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RESEARCH PAPER

Increasing water productivity enhances water saving for date palm cultivation in Oman

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زيادة إنتاجية المياه يعزز من توفير المياه من زراعة أشجار النخيل في سلطنة عمان

ياسين بن أحمد الملا و حمد الغيلاني

Abstract. The total amount of water consumption needed to irrigate the cultivated lands in the Sultanate Oman is 1487 Mm^3. There are 7.6 million date palm trees currently planted in the farms in Oman covering an area of 23241 hectares or 35% of total agricultural area in the Sultanate in addition to 0.9 million palm trees planted in homes or for landscaping in public parks and beside the roads. Hence, among all cultivated crops in Oman, date palms are the major water consuming plants. They consume 558 Mm^3 that is 38% of total irrigation water and 31% of groundwater recharge that suffers an annual water deficit estimated at 316 Mm^3. These findings framed the main objectives of this study: (1) to describe the current status of date palm tree cultivation in the Sultanate; (2) to suggest solutions to reduce high consumption of water while improve dates production; and (3) to explore how irrigation water can be saved through increasing water productivity through alternative date palm cultivation and irrigation practices. The water saving recommendation in this study was based on the collected from different sources in addition to the investigation on the water loss during irrigation practices. We found that it is possible to save a total of 396 Mm^3 of irrigation water by for instance reducing the cultivation of low quality/value date palm varieties and switching to modern over traditional irrigation systems. It is also important to determine the quality and value of the date palm cultivars to be planted in the proposed reduced area which will then contribute to an increased financial return for the farmers and thus to the country through increasing the water productivity by 64% of these new plots.

Keywords: Water productivity; irrigation water; economical return; date palm trees; Oman.

الملخص: اجمالي كمية المياه اللازمة لري الأراضي المزروعة في سلطنة عمان هو ١٤٨٧ مليون متر مكعب. ويبلغ عدد أشجار النخليل الموزرعة في عمان حاليا ٧,٦ مليون شجرة نخيل تغطي مساحة قدرها ٢٣٢٤١ هكتار أي ٣٥٪ من إجمالي المساحة الزراعية في السلطنة بالإضافة إلى ٠,٩ مليون شجرة نخيل مزروعة في البيوت و الحدائق العامة وبجوار الطرق . وبالتالي، من بين جميع المحاصيل المزروعة في عمان، تعتبر النخيل هي النباتات الأكثر استهلاكا للمياه. إنها تستهلك ٥٥٨ مليون متر مكعب من المياه أي ٣٨٪ من إجمالي مياه الري و ٣١٪ من المياه الجوفية التي تعاني من عجز مائي سنوي يقدر بـ ٣١٦ مليون متر مكعب.على ضوء هذه الدلالات تم تأطير الأهداف الرئيسية لهذه الدراسة: (١) لوصف الوضع الراهن لزراعة شجرة النخيل في السلطنة. (٢) لوضع اقتراحات من شأنها تساهم في ايجاد الحلول للحد من استهلاك الكميات الكبيرة من المياه مع تحسين إنتاجية التمور. و (٣) لإستكشاف آلية تمكن من ترشيد مياه الري من خلال زيادة إنتاجية المياه عن طريق ايجاد بدائل أخرى لممارسات زراعة النخيل وعمليات ري هذه الأشجار. استندت هذه الدراسة على بيانات تم جمعها من مصادر مختلفة بالإضافة إلى استقصاءات حول فقدان المياه من خلال ممارسات الري المختلفة. لقد وجدنا أنه من الممكن توفير ما مجموعه ٣٩٦ مليون متر مكعب من مياه الري من خلال على سبيل المثال الحد من زراعة أصناف النخيل المنخفضة الجودة / القيمة والتحول إلى أنظمة الري الحديثة. ومن المهم أيضا تحديد الأصناف الجيدة من النخيل ذات القيمة العالية لزراعتها في المساحات المقترحة والذي سيساهم في زيادة العائد الاقتصادي لأصحاب المزارع والدولة بشكل عام من خلال زيادة إنتاجية المياه بنسبة ٦٤٪ من المياه المستخدمة لري هذه النباتات.

