DRYING DATES USING SOLAR ENERGY UNDER POLYCARBONATE HOUSE- NEW PROMISING TECHNOLOGY TO DRY DATES IN OMAN

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Abstract: The project "Development of Sustainable Date Palm Production Systems" in GCC countries aims to use of proper agro-management techniques, and to develop proper post-harvest techniques to reduce losses, and improve marketing.

Drying dates by solar energy under Polycarbonate Drying House (PDH) is developed by the project. The PDH is a drying chamber cover by polycarbonate sheet equipped by exhaust fan. The polycarbonate sheet has superior properties in terms of transparency, transmissivity, property, anti-corrosion, tensile properties, tear-resistant, anti-puncture, water and moisture proof.

Principal advantages on using the PDH technology are the following: (1) Improves the quality of the dates, especially in humid areas; (2) Avoids the contamination of dates by insects, birds, dust, and rain; (3) Accelerates the drying process and (4) Reduces the loss rate.

The implementation of this improved technology can have positive socioeconomic impacts on local income generation, food security and consequently a sustainable date palm farming system.

Economic evaluation of the polycarbonate drying houses in Sultanate of Oman reveal the high profitability of the polycarbonate drying system, even when it is not subsidized by the government. At a real discount rate of 5%, the net present value (NPV) is positive and very high in all cases. The estimated Internal Rate Return (IRR) was higher than the current interest rate in the Sultanate, which could encourage both date palm growers and private investors to invest in polycarbonate drying houses.

Adoption and Diffusion Outcome Prediction Tool (ADOPT) was used to focus groups of date palm growers in Al Batina region in Sultanate of Oman to predicts the proportion of a target population that might adopt an innovation over time. The assessment of adoption of the (PDH) technology reveal that 95% of the farmers in Al

Batina region would adopt the innovation after 21 years. However, the predicted adoption levels in 5 and 10 years from start is 23% and 73%, respectively.

Key words: Date palm, dates, Drying, DPH, Economic evaluation, ADOPT, Oman

INTRODUCTION

In Oman, date palm is the primary agricultural crop, and it constitutes 80% of all fruit crops produced and 50 % of the total agricultural area in the country (FAO, 2013). Oman is the eighth largest producer of dates in the world with an average annual production of 260,000 tons per annum. There are approximately more than over seven million date palms and 250 cultivars in cultivation, primarily in the northern governorates of the sultanate. Only half of the dates produced are used for human consumption, with the other half being utilized primarily for animal feed or considered surplus and wasted (Al-Yahyai and Khan, 2015). The loss is high and estimated to more than 30% of the 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 the date production. In the region of Al Batina, major production is soft and semi-soft dates. For conservation it need to dry fruits. Traditional way of drying date is makes under the sun and dates are exposed to dust, birds and insects.

A series of experiments have been conducted to identified the appropriate technical specifications and dimensions of the drying houses to increase their efficiency. Drying dates inside plastic room was performed for the first time to ameliorate drying process. The quantity of dates to dry was limited and the colour was affected because limited aeration of the small plastic houses. Drying dates by solar energy under Polycarbonate Drying House (PDH) is developed by the project. The PDH is a drying chamber cover by polycarbonate sheet equipped by exhaust fan. The polycarbonate sheet has superior properties in terms of transparency, transmissivity, property, anti-corrosion, tensile properties, tear-resistant, anti-puncture, water and moisture proof.

The present paper present results of assessment in research station using one of the main important date palm cultivar (Khasab) compared with one other seedling selection, Economic evaluation of PDH with farmers in Sultanate of Oman and prediction of adoption of the technology in the Omani conditions.

MATERIALS AND METHODS

Dates of Khasab cultivar and dates of seed grown palm coded 6 were entered in the chamber at Bisr and Rutab stages of maturity. Simultaneously, a representative sample were placed in well aerated spot on stainless steel mesh under the direct sun and temperature and humidity were monitored using weather station data loggers set to take a reading every 30 minutes. Polycarbonate chamber is manufactured locally and placed in the Rumeis Research Station.

