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Research Paper

Investigating the Technical Efficiency of Date Palm Cultivation Using the Data Envelopment Analysis

Zeynab Latifi [a,*], *and Hossein Shabanali Fami* [b]

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Abstract

Khuzestan Province, especially Karun County, is one of the main pillars of date production in Iran. According to the limitations of date palm production in this county, optimal production management, and the efficient use of production inputs are required. The main goal of this study was to calculate the technical efficiency of date palm cultivators' management in the whole Karun, as well as the cities in this County including four cities, using a non-parametric approach such as the Data Envelopment Analysis (DEA) method. 200 date palm cultivators were selected as samples across the region, 50 date palm cultivators from each city in April 2017 till February 2018. The results showed that Rabie and Shirin-Shahr cities have the most efficient and non-efficient date palm cultivators' management, respectively. The average efficiency under constant returns to scale assumption was 100 percent, the variable returns to scale input-oriented and output-oriented in Rabie city were 100 and 100 percent, and in Shirin-Shahr city, the average efficiency under constant returns to scale was 97.56 percent, the variable returns to scale input-oriented and output-oriented were 98.69 and 98.04 percent, respectively. In Karun County, the average efficiency under constant returns to scale was 96.62 percent, the variable returns to scale input-oriented and output-oriented efficiencies were 98.66 and 97.57 percent, respectively. In this region, cultivators' management efficiency can be increased by increasing the awareness and skills of date palm cultivators and educating them in terms of optimal use of inputs.

Keywords:
Data envelopment analysis; date palm cultivators; Karun County; regression

[a] *Corresponding author: Department of Mechanical Engineering, Shohadaye Hoveizeh University of Technology, Susangerd, Iran*
[b] *Department of Agricultural Development & Management, Faculty of Agricultural Economics & Development, College of Agriculture & Natural Resources, University of Tehran, Karaj, Iran*

** Corresponding author's email: z.latifi@shhut.ac.ir*

INTRODUCTION

Technical efficiency is one of the most important factors of productivity growth, especially in the management of agricultural production in developing countries. The efficient use of inputs in the production of agricultural products can improve the quality and quantity of these products and, on the other hand, have a great impact on increasing the income of agricultural units, which will enhance the living standard of farmers and the development of rural communities. The existing farming system, especially in developing countries, are faced with a lack of sufficient resources and opportunities for the development and adoption of modern technologies. Moreover, the unbalanced use of resources in increasing the production of agricultural products has more limited the available resources in the agricultural sector than in the past and has faced the farming system with various problems in the process of growth and development. Therefore, paying attention to the issue of technical efficiency in the agricultural economy of developing countries, including Iran, is of particular importance (Gittinger & Price, 1997).

The date palm, as the second horticultural product of Iran, is very important due to its relative advantages compared to other agricultural products. Exchange, creating employment in the lateral industries, providing food and social security of the community, preserving the environment, and enhancing the competitiveness of the country in the world markets are due to the production and exports of the date palm. Iranian date's taste has attracted consumers around the world and it can be one of the major sources of currency earnings in the agricultural sector. As of 2017, Iran has produced nearly 14.5 percent of the world's dates by producing 1,185,165 tons with a total production of approximately $ 813,600, and it is ranked as second among varieties produced in the world (FAO, 2019). Karun has one of the best date palm trees in Khuzestan Province. Date palm trees in Karun County are the best date palms in Khouzestan Province because of their quality, diversity, and proximity to Karun River. The area of date palm trees in Karun is 2,800 hectares, out of which 2,600 hectares are fertile, producing more than 9 tons of dates each hectare. This amount of production which is the first-class date palm is exported to Turkey, Canada, Europe, Persian Gulf countries, Afghanistan, and Pakistan after being packaged (Agricultural Statistics, 2018).

The study of the determinants of the management of this product plays an important role in the economic development of agriculture in Iran and this region. Considering the shortage and limitation of production resources, one of the most efficient and effective methods for achieving economic growth and development in agriculture, especially palm production, is the evaluation of the technical efficiency of agricultural date palms production units. Therefore, increasing the technical efficiency of date palm production will help the movement of resources to sites with poor economic infrastructures and the restoration of competitive sites of this product. Basic studies on the efficiency and sustainability of date palm production in the area can act as a guide to overcome these challenges.

Regarding the issue of efficiency and its measurement methods, several studies have been carried out at the global and international levels, some of which will be briefly referred to. Chen and Song (2007) evaluated the efficiency of all cities in China. They used Data Envelopment Analysis (DEA) and showed that the eastern regions had the highest efficiency compared to other areas. Yuan et al. (2010) investigated water use efficiency in wheat fields in northwest China using the DEA method. They also used regression to determine the determinants of irrigation efficiency. The results of this study showed that the farmers' efficiency was between 20 percent to 100 percent, and its

