Technical Report

DEVELOPMENT OF SUSTAINABLE DATE PALM PRODUCTION SYSTEMS IN THE GCC COUNTRIES OF THE ARABIAN PENINSULA

Economic comparison and evaluation of manual and liquid pollination methods of date palm trees in the Sultanate of Oman (varieties *Fardh* and *Khalas*)




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1. Scope of the study

The present study is prepared within the framework of the **Development of Sustainable Date Palm Production Systems in Gulf Cooperation Council Countries** project. This research and development project aims to produce new knowledge and practices to improve date palm production systems in the Gulf region. The main activities of the project include improving the productivity of cultivars, managing natural resources (land and water) for optimal performance, optimizing the use of different inputs in the cropping process (fertilizers, pollinators, wastewater, etc.), and studying the genetic diversity of date palms. The transfer of technology and experience between partners is an integral part of the project.

One promising technology introduced through the project is liquid pollination. This technology reduces the cost of labor, saves time, and improves the quality of the fruits. This technical report focuses on the economic assessment of such a technology in the Sultanate of Oman and compares its profitability and costs with a manual approach to pollination using a partial budget analysis tool and data collected from rapid rural appraisal surveys with farmers and researchers.

2. Agriculture sector in the Sultanate of Oman: an overview

The Sultanate of Oman occupies the eastern corner of the Arabian Peninsula, stretching more than 1700 km from the Strait of Hormuz in the north to the frontiers of Yemen in the south. The country is located within the latitude and longitude of 21° 00 N, 57º 00 E. It occupies a total area of about 309,500 km^2, of which mountains, deserts, and coastal plains represent 16%, 81%, and 3%, respectively (FAO, 2014). The climate varies from arid in the interior areas, through humid in coastal ones, to tropical in the southern parts of the country. The temperature ranges from below zero (in Jebel Akhdar and Jebel Shams) to 50°C in summer in the desert. The average annual rainfall is about 100 mm (mostly distributed between November and February) except in the Dhofar Governorate where there is monsoon rainfall (200-250 mm) during the July-September period.

According to the Omani Statistical Year Book (2015), in 2014 the estimated population of Oman was around 4,423,815 (with 2,413,024 Omanis and 2,010,791 expatriates). The estimated annual growth rate was 2.04%. The population density is greatest in Muscat (30.46%) followed by Al Batinah (24.83 %). Around 28.4% of the population lives in the vast rural areas and nearly 5% live in the mountains and other hilly areas. The agro-ecological zones that might influence the agriculture sector (land, water, and cropping patterns) in Oman are:

- Northern Oman including the Batinah coastal plain, interior Oman and Dahira plains, Jebel Akhdar and Sharqiya plains
- Southern Oman, Dhofar – including the Salalah plain – Dhofar Jebel, and Najd.

In the Sultanate, the agriculture sector plays an important role in the economy of the country. According to the statistics of the Oman Ministry of Agriculture and Fisheries (MAF, 2015), the contribution of the two sectors (agriculture and fisheries) to the gross domestic product rose from OMR371 million in 2013 to OMR402 million in 2014. In 2012, the total cultivated area was about 725,977 ha, of which 60% is located in the coastal areas. In addition, the agricultural sector accounts for 37% of all the non-oil/gas exports. The main agricultural products that are exported are dried and fresh dates, dried limes, fresh fruits, and vegetables. The agriculture sector provides livelihoods for tens of thousands of the country's citizens with as many as 1.3 million Omanis (over 60% of the indigenous population) engaged in crop cultivation.

Total agricultural production stood at 1,515,000 tonne in 2014 compared to 1,484,000 tonne in 2013; a growth of 2% resulting from increased productivity from the vegetable cultivated areas. Production in this sector increased from 313,000 tonne in 2013 to 335,000 tonne in 2014 – a growth of 7% per year because of the introduction of modern systems and technologies (MAF, 2015).

For the animal sector, the agricultural census (2012/2013) pointed out that the amount of animal wealth increased by 39% compared to that in the 2004/2005 census. The current farming systems include production of crops –dates and fruits, vegetables, fodder and field crops – as well as livestock – cattle, sheep, goats, and poultry. Farm holdings vary from less than 0.4 ha to more than 84 ha. Those of less than 1.26 ha constitute about 11% of total farm holdings; those ranging between 1.26 and 12.60 ha represent 65%, while those greater than 12.6 ha are about 23.8% (FAO, 2014).