The dates' moisture was measured upon reception and after maturity when the fruits' weight stabilized. Data loggers (watch dog) supplied by Spectrum Technologies Inc.,

Aurora, USA was used to follow temperature inside and outside the polycarbonate house. Moisture balance supplied by KERN & Sohn, Baligen, Germany.

For technology economic evaluation, data was collected from two farmers in the Sultanate of Oman with two different polycarbonate drying houses sizes, using rapid rural appraisal surveys with a direct interview method conducted at the same time as the survey. The information collected covered the capital cost, capacity of dryer, maintenance costs, life of dryer, amount of subsidy received, and some technical information related to the condition of the fresh and dried dates. The data was used to assess and evaluate the economic significance of the polycarbonate dryer using the payback period method.

To evaluate a level of adoption of this technology, a focus group discussion (FGD) methodology was used to apply the ADOPT with group of date palm growers in North and South Al Batinah in Oman. Streamlined 22 discussion questions around four categories of influences on adoption: characteristics of the innovation, characteristics of the target population, relative advantage of using the innovation and learning of the relative advantage of the innovation.

RESULTS AND DISCUSSIONS

Drying dates assessment in research station

The dates drying process involves the loss of weight due to evaporation of moisture from the fruits which is assisted by high temperature and low humid moving air. The design of the Polycarbonate Drying House (PDH) (Fig. 1) is an attempt to provide optimal conditions to achieve drying requirements.

Data collected of the changes temperature and humidity in 24 hours during the maturing process in and outside the DPH are depicted in (Fig. 2), the highest temperature recorded was 69.6 at 1:26 p.m., the highest humidity was 62.7 at 4:56 a.m. while the highest temperature recorded outside was 99.9 and continued from 00.56 a.m. to 2:26 a.m., the highest humidity was 62.7 at 4:56 a.m.

Fruits of two cultivars (namely Khasab and seed grown cultivar coded C6) are ripened at Bisr or Rutab stages (as they are naturally mixed in the bunches) and immediately % moisture is measured, and three samples (each weighed between 400-500g) are placed in stainless steel trays and entered in the PDH, the same was repeated for samples to be placed in the open air under the sun and all are monitored daily for changes in their weight.

It was observed with Khasab cultivar (Fig. 3) that decrease in weight started rapidly from the first day and continued for four days in the PDH then stabilized. In the traditional drying the decrease was slower and continued for 12 days.

The decrease in weight was less prevalent in the C6 cultivar (Fig. 4), while decrease was steeper inside the PDH and prevailed in day 5 the difference between PDH drying

and traditional was slight. However, due to higher humidity the samples placed outside started gaining weight after day 7 which is attributed to the hygroscopic nature of the dates.

Economic evaluation of PDH with farmers in Sultanate of Oman

PDH were evaluated economically based on Payback Period (PBP) (Nayak et al., 2012) under two scenarios: with and without governmental subsidies (Table 3, Fig. 4 and 5). Empirical findings reveal the high profitability of the polycarbonate drying system, even when it is not subsidized by the government. At a real discount rate of 5.1%, the Net Present Value (NPV) is positive and very high in all cases. Given this, the decision criterion states that an investment is usually acceptable if the NPV is positive (the investment is profitable). This criterion was also supported by both the Internal Rate Return (IRR) and the PBP criteria. The estimated IRR was higher than the current interest rate in the Sultanate, which could encourage both date palm growers and private investors to invest in polycarbonate drying houses. The PBP was found, in the worst case scenario, to be 3.77 years, which is relatively short considering the life of the system (15-20 years). This suggests that investment or action costs in this dryer system are recovered quickly reducing the risk involved in the investment.

Prediction of adoption of the technology

The ADOPT tool predicts the proportion of a target population that might adopt an innovation over time. The assessment of PDH technology (Table 4, Fig. 6 and 7) reveal that 95% of Al Batinah community would adopt the innovations after 20.9 years. However, the predicted adoption levels in 5 and 10 years from start is 23.5% and 72.9%, respectively. These results are expected since the upfront cost of investment is quite high while the economic viability of this technology make the evidence of its profitability. Results suggest that triability of the innovation on a limited basis before a decision is made to adopt it on a larger scale, the perception and evaluation of the PDH technique. The size of the up-front cost of the investment relative to the potential annual benefit from using the innovation are the driving adoption factors for the PDH technology in the target area.

