Assessment of farmers practices to date palm soil fertilization and its impact on productivity at Al-Hassa oasis of KSA

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Abstract

Al-Hassa oasis is considered as the biggest irrigated one in the World, being well known for its extensive date palm cultivation with an estimate of at least three million trees. The aim of this study is to evaluate the impact of soil fertilization practices on the productivity potential of date palm trees grown under the climatic conditions of Al-Hassa oasis, KSA. The opinions of 258 active farmers were randomly surveyed using specifically designed questioners that were also fortified with personal communications. The size of the samples was designated in accordance to Cocoran equation. The total samples were allocated into two major parts (193 for the old oasis and 65 for the new oasis). Results showed that the farm features (utilized agricultural area (UAA), ownership and labors) are different in both parts of the oasis. Fertilization practices (quantity applied per area or per tree) were diverse causing dissimilar productivity potentials (total or per area or tree). The average production of a tree in the old oasis is 81.4 kg, whilst it is 54.6 kg in the new oasis. Date palm production is significantly affected by total number of trees, applied fertilizer quantity, cultivated area and labor power. The impact of these factors is unlike between the two parts of the oasis. It is then concluded from the study that there are sincere needs for improving the soil fertilization practiced for the date palm trees grown in the Al-Hassa oasis, KSA in order to increase their productivity potential and hence improve the farmers’ income.

Keywords:
Palm date
Productivity
Fertilization
Al-Hassa
Oasis

1. Introduction

Date palm (Phoenix dactylifera L.) is an old and eminent fruit crop cultivated since 4000–5000 years ago in the Arabian Peninsula, Middle East and North Africa (Chao & Krueger, 2007; Tenghberg, 2012). Currently, it is considered as one of the most fruit trees grown worldwide, as its cultivation extended to other areas in South Central Asia, South Africa, Europe, Australia and North America (Zohary & Hopf, 2000). Heuzé et al. (2016) indicated that date palm is an evergreen tree playing a vital role in the public social and economic lives of these regions. Date palm is also believed as a symbol of life in the desert areas for its capability to tolerate stresses of heat and dry conditions (El-Juhany, 2010). Moreover, it is observed as a keystone species in the oasis agro-ecosystems, due to its valuable fruits and other numerous roles in favoring the cultivation environment of other crops (Tenghberg, 2012; Heuzé et al., 2016). Al-Abid (2011) stated that date palm is a feasible solution to obtain food security for many countries, among which are the GCC (Gulf Cooperation Council) countries, as it provides a stable food source.

In the Kingdom of Saudi Arabia (KSA), the date palm trees are grown over 72% of the total permanent cultivated area with a total estimate of 25 million trees producing nearly 1 million ton of dates a year (i.e., ≥ 15% of the world production) (Al-Abbad et al., 2011; Al-Wusaibai et al., 2012). Studies indicated that there are more than 400 date palm cultivars grown in the KSA (DSPS, 2009). These figures prompted KSA to be among the global leading ranked countries in cultivation and production of date palm, where its cultivation is scattered all over the country. In the KSA, the largest cultivation of date palm is located in Al-Hassa oasis of the Eastern
Province, with an estimate of 3 million trees (Al-Wusaibai et al., 2012).

However, there are several constraints that hinder the development and sustainability of the date palm cultivation in the GCC countries (El-Juhany, 2010; Erskine et al., 2014), including planting cultivars of low quality; inappropriate farm management; pest, diseases and insufficient integrated pest management; inadequate practices of harvesting, processing and marketing; lack of national qualified and trained staffs and labors and shortage of research and development studies. Therefore, the aim of this investigation is to determine various aspects of date palm cultivation in Al-Hassa oasis: from land distribution and characteristics (areas, number) to various practices applied (fertilization and irrigation). Based on these findings, the main aim is to determine the most common fertilization program adopted for date palm trees in Al-Hassa oasis, KSA and to evaluate the impact of this program on their productivity potential.

