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STUDIES ON ADOPTION OF IRRIGATION METHODS BY THE DATE PALM FARMERS IN AL-QASSIM AREA – KINGDOM OF SAUDI ARABIA

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Abstract

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The Kingdom of Saudi Arabia is facing an acute scarcity of water resources. Present study was undertaken to identify the usage of different irrigation methods by date palm farmers in Al-Qassim area. Data were collected on the study sample of 429 farmers during face-to-face interviews by using a well-structured and pre-tested questionnaire. The data were subjected to statistical analysis by using percentages, means, standard deviation, and correlation. The findings of the study revealed that more than one third (38.3%) of the farmers were employing the flood irrigation tree/basin method with the highest usage mean 2.67; SD 1.28 whereas about 31.2% farmers put trickle/drip irrigation method into their practice with the second highest usage Mean 2.29; SD 1.28. Significant and positive correlations among the educational levels and the usage level of modern irrigation methods were realized. However, age and years of experience of the farmers were negatively correlated with the usage of modern irrigation methods. In addition, farm area was negatively correlated with the usage of traditional irrigation methods. In the light of the findings of the study, it seems logical to launch the extension education programs to enhance farmers' adoption rates of modern irrigation methods. The study further suggests investigating the barriers faced by farmers in the adoption of modern irrigation methods in order to conserve limited water resources.

Key words: water resources, water conservation, irrigation methods, date palm, extension education, capacity building

Introduction

The agriculture in the Kingdom of Saudi Arabia faces many challenges, typical for a semi-arid to hyper arid climate, that include scarce water resources, low annual rainfall, extremely high temperatures, and enormous evapo-transpiration. Farming consumes almost 88% of the total water extracted from all the sources. Applications of traditional irrigation methods such as flood irrigation are not only putting further stress on the already dwindling water resources but they also happen to be wasteful (FAO, 2009; Darfaoui and Al-Assiri, 2010).

Dates are considered one of the most important fruits in the Kingdom of Saudi Arabia and rank on the top of production list of fruits. Some 24 million palm trees are producing one million tons of dates annually, more than 15 percent of the world's production (MOA, 2010). Date palm represents roughly 74% of the total cultivated area under fruits in the entire Kingdom whereas date palm trees in Al-Qassim zone cover about 24% of the total area of the Kingdom sustaining this crop (Kassem, 2007).

Date palm trees are usually irrigated by the flood irrigation system that uses an abundant amount of water; however, the farmers' decisions on the quantity of water to be applied are usually based on their experience on the farms (Al-Amoud, 2010). Karami (2006) believe that traditional irrigation methods are more compatible with the traditional production systems. However, such wasteful irrigations are neither appreciated nor recommended by both the water experts and extension professionals of the area. Flood irrigation is popular among the date palm growers for its advantages: running costs are low; easy to apply; and initial costs are low if the area is fairly flat. However, some farmers do not put it into their practice due to its demerits like: difficult to achieve

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a high efficiency rate; labour intensive; irrigates areas in between where no palms are planted; and not well suited for sandy soils (FAO, 2002; Liebenberg and A-Zaid, 2002).

Bubbler irrigation method is known as one of the modern irrigation methods (Khan and Prathapar, 2012). In this system, water is applied through bubblers and there are small emitters placed in the basins which discharge water at the flow rates of 60–240 l/h (Nakayama and Bucks, 1986). The bubbler irrigation method has been proved a better one by producing higher vegetative growth as it also improved the minerals uptake in a study conducted by Amiri et al. (2007). Similarly, trickle/drip irrigation system is also known as a better system, capable of reducing cost of labor and improving the water-use-efficiency. The system minimizes the water losses by causing low evaporation and preventing deep percolation. In addition to its potential for increasing water use efficiency, drip irrigation technology can also provide opportunities to cultivate low quality lands, sandy and rocky soils (AOAD, 1998).