average was 61.51 percent. In addition, the results of regression showed that factors such as age, income, education level, and farm size have a positive effect on water use efficiency. Tajik et al. (2012) investigated the technical efficiency of the date palm cultivators in the river region of Hormozgan using DEA. The results of the research showed that about 62 percent of farmers had an efficiency below 20 percent and only about 15 percent of these farmers had a technical efficiency of more than 80 percent. Behrouz and Emami Meybodi (2014) measured the efficiency of watermelon producers in 12 provinces of Iran using DEA. The results of this study showed that Sistan and Baluchestan and Hamadan Province are the most efficient and non-efficient provinces in the production of this product, respectively. Dahmardeh and Sardar Shahraki (2015) studied the factors affecting risk-taking and risk aversion among grape growers. They analyzed 265 grape farmers in three counties of Zabol, Hirmand, and Zahak in the crop year of 2011-2012 using Stochastic Frontier Analysis, parametric approach as SFA. Zabol, Hirmand, and Zahak counties are located in Sistan and Baluchistan Province of Iran. The results showed that the cultivated areas are risk-reducing and risk-increasing in Zabol and Zahak counties, labor rental is risk-reducing in Zabol County, and animal manure is risk-reducing in Hirmand and Zahak counties, respectively. Abedpour et al. (2017) calculated the efficiency of date producers in Bam County using DEA and the results showed that all inputs were used more effectively. Sardar Sharaki et al. (2018) aimed to economically explore the efficiency of wheat production over the 2014-2016 period using the Window Data Envelopment Analysis (WDEA) approach. The results showed that the average annual efficiency of Zabol, Zehak, and Hirmand counties was 0.96, 0.95, and 0.96, respectively, implying that these counties were efficient. Also, an influential factor underpinning the variations of the total productivity of wheat growers was found to be technological variations. Sardar Shahraki and Karim (2018) used the DEA window analysis approach to determine date growers' efficiency in Saravan County over 2012-2016. The statistical population was composed of date farmers of Saravan County located in southern Sistan and Baluchistan Province of Iran in three districts of Zaboli, Sib, and Suran. The results showed that the efficiency score of farmers was <1, which indicates their efficiency. Efficiency score was found to be 0.93, 0.92, and 0.95 per year in Zaboli, Sib, and Suran districts, respectively. Technological change was one of the most influential factors in changing the total productivity of agriculture. Galluzzo (2018) to assess afterward the enlargement of the European Union in 2007, the technical efficiency by a non-parametric approach such as the Data Envelopment Analysis (DEA), using some findings and variables investigated in the Farm Accountancy Data Network annual survey since 2007 till 2015. Research findings have pointed out that specialized farms as dairy farms and granivores ones have had the highest levels of technical efficiency compared to mixed farms and wine farms. Karim and Sardar Shahraki (2019) studied the performance of Khash township pomegranate producers with a comprehensive analysis of supercharged performance. Khash is located in the Sistan and Baluchistan Province of Iran. The results showed that the average level of technical efficiency was 46 percent in the model assuming constant returns to scale and was 68 percent in the model assuming variable returns to scale also, pomegranate orchards under different levels of technical efficiency are the major cause of inefficiency in the management of inputs.

Due to the studies carried out and the limitations of date palm production factors in Karun County, optimal management of its production and the use of production inputs are necessary. Based on this, the present study is done to measure the technical efficiency of the management of agricultural

units producing date palm in Karun using DEA and to identify the determinants of management of the mentioned agricultural units.

Therefore, at first, in the materials and methods section, the inputs and outputs of the research, as well as the Data Envelopment Analysis (DEA) are explained. In the results and outcomes' section, factors affecting the management of date palm cultivators are expressed using regression analysis, after expressing the personal characteristics of date palm growers. In the following, by describing the statistical description of the product and inputs of the Karun County and its four cities, the calculation of the efficiency of date palm cultivators' management of this County and its four cities is discussed. In the last section, the results of the research and suggestions are presented.

METHODOLOGY

To evaluate the performance and efficiency of decision-making units, several methods are divided into two groups of parametric and nonparametric methods (Mohammadi & Sadrolashrafi, 2006). Parametric models are estimated by a certain production function using different statistical methods. Then, efficiency is determined using this function. The second group is nonparametric methods, the most important feature of which is the lack of need for particular distribution or a specific form of mathematical functions (Battese, 1992; Coelli, 1996; Rahimi Soreh & Sadeghi, 2004). In 1957 Farrell calculated the efficiency of the American agricultural sector based on economic theories using nonparametric methods. Citing five principles, he constructed a collection called production possibility and considered a part of its frontier as an estimation of the production function. Every Decision-Making Unit (DMU), which is placed on this frontier, is efficient and inefficient otherwise (Farrell, 1957). Because of scientific problems in measuring and limitations raised in the Farrell method, it did not find much practical application and remained silent for years until 1978. To remedy this problem, Charnes, Cooper, and Rhodes (CCR) introduced the method of Data Envelopment Analysis (DEA) by universalizing the Farrell method such that it includes the characteristic of the production process with several factors and outputs. In this method, it is not required to follow a certain default order to estimate the production function, and the efficiency of a firm (decision-making unit) is measured relative to the efficiency of other firms (Cooper et al., 2000; Zamanian & Khajeh Hassani, 2016; Yong & Chunweki 2003). One of the most important nonparametric methods is Data Envelopment Analysis, which is a kind of linear programming model that calculates the relative efficiency of a group of decision-making units. In other words, Data Envelopment Analysis is a quantitative programming technique for measuring the relative performance of decision-making units (Yong & Chunweki, 2003). Therefore, due to the research goal that determines the efficiency of the date cultivators' management, it is also important to use nonparametric methods in comparison with the parametric methods in providing models and the reference for inefficient units. Therefore, Data Envelopment Analysis (DEA) was used in this study. Considering the significance of indicators in evaluating the efficiency of date palm cultivators' management, the indicators using the views of experts and managers of the relevant area were used and defined as inputs of the model, which included: the rate of social cooperation and participation of date palm cultivators, the access to the communication channels and the Agricultural Jihad Organization of date palm cultivators, the level of the economic well-being of date palm cultivators, the soil fertility, use of principal irrigation, use of regular gardening operations such as Mechanical pollination; pruning; cluster arrangement; removing cluster residues at the appropriate time, reduction of losses, land area, age, and education level of date

