Feasibility and Technical Study for Establishing Recycling Date Palm by Product Unit (date palm waste) to Produce Organic Fertilizers (compost) in the GCC Countries

Developing Sustainable Production Systems for Date Palm in the Gulf Cooperation Council countries

Boubaker Dhehibi[(1)]; Arash Nejatian[(2)]; Muhi El Dine Hilali[(3)]; Azaiez Ouled Belgacem[(4)],Abdel Aziz Niane[(5)], and Abdulbasit Oudah Ibrahim[(6)]

1. Resilient Agricultural Livelihood Systems Program (RALSP) & Arabian Peninsula Regional Program (APRP) -International Center for Agricultural Research in the Dry Areas (ICARDA), Tunis - Tunisia. Email: b.dhehibi@cgia.org.
2. Arabian Peninsula Regional Program, - International Center for Agricultural Research in the Dry Areas (ICARDA), Dubai UAE. Email: a.nejatian@cgiar.org.
3. Resilient Agricultural Livelihood Systems Program (RALSP) - International Center for Agricultural Research in the Dry Areas (ICARDA), Amman – Jordan. Email: m.hilali@cgiar.org.
4. Sustainable Rangeland Management - Food & Agriculture Organization of the United Nation (FAO) – Riyadh – Saudi Arabia. Email: azaiez.ouledBelgacem@fao.org.
5. Arabian Peninsula Regional Program, - International Center for Agricultural Research in the Dry Areas (ICARDA), Dubai UAE. Email: Email: a.niane@cgiar.org.
6. Arabian Peninsula Regional Program, - International Center for Agricultural Research in the Dry Areas (ICARDA), Muscat, Oman. Email: Email: a.oudah-Ibrahim@cgiar.org.

December 2020

1 Introduction

1.1 Background of the study

Date palm production is a strategic sector in most of the Arab countries, particularly the GCC ones. The sector is one of the oldest economic activity in the Arabian Peninsula and continues to play a crucial role in the welfare, culture, history environment, and nutrition of its population. Currently, the Arab Region is the world leader of date cultivation with almost 75% of the global area under a date palm, around 77% of world production and approximately 69% of total world export of dates (FAOSTAT). In addition to the importance of dates for domestic consumption, this sector is also a source of employment, income generation, and essential trade activity in many of these countries. In some very arid areas, date fruits remain as an important source of subsistence and resilience for local population, given its adaptability to harsh environment and tolerance to high temperature, salinity, drought and other severe arid conditions.

As outlined above, in arid regions, the palm tree dates constitutes the pivot of the agriculture, offers a large agricultural by-product and date palm residues that could be used for many purposes (feeding of livestock, composting, etc.). The estimation of the tonnage of date palm grove waste in the GCC countries vary between 7734.4 tons in Qatar to 121974.4 in the UAE (FAOSTAT). Thus, in this report we provide a feasibility study on how the waste agricultural residues available in palm groves could be recycled and capitalized as organic fertilizer used in the GCC oasis farming system.

Having said that, the present study is prepared within the framework of the **Developing sustainable production systems for date palm in the Gulf Cooperation Council countries** project. This research and development project aim at producing 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 to the partners and promote exchange of experience between them is an integral part of the project.

1.2 Rational and justification

The objective of the feasibility study is to assess the technical feasibility, environmental and socio-economic benefits of utilization of waste agricultural residues available in palm groves and their recycling in the oasis farming system. It is a question of collecting all the vegetable (palm and other vegetables residues in the oasis orchards or groves) matter from the oasis environment and transforming it into compost which could be used as organic fertilizer input in the date palm farming system. This will help enrich the sandy soils with organic matter to enhance its water holding capacity in the root zone. Two basic arguments militate in favor of the implementation and investment of such a project: First, previous studies at ICARDA revealed the lack of manure in the date palm farming systems and oasis, which is the consequence of the very limited number of livestock and the extensive breeding system applied in these systems (Mazid et al. 2013). Second, the low level of know-how from date palm farmers on how to capitalize the use of these “free resources”, for which the accumulation is generating harmful effects such us proliferation of insects and parasites, causing infection to date palm trees decline in the quality of dates.