Several experiments conducted by Ahmed et al. (2011) and Al-Amoud et al. (2012) revealed that subsurface drip irrigation method holds the great potential and can play the significant role in overcoming the water shortage particularly in arid regions. They further reported that there is a need to maintain a balance between water resources and agriculture production by keeping in view the water requirement for date palm and water scarcity in the region. However, this balance can be maintained by implementing suitable irrigation technologies and lowering the stress on the current depleting groundwater resources by adopting measures to optimize water consumption without reducing agricultural production (KACST, 2012). Fruit orchards in the Kingdom are most often irrigated through traditional methods such as flood irrigation resulting in huge wastage of water with low water use efficiency. FWR (2005) have identified the factors affecting the efficiency and maintenance for sun-surface drip irrigation method. Whereas FAO (2009) maintains that water, use efficiency can be possibly increased by adopting efficient localized farm irrigation methods such as drip/trickle irrigation. Under the water scarce situations, the use of water for agricultural production requires innovation, research and transfer of technologies (Pereira et al., 2002).

Other researchers (Atta et al., 2011; Al-Zahrani et al., 2011) have expressed similar views. They are of the opinion that the appropriate agricultural technologies can help improve agricultural production in both quality and volume, and limit the depletion of the water resources. Recently with the guidance and assistance of the researchers, farmers have started using drip irrigation to irrigate their date palm trees in the Kingdom of Saudi Arabia that consequently helped in reducing water consumption (FAO, 2009; MOA 2010).

Realizing the importance of water and its depleting situation, the Ministry of Economic and Planning (MEP) (2010) stressed to bridge the gap between the groundwater extraction and their natural replenishment rates. The current Saudi agricultural development policy aims at conserving water and focuses on enhancing farmers' adoption of modern and efficient irrigation methods to conserve water and make agriculture sustainable. The Kingdom of Saudi Arabia has launched a program that focuses on exploring new sources of water, efficient utilization of irrigation systems, and employing of modern irrigation methods to save water that could lessen the stress on groundwater resources (MEP, 2010; Atta et al., 2011; KACST, 2012; JRCC, 2012). The current Saudi Agricultural Policy (SAP) is supporting adopting modern irrigation methods. The Saudi Agricultural Fund (SAF) is assisting the farmers on the installation of modern irrigation systems by sharing about 70% of the total cost. In addition, the Saudi government buys dates from farmers with higher prices (5SR/Kg) if they were raised by employing the modern irrigation methods.

Extension education systems aim at bringing about positive behavioral changes among the targeted farming communities. Generally, extension professionals help farmers enhancing their knowledge, upgrading their technical skills to help them running their farms efficiently by employing improved practices in order to elevate their livelihoods (Qamar, 2005). Agricultural extension is also known to be responsible for transferring superior, economical, effective, and efficient technologies as compared to traditional ones to the potential users. Such technologies, including irrigation systems, reduce the costs of production; protect the environment and conserve the natural resources (FAO, 2005), in turn resulting sustainable rural communities.

Looking at the importance of date palm cultivation, limited water ground supplies, stressed water resources, availability of efficient modern irrigation methods, and the productive potential role of extension education, it seems imperative to provide information on the irrigation methods used by farmers and identify relationships between some of the socioeconomic characteristics of farmers and irrigation practices. Present study is an endeavor aiming at enhancing farmers' adoption rates of the modern irrigation methods.

Research objectives

This research aims to study the irrigation systems used by date palm farmers in Al-Qassim area, Saudi Arabia with the following objectives:

- To understand the extent and types of different irrigation methods used to irrigate date palm in Al-Qassim area.

- To study the socio-economic characteristics of the farmers.
- To determine the relationships between some of the socio-economic characteristics of the farmers and the irrigation systems employed by them.

Research Methodology

Study area and sample population

With a population of 1,016,756 and an area of 65,000 km², the Qassim province is located approximately 300 km away from the Capital Riyadh. Al Qassim is well known for its dates, having more than 2.5 million date palm trees and sustains about 50 of the Kingdom's 65 date species. The study population consists of all the date palm farmers of Al-Qassim area i.e., 13,030 farmers (Al-Subaiee et al., 2011). For the study purposes, the General Department of Agriculture Affairs, Al-Qassim area provided the list of all date palm farmers of the area. A simple random sample of 429 farmers (3.3%) was drawn out of the entire population by using Random Number Generator Program (Star Trek, 2009).