Over the past years, the government has made concerted efforts to improve productivity in agriculture through modern irrigation techniques and crop husbandry practices. As a result, during the last decade the production of dates has increased by 30%, while yields of tomatoes, potatoes, and alfalfa have doubled. With the population increasing annually at a rate of more than 3.28 %, there is a need to increase food production and new strategies are being explored for achieving sustainable food security.

The Ministry of Agriculture and Fisheries (MAF) has made efforts since the 1990s to introduce modern irrigation techniques. In order to encourage farmers to use them, MAF has given financial subsidies for irrigation systems varying from 75% for small-scale schemes (less than 4.2 ha), through 50% for medium-scale schemes, to 25% for large-scale schemes (more than 21 ha). Despite these efforts, the traditional flood system still remains the most common irrigation technique and this is practiced by about 80% of farmers.

In 2013, the ministry started formulating a comprehensive strategy to develop animal and plant divisions of the agriculture sectors (2010-2040). The strategy, which has been developed in collaboration with the Food and Agriculture Organization of the United Nations (FAO), aims to ensure optimum use of resources, develop agricultural and food systems, enhance food security, generate jobs, increase incomes, and enhance the competitiveness of Omani products.

3. The date palm sector in the Sultanate of Oman

Date palm (*Phoenix dactylifera* L.) is a major fruit crop in the Arabian Peninsula, where it has been closely associated with the life of the people since pre-historic times. Date palm is a multipurpose tree used for food, feed, and fuel (fire wood). It provides fiber, carbohydrates, minerals, and vitamins besides having certain medicinal properties (Al-Farsi et al., 2005; Al-Yahyai and Khan, 2015).

In Oman, the date palm tree is considered the primary crop, occupying 49% of the cultivated area and constituting 82% of all the fruit crops grown in the country (Al-Yahyai and Khan, 2015). According to FAOSTAT (FAO, 2013), Oman is currently the eighth largest world producer of dates with an average production of 238,000 tonne. Just a small fraction (2.6 %) of the total date production is exported. Only half of the dates produced are used for human consumption, with the other half being utilized primarily for animal feed or considered a surplus and wasted. The dates are mainly harvested for fresh fruit consumption. However, alternative goods, such as date syrup, date sugar, and other by-products, can also be found in the local markets.

Oman has diverse topographical and climatic eco-regions that allow for the cultivation of various types of date palm cultivars, particularly in the northern coastal and interior regions. There are approximately

180 female and 48 male cultivated varieties among the 7.8 million date palm trees. Despite the great diversity of the cultivars, over 78% of the total production is from just 10 commercial cultivars (Al-Yahyai and Khan, 2015). These cultivars are dominant because of the marketability of their high quality fruit or their early and late season production. Given the variability in the topographic and climatic growing conditions, the date palm production season extends from May to November, the longest season of any date-producing country. According to Al-Marshudi (2002) and Al-Yahyai (2007), the yield of the date palm is considered to be low (40-80 kg/tree) compared to the yields in neighboring countries (i.e. Saudi Arabia and UAE). This low yield is a result of traditional management, lack of farmer know-how, high infestation by several pests, limited field expansion because date growing regions are fully dependent on groundwater extraction for irrigation, in addition to logistic problems, including an insufficient number of skilled laborers and underdeveloped facilities (transport, storage, market outlets, and large processing factories).

