LIQUID POLLINATION TECHNOLOGY AS NEW TECHNOLOGY TO AMELIORATE DATE PALM POLLINATION AND FACILITATE DATE PALM FIELD OPERATIONS

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Abstract: 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. Dry pollination is used utilizing hand and motorized dusters with no negative effect on fruit yield. However, larger pollen volumes are used with the dusters and uneven distribution of pollen grains is found when the palms are tall.

With Liquid Pollination (LP) female trees flowers are sprayed with pollen grains suspended in water using knapsack or motorized sprayers. LP is much quicker, cheaper and equally effective. In addition, the use of this technology contribute to saving time, reducing cost, and consequently, reduces the risk of climbing accidents to laborers.

LP was evaluated economically versus the traditional manual pollination (TMP) for Fardh cultivar based on the data collected from researchers from the Date Palm Research Center in Wadi Quriyat in Oman.

The reduction in pollination cost using LP in comparison with TMP is about 89% and, consequently, a reduction in the total variable costs per hectare against those for manual pollination of about 42-56%.

Economic indicators showed that LP will be highly profitable for Omani farmers. The Net Return (NT) using liquid pollination was very high (+ 674%). The benefit-cost ratio (BCR) is three times higher when using liquid pollination.

ADOPT (Adoption and Diffusion Outcome Prediction Tool) tool was used to focus groups of date palm growers in Sultanate of Oman to predict the proportion of a target population that might adopt an innovation over time. The empirical findings obtained from the LP technology assessment indicates that peak adoption rate for the technology in Al Batinah is predicted to be 95% after a period of 14-16 years. The predicted adoption level in 5 years and 10 years from start is expected to be 35-47% and 86-91%, respectively.

Key words: Date palm, pollination, LP, Economic evaluation, ADOPT, Oman.

INTRODUCTION

Date palm (*Phoenix dactylifera* L.) is the widest spread crop and attain great cultural, social and religious importance in the Sultanate of Oman. The total number of date palm trees in Oman is estimated at about 8 million which occupies about 49% of total area under cultivation and 85% of the area cultivated by fruit trees. Currently, Oman is the eighth largest world producer of dates with a total production reaching 361,000 ton (MAF, 2017). 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 females and 48 male cultivated varieties. 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 and Khan (2015), 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).

The date palm, being a dioecious plant, need to be pollinated. Pollination is performed traditionally in Oman and elsewhere by climbing the female trees to insert the male flower strands into the female spathe. This is laborious, time consuming and a risky operation to farm labors. A number of successful studies have been done in Oman and other countries to use machine for pollination in which farmers can perform the operation from the ground quickly and easily. Al-Bakr (1972) mentioned that pollination machine was introduced to the USA as early as 1952 to dust the pollen from ground level. The operation was completed in just few hours as compared to as long as two days to manually pollinate an area of two feddans. El Mardi, et al. (2002) found that the fruit set, yield and fruit quality in mechanical pollination was similar to that of traditional method which was supported by Brown et al. (1969) and Shabana et al., (1985) in: Dhehibi et al. 2018).

As a result, there is a great need and potential for improving the current date palm growing practices. In the current project a novel approach was used to pollinate female date palm flowers using pollen grains suspended in water (Liquid Pollination = LP) which is sprayed from ground level using motorized sprayers. Technical and economical aspects of adopting this technique were studied.

METHODOLOGY

A number of consecutive field experiments were conducted by the researchers of date palm horticulture research section, date palm research center (DPRC) starting from

2003/2004 season. The aim of the experiments was to standardize the LP technique by assessing various pollen grain concentrations using different varities in different agro-ecological zones in Oman. Subsequently, the technology was demonstrated at farmers' field level. Following the success of LP, it was disseminated to the various agricultural governorates through the extension specialists after conducting a series of workshops for training of the subject matter specialists. LP technique was disseminated to the various Gulf Cooperation Council (GCC) countries through the regional project entitled "Development of Sustainable Date Palm Production Systems in the GCC Countries of the Arabian Peninsula" coordinated by ICARDA. Furthermore, eeconomic comparison and evaluation of manual and liquid pollination methods of date palm trees was performed in the Sultanate of Oman for the varieties Fardh and Khalas by the project experts. A Case Study was performed from the date palm growers in the Sultanate of Oman for predicting farmers' willingness to adopt LP technique.

RESULTS AND DISCUSSION

The series of field trials conducted by DPRC revealed that LP resulted in fruit set and other fruit quality parameters similar to those obtained by TMP. The study conducted on Fardh variety proved that pollen grain suspension spray at 0.5g/L water resulted in fruit set (75.9 %) compared to the TMP (71.3%) with no statistical significant difference between the treatments (P>0.05). LP also resulted in as good fruit weight and total yield as the TMP with no significant difference. Increasing pollen grain concentration even up to triple the concentration, did not improve the studied parameters. However, significant reduction (P>0.05) on fruit set was observed on Barni variety fruit set using LP at 0.5g/L water (66.0%) when compared to TMP. However, the total yield (Kg/palm) was not affected (106.9 Kg/palm for LP V.S. 102.9 Kg/palm for TMP). Moreover, the fruit weight at the full mature Tamr stage was significantly increased (P>0.05) with LP (4.4g) compared to TMP (3.8g) (Table 1). Similar results were obtained with the variety Jabri (MAF, 2005/2006). This is considered as an advantage of LP resulting in less competition of the fruits for water and nutrients which plays as natural thinning of fruits.

Economic evaluation of LP with farmers in Sultanate of Oman

Economic assessment of the liquid pollination technology was performed from two perspectives, i.e, research and the end users (farmers) for Fardh as commercial variety in Oman. Affordability and profitability were analyzed using a partial budget analysis tool and disaggregated data gathered from researchers and farmers, using rapid rural appraisal surveys.