palm cultivators. Also, due to a large number of performance indicators in the evaluation of the performance of the date palm cultivators, it has been attempted to define and use the most important indicators of the performance of date palm cultivators using the scientific documents and the views of experts and managers of this field. In this way, the indicators used and defined as outputs of the model are date palm cultivators' management level, date palm cultivators' income level, and date palm cultivators' performance level.

It's noteworthy that this research uses two stages to calculate the efficiency of date palm cultivators' management. In the first stage, factors affecting the efficiency of date palm cultivators' management are identified and determined using the statistical analysis of regression. In the second stage, the efficiency of date palm cultivators in Karun County and each city is calculated and compared using the Data Envelopment Analysis with the help of the determinants identified in the first stage.

This research is conducted in Karun, one of the most important counties of Khuzestan Province, in southwestern Iran. The center of this County is Kut-Abdullah and it includes 4 cities of Kut-Abdullah, Kanan, Rabie, and Shirin-Shahr. To achieve the research goals, this research was started in April 2017 and completed in February 2018. In the study, library research, survey research, and the completion of the questionnaire by face-to-face interviews were used to collect the necessary statistics and data. The statistical population included all the date palm cultivators, who had at least one date palm tree with an area of at least one hectare. Therefore, the statistical population of the study consisted of 1032 date palm cultivators in 4 cities of Karun County. According to the Cochran formula, the sample size was 188 people, out of which 47 people in each city were assigned, using a cluster sampling method. To ensure that the desired number of the questionnaire was returned, 240 questionnaires were distributed in the abovementioned 4 cities (60 people in each city), and 200 questionnaires were returned (50 questionnaires from each city) and analyzed. The questionnaire was compiled based on the objectives, questions, and research hypotheses and had 9 sections:

The first part: date palm cultivators' management level. According to the priority of date palm cultivators' views, this section measured 14 effective items: the use of irrigation under pressure or other modern irrigation methods; the use of windbreaker; the use of special pollen; elimination of the remaining cluster; the absence of cultivation of date palm with other trees; removing the stems and trunks of the welds; pruning petioles; the use of covering for date palm clusters; the absence of a variety of date palm cultivars, arranging cluster as clamping on the petiole; observing the hygiene notes in the date palm trees, nutrition of the date palm tree; spraying of date palm trees against pests, and at the end, thinning date palm clusters;

The second part: social cooperation and participation of date palm cultivators. According to the priority of date palm cultivators' views, this section measured 5 effective items: local formations, rural production cooperation, rural cooperatives, village councils, and at the end, the Basij;

The third part: access to communication channels and the Agricultural Jihad Organization of date palm cultivators. According to the priority of date palm cultivators' views, this section measured 9 effective items: neighbors and friends; promotion and service centers of the Agricultural Jihad Organization; rural production cooperatives; TV and radio; sellers of chemical inputs; the agricultural Jihad organization; research centers; the Agricultural Jihad Organization Management of Karun County, and at the end, journals and newspapers;

The fourth part: the economic welfare of date palm cultivators. According to the

priority of date palm cultivators' views, this section measured 9 effective items: the physical and mental health of the members of the household, the use of health and medical facilities and the use of the proper insurance; the desire to continue living in the country; the sense of belonging to the village; the satisfaction of access to services and communications; having housing based on the status of the family; having facilities for leisure time in the country; access to sanitary drinking water; and the satisfaction of the government's performance at the village;

The fifth part: soil fertility. According to the priority of date palm cultivators' views, this section measured 7 effective items: Use of micronutrient elements; soil test; use of green manure; use of chemical fertilizers of high-consumable elements; use of organic fertilizers; having housing according to family status; integrated nutrition management, and at the end, cropping in date palm trees;

The sixth part: the rate of principle irrigation use. According to the priority of date palm cultivators' views, this section measured 5 effective items: the use of irrigation under pressure; supplementary irrigation to reduce soil salinity; irrigation in pollinating and fertile fields; regular irrigation during the year; and use of the mulch to reduce the amount of irrigation water consumed;

The seventh part: use of regular gardening operations. According to the priority of date palm cultivators' views, this section measured 8 effective items: mechanical pollination; pruning; arranging and directing the cluster; removing the remaining cluster at the proper time; using the coating on the cluster; thinning cluster; napping; and observing the ratio of the leaf to the cluster;

The eighth part: the amount of waste reduction. According to the priority of date palm cultivators' views, this section measures 8 effective items: the proper storage in date palm trees; harvest and transfer of date palm to the land; multi-stage harvest, the management of irrigation and nutrition of the date palm trees; the non-use of unsuitable date palm in different stages for the production of lateral products; controlling initial sorting weed for separating undesirable date palm from the harvested product, integrated management of pests and the packaging product;

In the end, the ninth part includes the age of date palm cultivars, the degree of education of date palm cultivars, the amount of income of the date palm cultivators per hectare, the yield (the level of performance) of the date palm cultivators in kilograms and the land area per hectare.