4. Development of sustainable date palm production systems in the Gulf Cooperation Council (GCC) countries of the Arabian Peninsula project

The project 'Development of sustainable date palm production systems in the GCC countries of the Arabian Peninsula', funded by the GCC, was implemented, in partnership, by ministries of agriculture, agricultural authorities, and agricultural research institutions and universities in the six GCC countries of the Arabian Peninsula (Kingdom of Bahrain, United Arab Emirates, State of Kuwait, State of Qatar, Sultanate of Oman, and Kingdom of Saudi Arabia) and the International Center for Agricultural Research in the Dry Areas (ICARDA). The major objectives of the project were to:

- Increase propagation efficiency and expedite production of offshoots in the quantities needed by growers at a reduced cost
- Improve date palm productivity per unit of water and rationalize the use of the available resources so that production becomes sustainable
- Define the nutritional requirements for the optimal growth of date palm through leaf tissue and soil analysis and establish the need to use macro and micro nutrients
- Improve date palm head practices and management for a vigorous tree with a high yield and better fruit quality at harvest
- Develop sustainable and ecologically sound integrated pest management systems that reduce crop losses caused by major pests and diseases and increase the quality and market value of the dates
- Establish efficient post-harvest management protocols, including processing and marketing, and the use of a value added products base for date palm
- Assemble a set of tools to enable researchers, extension workers, and growers to share the accumulated information, knowledge, and expertise
- Strengthen national institutions and human resource capacity and enhance technology transfer.

This project succeeded in introducing liquid pollination technology to improve the quality of fruits, reduce and save the time and effort during the pollination operation, reduce the risk of low fruit set by pollinating during the peak period of flowering, and contribute to reducing harvesting losses. This technology has received a great deal of attention from governments in recent years, but there is still no clear assessment of its profitability at the farmer level. The success of liquid pollination depends not only on good technology from a technical perspective, but on its affordability and profitability. This technical report focuses on an economic assessment of the liquid pollination technology from two perspectives – research and the end users (farmers). The following sections provide an economic assessment of two varieties largely commercialized in Oman (*Fardh* and *Khalas*). Affordability and

profitability were analyzed using a partial budget analysis tool and disaggregated data gathered from researchers and farmers, using rapid rural appraisal surveys.

5. Economic comparison and evaluation of manual and liquid pollination methods for date palm trees in the Sultanate of Oman (varieties *Fardh* and *Khalas*)

5.1. Data collection

The study took place in two regions in the Sultanate of Oman (Al Sharkia, and Al Dakilia and Al Batinah) characterized by an extensive date palm production and the common use of the liquid pollination technique. The data were collected using rapid rural appraisal surveys with researchers and farmers. Data were collected using the direct interview method at the time of the survey. The information collected covers the variable costs of farming (with special emphasis on the pollination costs), production, market price, margin, and revenue of the two varieties indicated. The data is used to assess, evaluate, and compare the liquid pollination technology with the traditional method using the partial budget analysis tool (or more precisely cost-benefit analysis).

5.2. Methodological framework – cost-benefit analysis (CBA)

Cost-benefit analysis – sometimes called benefit-cost analysis – is a systematic approach to estimating the strengths and weaknesses of alternatives that satisfy the transactions, activities, or functional requirements of a business. It is a technique that is used to determine options that provide the best approach to be adopted and practiced in terms of its benefits in labor, time, cost savings, etc. The CBA is also defined as a systematic process for calculating and comparing the benefits and costs of a project (or technology, as in this case) decision or government policy.

Broadly, CBA has two main purposes:

1. To determine if it is a sound investment/decision (justification/feasibility), to provide a basis for comparing projects/technologies. It involves comparing the total expected costs of each option against the total expected benefits, to see whether the benefits outweigh the costs, and by how much.
2. CBA is related to, but distinct from, cost-effectiveness analysis. In CBA, benefits and costs are expressed in monetary terms, and are adjusted for the time value of money, so that all flows of benefits and flows of project costs over time (which tend to occur at different points in time) are expressed on a common basis in terms of their 'net present value'.

As has been mentioned above, this tool has been used to provide a basis for comparing liquid pollination technology with the traditional one in order to assess its profitability.

5.3. Results and discussion

Pollination of date palm is normally carried out by hand in almost all date palm groves in Oman. Farmers mostly use various hand pollination techniques. They are unaware of the best techniques for pollination – which ones may be easiest and most convenient. According to Al-Yahyai and Khan (2015), there are several male palm cultivars that are used for pollination, most notably *Khoori* and *Bahlani*. El Mardi et al*.,* (2002) pollinated varieties of date palm by hand, and using a hand duster and motorized duster with no effect on fruit yield, despite the larger fruit volumes when dusters were used. They also reported that a pollen/flour (1:5) ratio for mechanical pollination produced lower sucrose and dry matter and a higher

yield. So it is necessary to find the best pollination technique for improving the fruit setting percentage, saving time, reducing cost, and, consequently, improving the quality of the dates.