CONCLUSION

The PDH was proved to be an efficient method to mature dates by providing optimal conditions to assist the drying of dates process. The drying in the PDH reduce the time of drying date to 4 days, instead 8-12 days by the traditional drying way in addition to protecting the dates from different elements such as high humidity, dust and attacks of insects and birds.

Based on economic indicators (NPV, IRR and PBP) the investment is highly profitable. The investment is usually acceptable if the NPV is positive.

The results of predict of the adoption of the PDH indicate that to meet the technical, economic, and socioeconomic requirements, there is a need for a greater political and institutional input into polycarbonate drying houses projects. In particular, there is a need to design and develop alternative policy instruments (other than subsidies) and institutions for extension, technical assistance, training, and credit services that will facilitate adoption of this technology.

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Tables:

Table 1. Moisture (%) of Khasab dates before and after maturity

Sample	Initial	Final
Inside the PDH	70.09	11.3
Outside	70.09	21.45

Table 1. Moisture (%) of C6 dates before and after maturity

Sample	Initial	Final
Inside the PDH	43.43	15.8
Outside	43.43	21.62

Table 3. Computation of economic indicators and financial indicators (NPV, IRR, and PBP) of the PDH

Items	**Subsidized dryer - FIRR**	**No subsidy for dryer - EIRR**
Fresh dates (OMR/kg)	0.8	0.8
Dried dates (OMR/kg)	1.2	1.2
Product net weight (kg/kg of fresh date)	0.75	0.75
Capacity of dryer (kg/year)	6000	6000
Cost of fresh materials	6000*0.8*0.65 3120	6000*0.8*0.65 3120
Labor and maintenance costs (OMR)	300	300
Electricity costs (OMR)	36	36
Cost of insurance (OMR)	0.0	0.0
Total cost of fresh materials	3456	3456
Capital cost of dryer (OMR)	1000	3000
Life of dryer (years)	15	15
Depreciation (OMR/year)	66.66	200
Total revenue (OMR)	(6000*0.75*0.75*1.2)+(6000*0.75*0.25*0.8) 4950	(6000*0.75*0.75*1.2)+(6000*0.75*0.25*0.8) 4950
Total cost (OMR/year)	4522.66	6656
Net income (OMR/year)	427.34	-1706
Financial Indicators		
Net present value (NPV)	12,764.184	7486.52
Financial and economic internal rates of return (FIRR, EIRR)	Very high (+100%)	76%
Payback period (PBP, years)	0.7	2.31

Source: Dhehibi et al. (2017)

Table 4. Predicted Adoption Levels of PDH Technology at "South Al Batinah" Governorate – Sultanate of Oman

Predicted Peak Level and Time of PDH Adoption	Al Batinah Governorate
Predicted years to peak adoption	20.9

Predicted peak level of adoption	95%
Predicted adoption level in 5 years from start	23.5%
Predicted adoption level in 10 years from start	72.9%

Source: Dhehibi et al (2017)

Figures

Fig. 1. Polycarbonate Drying House (PDH)