Data collection and analysis

Data were collected by using a well-structured questionnaire, reviewed by a group of faculty members at the Department of Agricultural Extension and Rural Society and Department of Agricultural Engineering. In addition, a group of 30 farmers, who were not study participants, was used to test the reliability of the questionnaire and degree of reliability was high (Cronbach's Alpha = 0.811). Data were collected by using the questionnaire in face-to-face personal interviews during the period from April to June, 2010.

The data were analyzed by using percentages, arithmetic means and standard deviation. Spearman Correlation Coefficient was used to find correlation between socio-economic characteristics of farmers and their usage of irrigation methods. Farmers' characteristics were taken as independent variables and their usage of traditional and modern irrigation methods were treated as dependent variables. The data were analyzed by using Statistical package for the Social Sciences (SPSS, 2009).

Results and Discussion

Socio-economic characteristics of date palm farmers in Al-Qassim area

The age of the respondents ranged from 30->70 years. More than two-thirds of the respondents (78.8%) were 50 years older or more (Table 1). Only 19.8% inhabitants of the

Table 1
Socioeconomic characteristics of Date palm farmers in Al-Qassim area (n = 439)

Age	
Age groups	%
Less than 30 years	0.9
31 – 40 years	7.3
41 – 50 years	13.0
51 – 60 years	27.1
61 – 70 years	26.4
71 years and above	25.3
Education	
Education level	%
Literate	19.8
Read and write	23.5
Primary school	8.7
Intermediate	9.3
High school	17.5
Graduate (University)	17.3
Post graduate	2.5
Missing	1.4

Family size	
Number of family members	%
1 – 5 members	14.6
6 – 10 members	64.0
11 members and above	21.4
Farm area	
Area (No. of donums)	%
1 – 10	14.6
11 – 25	12.3
26 – 50	16.6
51 – 75	7.1
76 – 100	19.1
More than 100	30.3
Agricultural work experience	
Years of experience	%
1 – 5 years	2.7
6 – 10 years	7.3
11 – 15 year	11.0
16 – 20 year	15.4
21 – 25 year	19.4
26 year above	44.2

Note: 1 dunum, = 0.1 hectare

study area had received their university education and earned bachelor or postgraduate degrees. Approximately one-fourth (26.8%) respondents received high school and intermediate education. The survey on the educational levels of the respondents indicates that 23.5 % of them can read and write and 19.8 as literates (Table 1). The results of the study reveal that the factors like: age and the educational levels of farmers could affect their usage of modern technologies.

As regards the family size, about 64.0 % respondents have 6 to 10 family members. Whereas about 21.4% of the respondents had big families with 11 or more members and only 14.6% of the respondents were having families with less than 6 members.

About 43.5% of respondents were owners of land area ranged from 1-50 donums (1 donum = 1000 m^2). The land area owned by 26.2% respondents ranged from 51- 100 donums. Little less than one third (30.3%) respondents owned the big land areas more than 100 donums. Simply more than half of the respondents (56.5%) owned lands more than 50 donums.

The study indicated that only a small segment of population of the farmers (2.7%) is new in the farming business (1-5 years) whereas over whelming majority (63.6%) of the respondents have been practicing agriculture for more than 20 years. Only 7.3% farmers were involved with agriculture sector for a period ranged from 6-10 years. Some 90.0% of respondents were associated with the farming profession and practicing agriculture for a period of more than 10 years.

Respondents using irrigation systems for date palms in Al-Qassim area

Flood irrigation (tree/basin)

The study results (Table 2) indicated that only 48.3% of the respondent farmers with the highest mean 2.67; SD 1.28 (Ranging from low to moderate use on the four degrees of usage level scale) employed flood irrigation tree/basin method. Date palm trees are usually irrigated by the flood irrigation system that uses an abundant amount of water; however, the farmers' decisions on the quantity of water to be applied are usually based on their practical experience on the farms (Al-Amoud, 2010). Karami (2006) believes that traditional irrigation methods are more compatible with the traditional production systems. However, such wasteful irrigations are neither appreciated nor recommended by both the water experts and extension professionals of the area. In the situation, the best viable option could be educating the farmers to adopt the efficient irrigation methods to conserve water and enhance the implementation of Saudi Water Policy towards sustainable agriculture. Many researchers such as Al-Zoubi (1997), Al-Subaiee (2006a), Al-Subaiee (2006b), EI-Hag (2008), Al-Zahrani and Baig (2011), Al-Zahrani et al. (2012) and MOA (2012), Al-Subaiee et al. (2011) have highlighted the significant potential role of agricultural extension in educating the farmers on the rational and judicious use of natural resources like water. The current Saudi agricultural policy provides all the possible support to famers for adopting modern irrigation methods. The Saudi Agricultural Fund provides substantial subsidies to the famers by sharing the cost of modern irrigation systems. In addition, the Saudi Government buys dates from farmers with higher rates if raised by employing modern irrigation methods. However, the adoption rates for modern irrigation methods as this study demonstrates are not still high. Therefore, it seems imperative to conduct a study to identify the barriers faced by the farmers in the adoption modern irrigation methods.