The first assessment of liquid pollination technology shows the following advantages and constraints regarding the use of this technology:

Advantages of using liquid pollination

- Saves time and effort (reducing labor cost and improving the effectiveness and productivity of the labor used)
- Reduces the quantity of pollen needed
- Reduces labor and pollen costs
- Reduces the risk low fruit set by pollinating during the peak period of flowering
- Improves the quality of the fruits and consequently the profitability of the varieties intended for export
- Improves the fruit setting percentage
- Contributes to reducing harvesting losses
- Reduces the risk of climbing accidents to laborers.

Constraints to using liquid pollination

- No interest from the younger generation in date palm production
- The pollination extraction device is expensive (around OMR3500), which small-scale farmers cannot afford
- Limited number of date palm trees per farmer (the investment in the pollination extraction device is not profitable)
- Resistance of farmers to adopting the new technology and to changing their practices (farmers are accustomed to the old technology of hand pollination)
- Lack of specialized extension for the date palm
- Difficulty of extension (limited number of extension staff with massive responsibilities).

Economic assessment of liquid pollination technology for Fardh variety: from the researchers' perspective

The intervention introduced by the project for the pollination of date palm trees was evaluated economically against the manual method for the *Fardh* variety based on the data collected from researchers and experts at the Date Palm Research Center, Experimental and Research Farm – Wadi Quriyat. According to Omani date palm researchers at this center, the advantages of using liquid pollination are that it saves time and reduces the risk of low fruit set by pollinating during the peak period of flowering of the date palm trees.

In the analysis below, we assume that the yield will be maintained the same using the two options (liquid pollination technology and manual pollination). The premise that even if the quantity is slightly reduced using liquid pollination, the weight of fruit will increase – given the advantage of a decreased proportion of the fruit set and concomitant increase in the quality of the fruit. In this case it was considered as natural fruit thinning. This improvement in the quality will affect the market price and for that we considered a higher price for the dates produced using liquid pollination. Given these logical and realistic assumptions, the total value of production per hectare is much higher under liquid pollination in comparison with the manual one (an increase of almost 50%). Table 1 indicates a reduction in pollination cost using liquid pollination in comparison to that for manual pollination of about 89.05%

and, consequently, a reduction in the total variable costs per hectare against those for manual pollination of about 56.48%. Moreover, the analysis reveals a total reduction in the variable costs of OMR1273.95 from using liquid pollination. This reduction in total variable costs results from an increase in the net revenue over that resulting from manual pollination of OMR2593.95/ha. The economic indicators (Table 1) show also the clear profitability of using liquid pollination where the percentage change in net returns is very high (+ 674.71%). The benefit-cost ration (BCR) is three times higher when using liquid pollination. Thus, with an internal rate of return with 12.04 and higher BCR, we can conclude how profitable it is for Omani farmers to use liquid pollination.

Table 1: Partial budget analysis for using liquid pollination with the date palm variety *Fardh* in the Sultanate of Oman

Variable	With technology option (liquid pollination)	Without technology option (manual pollination)
Yield (kg/tree) [(a)]	40	40
Number of date palm trees/ha	165	165
Yield (kg/ha)	6,600	6,600
Price (OMR/kg) [(b)]	0.6	0.4
Total value of production (OMR/ha)	**3,960**	**2,640**
Cost of pollen (OMR/ha)	125	935.55
Cost of device (OMR/ha)	11.6	0
Labor cost for pollination (OMR)	20	495
Total cost of pollination (OMR/ha) [(c)]	156.6	1,430.55
Other costs (irrigation, fertilization, pruning, thinning, harvesting, and post-harvest handling) (OMR/ha) [(d)]	825	825
Total variable costs (OMR/ha)	**981.60**	**2,255.55**
Net revenue (OMR/ha)	**2,978.40**	**384.45**
Economic indicators (1)		
Reduction of pollination cost per ha over manual pollination (%)	89.05	
Reduction of total variable costs per ha over manual pollination (%)	56.48	
Variable costs between the two technologies (OMR/ha)	- 1,273.95	
Increased net revenue over manual pollination (OMR/ha)	2,593.95	
Economic indicators (2)		
Net returns (NR)	**2,978.40**	**384.45**
Change in net returns (NR) (%)	674.71	
Change in total costs (TC) (%)	56.48	
Internal rate of return (IRR)	12.04	
Benefit-cost ratio (BCR)	4.03	1.17

