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A Review: Date Palm Irrigation Methods and Water Resources in the Kingdom of Saudi Arabia

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Authors' contributions

This work was carried out in collaboration between both authors. Author AE designed the study and collected the literature. Author JE wrote the first draft of the manuscript and revised it according to reviewers commends. Both authors read and approved the final manuscript.

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ABSTRACT

Date palm (*Phoenix dactylifera* L.), from Saudi Arabia, is a main tree particularly at arid areas. It plays an essential role in both food and food security. 75% of date production worldwide (approx. 5,096.99 tones) were come from Arab countries. Reduction of water opposite the increasing in the population are one of the future challenges for the country so, we focused in this study depending on the literatures to predict the novel approaches that can we used.

Keywords: Date palm; irrigation system; irrigation resources; food security; Saudi Arabia.

1. INTRODUCTION

The date palm (*Phoenix dactylifera* L.) is the most important fruit in the kingdom of Saudi Arabia (KSA), because it is representing 75% of fruit production in the kingdom. It is grown in the hot areas from Morocco in the West to the Indo-Iranian borderland in the East, and from central Syria in the North to Yemen in the South [1]. The average economic life of a date palm is 40 to 50 years, up to 150 years [2]. Date palm describes the landscapes of the hot deserts. The date palm

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tree has some of Features like tolerate drought and salinity up to 4 dS m^{-1} without any decrease in yield [3]. Although the root zone depth between 1.5 to 2.5 m, the tree can bear water shortage [4]. Date palm trees are often irrigated by flood irrigation system which uses a huge amount of water; it was expected that a huge quantity of water will be required to irrigate the date palms. Because of the limited water resources in the Kingdom, it is necessary to use some water conservation techniques such as drip irrigation [5]. Countries in the West Asia and North Africa regions suffer from severe water shortages, with some 16 countries below the internationally accepted 'water poverty limit' of 500 m^3/year/person. This compares with a global average of 7000 m^3/year/person. These rising nations in population need additional water for every capita which depend intensely on irrigated agriculture, which consume more than 80% of the available water resources for food security [6]. Despite water being a scarce resource in all the main producing countries, the irrigation requirements of such an important crop have been the focus of only a limited amount of research. Water shortage will increase pressure on the use for an ever increasing amount groundwater for developing date palm. The groundwater may be low quality Furthermore its expanded usage will influence the crop negatively which identified with surface saltiness Furthermore, sodicity due to secondary temperature, low precipitation and also excessive evaporation [7]. However, a lot of development in technology has occurred in every walk of life, unfortunately very less importance can be seen in case of date palm growing, production, preservation, irrigation. There is a dire need to make use of such technologies to profit date palm growers and help them not to deteriorating yields of date palm all over the world [7].

The essential target of this work is to predict the best irrigation system of date palm tree, in view of reviewing the literature, through water requirements of date palms in the KSA could be maintained later on if the current production trend continues in increasing to achieve food security in the country.

2. DATE PALM TREE

2.1 Origin of Date Palm

The date palm (*Phoenix dactylifera*) is one of the known fruit crops, it is subtropical in origin and cultivation. It may have originated in southern Iraq, where it was cultivated 5000 years ago [2]. The spread of Date Palm and migration had occurred over many centuries along two main route; first from Iraq towards east to Iran, Pakistan and India and secondly from Egypt towards west to Al-Maghreb Arabian countries, Spain and to the new world The Arabian Peninsula has also been the home of date palm from centuries to adopt with the prevailing harsh environmental conditions. This plant has been in the history and culture since ancient times of Arabian Peninsula region and has become a completely part of the economy of Arab culture [7].