It should be noted that the first to eight sections are based on a 5-point Likert scale from one (very low) to five (very high). The degree of education of date palm cultivators is also coded as one (illiterate), two (under diploma), three (diploma), four (associate), and five (Bachelor's degree and higher).

As it was stated, the factors affecting the management of date palm cultivators are examined first. For regression analysis, the management of date palm cultivators is examined as a dependent variable and the factors of the level of social cooperation and participation of date palm cultivators, the access to the communication channels and the Agricultural Jihad Organization of date palm cultivators, the economic welfare of date palm cultivators, the level of soil fertility, the use of irrigation principle, the use of regular gardening operations, the amount of waste reduction, the land area, the age, and the level of education of date palm cultivators are examined as independent variables. The results of this stage, which indicate the determinants of management of date palm cultivators, are applied in the next stage, which is the calculation of date palm cultivators' management technical efficiency.

In this study, Equation 1 was used to calculate the efficiency of date palm cultivators using the constant returns to scale of efficiency or CCR (Charnes et al., 1978) model, Notably, the constant returns to efficiency scale of a system mean that the

outputs increase by the increase in the inputs (Bojnec & Latruffe, 2008):

$$\begin{gathered} minY_0 = \theta \\ s.t. \sum_{j=1}^{n} \lambda_j X_{ij} \leq \theta X_{i0} \ , (i = 1, \ldots . m) \\ \sum_{j=1}^{n} \lambda_j Y_{ij} \geq Y_{r0} \ , (r = 1, \ldots . s) \\ \lambda_j \geq 0, j = 1, \ldots, n \end{gathered} \quad (1)$$

In the above equation, the matrix Y is an M×N matrix of products and the matrix X is a K×N matrix of the production factors, λ is an N×1 vector containing fixed numbers and determinants of the weights of the reference set. The scalar values obtained for will be firms' efficiency that meets condition (Mehregan, 2009).

To calculate variable returns to scale efficiency or BCC (Banker et al., 1984) model, Equation 2 was used. For this purpose, computations of variable returns to scale efficiency will be done with the formulation of the dual problem in linear programming, assuming constant returns to scale efficiency by adding constraint (Coelli et al., 2002; Cooper et al., 2000; Ghasiri et al., 2008).

$$\begin{gathered} minY_0 = \theta \\ s.t. \sum_{j=1}^{n} \lambda_j Y_{rj} \leq Y_{r0} \ , (r = 1, \ldots . s) \\ \theta X_{i0} - \sum_{j=1}^{n} \lambda_j X_{ij} \geq 0 \ , (i = 1, \ldots . m) \\ \sum_{j=1}^{n} \lambda_j = 1, (j = 1, \ldots, n) \\ \lambda \geq 0 \end{gathered} \quad (2)$$

In this study, the variable returns to scale input-oriented, and output-oriented efficiencies are calculated. In the output-oriented approach, the goal is to maximize the production according to a given amount of inputs, but in the input-oriented approach, the goal is to use minimal inputs to achieve a certain amount of product (Charnes et al., 1978; Farrell, 1957; Battese, 1992; Coelli, 1996; Galluzzo, 2013; 2016).

In this research, the constant returns to scale and the variable returns to scale input and output-oriented efficiencies are calculated for the date palm cultivators of Karun County as well as its 4 cities in the region, and the results are compared with each other. It should be noted that SPSS and MATLAB software was used to analyze the data. To determine the reliability of the questionnaire, 30 questionnaires were completed in an area other than the research area. Then, the reliability of the questionnaire was evaluated using Cronbach's alpha coefficient in SPSS software. According to the results, the questionnaires' reliability was 0.87, which is acceptable.

RESULTS

By analyzing the data obtained from the questionnaires, the following results can be deduced.

Personal characteristics of date palm cultivators are as follows. In a brief overview of the sample, the age of date palm cultivators of Karun is shown in Table 1. Based on the results, nearly 83 percent of the date palm cultivators in the region are between 42 and 82 years old. Therefore, the results indicate that there is a small percentage of young people under 42 years (only 17%) among the sample of date palm cultivators.

Table 2 also shows the education level of the date palm cultivators of Karun County. As can be seen, only 15 percent of the date palm cultivators in this region are illiterate and 48 percent are under diploma degrees.

To investigate the factors affecting the management of date palm cultivators, the linear regression model was used to find the relationship between the dependent variable and independent variables, as previously mentioned. In linear regression, the effect of each independent variable on the dependent variable is investigated. Thus, a linear regression test between the dependent variable and the independent variables has been carried out. The results of the regression test are presented in Table 3.