Source of information: Date Palm Research Center, Experimental and Research Farm – Wadi Quriyat)

Notes:

- The analysis is at the hectare level.
- Number of date palm trees/*feddan* (4200 m^2) = 64.
- Number of date palm trees/ha=165.

(a): The yield under liquid pollination is considered to be the same as that under manual pollination given that with liquid pollination, the reduction in production is compensated for by the increase in the fruit weight.

(b): Under liquid pollination, the quality is expected to be improved and consequently the market price will be higher than that for dates under manual pollination (the thinning process of the fruits under liquid pollination will improve the weight and quality).

(c): The cost of pollination per ha is determined as follows:

- Liquid pollination: (1) Cost of pollen, OMR125; (2) Labor cost, OMR20 OMR, (3) Cost of device, OMR11.6 (as the total cost of the device is estimated at OMR3500 with an expected life of 10 years and used for one month/year).
- Manual pollination: (1) Cost of pollen, OMR935.55 and (2) Labor cos, OMR495.

(d): The cost of agricultural practices is considered to be the same per hectare under the two technologies.

Economic assessment of liquid pollination technology for Khalas variety: from the farmers' perspective

Similar results were achieved from the data obtained from farmers for the *Khalas* variety. With the same assumptions on yield and related price-quality, the figures presented in Table 2 indicate an increase in the value of production of about 20% from using liquid pollination rather than the manual pollination. The analysis showed that using liquid pollination reduced the pollination operation costs by 89.05% (which is the equivalent of OMR1273.95/ha) compared to traditional pollination. The reduction in pollination induces a reduction in the total variable costs of 22.10%.

Economic analysis revealed that the net benefit to date palm farmers, using the cultivar *Khalas*, and applying liquid pollination was OMR15,310.5/ha (an increase of around 42.60% over that when using manual pollination). From Table 2, analysis of the IRR indicates that investment in liquid pollination technology is a profitable decision. The results presented in the table show that investing OMR1 yields almost two times the original investment. Generally, using liquid pollination will yield a cost-benefit ratio that reaches 3.41, which is almost twice that from using manual pollination.

Table 2: Partial budget analysis for applying liquid pollination to the date palm variety *Khalas* in the Sultanate of Oman

Variable	With technology option (liquid pollination)	Without technology option (manual pollination)
Yield (kg/tree) [(a)]	100	100
Number of date palm trees/ha	165	165
Yield (kg/ha)	16,500	16,500
Price (OMR/kg) [(b)]	1.2	1
Total value of production (OMR/ha)	**19,800**	**16,500**
Cost of pollen (OMR/ha)	125	935.55
Cost of devise (OMR/ha)	11.6	0
Labor cost for pollination (OMR)	20	495
Total cost of pollination (OMR/ha) [(c)]	156.6	1,430.55
Other costs (irrigation, fertilization, pruning, thinning, harvesting, and post-harvest handling) (OMR/ha) [(d)]	4,332.9	4,332.9
Total variable costs (OMR/ha)	**4,489.5**	**5,763.45**
Net revenue (OMR/ha)	**15,310.5**	**10,736.55**
Economic indicators (1)		
Reduction of pollination cost per ha over manual pollination (%)	89.05	
Reduction of total variable costs per ha over manual pollination (%)	22.10	
Variable costs between the two technologies (OMR/ha)	-1,273.95	-
Increased net revenue over manual pollination (OMR/ha)	4,573.95	-
Economic indicators (2)		
Net returns (NR)	**15,310.5**	**10,736.55**
Change in net returns (NR) (%)	42.60	
Change in total costs (TC) (%)	22.10	
Internal rate of return (IRR)	1.92	
Benefit-cost ratio	3.41	1.86

Source of information: Farmer from Wadi El Maouel region

Notes:

- The analysis is at the hectare level.
- Number of date palm trees/*feddan* (4200 m^2) = 64.
- Number of date palm trees/ha=165.

