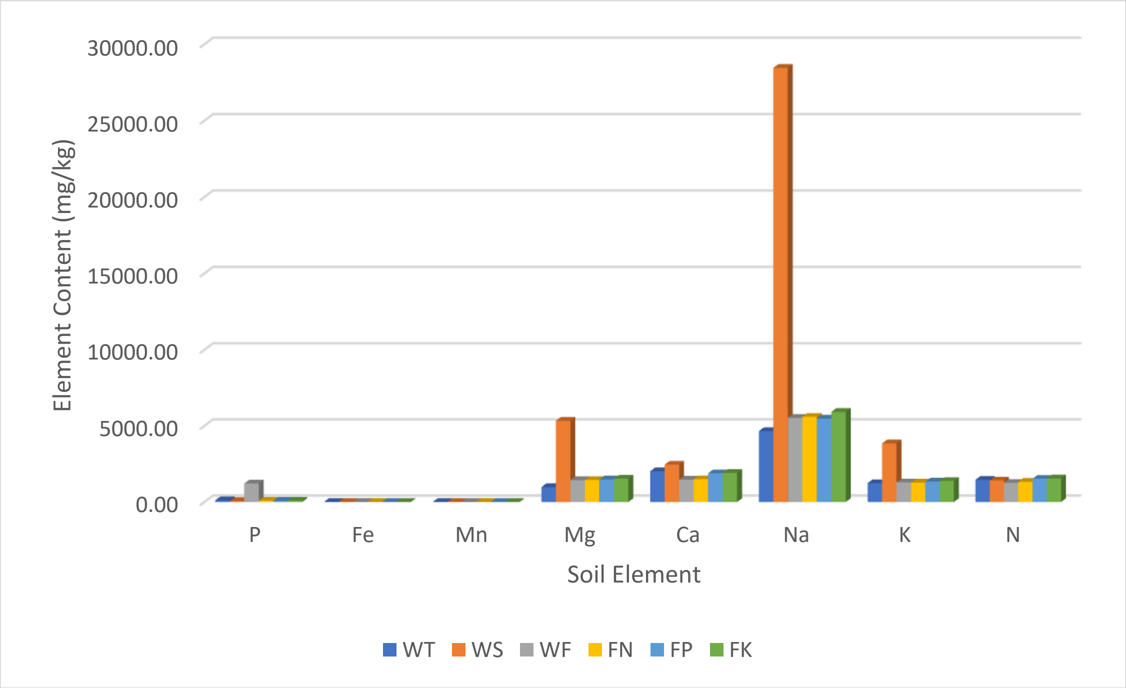


Fig. (4.4): Accumulated Soil Element Content during Treatments in All Plots

Tables (4.29) to (4.34) summarize the mean of element content accumulated in soil in each treatment plot and the significant between means of each treatment group.

As shown in table (4.29), the means of Mn and N content accumulated in soil are not significantly difference between all groups in treated water plot, while the mean of phosphorus content (P) is significantly different between all treatment groups in treated water plot. The mean of Fe content is not significantly difference in WT50, WT75 and WT125, while WT50 is significantly difference from WT510.

Table (4.29): Soil elemental content accumulated in treated water plot (WT) after experiment

Treatment / Parameter		WT50	WT75	WT100	WT125	WT150
P	Mean (mg/kg)	82.81	96.87	111.26	125.71	140.19
	Grouping	E	D	C	B	A
Fe	Mean (mg/kg)	0.10	0.13	0.24	0.22	0.26
	Grouping	C	B, C	B, A	B, A, C	A
Mn	Mean (mg/kg)	0.04	0.06	0.05	0.10	0.09
	Grouping	A	A	A	A	A
Mg	Mean (mg/kg)	539.47	772.17	912.40	1283.16	1385.54
	Grouping	C	C, B	B	A	A
Ca	Mean (mg/kg)	1132.60	1563.60	1917.90	2581.00	1888.30
	Grouping	C	C	B, C	B, A	A
Na	Mean (mg/kg)	3091.50	3187.50	4076.10	5771.20	7166.50
	Grouping	C	B, C	B, C	B, A	A
K	Mean (mg/kg)	926.80	962.00	1146.90	1380.30	1773.50
	Grouping	B	B	B	B, A	A
N	Mean (mg/kg)	1698.10	1349.60	1371.50	1299.5	1528.30
	Grouping	A	A	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

Table (4.30): Soil elemental content accumulated in salty water plot (WS) after experiment

Treatment / Parameter		WS50	WS75	WS100	WS125	WS150
P	Mean (mg/kg)	54.40	55.45	56.73	60.90	57.19
	Grouping	A	A	A	A	A
Fe	Mean (mg/kg)	0.28	0.37	0.45	0.74	0.68
	Grouping	B	B, A	B, A	A	B, A
Mn	Mean (mg/kg)	0.37	0.05	0.14	0.08	0.07
	Grouping	A	A	A	A	A
Mg	Mean (mg/kg)	3107.80	3907.80	5417.10	6469.00	7773.00
	Grouping	E	D	C	B	A
Ca	Mean (mg/kg)	1706.00	1715.20	2492.80	2797.90	3540.80
	Grouping	C	C	B	B, A	A
Na	Mean (mg/kg)	16364.40	21199.80	28601.20	34733.20	41361.00
	Grouping	E	D	C	B	A
K	Mean (mg/kg)	2425.18	2972.18	3916.38	4552.19	5380.68
	Grouping	E	D	C	B	A
N	Mean (mg/kg)	1371.30	1386.20	1808.80	1443.10	1047.30
	Grouping	A	A	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

Table (4.30), shows that the means of P, Mn and N had no significant difference with increasing the contribution of salty water in irrigation water (WS), while the means of K, Na and Mg content increased significantly with increasing salt levels.

Table (4.31): Soil elemental content accumulated in Fresh water plot (WF) after experiment

Treatment / Parameter		WF50	WF75	WF100	WF125	WF150
P	Mean (mg/kg)	68.50	72.99	80.82	87.57	95.27
	Grouping	D	D	C	B	A
Fe	Mean (mg/kg)	0.08	0.11	0.17	0.32	0.23
	Grouping	B	B	B, A	A	B, A
Mn	Mean (mg/kg)	0.06	0.07	0.09	0.10	0.13
	Grouping	C	B, C	B, C	B, A	A
Mg	Mean (mg/kg)	830.68	1183.31	1448.96	1667.71	2032.40
	Grouping	D	C	C, B	B	A
Ca	Mean (mg/kg)	851.00	1356.80	1537.20	1607.00	1960.70
	Grouping	B	B, A	B, A	B, A	A
Na	Mean (mg/kg)	3282.40	4514.30	5451.60	6484.80	7871.90
	Grouping	D	C	C, B	B	A
K	Mean (mg/kg)	938.96	1157.85	1292.22	1414.59	1612.67
	Grouping	D	D, C	B, C	B, A	A
N	Mean (mg/kg)	1341.90	1001.10	1131.30	1218.30	1581.90
	Grouping	A	A	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

The Mean of N content in all treatment groups are not significantly difference in the fresh water plot (WF), while there are some significant differences between treatment groups for other elements in the WF plot as shown in table (4.31). But, according to the treatment progress, the added N to soil is different between all treatment groups in FN plot and should be different in the accumulated N content, where may be this is due to the high N content in the soil before treatment and the added N didn’t make significant difference.

Table (4.32): Soil elemental content accumulated in nitrogen plot (FN) after experiment

Treatment / Parameter		FN0	FN7.5	FN15
P	Mean (mg/kg)	81.21	81.41	81.26
	Grouping	A	A	A
Fe	Mean (mg/kg)	0.17	0.16	0.14
	Grouping	A	A	A
Mn	Mean (mg/kg)	0.13	0.09	0.10
	Grouping	A	A	A
Mg	Mean (mg/kg)	1520.30	1339.30	1460.70
	Grouping	A	A	A
Ca	Mean (mg/kg)	1539.30	1220.40	1704.60
	Grouping	A	A	A
Na	Mean (mg/kg)	5803.70	5426.40	5559.00
	Grouping	A	A	A
K	Mean (mg/kg)	1308.89	1234.27	1293.87
	Grouping	A	A	A
N	Mean (mg/kg)	1022.30	1285.20	1664.10
	Grouping	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

In nitrogen fertilizer plot (FN), there is no significant difference between means of all elements in all treatment groups as indicated in table (4.32).

Nitrogen content in soil increased with increasing added N supply but the difference was not statistically significant.

Table (4.33): Soil elemental content accumulated in phosphorus plot (FP) after experiment

Treatment / Parameter		FP0	FP0.5	FP1
P	Mean (mg/kg)	28.96	79.52	132.58
	Grouping	C	B	A
Fe	Mean (mg/kg)	0.19	0.15	0.14
	Grouping	A	A	A
Mn	Mean (mg/kg)	0.13	0.10	0.13
	Grouping	A	A	A
Mg	Mean (mg/kg)	1513.79	1548.39	1510.12
	Grouping	A	A	A
Ca	Mean (mg/kg)	1894.30	2069.30	1749.50
	Grouping	A	A	A
Na	Mean (mg/kg)	5646.20	6084.00	6024.80
	Grouping	A	A	A
K	Mean (mg/kg)	1319.73	1421.69	1391.61
	Grouping	A	A	A
N	Mean (mg/kg)	1669.70	1167.40	1795.90
	Grouping	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

The means of Fe, Mn, Mg, Ca, Na, K and N accumulated in soil are not significantly difference between all treatment plots, while the mean of P content appears to be significantly differences between all treatment groups in phosphorus fertilizer plot (FP) as shown in table (4.33), which is *logically true*, where the added P is different between each treatment group in FP plot.

Table (4.34), shows the comparison of means of elements accumulated in soil, where the means of P, Fe, Mn, Mg, Ca, Na, and N content in soil are not significantly different in all treatment groups, while the mean of K content is significantly different between the three treatment groups, FK0, FK2 and Fk4, which is justified by the different K content added to soil for each treatment group in FK plot.

Table (4.34): Soil elemental content accumulated in potassium plot (FK) after experiment

Treatment / Parameter		FK0	FK2	FK4
P	Mean (mg/kg)	80.17	79.74	79.73
	Grouping	A	A	A
Fe	Mean (mg/kg)	0.14	0.14	0.14
	Grouping	A	A	A
Mn	Mean (mg/kg)	0.10	0.11	0.09
	Grouping	A	A	A
Mg	Mean (mg/kg)	1485.04	1495.61	1461.77
	Grouping	A	A	A
Ca	Mean (mg/kg)	1791.20	1923.00	1938.60
	Grouping	A	A	A
Na	Mean (mg/kg)	5350.30	5389.60	5679.50
	Grouping	A	A	A
K	Mean (mg/kg)	904.13	1300.93	1798.12
	Grouping	C	B	A
N	Mean (mg/kg)	1400.60	1681.10	1481.80
	Grouping	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

To have better understanding of the soil content before treatment and accumulated during treatment, Fig. (4.5) and Table (3.35) below summarize this type of comparison.

It can be noticed from table (4.35) and fig. (4.5) that all element contents in soil which accumulated in soil during treatment are higher than their content before treatment which is *logically true* because there is additional content of element added to soil during treatment even by irrigation water or by added fertilizer of both. But the increase of accumulated element content in soil is different from element to other and from treatment to other depends on the irrigation water added and on the added fertilizer.

The highest increase percentage of P was noticed in WT treatment due to the high concentration of P in treated water irrigation of (2.445 mg/L), while the highest Na content increase during treatment was noticed in Salty water plot (WS) which is due to the high concentration of Na in salty water irrigation of (1129.107 mg/L).

Fig. (4.5): Comparison of Soil Element Content Before treatment and accumulated during Treatments in All Plots: (a): P content, (b): Fe Content, (c): Mn Content, (d): Mg Content, (e): Ca Content, (f): Na Content, (g): K Content, (h): N Content.

Regarding Mg, Fe and K, it is clear from fig. (4.5) that the highest increase in these elements was noticed in WS treatment plot which is due to the high concentration of these elements in salty irrigation water (WS) which was found as follows: (210.660 mg/L), (0.018 mg/L) and (133.017 mg/L) respectively.

Table (4.35): Comparison between soil elemental content before treatment and that accumulated during treatment in all plots

Element		Mean of soil elemental content (mg/kg) in Plot					
		WT	**WS**	**WF**	**FN**	**FP**	**FK**
P	Before	0.82	1.93	1.97	2.23	1.29	0.82
	After	111.37	56.93	81.03	81.29	79.88	80.35
Fe	Before	0.01	0.07	0.05	0.02	0.02	0
	After	0.19	0.51	0.18	0.16	0.14	0.16
Mn	Before	0.04	0.1	0.02	0.03	0.05	0.03
	After	0.07	0.14	0.09	0.10	0.10	0.12
Mg	Before	224.44	294.43	167.26	174.77	258.75	215.46
	After	978.55	5334.93	1432.61	1440.12	1480.81	1524.10
Ca	Before	630	318.95	315.21	340.79	757.07	736.92
	After	2016.66	2450.54	1462.52	1488.10	1884.23	1904.38
Na	Before	1063.91	1435.52	437.11	512.45	834.43	389.22
	After	4658.58	28451.91	5521.00	5596.35	5473.11	5918.33
K	Before	280.74	272.66	157.07	152.82	251.49	208.2
	After	1237.92	3849.32	1283.26	1279.01	1334.39	1377.67
N	Before	1024.79	991.4	756.02	818.77	1039.23	1016.05
	After	1449.40	1411.36	1254.88	1323.88	1521.16	1544.34

4.1.5 Correlations of Soil characteristics and elemental content with date fruit quality parameters

Pearson correlations between soil parameters accumulated during treatment of P, Fe, Mn, Mg, Ca, Na, K, N, pH change, EC change and TDS change with green date fruit parameters of P, Fe, Mn, Mg, Ca, Na, K and N were studied in the six treatment plots of treated water plot (WT), salty water plot (WS), fresh water plot (WF), nitrogen fertilizer plot (FN), phosphorus fertilizer plot (FP) and potassium fertilizer plot (FK).

4.1.5.1 Correlations of Soil characteristics and elemental content with date fruit quality parameters in WT plot

Table 4.36 summarizes all Pearson correlations between soil parameters accumulated during treatment (P, Fe, Mn, Mg, Ca, Na, k, N, pH change, EC change and TDS change) between before and after treatment in treated water plot with date fruit quality parameters (fiber, fat, total soluble solids (TSS), invert sugar, pH, electrical conductivity (EC), and date fruit peel separation) in treated water plot.

Table 4.36: Pearson correlations between soil characteristics accumulated in soil and fruit quality parameters in treated water plot (WT).

Soil Parameter	Fruit Quality Parameters						
	Fiber	Fat	TSS	Invert Sugar	pH	EC	Peel Separation
P	0.835***	-0.865***	0.835***	0.835***	0.472	0.363	-0.892***
Fe	0.654**	-0.568*	0.628*	0.591*	0.406	0.260	-0.669**
Mn	0.580*	-0.597*	0.718**	0.653**	0.304	0.152	-0.488
Mg	0.904***	-0.914***	0.893***	0.904***	0.414	0.470	-0.899***
Ca	0.907***	-0.939***	0.911***	0.919***	0.495	0.394	-0.881***
Na	0.924***	-0.967***	0.905***	0.894***	0.461	0.382	-0.951***
K	0.910***	-0.951***	0.908***	0.914***	0.342	0.413	-0.985***
N	-0.198	0.153	-0.184	-0.224	-0.493	-0.194	-0.017
pH change	-0.012	-0.009	-0.056	0.063	-0.574*	0.131	-0.002
EC change	-0.719**	0.702**	-0.667**	-0.665**	-0.350	-0.199	0.550*
TDS change	-0.719**	0.702**	-0.667**	-0.665**	-0.350	-0.199	0.550*

*indicate significant at $P<0.05$, **indicate significant at $p<0.01$, ***indicate significant at $P<0.001$, n=3

The accumulated phosphorus content (P) in soil of treated water plot (WT) is positively correlated with date fruit fiber, total soluble solids (TSS) and invert sugar with high significance (<0.001) and person correlations coefficient (R^2) of 0.835 for each, while soil P content is negatively correlated with date fruit fat, and peel separation with high significance (<0.001) with person correlation coefficient (R^2) of 0.865 and 0.892 respectively. From previous studies, we can infer that the increase of K and P fertilization, leads to improved physical and chemical characteristics of fruits as mentioned by (Lustig, I.et al. 2014). Another authors, (Ibrahim and Zayed, 2019) and (Al-Yahyai, 2018) indicate that the results of decreased P are poor quality in fruits. On the other hand, there are different studies which present that the increase of NPK will increase TSS where this finding comes from (Elamin et al. 2018), (Zekri et al.2018) and (Weston and Barth1997) which are compatible with this study. In citrus, the increase in soil P, increase sugars, but decrease TSS (Zekri et al. 2018) which is the opposite of what was found in this study.

Ferrous Fe, which accumulated in soil of treated water plot was found to be positively correlated with date fruit fiber content and negatively correlated with fruit peel separation by a significance less than 0.01 and with person correlations (R^2) of 0.654 and -0.669 respectively. Fe is also positively correlated with TSS and invert sugar in date fruits and negatively correlated with fat content with significance less than 0.05 and person correlations (R^2) of 0.628, 0.591 and -0.568 respectively.

From table (4.36), Manganese (Mn) content in soil of treated water plot, has a positive correlation ($P< 0.01$) with TSS and invert sugars with person correlations (R^2) of 0.718 and 0.653 respectively, it also has positive correlation with fiber content and negative correlation with fat content ($P< 0.05$) with person correlations (R^2) of 0.580 and -0.597 respectively. In this study, there is no significance correlation between Fe and date fruit peel separation, there is even week negative correlation of R^2 -0.488.

Accumulated Magnesium in treated water plot soil shows a very high correlations date fruit parameters at a significance less than 0.001, where it has a positive correlation with fiber, TSS and invert sugars with R^2 of 0.904, 0.893 and 0.904 respectively, while it has a negative correlation with fat content and peel separation with R^2 of -0.914 and -0.899 respectively. In a previous study, the author found that the increase of Mg in soil increased the TSS of citrus fruit (Hossain, 2015) which agrees with the findings of this study.

The same trend and correlations of Mg above found for the accumulated Ca in treated water plot soil, where it has a positive correlation with fiber, TSS and invert sugars with R^2 of 0.907, 0.911 and 0.919 respectively ($P< 0.001$), while it has a negative correlation with fat content and peel separation with R^2 of -0.939 and -0.881 respectively. Ca develops cell wall structure as indicated by Kalaj (2016), this can justify the negative correlation between Ca and peel separation. Also, Weston and Barth (1997), mentioned that, the increase in Ca causes an increase in fruit firmness which reduces peel separation. High content of calcium carbonate in soil affects phosphorus mobility making it very restricted due to its strong retention by soil oxides and clay minerals because P ions rapidly undergo precipitation and adsorption reactions in the soil. Also, under calcareous conditions, P is readily fixed which is presented by Al-Qurashi et al. (2015). In another study by Crisosto and Costa (2008), they found that the Ca spray on Peach, reduces fruit peel russeting.

Sodium (Na), and potassium (K), accumulated in treated water plot soil shows the same trend correlations with date fruit quality parameters like Mg and Ca, where a strong correlation at significance less than 0.001, which are positively with fiber, TSS and invert sugars, while negatively with fat and peel separations with person correlations shown in table (4.36). Spraying of potassium silicate (K_2 SiO_3) and calcium carbonate on fruits increased TSS and total sugars in fruits as mentioned by (Aly and El Agamey, 2018) which agree with the results of this study.

Nitrogen (N) accumulated in treated water plot soil didn't show any significant correlations with date fruit quality parameters. In a previous study conducted by (Weston and Barth,1997), the author indicate that the increase of soil nitrogen decreases the fiber content in vegetables, but in this study, there is a negative correlation between soil nitrogen and fruit fiber, but this correlation is not significant.

The pH changes in treated water plot soil before and after treatment shows only significance correlation at less than 0.05 significance with fruit pH, where this correlation was found to be negative with person correlation (R^2) of -0.574.

Finally, the EC changes and TDS changes in treated water plot soil before and after treatment shows the same trend of correlations with date fruit quality parameters, where they are correlated at significance less than 0.01, positively with fat content and negatively with fiber, TSS and invert sugars with person correlations (R^2) of 0.702, -0.719, -0.667 and -0.665 for each EC and TDS respectively. There is also another correlation of EC and TDS of soil in treated water plot with date fruit peel separation which is positively at significance less than 0.05 with person correlation (R^2) of 0.550 for each. Fig. (4.6) shows the correlations of soil parameters with date fruit peel separation.

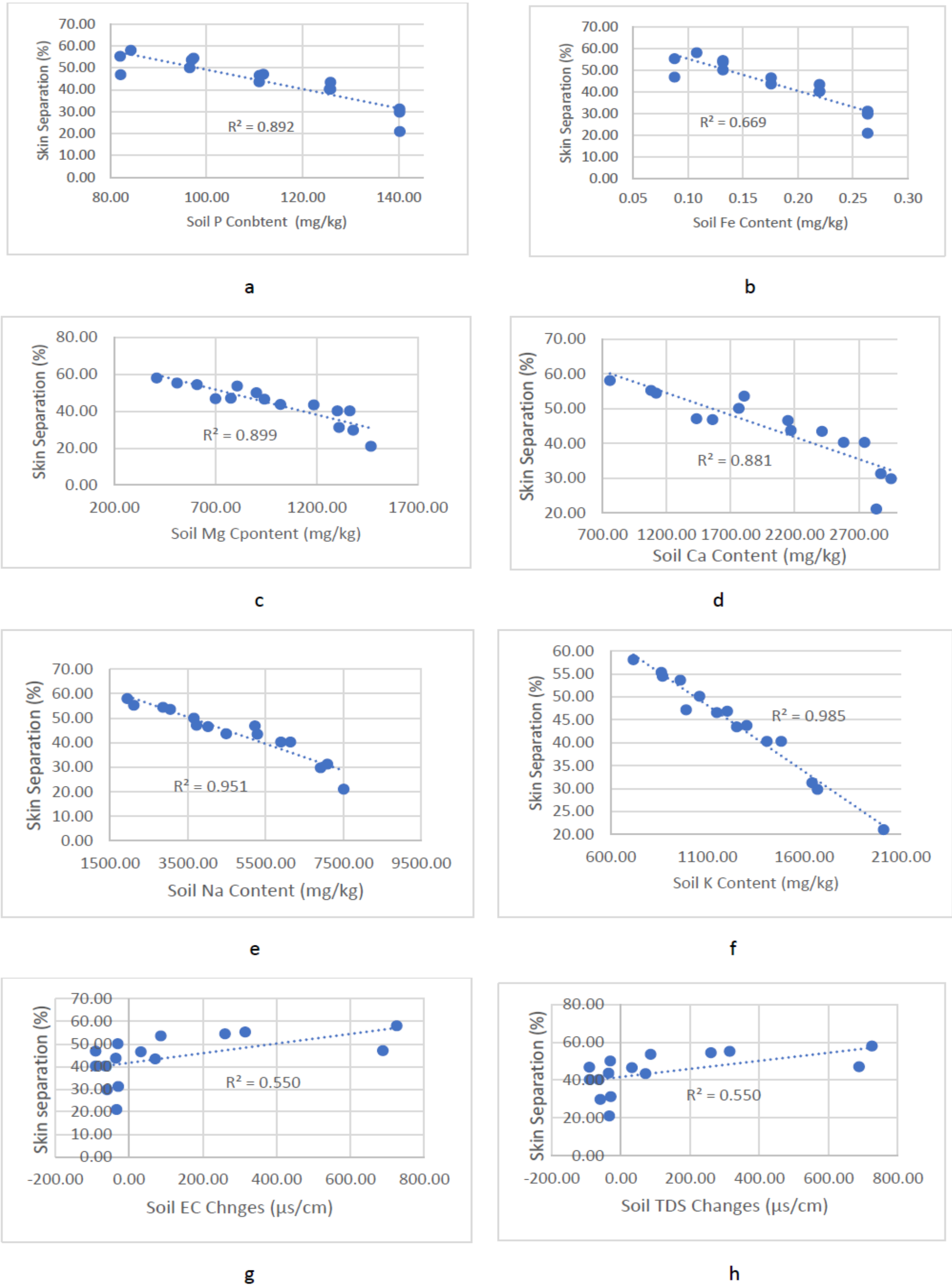


Fig. (4.6): correlations of soil parameters with date fruit peel separation in treated water plot (WT). (a): soil P content, (b): soil Fe content, (c): soil Mg content, (d): soil Ca content, (e): soil Na, (f): soil K content, (g): soil EC changes, (h): soil TDS changes.

4.1.5.2 Correlations of Soil characteristics and elemental content with date fruit quality parameters in WS plot

Phosphorous P, Nitrogen N, EC change and TDS changes in the salty water plot soil didn't show any significant correlation with date fruit quality parameters as shown in table (4.37).

The accumulated Fe in salty water plot soil correlations ($P<0.01$) are positive with fiber content ($R^2=0.680$) while negative with fat content ($R^2=0.749$) and with peel separation (R2=0.681). On the other hand, Fe has another tow positive correlation at significance ($P<0.05$) with TSS ($R^2=0.648$) and with invert sugar ($R^2=0.597$).

Mn accumulated in soil of salty water plot shows a strong positive correlation ($P<0.001$) with electrical conductivity (EC) of date fruit ($R^2=0.838$), while Mn in soil didn't show any significance correlation with other date fruit quality parameters.

Table (4.37) shows strong correlations (<P0.001) in Mg, Ca, Na and K, with fruit fiber, fat, TSS, invert sugars and peel separation, where these correlations are positive with fiber content ($R^2=0.976$ for Mg, 0.944 for Ca, 0.973 for Na and 0.977 for K), with TSS content ($R^2=0.964$ for Mg, 0.909 for Ca, 0.963 for Na and 0.965 for K), and with invert sugars content ($R^2=0.893$ for Mg, 0.864 for Ca, 0.889 for Na and 0.894 for K). In previous study conducted by Hossain (2015), the author found that the increase of Mg in soil increase the TSS of citrus fruit which is agrees with the findings of this study.

On the other hand, they show negative correlations with fat content (R^2=0.987 for Mg, 0.962 for Ca, 0.981 for Na and 0.984 for K), and with peel separation (R^2=0.962 for Mg, 0.904 for Ca, 0.962 for Na and 0.964 for K). It was indicated by Kalaj (2016), that Ca develops cell wall structure, this can justify the negative correlation between Ca and peel separation. Also, in another study done by Weston and Barth (1997), the authors found that the increase in Ca causes an increase of fruit firmness which means reduce peel separation. Spraying of potassium silicate (K_2 SiO_3) and calcium carbonate on fruits increased TSS and total sugars in fruits as mentioned by Aly and El Agamey (2018) which agrees with the results of this study.

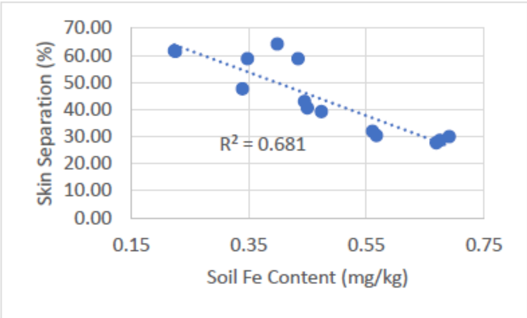
Finally, pH changes in soil of salty water plot have significance correlations at significance (<0.05) positively with fat content (R^2=0.566), while negatively with fiber content (R^2=0.605) and with fruit pH (R^2=0.630). From previous studies, the increase of soil pH leads to decrease Fe activity and availability of Mg which is shown by (Ibrahim and Zayed, 2019), which justifies the opposite correlation of soil Mg and Fe with soil pH change in fiber and fat of date fruits.

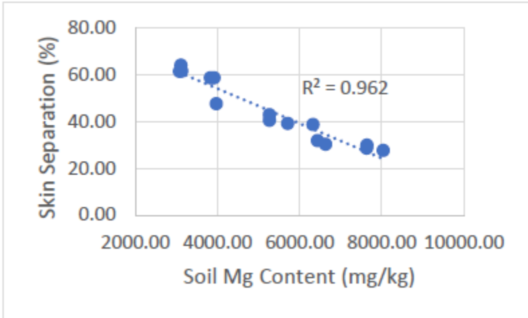
Table (4.37): Pearson correlations between fruit quality parameters and soil characteristics accumulated in salty water plot (WS).

Soil Parameter	Fruit Quality Parameters						
	Fiber	Fat	TSS	Invert Sugar	pH	EC	Peel Separation
P	0.343	-0.453	0.318	0.309	-0.157	-0.192	-0.390
Fe	0.680**	-0.749**	0.648*	0.597*	0.043	-0.302	-0.681**
Mn	-0.346	0.232	-0.446	-0.418	-0.217	0.838***	0.351
Mg	0.976***	-0.987***	0.964***	0.893***	0.165	-0.360	-0.962***
Ca	0.944***	-0.962***	0.909***	0.864***	0.192	-0.236	-0.904***
Na	0.973***	-0.981***	0.963***	0.889***	0.177	-0.370	-0.962***
K	0.977***	-0.984***	0.965***	0.894***	0.181	-0.374	-0.964***
N	-0.171	0.128	-0.093	-0.024	-0.516	-0.237	0.069
pH change	-0.605*	0.566*	-0.503	-0.410	-0.630*	0.388	0.509
EC change	0.359	-0.378	0.320	0.123	0.278	-0.234	-0.281
TDS change	0.359	-0.378	0.320	0.123	0.278	-0.234	-0.280

*indicate significant at $P<0.05$, **indicate significant at $p<0.01$, ***indicate significant at $P<0.001$, $n=3$

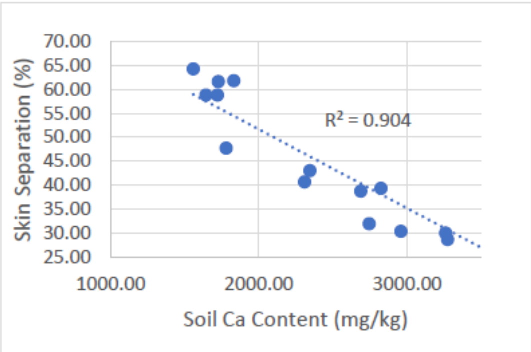
As summary of the correlations of soil parameters with date fruit peel separation in salty water plot, fig. (4.7) summarizes these correlations, which are all negative correlations between date fruit peel separation and Fe, Mg, Ca, Na and K.

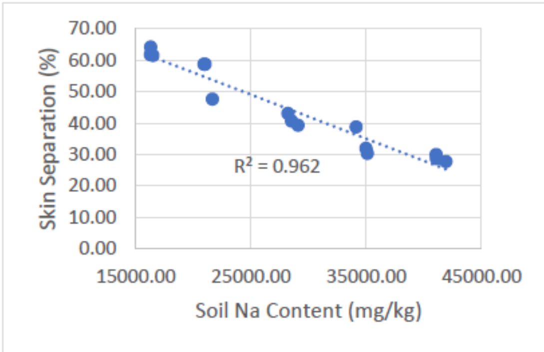




a

b





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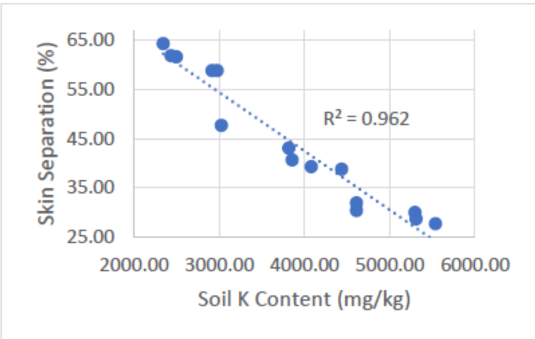


e

Fig. (4.7): correlations of soil parameters with date fruit peel separation in salty water plot (WS). (a): soil Fe content, (b): soil Mg content, (c): soil Ca content, (d): soil Na, (e): soil K content.

4.1.5.3 Correlations of Soil characteristics and elemental content with date fruit quality parameters in WF plot

It is shown in table 4.38 that date fruit EC didn't exhibit any significant correlation with soil parameters that was accumulated in fresh water treatment (WF). Also, pH change, EC change and TDS change in the soil of WF plot did not show any significant correlations with date fruit quality parameters including peel separation.

Soil element content accumulated in WF plot of P, Mn, Mg, Ca, Na and K showed strong correlations (P<0.001) with fiber, fat, TSS, invert sugars and peel separation, where fiber is correlated positively with all above mentioned soil elemental content (R^2= 0.955 for P, 0.935 for Mn, 0.986 for Mg, 0.853 for Ca, 0.977 for Na and 0.974 for K), while fiber content in date fruits is negatively correlated with all above mentioned soil elemental content (R^2= 0.951 for P, 0.939 for Mn, 0.980 for Mg, 0.839 for Ca, 0.981 for Na and 0.969 for K).

TSS of date fruits is positively correlated with P, Mn, Mg, Ca, Na, and K soil elemental content with R^2 of 0.884, 0.954, 0.981, 0.807, 0.965 and 0.977 respectively. On the other hand, invert sugars of date fruit are positively correlated with P (R^2= 0.811), Mn (R^2=0.876), Mg (R^2=0.926), Ca (R^2=0.856), Na (R^2=0.886) and K (R^2=0.927).

Table (4.38): Pearson correlations between fruit quality parameters and soil characteristics accumulated in fresh water plot (WF).