The objective of the project is to upgrade the date palm grove waste and their recycling and transformation in a well-studied system in order to transform them into organic fertilizer for improving soil quality, enrich organic matter in the sandy soils and reduce the use of high cost and environmentally damaging chemical fertilizers. As part of the project, it involves: (i) collecting dry palms, stipes, wasted dates, and other plant products, (ii) converting this waste into organic fertilizer through grinding and composting.

2 Principals of vegetal by-products valorization by composting: Technical Characteristics

2.1 Definition of Organic Matters

Mustin (1987) designate the biomass as "The total biomass of the organisms living on earth (plant and animal wastes) and which chemical energy comes from a very small amount of solar energy absorption''. Biomass is then defined as the energy source, available at all in nature.

2.2 Composting Process

Composting is a method of natural degradation of organic matters. It allows obtaining an organic amendment, named Compost. Mustin (1987) defines composting as "the biological process ensuring the decomposition of the organic components of the by-products and waste into organic product''.

Composting involves various microorganisms in an aerobic process. This process takes place in the presence of oxygen, essential to respiration of decomposers-organisms: bacteria, fungi, algae, protozoae, small invertebrates etc. These are primarily bacteria that operate best decomposition of fermentable organic matter by aerobic means and at neutral PH. During the process, a part of the organic matter is breathed by microorganisms that release of the carbon dioxide and water. Nitrogenous substances are recomposed into various molecules including precursors of humus acids. The first phases of composting concern simple hydrocarbon molecules, in very exothermic processes of respiration. All will be an important warm-up for bacteria that will survive are thermophile and some high mesophylls.

Complex molecules are degraded in a second time by other low mesophyll bacteria, or even by psychrophilic bacteria. The entire process is done in 2-3 months to get compost at the beginning of stabilization (Mustin, 1987).

2.3 Composting Methods

2.3.1 Composting in trench

This is the simplest mode consisting of infield deposits of organic waste either households or vegetation. It often incorporates manure to begin the process of degradation of organic matters and is watering to maintain a humidity of organic matter in transformation. The trench is usually covered with sand to keep the Interior moisture and avoid odors. The problem with this type of composting is no possibility of returning and airing composted wastes. Its advantage is to be able to mix lots of green wastes and even dry by-products if they are not woody.

2.3.2 Composting in stack

In stack composting is a long process. Composting of the waste lasts from 6 months to a year. It is common to mix shredded plants to manure (2/3, 1/3 or 3/4, 1/4) to balance the compost and help its decomposition. This is the system used in the open composting stations. The stack can be variable-length adapted to the available area. The advantage of this mode is that you can easily stir the compost to aerate it and easily control the temperature of the compost.

2.3.3 Composter composting

Composter is a widely used mode in Europe. The composter is a cylinder placed in a bathing area. This system accelerates the composting process and avoids the nuisance caused to animals. Its boundaries are the need for mixing of waste; however, it can see a less easy mixing and volume constraint.

2.3.4 Basic rules of composting

The first composting rule is to mix different organic wastes. As known that decomposition of organic waste can be done in the presence of water, the 2nd rule of composting is to maintain the organic product to compost sufficiently moist. The 3rd and last rule is to return and regularly aerate compost (ideally every 15 days) in order to work properly, micro-organisms which require oxygen and therefore air. It’s also possible to help ventilation by integrating fibrous elements (cut branches of approximately 5 cm in length).

2.4 Characteristics of compost

2.4.1 Definition of compost

Compost is the product resulting from the processing of mainly organic waste which is rich in stable organic matter (humus). Compost is a soil enriched with fulvic and humic acids (Mustin, 1987).

2.4.2 Organic composition of compost

The C/N ratio or carbon report on nitrogen is an indicator that allows judging the degree of evolution of organic matter, i.e. its ability to quickly break down in the soil.