2. Materials and methods

2.1. Study area

Al-Hassa (i.e., sometimes called Al-Ahsa) oasis is an area in the Eastern Province of KSA that is well-known for its agricultural activities. It is presumed the largest irrigated oasis in the world (Nakhlah, 1980; Alshobat, 1989; Tayeb, 1983). Historically, the oasis is well recognized for its water abundance (BRGM, 1977; Leichtweiss Institute, 1979; Tayeb, 1983; Al-Mahmoud, 1987; Rajab, 1990). It is located about 70 km west of the Arabian Gulf between the latitudes of 25° 21’ and 25° 37’ N and the longitudes of 49° 33’ and 49° 46’ E (Fig. 1).

Al-Hassa oasis consists of two major parts, the old and new oases (Almadini & Hassaballah, 2019). The total area of the old oasis is about 20,000 ha, of which 8200 ha are under irrigated cultivation being divided into 25,000 farms (Al-Kuwaiti et al., 2002). More than 96% of these farms are small having an area of 4 ha or less covering nearly 63% of the cultivated area. Historically, the old oasis goes back thousands of years. However, the new oasis was initiated in the 70’s of last century when the Saudi government decided to extend the agricultural area in the Al-Hassa by freely distributing new lands (i.e., farms) to the Saudi citizens in the Al-Ghwaibah area located southeast of the old oasis on both sides of the international road to gulf countries. The aim of this project was to introduce modern cultivating techniques to the main Al-Hassa oasis. This new oasis is consisted of thousands of farms that are relatively larger in area than those in the old oasis. The average of the farm in the new oasis is 5 ha or more (Almadini et al., 2007, 2012; Almadini & Hassaballah, 2019).

In Al-Hassa oasis, date palm cultivation is immensely prevalent. The total number of date palm trees exceeds 3 million covering nearly 70% of the total cultivated area (Al-Khateeb & Dinar, 2002), with 40 different cultivars. Among these cultivars and probably most important are Khlas, Shishi, Ruziz and Gar. The trees are planted apart from each other on a distance of 5–7 m, with the areas in between are usually utilized to grow other fruits, vegetables or cereal and forage crops (Almadini, 2006).

The cultivated soils in Al-Hassa oasis have widespread features that potentially lessen their productive capabilities. These features include prevailing light texture, low contents of organic matter (i.e., mostly < 1%), elevated soil salinity, high contents of total calcium carbonates and generally poor soil fertility potential (El-Prince, 1982; Al-Barrak, 1986, 1990; Abo-Rady, 1987; Al-Barrak & Al-Badawi, 1988; Almadini et al., 2007, 2012).

2.2. Research methodology

The use of survey methodology in agricultural sector has been widely adopted with the aim to describe a certain status in order to represents weaknesses, advantages and solutions (Escobar et al, 2019; Põder et al., 2019; Tyšer et al, 2019).

To accomplish the aim of this investigation, a research methodology was adapted, which was based on questioner forms with a statistical review. The total number of collected forms were 258 being allocated into 193 farms for the old agricultural area (i.e.,

![Fig. 1. The general layout of Al-Hassa oasis and its geographical position (Water Study Centers, 2009).](image-url)
old oasis) and 65 farms for the new agricultural area (i.e., new oasis). All questioner forms were randomly distributed between the farmers to assure reasonable representation of the Al-Hassa oasis. During collecting required data, personal communications were also implemented in order to overcome the confronted difficulties that mostly include the barrier of language, unavailability of farm owners, lack of detailed information regarding the farm or farming activities and others.

The used questioner form was especially designed to fulfill the objectives of this study. It was initially tested (pre-test) using 20 forms that were distributed randomly on both oases. After then, the form was readapted taking in considerations all observed field annotations. The form encompassed information regarding the farm general feature (i.e., area, total of date palm trees and their production), factors affecting production including the fertilizer utilizations, grown date cultivars, farm ownership, and labors involved.

2.3. Statistical analysis

Taking into considerations the type of data collected, the proper statistical procedure was used on basis of the study qualitative approach that was capable to describe the data of the farm general features. A quantitative approach (i.e., averages, percentages, standard deviations, stepwise, ANOVA and etc.) was also used to determine the effect of independent factors (e.g., soil fertilization) on dependent ones of date palm production based on cultivated area, per tree and per applied fertilizer unit. All tests were done using Statistical Package for Social Sciences (SPSS) software.

