The Effect of Irrigation with Fish and Dairy Farm Effluents on the Production of Date Palm cv. Medjool

تأثير الري بمياه المزارع السمكية ومياه مزارع الأبقار على إنتاج نخيل التمر صنف مجول

Alai Daoud Bitar
Associate Professor/Al-Quds Open University\ Palestine
abitar@qou.edu

Hassan Ahmad Abu Qaoud
Professor/ An-Najah National University/Palestine
Hassan@najah.edu

Husameddin Mustafa Isaid
Assistant Professor /Nakheel Palestine Company/ Palestine
hdsaeed@yahoo.com

Ismail Hasan Daiq
Researcher /Valley Trading Company/ Palestine
Daiq.Ismail@gmail.com

Khalid Wajdi Aslan
Researcher /Al-Quds Open University/Palestine
Khalidaslan94@gmail.com

Ziad Hussein Al-Zuhoor
Researcher /Valley Trading Company/ Palestine
Ziad_Zhour@hotmail.com

علائي داوود البيطار
أستاذ مشارك / جامعة القدس المفتوحة / فلسطين

حسان أحمد أبو قاعود
أستاذ دكتور / جامعة النجاح الوطنية / فلسطين

حسام الدين مصطفى اسعيد
أستاذ مساعد/ شركة نخيل فلسطين / فلسطين

إسماعيل حسن دعيق
باحث / شركة الوادي / فلسطين

خالد وجدي أصلان
باحث / جامعة القدس المفتوحة / فلسطين

زياد حسين الزهور
باحث / شركة الوادي / ف لسطين

Received: 23/ 11/ 2021, **Accepted:** 12/ 2/ 2022
DOI: 10.33977/2106-000-006-001
http://journals.qou.edu/index.php/PJTAS

تاريخ الاستلام: 23/ 11/ 2021م، **تاريخ القبول:** 12/ 2/ 2022م.
E - ISSN: 2521 - 411X
P - ISSN: 2520 - 7431

Abstract:

Since the 2000s, date palm trees have been rapidly spreading across the Jordan valley in the West Bank. Although the date palm may survive in arid climates, it needs enough water to reach its full potential production. The West Bank limited water resources are seen as the most significant obstacle to agricultural development.

This study was carried out over two growing seasons, 2019 and 2020, in order to assess the efficacy of alternative irrigated water resources for the date palm trees. A randomized complete block design (RCBD) was used in the experiment to replicate the three treatments: farm water (control), fish farm effluent, and dairy farm effluent. Microbial analyses (yeasts, molds, and *E. coli*) and chemical analyses (pH, EC, Cl, Na N, P, and K) were performed for all types of irrigated water used in the experiment.

The results indicated no harmful microbial existence in the three irrigation water treatments. The EC was higher in both fish and dairy effluents (6.85 and 6.41 dS/m) respectively compared to 2.89 ds/m in the control. The results of 2019 season showed no significant differences among the treatments in most parameters studied in the experiment, while the results of the 2020 season indicated the superiority of irrigation with fish farm effluent compared to other treatments. This treatment gave the highest number of leaves (26.5 leaves) per tree, the highest yield per tree (67 kg/ tree) and the highest fruit weight 18.78 g. Fish and dairy farm effluents were rich in nitrogen (N), phosphorus (P), and potassium (K) that could compensate the annual requirements of NPK for the date palm tree. Thus, fish and dairy farm effluents could be used as a source of irrigation and fertilizer in modern date palm cultivation, however, long run investigation is needed to study the impact of using such water sources on soil and plant.

Keywords: Date palm, Medjool, reuse water, farm water, fish farm effluent, dairy farm effluent.

الملخص:

منذ العقد الأول من القرن الحادي والعشرين، أخذت أشجار النخيل تنتشر بسرعة عبر وادي الأردن في الضفة الغربية. وعلى الرغم من أن نخيل التمر قد يعيش في المناخات القاحلة، إلا أنه يحتاج إلى كمية كافية من الماء للوصول إلى كامل إنتاجه المحتمل. يُنظر إلى الموارد المائية المحدودة في الضفة الغربية على أنها أكبر عقبة أمام التنمية الزراعية.

أجريت هذه الدراسة خلال موسمي 2019 و2020، من أجل تقييم فعالية مصادر مائية بديلة لري أشجار النخيل. تم استخدام تصميم القطاعات الكاملة العشوائية (RCBD) في التجربة لتكرار المعاملات الثلاثة: مياه المزرعة (شاهد)، ومياه المزارع السمكية، ومياه مزارع الأبقار. تم إجراء التحاليل الميكروبية (خمائر، أعفان، E. coli) والكيميائية (درجة الحموضة، الملوحة، الكلور، الصوديوم، النيتروجين، الفسفور، والبوتاسيوم) لجميع أنواع مياه الري المستخدمة في التجربة.