Soil Parameter	Fruit Quality Parameters						
	Fiber	Fat	TSS	Invert Sugar	pH	EC	Peel Separation
P	0.955***	-0.951***	0.884***	0.811***	0.193	-0.070	-0.839***
Fe	0.664**	-0.605*	0.546*	0.472	0.320	-0.110	-0.593*
Mn	0.935***	-0.939***	0.954***	0.876***	0.110	-0.072	-0.846***
Mg	0.986***	-0.980***	0.981***	0.926***	-0.017	-0.173	-0.942***
Ca	0.853***	-0.839***	0.807***	0.856***	-0.136	-0.362	-0.886***
Na	0.977***	-0.981***	0.965***	0.886***	0.046	-0.085	-0.927***
K	0.974***	-0.969***	0.977***	0.927***	-0.039	-0.145	-0.949***
N	0.200	-0.298	0.193	0.123	0.549*	0.251	-0.003
pH change	0.339	-0.360	0.358	0.269	-0.036	0.017	-0.363
EC change	-0.062	0.151	-0.210	-0.208	0.105	-0.256	0.164
TDS change	-0.062	0.151	-0.210	-0.208	0.105	-0.256	0.164

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

Regarding date fruit peel separation, it is shown from table (4.38) that the peel separation of date fruit is negatively correlated with P (R2=0.839), Mn (R2= 0.846), Mg (R2= 0.942), Ca (R^2=0.886), Na (R^2= 0.927) and K (R^2=0.949).

Fe accumulated in soil is positively correlated with fiber content in dated fruit at significance (<0.01) with R^2= 0.664 and correlated positively with TSS at significance (<0.05) with R^2=0.546. on the other hand, Fe correlated negatively with fruit fat content and fruit peel separation at significance (<0.05) with R^2= 0.605 and 0.593 respectively.

N accumulated in soil is only correlated with date fruit pH which is positive correlation at significance (<0.05) with R^2= 0.549.

The above correlations were found in some previous studies as discussed in sections (4.1.5.1) and (4.1.5.2).

Fig. (4.8) below summarize all correlations between soil parameters and date fruit peel separation in fresh water plots.

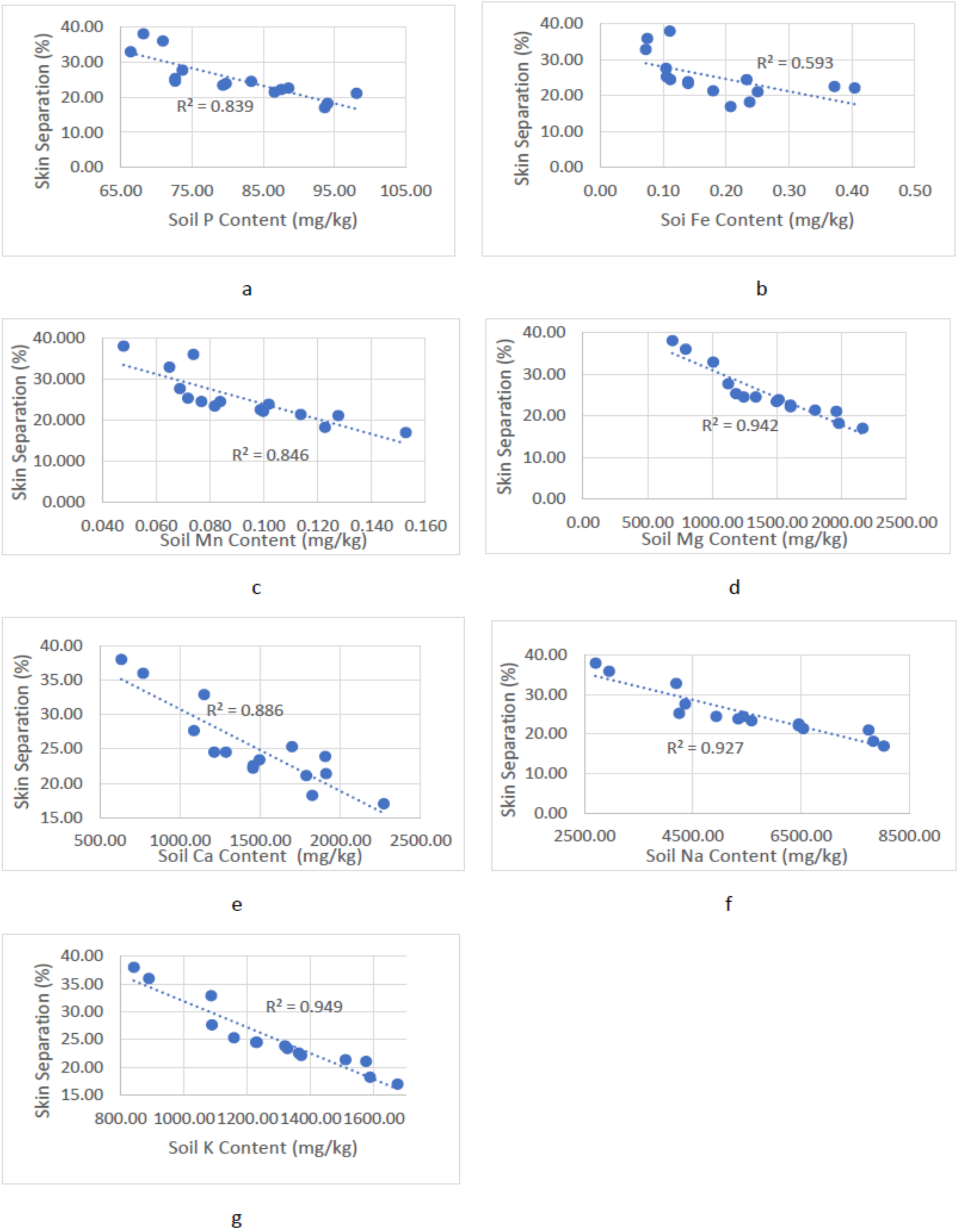


Fig. (4.8): correlations of soil parameters with date fruit peel separation in fresh water plot (WF). (a): soil P content, (b): soil Fe content, (c): soil Mn content, (d): soil Mg content, (e): soil Ca, (f): soil Na content, (g): soil K content.

4.1.5.4 Correlations of Soil characteristics and elemental content with date fruit quality parameters in Nitrogen Fertilizer plot (FN)

Phosphorous and Ferrous in FN plot react in different ways than their reaction in the water plots, WT, WS and WF where in FN plot, P and Fe did not show any significant correlations with date fruit quality parameters, fiber, fat, TSS, invert sugars, pH, EC and peel separation. On the other hand, Mn has significant correlation at significance (<0.05) with date fruit EC which is positive correlation and has person coefficient correlation R^2 of 0.702.

Magnesium Mg accumulated in soil has significant correlations with four date quality parameters at significance (<0.05), where three of these correlations are positive which are with fiber content (R^2=0.787), with TSS (R^2=0.707), and with invert sugars (R^2=0.734). The fourth correlation is negative which is with date fruit peel separation with R^2 of 0.704.

Calcium Ca accumulated in soil of FN plot correlated positively with date fruit fiber and TSS at significance (<0.01) and with person correlation coefficient R^2 of 0.841 and 0.859 respectively. On the other hand, Ca correlate at significance (<0.05) positively with fruit invert sugars (R^2=0.784), while negatively with fruit fat content (R^2=0.728) and peel separation (R^2= 0.739).

Sodium Na which accumulated in soil of FN plot shows a positive and strong correlation at significance (<0.001) with fiber content in date fruit (R^2=0.929), on the other hand, Na has another correlation at significance (<0.01) with fruit fat content, fruit TSS and fruit peel separation, where Na versus TSS is positive correlation with person correlation R^2 of 0.864, while Na correlations with fat content and peel separation are negative with person correlations R^2 of 0.858 and 0.873 respectively. At the end, Na also correlates positively with date invert sugar at significance (<0.05) with person correlation R^2 of 0.760.

There are four strong correlations of potassium K with date fruit fiber content, date fruit fat content, date fruit TSS and date fruit peel separation at significance (<0.001) where these correlations are positive with fiber content (R^2=0.982) and with TSS (R^2=0.9653), they are negative with fat content (R^2=0.906) and with peel separation (R^2=0.928). K shows another positive correlation at significance (<0.01) with date fruit invert sugar with person correlation R^2 of 0.882.

Soil pH change during treatment shows correlation with date fruit pH at significance (<0.01) with person correlations R^2 of 0.837.

Table (4.39): Pearson correlations between fruit quality parameters and soil characteristics accumulated in nitrogen fertilizer plot (FN).

Soil Parameter	Fruit Quality Parameters						
	Fiber	Fat	TSS	Invert Sugar	pH	EC	Peel Separation
P	-0.343	0.577	-0.508	-0.552	0.408	0.188	0.541
Fe	-0.549	0.382	-0.365	-0.316	-0.140	-0.398	0.373
Mn	0.480	-0.326	0.340	0.370	0.492	0.702*	-0.393
Mg	0.787*	-0.664	0.707*	0.734*	0.304	0.619	-0.704*
Ca	0.841**	-0.728*	0.859**	0.784	-0.081	0.327	-0.739*
Na	0.929***	-0.858**	0.864**	0.760*	-0.118	0.500	-0.873**
K	0.982***	-0.906***	0.953***	0.882**	-0.066	0.500	-0.928***
N	-0.195	0.400	-0.266	-0.433	-0.017	0.037	0.400
pH change	0.052	0.019	-0.066	0.2724	0.837**	0.654	-0.086
EC change	-0.925***	0.840**	-0.875**	-0.840**	-0.109	-0.672*	0.908***
TDS change	-0.925***	0.840**	-0.875**	-0.840**	-0.109	-0.672*	0.908***

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

Electrical conductivity changes and total dissolved solids TDS change in soil of FN plot show the same correlations with date fruit quality parameters where they show a negative and strong correlation with fiber content in date fruit at significance (<0.001) with person correlation R^2 of 0.925 for each EC change and TDS change, while they show a positive correlation at the same significance with date fruit peel separation with person correlation R^2 of 0.908 for each EC change and TDS change. Another correlation of EC changes and TDS change appears at significance (<0.01) with date fruit fat content, date fruit TSS and Date fruit invert sugars where these correlations are positive with Fat content (R^2=0.840 for each EC and TDS), while they are negative with TSS and invert sugars (R^2= 0.875 and 0.840 respectively for each EC and TDS). Finally, EC change and TDS change have a negative correlation with EC of date fruit at significance (<0.05) with person correlation coefficient R^2 of 0.672 for each soil EC change and soil TDS change.

The correlations of peel separation of date fruit with soil parameters in nitrogen plot (FN) are summarized in fig. (4.9) below.

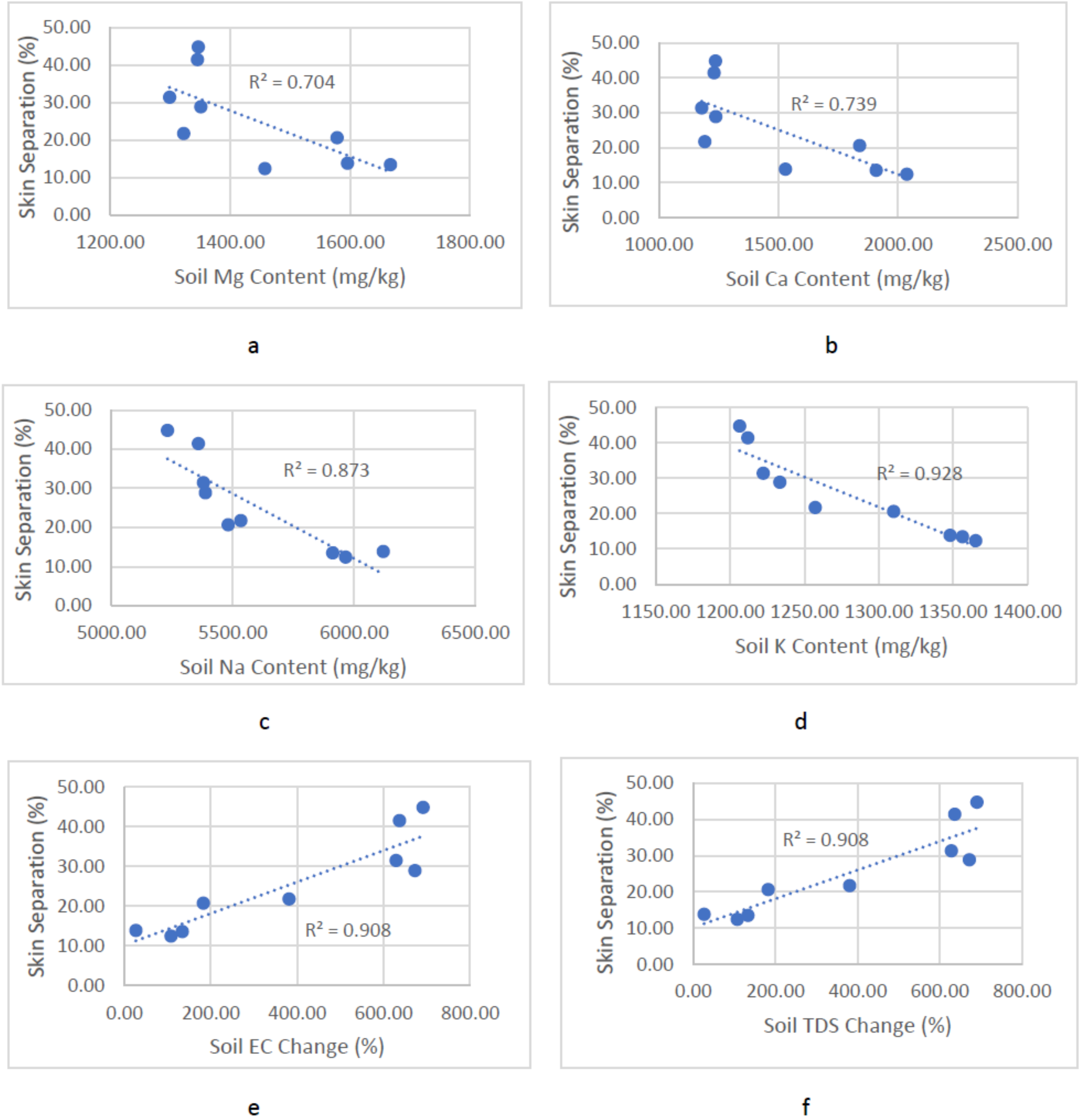


Fig. (4.9): correlations of soil parameters with date fruit peel separation in nitrogen fertilizer plot (FN). (a): soil Mg content, (b): soil Ca content, (c): soil Na content, (d): soil K content, (e): soil EC change, (f): soil TDS change.

4.1.5.5 Correlations of Soil characteristics and elemental content with date fruit quality parameters in phosphorus fertilizer plot (FP)

As shown in table (4.40), there are only three soil elements (Ca, Na and K) and pH change in phosphorous fertilizer plot (FP) that show significant correlations with date fruit quality parameters.

Calcium Ca, shows a negative correlation at significance (<0.05) with date fruit fat content and with date fruit peel separation with person correlation coefficients R^2 of 0.675 and 0.685 respectively. At significance (<0.05), the Na accumulated in soil shows positive correlations with date fruit fiber, date fruit TSS and date fruit invert sugars with person correlation coefficient R^2 of 0.703, 0.754 and 0.673 respectively, while it shows a negative correlation with date fruit fat content and date fruit peel separation with person correlation coefficient R^2 of 0.767 and 0.741 respectively.

The accumulated K in soil of FP plot shows very strong correlations at significance (<0.001) with date fruit fiber content, date fruit fat content, date fruit TSS, date fruit invert sugars and date fruit peel separation, where soil K correlations are positive with fiber content (R^2=0.909), TSS (0.952) and invert sugars (0.900), while soil K correlations are negative with fat content (R^2=0.964) and date fruit peel separation (R^2=0.964).

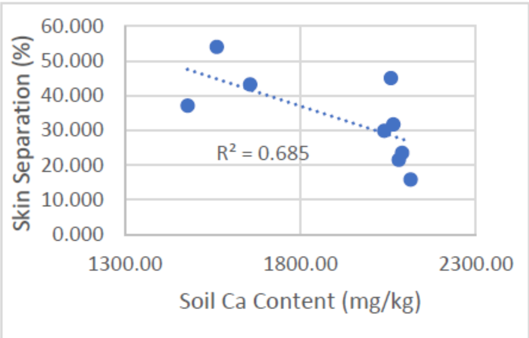
Table (4.40): Pearson correlations between fruit quality parameters and soil characteristics accumulated in phosphorous fertilizer plot (FP)

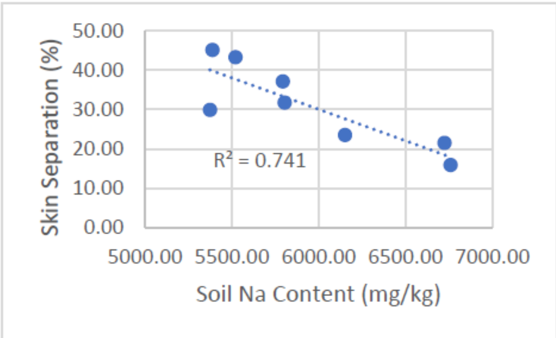
Soil Parameter	Fruit Quality Parameters						
	Fiber	Fat	TSS	Invert Sugar	pH	EC	Peel Separation
P	0.440	-0.325	0.380	0.390	0.212	0.492	-0.384
Fe	-0.521	0.395	-0.399	-0.391	-0.283	-0.348	0.369
Mn	-0.339	0.333	-0.226	-0.156	0.155	-0.115	0.411
Mg	0.248	-0.287	0.191	0.143	0.412	-0.211	-0.228
Ca	0.535	-0.675*	0.617	0.558	-0.241	-0.205	-0.685*
Na	0.703*	-0.767*	0.754*	0.673*	0.396	-0.224	-0.741*
K	0.909***	-0.964***	0.952***	0.900***	0.086	0.107	-0.964***
N	-0.316	0.411	-0.292	-0.224	0.223	0.126	0.459
pH change	0.111	-0.099	0.216	0.343	-0.713*	0.556	-0.071
EC change	0.129	-0.057	-0.040	0.016	-0.327	0.605	-0.037
TDS change	0.129	-0.057	-0.040	0.016	-0.327	0.605	-0.037

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

Finally, the soil pH correlates negatively with date fruit pH at significant (<0.05) with person correlation coefficient R^2 of 0.713.

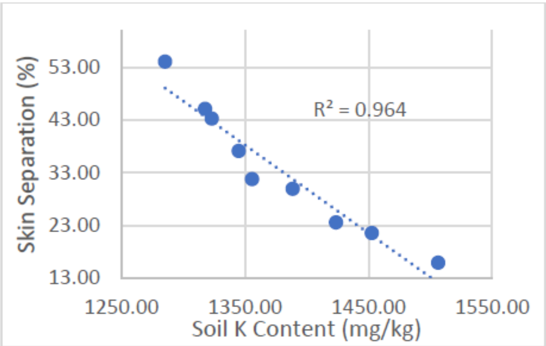
As a summary of the date fruit peel separation correlations with soil parameters of phosphorous fertilizer plot (FP), figure (4.10) below shows all these significant correlations.





a

b



c

Fig. (4.10): correlations of soil parameters with date fruit peel separation in Phosphorus fertilizer plot (FP). (a): soil Ca content, (b): soil Na content, (c): soil K content.

4.1.5.6 Correlations of Soil characteristics and elemental content with date fruit quality parameters in potassium fertilizer plot (FK)

Same as the phosphorous fertilizer plot (FP), the potassium fertilizer plot (FK) also shows the same correlations trend, where the significant correlations between soil parameters and date fruit quality parameters appears with soil Ca content, Na content, K content and pH change. Where soil Ca shows only significant correlation with date fruit invert sugars at significance (<0.05) and with person correlation coefficient R^2 of 0.724.

Sodium Na, correlate positively with date fruit TSS at significance (<0.01) with R^2 of 0.800, also it is correlated at significance (<0.05) positively with date fruit fiber content (R^2=0.707) and negatively with date fruit fat content (R^2=0.686).

A strong correlation appears between soil K and date fruit parameters where K correlates positively with date fiber content and date TSS at significance (<0.001) with R^2 of 0.995 and 0.951 respectively, while it correlates negatively at the same significance with date fat content and date fruit peel separation with R^2 of 0.988 and 0.938 respectively. There is also another correlation between soil K and date fruit invert sugars at significance (<0.01), where this correlation is positive with R^2 of 0.839.

Table: (4.41): Pearson correlations between fruit quality parameters and soil characteristics accumulated in potassium fertilizer plot (FK)

Soil Parameter	Fruit Quality Parameters						
	Fiber	Fat	TSS	Invert Sugar	pH	EC	Peel Separation
P	-0.321	0.274	-0.491	-0.561	0.557	0.347	0.393
Fe	-	-	-	-	-	-	-
Mn	-0.193	0.203	-0.333	-0.286	0.238	0.098	0.159
Mg	-0.228	0.266	-0.256	-0.118	0.211	0.143	0.191
Ca	0.481	-0.426	0.596	0.724*	-0.621	-0.136	-0.584
Na	0.707*	-0.686*	0.800**	0.373	-0.410	-0.206	-0.621
K	0.995***	-0.988***	0.951***	0.839**	-0.384	-0.369	-0.938***
N	0.066	-0.050	-0.028	-0.189	0.057	-0.276	-0.101
pH change	0.342	-0.251	0.453	0.375	-0.756*	-0.146	-0.470
EC change	-0.309	0.294	-0.426	-0.288	0.266	0.057	0.276
TDS change	-0.308	0.294	-0.426	-0.288	0.266	0.057	0.276

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

Finally, the soil pH change correlates negatively with date fruit pH at significant (<0.05) and with R^2 of 0.756.

There is only one significant correlation between soil parameters and date fruit peel separation which is very strong correlation with soil K, which appears negative correlation and reflected in figure (3.11) below.

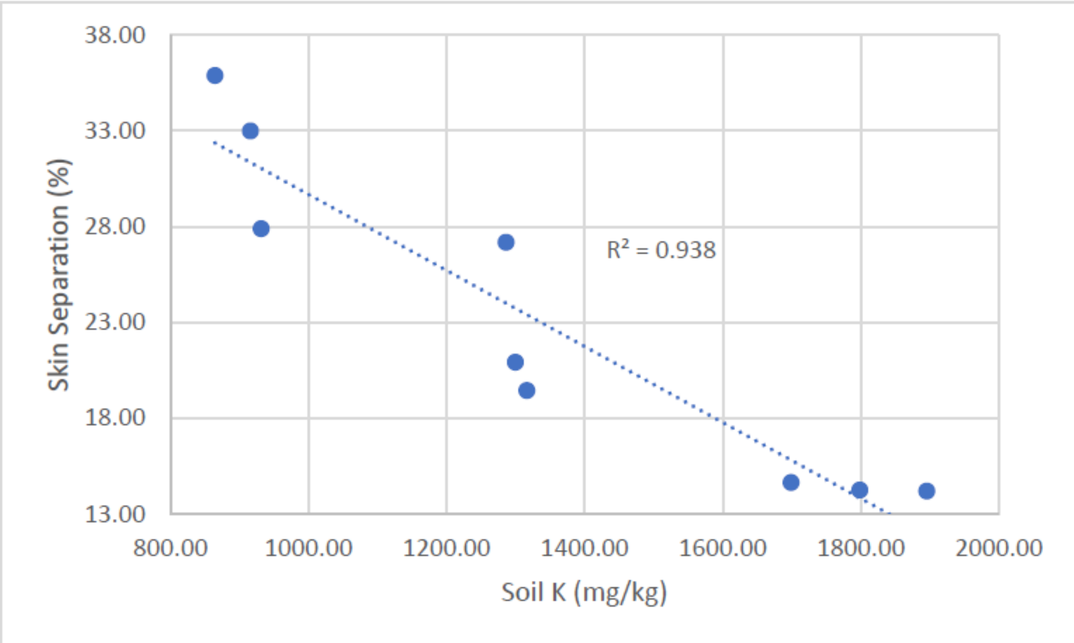


Fig. (4.11): correlation of soil potassium content with date fruit peel separation in potassium fertilizer plot (FK).

4.1.6 Correlations of Soil characteristics and elemental content with green date fruit parameters

The correlation between soil parameters accumulated during treatment of P, Fe, Mn, Mg, Ca, Na, K, N, pH change, EC change and TDS change with green date fruit parameters of P, Fe, Mn, Mg, Ca, Na, K, N were studied in the six treatment plots of treated water plot (WT), salty water plot (WS), fresh water plot (WF), nitrogen fertilizer plot (FN), phosphorus fertilizer plot (FP) and potassium fertilizer plot (FK).

4.1.6.1 Correlations of Soil characteristics and elemental content with green date fruit parameters in WT plot

Table (4.42), shows the correlations between soil parameters and green fruit parameters in treated water plot (WT), where it was found that there are three correlations at significance (<0.05) of soil P content with Mg, Ca and N content in green fruit, where the correlation between soil P content and green fruit content of N (R^2= 0.625) is positive, while the correlations between soil P content and green fruit content of Mg and Ca are negative (R^2=0.536 and 0.66 respectively).(Ibrahim and Zayed, 2019) found that the increase of P in soil reduced the absorption of N which is in opposition to the correlation found in this study between Soil P and N in green fruit which is a positive correlation. (HAAS, 1949) found that the application of N, P and K in avocados increased P and K in leaves and fruits, but in this study on date fruits, there are no significance correlations between soil P and green fruit content of P and K.

Ferrous Fe in soil was found to have positive correlation with green fruit content of N at significance (<0.01) with person correlation coefficient R^2 of 0.662, it has a negative correlation with green fruit content of Ca with person correlation coefficient R^2 of 0.564.

The accumulated manganese, Mn was found to have a strong positive correlation with green fruit Fe at significance (<0.01) with person correlation coefficient R^2 of 0.732. on the other hand, soil content of Mg correlates positively with N content of green fruit at significance (<0.05) with R^2 of 0.535, while Mg soil content correlates negatively at the same significance (<0.05) with green fruit content of Ca and Na with R^2 of 0.587 and 0.561 respectively. Ibrahim and Zayed, (2019) found that the increase of soil Mg and Zn decreased the absorbable Fe and reduce Fe and N in fruits, but in our study, there is no significance between soil Mg and green fruit Fe, while there is a positive correlation between soil Mg and fruit N which is opposite to the findings of (Ibrahim and Zayed, 2019)

Soil Calcium Ca correlates negatively at significance (<0.05) with both green fruit Mg and Ca with R^2 of 0.519 and 0.590 respectively. (Aly and El Agamey, 2018) found that, spraying of potassium silicate (K_2 SiO_3) and calcium carbonate on dates was increased the content of Ca and Mg in date fruits, while N, P and K content didn't statistically vary, this is opposite to the correlations found in this study between soil Ca content and both green fruit Ca and Mg which are negative correlations. The prior may be due to the fact that that the early stage of green fruit didn't absorb the fertilizer well. In another study, (Ibrahim and Zayed, 2019), the researchers found that the increase of soil Ca content reduced the absorption of Mg and K, which agrees with our study where there is a negative significance correlation between soil Ca and Mg of green fruits, also there is a non-significance negative correlation between soil Ca and green fruit. Mazahrih et al. (2018) found that the calcareous soil which is rich of Ca restricted the mobility of P and K which is not reflected in our study with significance correlations.

The soil parameters of Na, K, N and pH change didn't show any significance correlations with green date fruit parameters. (Al-Obeed et al.2013) found that the increase K fertilizer led to an increase in N, P, k and Fe, while the decrease in Mn and Zn. On the other hand, (Aly and El Agamey, 2018) found that, spraying potassium silicate (K_2 SiO_3) and calcium carbonate on dates increased the content of Ca and Mg in date fruits, while N, P and K content did not statistically vary. Other authors, like (Ibrahim and Zayed, 2019) found that the increase of K in soil reduced the absorption of Mg and Ca which agrees with negative correlations in this study while these correlations are not significant. HAAS (1949) found that the application of N, P and K in avocados increased P and K in leaves and fruits. It is also found by Kuzin et al. (2020) that the increase of soil k in apple plantation decreased fruit Ca, which agrees with the correlation trend in our study between soil k and green fruit Ca, but this correlation is not significance. Kassem, (2012) found also that the application of ammonium sulphate increased the fruit N, P, K, Fe and Zn.

Regarding soil pH, (Ibrahim and Zayed, 2019) found that the increase of soil pH decreased the Fe activity which is the same trend as in our study, but with no significance. On the other hand, the author found that the decrease of soil pH increased the availability of Mg which is also the same trend of correlation in our study but with no significance. In another study, (Reilly, 2015) found that the increase of soil pH reduced Na absorption, and reduced the availability of Zn, CU, Mn and Fe. The solubility and mobility of nutrients was increased by decreased soil pH which is found by (Mazahrih etal.2018).

Finally, the EC change and TDS change in soil during treatment correlates positively with Na in green fruits at significance (<0.05) with person correlation coefficient R^2 of 0.538 for each. This trend is *logically true*, where the increase in EC and TDS is due to the increase of Na in soil, which leads to an increase of Na in green fruits.

Table (4.42): Pearson correlations between green fruit parameters and soil parameters accumulated in treated water plot (WT)

Soil Parameter	Green Fruit Parameters							
	P	Fe	Mn	Mg	Ca	Na	K	N
P	0.292	0.457	-0.284	-0.536*	-0.600*	-0.454	-0.061	0.625*
Fe	0.401	0.340	-0.269	-0.396	-0.564*	-0.331	0.105	0.662**
Mn	0.029	0.732**	0.071	-0.114	-0.308	-0.408	0.055	0.210
Mg	0.288	0.424	-0.256	-0.480	-0.587*	-0.561*	-0.083	0.535*
Ca	0.172	0.446	-0.311	-0.519*	-0.590*	-0.510	-0.157	0.484
Na	0.309	0.420	-0.267	-0.502	-0.425	-0.496	-0.168	0.388
K	0.355	0.405	-0.324	-0.510	-0.434	-0.491	-0.187	0.446
N	0.352	-0.004	-0.104	-0.008	0.371	-0.007	0.072	-0.167
pH change	-0.007	-0.196	-0.377	-0.214	-0.012	-0.210	-0.184	0.145
EC change	0.044	-0.227	0.103	0.260	0.368	0.538*	0.156	-0.084
TDS change	0.044	-0.227	0.103	0.260	0.368	0.538*	0.156	-0.084

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

4.1.6.2 Correlations of Soil characteristics and elemental content with green date fruit parameters in WS plot

Table (4.43) shows the correlations between soil parameters of salty water plot (WS) and green fruit parameters. From this table we can see that only green fruit content of Fe, Na and N have correlations with some soil parameters, where green fruit Fe correlates positively only with Mn content in soil with significance (P<0.01) with R^2 of 0.721.

The green fruit Na content in green fruit negatively correlates with Fe content in soil at significance (P<0.01) with R^2 of 0.659. On the other hand, green fruit Na also correlates negatively at significance (P<0.05) soil content of P, Mg, Na and K with R^2 of 0.566, 0.576, 0.581 and 0.567 respectively.

Finally, the green fruit N correlates positively with soil Mn content at significance (P<0.05) with R^2 of 0.519.

Table (4.43): Pearson correlations between green fruit parameters and soil parameters accumulated in treated water plot (WS)

Soil Parameter	Green Fruit Parameters							
	P	Fe	Mn	Mg	Ca	Na	K	N
P	-0.043	-0.321	-0.418	-0.265	-0.338	-0.566*	0.050	-0.027
Fe	-0.128	-0.384	-0.306	-0.280	-0.410	-0.659**	0.144	-0.116
Mn	0.298	0.721**	0.262	0.481	0.455	0.441	0.246	0.519*
Mg	-0.103	-0.449	0.039	0.009	-0.369	-0.576*	-0.046	-0.008
Ca	-0.124	-0.396	0.091	0.025	-0.349	-0.450	-0.020	0.059
Na	-0.092	-0.444	0.031	0.007	-0.365	-0.581*	-0.048	-0.026
K	-0.100	-0.450	0.046	0.012	-0.372	-0.567*	-0.072	-0.009
N	-0.091	-0.283	-0.108	0.016	-0.144	-0.076	-0.226	0.248
pH change	0.210	0.218	-0.109	0.334	0.387	0.316	0.233	-0.060
EC change	0.099	-0.181	0.195	-0.224	-0.165	-0.431	0.207	0.057
TDS change	0.099	-0.181	-0.195	-0.224	-0.165	-0.431	0.207	0.057

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

4.1.6.3 Correlations of Soil characteristics and elemental content with green date fruit parameters in WF plot

From table (4.44), which summarizes all correlations between soil parameters of fresh water plot (WF) with green date fruit parameters in WF plot, it can be shown that only green fruit Mg content and green fruit N content have some significance correlations with some of soil parameters.

The Mg content of green date fruit is negatively correlated with soil Ca content at significance (P<0.01) with person correlation coefficient R^2 of 0.695. On the other hand, there are another three negative correlations of green fruit Mg at significance (P<0.05) with soil content of Mg, Na and K with R^2 of 0.597, 0.580 and 0.613 respectively.

Green date fruit N content is positively correlated with soil content of Fe at significance (P<0.05) with person correlation coefficient R^2 of 0.531.

Table (4.44): Pearson correlations between green fruit parameters and soil parameters accumulated in fresh water plot (WF)

Soil Parameter	Green Fruit Parameters							
	P	Fe	Mn	Mg	Ca	Na	K	N
P	-0.123	0.246	0.320	-0.508	0.343	-0.099	0.365	0.369
Fe	-0.213	0.381	0.388	-0.381	0.421	0.009	0.219	0.531*
Mn	-0.154	0.258	0.404	-0.468	0.327	-0.121	0.300	0.245
Mg	-0.130	0.257	0.360	-0.597*	0.334	-0.236	0.282	0.363
Ca	-0.168	0.166	0.321	-0.695**	0.132	-0.300	0.005	0.188
Na	-0.102	0.276	0.335	-0.580*	0.362	-0.243	0.367	0.422
K	-0.123	0.233	0.328	-0.613*	0.321	-0.286	0.273	0.346
N	0.099	-0.014	-0.191	-0.067	-0.087	0.035	0.428	-0.147
pH change	0.203	-0.088	-0.092	-0.264	-0.248	0.100	0.040	-0.184
EC change	0.025	0.394	0.287	0.211	0.206	0.299	-0.105	0.378
TDS change	0.025	0.394	0.287	0.211	0.206	0.299	-0.105	0.378

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

4.1.6.4 Correlations of Soil characteristics and elemental content with green date fruit parameters in FN plot

In nitrogen plot (FN) there are only correlations appear between soil parameters and green date fruit parameters, these two correlations are at significance (<0.05) and both are negative correlation. One of these correlations is between soil Mn content and green fruit content of K with R^2 of 0.771, while the other correlation is between soil N content and Na green fruit content with R^2 of 0.777.