2.2 Economic Importance of the Tree

Dates represent a huge part in the economy, society, and environment in the Middle East and North Africa. Dates were processed in different ways; furthermore, other parts of the tree are utilized to different purposes [1]. The number of trees may be more than 23 million, also it may be expanding consistently. The production has expanded to one million in 2007, occupy area of 156,000 ha [5]. World production of dates might have been around 7 million tones and the main producing countries were Egypt, Saudi Arabia, Iran, united Emirates, Pakistan, Algeria, Sudan, Oman, Libya, and Tunisia [8]. According to [9], the leading five countries in terms of production were Egypt (1.35 million t from 420,000 ha), Saudi Arabia (1.08 million t; 172,000 ha), Iran (1.02 million t; 156,000 ha), United Arab Emirates (0.83 million t; 197,000 ha) and Pakistan (0.76 million t; 72,000 ha). In 2010, the total planted area in the world was 1195,000 ha, producing 7.9 million t of fruit. Of this, West Asia and North Africa together produced nearly three quarters (74%) of the world total. The date as a fresh fruit ranks number five in the production list of tropical and subtropical crops after citrus, mango, banana, pineapple and as a dried fruit, it is first [10]. The date palm not just gave a concentrated energy food, which could be stored and carried on long journeys over the deserts, yet it additionally gave shade and insurance from leave winds [10]. Date palm is a harvest most appropriate to hot, dry areas. It doesn't grow well in the wet regions where rain prevents pollination [11]. Besides its valuable and abundant fruit, rich in sugar and vitamins, the date palm gives numerous other useful items the stem and the woody midribs of the leaves can be utilized for construction works and fuel [3]. Innovative developments have made it possible to look at the palm as a raw material source for industrial purposes [8]. The most part of date palm cultivation is concentrated mostly in the Near East and North Africa, supported by the suitable dry sub-tropical and high-temperature climate prevailing in these regions [12,13].

3. IRRIGATION REQUIREMENTS

Irrigation requirements of date palm trees are considered an essential element not only for the future development plans and strategic projects but also the key elements for water budget for any agricultural area. The rationalization of irrigation water use and conservation wealth of water comes via irrigation scheduling process and find out the actual water requirement. In the beginning, Furr and Armstrong [14] evaluated annual water use of palms (cv. Khadrawy) to be 1300–1600 mm, with monthly totals ranging from 60 mm in the winter to 190 mm in the summer. Then, [15], depend on gravimetric soil sampling, estimated crop water requirement for date palms at California. Since this early work in the United States, several attempts have been made to measure the actual water use (ET) of palms in West Asia and North Africa such as [16] in Egypt and the studies conducted in the Al-Hassa region in Saudi Arabia [17]; [18] and Iran [19]. Studies have shown that low-interval irrigation with high amounts for date palms is better contrasted with high-interval water system [17]. The consequences of an examination on date palm (Sakoti) in Egypt have demonstrated that the best interval between irrigation is a month with an amount equivalent to 71 mm for each irrigation [16]. In an investigation directed in Tunisia by [20], found that the least yearly water requirements were 63 m^3 for every tree, while the actual water requirements, including a wide range of losses, were 95 m^3/tree. [21] specified that the average amounts delivered to date palms every year were; 108 m^3/tree, 216 m^3/tree and 324 m^3/tree for water regimes of 50%, 100% and 150% of evaporation rate, respectively. [22] has decided the total annual amount of water in the southwestern district of Saudi Arabia as 136 m^3 per each tree. [23] has discovered that the actual yearly water use of the date palm ranged from137 and 55 m^3 in Eastern district to around 195 and 78 m^3 in the central area for surface and trickle irrigation, respectively. The total annual depth of water required was estimated to be 2700–3000 mm [24]. The water use of date palm over a season on a commercial farm in Saudi Arabia, using both the Bowen ratio energy balance method and a soil water balance approach, the actual annual water use of drip-irrigated 15-year-old palms (cv. Sukariah) to be 1780 and 1640 mm, respectively. Daily ET rates (averaged over a minimum of 20 d) varied between about 2.4 mm/d in February (at pollination) and about 7.6 mm d^{-1} in July (at the Khalal – mature soft fruit stage) [25]. Using a simple water balance approach, actual evapotranspiration (ET) rates by 11-year-old palms (cv. Medjool) in Jordan (32°00_N 35°18_E; alt. –224 m) over 12 months (2011). The measured annual ET totals by palms subjected to four drip-irrigated water regimes (50, 75, 100 and 125% of ETc) were 1300, 1600, 1800 and 2000 mm. Seasonal totals of water applied were 27, 40, 53 and 67 m^3 $tree^{-1}$ (156 trees ha^{-1}) [26]. The water use of date palm at seven representative sites in Saudi Arabia at each site, which extended from Najran in the south (17°28_N 44°06_E; alt. 1264 m) to Qaseem in the north (26°20_N 43° 59_E; alt. 179 m) Wadi Addwaser have shown the highest annual amount of 80 m^3/tree, followed by Hofuf of 70.7 m^3/tree, Madinah 69.3 m^3/tree, Riyadh 67.7 m^3/tree, Gaseem 66.9 m^3/tree, Makkah 60.4 m^3/tree and the lowest was 59.4 m^3/tree for Najran, The average daily net date palm water use rates measured were; 203, 200, 155, 161, 185, 190 and 218 L/day for same areas, respectively [27]. The average daily Date Palm water use was 184.4 l/day for all regions in KSA and the total net annual date palm water use has ranged between 59.4 and 80 m3/tree [27].