أشارت النتائج إلى عدم وجود ميكروبات ضارة في معاملات مياه الري الثلاثة. كانت الملوحة أعلى في كل من مياه الأسماك والأبقار (6.85 و6.41 dS/m) على التوالي مقارنة بـ 2.89 dS/m في الشاهد.

أظهرت نتائج موسم 2019 عدم وجود فروق معنوية بين المعاملات في معظم الصفات المدروسة في التجربة، بينما أشارت نتائج موسم 2020 إلى تفوق معاملة الري بمياه المزارع السمكية مقارنة بالمعاملات الأخرى، حيث أعطت هذه المعاملة أعلى عدد من الأوراق (26.5 ورقة) لكل شجرة وأعلى إنتاجية للشجرة (67 كغم/ شجرة) وأعلى وزن ثمرة (18.78 غم).

كانت مياه المزارع السمكية ومياه مزارع الأبقار غنية بالنيتروجين والفسفور والبوتاسيوم والتي يمكن أن تعوض الاحتياجات السنوية من NPK لنخيل التمر. وبالتالي، يمكن استخدام مياه المزارع السمكية ومياه مزارع الأبقار كمصدر للري والأسمدة في زراعة نخيل التمر الحديثة .في المستقبل، هناك حاجة لأجراء المزيد من البحوث حول تأثير استخدام مصادر المياه المستخدمة على التربة والنبات

الكلمات المفتاحية: نخيل التمر، مجول، إعادة استخدام المياه، مياه المزرعة، مياه المزارع السمكية، مياه مزارع الأبقار.

INTRODUCTION

The date palm (*Phoenix dactylifera L.*), represents a main resource for the development of the agricultural economy in Palestine and in other countries around the Mediterranean basin and the Middle East (Russo et al., 2017). In the previous ten years, date production has doubled, with global yields of almost 7.5 million tons in 2014 (Al Alawi et al., 2017).

Since the 2000s, date palm trees have been rapidly spreading across the Jordan valley in the West Bank. It offers promising opportunities for Palestinians to enhance their livelihoods and export profits (Abu-Qaoud, 2015). In Jericho and the Jordan Valley, the entire area of date palms is about 26,000 donum, with roughly 350,000 trees (Daiq, 2020). Although the date palm may survive in arid climates, it needs enough water to reach its full potential production (Abu-Qaoud, 2015). The West Bank's limited water resources are seen as the most significant obstacle to agricultural development (Mazahrih, 2012). The available water in the West Bank declined, and the water quality in many Jordan valley wells degraded. Similarly, the amount and quality of irrigation water in Jericho dropped and the majority of these wells aren't recharged on a regular basis.

In addition, the regional area including Palestine is expected to experience an average temperature rise of 1.4°C to 4°C over the next century, as well as a general decrease in precipitation of 25% regionally and up to 40% locally, a shift in rain seasons from winter and spring to autumn (East, 2019).

As a result of the intensive date palm agriculture in Jericho, as well as the influence of climate change on water availability and quality, including a rise in salinity in both irrigation water and soil, water availability and quality will be impaired (Russo et al., 2017). Therefore, another renewable water sources must be sought to fulfill the water shortage (Abu-Jaish, 2018). Several alternative renewable water sources have been proposed, including irrigation with fish waste and dairy farm effluent. In the last years, many large agricultural pools were constructed in Jericho and Jordan valley. Farmers and investors in agriculture have realized the importance of fish farming in agricultural pools used to irrigate date palm and other crops. Moreover, few farmers in Jericho and Jordan Valley adopted the integrated farming systems between aquaculture farms and plant production farms. These combinations may increase farm income and maximize the benefits from agricultural inputs and the conservation and the sustainable use of natural resources (Ahmed and Garnett, 2011). In 2020, the number of fish farm water pools in Jericho and Jordan valley was about 150 pools, while the number of dairy farm water pools was two pools (Daiq, 2020).