Trickle/Drip irrigation method

The study revealed that some 41.0 % farmers put trickle/drip irrigation method into their practice with the

Table 2
Percentages and averages irrigation systems used by date palms farmers in Al-Qassim area (n = 439)

Irrigation system	Do not use, %	Low use, %	Moderate use, %	High use, %	Did not respond, %	Mean	SD
Flood irrigation (tree/basin)	20.0	10.0	10.3	28.0	31.7	2.68	1.28
Trickle/Drip irrigation	30.8	9.8	10.7	20.5	28.2	2.29	1.28
Valves controlled irrigation	26.4	8.9	6.8	14.4	43.5	2.16	1.26
Flood irrigation (trees/basin)	37.6	6.8	7.1	13.0	35.5	1.93	1.22
Bubbler irrigation	42.1	2.1	2.5	0.5	52.8	1.18	0.56
Subsurface irrigation	43.3	1.6	1.4	0.7	53.1	1.14	0.51

Scale: 1 = No use; 2 = Low use; 3 = Moderate use; 4 = High use.

second highest Mean 2.29; SD 1.28 (Ranging from low to moderate use on the four degrees of usage level scale) as depicted in Table 2. Despite its higher efficiency, the adoption rates of trickle/drip irrigation methods by the farmers in the study area are still low in order to sustain and conserve water resources. Therefore, the findings of the study establish the need for the launching of efficient extension education programs to enable the farmers to increase their knowledge and skills on using trickle/drip irrigation methods and their efficient operating techniques.

Drip irrigation systems have been able to reduce water losses and enhance agricultural productions in most parts of the Arab region. For example, due to its application in the Jordan Valley, about 60% additional area has been brought under cultivation, average yields of vegetables have been elevated and doubled fruit yields have been realized. In Syria, although drip irrigation methods have been employed on less than 1.0 % of the total irrigated area yet about 45% water losses have been minimized (Abou-Hadid, 2010). Studies conducted by Al-Amoud et al., (2012) proved drip irrigation system to be superior to the other irrigation systems (surface) as it reduced the annual water consumption by date palm to an appreciable level.

Valves controlled irrigation method

The valves controlled irrigation method is an enhanced irrigation method. In this system, pipes are used to transport the water to the trees whereas the valves control its flow and deliver the required volume of to the tree basin in the end. While achieving the third highest mean (2.16; SD 1.26), only 30.1% percent respondents were irrigating their date palm plantations whereas some 26.4 % did not adopt this irrigation method at all.

Trees/basin irrigation method (more than one tree in the basin)

The study revealed that some 26.9% respondents put trees/basin irrigation method into their practice with the usage Mean 1.93; SD 1.22 (Ranging from no use to low use on the four degrees of usage level scale) as depicted in Table 2. This irrigation method closely resembles with the tree/basin method. The only difference between the two is the presence of number of trees in the basin. Therefore, there is a need to create awareness among the farmers and it seems important to make the farmers educated enough to replace these irrigation methods (tree/basin, trees/basin) with the modern irrigation ones in order to conserve and manage water resources wisely and efficiently.

Bubbler irrigation method

The second lowest mean 1.18 SD 0.56 (Ranging from no use to low use on the four degrees of usage level scale) was the with bubbler irrigation method. Despite its numerous benefits, only 5.1 percent farmers adopted this highly beneficial irrigation method. More than half of the participating farmers of the survey did not express their opinions when were asked about its usage whereas a vast majority (42.1%) was not using it at all. The findings revealed that farmers in the study area almost did not use bubbler irrigation method. The results of this study reveal that perhaps growers are not fully aware of the potential benefits of bubbler irrigation methods. This sort of information deficit necessitates the needs for launching the extension education programs for the farmers to provide them with the necessary knowledge and skills to enhance their adoption rates for this particular irrigation method.