(a): The yield under liquid pollination is considered to be the same as that under manual pollination, given that with liquid pollination the reduction in production is compensated for by the increase in fruit weight.

(b): Under liquid pollination, the quality is expected to be improved and consequently the market price will be higher than that for dates produced using manual pollination (the thinning process of the fruits under liquid pollination will improve the weight and quality).

(c): The cost of pollination per hectare is determined as follows:

- Liquid pollination: (1) Cost of pollen, OMR125; (2) Labor cost, OMR20 (3) Cost of device, OMR11.6 (the total cost of the device is estimated at 3500 OMR with an expected life of 10 years and used for one month/year).
- Manual pollination: (1) Cost of pollen, OMR935.55 (2) Labor cost, OMR495.

(d): The cost of the agricultural practices is considered to be the same per hectare under the two technologies.

6. Concluding remarks and policy implications

The results obtained from this research indicate that sustainable increases in productivity of date palm in the Sultanate of Oman can be achieved if farmers are encouraged to adopt the liquid pollination technology. However, the adoption of such technology needs to be accompanied by a supporting extension system and an enabling political environment to ensure the scaling-up and widespread use of this promising and profitable technology.

Some suggested policy options for accelerating the adoption process and scaling-up the use of liquid pollination technology include:

- Development of an agricultural management program for date palm tree services, the application of quality control measures, and an increase in capacity building to reduce the cost of production
- Creation of private companies to carry out and monitor the liquid pollination operations
- Enhancing the extension services (more and specialized extension agents) and the development of an effective extension service for Omani date palm growers
- Reinstatement of the subsidy system in the sector
- Creation of private services and marketing companies with support from the government
- Enhancing the awareness of farmers regarding the profitability of using this technology in comparison to the manual pollination method
- Make introducing the technology the responsibility of the government; it cannot be left to farmers
- Valorization of the date palm by-products (to generate more profit for the date palm producers).

7. References

Al-Farsi M., Alasalvar C., Morris A. et al. (2005). Comparison of antioxidant activity, anthocyanins, carotenoids, and phenolics of three native fresh and sun-dried date (*Phoenix dactylifera* L.) varieties grown in Oman. *Journal of Agricultural and Food Chemistry* 53: 7592–7599.

Al-Marshudi A.S. (2002). Oman traditional date palms: production and improvement of date palms in Oman. *Tropiculture* 20(4):203–209.

Al-Yahyai R. (2007). Improvement of date palm production in the Sultanate of Oman. *Acta Horticulturae* 736:337–343.

Al-Yahyai, R., Khan, M.M. (2015). Date palm and perspective in Oman. Pages 207–240. *In* Date Palm Genetic Resources and Utilization: Volume 2: Asia and Europe (J.M. Al-Khayri, S.M. Jain, and D.V. Johnson eds). Springer, Dordrecht, Heidelberg, New York, London.

El Mardi, M.O., Esechie, H., Al-Kharousi, L.M., Abdelbasit, K.M. (2002). Effect of pollination method on changes in physical and chemical characteristics of date fruit during development. *Agricultural Sci*ence 7(1):21–27.

Food and Agriculture Organization of the United Nations (FAO) (2011). FAOSTAT. Crop Production, Statistics Division, FAO, Rome. http://www.faostat.fao.org.

Food and Agriculture Organization of the United Nations (FAO) (2014). FAOSTAT. Crop Production, Statistics Division, FAO, Rome. http://www.faostat.fao.org.

Ministry of Agriculture and Fisheries (MAF) (2015). Annual report. MAF, Muscat, Sultanate of Oman.

Oman – Statistical Yearbook 2015. Issue 43. https://www.ncsi.gov.om/Elibrary/Pages/LibraryContentDetails.aspx?ItemID=lffQDcPJGNjEE5Xix4WK2g%3D%3D.

World Bank (2011). World Development Report. World Bank, Washington, DC.