3. Results

3.1. General features of date palm farms in Al-Hassa oasis

3.1.1. Farming and farm area in Al-Hassa oasis

The main features of the studied date palm farms in the Al-Hassa oasis were summarized in Table 1. The table shows that the average date palm trees per farm in the oasis is about 306 trees, with their average in the new oasis (i.e., 845 trees) is 6.8 folds bigger than that in the old oasis (i.e., 125 trees). The table also shows that the average of the utilized agricultural area in the oasis is also 30.45 donum, with a wide variation between the old oasis (i.e., 3.7 donum) and the new oasis (i.e., 57.2 donum). This is well expected as the farm area average in the new oasis is bigger than that in the farms of the old oasis as indicated earlier. The most common date palm cultivars in both oases are Khlas followed by Ruziz and the Shishi (Fig. 2), which also emphasizes the dominancy of the Khlas over other grown cultivars.

3.1.2. Farm ownership and manpower in Al-Hassa oasis

The farm ownership in Al-Hassa oasis wildly varies between the two oases (Table 1, Fig. 3). While it is dominated by the farmers in the old oasis (i.e., 59.1%), the majority of the owners in the new oasis are non-farmers (i.e., 84.6%), that they have other careers. This reflects the economical values of date palm cultivations to the owners in the old oasis.

The labors employed in both oases are mostly non-Saudis (Table 1, Fig. 4), signifying the deficit of national qualified and trained employees involved in date palm cultivation in the study area. In addition, it may be observed from Table 1 that there is a wide variation in the utilized labor per farm between the old oasis (i.e., 1.27) and the new oasis (i.e., 4.46). This is probably due to the differences is farm size between the oases of Al-Hassa (Section 3.1.1).

3.2. Soil fertilization features of date palm trees in Al-Hassa oasis

3.2.1. Total applied fertilizers in Al-Hassa oasis

Table 2 comprises of the summary of the main features of the soil fertilization practices adopted to date palm trees in Al-Hassa oasis. It may be seen from the table that there are major variations in the total quantities applied to the date palm trees between the two oases. The total quantity applied in the new oasis (i.e., 11,617 ton) is almost more than 10 folds than that quantity applied in the old oasis (i.e., 1097.10 ton). This is due to the farm size differences between the two oases of Al-Hassa area.

3.2.2. Applied fertilizers per area and tree

The variations in total applied quantities of fertilizers between the two oases are also observed in the quantities of fertilizers applied per donum (kg don.\(^{-1}\)) or per tree (kg tree\(^{-1}\)) (Table 2).

Table 1

| Items                  | Features                      | Old Oasis | New Oasis | Overall |
|------------------------|-------------------------------|-----------|-----------|---------|
| Farms                  | Number                        | 193       | 65        | 258     |
|                        | Total number of palm trees    | 24,060    | 54,925    | 78,985  |
|                        | Date palm trees / farm        | 125       | 845       | 306     |
| UAA                    | Total area (donum)            | 715.5     | 3720.8    | 4436.30 |
|                        | Area / farm (donum)           | 3.7       | 57.2      | 30.45   |
| Ownerships             | Farmers (%)                   | 59.1      | 15.4      | 38.95   |
|                        | Others* (%)                   | 40.9      | 84.6      | 62.75   |
| Labors                 | Saudi                         | 61 (25%)  | 24 (8%)   | 85      |
|                        | Non-Saudi                     | 186 (75%) | 266 (92%) | 425     |
|                        | Total of labors               | 247       | 290       | 537     |
|                        | Per farm                      | 1.28      | 4.46      | 1.65    |

* Other works include governmental or private employees, businesspersons and others.
** UAA refers to utilized agricultural area.

Fig. 2. The most common cultivars of the date palm grown in the Al-Hassa oasis, KSA.
The quantity applied per donum in the new oasis (i.e., 2509 kg donum⁻¹) is almost 60% more than that applied per donum in the old oasis (i.e., 1533 kg donum⁻¹). Furthermore, the quantity of fertilizers applied per tree in the new oasis (i.e., 154 kg tree⁻¹) is at least three folds more than that quantity applied per tree in the old oasis (i.e., 45.60 kg tree⁻¹). These variations in the applied quantities of fertilizers between both oases of Al-Hassa may be attributed to the variations in the soil properties as well as to the awareness of farmers to the principles of soil fertilization best practices.