Table 1

Frequency Distribution of Date Palm Growers Based on Age in Karun County

Age category (Year)	Frequency	Percent	Cumulative percent
22-32	5	2.5	2.5
32-42	29	14.5	17
42-52	65	32.5	49.5
52-62	48	24	73.5
62-72	38	19	92.5
72-82	15	7.5	100

Table 2

The Education Level of the Date Palm Cultivators of Karun County

Education level	Frequency	Percent	Cumulative percent
Illiterate	30	15	15
Under diploma	96	48	63
Diploma	52	26	89
Associate	19	9.5	98.5
Bachelor's degree and higher	3	1.5	100

Table 3

Investigating the Effect of Variables on the Management of Date Palm Cultivators Using Regression Test

Independent variables	Standardized coefficients	t-test	*p*-value
the degree of social cooperation and participation	0.01	1.30	0.20
accesses to communication channels and the agricultural Jihad organization	0.57	6.50**	0.00
economic welfare of date palm cultivators	0.11	3.46**	0.00
soil fertility	0.44	4.57**	0.00
use of principle irrigation	0.11	2.38*	0.02
use of regular gardening operations	0.31	5.22**	0.00
reduction of wastes	0.20	1.09*	0.03
lands area	0.12	2.50**	0.00
age of dte palm cultivators	0.41	2.37*	0.02
education of date palm cultivators	0.32	3.28**	0.00

R^2= 0.82, F= 79.419, *p*-value= 0.00, * $p< 0.05$, ** $p< 0.01$

As indicated in Table 3, according to the significant level (less than 0.05), all factors of access to communication channels and the Agricultural Jihad Organization; economic welfare of date palm cultivators; soil fertility, use of principle irrigation; use of regular gardening operations; reduction of wastes; land area; age and education of date palm cultivators have a significant effect on the management of date palm cultivators. So, in the next stage, they will be introduced into the calculation of the efficiency of date palm cultivators' management. Only the factor of the degree of social cooperation and participation doesn't have a significant effect on the management of date palm cultivators; therefore, it is not entered into the next stage. Also, for the interpretation of each of the regression coefficients mentioned in Table 3, it can be stated that for example, if the access to communication channels and the agricultural Jihad organization of date palm cultivators increases by one unit, management of date palm cultivators will be improved by 0.57 units. Also, if soil fertility increases by one unit, the management of date palm cultivators will increase by 0.44 units. The interpretation of the rest of the regression coefficients of other variables will be the same.

It is noteworthy that the value of F equal to 79.419, with a confidence level of 0.99 and a significant level of less than 0.01 expressed in Table 3, refers to the significance of the linear regression test.

A general description of the product and inputs of Karun County is presented in Table 4.

The average level of access to communication channels and the agricultural Jihad organization of date palm cultivators is low, which indicates the low access of date palm cultivators in the area to these channels. The economic welfare of date palm cultivators in Karun is at an average level. The average soil fertility of date palm trees indicates the lower soil fertility of date palm trees of this region from the viewpoint of date palm cultivators. The average level of use of principled irrigation and regular gardening operations is relatively low, which requires the training of date palm cultivators and more emphasis in this area. The results indicate the reduction of waste in Karun County at an average level. The average of the land area of date palm trees is about 3.3 hectares, which reflects the fact that agriculture in this area is mainly done on small farms. The average age of date palm cultivators in this area is approximately 54 years. On average, date palm cultivators of this region have a diploma degree. From the viewpoint of date palm cultivators, date palm cultivators' management in Karun is on the middle level. The performance of date palm cultivators indicates that in this area, on average, 4,379 kg of date is produced per hectare. The difference between the maximum and the minimum of the products obtained from date palm trees is high. Also, the average income from date palm production is 33,122,000 IRR per hectare. The difference between the lowest and the highest income obtained per hectare is high for date palm cultivators of this region.

The statistical description of the product and inputs of Karun for four cities

A general description of the products and inputs of the four cities of Karun is presented in Table 5.

It seems that in Shirin-Shahr, on average, the access to communication channels and the agricultural Jihad organization and the economic welfare of date palm cultivators is more than in other cities. The soil fertility in Rabie and Shirin-Shahr cities is almost identical, and it can be said that it is greater than the other two cities that have almost the same soil fertility. The use of principled irrigation of date palm cultivators is low in all four cities, which requires the training of date palm cultivators and more emphasis in this area. The use of regular gardening operations of date palm cultivators in Rabie city is more than other cities, which is the same in two

Table 4

Statistical Description of the Product and Inputs of Karun County

Variables	Mean	Standard deviation	Min.	Max.
Accesses to communication channels and the agricultural Jihad organization	2.2	0.63	1.3	4.1
Economic welfare of date palm cultivators	2.9	0.53	1.8	4
Soil fertility	1.4	0.46	1	2.6
Use of principle irrigation	2.1	0.32	1.2	2.6
Use of regular gardening operations	2.4	0.69	1.3	3.8
Reduction of wastes	2.5	0.28	1.9	3.1
Lands area (hectare)	3.3	3.02	1	25
Age of palm cultivators (year)	54.4	12	22	83
Education of date palm cultivators	2.4	0.9	1	5
Management of the date palm cultivators	2.5	0.3	1.9	3.1
Performance of the date palm cultivators (kilograms)	4397	1625	900	8000
The income of the date palm cultivators (1000 IRR per hectare)	33120	5440	23400	46000