Table (4.45): Pearson correlations between green fruit parameters and soil parameters accumulated in nitrogen fertilizer plot (FN)

Soil Parameter	Green Fruit Parameters							
	P	Fe	Mn	Mg	Ca	Na	K	N
P	-0.016	-0.102	-0.076	0.149	-0.218	-0.601	-0.175	-0.125
Fe	-0.436	0.328	-0.137	-0.175	0.182	0.641	0.301	0.225
Mn	-0.029	0.035	0.134	0.259	-0.029	-0.609	-0.771*	-0.498
Mg	-0.049	0.029	0.443	0.214	0.169	-0.453	-0.616	-0.571
Ca	-0.029	-0.195	0.599	0.153	0.407	-0.247	-0.159	-0.381
Na	0.463	-0.278	0.421	0.603	0.555	-0.149	-0.243	0.054
K	0.243	-0.234	0.480	0.378	0.457	-0.204	-0.304	-0.209
N	0.036	-0.478	-0.349	-0.248	-0.447	-0.777*	0.006	-0.109
pH change	-0.207	0.611	0.257	-0.030	-0.083	-0.212	-0.461	-0.632
EC change	-0.230	0.264	-0.284	-0.309	-0.310	0.288	0.464	0.299
TDS change	-0.230	0.264	-0.284	-0.309	-0.310	0.288	0.464	0.299

*indicate significant at $P<0.05$, **indicate significant at $p<0.01$, ***indicate significant at $P<0.001$, n=3

4.1.6.5 Correlations of Soil characteristics and elemental content with green date fruit parameters in FP plot

Table (4.46) shows the correlations between soil parameters in FP plot with green date fruit parameters, where it shows that the soil parameters of Mg, Na and K only from the studied soil parameters have significance correlations with some of green date fruit parameters like P, Na and K.

Soil Mg content correlates negatively with green fruit Na at significance (<0.05) with person correlation coefficient R^2 of 0.726. On the other hand, soil Na content correlate negatively with both green fruit P and K at significance (<0.05) with R^2 of 0.739 and 0.721 respectively. The final correlation noticed is also a negative correlation at significance (<0.05) between soil K and green fruit K with R^2 of 0.722.

Table (4.46): Pearson correlations between green fruit parameters and soil parameters accumulated in Phosphorus fertilizer plot (FP)

Soil Parameter	Green Fruit Parameters							
	P	Fe	Mn	Mg	Ca	Na	K	N
P	-0.503	0.109	0.514	0.557	0.482	0.478	-0.146	0.486
Fe	0.446	-0.281	-0.240	-0.122	-0.167	0.090	0.125	0.090
Mn	-0.559	0.161	-0.405	-0.493	-0.296	-0.348	0.380	-0.071
Mg	-0.500	0.399	-0.383	-0.645	-0.416	-0.726*	-0.336	-0.431
Ca	0.104	-0.174	-0.241	-0.191	-0.348	-0.150	-0.666	-0.307
Na	-0.739*	0.335	-0.305	-0.309	-0.229	-0.175	-0.721*	0.015
K	-0.575	0.128	-0.058	0.004	-0.059	0.056	-0.722*	-0.074
N	-0.422	0.245	-0.157	-0.062	0.107	0.077	0.512	0.160
pH change	0.113	-0.447	0.231	0.304	0.026	0.249	0.433	-0.310
EC change	0.288	-0111	0.494	0.260	0.148	-0.127	0.338	-0.565
TDS change	0.288	-0.111	0.494	0.260	0.148	-0.127	0.338	-0.565

*indicate significant at $P<0.05$, **indicate significant at $p<0.01$, ***indicate significant at $P<0.001$, n=3

4.1.6.6 Correlations of Soil characteristics and elemental content with green date fruit parameters in FK plot

The potassium fertilizer plot (FK) has some correlations between soil parameters and green date fruit parameters, where soil P content, soil Mn content, Soil Mg content, soil Ca content and soil pH change indicates significance correlations with Green fruit Fe, green fruit Mn and green fruit K content.

The soil P content shows positive correlation at significance (<0.05) with green fruit K content with R^2 of 0.769. This agrees with A. R. C. HAAS (104) who found that the application of N, P and K in avocados increased P and K in leaves and fruits. On the other hand, soil Mn content correlates positively with green fruit Mn at significance (<0.05) with R^2 of 0.677, also soil Mg correlate positively with green fruit Mn but at significance (<0.01) with R^2 of 0.811.

Soil Ca shows a negative correlation with green fruit K at significance (<0.05) with R^2 of 0.780. Finally, soil pH change shows significance correlation at significance (<0.05) with R^2 of 0.747 with green fruit Fe.

Table (4.47): Pearson correlations between green fruit parameters and soil parameters accumulated in Potassium fertilizer plot (FK)

Soil Parameter	Green Fruit Parameters							
	P	Fe	Mn	Mg	Ca	Na	K	N
P	0.335	-0.185	0.355	0.295	0.040	-0.078	0.769*	-0.046
Fe	-	-	-	-	-	-	-	-
Mn	0.379	0.167	0.677*	0.101	0.412	-0.054	0.638	-0.044
Mg	0.166	0.238	0.811**	0.078	0.483	0.491	0.456	-0.153
Ca	-0.291	0.335	-0.092	-0.083	0.380	0.030	-0.780*	0.245
Na	-0.632	-0.373	-0.263	0.447	0.247	-0.159	-0.582	-0.132
K	-0.550	-0.235	-0.072	0.198	0.579	-0.381	-0.659	0.084
N	0.275	-0.098	0.282	0.110	0.219	-0.342	0.432	-0.042
pH change	-0.400	0.747*	0.444	-0.176	0.510	-0.403	-0.379	-0.208
EC change	0.176	0.382	0.454	-0.357	-0.083	-0.452	0.609	-0.188
TDS change	0.176	0.382	0.454	-0.357	-0.083	-0.452	0.609	-0.188

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

4.1.7 Correlations of date leaves elemental content with date fruit quality parameters

The correlations between date leaves parameters of P, Fe, Mn, Mg, Ca, Na, K and N with ripen date fruit parameters of fiber content, fat content, TSS, invert sugars, pH, EC and date fruit peel separation in the six plots, Treated water plot WT, Salty water plot WS, fresh water plot WF, Nitrogen fertilizer plot FN, Phosphorus fertilizer plot FP and Potassium fertilizer plot FK.

4.1.7.1 Correlations of date leaves elemental content with date fruit quality parameters in water plots (WT, WS and WF)

Table (4.48) studies the date leaves parameters of P, Fe, Mn, Mg, Ca, Na, K and N with ripen date fruit parameters of fiber content, fat content, TSS, invert sugars, pH, EC and date fruit peel separation in water plots (WT, WS and WF).

The phosphorus content of date leaves correlates significantly only with date fruit EC in salty water plot (WS), where this correlation is a negative one at significance (<0.05) with R^2 of 0.560. Salinity is an indication of high EC, so (Al-Rawi and Al-Mohemdy,2012) found that the increase of salinity decreased the contents of N, P and K in leaves, which agrees with the correlation between fruit EC and leaves content of P, where this appears only in the salty water plot (WS). This phenomenon is justified by (Al-Qurashi et al.2015), where they said that Phosphorus mobility in soil is very restricted in salty soil due to its strong retention by soil oxides and clay minerals because P ions rapidly undergo precipitation and adsorption reactions in the soil.

The date leaves Fe content shows correlations only in treated water plot (WT), where these correlations are negative with fiber content, TSS and invert sugars at significance (<0.05) with person correlation coefficient R^2 of 0.634, 0.591 and 0.582 respectively, while the Fe correlations with fruit fat content and fruit peel separation is positive where correlation significance of date leaves Fe with fruit fat content is (<0.01) with R^2 of 0.656, while the significance of date leaves Fe with date fruit peel separation is (<0.05) with R^2 of 0.588.

The manganese (Mn) content of date leaves correlates significantly only with date fruit EC in salty water plot (WS), where this correlation is negative correlation at significance (<0.05) with R^2 of 0.621. The mean of K content in date leaves in salty water plot (WS) is higher than the mean of K content in date leaves in the other water plots, WT and WF, and from previous studies, (Ezz et al.2010) found that the increase of K content decreased the leaf content of Ca, Mg and Mn content which agrees with this study.

Magnesium (Mg) content in date leaves shows correlations only in the salty water plot (WS), where these correlations are at significance (<0.05) with date fruit Fiber content (positive correlation with R^2 of 0.540), date fruit TSS (positive correlation with R^2 of 0.555), date fruit invert sugars (positive correlation with R^2 of 0.0.617) and with date fruit EC (negative correlation with R^2 of 0.0.620). Zekri et al. (2018) found that the increase of Mg in citrus increases TSS, which agrees with the findings of this study. In another study, (Ritenour et al. 2002) found that the increase of Mg increased TSS.

Date leaves Ca content has only one significance correlation with ripen fruit parameters in salty water plot (WS), where it correlates positively with date fruit peel separation at significance (<0.05) with person correlation coefficient R^2 of 0.526. Ibrahim and Zayed, (2019) found that Ca increased date fruit peel separation where Lime reacts with glucose and fructose sugars to form sugar crystals containing Ca ++ in the form of calcium clocosite and calcium fructose. These sugary grains appear under the peel of the fruit, cause the peel to separate from the pulp, leading to some dryness and separation. The same authors justify the positive correlation between Ca content and fruit peel separation by finding that the decomposition of the carnivorous colloidal calcium pactites between cells into compounds that dissolve in water ends their role and soften the carnivores after it becomes easy to remove the peel from the fruit.

In fresh water plot (WF) only, the Date leaves Na content correlates at significance (<0.05) with ripen fruit fat content, TSS and invert sugars, where these correlations are positive with fat content (R^2= 0.614), while they are negative with TSS and invert sugars (R^2= 0.623 and 0.591 respectively). The positive correlation between Fat content and Na content was also found in previous studies by (Ragab, et al. 2011). These authors found the same negative correlations present in our study, between Na with TSS and invert sugars.

The potassium (K) content of date leaves didn't show any significance correlation with any ripen fruit parameters in all water plots (WT, WS and WF).

The nitrogen N content of date leaves in salty water plot did not show any significance correlation with ripen date fruit parameters, while there are four correlations between N content of date leaves with ripen fruit parameters in treated water plot (WT) and two correlations in fresh water plot (WF), where six correlations are at significance (<0.05). In treated water plot, the date leaves N content correlates positively with ripen date fiber content, TSS and invert sugars with person correlation coefficient R^2 of 0.546, 0.626 and 0.588 respectively. On the other hand, date leaves N content correlates negatively with date fruit fat content with R^2 of 0.575. Some authors like (Elamin et al. 2017) found that the increase of NPK fertilizer, increased the TSS of fruits which agrees the results of this study. On the other hand, (Ezz et al. 2010) found that the increase of N content decreased TSS in fruits which is opposite of the results in this study. Also, the (Ezz et al. 2010) found that the increase of N content decreased invert sugars, which is in contrast to the findings of this study. In another study, (Zekri et al. 2018) found that the increase of N content increased TSS, but the excess N in fact lowered TSS. El-Merghany, et al. (2014) found that the excess of N increased invert sugars and decreased TSS, while the decrease of N was increased both invert sugars and TSS. In the same manner, (Kassem, 2012) was found that the application of ammonium sulphate increased TSS. Regarding fruit fiber, (Weston and Barth, 1997) found that the increase of N content decreased the dietary fiber in fruits which is opposite to the findings of this study. Regarding invert sugars, (Al-Kharusi et al. 2009) found that the application of NPK Increased glucose and fructose content in fruits. (Ritenour, et al. 2002) found that the increase of N content increased TSS of fruits.

In fresh water plot (WF), the N date leaves content correlates with ripen date fruit fiber and fat content in opposite manner of these correlations in treated water plot (WT), but the correlation significance is the same (<0.05), where N content of date leaves correlates negatively with ripen date fruit fiber content and positively with fat content with R^2 of 0.533 and 0.553 respectively. L. A. (Weston and Barth, 1997) found that the increase of N content decreased the dietary fiber in fruits which agrees the findings in this study.

Table (4.48): Pearson correlations between ripen date fruit parameters and date leaves parameters in water plots (WT, WS and WF)

Plot	Ripen Fruit Parameters	Date Leaves Parameters							
		P	Fe	Mn	Mg	Ca	Na	K	N
WT	Fiber	0.323	-0.634*	0.213	0.410	0.334	0.237	-0.113	0.546*
	Fat	-0.409	0.656**	-0.135	-0.418	-0.257	-0.084	0.195	-0.575*
	TSS	0.367	-0.591*	0.055	0.429	0.312	-0.002	-0.115	0.626*
	In Sugar	0.335	-0.582*	0.007	0.466	0.221	-0.020	-0.178	0.588*
	pH	0.200	-0.221	0.416	0.340	0.304	0.020	-0.252	0.368
	EC	0.092	-0.477	0.482	0.292	0.112	0.230	0.025	0.245
	Separation	-0.274	0.588*	-0.102	-0.435	-0.345	-0.163	0.188	-0.501
WS	Fiber	0.150	-0.373	0.157	0.540*	-0.470	0.191	0.190	-0.090
	Fat	0.002	0.207	-0.079	-0.486	0.505	-0.236	-0.224	0.192
	TSS	0.200	-0.315	0.202	0.555*	-0.404	0.200	0.245	-0.089
	In Sugar	0.068	-0.186	0.215	0.617*	-0.418	0.426	0.372	-0.336
	pH	0.098	-0.360	-0.005	0.104	-0.049	-0.052	-0.056	0.065
	EC	-0.560*	-0.074	-0.621*	-0.620*	-0.256	-0.192	-0.229	-0.084
	Separation	-0.131	0.293	-0.169	-0.467	0.526*	-0.302	-0.384	0.186
WF	Fiber	-0.393	0.025	-0.277	-0.183	-0.101	-0.511	-0.442	-0.533*
	Fat	0.423	0.010	0.286	0.189	0.054	0.614*	0.483	0.553*
	TSS	-0.456	-0.070	-0.302	-0.109	-0.133	-0.623*	-0.377	-0.424
	In Sugar	-0.477	-0.041	-0.227	-0.159	-0.118	-0.591*	-0.321	-0.487
	pH	0.109	0.236	-0.310	-0.239	0.264	-0.037	-0.037	0.077
	EC	0.040	0.021	-0.200	0.033	0.144	0.234	-0.150	-0.048
	Separation	0.393	0.038	0.411	0.175	0.159	0.451	0.362	0.400

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

4.1.7.2 Correlations of date leaves elemental content with date fruit quality parameters in fertilizer plots (FN, FP and FK)

Table (4.49) study the date leaves parameters of P, Fe, Mn, Mg, Ca, Na, K and N with ripen date fruit parameters of fiber content, fat content, TSS, invert sugars, pH, EC and date fruit peel separation in fertilizer plots (FN, FP and FK).

Table (4.49) shows that there are no significance correlations between date leaves parameters and ripen fruit parameters except on the correlation at significance (<0.05) between Fe content of date leaves and EC of ripen date fruits with correlation coefficient R^2 of 0.758.

Table (4.49): Pearson correlations between ripen date fruit parameters and date leaves parameters in fertilizer plots (FN, FP and FK)

Plot	Ripen Fruit Parameters	Date Leaves Parameters							
		P	Fe	Mn	Mg	Ca	Na	K	N
FN	Fiber	-0.152	0.101	0.097	0.017	-0.212	0.195	0.144	-0.070
	Fat	-0.061	0.051	0.115	-0.181	0.265	-0.058	-0.342	0.129
	TSS	0.048	0.166	0.067	-0.075	-0.131	0.182	0.278	0.123
	In Sugar	0.125	-0.173	-0.120	0.140	-0.492	-0.089	0.479	-0.033
	pH	-0.295	-0.240	-0.065	0.188	-0.396	-0.084	-0.171	-0.200
	EC	-0.460	-0.086	-0.093	0.210	-0.332	0.058	-0.160	-0.115
	Separation	-0.027	0.001	0.168	-0.137	0.265	-0.057	-0.307	0.056
FP	Fiber	-0.515	0.492	-0.274	-0.574	-0.417	0.414	-0.362	-0.432
	Fat	0.484	-0.439	0.193	0.439	0.453	-0.361	0.484	0.363
	TSS	-0.350	0.377	-0.205	-0.421	-0.189	0.227	-0.399	-0.318
	In Sugar	-0.269	0.342	-0.120	-0.384	-0.101	0.183	-0.270	-0.240
	pH	-0.452	0.368	-0.300	-0.510	-0.434	0.544	-0.392	-0.486
	EC	-0.255	0.240	0.259	-0.391	-0.003	0.290	0.589	-0.153
	Separation	0.552	-0.484	0.185	0.460	0.323	-0.369	0.486	0.435
FK	Fiber	-0.519	-0.492	-0.390	0.425	-0.548	0.478	0.525	-0.086
	Fat	0.507	0.486	0.385	-0.400	0.555	-0.503	-0.523	0.150
	TSS	-0.594	-0.516	-0.406	0.591	-0.562	0.459	0.540	-0.019
	In Sugar	-0.596	-0.513	-0.438	0.232	-0.451	0.317	0.209	-0.242
	pH	0.312	0.615	0.480	-0.507	0.427	0.148	-0.563	-0.258
	EC	0.147	0.758*	0.315	0.170	0.596	0.461	-0.386	-0.265
	Separation	0.469	0.476	0.494	-0.378	0.465	-0.414	-0.393	-0.059

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

4.1.8 Correlations of date leaves elemental content with green date fruit parameters

The correlations between date leaves parameters of P, Fe, Mn, Mg, Ca, Na, K and N with green date fruit parameters of P, Fe, Mn, Mg, Ca, Na, K and N in the six plots, Treated water plot WT, Salty water plot WS, fresh water plot WF, Nitrogen fertilizer plot FN, Phosphorus fertilizer plot FP and Potassium fertilizer plot FK.

4.1.8.1 Correlations of date leaves elemental content with green date fruit parameters in water plots (WT, WS and WF)

Phosphorus P content of date leaves correlates only negatively with Fe content in date green fruits in the salty water plot (WS) only, where this correlation is at significance (<0.05) with person correlation R^2 of 0.660. This result agreed with previous results achieved by (Ibrahim and Zayed, 2019), who found that the increase of P content leads to precipitation of iron into iron phosphate. So, salinity of soil and water may be favoring this phenomenon, which justifies the fact that the correlation appears only in the salty water plot.

From the three water plots, only in fresh water plot (WF), there are two correlations of the Fe content in date leaves with Mn and Ca content of green date fruits, where the two correlations are negative ones at significance (<0.05) with R^2 of 0.601 and 0.525 respectively. In the same plot, date leaves content of Mn with green fruit content of P, where the correlation is positive at significance (<0.05) with R^2 of 0.519. The opposite correlation between P and Fe with Mn also is found by (Al-Obeed, et al. 2013).

Mg date leaves content correlates negatively with green fruit content of Fe, Ca and Na in the salty water plot only. These three correlations are at significance (<0.05) with R2 of 0.555, 0.581 and 0.595 respectively. Ibrahim and Zayed, (2019) also found a negative correlation between Mg with Fe and Ca. On the other hand, Ca content in date leaves did not show any significant correlations with green fruit parameters in water plots.

The Na content of date leaves shows significant correlation at significance (<0.05) with P content of green fruit in treated water plot (WT) which is a positive correlation (R^2=0.532), it also shows, at the same significance, a negative correlation with green fruit K content (R^2=0.529) in salty water plot (WS). Date leaves Na content also shows a stronger correlation with green fruit Ca content at significance (<0.01), which is negative correlation with person correlation coefficient R^2 of 0.675. There was a study conducted by (Al-Rawi et al. 2012) which found that the increase of Na leads to decreased K content in fruits, which is agrees with the results in this study, especially in salty water plot (WS).

K content of date leaves didn't show any significant correlations with green date fruit parameters in the three water plots. On the other hand, N content of the date leaves correlates positively at significance (<0.05) with green fruit Fe content in WT plot (R^2= 0.623) and with green fruit Ca content in WS plot (R^2 0.608). (Ezz, et al. 2010) found a positive correlation between N and Ca as the results in this study. Kassem (2012) found that the application of ammonium sulphate increased the Fe and Ca contents which agrees with the results of this study.

Table (4.50): Pearson correlations between green date fruit parameters and date leaves parameters in water plots (WT, WS and WF)

Plot	Green fruit Parameters	Date Leaves Parameters							
		P	**Fe**	**Mn**	**Mg**	**Ca**	**Na**	**K**	**N**
WT	**P**	-0.108	-0.162	0.116	0.298	0.273	0.532*	-0.052	0.051
	Fe	0.334	-0.219	-0.104	0.160	0.276	-0.402	0.109	0.623*
	Mn	0.127	0.298	0.002	-0.275	0.010	-0.303	0.133	0.028
	Mg	-0.026	0.385	-0.095	-0.009	0.005	-0.093	0.042	-0.152
	Ca	0.269	0.326	-0.100	-0.167	0.099	-0.139	-0.233	-0.206
	Na	-0.104	0.446	-0.051	0.151	0.068	-0.453	-0.261	-0.245
	K	-0.295	0.279	-0.151	-0.125	-0.112	0.197	0.083	-0.111
	N	-0.332	-0.063	-0.208	0.142	-0.067	0.140	0.097	0.188
WS	**P**	0.045	-0.207	0.020	-0.119	0.054	-0.281	-0.260	0.232
	Fe	-0.660**	-0.045	-0.503	-0.555*	-0.088	0.064	-0.062	-0.237
	Mn	0.123	-0.444	-0.416	-0.346	-0.258	-0.337	0.012	0.460
	Mg	-0.090	-0.251	-0.145	-0.385	-0.149	-0.247	-0.045	0.286
	Ca	0.199	-0.116	-0.282	-0.581*	0.021	-0.675**	-0.100	0.608*
	Na	-0.086	-0.161	-0.381	-0.595*	-0.042	-0.419	-0.164	0.412
	K	0.094	0.096	0.112	0.075	0.329	-0.529*	-0.507	0.400
	N	-0.490	-0.003	-0.253	-0.065	-0.017	0.147	-0.381	-0.033
WF	**P**	0.051	0.449	0.519*	0.391	0.268	0.106	-0.009	0.044
	Fe	-0.119	-0.214	0.225	0.127	-0.261	-0.126	-0.113	-0.184
	Mn	-0.251	-0.601*	-0.004	0.140	-0.510	-0.218	-0.290	-0.246
	Mg	0.004	-0.345	0.438	0.384	-0.187	0.325	-0.123	-0.064
	Ca	-0.349	-0.525*	-0.015	0.065	-0.353	-0.174	-0.421	-0.496
	Na	0.309	-0.399	0.086	-0.049	-0.104	0.382	-0.103	0.062
	K	-0.205	0.188	0.111	0.181	0.245	-0.195	-0.295	-0.245
	N	-0.424	-0.017	0.216	0.431	-0.223	-0.222	-0.415	-0.355

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

4.1.8.2 Correlations of date leaves elemental content with green date fruit parameters in fertilizer plots (FN, FP and FK)

The date leaves P content positively correlates with green fruits Na content in nitrogen plot fertilizer (FN) with significance (<0.01) and person correlation coefficient of (R^2= 0.868), it also correlates positively with P content of Green date fruit in Potassium plot fertilizer (FK) with significance (<0.05) and person correlation coefficient of (R^2= 0.775).

The Fe content of date leaves correlates only with K content in green date fruits, where this correlation is positive with significance (<0.01) and person correlation coefficient of R_2= 0.798.

The date leaves Mn content correlates with two parameters of Green date fruit which are Na content and Mn content at significance (<0.05), where the correlation between date leaves Mn content and green fruit Na content appears in the nitrogen fertilizer plot (FN) which is negative correlation with person correlation coefficient R_2=0.696, while the other correlation between date leaves Mn content and green fruit Mn content appears in the potassium fertilizer plot (FK) which is positive correlation with person correlation coefficient R_2=0.699.

Mg content of the date leaves appears to correlate only with P content of green date fruit in the Potassium fertilizer plot (FK), where this correlation is at significance (<0.01) and negative with person correlation coefficient R_2= 0.815.

Date leaves Ca content, Na content and K content correlate at significance (<0.05) with some green date fruits parameters, where Ca content of the date leaves correlates with Fe content in the nitrogen fertilizer plot (FN) which is negative with person correlation coefficient R_2= 0.684, while Na content of the date leaves correlates with Mg content of the green date fruits in the potassium fertilizer plot (FK) which is negative with person correlation coefficient R_2= 0.684. on the other hand, the K content of the date leaves correlates with Na content of the green date fruits in the nitrogen fertilizer plot (FN) which is positive with person correlation coefficient R_2= 0.685.

Finally, the N content of the date leave did not show any significant correlation with green date fruit parameters in all fertilizer plots (FN, FP and FK).

Table (4.51): Pearson correlations between green date fruit parameters and date leaves parameters in fertilizer plots (FN, FP and FK).

Plot	Green Fruit Parameters	Date Leaves Parameters							
		P	**Fe**	**Mn**	**Mg**	**Ca**	**Na**	**K**	**N**
FN	**P**	-0.318	-0.222	-0.325	0.296	-0.209	-0.263	-0.038	-0.518
	Fe	0.409	-0.662	-0.244	0.459	-0.684*	-0.429	0.580	-0.300
	Mn	0.294	0.074	0.198	-0.347	-0.437	-0.088	0.480	0.054
	Mg	-0.055	0.525	-0.089	-0.189	0.266	0.333	-0.136	-0.119
	Ca	0.450	0.551	-0.151	-0.517	0.100	0.073	0.403	0.386
	Na	0.868**	-0.008	-0.696*	-0.080	-0.040	-0.438	0.685*	0.147
	K	0.424	-0.113	-0.189	-0.332	-0.172	-0.587	0.481	0.199
	N	0.212	0.235	-0.363	-0.057	0.388	-0.079	0.042	-0.060
FP	**P**	0.379	-0.463	-0.131	0.636	0.383	-0.618	0.300	0.325
	Fe	-0.411	0.309	-0.168	-0.424	-0.642	0.557	-0.150	-0.433
	Mn	-0.265	-0.058	0.025	-0.393	-0.128	0.050	0.052	-0.006
	Mg	-0.354	-0.105	-0.026	-0.365	0.247	-0.053	0.259	-0.339
	Ca	-0.398	-0.025	0.077	-0.433	0.015	0.131	0.190	-0.403
	Na	-0.352	-0.265	0.036	-0.247	0.370	-0.160	0.193	-0.478
	K	0.495	-0.505	0.318	0.258	0.052	-0.296	0.730*	0.470
	N	-0.270	-0.109	-0.130	-0.302	0.614	-0.118	-0.267	-0.404
FK	**P**	0.775*	0.296	-0.172	-0.815**	0.652	-0.362	-0.642	0.362
	Fe	-0.183	0.014	0.044	0.150	-0.010	-0.283	-0.069	0.087
	Mn	-0.015	0.562	0.699*	-0.198	0.308	0.004	-0.237	0.080
	Mg	0.209	0.547	0.087	0.223	0.477	0.673*	-0.099	0.128
	Ca	-0.121	0.121	0.075	0.001	0.137	0.318	0.094	0.079
	Na	0.221	0.453	0.447	-0.343	0.639	-0.059	-0.492	-0.159
	K	0.558	0.798**	0.615	-0.576	0.581	-0.128	-0.604	0.221
	N	0.266	0.155	-0.544	-0.241	0.425	0.312	-0.508	0.086

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

Section Two: Irrigation Water Effect

4.2 Irrigation Water Effect

The irrigation water quantity and quality of date tree effects on the green date fruit nutrition and on the quality and nutrition of the ripen date fruits is discussed in this section.

The irrigation water quality effect on date fruits was studied and discussed in three types of water, which are treated water (WT), Salty water (WS) and fresh water (WF), while the water quantity effect on date fruits from each water quality was also discussed, where there are five different water regimes used from each water quality which includes: 50 m^3, 75 m^3, 100 m^3, 125 m^3 and 150 m^3.

During data analysis of this section, there are two main results under focus in this discussion which are the one-way Anova of the comparison of means of each water quantity and quality mentioned above, also the correlations between each water quality with green fruit nutrition and with ripen fruit nutrition and quality was discussed.

The elemental content of irrigation water is tabulated in table 4.52 below for all water quality type used for irrigation:

Table (4.52): Irrigation water Elemental Content

Element	Elemental Content in water (mg/L)		
	WT	WS	WF
P	2.445	0.121	1.127
Fe	0.007	0.018	0.006
Mn	0.001	0.002	0.003
Mg	31.517	210.660	52.883
Ca	57.953	89.087	47.950
Na	150.233	1129.107	212.473
K	23.440	133.017	30.510
N	5.229	1.862	1.667

It appears from table (4.52) that the Na content in water represents the highest content which appears in salty water (WS) with 1129.107 mg/L, the next high content nutrients are Mg and Ca with 210.660 mg/L in the WS water and 89.087 mg/L in the WS water also, while the minimum nutrient content is for Mn in all water types, but the minimum content of Mn appears in treated water (WT), the next low content nutrient in the water is Fe content.

4.2.1 Irrigation water effect in treated water plot (WT)

As shown in table (4.53), there are significant differences between all means of water quantity used for date tree irrigation in treated water plot (WT). This significance difference indicates that each treatment of water in the treated water plot is different in quantity and can give better image of the treated water quantity effect on the green date fruit nutrition and ripen date fruit quality.

Table (4.53): Irrigation water quantity applied on date trees in treated water plot (WT)

Treatment		WT50	WT75	WT100	WT125	WT150
Parameter						
Water	Mean (m^3)	50.00	75.00	100.00	125.00	150.00
	Grouping	E	D	C	B	A

For a given parameter, means within each line followed by the same letter are not significantly different. P<0.05, n=3.

4.2.1.1 Effect of treated water (WT) on green date fruits

The treated water quantity effect on green date fruit is discussed as in table (4.54) below, where there are three significance correlations between treated water quantity and green fruit nutrients, these correlations were found to have a significance (<0.05). The first correlation was with Mg content of green date fruit which is negative correlation with person correlation coefficient of R^2=0.537, while the second correlation also it is negative correlation with Ca content of green date fruits with R^2=0.605. The last correlation was found with N content of green date fruits, which is positive with R^2=0.620.

The positive correlation between treated water quantity used for irrigation and the nitrogen content in green date fruits can be justified from the high content of nitrogen in treated water as shown in table (4.52) where the N content in WT water is 5.229 (mg/L) which is three times higher the N content in the other two types of water (WS and WF).

Abd El-Kader et al. (2010) reach the same findings of the last correlation, where they mentioned that the increase of water irrigation leads to an increase in the uptake of NPK by fruits.

Table (4.54): Pearson correlations between irrigation water quantity and green date fruit nutrition parameters in treated water plot (WT)

Green fruit variable	R^2 in Treated Water plot (WT)
P	0.287
Fe	0.456
Mn	-0.283
Mg	-0.537 *
Ca	-0.605 *
Na	-0.469
K	-0.062
N	0.620 *

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

4.2.1.2 Effect of treated water (WT) on ripen date fruits

The treated water quantity shows a strong significant correlation with ripen date fruits quality parameters including fiber content, fat content, TSS, invert sugars and peel separation of date fruits, where these correlations are all at significance (<0.001) as shown in table (4.55).

The fiber content, TSS and invert sugars shows positive correlations with irrigation treated water quantity with person coefficient correlations of R^2= 0.845, 0.843 and 0.841 respectively, while the fat content and peel separation show negative correlation with irrigation treated water quantity with person coefficient correlation of R^2= 0.871 and 0.895 respectively.

The positive correlation between irrigation of treated water and fiber content in ripen date fruits agrees with a previous report by (Al-Yahyai et al. 2013), who indicated that the increase of irrigation water influenced the fiber content in date fruits. On the other hand, Weston and Barth (1997) mentioned that, the increase of nitrogen in soil leads to decrease of the fiber content in fruits, for that and in the case of treated water, the nitrogen content is high and will increase by increasing the treated water irrigation quantity, so this finding disagrees with the results of this study and with the previous findings by Al-Yahyai et al. (2013).

Table (4.55): Pearson correlations between irrigation water quantity and ripen date fruit nutrition and quality parameters in treated water plot (WT)

Ripen fruit variable	R^2 in Treated water plot (WT)
Fiber Content	0.845 ***
Fat Content	-0.871 ***
TSS	0.843 ***
Invert Sugars	0.841 ***
pH	0.474
Ec	0.362
Peel Separation	-0.895 ***

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

The increase in the proportion of treated water during irrigation leads to increase TSS in the date fruits as appears in this study, where this agrees with (Al-Qurashia et al. 2015) who found that the increase in fertilization leads to an increase in TSS in fruits. The same correlation is also found be (Elamin et al. 2017) and (El-Merghany et al. 2014), who mentioned that the increase in NPK fertilizer was increase the TSS in fruits. On the other hand, (Sadik et al. 2018) disagrees with these correlations and states that the increase in irrigation water decreases TSS in fruits. This is also the same finding by Al-Yahya Khan (2015) who also found that the irrigation water decreases TSS in fruits. On the same manner, (Sarker et al. 2016) also mentioned that the irrigation of mango trees leads to decreases TSS in mango fruits. The irrigation of Apple was decreased the TSS in Apple fruits as indicated by (Mohawesh and Al-Absi, 2009) who also disagree with the results of this study. Other authors found the increase of tomato fertilization increased TSS in tomato fruits as mentioned by (Wang and

Xing,2017). In citrus, (Zekri et al. 2018) published that the increase in irrigation water and the increase of N, P, K and Mg leads to increased TSS in citrus fruits which agrees with correlation found in this study between treated water irrigation and TSS of date fruits, where the treated water is rich in these nutrients (N, P, K and Mg).