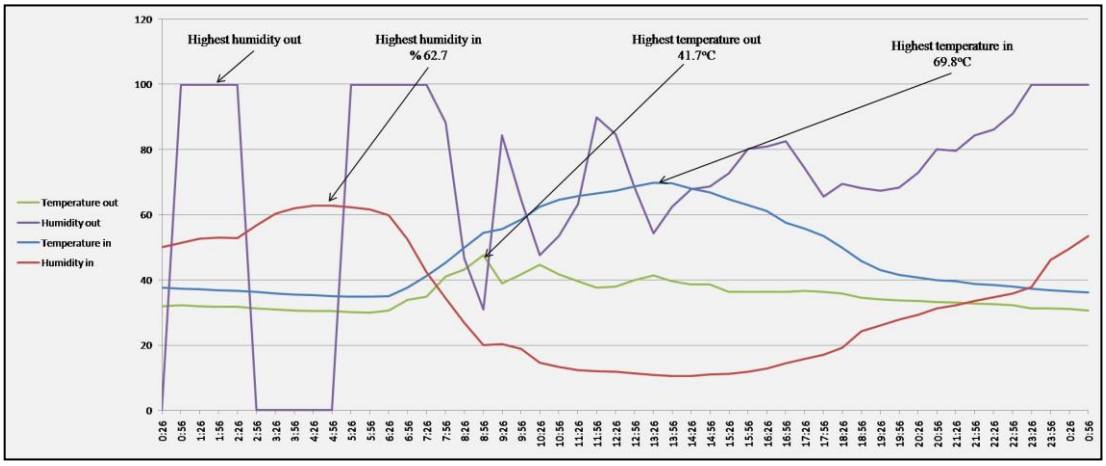


Fig. 2. Changes in temperature and humidity in and out of the PDH

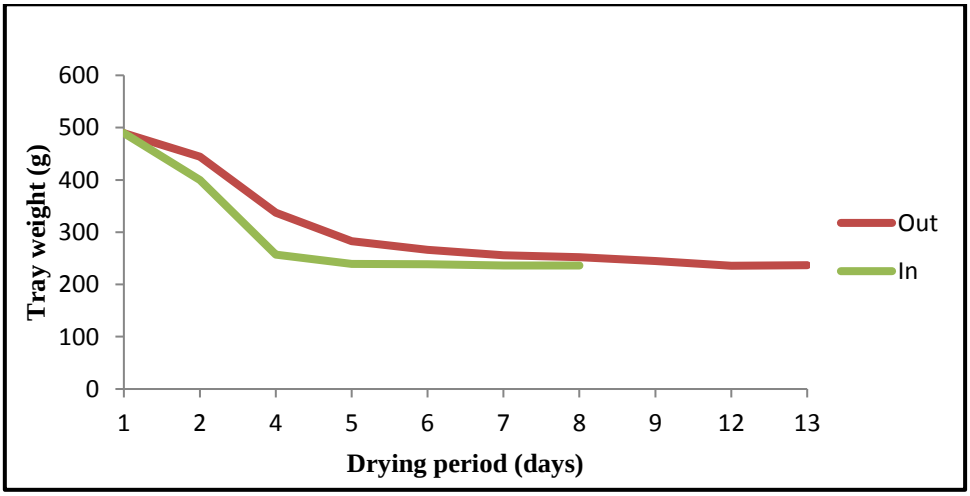