Subsurface irrigation system

Only 3.7 % respondent farmers mentioned using subsurface irrigation system, the lowest among all irrigation methods used in the study area. Subsurface irrigation system achieved the lowest mean 1.14 SD 0.51 (Ranging from no use to low use on the four degrees of usage level scale). Several experiments conducted by Ahmed et al. (2011; 2012) revealed that subsurface drip irrigation method holds the great potential and can play the significant role in overcoming the water shortage particularly in arid regions. The lowest farmers' usage level of subsurface irrigation system could be attributed because this system is relatively new to the framers and they do not have sufficient awareness and appropriate needed information on its use. This particular outcome of the study demonstrates the need for the extensive and vibrant extension education and capacity building programs for the farmers to upgrade their skills to enhance the adoption rates of the modern irrigation methods.

Correlations between Some Socio-Economic Characteristics of Date Palm Farmers and the Degree of Their Use of Irrigation Methods

The correlations between some socioeconomic characteristics of farmers and the degree of their use of the irrigation methods have been presented in Table 3. As revealed from the table, a negative and significant correlation between age and farmers' usage level of trickle/drip irrigation methods (R = - 0.117 at the 0.05 level) was found in the study. This result of the study also revealed that the majority of farmers in Al-Qassim area are old and therefore may not be in favor of the adoption of new technolo-

gies. Similarly, the study also resulted a positive and significant correlation between age and flood irrigation (tree/basin) method (R = 0.173 at the 0.01 level), indicating the greater adoption of flood irrigation method (an old primitive practice) by the older farmers whereas younger farmers are practicing it on smaller scale. Therefore, there is a need to educate the old farmers on the value and advantages of using modern irrigation methods in conserving water resources. In addition, extension needs to create awareness on the negative impacts of continues using of flood irrigation methods on the sustainability of farms and their production.

Many studies indicate that older farmers show greater resistance to change and usually try to stick to their traditional practices and are reluctant to adopt innovations despite their obvious benefits (FAO, 1997; Oakley and Garforth, 1997). In the situation, extension through its educational programs can modify the attitudes of change resistant farmers.

The study indicates the significant and positive correlations among the education levels and usage level of modern and enhanced irrigation methods. A significant correlation (R = 0.204 at the 0.01 level) between the educational levels and trickle/drip irrigation has been found. While realizing the correlation coefficient of (R = 0.261 at the 0.01 level), the educated farmers showed their usage of enhanced irrigation practice namely "Valves controlled irrigation method". Farmers that are more educated are assumed to have a higher capacity to accept change and modern irrigation methods (Karami, 2006). Other researchers have found that educational level of the rural community greatly influences the acceptance of extension advice and guidance (Anandajayasekeram et al., 2008; Baig and Aldosari, 2013).

A negative significant correlations (R = -0.249 at the 0.01 level; R = -0.126 at the 0.05 level), between the educational level and flood irrigation methods established the importance of education. These negative correlations revealed that farmers with better education could make smart choices and adopt better options. According to Tollefson and Wahab (2012), most of the traditional irrigation systems were located in areas where educational levels were low. Al-Shayaa (2011) found in Al-Medina area that about 67% farmers were well knowledgeable on the potential benefits of modern irrigation methods but for some reasons only 33% farmers were actually able to use them on their farms. A study conducted by Al-Zaidi et al. (2013) revealed that farmers with higher educational levels exercised a positive attitude towards the innovations. Findings of this study are also in agreement with the Akbar et al. (1990), Rogers (1995) and Khan et al. (2009). These researchers have also reported that farmers with high education adopted the innovations readily and had the positive implications on their behavioral change. They noticed that educated farmers are more likely to adopt modern technologies due to their welcoming attitudes for innovative ideas (Akbar et al., 1990; Rogers, 1995; Khan et al., 2009).