Reusing the drained water of fish farms is a critical approach to sustainable use of available water for irrigation. Drained water of fish farming as a good irrigation resource increased crop productivity and reduced the total costs of fertilizers (Abdelraouf and Hoballah, 2014). Furthermore, Abdelraouf (2017) reported the benefits of fish water effluent as a new water source to irrigate potato, soybean, and onion crops. This application did not require additional fertilizers and thus reduced the fertilizer costs. Khater (2006) utilized the outputs of fish farming as a new technique to minimum requirements of nutrients in growing vegetables, i.e., lettuce, cucumber, tomato, cabbage, etc. Drained water of fish culture was evidenced to be highly enriched with natural fertilizers due to fish excrete which contains high content of ammonia and urea, and organic matter (Elnwishy, 2008). Consequently, this promotes increased nitrogen and phosphorus in the water due to fish excretion and feed leftovers. Therefore, the fish farming effluent water could be noticeable as a source of irrigation and fertilizers in agriculture, especially in areas that suffer from water scarcity (Kaab Omeir et al., 2020).

Dairy farms produce large quantities of wastewater as a result of the thorough washing of milking and feeding parlours, such as wastewater distinguished by certain level milk components, such as casein, lipids, and lactose (Roufou et al., 2021). Applying t hese dairy farm effluents (DFE) to agricultural soils is a widely utilized disposal method due to the benefits these wastewaters bring to the soil and the accompanying improved crop productivity (Longhurst et al., 2000). Among the benefits of land application of DFE, the added organic matter, nutrients, and microbial mass are known to improve soil aggregation, soil fertility, and water holding capacity (Barkle et al., 2000). Irrigation with DFE onto pasture was increasingly recognized as a means for biological treatment, and realized that DFE was a resource for its mineral content rather than a waste (Hawke and Summers, 2006). An experiment by Islam et al. (2017) studied the impacts of dairy farm's wastewater irrigation on maize's growth and yield attributes. The investigation showed that dairy farm wastewater contained different nutrients and organic matter, which optimistically contributed to the development and production of maize. The highest grain yield, was recorded under dairy farm wastewater irrigation with no fertilizer application. Similar results obtained by Islam (2015) who reported that dairy farm wastewater might be used as a source of irrigation and fertilizer for wheat production without any hazard to soil.

The importance of this study lies in its attempt to test other water sources to compensate the scarcity of water for irrigating date palms, such as fish and dairy farm waste water. There have been no research on the effect of fish and dairy farm effluents on the production of date palm. As a result, our research's goals were as follows:(1) evaluate the use of various water resources (fish and dairy farm effluents) in date palm irrigation in Jordan valley; and (2) examine the fruit quality and air fruit content under various water resources (fish and dairy farm effluents).

MATERIAL AND METHODS

Study site and climatic conditions: This study was conducted at Al-Wadi farm (Daiq Brothers) in Jericho/Palestine, and carried out by Al-Quds Open University Center for Agricultural Research-Jericho for two growing seasons, 2019 and 2020. The experimental site was located at 31°52′16″N latitude and 35°26′39″E longitude. The farm was located in the elevated plain at an altitude of 360 meters below the sea level (bsl). The area received rains about 166 mm annually (PMD, 2020). The climatic conditions at the site are characterized by hot dry summer and relatively warm winter, while the soil is characterized by having silt texture with high pH and high salts content (Dudeen et al., 2001).

Plant materials: The experiment was conducted on six-year-old Medjool date palm trees, spaced at 8×9 meters grown under a drip irrigation system. Date palm trees were selected for their uniformity in vigor and size.

Treatments, replicates, and experimental design: the plot size was one date palm tree. The experiment consisted of three treatments viz., farm water (control), fish farm effluent, and dairy farm effluent, in four replicates using randomized complete block design (RCBD) according to Little and Hills (1978). All trees in the experiment were subjected to the same usual horticultural practices.

Water sources: the Arab Development Society (ADS) provided the fish farm effluent for this experiment, while the dairy farm effluent was got from Al-Juneidi Dairy and Food Products Company which was established recently in Jericho as the biggest modern dairy farm.

Amount of water: Table 1. shows the amount and time of irrigation used in the experiment for all the types of irrigation water.

Table 1 :

Amount of monthly irrigation (m3 of water/tree of date palm cv. Medjool) schedule for all types of water used in the experiment during the two seasons of 2019 and 2020.

No.	Month	Amount of irrigation (m^3 of water/tree)	
		2019	2020
1	January	3.6	4
2	February	3.8	4
3	March	5.2	6
4	April	7.1	8
5	May	9.0	10
6	June	11.0	12
7	July	12.0	13
8	August	12.0	13
9	September	10.0	11
10	October	7.1	8
11	November	6.2	7
12	December	3.7	4
Total		90.7	100

Water analysis:

At the beginning of the experiment, water samples for all types of water sources were collected and sent to the Chemical and Biological Analysis Unit at An-Najah National University to test some microbial analysis (total yeasts count, total molds count and *E.coli*) and some chemical analysis (pH, EC, Cl, Na, N, P, and K) according to Fresenius et al.(1988).