4. IRRIGATION SYSTEMS

The type of irrigation system is important and the availability of suitable irrigation systems scarcely meets the needs of agricultural development. Irrigation water is rapidly becoming the primary limiting factor for crop production [28].

4.1 Flood Irrigation System

Date palm trees are generally irrigated by surface irrigation system that uses a lot of water as indicated by [6]. The amount is normally decided by the farmer’s experience. The crop water requirement for mature date palms ranges between 115 and 306 m^3, that is equal to 1.15 to 3.06 m^3 h^{-1} [5]. The old date palm orchards in KSA were irrigated from wells using surface irrigation methods, especially basins and they were usually irrigated once a week in the summer and every three weeks in the winter [29]. The 2004-2005 agricultural census shows that 96% of palm trees are irrigated using the flood irrigation system [6]. The suggested values of irrigation needs for date palm trees planted in different parts of the Kingdom were ranging between 39585 and 72270 m^3/h/year for flood irrigation, and between 28275 and 51621 m^3 h^{-1}/year for sprinkler irrigation [27]. The flood irrigation system consume 33,230 m^3 h^{-1} [6] as in Table 1.

4.2 Bubbler Irrigation System

Bubbler irrigation is a modified version of drip irrigation system for groves crops; the powerful utilization of bubbler irrigation system continued the work of improving system design that can be depended under different conditions [30]. It consists of a water source, a pumping unit, a mixing chamber, mainline, several submain lines, laterals, bubblers, etc. [31]. The system layout is the typical one of all pressurized systems. It consists of a simple head control unit without filters and fertilizer apparatus. The mains and the submains are usually buried rigid PVC pipes, with hydrants rising on the subsurface. The manifolds and laterals are also often buried solid PVC pipes. The bubblers are placed above ground and associated with the laterals with a small flexible tube rising on the surface, or they can be fitted on small PVC risers associated with the buried laterals [32]. Drippers produce a maximum flow of 9.45 liters per minute for each lateral, it is imperative to control irrigation water through some water conservation methods, such as drip irrigation systems [33]. [34] have studied the response of date palm (cultivar Zahdi) under three different irrigation systems: basin, bubbler and sprinkler. They found that there was an expansion in growth with an increment in water and the bubbler the bubbler irrigation system is the best. In another investigation, they got with the bubbler irrigation followed by basin and sprinkler irrigation [35]. The advantage of bubblers over basin irrigation may be caused by providing the crop with satisfactory water requirement. These outcomes are in computability with those obtained by [36,21,34]. The bubbler irrigation system was satisfactory for what it was designed in terms of distribution uniformity, the distribution uniformity varied by 92.6% for laterals and 93.9% for the entire system and the results indicated that about 30.94% water was saved under bubbler irrigation method when contrasted with the basin irrigation method [31].