Recommendations

Based on findings of this study, the following recommendations were developed:

- Extension education programs are to be developed and implemented in order to enhance farmers' adoption rates of modern irrigation methods.
- Further studies could be carried out to investigate the barriers of adoption of new irrigation method by farmers

Table 3
Correlations between some socioeconomic characteristics of date palm farmers and the degree of their use of irrigation methods, using spearman correlation coefficient

Independent variables	Dependent variables	Correlation coefficient (R)
Age	Trickle/Drip irrigation Flood irrigation (tree/basin)	-0.117* 0.173**
Education	Trickle/Drip irrigation Valves controlled irrigation Flood irrigation (tree/basin) Flood irrigation (trees/basin)	0.204** 0.261** -0.249** -0.126*
Years of experience	Trickle/Drip irrigation	-0.132*
Farm area	Flood irrigation (trees/basin)	-0.151*

*Correlations significant at p = 0.05
**Correlations significant at p = 0.01

and develop solutions to overcome these barriers to conserve limited water resources for obtaining Saudi sustainable agriculture goals.

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References

Abou-Hadid, A. F., 2010. Agriculture Water Management. Chapter 4. In. Arab Environment-Water Sustainable Management of a Scarce Resource. Arab Forum for Environment and Development. *Report of the Arab Forum for Environment and Development.*

Ahmed, T. F., H. N. Hashmi and A. R. Ghumman, 2011. Performance assessment of Subsurface Drip Irrigation System using pipes of varying flexibility. *Mehran University Research Journal of Engineering & Technology,* **30** (3): 361-370. [ISSN 0254-7821].

Ahmed, T. F., H. N. Hashmi., A. R. Ghumman and A. A. Sheikh, 2012. Performance assessment of surface and subsurface drip irrigation system for date palm fruit trees. *African Journal of Agricultural Research*, **7** (10): 1542-1549, 12 March, 2012. Available online at: http://www.academicjournals.org/AJAR. DOI: 10.5897/AJAR11.1178. ISSN 1991-637X ©2012 Academic Journals.

Akbar, M. J., N. H. Malik, M. M. Bajwa and J. Ahmad, 1990. Impact of education on the behavioral change in the farmers. *Pakistan Journal of Agricultural Sciences,* **27:** 207-211.

Al-Amoud, A. I., 2010. Subsurface drip irrigation for date palm trees to conserve water. Proc. 4th Int. Date Palm Conference, Eds. A. Zaid and G. A. Alhadrami. *Acta Hort*., 882, ISHS 2010.

Al-Amoud, A. I. and M. I. Al-Saud, 2011. Subsurface drip irrigation for Date Palm trees to conserve water. *Journal of Saudi Society for Agricultural Science*, **10** (1a): 94-120.

Al-Amoud, A. I., Fawzi S. Mohammad, Saad A. Al-Hamed and Ahmed M. Alabdulkader, 2012. Reference evapotranspiration and date palm water use in the Kingdom of Saudi Arabia. *International Research Journal of Agricultural Science and Soil Science* (ISSN: 2251-0044), **2** (4): 155-169, April 2012. Available online http://www.interesjournals.org/IRJAS

Al-Shayaa, M. S., 2011. Barriers of adopting the modern irrigation systems in the Medina in Saudi Arabia. *The Bulletin of Faculty of Agriculture*, Cairo University, **62** (3): 261-273.

Al-Subaiee, Suaiban, 2006a. Farmers' knowledge and skills levels in environmentally sound agriculture in Adlum Area of Saudi Arabia. *Alexandria Science Exchange Journal*, **27** (1): 1-11.

Al-Subaiee, Suaiban, 2006b. Farmers' attitudes toward sustainable agriculture in Al-Kharj Governorate of Saudi Arabia. *Bull. Faculty of Agriculture*, Cairo University, **57:** 199-214.

Al-Subaiee, F., Sultan, Yousif, N. Aldrehiem, Hussain M. Algobari, Subhi M. Ismail, Rashid S. Alobeid, Mohumed S. Al-Sakran , Fahad N. Albarakah, Siddig E. Muneer and Khalid N. Alriwais, 2011. Improving the quality and productivity of dates in Saudi Arabia by using the modern agricultural technologies. College of Food and Agricultural Sciences, King Saud University. Revised Final Technical Report of the Research Project Funded by the King Abdulaziz City for Science and Technology, Riyadh - Saudi Arabia.