Observations:

At harvest time, the number of leaves with thorn per each tree in the experiment was counted. The yield (kg/tree) was weighed. Average fruit weight (g) was measured by collecting 25 fruits randomly from each tree and weighed. The value obtained for 25 fruits was divided by 25 to obtain the average fruit weight and expressed in grams. Balah fruits refer to the yellow fruits (khalal stage) were computed by weighing the yellow fruits on the tree and expressed in kg /tree. Fruit with stalk refers to the fruit with calyx or cap, and fruit without stalk were those that their calyx or cap have detached from the fruit. Fruit with stalk was computed by weighing the fruit with stalk on the tree (yield /tree), whereas fruit without stalk was computed by weighing the fruit without a stalk (yield /tree). Skin separation (loose skin) refers to air content between the skin and the fleshy parts of the fruit. It categorized from 0-10%, 11-30%, 31-50% and>50% according to air content in the fruit. Air content (%) in the fruit were computed by weighing the fruit for each category (0-10%, 11-30%, 31-50% and >50%) on the tree (Daiq, 2020).

Statistically analysis:

All the data were statistically analyzed and the significant differences in the treatment means were separated according to the LSD test at a 5% level (SAS software, 1990).

RESULTS AND DISCUSSION

Microbial analysis of irrigation water: Yeasts and molds are two different forms of naturally occurring fungi present in the environment. Total Yeasts and Molds Counts (TYMC) are used to detect and quantify the amount of fungal growth on material.

In the present study, total yeasts count (3 CFU/100 ml) were found in dairy farm effluent, while no yeasts were present in both farm water and fish farm effluent (Table 2).

The highest total molds count (2.1 * 102 CFU/100 ml) were found in farm water, followed by fish farm effluent (1.9 * 102 CFU/100 ml), and the lowest (6 CFU/100 ml) were found in dairy farm effluent (Table 2). The higher molds count in the farm water treatment than the other treatments may be attributed to the presence of high content of Cl in both fish farm effluent (2220 mg/l) and dairy farm effluent (2000 mg/l) as compared to farm water (950 mg/l) (Table 3). It is well known that Cl is used extensively as a water disinfectant.

Regarding *Escherichia coli*, there is a human pathogen in irrigation water that can be transmitted to plants. Thus, consumption of fruits irrigated with *E. coli*-contaminated water can cause illness to humans. Fortunately, in the present study, the microbial analysis (Table 2) indicated that all types of water used in the experiment were free from *E. coli*. Based on the total number of *E. coli*, the standards of California recommend a 7-day median value of 2.2 CFU/100 ml, and a maximum value of 240 CFU/100 ml (Fewtrell and Bartram, 2001). On the contrary, the World Health Organization guidelines recommend 1000 CFU/100 ml (WHO, 2006).

Table 2:

Some microbial analyses of farm water, fish farm effluent, and dairy farm effluent used in the experiment.

No.	Test	Farm water	Fish farm effluent	Dairy farm effluent
1	Total yeasts count (CFU/100 ml)	Nil	Nil	3
2	Total molds count (CFU/100 ml)	$2.1 * 10^2$	$1.9 * 10^2$	6
3	E. coli (CFU/100 ml)	Nil	Nil	Nil

Chemical analysis of irrigation water: In the present study, the pH of the water was slightly alkaline, ranging from 7.43 in dairy farm effluent to 8.11 in farm water (Table 3). Generally, the pH of irrigation water used in most date-growing regions in the world ranges from pH 6.5 to 8.8. The pH outside of the normal range has the potential to cause an imbalance of nutrients (Bauder et al., 2011).

In this study, the EC of the water was very high in both fish farm effluent (6.85 dS/m) and dairy farm effluent (6.41 dS/m), while in farm water (2.89 dS/m) was accepted in date palm plantation (Table 3). The EC of irrigation water which was used in Jericho and Jordan valley ranges from 2.8 to 6.0 dS/m. Date palm is classified as the most salt-tolerant fruit crop (Fipps, 2003). However, the Food and Agriculture Organization (FAO) has established guidelines for agricultural water primarily based on salinity. These guidelines have been modified by Ayers and Westcot in 1985, and are being internationally accepted.

In the present study, Cl was very high in both fish farm effluent (2220 mg/l) and dairy farm effluent (2000 mg/l), while in farm water (950 mg/l) was high (Table 3). Although chloride is essential to plants in very low amounts, but it can cause toxicity to crops at high concentrations.