الكلمات المفتاحيه: :إنتاجية المياه، أشجار النخيل، مياه الري، العائد الاقتصادي، عمان

Introduction

One total area of the Sultanate of Oman is 30.95 million hectares, where around 4.8%, i.e. 1.5 million hectares, of this area is considered suitable for growing crops. Only 4.4% of these available arable lands, i.e. 0.21% of the total country area, are currently cultivated covering an area of 65967 hectares (World Bank, 2015; MAF, 2014).

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There are 7.6 million date palm trees currently planted in the farms in Oman covering an area of 23241 hectares or 35% of total agricultural area in the Sultanate in addition to 0.9 million palm trees planted in homes or for landscaping in public parks and beside the roads. Hence, date palm is considered as plant number one in the country. The total production of date palm trees in 2014 was 317 million kg of dates. Around 54% of these dates (Fig. 1) were consumed by people locally whereas 24% and 19%of the dates were used for industry and as forage for animals, respectively, and 3% of them were exported outside the country (MAF, 2015).

The total production of date palm trees and the production per tree in the Sultanate from 1998 to 2014 are

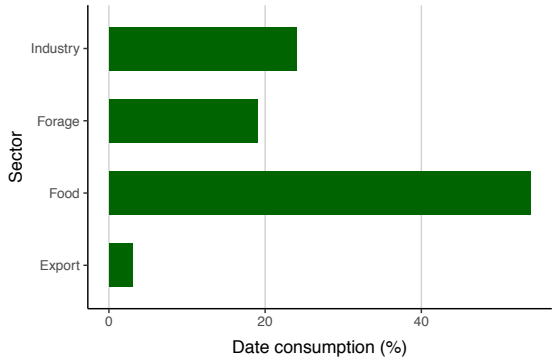

Figure 1. Dates consumption in 2014 by different sectors in Oman.

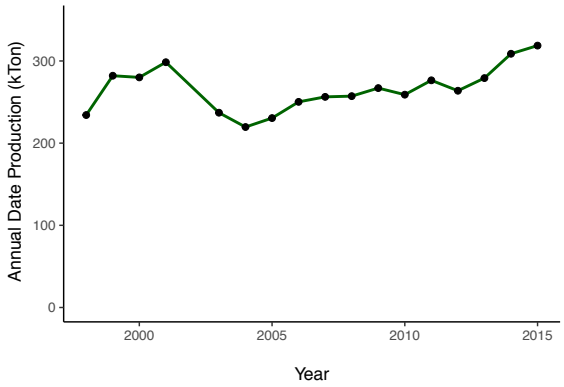

Figure 2. Annual dates prodution (Mkg) in Oman.

presented in (Fig. 2) (Kamoonpuri, 2014; MAF, 2014, MAF; 2010, MAF, 2007; MAF, 2004a; MAF, 1999) whereas (Table 1) presents the annual production of top cultivars of date palm trees. These cultivars produce 44% of total dates production in Oman (MAF, 2010, 2013, 2015). From this table, it can be noticed that the five most productive date palm trees in the Sultanate are "Neghal", "Khesab", "Fard", "Khalas", and "Um silla", with production percentages of 12%, 9.8%, 7.6%, 7.3%, and 7.1% of total dates production. Each hectare planted with date palm trees produce an average of 6075 kg of dates with an average income of 1065 OMR.

The water recharge in the Sultanate of Oman is estimated at 1267 million m^3 per year. Additional water recharge comes from treated wastewater with amount of 42 million m^3 and from desalination with an amount of 196 million m^3. From the available water resources 1487 million m^3 is used for agricultural purposes, whereas, 158 million m^3 is used for domestic, commercial, municipal, and industrial purposes (Al Shibli, 2014, Al-Jabri, 2013, FAO, 2009, Al-Hattaly, 2005 and McDonald, 2004). The water deficit in Oman, however, is estimated at 316 million m^3 i.e. 31% of total recharge because of groundwater out flowing due to storage depletion and sea water intrusion (Al Shibli, 2014, FAO, 2009).

The total amount of water consumption needed to irrigate the cultivated lands in the Sultanate is 1487 million m^3. Wells are the dominating source of irrigation providing 1204 million m^3 followed by Aflaj (single falaj, which is an ancient canal based water distribution system) providing 164 million m^3 and springs providing 119 million m^3 of irrigation water (Fluet et al., 2009; Al-Mamari, 2001; MAF, 2014). Around 907 million m^3 of the irrigation water is consumed by the farming practices applying traditional irrigation systems whereas around 580 million m^3 of water is consumed by modern irrigation systems (MAF, 2014).