Al-Zahrani, K. H. and M. B. Baig, 2011. Water in the Kingdom of Saudi Arabia: Sustainable management options. *The Journal of Animal & Plant Sciences*, **21**(3): 601-604.

Al-Zahrani, K. H., M. S. Al-Shayaa and M. B. Baig, 2011. Water conservation in the Kingdom of Saudi Arabia for better environment: Implications for extension and education. *Bulgarian Journal of Agricultural Science,* **17** (3): 389-395.

Al-Zahrani, K. H., S. E. Munir, A. S. Taha and M. B. Baig, 2012. Appropriate cropping pattern as an approach to enhancing irrigation efficiency in the Kingdom of Saudi Arabia. *The Journal of Plant and Animal Sciences*, **22** (1): 224-232.

Al-Zaidi, A. A., M. B. Baig, E. A. Elhag and M. A. Al-Juhani, 2013. Farmers' attitude towards the traditional and modern irrigation methods in Tabuk Region - Kingdom of Saudi Arabia. Chapter 8. In. Science, Policy and Politics of Modern Agricultural System: Global Context to Local Dynamics of Sustainable Agriculture. Springer Science+Business Media.

Al-Zoubi, A. M., 1997. Teaching of curriculum and planning of training programs during service and agricultural extension training] [Arabic]. National Centre for Agro Information and Documentation, Ministry of Agriculture and Agrarian Reform. Damascus. Syrian Arab Republic.

Amiri, M. E., M. Panahi and G. Aghazadeh, 2007. Comparison of bubbler, sprinkler and basin irrigation for date

palms (Phoenix dactylifera, cv. Zahdi) growth in Kish Island, Iran. *Journal: Food, Agriculture and Environment (JFAE),* **5** (3&4): 185-187. Print ISSN: 1459-0255 Online ISSN: 1459-0263 Year: 2007.

Anandajayasekeram, P., R. Puskur, W. Sindu and D. Hoekstra, 2008. Concepts and Practices in Agricultural Extension in Developing Countries: A source book. IFPRI (International Food Policy Research Institute), Washington DC, USA, and ILRI (International Livestock Research Institute), Nairobi, Kenya.

AOAD, 1998. An Overview of AOAD's Strategies in Relation to Water Policy Reform in the Arab Region. Arab Organization for Agricultural Development (AOAD). In Proceedings of the Second Expert Consultation on National Water Policy Reform in the Near East. Food and Agriculture Organization, Regional Office for the Near East, Cairo, Arab Republic of Egypt.

Atta, R., T. Boutraa and A. Akhkha, 2011. Smart irrigation system for wheat in Saudi Arabia using wireless sensors network technology. *International Journal of Water Resources and Arid Environment*, **1** (6): 478-482.

Baig, M. B. and F. Aldosari, 2013. Agricultural extension in Asia: Constraints and options for Improvement. *The Journal of Animal & Plant Sciences*, **23** (2): 619-632. ISSN: 1018-7081.

Darfaoui, El-Mostafa and A. Al-Assiri, 2010. Response to climate change in the Kingdom of Saudi Arabia. *A report prepared for FAO-RNE*. Available at: Accessed on March 23, 2013.

El-Hag, A. El-Hag, 2008. Cognitive level skills farmers in sustainable agriculture in Al-kharj province. *Journal of the Saudi Society for Agricultural Sciences,* **7** (1).

FAO, 1997. Guide to extension training. Agriculture Extension and Rural Development Centre, Food and Agriculture Organization of the United Nations, Rome, Italy. Available at: http://www.fao.org/docrep/t0060e/T0060E00.htm#Contents; Accessed on Aril 09, 2013

FAO, 2002. Date palm cultivation. FAO Plant production and protection paper 156 rev. 1. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO, 2005. Modernizing national agricultural extension systems: A practical guide for policy makers of developing countries. Research, Extension and Training Division, Sustainable Development Department, Food and Agriculture Organization of the United Nations, Rome. Italy.

FAO, 2009. Water and agriculture in Saudi Arabia. AQUASTAT - FAO's Information System on Water and Agriculture. Food and Agriculture Organization of the United Nations. Available at: http://www.fao.org/nr/water/aquastat/countries/saudi_arabia/index.stm; Accessed on March 28, 2013.