The microorganisms in the soil (micro fauna) have an average C/N ratio of 8. They consume two-thirds of carbon for energy (converted to carbon dioxide) and a third for their constitution. Nitrogen is to him (them?) almost only used for the constitution.

The nutritional balance of microorganisms is therefore located at C/N ratio of 24. Below this ratio, nitrogen is in excess and therefore will be released, the availability of plants. Above, the nitrogen will be collected in the soil solution to meet the needs of microorganisms.

It is commonly accepted that the ratio C/N of a product is high, more it slowly decomposes in the soil, but most got humus is stable. This indicator is frequently used in practice to clarify the use of an unknown organic product. To make composting under optimal conditions, the C/N ratio should be between 15 and 30. Indeed, if the mixture to compost is too low in nitrogen, it will not (no degradation) heat. If the proportion of nitrogen is too high, the compost can overheat and kill microorganisms in the compost. The C/N ratio is very high for the material plant cool (50 to 150 for straw) and decreases throughout its decomposition by stabilizing around 10 per humus.

The effect of the incorporation of residues on the dynamics of nitrogen in the soil can be described by three parameters: the assimilation efficiency (proportion of carbon decomposed by microorganisms which is assimilated), the ratio of residues and microbial biomass C/N ratio. Used alone, this criterion of quality has its limits: two products with the same C/N can have different actions on the evolution of the content of soil microorganisms. The C:N ratio must therefore be regarded as an indicator of quality to be supplemented by other information (Mustin, 1987).

2.4.3 Mineral composition of compost

Nitrogen: A portion of the organic nitrogen (proteins, nucleic acids, urea) turns into mineral nitrogen (NO_3^-, NH_4^+, NH_3) under the action of bacteria and other specific microorganisms that possess an effective biochemical degradation process. The other part of the organic nitrogen forms complexes with derivatives of lignin or humus. These complexes are stable structures that slow down the degradation of organic nitrogen. There is conservation of a portion of the nitrogen in organic form that limits losses by nitrogen leaching during storage and spreading. There is very little loss of nitrogen, and when this is the case it is especially form gaseous (NH_2 and NH_4^+). Thus, when compost is brought down, nitrogen is, the first year especially in organic form while it mineralizes more subsequent years. The fertilizing value of nitrogen is therefore, generally low but should not be overlooked in the event of significant contribution.

Phosphorus: After degradation of single elements, phosphoric acid is released. Its rate then decreases but very little. However, composts have a generally rather interesting content of phosphorus.

Potassium: Potassium is a highly soluble in water. Unless it is highly leached, it diminishes very little also. Thus, found in sizeable concentration in compost manure.

2.5 Control of compost

Compost is more interesting to use it is well stabilized. Indeed, the presence of materials yet which may be fermented opposes the germination of the seeds. Composts produced on areas of urban waste composting are often sold. Therefore, these products require monitoring of their quality on the one hand and their composition on the other hand.

The fact that these composts can contain toxic materials, heavy metals and various other contaminants (pesticides, etc.) prompted legislation involving their analysis. The French Standards (NF U 44-051, NF U 44-095) require the composts to meet certain standards before being put on the market.

3 Project design and component

3.1 Promoters - Investors

The promoters could be pilot farmers, associations, cooperatives or producer groups in the GCC countries.

3.2 Types of date palm groves

The project could be implemented in any date palm production farming system. Therefore, with the purpose of efficiency and profitability, the project is aiming to cover an area of around 500 ha. It would therefore be necessary to set up the project in an area with a high concentration of date palm producers or in a location neighboring an important date palm production area.

3.3 Period of operation

The project is designed to operate throughout the full year. Therefore, since the transformation of the raw material into compost takes, from technical point of view, approximately 3 to 4 months, it is expected to have three (3) production cycles per year.

3.4 Capacity of production

Based on findings from similar studies, in this project, we are suggesting producing 1,500 tonnes of compost per year, at an average of 500 tonnes per cycle (i.e. 4 months). The capacity for collecting waste and grinding it is expected to be 5 tonnes per day.