Fig. 3. Changes in Khasab dates weight maturity

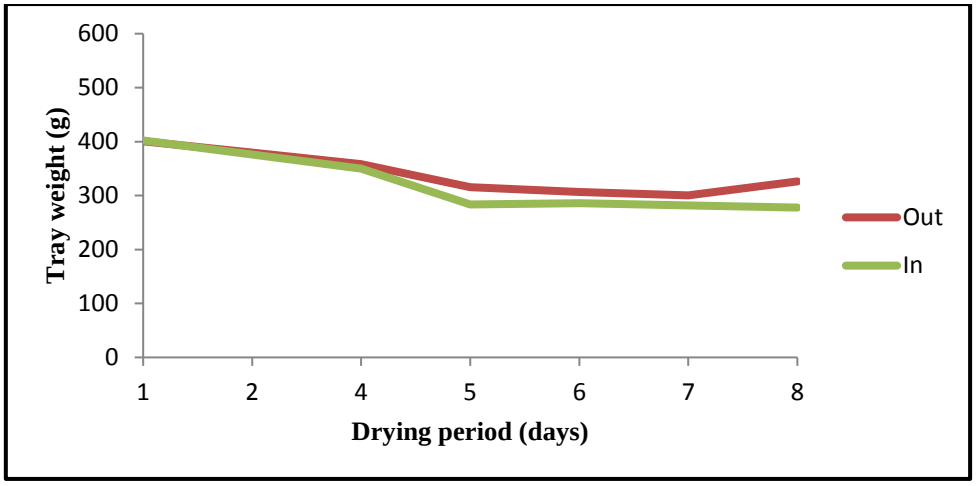
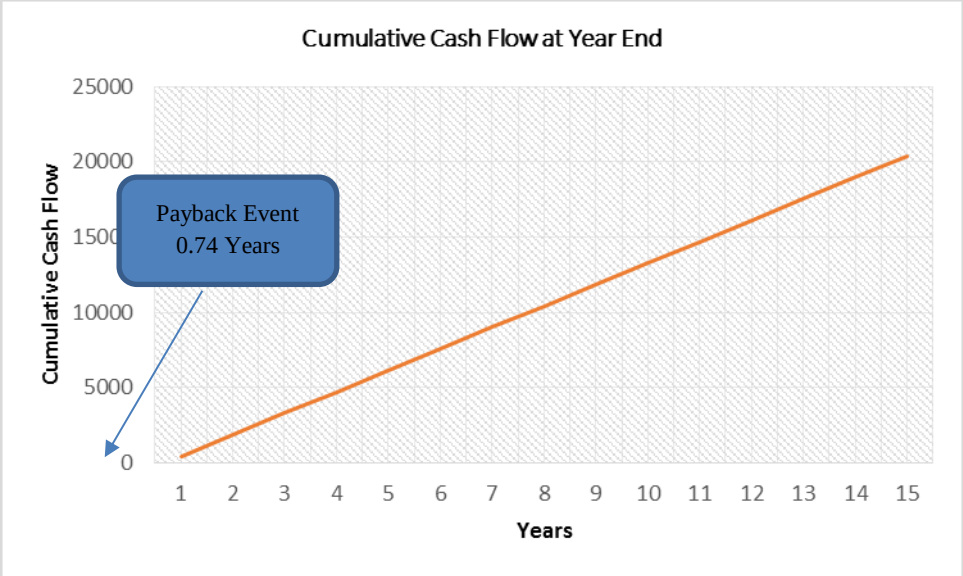
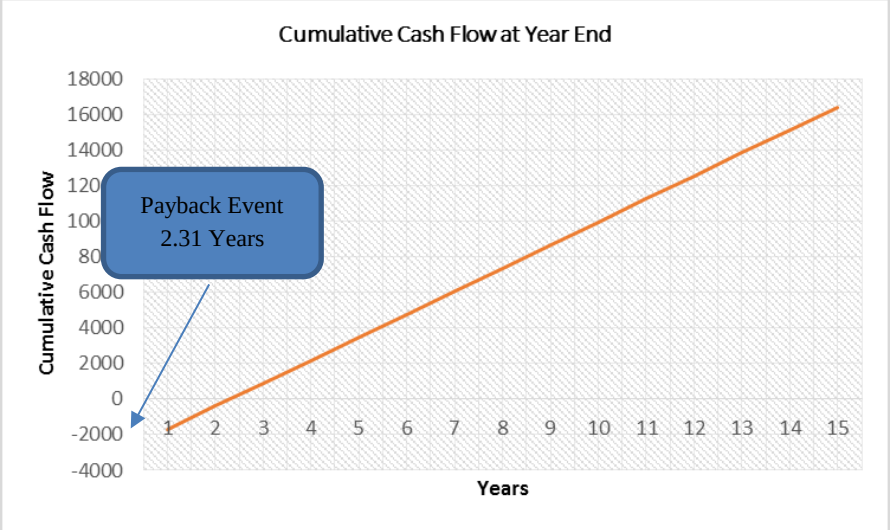