Table 5

Statistical Description of the Product and Inputs for Kut-Abdollah, Kanan, Rabie and Shirin-Shahr Cities

Variables	Kut-Abdollah			Kanan			Rabie			Shirin-Shahr		
	Mean (SD)	Min.	Max.	Mean (SD)	Min.	Max.	Mean (SD)	Min.	Max.	Mean (SD)	Min.	Max.
variable1	1.7(.27)	1.3	3.2	1.9(.42)	1.9	3.2	2.2(.45)	1.7	2.8	3(.44)	2	4.1
variable2	2.9(.49)	1.8	3.7	2.5(.35)	2.3	3.7	2.8(.32)	2.3	3.1	3.6(.25)	2.9	4
variable3	1.1(.16)	1	1.9	1.2(.45)	1	2.1	1.6(.50)	1	2.1	1.8(.25)	1.1	2.6
vriable4	2(.34)	1.6	2.6	2(.30)	1.4	2.6	2.2(.41)	1.6	2.6	2(.16)	1.2	2.4
variable5	1.9(.39)	1.3	3	1.9(.52)	1.5	3.8	3.1(.65)	1.5	3.3	2.5(.55)	2.6	3.6
variable6	2.5(.15)	1.9	2.7	2.4(.31)	1.9	3	2.8(.32)	2.2	3	2.7(.18)	1.9	3.1
variable7	4.1(3.7)	1	25	2.7(1.94)	1	10	2.6(1.8)	1	9	3.93(3.82)	1	19
variable8	53.8(11)	32	78	58(11)	39	78	54(9)	38	74	52(16)	22	83
variable9	2.3(.93)	1	4	2.3(.89)	1	4	2.7(.94)	1	5	2.2(.77)	1	5
variable10	2.5(.22)	2.1	3	2.2(.33)	2.6	2.9	2.6(.29)	2.1	2.9	1.9(.16)	2	3.1
variable11	4400 (1161)	1200	6200	3950 (1596)	4557	7000	4650 (1805)	1200	8000	1000 (1801)	6200	900
variable12	31938 (3736)	23400	39000	34300 (5617)	24000	46000	34390 (6091)	24000	46000	31858 (5609)	23400	38000

Variable1: accesses to communication channels and the Agricultural Jihad Organization;
Variable2: the economic welfare of the date palm cultivators;
Variable3: soil fertility;
Variable4: use of principle irrigation;
Variable5: use of regular gardening operations;
Variable6: reduction of wastes;
Variable7: lands area; Variable8: age of the date palm cultivators;
Variabble9: education of the date palm cultivators;
Variable10: management of the date palm cultivators;
Variable11: performance of the date palm cultivators;
Variable12: income of the date palm cultivators;

Kut-Abdollah and Kanan cities. The reduction of wastes is almost the same in all cities. On average, the lands of date palm trees of two cities of Kut-Abdollah and Shirin-Shahr are the same, which are greater than the other two cities. The average age of date palm cultivators of Kanan is more than the other cities (the mean age of the other three cities is approximately the same). The level of education of date palm cultivators of Kut-Abdollah, Kanan, and Shirin-Shahr are almost the same (under diploma), but the level of education of date palm cultivators of Rabie city is higher (diploma) than the other three. According to date palm cultivators, the level of management and performance of date palm cultivators of the three cities of Kut-Abdollah, Kanan, and Rabie is almost the same, but more than Shirin-Shahr. The average income of date palm cultivators of Rabie and Kanan per hectare is almost the same and more than other cities (the average income of date palm cultivators of Kut-Abdollah and Shirin-Shahr is almost the same). The lands of Kanan and Rabie is also almost the same.

Calculation of the efficiency of date palm cultivators' management of Karun for four cities

The results related to the calculation of a variety of efficiencies included the Constant Returns to scale, the Variable Returns to Scale input, and output-oriented efficiency of date palm cultivators' management in each city, which indicate the situation of date palm cultivators with increasing inputs, increasing outputs, minimizing inputs, and maximizing outputs, presented in Tables 6, 7, 8 and 9, respectively.

In the Constant Returns to scale efficiency, Rabie city has allocated the most efficiency with an average of 100 percent and Shirin-Shahr has the most inefficiency with an average of 97.56 percent, with a difference of 2.44 percent between them, indicating a very small difference between the date palm cultivators and the optimal use of inputs and achievement of the optimal amount of output. On the other hand, in Shirin-Shahr, the lowest and highest efficiency of the Constant Returns to scale is 80 percent and 100 percent, respectively, the difference of 20 percent shows that there is still a great potential for increasing this efficiency of date palm cultivators' management in this city. Also, the average efficiency of the cities of Kut-Abdollah and Kanan with 98.81 percent and 98.35 percent is almost the same.