3.5 Description of final product

The final product consists of compost which will be used as organic fertilizer in date palm farming system. From technical point of view, this production input has an advantage over manure given its more durable action in the soil. This is a very important factor when it comes to soils subject to intense leaching, which is the case in the date palm oases. In addition, the compost product is very rich in comparison to manure in organic matter and mineral elements. Moreover, in the case of establishment of an enterprise or a business unit a JIFFY like pots and pellet processing can be considered in the future for plant seeding.

3.6 Description of the production process

Composting is a way to reduce farm waste and in the same way to enhance sand and soil structure and properties for the benefit of plants. The process is based on the decomposition of plant residues in an aerated environment. All compostable materials are either carbon or nitrogen-based, to varying degrees. The secret to a healthy compost pile is to maintain a working balance between these two elements. Therefore, considering green material that is rich in nitrogen is important. Composting needs water that is important for compost development. break down the organic matter. Plant material should be down sized to at least 7-10 cm. The pile will compost in 4 to 6 months, till it become a dark and crumbly material.

3.6.1 Collection

The baseline information considered in this study is as follows:

- It is expected that a date palm tree produces around 20 kg of waste (dry weight), which, on average, 3 tonnes per hectare (i.e. we considered 150 date palm trees planted per hectare).
- The capacity of one worker is to collect date palm grove waste is around 700 kg per day. Under this hypothesis, a worker needs approximately 2,143 working days to cover the 500 hectares targeted (covered) by the project.
- The date palm farmer is benefiting from this cleaning operation of his farm. Thus, it is considered that farmer provide this input for free.

- The collected waste is transported to the transformation (composting) unit by a 50 HP tractor with trailer to the composting site. The calculated overall distance is around 9,000 km, while the total traction time is 2,250 hours.

3.6.2 Grinding (Crushing)

The grinding operation is taking place at the composting site. The project suggests the use of a crusher- a knife grinder (40 mm) with a power of 20 HP, mobile, with a capacity of 600 to 700 kg / Hour. 720 working days are planned for the grinding, the homogenization of the crushed product and its transfer to the next operation which is the windrow formation.

3.6.3 Adding treated biosolid sludge

The project estimate that 100 tonnes of treated biosolid sludge to the crushed material in order to initiate and promote the composting process. This treated biosolid sludge comes from the treatment plants of the neighboring localities and their transport to the site, expressed in hours of traction, is estimated at 300 Hours.

3.6.4 Windrow formation process

The windrow forming a natural slope will be packed at the top and it is expected to be approximately at one-meter high. The final shape of the windrows (swaths) will depend on the configuration of the available land. The expected volume per day is around 10 m^3.

3.6.5 Monitoring of composting operation process

From technical point of view, the monitoring process of composting is based on the control of three key factors: humidity, oxygenation, and temperature. The selection of the composting site inside the oasis farm is crucial as it can contribute to reduce the risk of drying out by the sun. Regular watering and turning (moving the compost product) are recommended with the aim to compensate the evaporation and enhance oxygenation. An annual volume of water consumption is estimated at 6,000 m^3 and the number of working days for turnarounds at 375 days.

3.7 Description of the equipment

For this type of project, the site must include:

- A space for windrow (swaths), a space for shredding and storage of chopped material;
- At least 100 m^2 covered with a height of 6 m (metal frame) for storage of final product;
- A 50 HP tractor with trailer;
- A grinder with a capacity of 5 tonnes per day and
- Various small equipment (i.e. lab equipment, etc.).

4 Economic analysis

4.1 Collect of raw materials

The supply of raw materials (Palm leaves, fibers and all dry wood) is summarized in its collection and transport.

4.2 Sale of compost (including marketing strategy, demand, distribution channels)

The estimated quantity to be sold is around 1,500 Tons. It is considered that losses are compensated by the supply of treated biosolid sludge and water. The market price of the final product is estimated at 100 $ per tonne, while the price of bad quality manure is round 150 $ per tonne.