Weston and Barth (1997) found an opposite correlation to the one found in this study between irrigation water and TSS in fruits. They found that the increase in irrigation water decreased TSS in vegetables. In the same manner and in the peach production in particular, (Crisosto and Costa 2008) found that the decrease in irrigation water was increased TSS in peaches. The same conclusion was also found by (Ritenour et al. 2002) who indicated that the increase of citrus tree irrigation decreased TSS in citrus. But this author mentioned that the increase in nitrogen for citrus trees was increased TSS in citrus which agrees with this study because the treated water is rich in nitrogen.

In accordance with the findings of this study, the increase of irrigation water causes an increase in invert sugars, which agrees with a previous study by (Sadik et al. 2018) who indicated that the increase of irrigation water was increased total sugars in date fruits. An opposite correlation to this study and to the previous correlation was found by (Al-Yahyai and Khan 2015) who found that the increase in irrigation water was decrease both the total sugars and reducing sugars. In the same manner, (Sarker et al. 2016) show in their study that the increase in irrigation water decreased total sugars, reducing sugars and non-reducing sugars.

As agreed with this study, (Al-Yahyai andManickavasagan,2013) indicated that the increase of irrigation water influenced the reducing sugars in date fruits. It appears in table (3.55) that the peel separation of date fruits was correlated negatively with treated water quantity at significance (<0.001) with person correlation coefficient of R^2= 0.895, this correlation is also shown in figure (4.12) below.

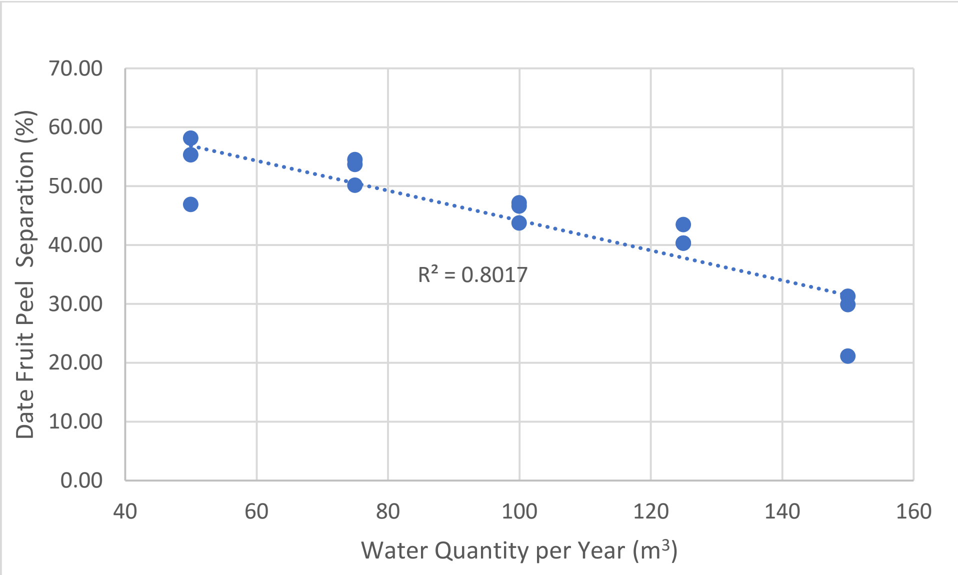


Fig. (4.12): Date fruit peel separation correlation with treated water quantity

Ibrahim and Zayed (2019) indicated in their study that, the increase of irrigation in summer causes fracture of date peel and leads to increase peel separation, especially at the end of khalal stage passing to rutab and Tamar stage. They mentioned that the decrease of irrigation times per month leads to decreased peel separation of date fruits according to the previous findings and the results of this study. We can conclude that the frequency of irrigation is very important on the effect of date peel separation and we cannot generalize that the increase of irrigation water can lead to reduce peel separation. It was also mentioned by the same authors that the increase of K content in water decreases the peel separation of date fruits, for that, this is justified by the increase of K content in treated water irrigated to date trees by increasing treated water quantity, which agrees with the findings of (Ibrahim and Zayed, 2019). In the same manner, Al-Hajaj et al. (2020) indicated that the peel separation is related to relative humidity around date fruit, where the peel separation increases by increasing relative humidity. The prior agrees with the results found by Ibrahim and Zayed (2019), who found that, the decrease of irrigation times per month will decrease peel separation which in turn decreases relative humidity and leads to decreased peel separation.

4.2.2 Irrigation water effect in salty water plot (WS)

It appears from table (4.56) that there is a significant difference between means of salty water quantity used for irrigation of date trees in our study. This significant difference is a good starting point to study the effect of salty water irrigation on date fruit quality and nutrition, where salty water treatment irrigated with different water quantity.

Table (4.56): Irrigation water quantity applied on date trees in salty water plot (WS)

Treatment / Parameter		WS50	WS75	WS100	WS125	WS150
water	Mean (m^3)	50.00	75.00	100.00	125.00	150.00
	Grouping	E	D	C	B	A

For a given parameter, means within each line followed by the same letter are not significantly different. P<0.05, n=3.

4.2.2.1 Effect of salty water on green date fruits

Table (4.57) shows only one significant correlation between salty water quantity and green date fruits nutrition that is Na content which is a negative correlation at significance (<0.05) with person correlation coefficient of R^2=0.614. This can be justifying by the fact that the increase of the availability of Na in soil by salty water leads to decreased absorption of Na by trees to fruits, where the salty water contains high content of Na as shown in table (4.52) which is 1129.107 mg/L, which also blocks the effect of water on all other nutrients in green date fruits. As mentioned, by (Mazahrih, et al. 2018), the salty soil restricts the mobility of P and K as it appears in our study that there are no significant correlations between salty water with P and K in green date fruits.

Table (4.57): Pearson correlations between irrigation water quantity and green date fruit nutrition parameters in salty water plot (WS)

Green fruit variable	R^2 in Salty water Plot (WS)
P	-0.073
Fe	-0.454
Mn	0.007
Mg	-0.007
Ca	-0.374
Na	-0.614 *
K	-0.049
N	-0.029

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

The results in our study of negative correlation between salty water and Na content in green date fruits disagrees with the results found by (Al-Rawi and Al-Mohemdy, 2012) whom found that the increase of salty water irrigation increased Na content in date fruits. In our study, and because the green fruits picked early; by May 2019 where the fruits were hardly exposed and there was no time to observe the effect of salty water on the new growth of green fruits.

4.2.2.2 Effect of salty water (WS) on ripen date fruits

The salty water quantity shows a good significant correlation with ripen date fruits quality parameters including fiber content, fat content, TSS, invert sugars and peel separation of date fruits, where these correlations are all at significance (<0.001).

The fiber content, TSS and invert sugars shows positive correlations with irrigation treated water quantity with person coefficient correlations of R^2= 0.972, 0.952 and 0.890 respectively, while the fat content and peel separation show negative correlation with irrigation treated water quantity with Pearson coefficient correlation of R^2= 0.975 and 0.960 respectively.

Table (4.58): Pearson correlations between irrigation water Quantity and ripen date fruit nutrition and quality parameters in salty water plot (WS)

Ripen fruit variable	R^2 in Salty Water Plot (WS)
Fiber Content	0.972 ***
Fat Content	-0.975 ***
TSS	0.952 ***
Invert Sugars	0.890 ***
pH	0.122
Ec	-0.284
Peel Separation	-0.960 ***

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

The positive correlation between irrigation of salty water quantity and fiber content in ripen date fruits agrees with previous findings by (Al-Yahyai and Manickavasagan, 2013), whom indicated that the increase of irrigation water influenced the fiber content in date fruits.

The increase of salty water during irrigation leads to increased TSS in the date fruits as appears in this study. The prior agrees with (Al-Qurashia et al. 2015) who found that the increase in fertilization leads to an increase in TSS in fruits. On the other hand, (Sadik et al. 2018) disagrees with the results of this study where they found that the increase in irrigation water decreased TSS in fruits. This is also the same finding by (Al-Yahyai and Khan, 2015) who also found that the irrigation water decreases TSS in fruits. In the same line, (Sarker et al. 2016) also mentioned that the irrigation of mango trees leads to decreased TSS in mango fruits. The irrigation of apples decreased the TSS in apple fruits as indicated by (Mohawesh and Al-Absi, 2009) who also disagree with the results of this study. Regarding citrus, (Zekri et al. 2018), published that the increase in irrigation water and the increase of N, P, K and Mg lead to increased TSS in citrus fruits which agrees with correlation found in this study between treated water irrigation and TSS of date fruits, where the treated water is rich in these nutrients (N, P, K and Mg).

It is also found the opposite correlation of the that found in this study between irrigation water and TSS in fruits by (Weston and Barth 1997) who found that the increase in irrigation water decreased TSS in vegetables, they also indicated that the increase of salinity stress in water cause was increased TSS and sugars in vegetables, which agrees with the results of this study. In the same manner and in the peach production in particular, (Crisosto and Costa 2008) found that the decrease in irrigation water increased TSS in peaches. The same was also thing found by (Ritenour et al. 2002) who indicated that the increase of citrus tree irrigation decreased TSS in citrus. Never the less this author mentioned that the increase in nitrogen for citrus trees increased TSS in citrus which agrees with this study because the treated water is rich in nitrogen.

In this study, the increase of irrigation water causes an increase in invert sugars and this agrees with previous study by (Sadik et al. 2018) who indicated that the increase of irrigation water was increase total sugars in date fruits. An opposite correlation to this study and to the previous correlation was found by (Al-Yahyai and Khan, 2015) who found that the increase in irrigation water decreased both the total sugars and reducing sugars. In the same manner, (Sarker et al. 2016) shows in their study that the increase in irrigation water was decreases total sugars, reduces sugars and non-reducing sugars. As agreed with this study, (Al-Yahyai and Manickavasagan, 2013) indicated that the increase of irrigation water influenced the reducing sugars in date fruits.

It appears from table (4.58) that the peel separation of date fruits correlated negatively with salty water quantity at significance (<0.001) with Pearson correlation coefficient of $R^2 = 0.960$, this correlation is also shown in figure (4.13) below.

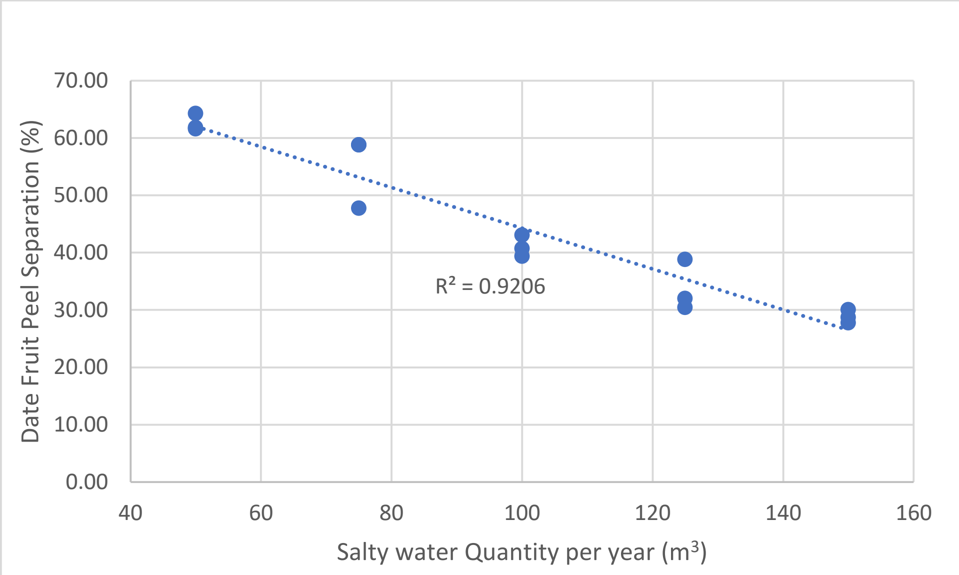


Fig. (4.13): Date fruit peel separation correlation with salty water quantity

4.2.3 Irrigation water effect in fresh water plot (WF)

The same as treated water and salty water, it appears from table (4.59) that there is a significant difference between means of fresh water quantity used for irrigation of date trees in our study. This significant difference is a good starting point to study the effect of fresh water irrigation on date fruit quality and nutrition.

Table (4.59): Irrigation water quantity applied on date trees in fresh water plot (WF)

Treatment / Parameter		WF50	WF75	WF100	WF125	WF150
Water	Mean (m^3)	50.00	75.00	100.00	125.00	150.00
	Grouping	E	D	C	B	A

For a given parameter, means within each line followed by the same letter are not significantly different. P<0.05, n=3.

4.2.3.1 Effect of fresh water on green date fruits

The fresh water quantity effect on green date fruit is discussed as in table (4.60) below, where there is one significance correlation at significance (<0.05) between fresh water quantity and green fruit nutrients, this correlation is found with Mg content of green date fruit which is a negative correlation with Pearson correlation coefficient of R^2=0.556. It is noticed that this Mg correlation is also found in treated water with green date fruits with negative correlation.

The Mg content in fresh water was tested to be 52.883 mg/L, so as the fresh water increase, the Mg added to soil increase. May be due to absorptivity restrictions of Mg by plant from salty and calcareous soil, the Mg content in green fruits appear to decrease, also the green fruit was picked early when as it appeared in the beginning of May, so this will not give a strong and clear correlation between fresh water quantity used for irrigation and the Mg content in green fruits.

Table (4.60): Pearson correlations between irrigation water quantity and green date fruit nutrition parameters in fresh water plot (WF)

Green fruit variable	R^2 in Fresh water plot (WF)
P	-0.128
Fe	0.265
Mn	0.354
Mg	-0.556 *
Ca	0.356
Na	-0.176
K	0.311
N	0.413

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

4.2.3.2 Effect of fresh water (WF) on ripen date fruits

The same as treated water and salty water, the fresh water quantity shows a good significance correlation with ripen date fruits quality parameters including fiber content, fat content, TSS, invert sugars and peel separation of date fruits, where these correlations are all at significance (<0.001) as shown in table (4.61).

The fiber content, TSS and invert sugars shows positive correlations with irrigation treated water quantity with person coefficient correlations of R^2= 0.987, 0.933 and 0.876 respectively, while the fat content and peel separation show negative correlation with irrigation treated water quantity with person coefficient correlation of R^2= 0.973 and 0.905 respectively.

Table (4.61): Pearson correlations between irrigation water quantity and ripen date fruit nutrition and quality parameters in fresh water plot (WF)

Ripen fruit variable	R^2 in Fresh water plot (WF)
Fiber Content	0.987 ***
Fat Content	-0.973 ***
TSS	0.933 ***
Invert Sugars	0.876 ***
pH	0.076
Ec	-0.152
Peel Separation	-0.905 ***

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

The positive correlation between irrigation of fresh water and fiber content in ripen date fruits agreed with previous foundation by (Al-Yahyai and Manickavasagan, 2013), who indicated that the increase of irrigation water was influenced the fiber content in date fruits.

The increase of fresh water during irrigation leads to increased TSS in the date fruits as appears in this study, which with (Al-Qurashia et al. 2015) who found that the increase in fertilization leads to increase in TSS in fruits.

It is apparent from table (4.61) that the peel separation of date fruits was correlated negatively with fresh water quantity at significance (<0.001) with Pearson correlation coefficient of R^2= 0.905, this correlation is also shown in figure (4.14) below.

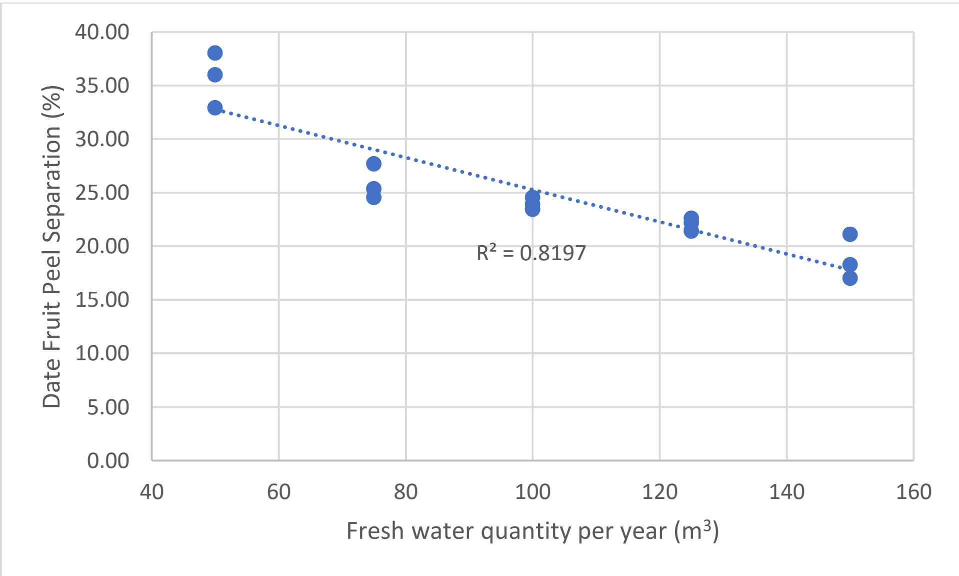


Fig. (4.14): Date fruit peel separation correlation with fresh water quantity

Section Three: Fertilizer Effect

4.3 Fertilizer Effect

There are three fertilizer plots studied in this research to see the effect of fertilizer on green date fruit nutrition and ripen date fruit nutrition and quality. One plot called nitrogen fertilizer plot (FN) and is used to study the nitrogen fertilizer effect, the second plot called phosphorus fertilizer plot (FP), and is used to study the effect of phosphorus, while the third plot was potassium fertilizer plot which is used to study the effect of potassium fertilizer. The other water plots get the same amount of fertilizer from each of N, P, K fertilizer which was added as $(NH_4)_2SO_4$, P_2O_5 and K_2O.

The date collected in this study was analyzed by SAS statistical program and excel program in terms of means of the used N, P, K for date trees in each plot in this study which are: nitrogen fertilizer plot (FN), phosphorus fertilizer plot (FP) and potassium fertilizer plot (FK). Also, correlations were studied between each fertilizer used from N, P and K with green date fruit nutrition and with the ripen date fruit nutrition and quality.

4.3.1 Fertilizer effect in nitrogen fertilizer plot (FN)

The means of fertilizer quantities of N, P and K used in nitrogen fertilizer Plot as $(NH_4)_2SO_4$, P_2O_5 and $K_2O$for all treatments of FN0, FN7.5 and FN 15 are shown in table (4.80). It is shown from this table that there is significant difference between the means of nitrogen fertilizer in the nitrogen plot (FN), where the mean of N fertilizer is 0.00, 7.5 and 15 kg/tree/year in FN0, FN7.5 and FN15 respectively.

On the other hand, table (4.62) shows that there is no significant difference between the means of P and K between all treatments of FN0, Fn7.5 and FN15 in the FN plot.

Table (4.62): Fertilizer quantity applied on date trees in nitrogen fertilizer plot (FN)

Treatment / Parameter		FN0	FN7.5	FN15
N	Mean (kg)	0.00	7.50	15.00
	Grouping	C	B	A
P	Mean (kg)	0.50	0.50	0.50
	Grouping	A	A	A
K	Mean (kg)	2.00	2.00	2.00
	Grouping	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

4.3.1.1 Fertilizer effect on green date fruits in nitrogen fertilizer plot (FN)

Green date fruit content of P, Fe, Mn, Mg, Ca, Na, K and N didn’t show any significance correlations with N, P and K fertilizer used in the FN plot, even there are some insignificant correlations that appear in for nitrogen fertilizer.

From section (4.3.1) it was anticipated to have correlation between nitrogen fertilizer and the green fruit parameters, but the correlations that appear are not of significance. Regarding other fertilizers, P and K, there are no correlations as anticipated since the mean of these fertilizers used are the same with no significance difference.

The negative insignificant correlation with person correlation coefficient of R2= 0.486 between nitrogen fertilizer and Mg content in green fruits comply with the results found by (Ibrahim and Zayed, 2019) who indicate that the increase of nitrogen in the soil leads to lack the absorption of Mg.

Table (4.63): Pearson correlations between NPK fertilizer quantity and green date fruit nutrition in nitrogen fertilizer plot (FN)

Plot	Fertilizer	Green Fruits Parameters							
		P	**Fe**	**Mn**	**Mg**	**Ca**	**Na**	**K**	**N**
FN	$(NH_4)_2SO_4$	-0.089	-0.382	-0.219	-0.486	-0.384	-0.388	0.233	-0.146
	P_2O_5	-	-	-	-	-	-	-	-
	K_2O	-	-	-	-	-	-	-	-

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

4.3.1.2 Fertilizer effect on ripen date fruits in nitrogen fertilizer plot (FN)

Ripen date fruit content of fiber, fat, TSS, invert sugars, pH, EC and peel separation did not show any significance correlations with N, P and K fertilizer used in the FN plot, despite the fact that there are some insignificant correlations that appear for nitrogen fertilizer as shown in table (4.64).

From section (4.3.1), since there is significance difference between the means of nitrogen fertilizer in FN plot, significance correlation between N fertilizer and ripen date parameters should be found, but these correlations are insignificance, while the other fertilizers of P and K didn’t show any correlations with ripen date fruits because there is no significance difference between means of quantity of P and K fertilizers in all treatments.

Zekri et al. (2018) published that the increase of nitrogen in soil increased the TSS in citrus fruits, but the excess of nitrogen fertilizer decreased TSS. The previous result complies with the results of this study as appear in table (3.64) where there is a negative correlation between nitrogen fertilizer and the TSS in date fruits, but this correlation is not significance at significance (<0.05). The correlation between nitrogen fertilizer and fiber content in date fruits is negative, but insignificant where this complies with the results found by (Al-Farsi and Chang Yong Lee, 2008) who indicated that the increase of nitrogen in soil leads to a decrease the in dietary fiber in date fruits. On the other hand, (Ritenour et al. 2002) disagrees with the results of this study and indicated that the increase of the nitrogen in soil increased the TSS in citrus fruits.

Table (4.64): Pearson correlations between NPK fertilizer quantity and ripen date fruit nutrition and quality in nitrogen fertilizer plot (FN)

Plot	Fertilizer	Fruit Quality						
		Fiber	**Fat**	**TSS**	**In Sug**	**pH**	**EC**	**Separation**
FN	$(NH_4)_2SO_4$	-0.120	0.207	-0.083	-0.192	-0.204	-0.196	0.228
	P_2O_5	-	-	-	-	-	-	-
	K_2O	-	-	-	-	-	-	-

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

4.3.2 Fertilizer effect in phosphorus fertilizer plot (FP)

In phosphorus plot (FP), as shown in table (4.65), there is a significance difference between means of P fertilizer used in all treatments of FP0, FP0.5 and FP1 in FP plot, where the means used in the three treatments of P_2O_5 are 0.00, 0.5 and 1.00 kg/tree/year, while there are no significance difference between means of N and K fertilizers in all treatment of FP0, FP0.5 and FP1 in FP plot where the mean used of $(NH_4)_2SO_4$ and K_2O are fixed in all treatments with 7.50 and 2.00 kg/tree/year respectively.

Table (4.65): Fertilizer quantity applied on date trees in phosphorus fertilizer plot (FP)

Treatment / Parameter		FP0	FP0.5	FP1
N	Mean (kg)	7.50	7.50	7.50
	Grouping	A	A	A
P	Mean (kg)	0.00	0.50	1.00
	Grouping	C	B	A
K	Mean (kg)	2.00	2.00	2.00
	Grouping	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

4.3.2.1 Fertilizer effect on green date fruits in phosphorus fertilizer plot (FP)

Green date fruit content of P, Fe, Mn, Mg, Ca, Na, K and N didn't show any significance correlations with N, P and K fertilizer used in the FP plot, even there are some insignificant correlations appear in for phosphorus fertilizer plot FP.

From section (4.3.2) it was anticipated to have correlations between phosphorus fertilizer and the green fruit parameters, but these correlations that appear are not significance. Regarding other fertilizers, N and K, there are no correlations as anticipated since the mean of these fertilizers used are the same with no significance difference.

Ibrahim and Zayed (2019), in their study mentioned that the increase of P fertilizer leads to precipitation of iron into iron phosphate, and then the reduction of the absorbed of Fe. The authors mentioned the same behavior of N in green fruits like Fe, but this disagrees with the results of this study in terms of the correlation between P fertilizer and green fruit content of Fe is positive, but this correlation was not significant. In the same manner, (HAAS,1949) indicate that the application of P and K plus N in avocado leads to increased P and K in avocado leaves and fruits, but this disagrees with the results of this study where the correlations between P_2O_5 used for date trees and the contents of P and K in green date fruits are negative.

Table (4.66): Pearson correlations between NPK fertilizer quantity and green date fruit nutrition in phosphorus fertilizer plot (FP)

Plot	Fertilizer	Green Fruits Parameters							
		P	**Fe**	**Mn**	**Mg**	**Ca**	**Na**	**K**	**N**
FP	$(NH_4)_2SO_4$	-	-	-	-	-	-	-	-
	P_2O_5	-0.493	0.105	0.519	0.566	0.485	0.483	-0.165	0.484
	K_2O	-	-	-	-	-	-	-	-

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

4.3.2.2 Fertilizer effect on ripen date fruits in phosphorus fertilizer plot (FP)

Ripen date fruit content of fiber, fat, TSS, invert sugars, pH, EC and peel separation showed some correlations P fertilizer used in the FP plot, where these correlations are positive with fiber content, TSS, invert sugars, pH and EC, while they are negative with fat content and peel separation, but all these correlations are not significant at significance (<0.05) as shown in table (3.67).

From section (4.3.2), since there is significance difference between the means of phosphorus fertilizer in FP plot, there are possibilities to find correlation between P fertilizer and ripen date parameters, but these correlations are insignificance, while the other fertilizers of N and K did not show any correlations with ripen date fruits because there is no significance difference between means of quantity of N and K fertilizers in all treatments.

The increase of P fertilizer in Citrus increased TSS and decreased acid concentration in citrus fruits as published by (Zekri et al. 2018). This foundation is in agreement with the results of this study for TSS, where the correlation between P_2O_5 used TSS is positive, while this foundation is disagreeing with this study for pH where the correlation between P_2O_5 is positive. In the same manner, (El-Merghany et al. 2014) mentioned that the application mixed NPK fertilizer leads to increase TSS in date fruits. This finding agrees with the results of this study.

(Weston and Barth et al. 1997) indicates that the increase of phosphorus fertilizer was increased both TSS and total sugars in tomato, this foundation agrees with the results of this study where the correlations between P2O5 used and both TSS and invert sugars content in the ripen fruits are positive. In the same manner, (Al-Kharusi et al. 2009) indicates that the application of NPK fertilizer was increase glucose and fructose content which are the invert sugars in dates, also increased titratable acidity in date fruits. The prior findings agree with the results of this study where the correlations between P2O5 used and both invert sugars and pH are positive. In some differences with citrus fruits, (Ritenour et al. 2002) indicated that the increase of P fertilizer in citrus was increased sugars, which agrees with the results of this study, while decreased the acid content and TSS which both disagree with the results of this study.

Table (4.67): Pearson correlations between NPK fertilizer quantity and ripen date fruit nutrition and quality in phosphorus fertilizer plot (FP)

Plot	Fertilizer	Fruit Quality						
		Fiber	**Fat**	**TSS**	**In Sug**	**pH**	**EC**	**Separation**
FP	$(NH_4)_2SO_4$	-	-	-	-	-	-	-
	P_2O_5	0.445	-0.342	0.394	0.402	0.208	0.494	-0.403
	K_2O	-	-	-	-	-	-	-

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

4.3.3 Fertilizer effect potassium fertilizer plot (FK)

As shown in table (4.68), in potassium plot (FK), there are no significance difference between means of N and P fertilizers in all treatment of FP0, FP0.5 and FP1 in FP plot where the mean used of $(NH_4)_2SO_4$ and P_2O_5 are fixed in all treatments with 7.50 and 0.50 kg/tree/year respectively. But there is a significance difference between means of K fertilizer used in all treatments of FP0, FP0.5 and FP1 in FK plot, where the means used in the three treatments of K_2O are 0.00, 2.00 and 4.00 kg/tree/year.

The significance difference between means of K fertilizer used for date trees in FK plot establish a possibility of finding correlations between K fertilizer, the date fruit nutrition, and the quality parameters.

Table (4.68): Fertilizer quantity applied on date trees in potassium fertilizer plot (FK)

Treatment / Parameter		FK0	FK2	FK4
N	Mean (kg)	7.50	7.50	7.50
	Grouping	A	A	A
P	Mean (kg)	0.50	0.50	0.50
	Grouping	A	A	A
K	Mean (kg)	0.00	2.00	4.00
	Grouping	C	B	A

For a given parameter, means within each line followed by the same letter are not significantly different. P<0.05, n=3.

4.3.3.1 Fertilizer effect on green date fruits in potassium fertilizer plot (FK)

The contents of green date fruit of P, Fe, Mn, Mg, Ca, Na, K and N did not show any significance correlations with N, and P fertilizer used in the FK plot, but there are some weak correlations that appear in FK plot between K fertilizer and green date fruit nutrition, but these correlations are with no significance; at significance (<0.05) as shown in table (4.68).

From section (4.3.3) it was anticipated to have correlations between potassium fertilizer and the green fruit parameters because there is significance difference between means of K_2O and green date fruit nutrition, there are some correlations, but these correlations that appear are not significance. Regarding other fertilizers, N and P, there are no correlations as anticipated since the mean of these fertilizers used are the same with no significance difference.

Ibrahim and Zayed, (2019) indicated that the fertilization by nitrogen or potassium leads to lack of absorption of Mg, this result did not comply with results of this study, where the correlation between K2O used and Mg is positive. The prior may be is due to the fact that the green fruit did not have sufficient time to absorb Mg and show real correlation.

Kassem, (2012) found in his paper that the increase of potassium fertilizer increased the fruit content of N, Fe, Mn. This foundation agrees with the results of this study in terms of the correlation between K_2O and N which is positive, while this foundation disagrees with results of this study in terms of Fe and Mn which are indeed negative correlations.

Increase of K fertilization was found to increase N, P, K and Fe while it decreases Mn. The prior finding was achieved by (Al-Obeed et al. 2013), in comparison with the results of our study, this finding agrees with correlations of N and Mn with K_2O used, but disagree with the correlations of P and K with K_2O. Another finding that actually disagrees with the results of this study was reached by (Ibrahim and Zayed, 2019) who state that the increase of K fertilization reduced the absorption of Ca and Mg, while in this study, the increase of K_2O fertilizer found to increase Ca and Mg content in green date fruits which contradicts the anticipation where the charge of K ion is (+) while the charge of Ca and Mg ions are (++), for that the activity of K should restrict the absorption of Ca and Mg. The same was also found for the Ca content in fruits by (Kuzin et al. 2020) who indicate that the increase of K fertilizer in apples decreased the K content in the fruits.

Table (4.69): Pearson correlations between NPK fertilizer quantity and green date fruit nutrition in potassium fertilizer plot (FK)

Plot	Fertilizer	Green Fruits Parameters							
		P	**Fe**	**Mn**	**Mg**	**Ca**	**Na**	**K**	**N**
FK	$(NH_4)_2SO_4$	-	-	-	-	-	-	-	-
	P_2O_5	-	-	-	-	-	-	-	-
	K_2O	-0.488	-0.230	-0.008	0.140	0.629	-0.384	-0.606	0.110

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

4.3.3.2 Fertilizer effect on ripen date fruits in potassium fertilizer plot (FK)

As shown by table (4.70), the ripen date fruit parameters of fiber, fat, TSS, invert sugars, pH, EC and peel separation show a good correlations with potassium fertilization in the potassium plot (FK), while the other two fertilizers of N and P did not show any correlation with ripen date parameters which is *true* *logic* where in section (4.3.3), there are significance difference between means of K_2O fertilizer used in all treatments of FK0, FK2 and FK4, while there was no significance differences between means of $(NH_4)_2SO_4$ and P_2O_5 fertilizers used in all FK treatments.

Table (4.70): Pearson correlations between NPK fertilizer quantity and ripen date fruit nutrition and quality in potassium fertilizer plot (FK)

Plot	Fertilizer	Fruit Quality						
		Fiber	**Fat**	**TSS**	**In Sug**	**pH**	**EC**	**Separation**
FK	$(NH_4)_2SO_4$	-	-	-	-	-	-	-
	P_2O_5	-	-	-	-	-	-	-
	K_2O	0.995 ***	-0.997 ***	0.909 ***	0.878 **	-0.314	-0.389	-0.936 ***

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

The fiber content of ripen date fruits shows a positive significance correlation at significance (<0.001) at person correlation coefficient R^2 0.995 with K fertilizer of K_2O. On the other hand, the fat content in ripen date fruits correlate negatively with K fertilizer at significance (<0.001) with person correlation coefficient R^2 of 0.997. In this manner, (Ragab, et al. 2011) indicates that the fruit development to tamer stage leads to decreased fat content in the date fruit. On the other hand, (Salem and Hassan,2020), mentioned that the application of K fertilizer was enhance the formation of fat in date fruits which is opposite of the results in this study.

The TSS shows a positive correlation with K fertilizer at significance (<0.001) with R^2 of 0.909, this result complies with the results suggesting that the TSS increases by spraying date trees with potassium silicate, this was found by (Aly and El Agamey,2018). This result was also approved by (Elamin et al. 2017) who indicated that the increase of NPK fertilizer increased TSS in date fruits.

This also agrees with the result found by (Elsayd, et al. 2018) who mentioned that the date trunk injection with 3% K_2SO_4 increased TSS in date fruits. Ezz et al. (2010) mentioned that the increase of K fertilizer increased TSS in date fruits which also agrees with the results of this study. In the same manner, (Zekri et al. 2018) published that the increase of K fertilizer of citrus was increase TSS in citrus fruit, which is in line with the results of this study. However, (Ritenour et al. 2002) indicated in their study an opposite finding to this study and all above publication and said that the increase of K fertilizer in citrus indeed decreased the TSS in citrus fruits.