In addition, Na was very high in both fish farm effluent (1420 mg/l) and dairy farm effluent (1310 mg/l), while in farm water (481 mg/l) could be considered as a medium amount of Na in irrigation water (Table 3). Sodic water is not the same as saline water. The application of water with a high sodium content can reduce yield.

Consequently, in this study, the Cl and Na contents in both fish and dairy farm effluents were high to very high. Thus, the long term irrigation with such types of water may have a negative effect on soil and subsequently decreased growth and production of date palm.

In the present study, the total N was high in fish farm effluent (35 mg/l), followed by dairy farm effluent (15 mg/l). However, N was absent in farm water (Table 3).

The highest amount of total P (2.1 mg/l) was found in fish farm effluent, followed by dairy farm effluent (0.35 mg/l), while the lowest (0.04 mg/l) was found in farm water (Table 3).

Similarly, K was very high in both fish farm effluent (118 mg/l) and dairy farm effluent (110 mg/l), while the lowest (30 mg/l) was found in farm water (Table 3).

Because NPK were major nutrient elements in plant production and used extensively in date palm fertilization, the amount of NPK contents in 100 m3 of water/tree/year of all types of water used in the experiment was calculated by divided the values of NPK in Table 3 by 10. The converted values are presented in Table 4.

Fish and dairy farm effluents were rich in nutrient elements. The present study recorded the highest amounts of NPK in irrigation water with fish farm effluent, followed by dairy farm effluent. However, the lowest was recorded with farm water control (Table 3). These considerable amounts of NPK in fish and dairy farm effluents matched the yearly needs for date palm trees (AL-Rawi, 1998).

Table 3:

Some chemical analyses of farm water, fish farm effluent, and dairy farm effluent used in the experiment.

No.	Test	Farm water	Fish farm effluent	Dairy farm effluent
1	pH	8.11	7.88	7.43
2	EC (dS/m)	2.89	6.85	6.41
3	Cl (mg/l)	950	2220	2000
4	Na (mg/l)	481	1420	1310

No.	Test	Farm water	Fish farm effluent	Dairy farm effluent
5	Total N (mg/l)	0	35	15
6	Total P (mg/l)	.04	2.10	.35
7	K (mg/l)	30	118	110

Table 4:

Amount of NPK contents in 100 m3 of water/tree/year in all types of water used in the experiment and annual amount of nutrient requirement (kg/adult date palm tree).

Nutrient	Farm water (kg/100 m^3 of water)	Fish farm effluent (kg/100 m^3 of water)	Dairy farm effluent (kg/100 m^3 of water)	The standard amount of nutrient requirement (kg/tree/year)*
Total N	0	3.5	1.5	1.5–3.0
Total P	0.004	0.210	0.035	0.5
K	3.0	11.8	11.0	2-3

*Generally, 1.5–3.0 kg of nitrogen, 0.5 kg of phosphorus and 2.0–3.0 kg of potassium per tree yearly is recommended to maintain optimum growth of date palm tree (AL-Rawi, 1998).

Growth, yield, and quality:

In the season of 2019, there were no significant differences in the number of leaves with thorn per tree and yield (kg/tree). The highest significance fruit weight (16.40g) was recorded with farm water on par with dairy farm effluent (13.34g). However, in the 2020 season, the highest number of leaves with thorn per tree (26.5), yield (67 kg/tree), and fruit weight (18.78g) were recorded with fish farm effluent (Table 5).

Table 5.

show the effect of different quality of irrigated water on the number of leaves with thorn per tree, yield (kg/tree), and fruit weight (g) of date palm cv. Medjool, in 2019 and 2020.

Irrigation treatment	Number of leaves with thorn per tree		Yield (kgltree)		Fruit weight (g)	
	2019	2020	2019	2020	2019	2020
Farm water (control)	* 20.5 a	b 21.3	60.78 a	60.5 b	16.40 a	15.88 b
Fish farm effluent	21.5 a	26.5 a	59.66 a	67.0 a	12.28 b	18.78 a
Dairy farm effluent	19.3 a	23.5 b	50.04 a	61.8 b	13.34 ab	16.58 b

*Means followed by similar letters in each column are not significantly different according to the Fisher LSD at $p \leq .05$.

These results may be attributed to the fact that fish farm effluent containing high amounts of nutrients NPK (Table 3), which produced the highest number of leaves with thorn per tree (Elnwishy, 2008). This directly or indirectly has a positive effect on fruit weight and yield. Similar results were reported in other crops like tomato (Castro et al., 2006), potato (Abdelraouf and Hoballah, 2014), cucumber (Buang et al., 2018), maize and bean (Silva et al., 2018), and basil and purslane (Kaab Omeir et al., 2020) who reported improved in crop productivity and reduced in the total costs of fertilizers.