Fig. 4. Changes in C6 seedling dates weight maturity



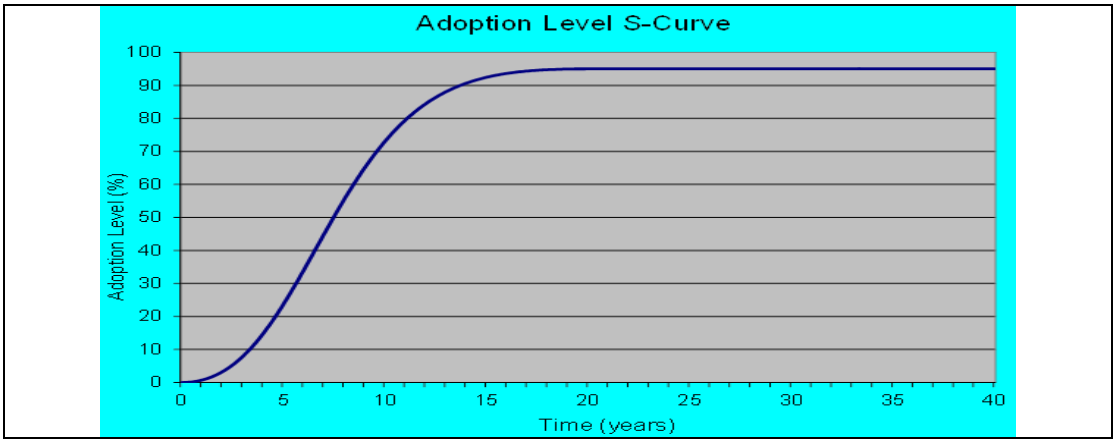
Source: Dhehibi et al. (2016)

Fig. 5. Cumulative cash flow at year end (PBP) when the PDH is subsidized



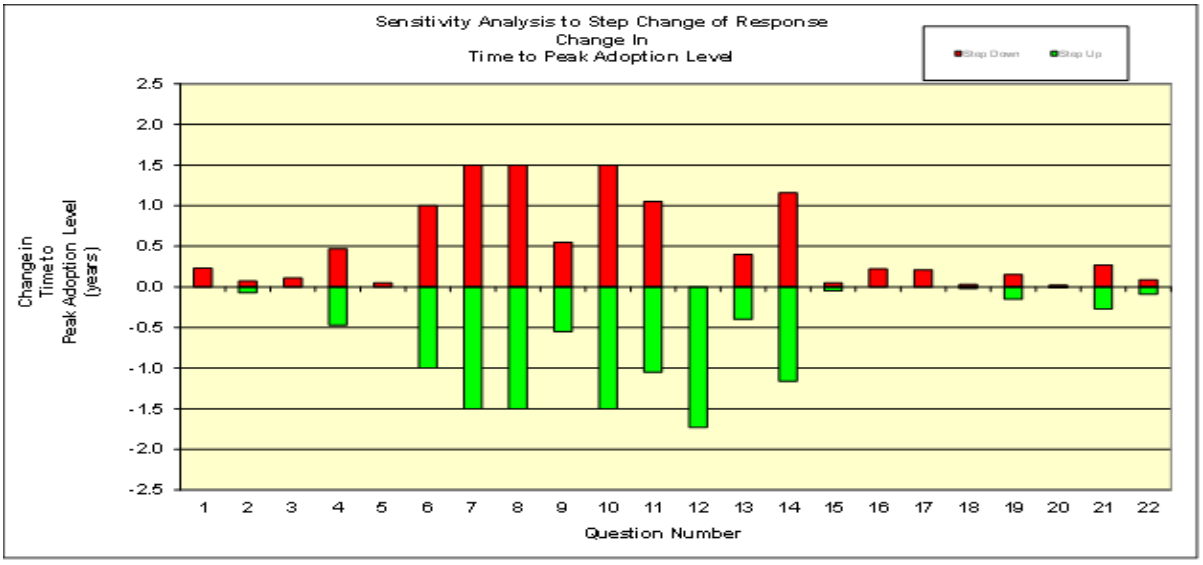
Source: Dhehibi et al. (2016)

Fig. 6. Cumulative cash flow at year end (PBP) when the PDH is not subsidized



Source: Dhehibi et al. (2017)

Fig. 7. Predicted Adoption Curve of PDH Dryer Technology at the "South Al Batinah" Governorate - Sultanate of Oman



Source: Dhehibi et al. (2017)

Fig. 8. Sensitivity Analysis of Adoption Curve of PDH Dryer Technology at the "South Al Batinah" Governorate - Sultanate of Oman