Invert sugars also show positive significance correlation at significance (<0.01) with R2 of 0.878 with K_2O fertilizer. This complies with the results found by (Aly and El Agamey, 2018), who indicated that the total sugars increased by spraying date trees with potassium silicate. This also agrees with the result found by (Elsayd, et al. 2018) who mentioned that the date trunk injection with 3% K_2SO_4 was increased the reducing sugars (invert sugars) in date fruits. As agreed with the results of this study, (Ezz et al. 2010) mentioned that the increase of K fertilizer increased reducing sugars in date fruits.

In terms of peel separation, the results show a negative correlation between peel separation of date fruits and K fertilizer of K_2O at significance (<0.001) with person correlation coefficient of R2=0.936. This may be due to the fact potassium play a good rule in balancing the water and osmotic pressure in the cell and decreases the effect of turgor pressure during ripening which reduces the possibilities of separation of date peel. (Ibrahim and Zayed, 2019) published that the increase of K fertilizer in date trees was decrease the date fruit peel separation which agrees with the results of this study. Figure (4.15) below describe the correlation between date fruit peel separation and potassium fertilizer as k_2O.

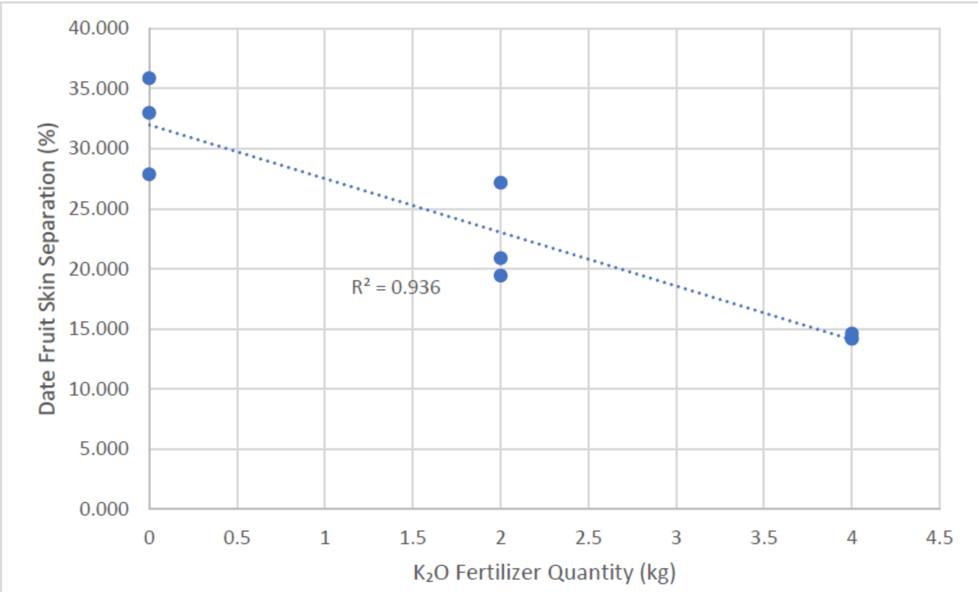


Fig. (4.15): ripen date fruit peel separation vs. potassium fertilizer as P_2O in potassium fertilizer plot.

Regarding ripen date fruits pH and EC, it is shown in table (4.70) that there are no significance correlations between ripen date fruit pH and EC in terms of pH and EC with potassium fertilizer as K_2O in potassium plot (FK).

In a previous study conducted by (Weston and Barth,1997), the authors indicated that the increase in potassium fertilizer leads to increased vegetables pH, which is opposite to the results in this study.

Section Four: Ripen date Nutrition Effect

4.4 Ripen date nutrition Effect

The nutrition parameters of ripen date fruits studied in this this study are the fiber content, the fat content, TSS, Invert sugars, pH, EC and date fruit peel separation, where the mean of each quality parameter of date fruits firstly compared in each treatment plot of the six plots in this study which are treated water (WT), Salty water (WS), fresh water (WF, nitrogen fertilizer plot (FN), Phosphorus fertilizer plot (FP) and potassium fertilizer plot (FK).

During this section, the correlations between nutrition parameters of fiber, fat, TSS, invert sugars, pH and EC with date fruit peel separation were discussed to analyze the effect of nutrition parameters on peel separation of date fruit, where this discussion include that effect in the six treatment plots of WT, WS, WF, FN, FP and FK.

Firstly, the means of each nutrition parameters and fruit peel separation were discussed and compared to check the significant difference between means of each parameters in all treatments of each plot of WT, WS, WF, FN, FP and FK as discussed in Tables (4.89), (4.91), (4.93), (4.95), (4.97) and (4.99). Then the correlations between the nutrition parameters of date fruits with date fruit peel separation were discussed as shown in tables (4.90), (4.92), (4.94), (4.96), (4.98) and (4.100). Also, the prior correlations were presented in figures (4.17), (4.18), (4.19), (4.20), (4.21), (4.22).

4.4.1 Ripen date nutrition parameters effect on date fruit peel separation in treated water plot (WT)

In treated water plot and as shown from table (4.71) that the means of fiber content in date fruits increased with treated water and these means were significantly difference between WT50 and WT150, while there was no significant difference between means of fiber content in all treatments of WT50, WT75, WT100 and WT125. Besides, there were no significance difference of means of fiber content between WT150, WT75, WT100 and WT125. This nearly approves the significance that appears between means of peel separation in all treatments of WT plot, where there were significant difference of peel separation means between WT50, WT125 and WT150, while there were no significance difference of peel separation means between WT50, WT75 and WT100, also there were no significant difference of peel separation means between WT75, WT100 and WT125.

The mean of fat content in date fruit of Treated water plot (WT) were decrease with increasing treated water quantity and there was significantly difference between WT75 and both WT125 and WT150, while there was no significant difference between means of fat content in WT50, WT75 and WT100. In the same manner there was no significant difference between means of fat content in WT50, WT100 and WT125. The fat content significance was closer to the significance of date fruit peel separation where there was significant difference between means of peel separation in WT50, WT125 and WT150; also, there was significance difference of peel separation means in WT75 and WT150. In the same manner there was significant difference of peel separation means in WT100 and WT150, while there was no significance difference between WT50, WT75 and WT100, also there was no significant difference of peel separation means in WT75, WT100 and WT125.

The TSS and invert sugars in date fruits within WT plot has the same significance of means between treatments, where both TSS and invert sugars increased with treated water, and there was significance difference of TSS and invert sugars means in WT50 and WT150. In addition to the prior, there was significant difference of means of both TSS and invert sugars in WT75 and WT150, while there was no significant difference of TSS and invert sugars means in WT50, WT75, WT100 and WT125, also there was no significant difference of TSS and invert sugars means in WT75, WT100, WT125 and WT150

The means of both pH and EC of the date fruits didn't show any significant difference between all treatments in WT plot.

Table (4.71): Date fruits nutrition and quality in treated water plot (WT)

Treatment / Parameter		WT50	WT75	WT100	WT125	WT150
Fiber	Mean (%)	1.54	1.58	1.62	1.64	1.68
	Grouping	B	B, A	B, A	B, A	A
Fat	Mean (%)	0.48	0.49	0.39	0.33	0.25
	Grouping	B, A	A	B, A, C	B, C	C
TSS	Mean (%)	81.71	82.77	85.91	86.49	90.09
	Grouping	B	B	B, A	B, A	A
Invert Sugar	Mean (%)	42.80	43.69	46.43	47.29	50.38
	Grouping	B	B	B, A	B, A	A
pH	Mean (mg/kg)	4.68	4.71	4.78	4.75	4.78
	Grouping	A	A	A	A	A
EC	Mean (ms)	3.26	3.14	3.20	3.75	3.41
	Grouping	A	A	A	A	A
Separation	Mean (%)	53.44	52.76	45.82	41.36	27.39
	Grouping	A	B, A	B, A	B	C

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

The date peel separation in WT plot correlates with four nutrition parameters at significance (<0.001) as shown in table (4.72) and fig. (4.16), where it correlates negatively with date fruit fiber contents, TSS and invert sugars with person correlation coefficient of R^2 of 0.899, 0.900 and 0.898 respectively, while it correlates positively with fat content with person correlation coefficient of R^2 of 0.935. These correlations were justified by the significance difference of means of fiber content, fat content, TSS and invert sugars discussed above between WT treatments. On the other hand, there was no significant correlation between date fruit peel separation and both date fruit pH and EC. The non-significance correlations between date fruit peel separation and both date fruit pH and EC were justified by the non-significance difference between means of these parameters in the WT treatments.

Regarding fiber content, (Ibrahim and Zayed, 2019) found that the increase in fiber content leads to increase in the peel thickness of the fruit which decreases peel separation of date fruit. This finding agrees with the results of this study where the correlation between fiber content and peel separation in WT plot was negative. In another study conducted by (Ragab, et al. 2011), he mentioned that during fruit development from Khalal to rutab stage, the fiber content decreased and the highest percentage of peel separation occurred in this transition stage which agrees with our study which suggests an increase in the peel separation by decreasing the fiber content. The irrigation was found to influence fiber content in dates as found by (Al-Yahyai and Manickavasagan,2013) which decrease peel separation, this finding also agreed with the results in this study.

Table (4.72): Pearson correlations between ripen date nutrition parameters and date fruit peel separation in treated water plot (WT)

Date fruit Parameter	Date fruit peel separation in WT
Fiber	-0.899***
Fat	0.935***
TSS	-0.900***
Invert	-0.898***
pH	-0.357
Ec	-0.377

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

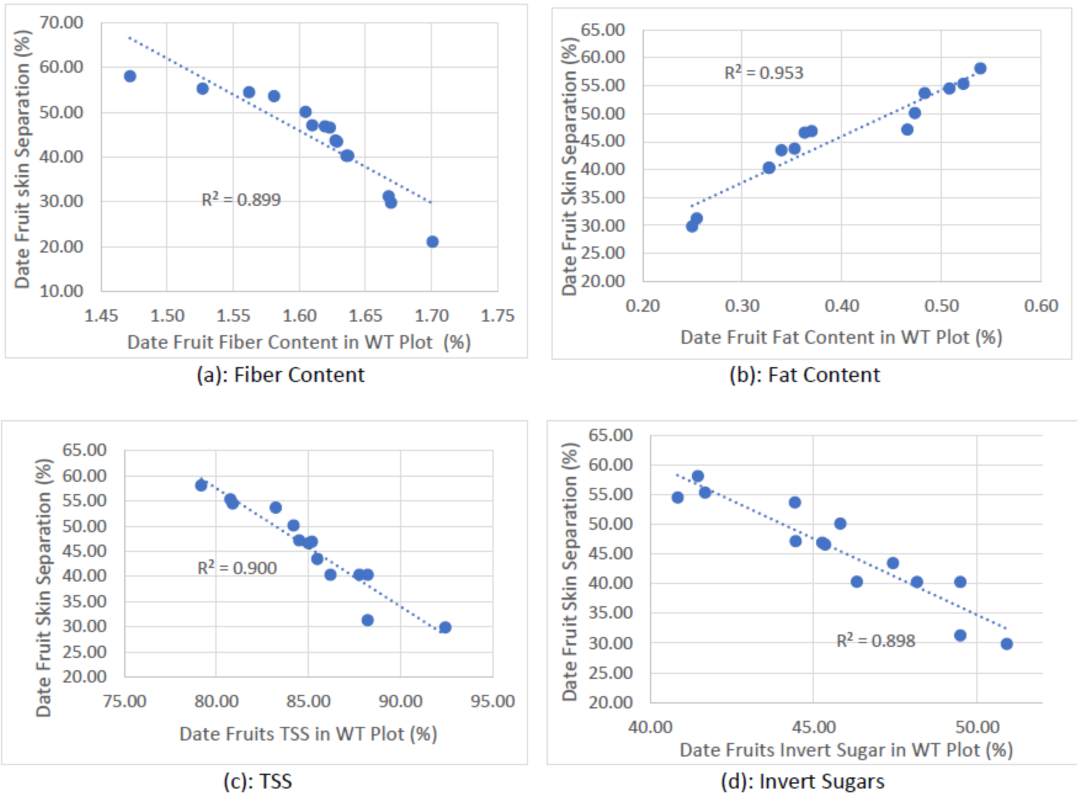


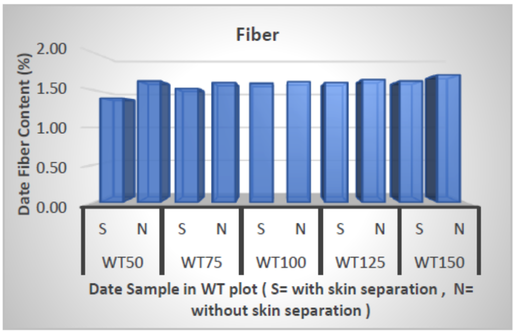
Fig. (4.16): Correlations between ripen date fruit nutrition parameters and date fruit peel separation in treated water plot (WT). (a)= fiber content vs. peel separation, (b) = fat content vs. peel separation, (c) = TSS content vs. peel separation, (d) = invert sugars vs. peel separation.

To compare the nutrition content of the same sample of date fruits with and without peel separation, five samples were selected and studied from the five treatments in WT plot which are: WT50, WT75, WT100, WT125 and WT150 where the results of the nutrition content of these samples were tabulated and studied as shown in Table (4.73) and fig. (4.17).

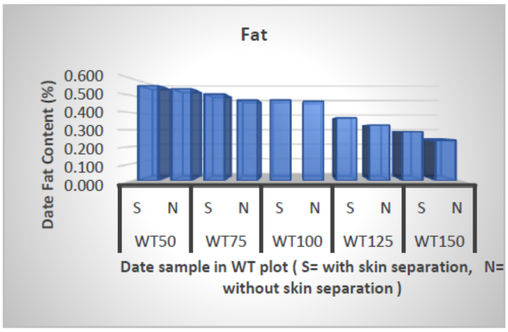
Table (4.73): Comparison between peel separated date fruits and non-separated date fruits in terms of nutrition content in WT plot

Treatment	Separation	Nutrition Content in WT plot of dates with and without peel separation					
		Fiber	Fat	TSS	Invert Sugars	Ph	EC
WT50	S	1.390	0.557	78.422	37.683	4.760	3.180
	N	1.620	0.539	79.180	41.457	4.670	3.370
WT75	S	1.520	0.509	82.256	44.042	4.590	3.650
	N	1.600	0.473	84.200	45.809	4.650	3.180
WT100	S	1.590	0.474	81.648	42.187	4.690	3.080
	N	1.610	0.466	84.501	44.446	4.750	3.250
WT125	S	1.600	0.369	82.742	42.752	4.570	3.500
	N	1.640	0.327	87.766	48.152	4.700	3.500
WT150	S	1.620	0.288	86.994	47.512	4.820	3.410
	N	1.700	0.238	89.631	50.747	4.670	3.890

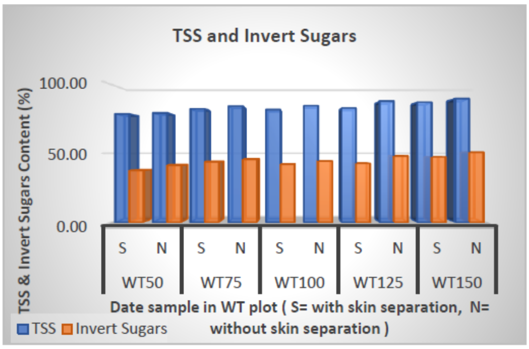
S= with peel separation N= without peel separation

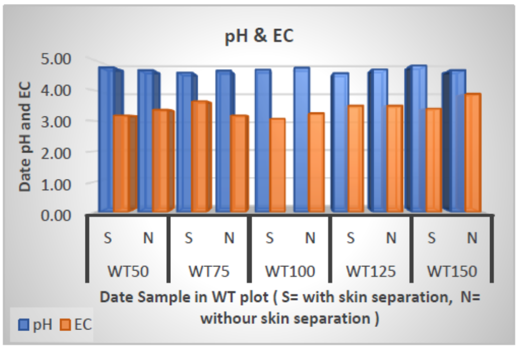


(a):Fiber



(b): Fat





(c): TSS and Invert Sugars

(d): pH and EC

Fig. (4.17): comparison between ripen date fruit with and without peel separation in terms of nutrition parameters in treated water plot (WT). (a)= fiber content, (b)= fat content, (c)= TSS $ invert sugars content, (d)= pH and EC.

It is shown in the above table (4.73) and fig. (4.17) that the fiber content in the date samples without peel separation higher than that in the same samples with peel separation, which gives an indication that the fiber content helps the date cell to be more rigid and keep the peel in more contact with the date pulp. On the other hand, the opposite phenomenon was found for fat content, where the date sample without peel separation contains lower fat content than that samples with peel separation, this may be due to fact that the fat content in dates may facilitate for the date peel separation from pulp during evaporation under hot temperature.

Regarding TSS and invert sugars, it appears that the TSS and invert sugars content in date samples without peel separation was higher than in samples with peel separation. The prior may be due to the increase of soluble contents in dates without peel separation, and this can control the water evaporation speed through date peel, and reduce the possibility of separation date peel from pulp.

The pH date samples at very low and very high treated water quantity (WT50 and WT150 show higher values in samples with peel separation, whereas they show higher values in sample of without peel separation in medium quantity of treated water (WT75, WT100 and WT125). On the other hand, EC of date fruits did not show any clear trends between date samples with and without peel separation.

4.4.2 Ripen date nutrition parameters effect on date fruit peel separation in salty water plot (WS)

From table (4.74), it can be inferred that the means of fiber content of date fruits in salty water plot (WS) in fact increase with salty water like the behavior with treated water, and were significant differences between treatments of WS50 and WS100, WS50 and WS125, WS50 and WS150, WS75 and WS125, WS75 and WS150, WS100 and WS150, and WS125 and WS150. While there was no significant difference between fiber content means of WS50 and WS75, WS75 and WS100 and WS100 and WS125. In comparison of fiber content with date peel separation, it was shown in table (4.74) that the means of peel separation had significant differences between WS50 and WS100, WS50 and WS125, WS50 and WS150, which are the same as fiber content, WS75 and WS100, which is different than fiber content, WS75 and WS125, WS75 and WS150, and WS100 and WS150, which are the same as in fiber content. While there was no significance difference between means of peel separation between WS50 and WS75, WS100 and WS125, which is also the same as fiber content.

The means of fat content decreased with salty water and had significant differences between WS50 and WS100, WS50 and WS125, WS50 and WS150 which were all the same as in peel separation means. There also were no significant differences between fat contents of WS75 and WS100, WS75 and WS125, WS75 and WS150 which are also the same as the means of peel separation. In the same manner, the means of fat content were significantly different between WS100 and WS125, which were different than means of peel separation, WS100 and WS150 which comply with the mean of peel separation. Finally, the mean of fat content was significantly different between WS125 and WS150 which was opposite of the significance in peel separation.

The means of TSS increased with salty water, and were significantly different between WS50 and WS100, WS50 and WS125, WS50 and WS150, WS75 and WS125, WS75 and WS150 and WS100 and WS150. While the TSS means didn't show any significant differences between WS50 and WS75, WS75 and WS100, WS100 and WS125, and WS125 and WS150. These significances were complying with peel separation in WS50 and WS75, WS50 and WS100, WS50 and WS125, WS50 and WS150, WS75 and WS125, WS75 and WS150, WS100 and WS125, WS100 and WS150 and WS125 and WS150, while they were in contradiction in WS75 and WS100.

The Invert sugars also increased with salty water and had significant differences between WS50 and WS125, WS50 and WS150, WS75 and WS125 and WS75 and WS150. While the invert sugars means were not significantly difference between WS50 and WS75, WS50 and WS100, WS75 and WS100, WS100 and WS125, WS100 and WS125 and WS125 and WS150. The invert sugars significance was complying with significance of peel separation in WS50 and WS75, WS50 and WS125, WS50 and WS150, WS75 and WS125, WS75 and WS150, WS100 and WS125, and WS125 and WS150, while these significances didn't comply with peel separation in WS50 and WS100, WS75 and WS100 and WS100 and WS150.

The means of both pH and EC of the date fruits didn't show any significant differences between all treatments in WS plot, which is the same as in WT plot.

Table (4.74): Date fruits nutrition and quality in salty water plot (WS)

Treatment / Parameter		WS50	WS75	WS100	WS125	WS150
Fiber	Mean (%)	1.45	1.48	1.52	1.55	1.61
	Grouping	D	C, D	C, B	B	A
Fat	Mean (%)	0.32	0.31	0.25	0.21	0.17
	Grouping	A	A	B	C	D
TSS	Mean (%)	80.80	82.02	82.75	83.43	84.38
	Grouping	D	D, C	B, C	B, A	A
Invert Sugar	Mean (%)	41.68	42.24	43.06	44.17	44.35
	Grouping	B	B	B, A	A	A
pH	Mean (mg/kg)	4.63	4.62	4.59	4.57	4.68
	Grouping	A	A	A	A	A
EC	Mean (ms)	3.58	3.14	3.04	3.27	3.15
	Grouping	A	A	A	A	A
Separation	Mean (%)	62.54	55.11	41.04	33.75	28.86
	Grouping	A	A	B	C, B	C

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

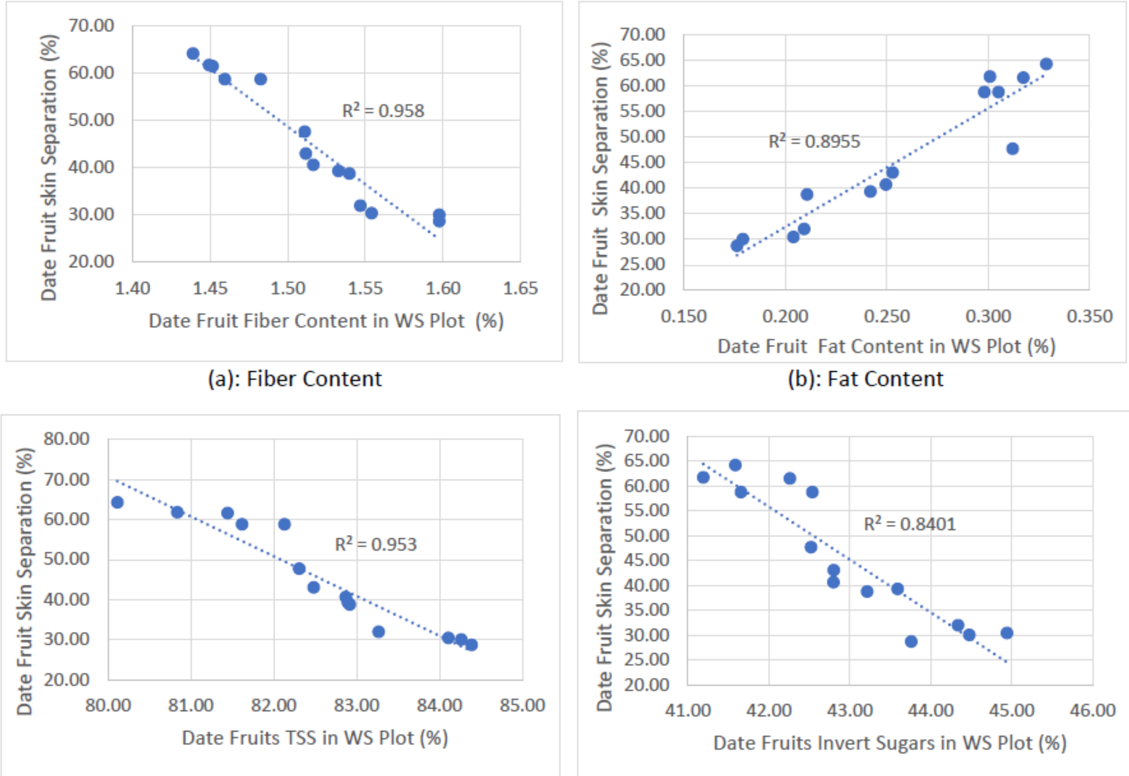
The date peel separation in WS plot correlates with four nutrition parameters of fiber content, fat content, TSS and invert sugars at significance (<0.001) as shown in table (4.75) and fig. (4.18), where it correlates negatively with date fruit fiber contents, TSS and invert sugars with person correlation coefficient of R^2 of 0.958, 0.953 and 0.926 respectively, while it correlates positively with fat content with person correlation coefficient of R^2 of 0.955. These correlations were justified by the significance difference of means of fiber content, fat content, TSS and invert sugars discussed above between WS treatments. On the other hand, there was no significant correlation between date fruit peel separation and both date fruit pH and EC. The non-significance correlations between date fruit peel separation and both date fruit pH and EC were justified by the non-significance difference between means of these parameters in the WS treatments.

Ibrahim and Zayed, (2019) found that the increase in fiber content leads to an increase the peel thickness of fruit which decreases peel separation of date fruit. This finding agreed with the results of this study where the correlation between fiber content and peel separation in WS plot was negative. In another study conducted by (Ragab, et al. 2011) he mentioned that, during fruit development from Khalal to rutab stage, the fiber content decreases and the highest percentage of peel separation happened in this transition stage which agrees with the results of this study; regarding “increasing the peel separation by decreasing the fiber content.” The irrigation was found to influence fiber content in dates as found by (Al-Yahyai and Manickavasagan,2013) which decreases peel separation, this finding also agrees with the results in this study.

Table (4.75): Pearson correlations between ripen date nutrition parameters and date fruit peel separation in salty water plot (WS)

Date fruit Parameter	Date fruit peel separation in WS
Fiber	-0.958***
Fat	0.955***
TSS	-0.953***
Invert	-0.926***
pH	0.004
Ec	0.293

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3



(a): Fiber Content (b): Fat Content

(c): TSS (d): Invert Sugars

Fig. (4.18): Correlations between ripen date fruit nutrition parameters and date fruit peel separation in salty water plot (WS). (a)= fiber content vs. peel separation, (b)= fat content vs. peel separation, (c)= TSS content vs. peel separation, (d)= invert sugars vs. peel separation.

In line with the discussion in section (4.4.1), the nutrition content of the same sample of date fruits with and without peel separation in WS plot were compared and discussed, in this manner, five samples were selected and studied from the five treatments in WS plot which are: WS50, WS75, WS100, WS125 and WS150 where the results of the nutrition content of these samples were tabulated and studied as shown in Table (4.76) and fig. (4.19).

Table (4.76): Comparison between peel separated date fruits and non-separated date fruits in terms of nutrition content in WS plot

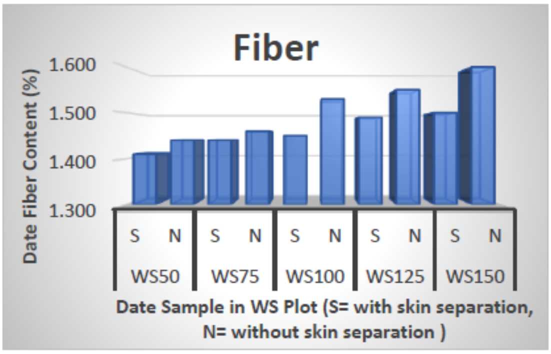
Treatment	Separation	Nutrition Content in WS plot of dates with and without peel separation					
		Fiber	Fat	TSS	Invert Sugars	Ph	EC
WS50	S	1.410	0.337	78.307	39.413	4.620	3.060
	N	1.440	0.329	80.112	41.587	4.650	2.980
WS75	S	1.440	0.322	79.681	40.609	4.760	3.190
	N	1.460	0.305	81.616	42.537	4.540	3.240
WS100	S	1.450	0.264	78.549	41.798	4.720	3.240
	N	1.530	0.242	82.894	43.594	4.520	2.880
WS125	S	1.490	0.221	82.229	42.671	4.590	3.240
	N	1.550	0.204	84.108	44.943	4.460	3.280
WS150	S	1.500	0.188	83.190	43.358	4.620	3.070
	N	1.600	0.163	84.479	44.801	4.630	2.950

S= with peel separation N= without peel separation

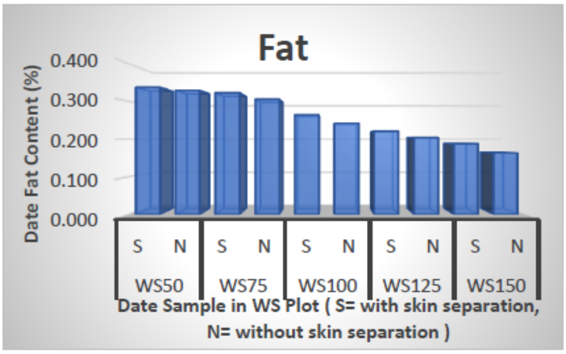
It is shown in the table (4.76) above and fig. (4.19) below, that the fiber content, TSS and invert sugars in the date samples without peel separation were higher than that in the same samples with peel separation in all WS treatments of WS50, WS75, WS100, WS125 and WS150, which give an indication that, the increase of these nutrients can play a role in reducing date fruit peel separation by increase solid content in date fruits and controlling the water evaporation process. On the other hand, the opposite phenomenon was found for fat content, where the date sample without peel separation contains lower fat content than that sample with peel separation in all WS treatments. This may be due to fact that the fat content in dates may facilitate the date peel separation from pulp during evaporation under hot temperature.

The pH in date samples without peel separation reflected higher values at very low, and very high salty water quantity (WS50 and WS150), while the pH in samples with peel separation have higher values at medium salty water quantity

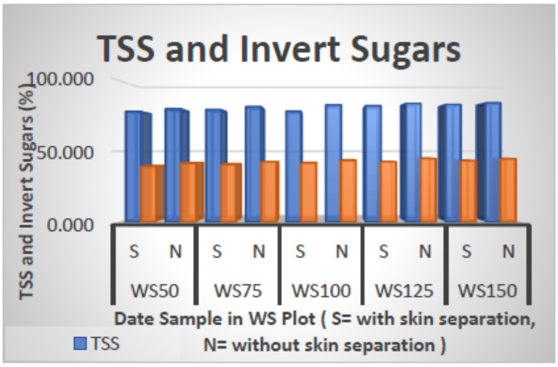
(WS75, WS100 and WS125). On the other hand, the EC of date fruits did not show any clear trend between date samples with and without peel separation in WS plot.



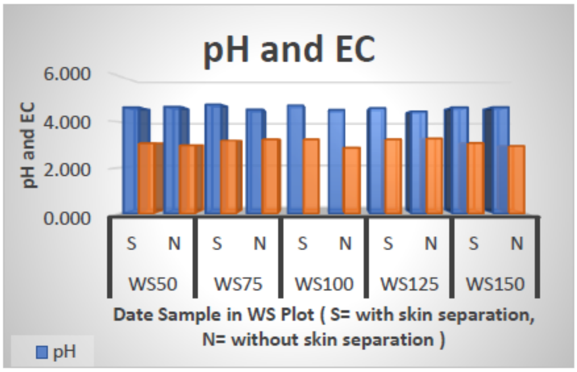
(a):Fiber



(b): Fat



(c): TSS and Invert Sugars



(d): pH and EC

Fig. (4.19): comparison between ripen date fruit with and without peel separation in terms of nutrition parameters in salty water plot (WS). (a)= fiber content, (b)= fat content, (c)= TSS $ invert sugars content, (d)= pH and EC.

4.4.3 Ripen date nutrition parameters effect on date fruit peel separation in fresh water plot (WF)

From table (4.77), it is shown that the means of fiber content increased with fresh water which are the same as in treated water and salty water. The means of fiber content in date fruits were significantly difference in WF plot between WF50 and WF75, WF50 and WF100, WF50 and WF125, WF50 and WF150, WF75 and WF100, WF75 and WF125, WF75 and WF150, WF100 and WF150 and WF125 and WF150. While the fiber means were not significantly different between WF100 and WF125. In comparison with the significance in peel separation, it can be shown that the fiber content significance complies with peel separation significance in WF50 and WF75, WF50 and WF100, WF50 and WF125, WF50 and WF150, WF75 and WF150, WF100 and WF125 and WF100 and WF150, while different in WF75 and WF100, WF75 and WF125 and WF125 and WF150.

The means of fat content decreased with fresh water and they were significantly different in WF plot between treatments of between WF50 and WF75, WF50 and WF100, WF50 and WF125, WF50 and WF150, WF75 and WF100, WF75 and WF125, WF75 and WF150, WF100 and WF150 and WF125 and WF150. While the fat means were not significantly different between WF100 and WF125. In comparison with the significance in peel separation, it can be shown that the fat content significance complies with peel separation significance in WF50 and WF75, WF50 and WF100, WF50 and WF125, WF50 and WF150, WF75 and WF150, WF100 and WF125 and WF100 and WF150, while they were different in WF75 and WF100, WF75 and WF125 and WF125 and WF150.

The TSS means appear to increase with increasing fresh water and show significant difference between treatments of WF50 and WF100, WF50 and WF125, WF50 and WF150, WF75 and WF150 and WF100 and WF150. In contrast, the means of TSS showed no significant difference between WF50 and

WF75, WF75 and WF100, WF75 and WF125, WF100 and WF125 and WF125 and WF150. By comparing the significance of TSS and peel separation, it can be concluded that these significances were the same in WF50 and WF100, WF50 and WF125, WF50 and WF150, WF75 and WF100, WF75 and WF125, WF75 and WF150, WF100 and WF125, WF100 and WF150 and WF125 and WF150, while different in WF50 and WF75.

Regarding the invert sugars in date fruits in WF plot, it can be shown that the means of invert sugars increase with fresh water plot like other water plots and there were significant differences between treatments of WF50 and WF125, WF50 and WF150 and WF75 and WF150. While the means of invert sugars showed no significant difference between WF50 and WF75, WF50 and WF100, WF75 and WF100, WF75 and WF125, WF100 and WF125, WF100 and WF150 and WF125 and WF150. By comparing the significancy of invert sugars and peel separation, it can be concluded that these significances were the same in WF50 and WF125, WF50 and WF150, WF75 and WF100, WF75 and WF125, WF75 and WF150, WF100 and WF125 and WF125 and WF150, while different in WF50 and WF75, WF50 and WF100 and WF100 and WF150.