The points of sale are:

- Outlets in the region (other vendors of agricultural input providers);
- In local Markets (inputs and outputs local markets);
- Deliver directly to large date palm framers in the country;
- Deliver directly to the large date palm farmers in the neighboring countries (i.e. KSA).

Marketing strategy:

- Free of cost distribution of the compost product (of a limited quantity) to the large date palm farmers at the start to make known and appreciate the new product in the region;
- Prepare and distribute the technical information and guideline sheets about the characteristics of this organic fertilizer and its use;
- Advertising using local medias, information and communication technologies (ICT), etc.
- Organize information (filed) days to raise awareness campaigns in the farmer's communities.

4.3 Profitability of the project

4.3.1 Operating costs

This item includes staff costs, inputs and overhead (for one year).

Operation Costs (US $)			
Personnel Costs			
Collection of primary material	2,143 days × 15 $	32,145 $	
Sorting shredding swath formation	720 days × 15 $	10,800 $	
Mixing and watering of windrow	375 days × 15 $	5,625 $	
Tractor driver	1 × 13,770 $	13,770 $	
Consultation costs	1 × 5,000 $	5,000 $	
Total personnel costs			**67,340 $**
Other costs			
Fuel	5 l × 2,600 Hrs × 0.54 $	7,020 $	
Maintenance of Equipment (machines, etc.)	Flat rate	12,000 $	
Water	6,000 m^3 × 1.08 $	6,480 $	
Management costs (stationery, etc.)	Flat rate	3,000 $	
Marketing and communication (flyer)	Flat rate	3,000 $	
Total other costs			**31,500 $**
Total Operational Costs			**98,840 $**

4.3.2 Working capital funds

The working capital fund is estimated at 30% of the total staff and general expenses or: $ 29,652.

4.3.3 Investments

In addition to working capital, some investments like acquisition of means of transport and equipment, and approach costs might be necessary.

Investment Costs (US $)			
	Civil engineering costs		
Land 1000 m2	Own property (date palm farmer)		
Construction 200 m^2	Flat rate	30,000 $	
Total Civil Engineering Costs			**30,000 $**
Means of transport costs			
Tractor 40 HP	31 590 $		
Trailer 2 tons	2 484 $		
Total Means of Transportation			**34,074 $**
Equipment			
Machine (Grinder)	1 × 3024 $	3,024 $	
6000 liter water tank	1 × 4000 $	4,000 $	
Small material	Flat rate	2,000 $	
Total Equipment Costs			**9,024 $**
Total Investment Costs			**73,098 $**

4.3.4 Depreciation table

Designation	Amount	Depreciation rate	Depreciation value
Civil Engineering	30 000 $	5 %	1,500 $
Transportation material	34 074 $	20 %	6,815 $
Equipment	9 024 $	10 %	903 $
Total Depreciation Costs			**9,218 $**

4.3.5 Funding

This is the total investment including working capital.

Designation	Amount
Own funds	40,000 $
Short term loaning	29,652 $
Medium term Loaning	33,098 $
Loong term loaning	0 $
Total Funding	**102,750 $**

4.3.6 Project profitability

4.3.6.1 Economic Profitability Analysis

Costs		
Collection and operational costs	98,840 $	
Financial operating costs	4,393 $	
Depreciation and amortization	9,218 $	
Total Costs		**112,451 $**
Revenue		
Compost: 1500 T × 100 $		150,000 $
Total Revenues		**150,000 $**

The study of the gross margin allows the monitoring of the profitability of the project and therefore of its performance. It is a benchmark indicator. The greater the margin, the more profitable is the project. The calculated margin for this project is around 25% of the turnover. It is practically impossible to reduce the operational costs. However, the difference between the current price of poor-quality manure (150 $) and the price of compost (100 $) allow to consider an increase of 45% %, which permit the margin to be around 105,049 $.