3.3. Production features of date palm trees in Al-Hassa oasis

3.3.1. Total production of date palm farms in Al-Hassa oasis

The obtained data in this study showed that the overall production of date palm trees in the old oasis is estimated to reach 3095.80 tons (Table 3), where the total production in the old oasis (1225.20 ton) and the new oasis (1870.60 ton) is at least 53% more than the total production in the old oasis (1225.20 ton). These data are parallel with the differences in farm sizes between the two oases.

3.3.2. Production of date palm trees per donum and tree in Al-Hassa oasis

The data in Table 3 also showed that the values of production per donum (kg donum⁻¹) or per tree (kg tree⁻¹) differ between the two oases of Al-Hassa. They are higher in the old oasis as compared to those in the new oasis. The production per donum was almost six fold higher in the old oasis (3345 kg donum⁻¹) than in the new oasis (571 kg donum⁻¹), whilst it was nearly 1.5 folds higher per tree in the old oasis (81.40 kg tree⁻¹) than that in the new oasis (54.60 kg tree⁻¹) (Table 3 and Fig. 5). This implies that the production of date palm trees in the studied area is affected by variable factors including soil fertility status and soil fertilization practiced by farmers of the Al-Hassa oasis.

3.3.3. Production of date farm categories per donum or tree in Al-Hassa oasis

The farms in Al-Hassa oasis were categorized based on their productions per donum (kg donum⁻¹) as well as per tree (kg tree⁻¹) in the old and new oases of the study area (Tables 4 and 5, respectively). The data of each oasis were divided into equal intervals in order to classify their distribution percentages. The production of the farms in the old oasis was divided into categories of 1000 kg donum⁻¹ or less to 5000 kg donum⁻¹ or more, whilst it was divided into categories of 250 kg donum⁻¹ or less to 1000 kg donum⁻¹ or more (Table 4).

Most farms in the old and new oases were within the categories of 1000–2000 kg donum⁻¹ (i.e., 31.09%) and 250–500 kg donum⁻¹ (38.46%), respectively (Table 4). Also, the production of trees varied widely in the studied Al-Hassa oasis (Table 5). In the old oasis, the production per tree varied from 15 kg tree⁻¹ or less to 156 kg tree⁻¹ with an average of 81.40 kg tree⁻¹, whilst in the new oasis it ranged from 18.50 kg tree⁻¹ or less to 108 kg tree⁻¹ or more with an average of 54.60 kg tree⁻¹ (Table 5). Their highest categories were within the 50–100 kg tree⁻¹ in the old oasis and 25 kg tree⁻¹ in the new oasis with percentages of farms 45.10% and 53.80%, respectively (Table 5).

These values of the production of date palm trees in Al-Hassa oasis generally appeared to be low, which might be inferred to the poor soil fertility with the lack farm management practiced by the farmers of Al-Hassa oasis.

3.3.4. Production of date farm categories based on applied fertilizer in Al-Hassa oasis

The production of farms in both old and new oases of Al-Hassa was also categorized on basis of the applied fertilizer unit (kg ton⁻¹) (Table 6). The values presented in the table show that there were...
wide variations in obtained data whether between the oases or within each one.

In the old oasis, the values in Table 6 showed that the obtained data of the production varied from 604 kg ton\(^{-1}\) of applied fertilizer unit to 8896 kg ton\(^{-1}\) of applied fertilizer unit. However, in new oasis, it ranged from 83.9 kg ton\(^{-1}\) applied fertilizer unit and 1141 kg ton\(^{-1}\) applied fertilizer unit with an average of 403.5 kg ton\(^{-1}\) applied fertilizer unit (Table 6). These variations in the production of farms based on their applied fertilizer unit commonly agree with the other production values obtained in this study. This emphasizes the values of the obtained findings of this study for the sustainability of the date palm cultivations in the study area of Al-Hassa oasis.

### 4. Factors affecting date palm productions

Factors affecting the date palm productions in the Al-Hassa oasis were also evaluated by conducting a statistical multiple-regression test on the data of the old and the new oases. The test was applied for each oasis separately because of their differences as previously discussed. The results of these tests for both oases are presented in equations (1) and (2), respectively. In addition, Table 7 includes the outcomes of their significance tests.