Regarding the means of both pH and EC of the date fruits did not show any significant differences between all treatments in WF plot which is the same as in the previous two water plots (WT and WS).

Table (4.77): Date fruit nutrition and quality in fresh water plot (WF)

Treatment / Parameter		WF50	WF75	WF100	WF125	WF150
Fiber	Mean (%)	1.45	1.56	1.66	1.72	1.82
	Grouping	D	C	B	B	A
Fat	Mean (%)	0.45	0.39	0.35	0.32	0.23
	Grouping	A	B	C	C	D
TSS	Mean (%)	81.31	82.21	82.69	83.32	84.49
	Grouping	C	B, C	B	B, A	A
Invert Sugar	Mean (%)	41.95	43.06	43.62	44.56	45.34
	Grouping	C	B, C	B, A, C	B, A	A
pH	Mean (mg/kg)	4.70	4.64	4.59	4.72	4.69
	Grouping	A	A	A	A	A
EC	Mean (ms)	3.79	3.62	3.47	3.47	3.70
	Grouping	A	A	A	A	A
Separation	Mean (%)	35.65	25.86	23.96	22.07	18.80
	Grouping	A	B	B	C, B	C

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

From table (4.78) and figure (4.20), it can be concluded the correlations appears in WF plot between date fruit nutrition parameters and peel separation, where date peel separation in WF plot correlates with four nutrition parameters of fiber content, fat content, TSS and invert sugars at significance (<0.001), where it correlates negatively with date fruit fiber contents, TSS and invert sugars with person correlation coefficient of R^2 of 0.943, 0.917 and 0.872 respectively, while it correlates positively with fat content with person correlation coefficient of R^2 of 0.911. These correlations were justified by the significance difference of means of fiber content, fat content, TSS and invert sugars discussed above between WF treatments. On the other hand, there was no significant correlation between date fruit peel separation and both date fruit pH and EC. The non-significance correlations between date fruit peel separation and both date fruit pH and EC were justified by the non-significance difference between means of these parameters in the WF treatments.

Regarding fiber content, (Ibrahim and Zayed, 2019) found that the increase in fiber content leads to increase the peel thickness of fruit which decrease peel separation of date fruit. This finding agrees with the results of this study where the correlation between fiber content and peel separation in WF plot was negative. In another study done by (Ragab, et al. 2011) who mentioned that during fruit development from Khalal to rutab stage, the fiber content decreases and the highest percentage of peel separation happened in this transition stage which agrees with the finding of this study regarding “the peel separation increases by decreasing the fiber content.” The irrigation was found to influence fiber content in dates as found by (Al-Yahyai and Manickavasagan, 2013) which decreases peel separation, this finding also agrees with the results of this study.

Table (4.78): Pearson correlations between ripen date nutrition parameters and date fruit peel separation in fresh water plot (WF)

Date fruit Parameter	Date fruit peel separation in WF
Fiber	-0.943***
Fat	0.911***
TSS	-0.917***
Invert	-0.872***
pH	0.115
Ec	0.216

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

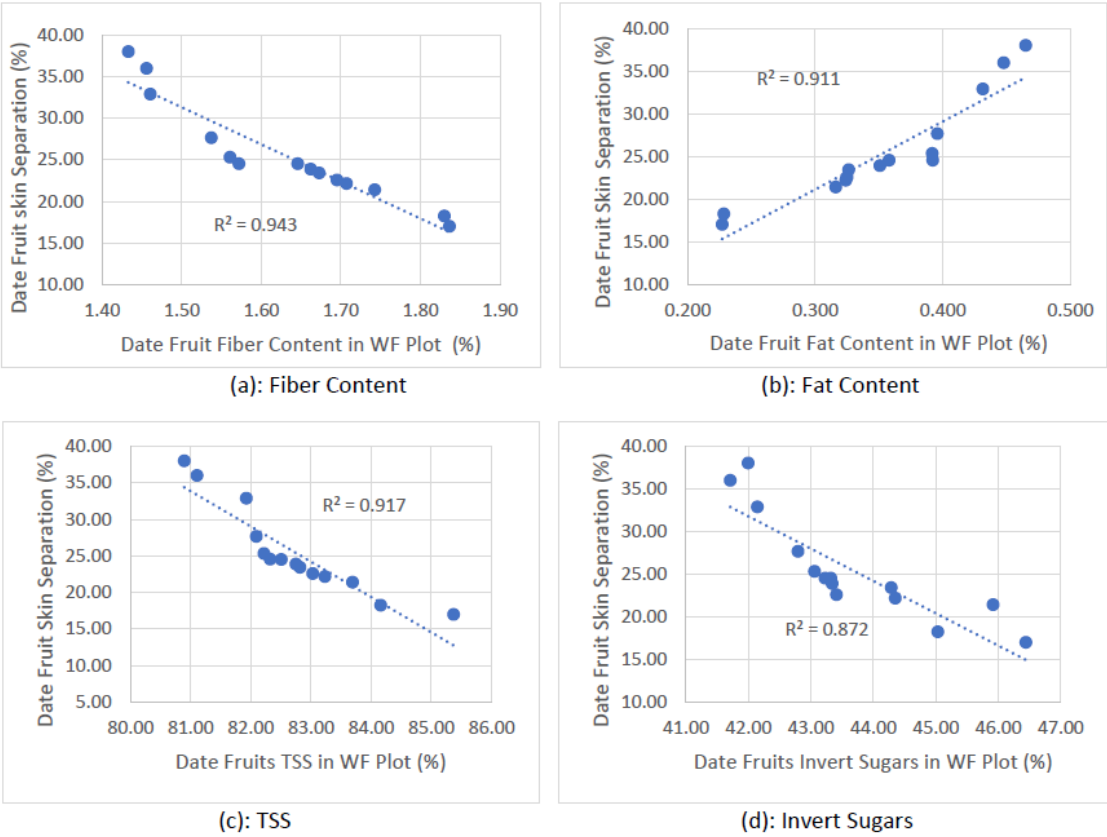


Fig. (4.20): Correlations between ripen date fruit nutrition parameters and date fruit peel separation in fresh water plot (WF). (a)= fiber content vs. peel separation, (b)= fat content vs. peel separation, (c)= TSS content vs. peel separation, (d)= invert sugars vs. peel separation.

It is shown in table (4.79) and in figure (4.21) that in all WF treatment of WF50, WF75, WF100, WF125 and WF150, the fiber content, TSS and invert sugars showed higher values in dates with no peel separation than that in dates with peel separation. On the other hand, the fat content values showed higher values in the date fruits with peel separation than that samples without peel separation.

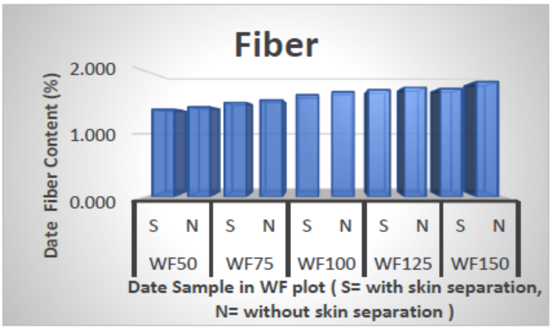
The pH of the date fruits with no peel separation was higher than that of dates with peel separation only at the low quantity of fresh water (WF50 and WF75), the opposite trend of pH appears where the pH of date with peel separation was higher than that in date without peel separation at medium and high quantity of fresh water (WF100, WF125 and Wf150).

The EC of date fruits was higher in dates without peel separation at low and high fresh water quantity (WF50, WF75, WF125 and WF150), while the EC in dates of medium fresh water quantity (WF100) was higher in the date sample with peel separation.

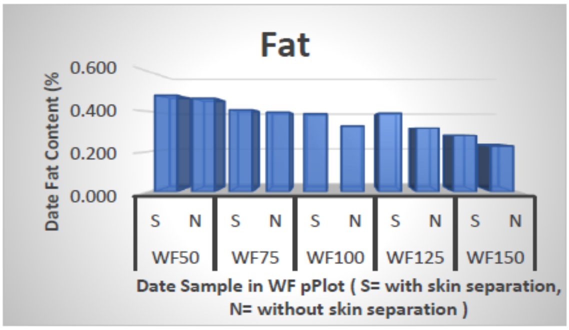
Table (4.79): Comparison between peel separated date fruits and non-separated date fruits in terms of nutrition content in WF plot

Treatment	Separation	Nutrition Content in WF plot of dates with and without peel separation					
		Fiber	Fat	TSS	Invert Sugars	Ph	EC
WF50	S	1.390	0.480	79.689	41.539	4.640	3.480
	N	1.430	0.465	80.894	41.997	4.690	3.650
WF75	S	1.500	0.408	80.755	42.009	4.550	3.210
	N	1.540	0.396	82.089	42.795	4.630	3.350
WF100	S	1.620	0.388	82.016	42.187	4.640	3.600
	N	1.670	0.327	82.815	44.287	4.440	3.310
WF125	S	1.700	0.391	83.188	43.783	4.720	3.360
	N	1.740	0.316	83.687	45.918	4.630	3.410
WF150	S	1.720	0.281	80.859	41.979	4.700	3.760
	N	1.830	0.229	84.158	45.033	4.520	3.780

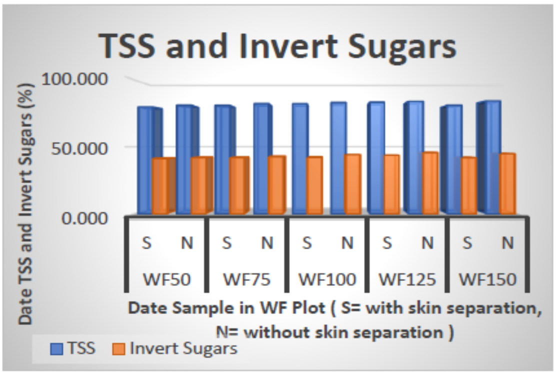
S= with peel separation N= without peel separation



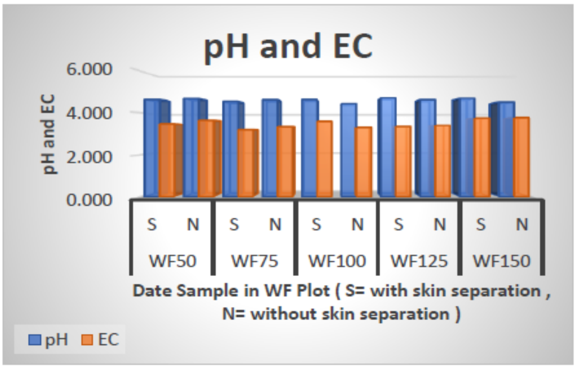
(a):Fiber



(b): Fat



(c): TSS and Invert Sugars



(d): pH and EC

Fig. (4.21): comparison between ripen date fruit with and without peel separation in terms of nutrition parameters in fresh water plot (WF). (a)= fiber content, (b)= fat content, (c)= TSS $ invert sugars content, (d)= pH and EC.

4.4.4 Ripen date nutrition parameters effect on date fruit peel separation in nitrogen fertilizer plot (FN)

In the nitrogen fertilizer plot, it can be shown from table (4.80) that there was no significant difference between means of each nutrition and quality parameters of fiber content, fat content, TSS, invert sugars, pH, EC and peel separation in all FN treatments of FN0, FN7.5 and FN15.

Table (4.80): Date fruit nutrition and quality in nitrogen fertilizer plot (FN)

Treatment / Parameter		FN0	FN7.5	FN15
Fiber	Mean (%)	1.69	1.64	1.68
	Grouping	A	A	A
Fat	Mean (%)	0.34	0.39	0.37
	Grouping	A	A	A
TSS	Mean (%)	82.01	80.73	81.79
	Grouping	A	A	A
Invert Sugar	Mean (%)	43.23	42.46	42.81
	Grouping	A	A	A
pH	Mean (mg/kg)	4.69	4.71	4.63
	Grouping	A	A	A
EC	Mean (ms)	3.63	3.52	3.51
	Grouping	A	A	A
Separation	Mean (%)	19.60	30.69	25.96
	Grouping	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. $P<0.05$, $n=3$.

The same as in water plots, it is shown in table (4.81) and figure (4.22) that the date fruit peel separation correlates negatively with fiber content at significance (<0.001) with person correlation coefficient of R^2= 0.947. On the same manner, TSS and invert sugars were correlated negatively with date fruit peel separation at significance (<0.001) with person correlation coefficient R^2 of 0.940 and 0.947 respectively. On the other hand, the fat content correlated positively at significance (<0.001) with date peel separation with person correlation coefficient R^2 of 0.978. While, pH and EC in the date fruits did not show any significant correlation with date fruit peel separation in FN plot.

Regarding fiber content, (Ibrahim and Zayed, 2019) found that the increase in fiber content leads to an increase the peel thickness of fruit which decreases peel separation of date fruit. This foundation agrees with the results of this study where the correlation between fiber content and peel separation in FN plot was negative. In another study done by (Ragab, et al. 2011), he mentioned that during fruit development from Khalal to rutab stage, the fiber content decreases and the highest percentage of peel separation in fact occurred in this transition stage which agrees with the findings of our study regarding “increasing peel separation by decreasing the fiber content.” The irrigation was found to influence fiber content in dates as found by (Al-Yahyai and Manickavasagan,2013) which decreases peel separation, this finding is also in line with the results of this study.

Table (4.81): Pearson correlations between ripen date nutrition parameters and date fruit peel separation in nitrogen fertilizer plot (FN)

Date fruit Parameter	Date fruit peel separation in FN
Fiber	-0.947***
Fat	0.978***
TSS	-0.940***
Invert	-0.947***
pH	0.079
Ec	-0.478

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

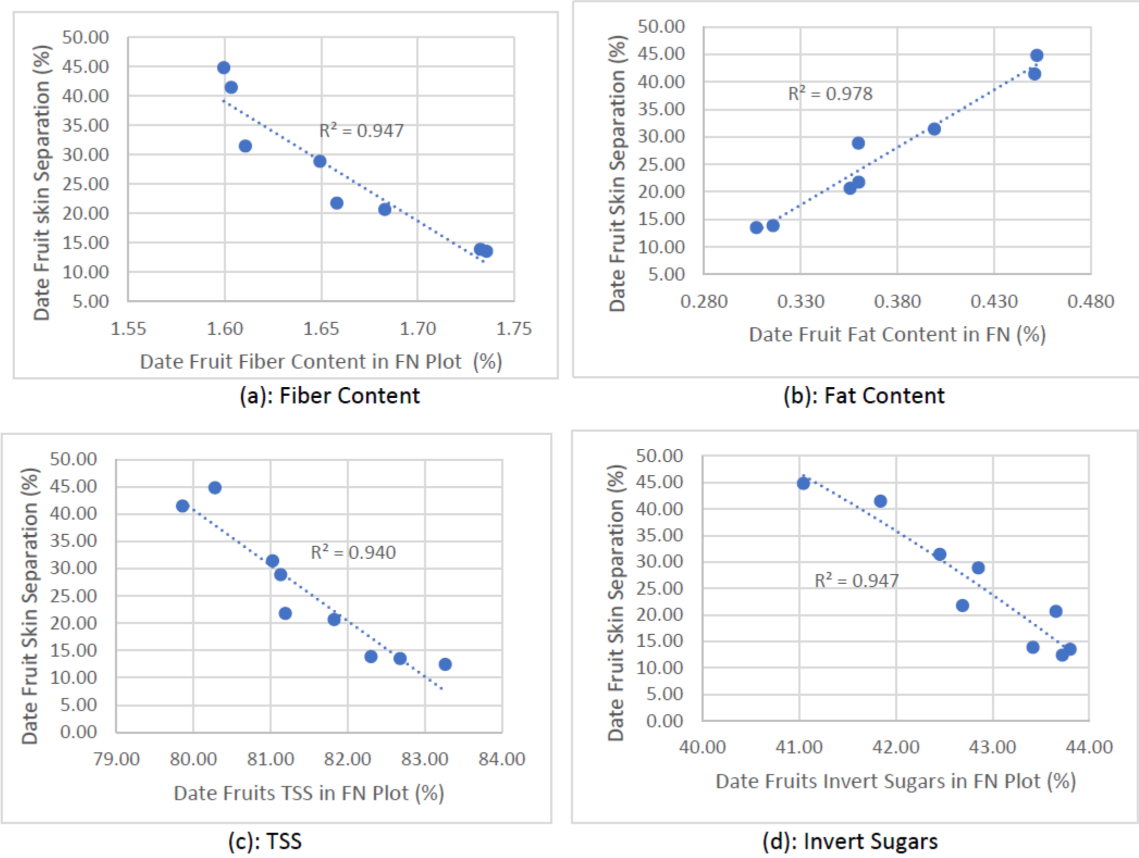


Fig. (4.22): Correlations between ripen date fruit nutrition parameters and date fruit peel separation in nitrogen fertilizer plot (FN). (a)= fiber content vs. peel separation, (b)= fat content vs. peel separation, (c)= TSS content vs. peel separation, (d)= invert sugars vs. peel separation.

It is shown from table (4.82) and in figure (4.23) that in all FN treatment of FN0, FN7.5, and FN15, the fiber content, TSS and invert sugars showed higher values in dates with no peel separation than that in dates with peel separation. On the other hand, the fat content values showed higher values in the date fruits with peel separation than that samples without peel separation, where these trends the same as the trend in the previous three plots of WT, WS and WF.

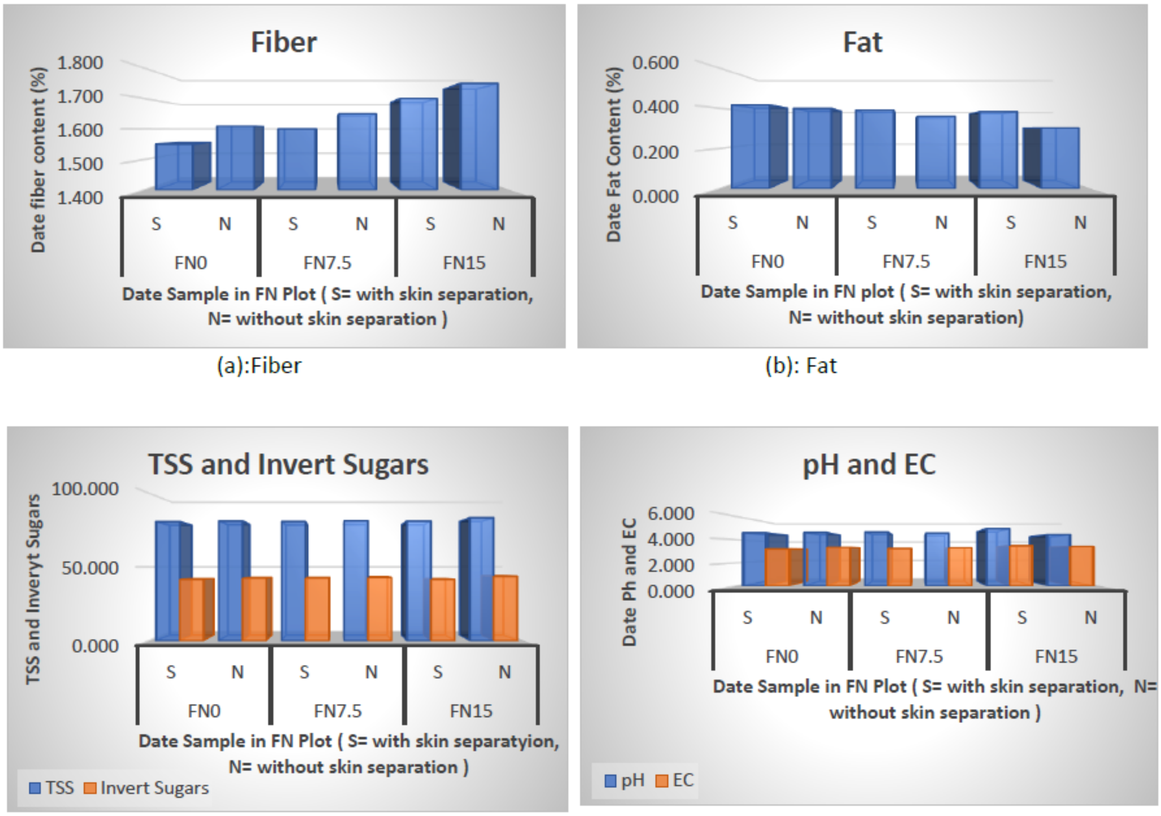
Table (4.82): Comparison between peel separated date fruits and non-separated date fruits in terms of nutrition content in FN plot

Treatment	Separation	Nutrition Content in FN plot of dates with and without peel separation					
		Fiber	Fat	TSS	Invert Sugars	PH	EC
FN0	S	1.550	0.416	80.551	41.574	4.600	3.190
	N	1.610	0.399	81.028	42.456	4.620	3.340
FN7.5	S	1.600	0.391	80.677	42.475	4.660	3.240
	N	1.650	0.360	81.134	42.856	4.570	3.290
FN15	S	1.700	0.383	80.930	41.559	4.950	3.480
	N	1.750	0.303	83.269	43.723	4.430	3.420

S= with peel separation   N= without peel separation

Both, pH and EC of the date fruits with no peel separation was higher than that of dates with peel separation at zero quantity of nitrogen (FN0), the opposite trend of both, pH and EC appear, where the pH and EC of date with peel separation was higher than that in date without peel separation at the high quantity of nitrogen used (FN15).

At medium quantity of nitrogen (FN7.5), The pH of date fruits was higher in dates with peel separation, while the EC at the same condition was higher in dates sample without peel separation.



(a):Fiber (b): Fat

(c): TSS and Invert Sugars (d): pH and EC

Fig. (4.23): comparison between ripen date fruit with and without peel separation in terms of nutrition parameters in Nitrogen plot (FN). (a)= fiber content, (b)= fat content, (c)= TSS $ invert sugars content, (d)= pH and EC.

4.4.5 Ripen date nutrition parameters effect on date fruit peel separation in phosphorus fertilizer plot (FP)

The same as nitrogen fertilizer plot (FN), it is shown in table (4.83) that there was no significant difference between means of each nutrition and quality parameters of fiber content, fat content, TSS, invert sugars, pH, EC and peel separation in all phosphorus Treatments in FP plot of FP0, FP0.5 and FP1.

Table (4.83): Date fruit nutrition and quality in phosphorus fertilizer plot (FP)

Treatment / Parameter		FP0	FP0.5	FP1
Fiber	Mean (%)	1.60	1.70	1.66
	Grouping	A	A	A
Fat	Mean (%)	0.36	0.32	0.34
	Grouping	A	A	A
TSS	Mean (%)	81.69	83.30	83.07
	Grouping	A	A	A
Invert Sugar	Mean (%)	41.95	43.78	43.78
	Grouping	A	A	A
pH	Mean (mg/kg)	4.65	4.69	4.68
	Grouping	A	A	A
EC	Mean (ms)	3.32	4.08	4.04
	Grouping	A	A	A
Separation	Mean (%)	43.67	25.02	32.11
	Grouping	A	A	A

For a given parameter, means within each line followed by the same letter are not significantly different. P<0.05, n=3.

It is shown in table (4.84) and figure (4.24), which describe the correlations between date fruit nutrition parameters and date fruit peel separation in phosphorus fertilizer plot (FP), that the date fruit peel separation correlates negatively with fiber content at significance (<0.001) with person correlation coefficient of R^2= 0.969. On the same manner, TSS and invert sugars were correlates negatively with date fruit peel separation at significance (<0.001) with person correlation coefficient R^2 of 0.935 and 0.859 respectively. On the other hand, the fat content correlates positively at significance (<0.001) with date peel separation with person correlation coefficient R^2 of 0.986. While, pH and EC in the date fruits didn't show any significant correlation with date fruit peel separation in FP plot.

Regarding fiber content, (Ibrahim and Zayed, 2019) found that the increase in fiber content leads to increase the peel thickness of fruit which decreases peel separation of date fruit. This foundation agreed with the results of this study where the correlation between fiber content and peel separation in FP plot was negative. In another study done by (Ragab, et al. 2011) he mentioned that during fruit development from Khalal to rutab stage, the fiber content decreases and the highest percentage of peel separation occurred in this transition stage which agrees with the finding of this study regarding “increasing the peel separation by decreasing the fiber content.” Irrigation was found to influence fiber content in dates as found by (Al-Yahyai and Manickavasagan,2013) which decreases peel separation, this finding also agrees with the results of this study.

Table (4.84): Pearson correlations between ripen date nutrition parameters and date fruit peel separation in phosphorus fertilizer plot (FP)

Date fruit Parameter	Date fruit peel separation in FP
Fiber	-0.969***
Fat	0.986***
TSS	-0.935***
Invert	-0.859***
pH	-0.147
Ec	-0.165

*indicate significant at $P<0.05$, **indicate significant at $p<0.01$, ***indicate significant at $P<0.001$, n=3

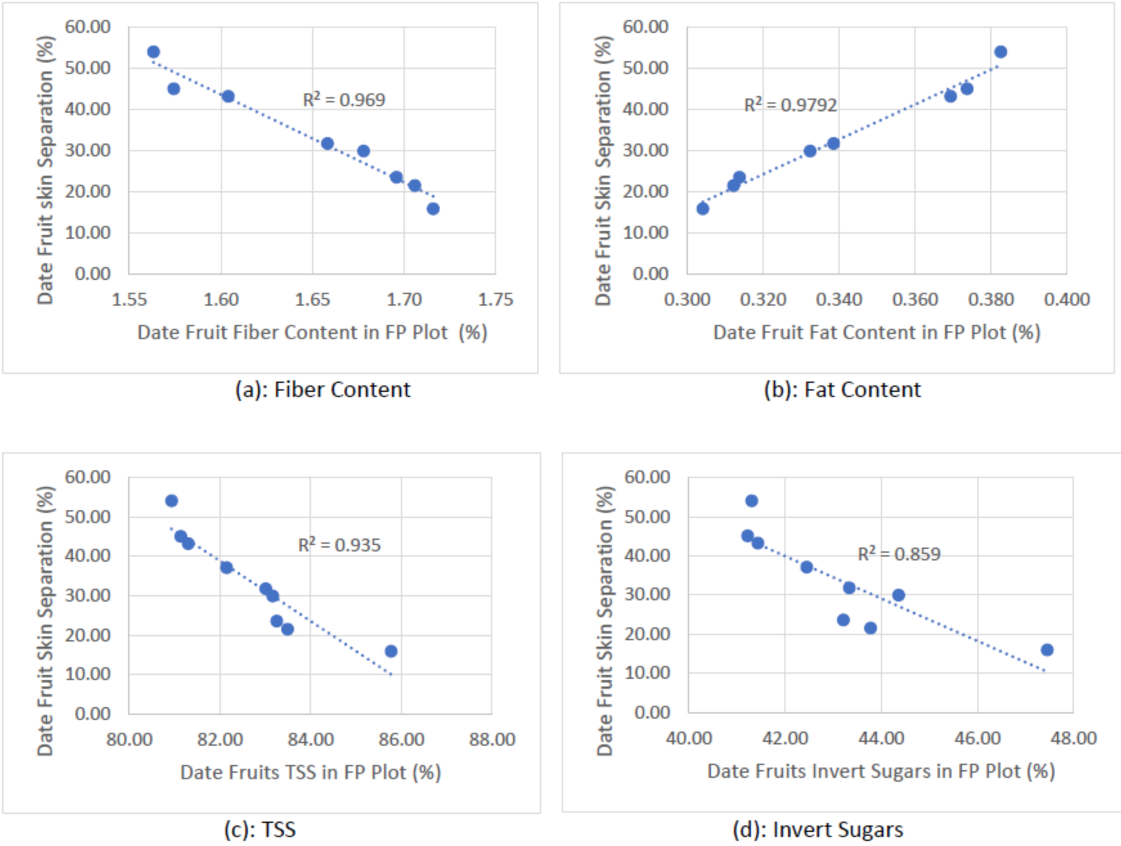


Fig. (4.24): Correlations between ripen date fruit nutrition parameters and date fruit peel separation in phosphorus fertilizer plot (FP). (a)= fiber content vs. peel separation, (b)= fat content vs. peel separation, (c)= TSS content vs. peel separation, (d)= invert sugars vs. peel separation.

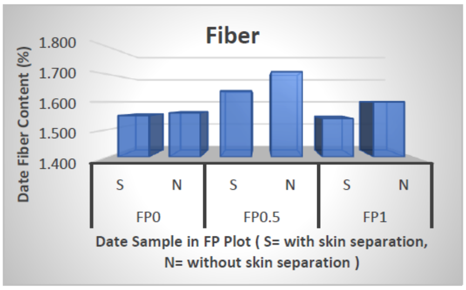
Table (4.85) shows that, the dates without peel separation from the three phosphorus plots (FP0, FP0.5 and FP1) contain higher values of fiber, TSS and invert sugars. On the other hand, the date samples with peel separation show higher values of fat content; these trends also appear in fig. (4.25).

Table (4.85): Comparison between peel separated date fruits and non-separated date fruits in terms of nutrition content in FP plot

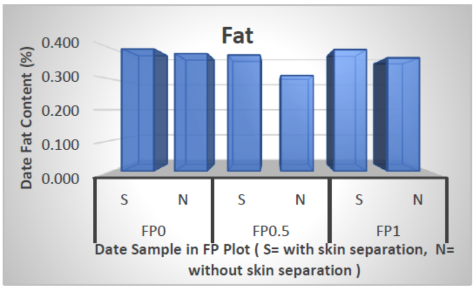
Treatment	Separation	Nutrition Content in FP plot of dates with and without peel separation					
		Fiber	Fat	TSS	Invert Sugars	Ph	EC
FP0	S	1.550	0.398	79.823	40.938	4.390	3.260
	N	1.560	0.383	80.928	41.306	4.650	3.340
FP0.5	S	1.640	0.378	81.761	42.653	4.720	3.180
	N	1.710	0.312	83.485	43.774	4.770	3.750
FP1	S	1.540	0.396	80.901	41.863	4.540	3.370
	N	1.600	0.369	81.299	41.431	4.670	3.780

S= with peel separation N= without peel separation

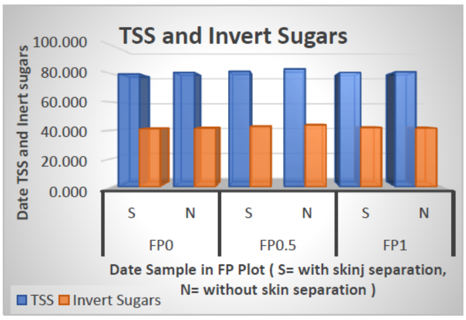
Both pH and EC of date samples without peel separation were higher values in samples from all phosphorus treatments (FP0, FP0.5 and FP1) than that in samples with peel separation.



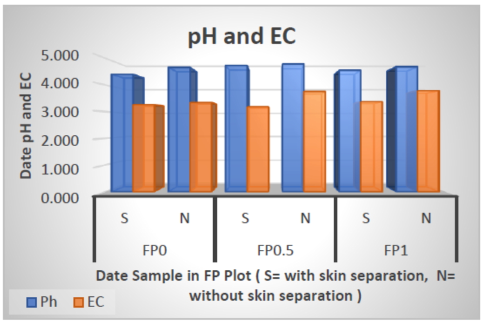
(a):Fiber



(b): Fat



(c): TSS and Invert Sugars



(d): pH and EC

Fig. (4.25): comparison between ripen date fruit with and without peel separation in terms of nutrition parameters in Phosphorus plot (FP). (a)= fiber content, (b)= fat content, (c)= TSS $ invert sugars content, (d)= pH and EC.

4.4.6 Ripen date nutrition parameters effect on date fruit peel separation in potassium fertilizer plot (FK)

In potassium fertilizer plot (FK), and as appear in table (4.86), the significances between means of the nutrition and quality parameters of dates in terms of fiber content, fat content, TSS, invert sugars, Ph, EC and date fruit peel separation were different from the previous FN and FP fertilizers plots, where there are significance differences between means of some parameters in FK0, FK2 and FK4.

The means of fiber content in FK plot appeared to increase with increasing potassium fertilizer and there were significant differences between means of fiber content in FK0, FK2 and FK4. In comparison with significance of peel separation means, it can be shown that the fiber content and peel separation have the same significance in FK0 and FK2 and FK0 and FK4, while have different significance in FK2 and FK4.

Regarding fat content, it decreased with increasing potassium fertilizer, also fat content shows significant differences between means in FK0, FK2 and FK4. These significance behaviors comply with the significance behavior of peel separation in FK0 and FK2 and FK0 and FK4, while they have different significance in FK2 and FK4.

The TSS means increase with increase potassium fertilizer, and there was significant difference of TSS means between FK0 and FK4, also between FK2 and FK2, while there was no significant difference between means of TSS between FK0 and FK2. Referring to the significance between means of peel separation, it can be concluded that the same significance was noticed in FK0 and FK4, while opposite significance between TSS and peel separation in FK0 and FK2, also in FK2 and FK4.

The invert sugars also increased with increased potassium fertilizer and there were significant differences of invert sugars means between FK0 and FK4, while there was no significant difference between means of invert sugars between FK0 and FK2, also between FK2 and FK4. By comparing the invert sugars significance behavior with peel separation behavior, it can be concluded that the significance between invert sugars and peel separation are the same in FK0 and FK4, also in FK2 and FK4, while different in FK0 and FK2. It also appears that, as the potassium increases, the mean of peel separation decreases.

The pH and EC of date fruits did not exhibit any significant difference between means of then in all FK plots of FK0, FK2 and FK4.