In both seasons, no significant differences were recorded among treatments for Balah weight (Table 6). Balah fruits, yellow fruits, or khalal fruits of Medjoul variety (not like Barhi variety) were not palatable because of astringency taste (Alsmairat et al., 2013). Therefore, the less Balah weight per tree is the better. In this experiment, the weights of Balah fruits (kg/tree) in the whole experiment were relatively low and generally, these weights were accepted as postharvest losses in Medjoul production.

In the 2019 season, the highest significant fruit with a stalk (7.58 kg/tree) was recorded with fish farm effluent, which was on par with farm water (4.91 kg/tree), while in the 2020 season, no significant differences were recorded among the treatments (Table 6).

In the 2019 season, no significant differences were recorded among treatments for fruit without a stalk. In contrast, in the 2020 season, the highest significant fruit without a stalk (28.5 kg/tree) was recorded with fish farm effluent (Table 6).

It is well known that fruits with stalks are better than without stalks because of the fruits' good appearance, and the shelf life of the fruits will be extended because the harmful microbes cannot easily enter inside the fruits due to fewer opens on the surface of the fruits (Kader and Hussein, 2009). Unfortunately, in the whole experiment, the weights of fruits with a stalk were much less than those without a stalk (Table 6).

Table 6:

Effect of different quality of irrigated water on Balah fruits (kg/tree) and fruit with and without a stalk (kg/tree) of date palm cv. Medjool, in 2019 and 2020.

Irrigation treatment	Balah fruits (kg/tree)		Fruit with stalk (kg/tree)		Fruit without stalk (kg/tree)	
	2019	2020	2019	2020	2019	2020
Farm water (control)	1.49 a*	2.18 a	4.91 ab	6.90 a	25.23 a	24.50 b
Fish farm effluent	3.44a	2.43 a	7.58 a	7.90 a	24.40 a	28.50 a
Dairy farm effluent	2.03 a	2.18 a	3.60 b	7.50 a	19.39 a	25.50 b

*Means followed by similar letters in each column are not significantly different according to the Fisher LSD at p ≤ .05.

Skin separation:

The less air content in date palm fruit means the better fruit quality. Fortunately, in the whole experiment, the weights of fruits in this category (from 0-10 %) were higher than the weights for the other categories (Table 7).

In the season of 2020, there were significant differences among the treatments in the category from 11-30 (%) which recorded the lowest significant skin separation with the farm water (5.05 kg/tree). Similarly, there were significant differences in the season of 2020 in the category from 31-50 (%) which recorded the lowest significant skin separation with the farm water (3.43 kg/tree). This treatment was on par with dairy farm effluent (4.10 kg/tree) (Table 7).

Moreover, there were significant differences among the treatments in the category > 50 (%) in the season of 2019 which recorded the lowest significant skin separation with the dairy farm effluent (0.95 kg/tree). This treatment was on par with farm water (1.56 kg/tree) (Table 7).

The phenomenon of skin separation occurs in fruits of many date palm cultivars (Gophen, 2014), it is crucial in Medjool (Lustig et al., 2014), and the price for fruit with skin separation is only one-half of similar fruit without it (Cohen and Glanser, 2015). Thus, improving the quality of the fruits is extremely important, and the elimination of skin separation in 'Medjool' fruits is a significant concern for date producers and the economy of this variety (Kader and Hussein, 2009).

Table 7:

Effect of different quality of irrigated water on the air content (%) in the fruit of date palm cv. Medjool, in 2019 and 2020.

Irrigation treatment	Air content (%) in fruit							
	0-10 (%)		11-30 (%)		31-50 (%)		> 50 (%)	
	2019	2020	2019	2020	2019	2020	2019	2020
Farm water (control)	22.38 a*	25.75 a	3.75 a	5.05 b	2.28 a	3.43 b	1.56 ab	1.68 a
Fish farm effluent	22.59 a	27.50 a	4.02 a	6.28 a	2.41 a	4.40 a	2.64 a	2.05 a
Dairy farm effluent	18.35 a	25.25 a	2.82 a	6.15 a	1.82 a	4.10 ab	0.95 b	1.71 a

*Means followed by similar letters in each column are not significantly different according to the Fisher LSD at $p \leq 0.05$.