According to [6], The bubbler irrigation system consumes 24,288 m^3 h^{-1} which save 9000 m^3 h^{-1} comparing flood irrigation system. as in Table 1.

4.3 Surface Drip Irrigation System

Reuveni [37] studied the impact of a trickle as compared to sprinkler irrigation on growth and yield of date palms; he discovered that trickle irrigation has definite advantages over sprinkler irrigation as the tree irrigated with trickle irrigation could be grown with the limited wetted volume of soil. Results have also shown that date palms irrigated with drip irrigation show an acceptable expansion in leaves, flowers and fruits compared to those irrigated by a sprinkler system [38]. Drip irrigation system gained popularity in the recent years due to the benefits gained from minimizing soil erosion, uniform distribution of water, minimizing labor cost, variation in supply, reducing the risk of disease. Moreover, it can be operated at lower pressure than other types of pressurized irrigation, which resulted in reducing energy costs [39].

The yield of drip irrigated palm trees was significantly higher than those irrigated by sprinklers [21]. Comparing this system with both surface and sprinkler irrigation systems demonstrate that there is more advantageous with respect to the others [40]. According to [6], the surface drip irrigation system consume 19,946 m^3 h^{-1} which save 4,332 m^3 h^{-1} comparing bubbler irrigation system through a year as in Table 1.

Beside drip irrigation is the most efficient irrigation system available, growers can achieve both application and water use efficiencies exceeding 85% with drip irrigation (surface or subsurface), it is durable and can easily last in the field for 20 years or more with proper installation and maintenance [41]. The drip irrigation system has proven its efficiency over other irrigation systems in reducing the cost of labor and energy. In addition, it improves efficiency and reduces water losses due to evaporation and deep percolation [5].

Several authors [5,42] have reported that there are a lot of problems in trickle system, e.g. the possibility of damage because of the pipe network is detected to the sun and the salts gathering. So, the subsurface drip irrigation has been recommended, due to its efficiency and productivity regardless some little problems in this system that treated by clogging of emitters by small roots, lateral installation and fertigation.

Table 1. Annual consumptive use of water in some regions ($m^3 h^{-1}$)

Irrigation system regions	Surface irrigation ($m^3 h^{-1}$)	Bubbler irrigation ($m^3 h^{-1}$)	Drip irrigation ($m^3 h^{-1}$)
Riyadh	34,343	25,046	20,602
Makkah	34,451	25,095	20,667
Madinah	43,305	31,545	25,978
Qaseem	35,204	25,647	21,121
Eastern	34,782	26,120	20,865
Asser	25,107	18,289	15,061
Tabuk	32,157	23,424	19,290
Hail	35,254	25,680	21,148
Northern	34,976	25,647	21,121
Najran	28,868	21,028	17,317
ABaha	25,107	18,289	15,061
Jouf	35,204	25,647	21,121
Average	33,230	24,288	19,946

4.4 Subsurface Drip Irrigation (SSDI)

The subsurface drip irrigation define is related to drip irrigation but, the system is beneath the soil surface. [43] mentioned that the SSDI was referred to as sub- irrigation and subsurface irrigation and sometimes referred as water table management. SSDI is the recently irrigation approach and considered the best technique for both irrigating agricultural crops and landscape [42]. The structure and texture of the soil, and crop's root improvement pattern is considered in design of SSDI [44]. There is an increase in the yield and a considerable saving in water compared to the conventional drip irrigation method. In addition, there was a high increase in water use efficiency [5]. Several authors [45,46] also reported that SDI systems and SSDI can increase water use efficiency only if the system is designed to meet the soil and plant conditions. Comparing the SSDI system with the traditional SDI and the sprinkler irrigation system, the overall water use is reduced by 50% compared to the sprinkler system and 30% compared to the conventional trickle irrigation system. It was also noted that production increased by a percentage ranging between 30 to 70% compared to the surface irrigation system [10].