In terms of the value of the variable Returns to Scale input-oriented efficiency, Rabie is the most efficient city with an average of 100 percent and Shirin-Shahr is the most inefficient city with an average of 98.69 percent, with a difference of 1.31 percent, which indicates that there is a low difference between the date palm cultivators of two cities and the effort of date palm cultivators in the reduction of inputs to the specifically defined output. However, date palm cultivators of Shirin-Shahr can reduce 1.31 percent of their input without the need to reduce output to achieve full efficiency. On the other hand, in Shirin-Shahr, the least and the most variable returns to scale input-oriented efficiencies are 89 percent and 100 percent, respectively. The difference indicates that there is still a potential to increase the efficiency of date palm cultivators' management of this city and reduce input without the need to reduce output. Also, the average input-oriented efficiency of the cities of Kut-Abdullah and Kanan is almost the same with a value of 99.71 percent and 99.96 percent, respectively. The negligible difference with complete efficiency indicates that date palm cultivators of these two cities have made a great effort to reduce input without the need to reduce output in achieving optimal efficiency.

Also, in terms of the Variable Returns to Scale output-oriented efficiency, Rabie city is the most efficient city with an average of 100 percent and Shirin-Shahr is the most inefficient city with an average of 98.04 percent. The difference between these two

cities is 1.96 percent and shows the low difference between date palm cultivators and their effort to increase the output without the need to increase total input. It can be said that date palm cultivators of Shirin-Shahr can increase 1.96 percent of their output without any need to increase input to achieve full efficiency. On the other hand, in Shirin-Shahr, the lowest and the highest output-oriented efficiencies are 83 percent and 100 percent, respectively. Their difference indicates that there is still a great potential to increase the efficiency of date palm cultivators' management and increase output without the need to increase input. Also, the average of this efficiency in Kut-Abdollah and Kanan is almost identical with a value of 99.13 percent and 98.44 percent, respectively. Their difference with full efficiency shows that the date palm cultivators of these two cities can try to achieve optimal efficiency by increasing output without the need to increase input.

Various types of technical efficiencies, including the Constant Returns to scale and the Variable Returns to Scale input and output-oriented efficiency of date palm cultivators' management of Karun, are presented in Table 10.

Table 6

A Variety of the Date Palm Cultivators' Management Efficiency of Kut-Abdollah

Efficiency (%)	CRS		VRS input-oriented		VRS output-oriented	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
80-85	-	-	-	-	-	-
85-90	-	-	-	-	-	-
90-95	6	12	-	-	5	10
95-100	44	88	50	100	45	90
Mean	98.81		99.71		99.13	
Standard deviation	2.65		0.96		2.32	
Min.	90		95		90	
Max.	100		100		100	

Table 7

A Variety of the Date Palm Cultivators' Management Efficiency of Kanan

Efficiency (%)	CRS		VRS input-oriented		VRS output-oriented	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
80-85	-	-	-	-	-	-
85-90	-	-	-	-	-	-
90-95	5	10	-	-	5	10
95-100	45	90	50	100	45	90
Mean	98.35		99.96		98.44	
Standard deviation	2.12		0.26		2.11	
Min.	93		98		93	
Max.	100		100		100	

Table 8

A Variety of the Date Palm Cultivators' Management Efficiency of Rabie

Efficiency (%)	CRS		VRS input-oriented		VRS output-oriented	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
80-85	-	-	-	-	-	-
85-90	-	-	-	-	-	-
90-95	-	-	-	-	-	-
95-100	50	100	50	100	50	100
Mean	100		100		100	
Standard deviation	0		0		0	
Min.	100		100		100	
Max.	100		100		100	

Table 9

A Variety of the Date Palm Cultivators' Management Efficiency of Shirin-Shahr

Efficiency (%)	CRS		VRS input-oriented		VRS output-oriented	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
80-85	4	8	-	-	3	6
85-90	2	4	1	2	1	2
90-95	1	2	4	8	2	4
95-100	43	86	45	90	44	88
Mean	97.56		98.69		98.04	
Standard deviation	5.07		2.64		4.31	
Min.	80		89		83	
Max.	100		100		100	

Table 10

A Variety of the Date Palm Cultivators' Management Efficiency of Karun County

Efficiency (%)	CRS		VRS input-oriented		VRS output-oriented	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
80-85	7	3.5	-	-	6	3
85-90	16	8	7	3.5	9	4.5
90-95	29	14.5	16	8	26	13
95-100	148	74	177	88.5	159	79.5
Mean	96.62		98.66		97.57	
Standard deviation	4.54		2.92		3.98	
Min.	80		86		83	
Max.	100		100		100	