Table (4.86): Date fruit nutrition and quality in potassium fertilizer plot (FK)

Treatment / Parameter		FK0	FK2	FK4
Fiber	Mean (%)	1.49	1.64	1.80
	Grouping	C	B	A
Fat	Mean (%)	0.41	0.36	0.31
	Grouping	A	B	C
TSS	Mean (%)	80.81	81.50	82.56
	Grouping	B	B	A
Invert Sugar	Mean (%)	40.45	42.34	43.61
	Grouping	B	B, A	A
pH	Mean (mg/kg)	4.53	4.46	4.47
	Grouping	A	A	A
EC	Mean (ms)	3.65	3.17	3.40
	Grouping	A	A	A
Separation	Mean (%)	32.26	22.52	14.37
	Grouping	A	B	B

For a given parameter, means within each line followed by the same letter are not significantly different. P<0.05, n=3.

As shown in table (4.87) and from figure (4.26), the fiber content, the fat content, TSS and invert sugars have significant correlations with date fruit peel separation in potassium fertilizer plot, while the date fruit pH and EC didn't have significant correlation with date fruit peel separation.

The fiber content correlates significantly with date fruit peel separation at significance (<0.001) which is a negative correlation with person coefficient correlation R^2 of 0.957. In the same manner, TSS show also negative significant correlation with date peel separation at significance (<0.001) with person coefficient correlation R^2 of 0.940. The invert sugars also show the same negative significance correlation with date fruit peel separation, but at lower significance of (<0.01) with person coefficient correlation R^2 of 0.896. As opposite of the above correlations, the fat content of date fruits correlates significantly and positively with date fruit peel separation at significance R^2 of 0.926.

Table (4.87): Pearson correlations between ripen date nutrition parameters and date fruit peel separation in potassium fertilizer plot (FK)

Date fruit Parameter	Date fruit peel separation in FK
Fiber	-0.957***
Fat	0.926***
TSS	-0.940***
Invert	-0.896**
pH	0.485
Ec	0.328

*indicate significant at P<0.05, **indicate significant at p<0.01, ***indicate significant at P<0.001, n=3

Ibrahim and Zayed, (2019) found that the increase in fiber content leads to increase the peel thickness of fruit which decrease peel separation of date fruit. This foundation agreed with the results of this study where the correlation between fiber content and peel separation in FK plot was negative. In another study done by (Ragab et al. 2011) whom mentioned that during fruit development from Khalal to rutab stage, the fiber content decreases and the highest percentage of peel separation happened in this transition stage which agrees with the finding of this study regarding "increasing the peel separation by decreasing the fiber content." The irrigation was found to influence fiber content in dates as found by (Al-Yahyai and Manickavasagan, 2013) which decreases peel separation, this finding also agrees with the results in this study.

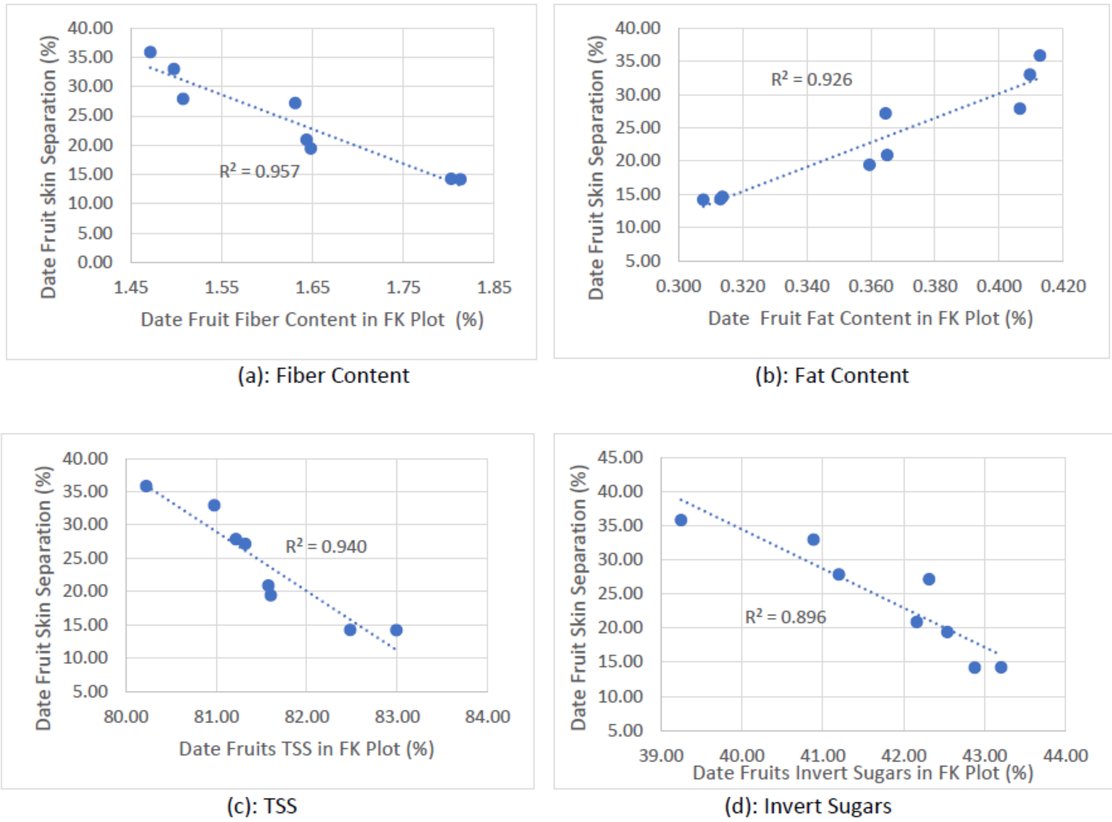


Fig. (4.26): Correlations between ripen date fruit nutrition parameters and date fruit peel separation in potassium fertilizer plot (FK). (a)= fiber content vs. peel separation, (b)= fat content vs. peel separation, (c)= TSS content vs. peel separation, (d)= invert sugars vs. peel separation.

In potassium plot (FK), as shown in table (4.88) and as appear in figure (4.27), the fiber content in date samples without peel separation was higher than that in samples with peel separation in all FK treatments (FK0, FK2 and FK4). In the same manner, both TSS and invert sugars shows the same trend where their contents in date samples without peel separation were higher than that in date samples with peel separation.

The fat content in date samples reflects an opposite trend, where the fat content in samples with peel separation were higher than that in dates without peel separation in all FK treatments (FK0, FK2 and FK4)

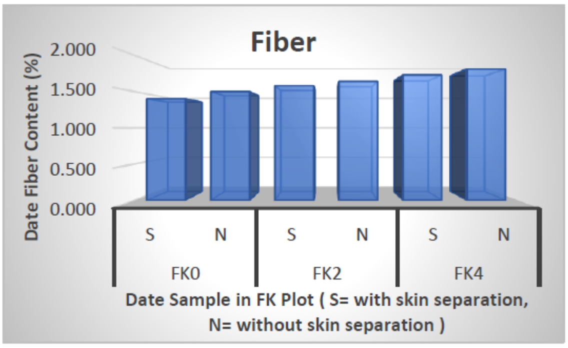
Table (4.88): Comparison between peel separated date fruits and non-separated date fruits in terms of nutrition content in FK plot

Treatment	Separation	Nutrition Content in FK plot of dates with and without peel separation					
		Fiber	Fat	TSS	Invert Sugars	Ph	EC
FK0	S	1.400	0.453	79.471	40.230	4.490	3.260
	N	1.500	0.410	80.975	40.887	4.570	3.570
FK2	S	1.580	0.401	80.162	41.763	4.690	2.860
	N	1.640	0.365	81.575	42.162	4.420	3.270
FK4	S	1.730	0.332	81.805	42.125	4.710	2.860
	N	1.810	0.308	82.991	42.881	4.390	3.070

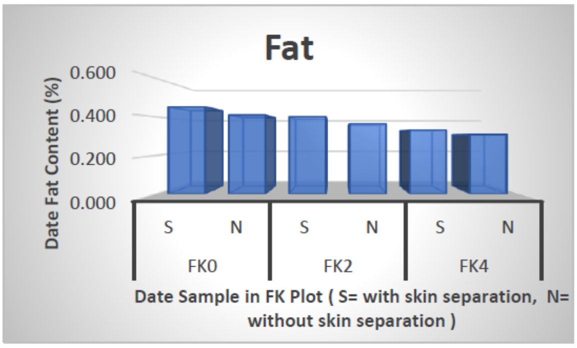
S= with peel separation N= without peel separation

Regarding date pH, it was shown in table (4.88) and fig. (4.27), that the pH of date sample without peel separation was higher than that in sample with peel separation only at zero potassium treatment (FK0), while at medium and high potassium content, the pH of date samples with peel separation were higher than that in dates without peel separation.

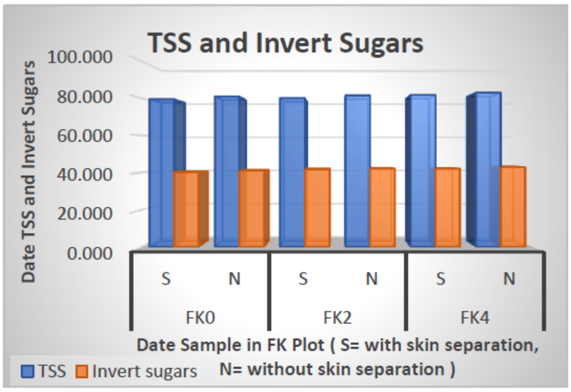
EC of date samples without peel separation were higher than that of samples with peel separation in all potassium treatments (FK0, FK2 and FK4).



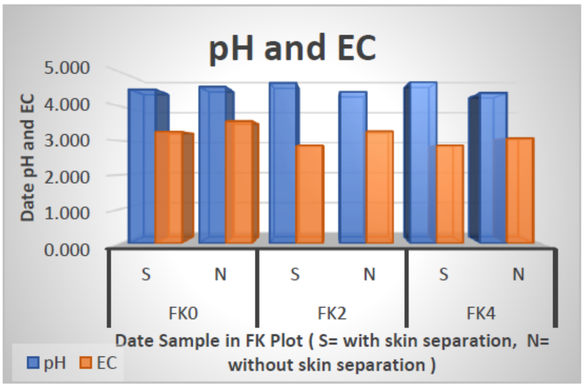
(a):Fiber



(b): Fat



(c): TSS and Invert Sugars



(d): pH and EC

Fig. (4.27): comparison between ripen date fruit with and without peel separation in terms of nutrition parameters in Potassium plot (FK). (a)= fiber content, (b)= fat content, (c)= TSS $ invert sugars content, (d)= pH and EC.

Section Five: Meteorological Parameters Effect

4.5 Meteorological Parameters Effect

The meteorological data collected were monthly average temperature, mean monthly maximum temperature, mean monthly minimum temperature, monthly heat summation units, monthly total rain fall, mean monthly relative humidity, monthly sunshine duration, monthly evaporation and mean monthly wind speed, where the results are tabulated in table (4.89) below.

To have better understanding of the effect of these meteorological data on date fruit peel separation, a statistical data about the percentages of peel separated date fruits were collected from four date packing houses for sorting and grading in Jericho for three years, 2017, 2018 and 2019 as the year of this study. These packing houses are Al-Reef packing house, Nakheel Palestine Packing house, Arab farmers packing house and A-Wadi packing house, where the data collected represent the average percentage of dates with and without peel separation that graded in these packing houses, in order to correlate these data with the meteorological data and study the effect of the meteorological data the date fruit peel separation. These data were tabulated in table (4.90) below.

Table (4.89): Meteorological data of Jericho station for three years

Meteorological Data									
Station Name : JER00005					**Latitude : 31.86 N**			**Longitude : 35.47 E**	
Parameter	**Year**	**Month**							**Average/ Total**
		Mar	**Apr**	**May**	**June**	**July**	**August**	**Sep**	
Monthly Average Temperature (C)	2017	19.9	24.8	28.4	31.0	34.2	32.9	31.5	**29.0**
	2018	22.1	24.4	30.2	31.0	32.7	32.6	31.7	**29.2**
	2019	18.5	22.8	30.3	32.8	32.8	33.8	31.4	**28.9**
Mean Monthly Max. Temp. (C)	2017	26.5	32.2	36.1	39.0	42.3	40.5	38.8	**36.5**
	2018	29.7	32.0	38.4	39.9	39.4	38.7	38.7	**36.7**
	2019	24.1	29.2	38.2	39.6	40.3	40.3	38.1	**35.7**
Mean Monthly Min. Temp. (C)	2017	14.0	18.3	22.0	24.9	28.1	27.2	26.0	**22.9**
	2018	15.9	18.4	24.0	25.1	26.7	27.2	26.0	**23.3**
	2019	12.9	16.4	22.5	26.0	26.5	27.2	25.5	**22.4**
Monthly Heat Units (C)	2017	58.9	204.0	322.4	390.0	502.2	461.9	405.0	**2344.4**
	2018	127.1	192.0	378.2	390.0	455.7	452.6	411.0	**2406.6**
	2019	15.5	144.0	381.3	444.0	458.8	489.8	402.0	**2335.4**
Monthly Total Rainfall(mm)	2017	4.0	0.4	0.0	0.0	0.0	0.0	0.0	**4.4**
	2018	0.0	47.5	2.0	0.0	0.0	0.0	0.0	**49.5**
	2019	22.2	2.6	0.0	0.0	0.0	0.0	0.0	**24.8**
Mean Monthly Relative Humidity (%)	2017	44.8	32.9	31.6	35.2	35	41.3	43.2	**37.7**
	2018	42.5	40.9	33.7	38.2	38.6	40.7	42.8	**39.6**
	2019	42.5	41.5	28.9	35.4	36.7	39.4	41.8	**38.0**
Monthly Sunshine Duration (hrs.)	2017	244.9	288.0	318.0	357.0	341.0	341.0	312.0	**2201.9**
	2018	269.7	273.0	260.4	345.0	356.5	337.9	318.0	**2160.5**
	2019	206.0	264.3	317.2	333.0	353.5	348.8	308.5	**2131.3**
monthly evaporation (mm)	2017	248.0	360.0	387.0	354.0	396.8	384.4	294.0	**2424.2**
	2018	263.5	306.0	387.5	369.0	393.7	365.8	300.0	**2385.5**
	2019	128.0	187.3	313.1	331.8	328.9	313.9	233.1	**1836.1**
Mean Monthly Wind Speed (Kt)	2017	2.2	2.6	2.3	2.2	2.3	2.0	1.9	**2.2**
	2018	2.0	2.1	2.2	2.1	2.8	2.3	2.0	**2.2**
	2019	2.2	2.5	2.5	2.5	2.3	2.4	2.1	**2.4**

Table (4.90): Average Percentage of date peel separation in during three years in four date packaging houses in Jericho.

Date peel separation in four packing house during three harvesting years					
Year	Packing House	Peel separation (%)			
		with peel separation		without peel sepatration	
		Packing house %	Average	Packing house %	Average
2017	Al Reef	51.9	56.7	48.1	43.3
	Nakheel Palestine	57.0		43.0	
	Al Wadi	46.1		53.9	
	Palestine farmers	71.8		28.2	
2018	Al Reef	44.2	51.2	55.8	48.8
	Nakheel Palestine	54.0		46.0	
	Al Wadi	35.6		64.4	
	Palestine farmers	71.1		28.9	
2019	Al Reef	38.3	47.2	61.7	52.8
	Nakheel Palestine	52.0		48.0	
	Al Wadi	45.7		54.3	
	Palestine farmers	52.8		47.2	

The correlations between meteorological data and the average percentage of date peel separation in three harvesting years, 2017, 2018 and 2019 were discussed in the below sections.

4.5.1 Monthly Average Temperature Effect

It is appearing from fig (4.29), that the average monthly temperature in the three years increased from March to reach highest temperature during July and August, then it starts declining. The most important time for dates, which affects the date peel separation is the time of transition stage of dates from khalal stage to rutab and tamer stages which occur naturally in August and September, in this manner, the highest average temperature in August was registered in the year 2019, whereas the lowest total average temperature was registered in the year 2019.

By observing the peel separation data from the four packing houses as summarized in table (4.90), it appears that the best year in terms of low percentage of date peel separation in the four packing houses was in the year 2019; with average peel separation of 47.2% compared to the highest average peel separation that appears in the year 2017; of 56.7%. From the previous comparison and discussion, it can be concluded that the increase of the average monthly temperature during transition stage of date from khalal to rutab stage which is during August in Jericho, this will decrease the date peel separation because the temperature plays a vital rule in ripening of dates and converting the sucrose sugars to glucose and fructose sugars which can increase the adhesive of the date peel to the pulp. The increase of average temperature in August can increase the tolerance of hot air to absorb more water and increase the evapotranspiration around the date fruit, and consequently reduce the water vapor pressure under date peel.

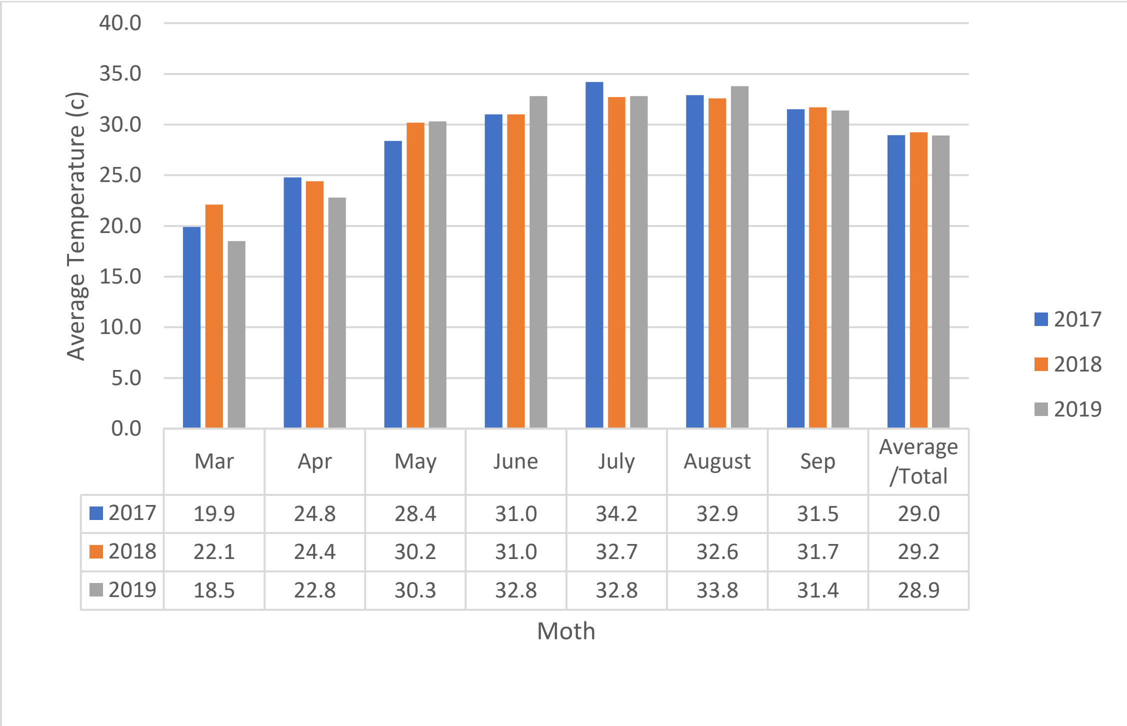


Fig. (4.28): Monthly and annual average temperature

Abul-Soad et al. (2013) indicated that the increase of temperature above 40 c results in demolishing the impact of high air relative humidity on fruit and decrease the fruit peel separation possibilities. On the other hand, (Ibrahim and Zayed, 2019) found that the increase of temperature increases the activity of invertase enzyme to convert Sucrose to glucose, fructose and softness of fruits, the same authors also indicated that the temperature fluctuation affects the expansion and contraction of the two tissues, Thus, the peel is shed from the fruit, which leads to increased fruit peel separation. They also found that the drying temperature should not exceed 55 c or below 40 to reduce the fruit peel separation. In the same manner, (Al-Hajaj et al. 2020) mentioned that the increase in temperature leads to increased peel separation.

High temperature and humidity Predispose the date to peel separation and leads to increased date fruit peel separation as mentioned by (Lobo, et al. 2013). In the same manner, (Kalaj, 2016), indicated that the increase of temperature enhances transpiration and decreases metabolism and nutrient uptake. Regarding the increase of temperature and its effect on some physical properties of date fruits, (Brüggenwirth and Knoche,2016) fond that the increase of temperature decreased elasticity, fracture pressure, peel stiffness, turgor by transpiration and viscosity of pectin, which all of these lead to increase peel separation.

4.5.2 Mean Monthly Maximum Temperature Effect

The monthly Maximum temperature data collected from Palestine meteorological department during the period from March till September were illustrated in figure (4.29) for three years, 2017, 2018 and 2019, where the year 2019 is the year of this study.

From figure (4.29), it appears that the lowest average maximum temperature was in 2019 with 35.7 c, while the lowest monthly maximum temperature was registered in September which was the harvest time of date in 2019, also from table (4.90), it appears that the lowest peel separation occurred in the year 2019. For that it can be concluded that the increase of the maximum temperature for higher limits was enhances the date peel separation, which agreed with some of previous studies which are discussed below.

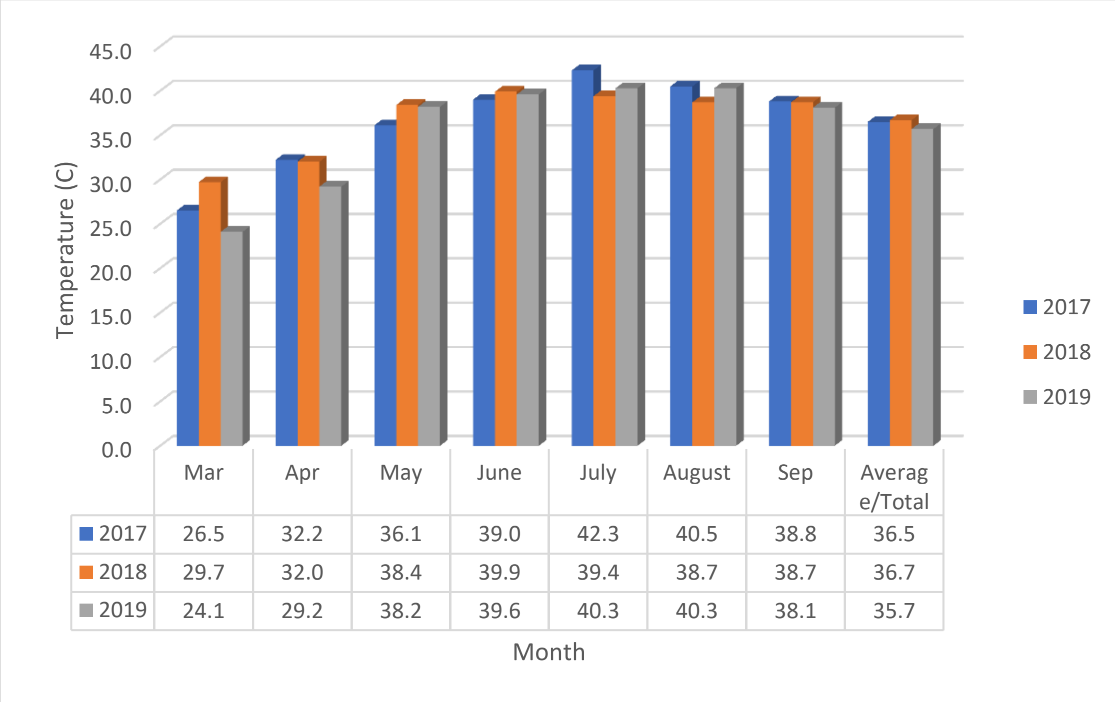


Fig. (4.29): Mean monthly and annual maximum temperature

High temperature and humidity Predispose the date to peel separation and lead to increase date fruit peel separation as mentioned by (Lobo et al. 2013). In the same manner, (Kalaj, 2016) indicated that the increase of temperature enhances transpiration and decrease metabolism and nutrient uptake. Regarding the increase of temperature and its effect on some physical properties of date fruits, (Brüggenwirth and Knoche,2016) found that the increase of temperature decreased elasticity, fracture pressure, peel stiffness, turgor by transpiration and viscosity of pectin, which all lead to increased peel separation.

4.5.3 Mean Monthly Minimum Temperature Effect

The lowest average mean monthly minimum temperature was registered in the year 2019; the same also appears in September of the same year as shown in figure (4.30), where September is the harvesting month of dates. In comparison with the mean monthly maximum temperature in section (4.5.2), the highest difference between the mean monthly maximum and minimum temperature in September was appears on the year 2019 with 13.3 c, this may reduce the evaporation flux which may in turn enhance the separation of date peel from date pulp, for that, it can be seen from table (4.90) that the lowest percentage of peel separation date indeed occurred in the year 2019.

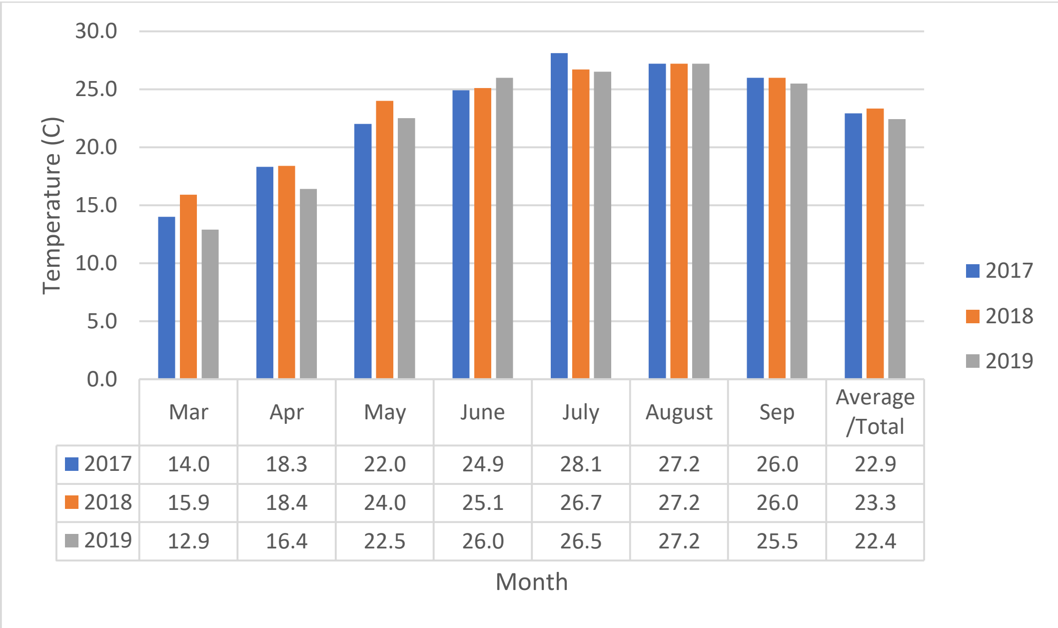
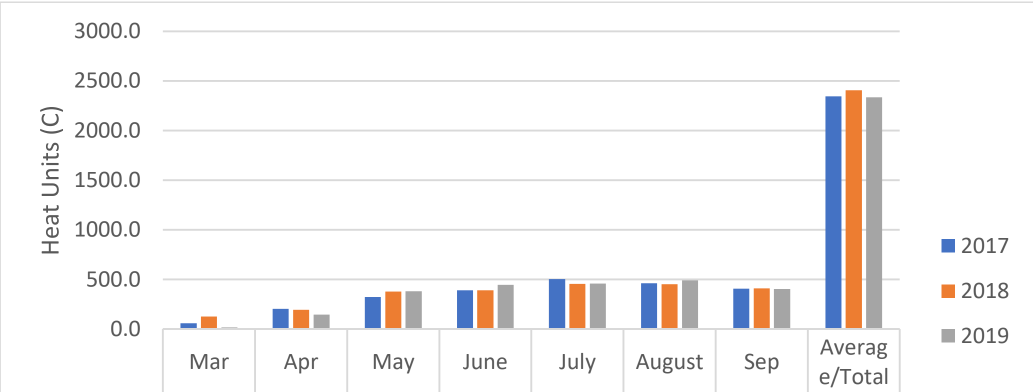


Fig. (4.30): Mean monthly and annual minimum temperature

4.5.4 Monthly Heat Summation Units Effect

Heat summation units are representing the total temperature degrees from flowering time until the harvesting time of date, where the date need minimum heat units to be ripen and be in a good quality and these minimum heat summation units depends on the region where the date grown. Heat summation units are very important for ripening date fruits and enhancing invertase enzyme to convert sucrose to fructose and glucose.

The number of heat units (degree days) needed to ripen the fruit varies with cultivar and ranges between 2100 and 4700 for early and late ripening cultivars, respectively as indicated by (Yahia and Kader, 2011).



	Mar	Apr	May	June	July	August	Sep	Average/Total
2017	58.9	204.0	322.4	390.0	502.2	461.9	405.0	2344.4
2018	127.1	192.0	378.2	390.0	455.7	452.6	411.0	2406.6
2019	15.5	144.0	381.3	444.0	458.8	489.8	402.0	2335.4

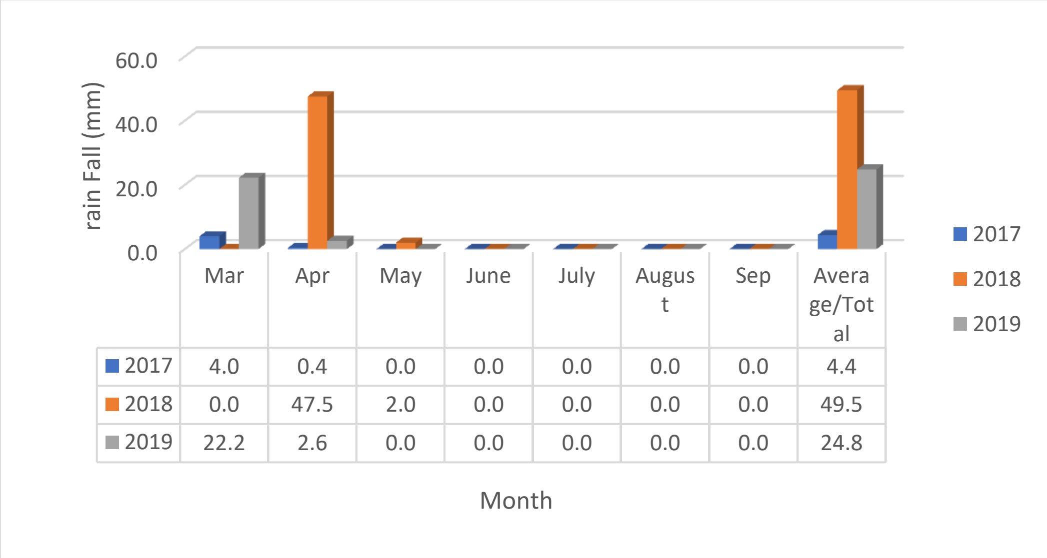
Fig. (4.31): Monthly and annual heat summation units

From figure (4.31), it can be seen that the total heat summation units in the three years are within the limit of 2335.4 in the year 2019 to 2406.6 in the year 2018 (2100-4700). From table (4.90), it can be seen that the lowest peel separation percentage was in 2019 with 47.2%, while the heat summation units also found in the year 2019, so we can say that if the heat summation units exceed the lower limit of 2100; which is the minimum heat units for date ripening, the lowest heat summation units can produce lower peel separation percentage, this may be is due to the fact that the high heat units may increase the evapotranspiration and the vapor flux from inside date fruit and leads to enhance date peel to separate from date pulp.

Heat summation units increase the fruit ripening and increase the percentage of rutab in bunch as indicated by (Awad, 2007). For different date verities, (Al-Yahyai, 2018) indicated that the heat units accumulated over the growing season (bloom-harvest) to mature date, where dry dates require > 6000 HU; semidry dates 5000-6000; soft dates: 3000-4000). In different study conducted by (Awad, 2007), the author indicated that the bunch bagging, especially with black and blue polyethylene bags, accumulated higher heat units than other bags and controls.

4.5.5 Monthly Total Rain Fall Effect

As shown in fig. (4.32), there is no rain fall from May until September in the three years of 2017, 2018 and 2019; except for small amount of rain fall of 2 mm in 2018 fall in May, for that we cannot correlate the date peel separation with rain fall in Jericho, a region that is arid, with no rain from the start of the date fruit appearance as a green fruit in May, until harvest the ripen date fruits in September.



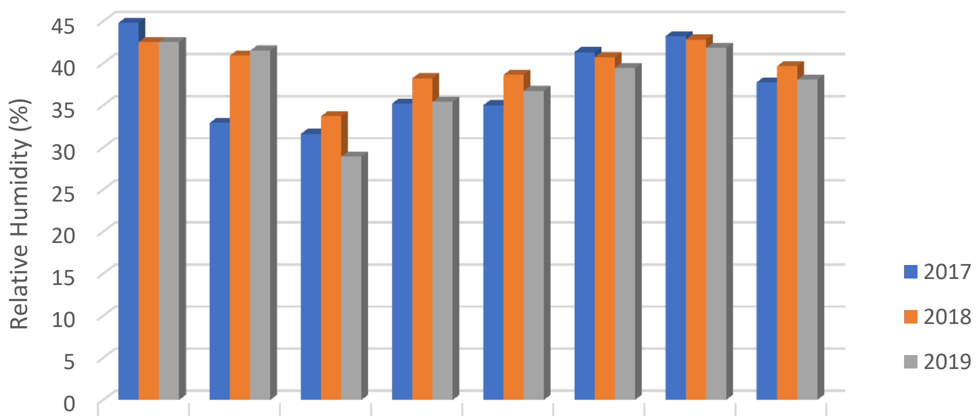
	Mar	Apr	May	June	July	August	Sep	Average/Total
2017	4.0	0.4	0.0	0.0	0.0	0.0	0.0	4.4
2018	0.0	47.5	2.0	0.0	0.0	0.0	0.0	49.5
2019	22.2	2.6	0.0	0.0	0.0	0.0	0.0	24.8

Fig. (4.32): Monthly and annual total rain fall

4.5.6 Mean Monthly Relative Humidity Effect

The relative humidity has a direct impact on the phenomenon of date peel separation, especially during the ripening period which occurs in August and September. From table (4.90), the lowest peel separation percentage was in 2019, and if we look to figure (4.33), the lowest relative humidity during August and September was in the year 2019, this means that the increase of relative humidity during ripening stage leads to increase in peel separation.