**Old oasis**

\[ Y_{\text{old}} = 3312 - 6.43X_{O1} + 0.415X_{O2} + 37.1X_{O3} + 1050X_{O4} \]  

where:

- \(Y_{\text{old}}\) = date palm production (kg) in the old oasis,
- \(X_{O1}\) = total number of trees,
- \(X_{O2}\) = applied fertilizer quantity (kg),
- \(X_{O3}\) = cultivated area (donum), and
- \(X_{O4}\) = labor power (person/hour/day).

**New oasis**

\[ Y_{\text{new}} = 1917.92 + 4.134X_{N1} + 0.076X_{N2} + 185.26X_{N3} - 435X_{N4} \]  

where:

- \(Y_{\text{new}}\) = date palm production (kg) in the new oasis,
- \(X_{N1}\) = total number of trees,
- \(X_{N2}\) = applied fertilizer quantity (kg),
- \(X_{N3}\) = cultivated area (donum), and
- \(X_{N4}\) = labor power (person/hour/day).

Both Eqs. (1) and (2) illustrate that the date palm production in both oases are mainly affected by the total number of trees, applied fertilizer quantity, cultivated area and labor power. The effects of these factors on the production in both oases were significant with \(r^2\) values of 0.507 and 0.584, respectively (Table 7). The impacts of these factors on the production however are diverse among them as well as in each oasis (Table 7). Yet, the effects of applied fertilizer quantity were consistently significant on the production in both oasis, which suggests its reigning impacts on date palm production in the Al-Hassa oasis.

The previous findings could be sustained by the results of the t-test statistical analysis that was done to the date palm production on basis of area (kg don\(^{-1}\)), grown tree (kg tree\(^{-1}\)) and applied fertilizer unit (kg ton\(^{-1}\)) (Table 8). The results of the t-test showed the highly significant impact of the applied fertilizer unit (i.e., F-value = 38.179**) as compared with other tested factors.

These findings however substantiate the previously depicted inappropriate soil fertility properties and soil fertilization practices to the date palm cultivation in Al-Hassa oasis and their negative impact on the production. Furthermore, it insights its effects on the economic returns of the farmers and ultimately the sustainability of date palm cultivation in the area.

### 5. Discussion

Date palm (Phoenix dactylifera L.) cultivation in Al-Hassa oasis of the KSA is a commanding activity and incorporates an impact on the local social economic life. The findings of this study suggested prominent aspects regarding the cultivation of date palm in the oasis. It was found that there were variations in the general features of the date palm farms between the old and the new oases of the study area (Table 1). This is well expected as the farm area average in the new oasis is much bigger than that in the old one as indicated earlier (Section 2.1). However, these variations in
Table 5
The categories of farms based on their date palm production per tree (kg tree\(^{-1}\)) in the old and new oases of Al-Hassa, KSA.

| Production category | Number of farms | Number of palm trees | Prod. average (kg tree\(^{-1}\)) | % of farms |
|---------------------|-----------------|----------------------|----------------------------------|------------|
| **Old Oasis**       |                 |                      |                                  |            |
| ≤ 25                | 13              | 6750                 | 15                               | 6.70       |
| 25–50               | 44              | 7296                 | 28                               | 22.80      |
| 50–100              | 87              | 6285                 | 71                               | 45.10      |
| ≥ 100               | 49              | 3729                 | 156                              | 25.40      |
| **Total/average**   | 193             | 24,060               | 81.4                             | 100        |
| **New Oasis**       |                 |                      |                                  |            |
| ≤ 25                | 35              | 29,455               | 18.5                             | 53.80      |
| 25–50               | 19              | 18,075               | 31                               | 29.20      |
| 50–100              | 4               | 5675                 | 61                               | 10.80      |
| ≥ 100               | 4               | 1720                 | 108                              | 6.20       |
| **Total/average**   | 65              | 54,925               | 54.6                             | 100        |

Table 6
The date palm production categories of the farms on basis of the applied fertilizer unit (kg ton\(^{-1}\)) in the old and new oases of Al-Hassa, KSA.