The highest and the lowest efficiencies of the Constant Returns to scale are 100 percent and 80 percent, respectively, and the mean value is 96.62 percent. The difference between the most efficient and the most inefficient producer is 20 percent, which indicates that there is a huge difference between manufacturers and the absence of a specific program by date palm cultivators of the region to produce. Also, the difference in efficiency between the most inefficient production unit and the average efficiency is 16.62 percent, which suggests that the desired efficiency can be achieved with greater effort. A review of the frequency of date palm cultivators' management indicates that 74 percent of date palm cultivators have a Constant Returns to scale efficiency of between 95 percent and 100 percent. Concerning the Variable Returns to Scale input-oriented efficiency, the highest and the lowest values are 100 and 86 percent, and the average is 98.66 percent. The difference between the most efficient and inefficient date palm cultivator is 14 percent, which indicates a significant difference between the date palm cultivators' management and their lack of planning for optimal use of production inputs. The efficiency difference between the most inefficient unit and the average efficiency is 12.66 percent, which shows that there is still a potential for increasing this efficiency. Therefore, it can be said that date palm cultivators, who are involved in the study, do not use product-specific optimal input. The farms can increase their efficiency by reducing the use of inputs without decreasing a given product, thereby, preventing the loss of production inputs. Also, 88.5 percent of date palm cultivators have an efficiency of between 95 percent and 100 percent. The highest and the lowest efficiency values of Variable Returns to Scale output-oriented efficiency values are 100 percent and 83 percent, respectively, and the average value is 97.57 percent. The difference between the most efficient and the most inefficient management of date palm cultivators is 17 percent, which indicates that there is a huge difference between date palm cultivators and there is a need for more effort in increasing output without increasing input. Also, the difference in efficiency between the most inefficient production unit and the average efficiency is 14.57 percent, which shows that there is still a potential for increasing this efficiency. Therefore, farms understudy can increase their efficiency by increasing output without increasing inputs to use inputs of production and to be on the border of efficiency of production. Also, 79.5 percent of date palm cultivators have an efficiency of between 95 percent and 100 percent. The most effective efficiency mean in the region is the Variable Returns to Scale input-oriented efficiency, which is 98.66 percent. This suggests that, in general, date palm cultivators of Karun have been doing well in reducing inputs specific to a given product. Also, the most inefficient average value is related to the Constant Returns to Scale efficiency, which is 96.62 percent.

DISCUSSION

After identifying the factors affecting the management of date palm cultivators using regression, the Constant Returns to scale and the Variable Returns to Scale input and output-oriented efficiency of date palm cultivators' management in Karun County and four cities of this County were calculated. The results of the study showed that Rabie and Shirin-Shahr cities have the most efficient and the most inefficient of date palm cultivators' management, respectively. All the average efficiencies were 100 percent for Rabie and equal to 97.56 percent, 98.69 percent, and 98.04 percent for Shirin-Shahr, respectively. Considering the desirable situation of Shirin-Shahr inputs, as previously stated, it seems that the date palm cultivators of this city do not use the available inputs efficiently and they can increase output without the need to change the input. The cities of Kut-Abdullah and Kanan have almost the same efficiency levels. Comparing the

average values of the technical efficiency in Karun County and other counties of Iran assessed in several previous studies, contrary to the results of others' research, such as Tajik et al. in 2012, Karim and Sardar Shahraki in 2019, it can be said that the efficiency of date palm cultivators' management in four cities of Karun County is appropriate. In other words, the technical efficiency of this region has been equal to 1 or very close to the optimal threshold equal to 1. The date palm cultivators of Shirin-Shahr (the most inefficient city), Kut-Abdullah, and Kanan are not so far from the full efficiency, implying that they can still achieve the desired efficiency by more effort.

The Constant Returns to Scale and the Variable Returns to Scale input and output-oriented efficiencies of date palm cultivators' management of Karun were 96.62 percent, 98.66, and 97.57 percent, respectively. The difference of the Constant Returns to scale efficiency was 20 percent between the most efficient and the most inefficient producers, indicating a large difference between producers and the absence of a specific production program by date palm cultivators. On the other hand, the difference in the Variable Returns to Scale input-oriented efficiency between the most efficient and the most inefficient date palm cultivars was 14 percent, indicating a rather large difference between the date palm cultivators' management and lack of their planning for the optimal use of production inputs. Besides, the difference between the Variable Returns to Scale output-oriented efficiency between the most efficient and the most inefficient management of date palm cultivators is 17 percent , indicating an approximate high difference between date palm cultivators and the need for more effort to increase the output without increasing the input. The results of this study are in line with other researches carried out by Abedpour et al. in 2017, Sardar Shahraki and Karim in 2018, and Sardar Shahraki et al. in 2018, it emerges that the most effective average of efficiencies in the region is related to the Variable Returns to Scale input-oriented efficiency. This suggests that, in general, date palm cultivators have been doing well in reducing inputs of a given product. Moreover, the most inefficient average value of efficiencies is related to the Constant Returns to Scale efficiency.

CONCLUSION

The difference in the technical efficiency indicates the weakness of date palm cultivators in terms of knowledge and skills of production, so it is important to increase the awareness and skills of date palm cultivators in this context. Therefore, educating the date palm cultivators through training courses can be helpful. It should be noted that such courses must use learner-centered participatory training approaches. The goodness of these approaches is that date palm cultivators can better understand and use what they are participating in.

It should also be noted that educational content for empowering date palm cultivators is to improve the optimal production and use of inputs to maximize profits. For this, the provincial agricultural organizations should train native extension workers to attract farmers' participation in the extension programs, while tackling the educational problems of farmers. It can, thereby, increase the scope of the relations between farmers and agricultural extension workers. Training native extension workers increase farmers' confidence and trust in the extension programs, so it can ensure the effectiveness and efficiency of the programs. Also, the results obtained from the inputs among date palm cultivators indicate that water is used inefficiently. Due to the water shortage and the critical status of groundwater aquifer in Iran, regional water management of the County is suggested to be taken into account to reduce water over-consumption and properly distribute water among date palm cultivators. In this way, according to the principles of aquifer

stability, the production efficiency of the producers will also be enhanced. On the other hand, equipping date palm farms with physical infrastructure, including water channels, precision measuring instruments, and encouraging investors to invest in water resources in these areas will lead to an increase of added value and optimal use of water.

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