5 Conclusion

Date palm by-products constitute the largest volume of research station agricultural waste. The implementation of date palm by-products composting can join tow benefits: reduce the environmental effect agricultural waste and improve the soil fertility.

The objective of this feasibility study is to upgrade the date palm grove waste and their recycling and transformation in a well-studied system in order to transform them into organic fertilizer for improving the soil quality, enrich the sand with organic matter and reduce the use of high costly and environmental damaging chemical fertilizers. As part of the project, it involves: (i) collecting dry palms, stipes, wasted dates, and other plant products, (ii) converting this waste by grinding and composting.

The economic and financial indicators reveal the profitability of implementing this kind of project in the GCC countries.

Acknowledgement

We would like to express our sincere gratitude and appreciation to the Gulf Cooperation Council (GCC) Secretariat for funding this research conducted in the framework of the “Developing Sustainable Production Systems for Date Palm in the Gulf Cooperation Council countries” project.

We are very grateful to the Ministries of Agriculture, Agricultural Authorities, and Agricultural Research Institutions and Universities in the GCC countries of the Arabian Peninsula for their continuous support and great collaboration in the implementation of the project activities.

Special thanks go to the project national and technical coordinators as well as their research teams in all six GCC countries for their dedication and hard works toward the success of the project “***Developing Sustainable Production Systems for Date Palm in the Gulf Cooperation Council countries***”.

6 Further reading

AFNOR (Association Française de Normalisation) 2004. French regulation of the organic waste’s agronomic valorization. Microbiological Test. Paris: French Association of standardization.

Atkinson G., Dubourg, W. R., Hamilton, K., Munasinghe, M., Pearce D. W. and C.E.F. Young 1997. *Measuring Sustainable Development:* Macroeconomics and the Environment. Conference Justice and Poverty: Examining Sen’s Capability Approach, 5-7 June 2001, Cambridge University.

Ben Salah M. 2012. Rapport d’expertise technique sur la biodiversité oasienne en Tunisie. RADDO & ASOC Gabès.

Bouhaouach H., M. Culo et K. Kouki, 2009. Compostage et valorisation des déchets oasiens pour l’amélioration du sol et de la productivité. Actes du Symposium international « Agriculture durable en région méditerranéenne » AGDUMED. Rabat. Maroc 14-16 Mai 2009. Partie 4- Cultures, itinéraires techniques et productivité : 235-240.

Farag Kassem A.M. and Lairje A.B. 2010. An economic study of palm dates trees residues and methods of using it in the Arab World. Faculty of Economics - Derna - Omar Al- Mukhtar University.

Kouki K. et H. Bouhaouach 2009. Etude de l’oasis traditionnelle Chenini Gabès dans le Sud Est de la Tunisie TROPICULTURA, 2009 (27-2) : 93-97

Mazid, A., Al Hashimy, M.J., Zwain, A., Haddad, N., Hadwan, H. 2013. Improved livelihoods of smallholder farmers in Iraq through integrated pest management and use of organic fertilizer. International Center for Agricultural Research in the Dry Areas – ICARDA . Working paper, p 66.

Mustin M. 1987. Le compost. Gestion de la matière organique. Ed. Francois Dubusc. France. 954 pages.

NF. Normes Françaises NF U 44-051 "amendements organiques" et norme NF U 44-095 " amendements organiques obtenus par compostage et contenant des matières issues du traitement des eaux, d'intérêt agronomique". www.valid-compost.com/valorisation/cadre-reglementaire/. Consultation : Aout 2011.

Sghairoun M., M.S. Belkhadi et A. Ferchichi. 2006. L’estimation quantitative des sous-produits de palmiers dattiers. *Revue des Régions Arides -Numéro spécial.* Actes du séminaire international : Aridoculture et cultures oasiennes : voies pour un développement durable en zones arides. pp: 422-424.

Westerman P.W. and J.R. Bicudo. 2005. Management considerations for organic waste use in agriculture. Bioresource Technology » 96 (2005): 215-221.