Among all cultivated crops in Oman, date palms are the major water consuming plants followed by rhodes grass and alfalfa and then by other fruits and vegetables. The date palm trees consume 558 million m^3 (Fig. 3) that represent 38% of total irrigation water and 31% of groundwater recharge for an annual water deficit estimated at 316 million m^3. Rhodes grass and alfalfa on other hand consume 457 and 117 million m^3 of irrigation water respectively while the remaining water for irrigation around 342 million m^3 is used to irrigate the other fruits and vegetables (MAF 2014, MAF, 2015; Al-Hattaly, 2005, McDonald, 2004). Besides the fact of predominating the irrigation water consumption, 84% of date palm trees are irrigated by flooding an irrigation

Table 1. Date cultivars annual production (Mkg) in Oman.

Date Cultivar	2008	2009	2010	2011	2012	2013	2014
Naghal	24.6	24.9	24.1	28.0	29.7	33.3	37.8
Khussab	27.9	25.4	26.4	26.2	26.1	27.9	30.9
Fardh	20.5	15.8	20.9	16.4	16.9	20.9	24.1
Khallass	12.7	16.9	20.5	20.3	22.4	24.8	23.0
Um Silla	35.2	27.5	29.1	26.3	28.9	31.0	22.4
Mabsali	31.2	19.4	14.7	19.4	19.9	19.5	18.9
Shahel	12.6	16.9	19.7	16.6	17.4	19.1	18.4
Khunaizi	11.3	15.8	15.8	13.7	15.6	17.2	14.9
Qash	NA	8.3	9.9	7.0	8.5	9.1	7.8

system that causes a loss of half of supplied water (MAF, 2004b). Based on the fact that the water productivity of the date palm trees (Table 2) does not go beyond 0.57 kg of yield/m^3 of consumed water and 0.23 OMR revenue/m^3 of consumed water (MAF, 1999; MAF 2014).

There are around 300 varieties of date palm trees in Oman (Al- Al-Ruqaishi, 2009) but some of these trees are of low quality and give very low production yet they are planted in large areas while others which are of high quality, are planted in small areas but give high production. Other planted date palms trees in Oman are not productive at all due mainly to salinity problems and also some of them are male type of trees. Although people in Oman prefer Khalas dates they also consume other good quality dates like Nighal, Khessab, Khenaizi and others while the consumption of low quality dates is almost negligible. These ground based information have led to a fact that only one half of planted date palm trees are producing high value dates (Al-Yahyai and Khan, 2015; Al-Mamari, 2001).

These findings focused the main objectives of this study which were (1) to evaluate the current status of date palm tree cultivation in the Sultanate; (2) to suggest solutions for reducing high consumption of water and improving dates production at same time; and (3). to explore how irrigation water can be saved through increasing water productivity by finding alternative date palm cultivation and irrigation practices.

Methodology

All data related to date palm trees in the Sultanate of Oman were collected and used as a base for this study. These data included scientific studies that determine the country's groundwater recharge amount according to FAO (2009), Al-Hattaly (2005) and McDonald (2004). We also included data from agricultural census conducted by the Ministry of Agriculture and Fisheries Wealth which determined the date palm trees planted areas, water consumption, total and per tree production, and their different cultivars (MAF, 2014; MAF, 2004a). Another data set used were those related to dates production per hectare of land in addition to the technical and economical returns of these dates and water productivity (MAF, 2004b), historic date production data (MAF, 2015; MAF, 2013; MAF, 2004a and MAF, 1999) and data related to different cultivars of date palm trees in the Sultanate and what are the most productive cultivars among them (MAF, 2015; MAF, 2000).