The increase of relative humidity during ripening stage reduces the evapo-transpiration from the date fruit where the air will be more saturated with water vapor, on the other hand, the date fruits during ripening stage contain high water content and need to lose it, but if the evapotranspiration process around date fruits was slow due to high relative humidity, the water content in date fruit will accumulated under peel and reduce sugar contents and gumming materials under peel which enhances the date peel to separate from date pulp.



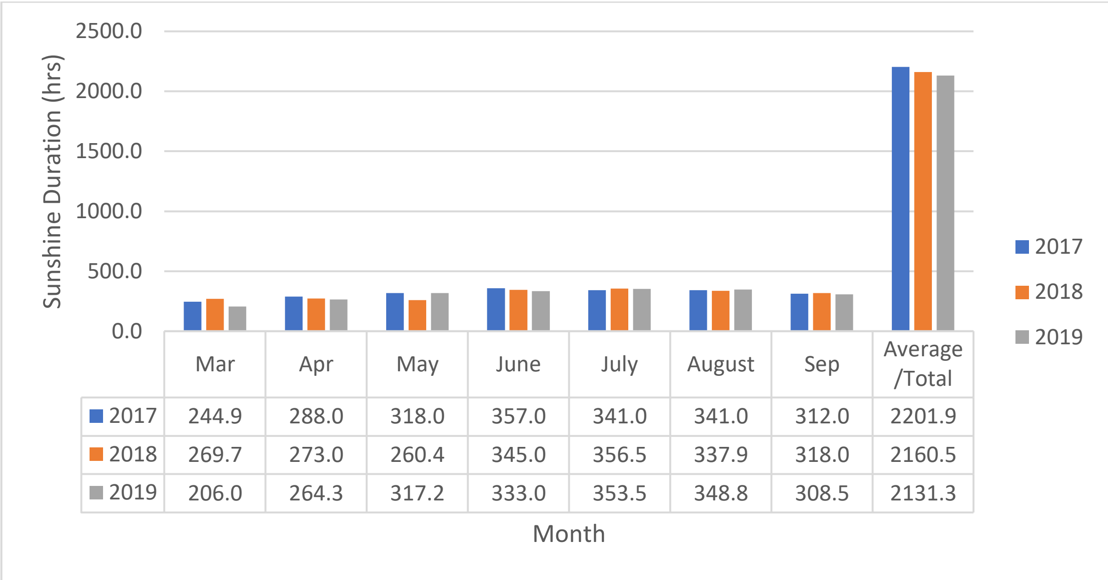
	Mar	Apr	May	June	July	August	Sep	Averag e/Total
2017	44.8	32.9	31.6	35.2	35	41.3	43.2	37.7
2018	42.5	40.9	33.7	38.2	38.6	40.7	42.8	39.6
2019	42.5	41.5	28.9	35.4	36.7	39.4	41.8	38.0

Fig. (4.33): Mean monthly and annual relative humidity

The relative humidity has a direct effect the date fruit peel separation as mentioned by (Ibrahim and Zayed,2019) who found that the increase in relative humidity around the fruits during the transition of the fruits from the Kimri to the khalal stage causes Evaporation stops which leads to increased date fruit peel separation. In the same manner, High temperature and humidity Predispose the date to peel separation and leads to increased date fruit peel separation as mentioned by (Lobo et al. 2013).(Al-Hajaj et al. 2020) agreed with the above authors and found that the increase of relative humidity leads to increase fruit peel separation.

4.5.7 Monthly Sunshine Duration Effect

The sunshine during August (ripening month) in 2019 was the highest sunshine hours as shown in figure (4.34) at 348.8 hrs. And from table (4.90), it can be seen that the lowest peel separation percentage was in 2019, for that we can conclude that the increase of sunshine hours during ripening stage was decrease the percentage of date with peel separation. This conclusion agrees with (Al-Qarni,2020) who mentioned that the increase of direct sunshine leads to increased sugar content in fruits which decreases the possibility of peel separation phenomenon in date fruit.



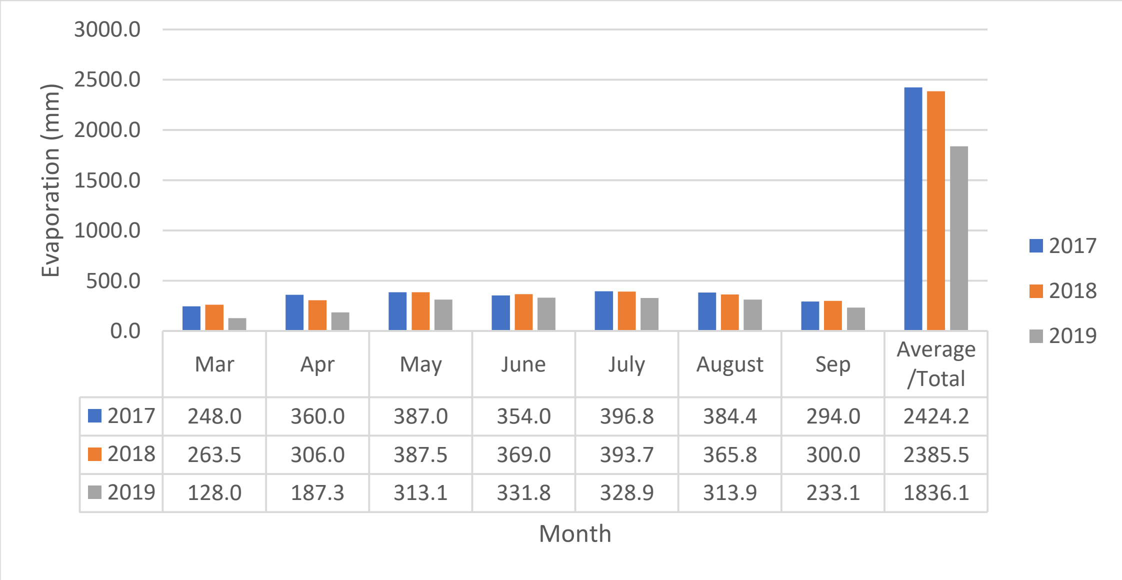
	Mar	Apr	May	June	July	August	Sep	Average /Total
2017	244.9	288.0	318.0	357.0	341.0	341.0	312.0	2201.9
2018	269.7	273.0	260.4	345.0	356.5	337.9	318.0	2160.5
2019	206.0	264.3	317.2	333.0	353.5	348.8	308.5	2131.3

Fig. (4.34): Monthly and annual sunshine duration

4.5.8 Monthly Evaporation Effect

The monthly evaporation has the same effect of relative humidity of air, where the increase of evaporation will result in higher air saturation in water vapor and this will reduce the evapo-transpiration from date fruits and leads to increased date peel separation percentage, this agreed with (Sadik et al. 2018) and with (Tripler, et al. 2011) who mentioned in their studies that the increase of evaporation decreased the evapo-transpiration from fruits and led to increased fruit peel separation.

In our study, the lowest evaporation was 1836.1 mm which was in 2019 and the highest evaporation was 2424.2 mm which was in 2017 as shown in fig. (4.35), then by correlate these data with the data collected from date grading and packing houses, it can see in table (4.90) that the lowest peel separation was 47.2% in 2019, while the highest peel separation was 56.7% in 2017, so the results in this study agree with scientific logic and with the results found by (Sadik, et al. 2018) and (Tripler, et al. 2011).



	Mar	Apr	May	June	July	August	Sep	Average /Total
2017	248.0	360.0	387.0	354.0	396.8	384.4	294.0	2424.2
2018	263.5	306.0	387.5	369.0	393.7	365.8	300.0	2385.5
2019	128.0	187.3	313.1	331.8	328.9	313.9	233.1	1836.1

Fig. (4.35): Monthly and annual evaporation

4.5.9 Mean Monthly Wind Speed Effect

As shown in fig. (4.36), the wind speed in 2019 was higher that its counterpart in 2018 and 2017 as average and also during the ripening stage months of August and September, and from table (4.90), the lowest peel separation was in 2019, this can lead to a conclusion that the increase of wind speed was a lower percentage of peel separation. The results of this study disagree with the results found by (Ibrahim and Zayed, 2019), who claims that, the wind, with higher temperatures, causes the crust to separate from the pulp of the date.

Logically speaking, the wind speed will accelerate the movement of saturated air around date fruit and bring new dry air, this will increase the evapo-transpiration of the date fruit and decrease the percentage of peel separation which as appears in the results of this study.

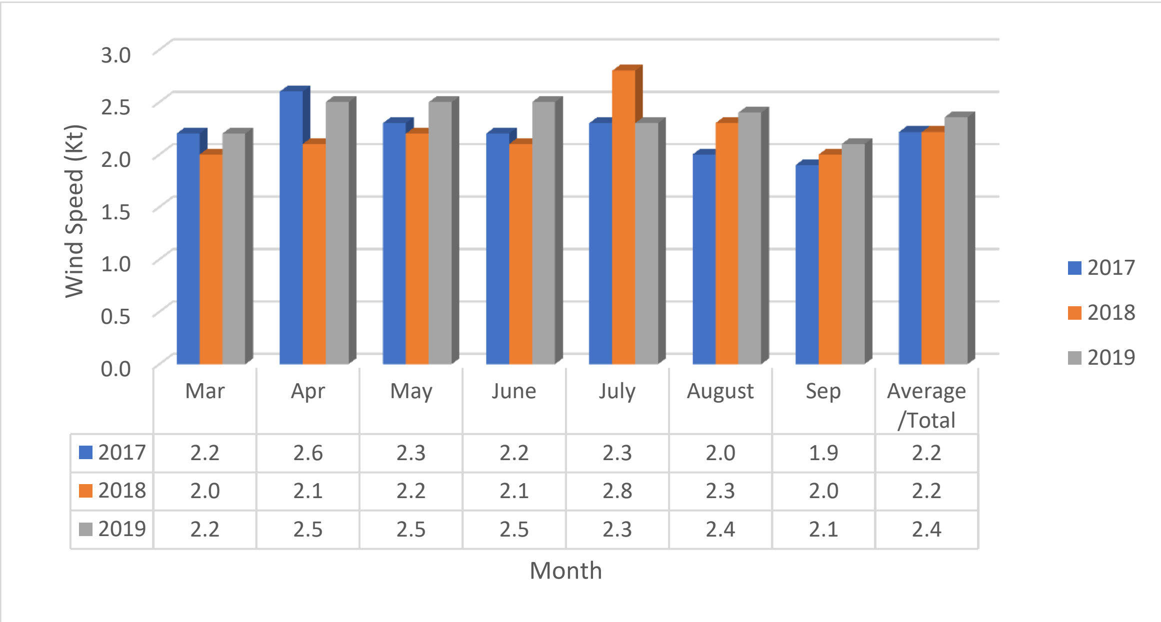
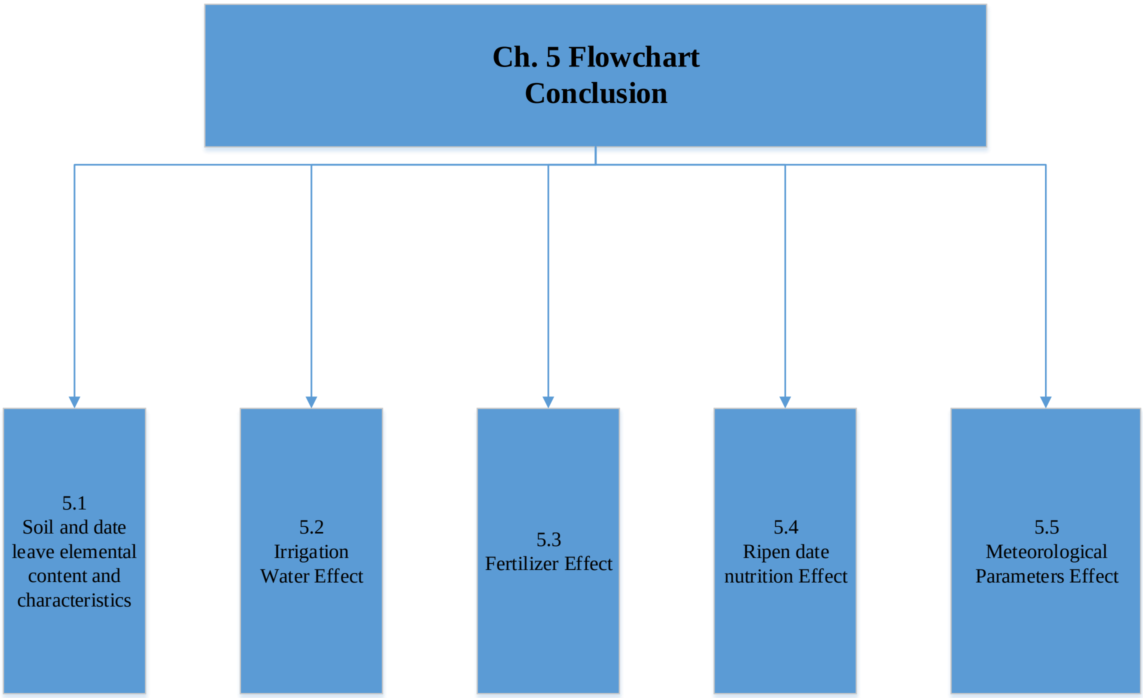


Fig. (4.36): Mean monthly and annual wend speed

Chapter Five

Conclusion



5.1 Conclusion

The date sector in Palestine, particularly the Medjoul type, is one of the most important economic sectors, accounting for the second largest national economic agriculture sector after olive oil. Because of the high quality of this date variety and the specialty and uniqueness of production areas in terms of high temperatures, low humidity, or dry conditions, medjoul dates are in high demand on the international market. Jericho and Jordan Valley are the primary locations for medjoul date plantations.

The international market and the local market alike required high quality dates in terms of size and peel separation (skin separation), but peel separation is the predominant factor for marketing medjoul date with reasonable or high price. The market classifies medjoul dates in terms of peel separation into three grades, grade A with peel separation below 10% from the surface of each fruits which can be sold with triple price of production cost, Grade B with peel separation between 10% and 35% of the surface of each fruit which can be marketed with price that could cover the production cost and yield only marginal profit, finally, grade C with peel separation above 35% of the surface of each fruit, where this grade marketed with price below production cost, which results in tremendous losses for Palestinian farmers and the National economy at large if the percentage of grade C date are high. In this manner, as much as the date percentage of peel separation reduced, the income of the date sector increases and the dates can be marketable especially in the international market.

Another problem that is generated from date peel separation is sugar crystals under peel which appears as white granules between date peel and date pulp during cold storage, where the air space between date pulp and date peel contains water vapor which condensate under peel and cause difference in sugar concentration between date surface of date pulp and inside date pulp. The prior causes the sugars to move from inside date pulp to the date pulp surface under separated peel and appears as mold spots which makes the appearance of date unappealing and the taste of sugar crystals become not very acceptable by consumers, so the price of the date plummets resulting in major losses.

Date peel separation may be affected by numerous factors like soil, water, fertilizer, nutrition fact and meteorological date, for that in this study, these factors were studied to see how are these factors affect date peel separation to be able to improve date plantation to reduce peel separation percentage.

5.2 Soil and date leave elemental content and characteristics

The soil where the date trees of study are planted is basic soil with average pH in all plots of 8.465; the soil is also classified as salty soil with average EC of 4782.30 µS/cm, which means that date tree can tolerate salty soil condition. In terms of elemental content of soil, the highest elemental content was Na and N, while the lowest elemental content was Fe, Mg and P. By comparing the two soil parameters of pH and EC before and after treatment, it can be shown from the results that the pH insignificantly affected by treatment, while the EC in soil increase in five treatments of WS, WF, FN, FP and FK where the salinity of irrigation water to all these plots are high, while EC decrease after treatment in one plot which is WT, where treated water was diluted and is characterized by less salinity than salty water and fresh water.

The highest elemental content in date leaves were N and K, while the lowest were Mn and Na. This means that the main nutrients of N and K are concentrated in date leaves, with merely traces of Na still available in date leave.

The highest accumulated element in soil was Na which appears in WS plot, that is justified due to the high salinity in WS soil and in the salty irrigation water, on the other hand the lowest accumulated element in soil after treatment was Fe and Mn because the contents of these elements was small in soil and also in irrigation water, where there was no addition of Fe or Mn as fertilizer.

The ripen date fruit peel separation correlates significantly with accumulated soil content, where the increase of potassium (K) in soil decreased the percentage of peel separation fruits in all six plots of this study. The increase of sodium (Na) and Calcium (Ca) also decreased the percentage of peel separated dates in five plots, WT, WS, WF, FN and FP. On the other hand, Magnesium (Mg) was decreased the percentage of peel separated dates in four plots, WT, WS, WF and FN. Manganese (Mn) was also decrease peel separation in three plots, WT, WS and WF. It also appeared in two plots of WT and WF that phosphorus (P) decreases peel separation date percentage, while the soil EC shows positive correlation with date peel separation in two plots of WT and FN.

Date leave contents of P, Mn, Mg, Na, K and N did not affect date fruit peel separation in all plots, while Fe content in date leave correlated positively with peel separation in WT plot, also Ca correlates positively with date peel separation in WS plot.

5.3 Irrigation Water Effect

Irrigation water plays a very important role in date plantation, where the area of date plantation is an arid area with very hot temperatures and salty soil, so the date trees require irrigation continuously. On the other hand, the irrigation water quality and quantity affect directly the date fruit quality in terms of nutrition facts and peel separation.

The irrigation water of date trees in this study were selected from three quality types, treated water (WT), salty water (WS) and fresh water (WF). The elemental content of these water quality appear that the highest content was for Na in the three types with too high concentration of Na in WS water. The main nutrients of NPK available in irrigation water exists with the highest content of

K nutrient which exist in salty water (WS), the N and P nutrients exist in treated water (WT) with high quantity compared with other water types used.

The increase of treated water affected both green date fruit nutrients and ripen date fruit nutrition and quality, where the increase in treated water leads to decrease the Mg and Ca nutrients and increase N nutrient in green date fruits. On the other hand, the increase of treated water increased fiber content, TSS and invert sugars, while decreased fat content and peel separation in ripen date fruits.

Salty water has also an effect on green date fruit nutrients and ripen date fruit nutrition and quality, where the increase of salty water irrigation decreased Na content in green fruit. On the other hand, the increase of salty water irrigation increased fiber content, TSS and invert sugars while it decreased fat content and peel separation in ripen date fruits as appears in treated water as well.

The green date fruit nutrients also affected by fresh water, where Mg content was decrease by increase fresh water. On the other hand, the ripen date fruit nutrition and quality parameters are also affected by fresh water regimes, where fiber content, TSS and invert sugars increased by increasing fresh water quantity, whereas the fat content and peel separation of dates decrease with increase fresh water.

5.4 Fertilizer Effect

The main fertilizers used for date trees are the NPK, which are Nitrogen (N), Phosphorus (P) and Potassium (K). These main fertilizers are normally used to improve the growth of date tree and enhance production and quality of dates. In this study, the effects NPK were discussed, in terms of their effect on green date nutrient and ripen date nutrition and quality, especially the peel separation parameter.

The nitrogen fertilizer used was found to increase potassium in green date fruit, while it decreased phosphorus, ferrous, manganese, magnesium, calcium, sodium and nitrogen. On the other hand, the nitrogen fertilizer was found to increase fat content and peel separation in ripen date fruits.

Phosphorus fertilizer affected nutrients in green date fruit and both nutrition and quality of ripen date fruit. It was found to increase ferrous, manganese, magnesium, calcium, sodium and nitrogen, while it decreased phosphorus and potassium in green date fruit. On the other hand, phosphorous increased fiber, TSS, invert sugars, pH and EC of ripen date fruit, while it decreases fat content and peel separation of the ripen date fruit.

Potassium fertilizer was found to increase magnesium, calcium and nitrogen in green date fruit, while it was found to decrease phosphorus, ferrous, manganese, sodium and potassium in green date fruits. On the other hand, the ripen date fruit contents of fiber, TSS and invert sugars was found to increase in ripen date fruit with increase potassium fertilizer, while the content of fat was decreased. It was also found that the peel separation in ripen date fruit was decreased by increasing the potassium fertilizer.

5.5 Ripen date nutrition Effect

The ripen date fruit nutrition like fiber content, fat content, TSS, invert sugars, pH and EC have an effect on date fruit peel separation in all plots of this study. In treated water plot (WT), the fat content was found to increase ripen date fruit peel separation, while the fiber content, TSS, invert sugars, pH and EC of ripen fruits was found to decrease date fruit peel separation in WT plot.

In salty water plot (WS), the fat content of ripen date fruit was found to increase date peel separation, while the fiber content, TSS and invert sugars in ripen date fruit was found to increase the percentage of date peel separation in salty water plot, where these results the same as in treated water plot.

The fat content of ripen date fruit was found to increase the ripen date fruit peel separation in fresh water plot (WF), it was also found that the pH and EC of ripen date fruit increased date fruit peel separation, nonetheless with low significance, while the fiber content, TSS and invert sugars were found to decrease dater fruit peel separation in fresh water plot.

Same as in water plots, in fertilizer plots of nitrogen fertilizer (FN), phosphorous fertilizer (FP) and potassium fertilizer (FK), the fat content in ripen date fruit increased ripen date fruit peel separation, while the fiber content, TSS and invert sugars was found to decrease ripen date fruit peel separation.

5.6 Meteorological Parameters Effect

Meteorological parameters like monthly average temperature, mean monthly maximum temperature, mean monthly minimum temperature, monthly heat summation units, monthly total rain fall, mean monthly relative humidity, monthly sunshine duration, monthly evaporation and mean monthly wind speed are very important parameters that affect date growing, production, maturation and quality, especially peel separation of ripen date.

Increase of the average monthly temperature during transition stage of date from khalal to rutab stage which is during August in Jericho, enhanced ripening of dates and converting the sucrose sugars to glucose and fructose sugars which can increase the adhesive of the date peel to the pulp, which can decrease the date peel separation.

Mean monthly maximum temperature also affect the date fruit peel separation where the increase of the maximum temperature for higher limits during ripening of date fruits made the date peel more brittle and increase the vapor flux on date peel during evapotranspiration, so this was seen to enhance the date peel separation. On the other hand, the mean monthly minimum decreased date fruit peel separation by decreasing the heat flux on date peel during ripening and evapotranspiration.

Monthly heat summation units are among the most important meteorological parameter that affect date fruit quality. The lower heat summation units in Jericho required for ripening of medjoul date is 2100 het units, so if the heat summation units exceed the lower limit, the lowest heat summation units can produce lower peel separation percentage. The prior may be due to the fact that the high heat units may be increase the evapo-transpiration and the vapor flux from inside date fruit and leads to enhance date peel to separate from date pulp.

Rain fall in Jericho has no effect on date peel separation in Jericho because there is no rain fall during the ripening or the harvesting of medjoul date. But on the other hand, the relative humidity of the air was found to have high effect on date fruit peel separation, where the increase of relative humidity during ripening or harvesting of dates increased date fruit peel separation by reducing the evapotranspiration from date fruits and increased the vapor pressure under peel of date fruit which leads to stimulate date peel to separate from date pulp.

The increase of monthly sunshine duration during ripening stage of dates decreased the percentage of date with peel separation, where the sun shine improved the evapotranspiration from date fruit.

The monthly evaporation, which is related directly with relative humidity, has direct effect on date fruit peel separation, where the increase of evaporation leads to increase relative humidity in air and this increase peel separation of date fruits.

Finally, the increase of the wind speed was found to decrease the date fruit peel separation, where the wind speed can circulate the saturated water around date fruit and reduce relative humidity, but the wind speed should not be too high to make the date peel to dry and brittle.

5.7 Recommendations for Future Work

After conducting this deep study on medjoul date quality in Palestine, especially the crucial problem that threatens the marketing and development of date sector which is date fruit peel, I can recommend myself and other interested researchers to build on this study and go deep on studying each component related to date peel separation as follows:

1. Studying the optimum dose of NPK fertilizer and other nutrients and minerals that are required by date tree to have lower date fruit peel separation.

2. Investigating the best timing of adding nutrients to the date trees and the optimum nutrient quantity on each time.

3. Studying the optimum water regimes from each water type of salty water, treated water and fresh water that are required by date tree to have lower date fruit peel separation.

4. Investigating the best timing of adding irrigation water to the date trees and the optimum quantity each time.

5. Studying the industrial ripening techniques of medjoul date fruits that reduce date fruit peel separation without affecting the date fruit nutrition, quality, taste and shelf life. This can reducing the effect of un-controlled meteorological parameters.

6. Investigating the drying techniques of medjoul date fruits in packaging houses which include direct sun drying, green house sun drying, solar energy drying and drying cabins and their effects on date fruit peel separation.

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جامعة النجاح الوطنية
كلية الدراسات العليا

دراسة المتغيرات الكيميائية والبيولوجية التي تؤثر على انفصال قشرة ثمرة تمر المجول الفلسطيني

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قدمت هذه الأطروحة استكمالا لمتطلبات الحصول على درجة الدكتوراة، في برنامج الكيمياء، من كلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس – فلسطين

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الملخص

تمت زراعة نخيل التمر (Phoenix dactylifera L) في العالم منذ 4000 قبل الميلاد. وتكتسب أهمية كبيرة في الديانات الثلاث اليهودية والمسيحية والإسلام من خلال ذكر التمر ونخيل التمر في هذه الديانات. الاحتمال الأكثر ترجيحا للموطن الأصلي لنخيل التمر في او بالقرب من العراق، لكن زراعة النخيل انتشرت في العديد من البلدان ابتداء من العصور القديمة. يمكن أن تنمو نخلة التمر في الظروف الجافة والحارة جدًا، حيث يمكنها تحمل التربة المالحة والقلوية نسبيًا، ويمكنها أيضًا تحمل المياه شبه المالحة وتتطلب صيفًا طويلًا وحارًا مع رطوبة منخفضة وقليل من الأمطار من التلقيح إلى الحصاد، ولكنها تحتاج إلى الري لأن التبخر مرتفع في بيئة حارة وجافة.

هناك المئات من أصناف التمور في العالم مصنفة إلى ثلاث مجموعات على أنها أصناف طرية وشبه جافة وجافة حسب محتوى الرطوبة في التمر. أصناف التمر الطرية مثلاً المجول المصنفة على أنها فاكهة تمور مائدة عالية الجودة، والتي تشتهر بحجمها الكبير بشكل غير عادي ونكهتها اللذيذة. تعتبر ثمار التمر مصدر غذائي عالي الطاقة بنسبة 72٪ إلى 88٪ سكر عند النضج. السكر الموجود في التمر بشكل أساسي هو السكروز والذي يمثل 80–85٪ خلال مرحلة الخلال، لكن السكريات الرئيسية بعد النضج هي الجلوكوز والفركتوز اللذان ينتجان من تفكك السكروز أثناء النضج بواسطة التحلل المائي بمساعدة إنزيم الإنفرتيز.

تعتبر المناطق القاحلة الحارة في جنوب غرب آسيا وشمال إفريقيا من أهم مناطق إنتاج واستهلاك ثمار التمر، كما أن منطقة الشرق الأوسط وشمال إفريقيا هما المنتجان الرئيسيان للتمور في العالم. هناك تباين كبير في متوسط أسعار الصادرات التي حققتها الدول المختلفة. حيث أن هنا كأصناف عالية الجودة مثل المجول تصل إلى أعلى سعر للتصدير. المشكلة الرئيسية التي تواجه تصدير وتسويق تمور المجول هي مشكلة انفصال القشرة عن الثمرة، والتي تحدث أثناء التحول من مرحلة الخلال إلى مرحلة التمر مروراً بمرحلة الرطب، حيث ينفصل الجلد عن اللب عندما تفقد ثمرة التمر جزءًا من محتواها من الرطوبة عن طريق التبخر. تتسبب هذه المشكلة في خسارة كبيرة تتجاوز 40٪ من الإنتاج وخسارة تجارية ضخمة بتخفيض سعر البيع أكثر من 50٪.

في هذه الدراسة، سيتم تقييم جودة المياه المختلفة من مصادر مختلفة في أريحا كيميائيًا وتحليليًا بما في ذلك مياه الصرف الصحي المعالجة. ومن ثم سيتم دراسة تأثير كمية ونوعية مياه الري على انفصال قشرة ثمار تمر المجول وجودة الثمار وقيمتها الغذائية لوضع توصيات في استخدام نوعية المياه المختلفة وكميتها في ري أشجار النخيل. تمت دراسة تأثير كمية السماد وتركيبته، وتأثير العوامل الجوية الأخرى بما في ذلك التربة والمعايير البيئية على انفصال قشرة تمور المجول وجودته، وذلك لاقتراح حلول لتقليل مشكلة انفصال قشرة تمور المجول عن اللب.

تم اختيار 72 شجرة نخيل من مزارع التمر في مدينة أريحا في غور الأردن، حيث تم اختيار 57 شجرة من مزرعة دعيق في شارع المغطس، وتم اختيار 15 شجرة من مزرعة الرائد في كتف الواد حيث تتوفر ثلاثة أنواع مختلفة من المياه: مياه حلوة مياه مالحة ومياه معالجة. تم اختيار 45 شجرة وتعريضها لنوعية وكمية مياه مختلفة، حيث تم اختيار 30 شجرة من مزرعة دعيق، وتم تحديد 15 شجرة منها بعلامة WSi، حيث i = كمية مياه الري بالمتر المكعب (50،75،100،125، 150) وتم ريها بمياه مالحة، حيث تم ري كل ثلاث شجرة بنفس كمية المياه المالحة، بينما تم تحديد 15 شجرة أخرى بعلامة WFi، حيث i = كمية مياه الري بالمتر المكعب (50،75،100،125، 150) وتم ريها بمياه حلوة، بحيث كل ثلاث شجرات تم ريها بنفس كمية المياه الحلوة. وتم اختيار 15 شجرة المتبقية من مزرعة الرائد وتم ريها بمياه معالجة وتم تسميتها بعلامة WTi حيث i = كمية مياه الري (50،75،100،125،150)، حيث

ري كل ثلاث شجرات بنفس كمية المياه المعالجة. تم اختيار 27 شجرة نخيل الأخيرة من مزرعة دعيق ومعالجتها بأنواع مختلفة من الأسمدة بالمعيار الطبيعي وبكمية أقل من المعيار وأعلى منه، حيث تعريض 9 شجرات لكميات مختلفة من النيتروجين وتم وضع علامة عليها بواسطة FNwn، حيث wn = الكمية بالكيلوجرام من النيتروجين المطبق (0، 7.5، 15)، و9 شجرات خضعت لكميات مختلفة من الفوسفور وتم تسميتها بعلامة FPwp، حيث wp = الكمية بالكيلوغرام من الفسفور المطبق (0، 0.5، 1)، و9 شجرات تعرضت لكميات مختلفة من البوتاسيوم وتم تسميتها بعلامة FKwk، حيث wk = الكمية بالكيلوجرام من البوتاسيوم المطبق (0، 2، 4) حيث تروى جميع الأشجار الـ 27 بنفس الكمية من المياه الحلوة (100 م 3) لكل شجرة سنوياً، بينما تخضع كل ثلاث أشجار لنفس المعاملة في كل سماد.

أظهرت نتائج هذه الدراسة أن شجرة التمر يمكن أن تتحمل التربة القاعدية والمالحة، حيث يبلغ متوسط درجة حموضة التربة في جميع قطع الأراضي المدروسة8.465، ومتوسط الموصلية الكهربائية 4782.30 ميكروغرام/ سم، مع نسبة عالية من الصوديوم والنيتروجين، بينما كان أقل محتوى عنصري Fe، Mg، P. تبين أن انفصال قشرة التمر الناضج يقل مع تراكم محتوى التربة من K وNa وCa وMg وMn وP ولم يُظهر محتوى أوراق النخيل ارتباطًا معنويًا مع انفصال قشرة التمر. تظهر زيادة مياه الري انخفاضًا في انفصال قشرة التمر. من ناحية أخرى، وجد سماد K وP أنه يقلل من انفصال قشرة التمر بينما يزيد سماد N من انفصال قشرة التمر. تبين أن محتوى الألياف، والمواد الصلبة الذائبة والسكريات المتحولة تعمل على تقليل نسبة انفصال قشرة التمر، في حين وجد أن محتوى الدهون يزيد من انفصال قشرة التمر. وأخيرًا، بينت الدراسة أن العوامل الجوية أيضًا تؤثر على انفصال قشرة التمر، حيث يزداد انفصال القشرة مع زيادة متوسط درجة الحرارة الشهرية القصوى، ووحدات تجميع الحرارة الشهرية، والتبخر الشهري ومتوسطالرطوبة النسبية الشهرية خلال مرحلة تحول التمر من مرحلة الخلال إلى مرحلة الرطب، بينما يقل انفصال القشرة في التمر مع زيادة متوسط درجة الحرارة الشهرية، ومتوسط درجة الحرارة الدنيا الشهرية، ومدة سطوع الشمس الشهرية ومتوسط سرعة الرياح الشهرية. من ناحية أخرى، لم يُظهر إجمالي هطول الأمطار الشهري أي تأثير على انفصال القشرة لكونه لم يكن هناك هطول مطري من عقد الثمار ولغاية الحصاد للتمر.

في الختام، يجب معالجة نخيل التمر أثناء الزراعة بالسماد N وP فقط في مرحلة مبكرة وقبل مرحلة الخلال، ثم يجب اعطاء سماد K قبل مرحلة النضج، كما يجب اختبار العناصر الغذائية مثل Mg وCa في التربة واضافتها إذا لزم الامر. فيما يتعلق بمياه الري، فإن المياه المالحة مناسبة لإنتاج تمر بجودة عالية ويجب أن تكون كافية لتجنب الإجهاد المائي لشجرة النخيل، ولكن يجب تقليل مياه الري بأكثر من 50٪ خلال مرحلة النضج لتقليل الرطوبة النسبية حول ثمار التمر.