Results (Table 2) 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 LP. 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 2) 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.

Analyze of Adoption of LP in Sultanate of Oman

The adoption of new agricultural technologies has generally been found to be a function of farm and farmer characteristics and specific features of the particular technology (Feder et *al*., 1985; Marra and Carlson, 1987; Rahm and Huffman, 1984 in Dhehibi et al. 2018). A considerable set of literature was developed regarding factors that influence the adoption of new technologies by farmers through use of innovation theory (Feder et *al*., 1985; Griliches, 1957, and Rogers, 1995 in Dhehibi et al. 2018).

Rogers (1995) identified five characteristics of an innovation that affect an individual's adoption decision:

- Relative advantage: how the innovation is better than existing technology;
- Compatibility: the degree to which an innovation is seen as consistent with existing experiences, needs, and beliefs of adopters;
- Complexity: how difficult the innovation is to understand and use;
- Trialability: the degree to which the innovation may be used on a limited basis;
- Observability: the degree to which the results of an innovation are visible to others.

As the relative advantage, compatibility, complexity, trialability, and observability of liquid pollination have caused more farmers to adopt it in the Sultanate of Oman, in particular, and in the GCC countries in general. We can consider the adoption of LP as an innovation. The utilization and critical mass adoption of such technologies is an important prerequisite for agricultural development, particularly for the date palm producing countries in the Arabian Peninsula.

The results obtained about the LP technology adoption (Figure 1) in North Al-Batinah region as example (Dhehibi et al. 2018), 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. The peak adoption rate for liquid pollination technology in the "North Al-Batinah" is predicted to be 95% after a period of 14.5 years. The predicted adoption level in 5 years and 10 years from start is expected to be 46.9% and 91.5%, respectively. 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.

CONCLUSION

Extension of LP as new technology, economic evaluation and analyze of adoption in Sultanate of Oman shows the following advantages and constraints regarding the use of this technology:

The main advantages of using liquid pollination are:

- 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.

Liquid pollination have also some constraints:

- 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 staff for the date palm,
- No interest from the younger generation in date palm production.

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 with support from the government,
- 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,
- Enhancing the awareness of farmers regarding the profitability of using this technology in comparison to the manual pollination method.

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Tables

Table 1. Fruit set, total yield and fruit weight at Tamr stage of Barni date palm variety as affected by Liquid pollination (LP) compared to traditional manual pollination (TMP) during 2004/2005 seasons

Season	First season			Second season		
Treatment	Fruit set (%)	Total yield (Kg/palm)	Fruit weight (g)	Fruit set (%)	Total yield (Kg/palm)	Fruit weight (g)
Control (TMP)	83.1	102.9	3.8	77.3	63.4	5.6
LP (0.1 g/L)	58.7	85.6	5.4	57.4	68.9	6.7
LP (0.3 g/L)	68.5	102.2	4.8	52.1	52.5	7.4
LP (0.5 g/L)	66.0	106.9	4.4	62.2	60.2	7.0
LSD 5%	8.3	8.3	0.4	8.3	8.3	0.4

Source: (MAF, 2005/2006).

Table 2. Partial budget analysis for using liquid pollination with the date palm variety *Fardh* in the Sultanate of Oman

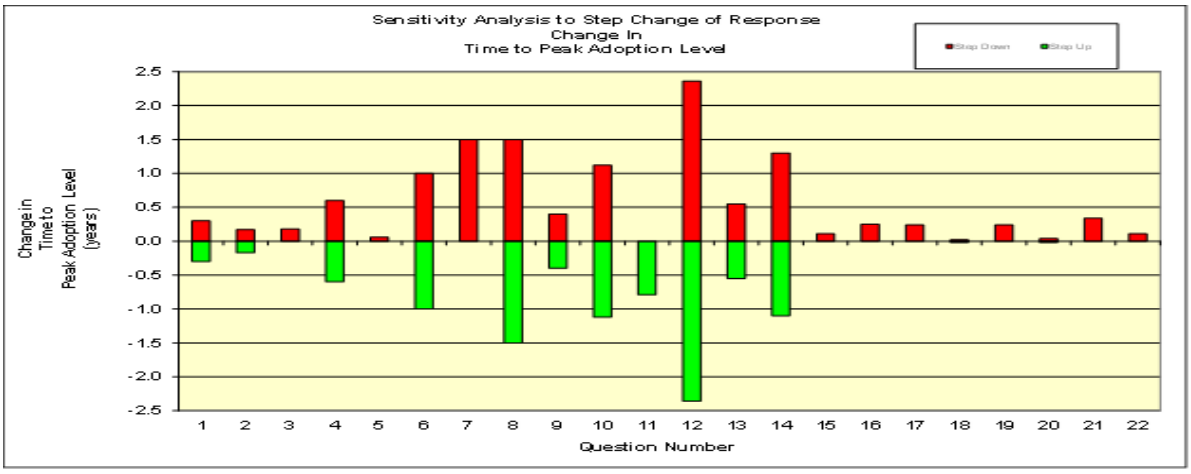
Variable	With technology option (liquid pollination)	Without technology option (manual pollination)
Yield (kg/tree) [(a)]	40	40
Number of date palm trees/ha	165	165
Yield (kg/ha)	6,600	6,600
Price (OMR/kg) [(b)]	0.6	0.4
Total value of production (OMR/ha)	**3,960**	**2,640**
Cost of pollen (OMR/ha)	125	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: Dhehibi et al. 2016

Figures

Fig. 1. Sensitivity Analysis of Adoption Curve of Liquid Pollination Technology at "North Al Batinah" Governorate - Sultanate of Oman



Source: Dhehibi et al. 2018