| Production category | Number of farms | Production average per applied fertilizer unit (kg ton\(^{-1}\)) | Number of palm trees | % of farms |
|---------------------|-----------------|---------------------------------------------------------------|----------------------|------------|
| **Old Oasis**       |                 |                                                              |                      |            |
| ≤ 1000              | 40              | 604                                                           | 12,452               | 20.73      |
| 1000–2000           | 34              | 1438                                                          | 4116                 | 17.62      |
| 2000–3000           | 30              | 2540                                                          | 2529                 | 15.54      |
| ≥ 3000              | 89              | 8896                                                          | 4963                 | 46.11      |
| **Total/average**   | 193             | 3369.5                                                        | 24,060               | 100        |
| **New Oasis**       |                 |                                                              |                      |            |
| ≤ 100               | 7               | 83.9                                                          | 7810                 | 10.77      |
| 100–200             | 35              | 149.7                                                         | 32,750               | 53.85      |
| 200–300             | 5               | 239.7                                                         | 4375                 | 7.69       |
| ≥ 300               | 18              | 1141                                                          | 8790                 | 27.69      |
| **Total/average**   | 65              | 403.5                                                         | 54,925               | 100        |

Table 7
Summary of multi-regression statistical analysis results for factors affecting date palm production in Al-Hassa oasis, KSA.

| Model | ß | Standard Error | t-test | Significance |
|-------|---|----------------|--------|--------------|
| **Old Oasis** |     |                |        |              |
| Constant | 3312 | 628.03 | 5.274 | 0.000** |
| XO1     | -6.43 | 1.912 | -3.363 | 0.001** |
| XO2     | 0.415 | 0.041 | 10.162 | 0.000** |
| XO3     | 37.1 | 34.757 | 1.067 | 0.287 |
| XO4     | 1050 | 439.147 | 2.391 | 0.018* |
| r²      | 0.507 | - | - | - |
| F-value | 48.38 | - | - | ** |
| **New Oasis** |     |                |        |              |
| Constant | 1917.92 | 4868.058 | 0.394 | 0.695 |
| XN1     | 4.134 | 5.697 | 0.726 | 0.471 |
| XN2     | 0.076 | 0.018 | 4.158 | 0.000** |
| XN3     | 185.26 | 76.997 | 2.406 | 0.019* |
| XN4     | -435 | 643.789 | -0.676 | 0.502 |
| r²      | 0.584 | - | - | - |
| F-value | 21.1 | - | - | ** |

Where: * and ** refer to the levels of significance at 0.05 and 0.01, respectively.

Table 8
The results of the t-test done on the factors determining the date palm production in both old and new Al-Hassa oases, KSA.

| Item | Per area Kg don\(^{-1}\) | Per tree Kg tree\(^{-1}\) | Per applied Fertilizer unit Kg ton\(^{-1}\) |
|------|---------------------------|---------------------------|------------------------------------------|
| Oasis | Old | New | Old | New | Old | New | Old | New |
| N     | 193 | 65 | 193 | 65 | 193 | 65 | 193 | 65 |
| Mean  | 3345 | 571 | 81.4 | 54.6 | 3368.5 | 403.4 |
| Std. error mean | 322.97 | 73.90 | 4.05 | 8.20 | 244.84 | 102.78 |
| Std. deviation | 4486.87 | 595.82 | 56.2 | 66.1 | 3401.52 | 828.68 |
| T-value | 4.964 | 3.177 | 6.951 | 9.284 |
| Significance | 0.000 | 0.346 | 0.000 | 0.000 |
| F-value | 14.978** | 0.890 | 38.179** |

Where: * and ** refer to the levels of significance at 0.05 and 0.01, respectively.
the areas of farms between the old and new oases manipulated the average date palm trees per farm and the utilized agricultural area, with a superiority of the new oasis over the old one. The outcomes of these general features also revealed that Khlas cultivar is the dominant one as compared to other cultivars, including Shishi, Ruziz and Gar (Fig. 2). These finding are similar to those referred by Al-Abbad et al. (2011) and Al-Wusaibai et al. (2012).

The findings of this study also indicated that there were marked variations in the ownerships of the farms in the studied area (Table 1, Fig. 3), where farmers are dominant owners in the old oasis and others (i.e., non-farmers) prevail in the new oasis. It was also observed that the sector of date palm cultivation in the oasis relies on non-Saudi labor signifying the deficit of national qualified and trained employees involved in the sector (Table 1, Fig. 4). Such deficit of national qualified and well-trained staffs and labors forms an obstacle hindering the development of date palm cultivations, not only in Al-Hassa oasis but also in the GCC and Arab countries (El-Juhany, 2010; Erskine et al., 2014). Also, there was a variation in the average number of labors per farm (Table 1), as they are more in the new oasis than in the old oasis. This means more running costs for the farm in the new oasis, imposing extra economic impacts on owners. All these general features however had negative impacts on the production capacity of the date palm in the studied area that will affect its sustainability.