The dataset indicated that only 50% of planted date palm trees were producing high value dates. Hence, water consumption of the other 50% of lower quality date palm trees can be considered as water loss and removing these types of trees will result in water saving by 50% of total date palm water consumption which is 38% of total irrigation water. Furthermore, 84% of date pam cultivations

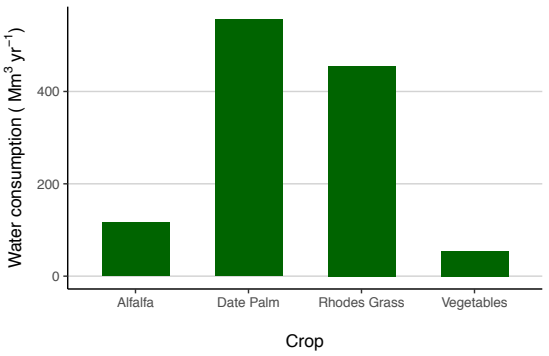

Figure 3. Dates consumption in 2014 by different sectors in Oman.

are under traditional irrigation systems which consume around 468 million m^3 of irrigation water. According to reported water saving using modern irrigation systems over traditional methods (e.g. Reilly, 2005), around 50% of the water cunsumption could be saved if switching to modern irrigation systems.

Water productivity of the proposed changes on date palm cultivations is based on above data and analysis that is calculated in terms of the drop per crop (yield) and the economic return (revenues) using the following two equations:

$$WP_y = \frac{Y}{W} \quad (1)$$

$$WP_e = \frac{R}{W} \quad (2)$$

Where WP_y is the water productivity based on yield (crop per drop) in kg·m^{-3}, WP_e is water productivity based on economic return in OMR·m^{-3} , Y is date palm tree yield in kg, W is amount of irrigation water consumed to irrigate the palm tree in m^3 , and R is the revenue in Omani Rials (OMR).

Results and discussion

As mentioned earlier date palm trees consume 38%, i.e. 558 Mm^3 of the irrigation water in Oman, hence, the water loss due to planting of low value date palm trees accounts for (0.5 x 38 = 19%), i.e. (0.5 x 558 = 279 million m^3) of irrigation water. This means that out of 1487 million m^3 of total irrigation water, only 279 million m^3 will be used to irrigate the date palm trees while the remaining 279 million m^3 could be saved for other water usage after removing low quality types of date palm trees.

By replacing the traditional irrigation systems which are applied in 84% of the proposed reduced date palm cultivation, this means about (0.5 x 0.84 x 279 =117) an

additional 117 million m^3 of irrigation water could be saved for other water consumption purposes and only (279 - 117 =) 162 million m^3 will actually be needed to irrigate the high quality types of date palm trees.

By combining both practices of avoiding planting low quality date palm trees and introducing modern irrigation systems, the total water saving can reach up to (279 +117 = 396) 396 million m^3 that can be used in reducing the groundwater recharge deficit and increasing water productivity. These practices will encourage planting other types of crops of high quality and value which will contribute in increasing the economical return to the farmers and to the country.

The water productivity, after introducing the proposed changes mentioned above of the cultivation and irrigation practices of date palm trees, can be calculated using equations 1 and 2.

We showed above that the total production of date palm trees in 2014 was 317 million kg of dates and that only 50% of planted dates tress should be kept to account for high quality and production trees while the other 50% should be removed as it consists of low quality, low productive, or non-productive types of date palm trees. If we we assume that high quality and yield dates have contributed to total production in 2014 by as much as 80%, i.e. with a production of (0.8 x 317 =), the production of these "good quality" trees was 253.6 million kg.

We also showed above that by replacing traditional irrigation with modern systems would reduce irrigation water consumption to 162 million m^3 to irrigate the high quality types of date palm trees.

If we consider that the average price of dates was 0.400 OMR per kg, the water productivity based on economic return can be obtained as [(0.400 OMR x 253.6M kg) / 162M m^3] = 0.63 OMR/m^3, while the water productivity based on yield (crop per drop) can be obtained as (253.6M kg / 162M m^3 = 1.56 kg/m^3).

Therefore, introducing the above mentioned changes of the cultivation and irrigation practices of date palm trees will increase the water productivity by 64% from 0.57 kg·m^{-3} to 1.56 kg·m^{-3} and from 0.23 OMR·m^{-3} to 0.63 OMR·m^{-3}.

Conclusion

Date palm trees consume 558 million m^3 that is 38% of total irrigation water and 38% of groundwater recharge. The water saving recommendation in this study was based on the above mentioned data in addition to the investigation on the water loss during irrigation practices. It is shown in this study that changing cultivation practices and converting irrigation system to modern system would increase the water productivity by 64% which should contribute in increasing the economical return for the farmers and so the country.

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