FWR, 2005. Sub-Surface Drip Irrigation: Factors affecting the efficiency and maintenance. Report No 1189/1/05. Available at: http://www.fwr.org/wrcsa/1189105.htm; Accessed on April 28, 2013.

JRCC, 2012. Assessment of climate change on water resources in Kingdom of Saudi Arabia. First National Communication water Resources. Jeddah Regional Climate Center. 2012. Available at: http://jrcc.sa/First_National_Communication_Water_Resources.php. Accessed on 1 Oct. 2012.

KACST, 2012. Strategic Priorities for agricultural research. King Abdulaziz City for Science and Technology. Ministry of Economy and Planning, Doc. No. 40P0001-PLN-0001-ER01. Kingdom of Saudi Arabia. Accessed on March 28, 2012. Available at: http://nstip.kacst.edu.sa/cs/groups/public/documents/document/~edisp/agriculturetech.pdf

Karami, E., 2006. Appropriateness of farmers' adoption of irrigation methods: The application of AHP model. *Agricultural Systems*, **87:** 101-119. Doi:10.1016/j.agsy.2005.01.001.

Kassem, M. A., 2007. Water requirements and crop coefficient of date palm trees "Sukariah CV." *Misr Journal Agricultural Engineering*, **24** (2): 339-359.

Khan , N. M., M. Akram, Amanullah, U. Pervaiz and I. U. Jan, (2009. Impact of education on diffusion of Dates Palm Orchards in Northwest Pakistan. *Sarhad Journal of Agriculture,* **25** (3): 495-499.

Khan, M. Mumtaz., and S. A. Prathapar 2012. Water Management in Date Palm Groves. Book Chapter 4 Published in Dates: Production, Processing, Food, and Medicinal Values. Taylor and Francis Group. USA. Pp. 44-66.

Liebenberg, P.J., and A. Zaid. 2002. Date Palm Irrigation. Chapter 7. In. Date palm cultivation. Plant Production Paper 156 Rev.1. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy.

MEP, 2010. Agriculture - Chapter 28, Ninth Development Plan (2010-15). Ministry of Economy and Planning (MEP), Riyadh, Kingdom of Saudi Arabia.

MOA, 2010. Agricultural Statistical Year Book, Twenty third Volume (1431 H.), Department of Economic Studies and Statistics, Ministry of Agriculture and Water, Riyadh, Saudi Arabia.

MOA, 2012. A glance on agricultural development in the Kingdom of Saudi Arabia. Ministry of Agriculture, Riyadh, Kingdom of Saudi Arabia. Available at: www.moa.gov.sa; Accessed on March 23, 2013.

Nakayama, F. S. and D. A. Bucks, 1986. Trickle Irrigation for Crop Production: Design, Operation and Management. *Elsevier Science Publishers* B.V., Amsterdam, The Netherlands, p. 383.

Oakley, P. and C. Garforth, 1997. Social and cultural factors in extension. Chapter 3. Guide to extension training.

Agriculture Extension and Rural Development Centre, Food and Agriculture Organization of the United Nations, Rome, Italy. Available at: http://www.fao.org/docrep/t0060e/T0060E00.htm#Contents; Accessed on Aril 09, 2013

Pereira, L. S., T. Oweis and A. Zairi, 2002. Irrigation management under water scarcity. *Agricultural Water Management*, **57** (3): 175-206.

Qamar, M. K., 2005. Modernizing national agricultural extension systems: A practical guide for policy makers of developing countries. Research, Extension and Training Division Sustainable Development Department, Food and Agriculture Organization of the United Nations Rome, Italy.

Rogers, E. M., 1995. Diffusion of Innovations (4th Edition). *The Free Press*, New York.

Star Trek, 2009. Random Generator and Random Number table. Available at: http://stattrek.com/tables/random.aspx. Accessed on February 23, 2009.

SPSS, 2009. Statistical Package for Social Sciences. IBM Corporation, Route 100 Somers, NY 10589, USA.

Tollefson, L.C. and M. N. J. Wahab, 2012. Better research-extension-farmer interaction can improve the impact of irrigation scheduling techniques. Available at: http://www4.agr.gc.ca/resources/prod/doc/pfra-arap/csidc-crdi/pdf/research-recherche_eng.pdf; Accessed on June 06, 2013.

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