Mohammad and Al-Amoud [47] have revealed that SSDI is the optimum solution for saving water and yield increment. In other studies, [45] and [5] have found a significant increase in production and an improvement in quality. SSDI has also restricted groundwater pollution with nitrate and salts in the long run as the water is actually added to the active roots, In addition to the control of salinity, deep percolation and durability of the system [45]. There are some additional practical advantages associated with SSDI: a relatively dry soil surface permits farm equipment access and movement during the whole irrigation period, and reduces weed growth significantly [42,48]. SSDI limits root rot and other soil diseases. Also, it inhibits crust that reduce soil air circulation and rainwater infiltration into the soil resulting in extreme surface run-off [42]. In addition, SSDI is not affected by the sun or the extreme weather conditions that mean longer material life, permanent installation below the plough depth, reduce labor costs [42]. Farmers have adopted SSDI because of different points for example, higher yield, higher nature of products and vegetable yields, facility of various harvests with vegetable yields, the ability to apply chemicals (fertilizers and pesticides) through the SSDI tubing, and the reduction of plant infections through keeping up a dry soil surface [41]. [49] reviewed 10 years of SSDI research on corn in the Great Plains and reported that water savings of 35% to 55% were possible compared to traditional forms of irrigation such as sprinkler and furrow [50]. The subsurface drip irrigation system was more efficient than surface drip irrigation system on improving potato tubers yield quantity, quality parameters and nutrients concentration content. In addition to soil fertility after harvesting [51]. [52] made a detailed experimental investigation on corn crop under subsurface drip irrigation, he suggested that 60% of the estimated daily evapotranspiration with SDI is sufficient for maximum corn yields.

Al-Amoud [5] found that water saving could reach up to 60% with an increase of yield that achieves an average of 25% by utilizing SSDI, subsurface drip irrigation systems have exhibited high water use efficiency of more than three-fold the conventional surface drip systems. Based on the results of some experiments, SSDI systems prove to be durable and highly efficient for irrigating date palm trees. In order for the kingdom to maintain the production growth in date palms cultivation and industry without losing water (Water is the most precious thing for the kingdom which is located in hot area where rainfall is rare). The kingdom needs to put laws that enforce the farmer to use subsurface irrigation systems on their farms. The SSDI represents the improvement application, as it prevents considerably the evaporation from soil surface and the evapotranspiration is satisfied in a better way due to upward movement of water in the root zone, in addition, it prevents the growth of weeds around the crop [5].

Under the arid and semiarid climates, where precipitation is insignificant and the air temperature is high, this prompts salt gathering in the top layer of the soil where active roots concentrates which in turn lead to yield reduction, SSDI system should apply to wash away salts beyond root zone to minimize salt accumulation caused by evaporation, this method was applied successfully, on mature pear trees, where subsurface laterals were laid at depths of 30 cm and 60 cm under soil surface [53,54].

SSDI techniques was conducted on a variety of crops, it has proven its superiority in cotton [42], tomato, potato [55], corn [1], row crops [56], cucumber [57] and with date palms [5]. If the enlargement in date palm agriculture remains at a similar present rate in the Kingdom it is expected that an enormous amount of water will be required to irrigate the date palms due to the limited water resources in the Kingdom. It is vital to utilize some water saving strategies, like recent irrigation systems [5].

In spite of, the significance of date palm fruit product in dry regions particularly in KSA where water is rare there are not enough studies on date palm trees under subsurface drip irrigation comparing with crops, where water is scarce there on date palm trees under. SSDI was applied on a limited scale, although this is necessary for water conservation due to the limited water resources in the kingdom. Irrigation management could be done through adoption the best agricultural practices and irrigation methods, including deficit irrigation and irrigation scheduling, in order to reduce watering amounts, increase water [5,58].