Conclusions

It could be concluded from this study that the most effective treatment as an alternative source of irrigation water was fish farm effluent. No harmful microbial (*E. coli*) present in the three irrigation water treatments. The EC in both fish and dairy farm effluents was high, while the EC in farm water was accepted in date palm plantation. Fish and dairy farm effluents were rich in nitrogen, potassium, and phosphorus that could cover the annual requirements of NPK for the date palm tree. Thus, fish and dairy farm effluents could be used as a source of irrigation and fertilizer in modern date palm cultivation. However, long run investigation is needed to study the impact of using such water sources on soil and plant.

Acknowledgement

The authors would like to thank the Deanship of Scientific Research at Al-Quds Open University and the Palestinian Ministry of Higher Education and Scientific Research for the financial support of the present research project. Special thanks to the Al-Wadi farm (Daiq Brothers) for their great help in the accomplishment of this research in their farm. Great thanks for the Arab Development Society-Jericho for providing fish farm effluent and for the Al-Juneidi Dairy and Food Products Company for providing dairy farm effluent.

References:

- Abdelraouf, R.E. (2017). Reuse of fish farm drainage water in irrigation. In: The handbook of environmental chemistry. Springer, Berlin, Germany.
- Abdelraouf, R.E. & Hoballah, E.A. (2014). Impact of irrigation systems, fertigation rates and using drainage water of fish farms in irrigation of potato under arid regions conditions. International Journal of Scientific Research in Agricultural Sciences, 1(5), 67-79.
- Abu-Jaish, A.A. (2018). Determinants of the expansion of palm growing within the natural resources (land, water) available for the development of the agricultural sector in the Jordan Valley region. M.Sc. Thesis in Sustainable Rural Development, al-Quds University in Abu Dees, Jerusalem, Palestine.
- Abu-Qaoud, H. (2015). Date palm status and perspective in Palestine. In J.M. Al-Khayri, S.M. Jain, & D.V. Johnson. Date Palm Genetic Resources and Utilization, eds.: Volume 2: Asia and Europe, (Springer Press), p.423-439.
- Ahmed, N. & Garnett, S.T. (2011). Integrated rice-fish farming in Bangladesh: meeting the challenges of food security. Food Security, 3(1), 81-92.
- Al-Alawi, R.A., Al-Mashiqri, J.H., Al-Nadabi, J.S., Al-Shihi, B.I., & Baqi, Y. (2017). Date palm tree (*Phoenix dactylifera* L.): natural products and therapeutic options. Frontiers in Plant Science, 8, 845. https://doi.org/ 10.3389/fpls.2017.00845.
- Al-Rawi, A.A.H. (1998). Fertilization of date palm tree (*Phoenix dactylifera* L.) in Iraq. In: Proceedings of the 1st international conference on date palm, 8–9 Mar 1998, Al-Ain Hilton Hotel, Al-Ain, United Arab Emirates. pp 320–327.
- Alsmairat, N.G., El-Assi, N.M., Al-Abdallat, A.M. & Mehyar, G.F. (2013). Enhancement of edibility of" Barhi" and" Medjool" date palm cultivars at khalal mature stage. International Journal of Botany, 9(3), 123-132.
- Ayers, R.S. & Westcot, D.W. (1985). Water quality for agriculture. FAO Irrigation and drainage paper 29 Rev. 1. Food and Agricultural Organization. Rome, 1, 74.
- Barkle, G.F., Stenger, R., Singleton, P.L. & Painter, D.J. (2000). Effect of regular irrigation with dairy farm effluent on soil organic matter and soil microbial biomass. Australian Journal of Soil Research, 38(6),

1087-1097.