The obtained results also showed noticeable variations in soil fertilization practices between the two oases of Al-Hassa (Table 2). The observed variations were in total quantity of applied fertilizers to each oasis, applied quantity per donum and applied quantity to each date palm tree. These values may be accredited to the absence of common practice of soil fertilization being adopted by local farmers, which reflects their poor awareness toward the importance of soil fertility and soil fertilization practices in date palm cultivation. The farmers however mainly depend on their inherited knowledge to apply organic fertilizers in form of dairy farm manures (Al-Kaidy, 2000; Al-Khateeb & Dinar, 2002; AEA, 2017).

Nonetheless, it ought to be mentioned that the cultivated soils in Al-Hassa oasis are general characterized by dominant light texture, low contents of organic matter (mostly ≤ 1%), elevated soil salinity and high contents of total calcium carbonates (El-Prince, 1982; Al-Barrak, 1986, 1990; Abo-Rady, 1987; Al-Barrak & Al-Badawi, 1988; Almadini et al., 2007, 2012). Various investigators however indicated that date palm trees grow and yield better in good deep aerated soils with low level of salinity and calcium carbonate as well as high content of organic matter (Abdul Fatah, 2000; Al-Bakr, 2002; Ibrahim and Kholafa, 2004; Ali, 2005; El-Juhany, 2010). The lack of good soil fertilization practices in the studied area is expected to potentially reduce the capabilities of cultivated soil productivity and hence the date palm trees.

The obtained data of this study showed that the production values of date palm trees in Al-Hassa oasis generally appeared to be low as compared with other regions of KSA (Harhash and Abdel-Nasser, 2010; Al-Obeed et al., 2013; Aleid et al., 2015). Such findings are in harmonies with those obtained by Hussein (2008) and Al-Abbad et al. (2011), who ascertained the declined in date palm production at Al-Hassa oasis. Data also indicated that the features of date palm production in the oasis also exhibited apparent variations in the quantities that imposed their effects on quantity per donum and per tree (Table 3, Fig. 3). These data are probably due to the poor soil fertility as well as to the lack of proper farm management practiced by the farmers in the oasis, which were also suggested by other researchers (Al-Yahyai and Manickavasagan, 2013; Erskine et al., 2014). Other researchers also concluded that soil fertilization practices improve date palm production (Kassem, 2012; Elamin et al., 2017).

The results of the statistical tests to evaluate the factors affecting the production affirmed that the applied quantity of fertilizer is the principle factor causing such reduction in the production (Eqs. (1) & (2), Tables 7 & 8). This agrees with the findings of Almadini et al. (2012) who indicated that the productivity potential of date palm trees in Al-Hassa oasis is about 70%, being limited by several factors among which are the degraded soil fertility status and their improper management. In brief, these decreases and variations in date palm production in Al-Hassa oasis will affect the economic returns to the local farmers, imposing an economic depression that might frightened the sustainability of the date palm cultivations in the Al-Hassa oasis.

6. Conclusions

It may be concluded from the findings of this investigation that the date palm cultivation sector in Al-Hassa oasis possesses a great value to the farmers of the region. Though it is historically well recognized, this investigation has attested that the sector suffers from several factors that descend its production capabilities. Among these factors and probably the most influential one is the soil fertilization practices adopted by farmers that showed a significant impact on the palm production in the oasis. Another proposed factor that negatively affected the date palm production in the oasis is the poor farm management that includes lack of trained labors and good farming practices. Finally, further investigations to evaluate impacts of these factors are suggested. It is also worth to propose that detailed soil fertilization studies on date palm trees to be undertaken aiming to improve their productivity. These future studies should aim to improve the economic values of the date palm cultivation in the Al-Hassa oasis in order to sustain this sector.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

The authors extend their appreciations to the Deanship for Research and Innovation at the Ministry of Education, KSA for funding this research work through the Project number (IFT 20042) of the Institutional Financing Track 2020, provided by the Deanship of Scientific Research, KFU.

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