5. IRRIGATION WATER RESOURCES

The Kingdom of Saudi Arabia (KSA) is a big country, with a total area of about 2.15 million km². KSA lies in the semiarid desert region, and the winds reaching the country is dry. Also, there are extremes of temperature, there are wide variations between seasons and regions all of them make the climate of KSA is harsh. It is also described by low rainfall or permanent sources of water. The climatic conditions represent a great challenge due to the depletion of underground water resources because of increasing evapotranspiration, reduce soil moisture. These conditions have a negative effect on agriculture and water availability and make Saudi Arabia a very poor country in terms of agricultural potential and water resources. The relatively small temperature increase of about 1.5°C in the lower latitudes would increase evapotranspiration by 5 to 15% [59]. Due to a severe deficit, water has always been a precious resource and occupies the main position between the natural resources of the kingdom [60].

The source of water differs from country to country. Some like Egypt and Iraq mostly depend on surface water from large universal rivers. Others, like Yemen and the Arab States of the Gulf Cooperation Council countries depend almost on groundwater and desalinized, while others use a combination of surface and groundwater. The water resources in the Kingdom are divided into surface water (2 billion cubic meters per year), underground water (1.5 million cubic meter, MCM), desalinated water (740.52 million American Gallons daily) and about (1.5 million cubic meter) of treated sewage water per day [61]. The wells represent more than 40810 artesian wells and 52327 traditional wells, yet dams were only 16 dams in the kingdom before 1975; the number increased to 190 by 1999 and 223 by 2004, with the collective storage capacity of 836.6 MCM [62]. The available surface water and groundwater resources are limited, rainfall rates are less than 150 mm in most areas of the country, also the development realized in all sectors, these factors make the kingdom a water scarcity state and the annual national water demand has exceeded 30000 MCM [63]. To achieve the goal of sustainable water resources management, there are three major water challenges: the growing water scarcity, greater sensitiveness of water to contamination and the regional conflicts over water in the developing world. All these problems must be addressed effectively. In a study

Table 2. Growth of water use in Saudi Arabia, 1980-2010 (million cubic meter)

Year	Domestic and industrial (percentage)		Agricultural (percent age)		Total
1980	502	(21.3)	1,850	(78.7)	2,352
1990	1,650	(6.06)	25,589	(93.94)	27,239
1992	1,870	(5.9)	29,826	(94.1)	31,696
1997	2,063	(11.17)	16,406	(88.83)	18,469
2000	2,900	(20.57)	11,200	(79.43)	14,100
2010	3,600	(19.67)	14,700	(80.33)	18,300

Source: [64]

Table 3. Water supply in Saudi Arabia, 1990–1997 (million cubic meter)

Year	1990 (percent)	1992 (percent)	1997 (percent)
Surface water and shallow aquifers (renewable)	2100 (13%)	2140 (7%)	2140 (13%)
Groundwater (non-renewable)	24489 (83%)	28576 (90%)	15376 (83%)
Desalination	540 (3%)	795 (2%)	795 (4%)
Treated wastewater effluents	110 (0.7%)	185 (0.6%)	185 (1)
Total	27,239	31,696	18,496

Source: [64]

conducted by many researchers to estimate the current and future water needs for all purposes of agricultural, urban and industrial, as well as estimating the amount of water available from surface water and groundwater, desalinated water and treated wastewater until the year 2025, assuming several scenarios based on the estimation of agricultural consumption in the future, according to a proposed combination crop and in the light of the expected increase in population and other water needs assumptions, to avoid the expected deficit in various sectors of solutions (Tables 2 and 3).

6. PRODUCTIVITY

Water productivity is important for the global water challenge. In order to estimate the effect of water levels on the yield, the WUE will be calculated, according to [65] using the equation:

> Water use efficiency (kg crop/m^3 of water) = Gross yield weight (kg/ha)/amount of irrigation water used (cubic meter/ha).