- Bauder, T.A., Waskom, R.M., Sutherland, P.L. & Davis, J.G. (2011). Irrigation water quality criteria (Doctoral dissertation, Colorado State University. Libraries).
- Buang, E.A., Nornasuha, Y., Nashriyah, M. & Khandaker, M.M. (2018). Effects of fish waste effluent on the growth, yield and quality of Cucumis sativus L. J. Agrobiotech., 9, 258–267.
- Castro, R.C., Azevedo, C.B. & Neto, F.B. (2006). Increasing cherry tomato yield using fish effluent as irrigation water in Northeast Brazil. Scientia Horticulturae, 110(1), 44-50.
- Cohen, Y. & Glanser, B.A.B. (2015). Date palm status and perspective in Israel. In J.M. Al-Khayri, S.M. Jain and D.V. Johnson. Date Palm Genetic Resources and Utilization, eds.: Volume 2: Asia and Europe, (Springer Press), p.265-298.
- Daiq, I. (2020). International date palm expert. Personal communication, Jericho, Palestine.
- Dudeen, B., Lacirignola, C., Montanarella, L., Steduto, P. & Zdruli, P. (2001). The soils of Palestine (The West Bank and Gaza Strip) current status and future perspectives. Soil Resources of Southern and Eastern Mediterranean Countries, 203-233.
- East, E.M. (2019). Climate change, water security, and national security for Jordan, Palestine, and Israel.
- Elnwishy, N.H. (2008). Effectiveness of fish culture implementation to improve irrigation water quality. International Journal of Agriculture and Biology, 10(5), 591-592.
- Fewtrell, L. & Bartram, J. (2001). Water quality: guidelines, standards & health. IWA publishing.
- Fipps, G. (2003). Irrigation water quality standards and salinity management strategies. Texas FARMER Collection.
- Fresenius, W., Quentin, K.E. & Schneider, W. (1988). Water analysis. A practical guide to physico-chemical, chemical and microbiological water examination and quality assurance.
- Gophen, M. (2014). Skin separation in date fruits. International Journal of Plant Research, 4(1), 11-16.
- Hawke, R.M. & Summers, S.A. (2006). Effects of land application of farm dairy effluent on soil properties: A literature review. New Zealand Journal of Agricultural Research, 49(3), 307-320.
- Islam, M.T. (2015). Effects of dairy farm's wastewater irrigation on wheat production and soil health. M.Sc. Thesis in Irrigation and Water Management, Bangladesh Agricultural University, Mymensingh, Bangladesh.
- Islam, M.S., Islam, M.T., Hossain, S.A., Adham, A.K.M. & Islam, D. (2017). Impacts of dairy farm's wastewater irrigation on growth and yield attributes of maize. Fundamental and Applied Agriculture, 2(2), 247-255.
- Kaab Omeir, M., Jafari, A., Shirmardi, M., & Roosta, H. (2020). Effects of irrigation with fish farm effluent on nutrient content of Basil and Purslane. Proceedings of the National Academy of Sciences, India Section B: Biological Sciences, 90(4), 825-831.
- Kader, A.A. & Hussein, A.M. (2009). Harvesting and postharvest handling of dates, ICARDA, Aleppo, Syria, 15p.
- Khater, E.G. (2006). Aquaponics: the integration of fish and vegetable culture in recirculating systems. M.Sc. Thesis, in Agric. Eng., Fac. Agric., Moshtohor, Benha Univ., Egypt.
- Little, T.M. & Hills, F.J. (1978). Agricultural Experimentation. John Wiley and Sons, Inc., New York, USA.
- Longhurst, R.D., Roberts, A.H.C. & O'Connor, M.B. (2000). Farm dairy effluent: A review of published data on chemical and physical characteristics in New Zealand. New Zealand Journal of Agricultural Research, 43(1), 7-14.
- Lustig, I., Bernstein, Z. & Gophen, M. (2014). Skin separation in Majhul fruits. International Journal of Plant Research, 4(1), 29-35.
- Mazahrih, N.T., Al-Zubi, Y., Ghnaim, H., Lababdeh, L., Ghananeem, M. & Ahmadeh, H.A. (2012). Determination actual evapotranspiration and crop coefficients of date palm trees (*Phoenix dactylifera* L.) in the Jordan valley. American-Eurasian J. Agric. & Environ. Sci., 12 (4), 434-443.
- Palestinian Meteorological Department (2020). Climatic data for Jericho. https://www.pmd.ps/en
- Roufou, S., Griffin, S., Katsini, L., Polańska, M., Van Impe, J.F. & Valdramidis, V.P. (2021). The (potential) impact of seasonality and climate change on the physicochemical and microbial properties of dairy waste and its management. Trends in Food Science & Technology, 116, 1-10.
- Russo, G., Dalla Ragione, I., Fantinati, L., Simonetti, C. & Lauteri, M. (2017, November). A socio-ecological analysis of the date palm (*Phoenix dactylifera* L.) system in Jericho Area, Palestine. In Euro-Mediterranean Conference for Environmental Integration (pp. 1425-1427). Springer, Cham.
- SAS Institute (1990). ''User's guide. Statistics. Ver. 6.4th ed. SAS Inst. Cary. N. C, 956.
- Silva, E.F.L., Botelho, H.A., Venceslau, A.D.F.A. & Magalhães, D.S. (2018). Fish farming effluent application in the development and growth of maize and bean plants. Científica, 46(1), 74-81.
- World Health Organization (2006). WHO guidelines for the safe use of wastewater excreta and greywater (Vol. 1). World Health Organization.