In study of yield responses to water treatments by [6], it has been proved that yield responses to the different water treatments were inconsistent. The irrigation water productivity values varied between 0.55 kg m^{-3} and 1.40 kg m^{-3}. Also in Jordan, water productivities over one year declined from 1.25 to 0.64 kg m^{-3} as the amount of irrigation water applied increased (50, 75, 100 and 125% ETc). The corresponding yields of fresh fruit were 34, 36, 38 and 43 kg tree^{-1} [26]. [66] Yet, [21] mentioned the average yield across all treatment combinations through four years, it was 173 kg tree^{-1}. Trees irrigated with trickle out-yielded those irrigated by the other two methods in some years but not all (overall by about 20%).

7. EFFECT OF DEFICIENCY OF IRRIGATION WATER ON GOOD QUALITY

The Middle East and North Africa (MENA) Region is the most water scarce area in the world. This region is home of five percent of the world's population, the average water availability per person only around 1,200 m^3/person/year. One half of MENA's population lives under conditions of water stress. Moreover, with the population expected to grow from around 300 million todays to around 500 million in 2025 [67].

The entire Middle East faces diverse water challenges, but for the GCC itself, the number one threat is scarcity. Water here is not renewable. Sandy nature of most of the soils coupled with high drainage enhances leaching losses and reduces water supplying capacity of the soils. Egypt, one of the leading date palm growing countries, is also facing great challenges due to its limited water resources represented mainly by its fixed share of the Nile water and its aridity characteristic [67].

Due to scarcity of good quality water the usage of saline water shares very high in date palm irrigation because the general notion is that date palm is a salt tolerant tree.

However, this blind statement cannot be accepted as basis because studies have indicated that growth and yield losses start occurring at water EC of 4-6 dS m^{-1} depending upon varietal potential, soil texture, drainage and climatic factors. The values of water EC for 10, 25 and 50 % yield losses have been reported as 4.5, 7.3 and 12.2 dS m^{-1}, whereas soil EC for the same magnitude of losses were 6.8, 11.0 and 18.0 dS m^{-1} (Table 3). The quality assessment studies indicated that major portion of groundwater is saline and there is hidden danger negative effects on date palm growth and yields. Just as an example, the groundwater quality categorization of Oman is presented here [7].

8. FUTURE MANAGEMENT OF DATE PALM IRRIGATION

All the indicators show that date palm farming in Saudi Arabia and dates production are expected to continue in a sharp increasing trend. Creating a very challenging situation related to the huge amounts of water needed for the irrigation, with further shortage in the available water resources in the country when the groundwater aquifers will be disappeared. Since, the groundwater aquifers, which are the main irrigation resource, have specific life time expectancy, this problem can't be solved totally, however, it could be best mitigated through different ways including in the first place irrigation management and strategic planning [58].

FAO [68] has offered some recommendations for managing water for agriculture:

- There is a need for procedures for using water and adoption of conservation water.
- Improving the available irrigation methods and exploring new irrigation methods to use the limited water resources effectively. Farmers must plant drought resistant/ tolerant varieties of crops and trees. And also encouraged them to use modern irrigation systems and to adopt irrigation scheduling to minimize water demand.
- Creating awareness between the citizens in both rural and urban areas to adopt water conservation methods.
- Training programs for the users on the water demand management.
- Recycling treated industrial wastewater to irrigate various industrial plants.
- Surface irrigation systems should be replaced by drip, sprinkler irrigation and micro irrigation systems.
- Encourage the cultivation of crops with lower water requirements.
- The kingdom regulations on the use of water, reduction in domestic water demand by the introduction of new water pricing policies, leakage detection and all other control measures that could conserve water must be applied with letter and spirit.

9. CONCLUSION AND RECOMMENDATION

Finally, it's very clear from this review that, any further expansion in palm trees in the following years and in the agricultural sector generally, have to be under absolute control and have to be cautiously evaluated and managed from decision makers; in order to best fulfill the sustainable approach for the future of agriculture in the country. However, a lot of development in technology has occurred in every walk of life unfortunately, very less can be seen in case of date palm growing, production, preservation, irrigation. There is a dire need to make use of such technologies to benefit date palm growers and help them to breaking stagnating rather deteriorating yields of date palm all over the world.

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Authors have declared that no competing interests exist.

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