Estimating the economic efficiency and its components for date orchard farmers in Salah al-Din Governorate using data envelopment analysis (DEA) for the agricultural season 2022-2023

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Abstract:
The research aims to estimate the economic efficiency (EE) and its components—technical efficiency (TE) and allocative efficiency (AE)—of date orchard farmers in Salah al-Din Governorate, Al-Dhuluiyah District, for the agricultural season (2022-2023). Using the Data Envelopment Analysis (DEA) method for each orchard in the sample, the research data was collected through a questionnaire specifically prepared for this study. The random sampling method was employed for field data collection, resulting in a sample of 160 orchards.The analysis results indicated that the average technical efficiency (TE) on the input side, assuming constant returns to scale for the total sample, was 0.82, while the average technical efficiency (TE) on the output side, with variable returns to scale, was 0.80. The average allocative efficiency (AE) on the input side, considering variable returns to scale for the total sample, was 0.85. The average economic efficiency (EE) on the input side, with variable returns to scale for the total sample, amounted to 0.81.The research concluded with several findings, the most significant being that the lower value of economic efficiency (0.81) alongside the higher value of technical efficiency (0.95) for the total sample indicates the potential to achieve better results with the same resources or to attain the same results with fewer resources, provided that expertise is available.

Introduction

Iraq is considered one of the most suitable geographical areas for date palm cultivation in the world, as the environmental requirements of the date palm tree align with the prevailing climatic conditions, which are characterized by high temperatures and low humidity in the central and southern regions of Iraq, where date palm cultivation thrives and dates are produced (Jubair et al., 2020: 1). The date palm is one of the oldest fruit trees cultivated by humans and is an essential element in agricultural, nutritional, and economic life in Iraq. Dates represent an important food source, being rich in essential nutrients such as vitamins, minerals, and fiber, and they contribute to enhancing human health.Economically, the date palm is a crop of high economic value, as Iraq is one of the largest date producers in the world. In 2021, date production in Iraq reached 11,242,747 tons, while in Salah al-Din Governorate, it amounted to 697,120 tons, with a relative importance of 6% (Republic of Iraq, Ministry of Planning: 2021.(

Date palm cultivation in Iraq, particularly in Salah al-Din, faces a range of problems and challenges that negatively impact its productivity and quality. Among the most

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prominent issues are water scarcity, poor management of water resources, desertification, degradation of agricultural land, lack of technical support, the spread of pests and diseases, outdated cultivars, insufficient investment in cultivar improvement, marketing problems for dates, rising costs, and other challenges.The study of economic efficiency is an important topic, where efficiency is an indicator of the system's success and represents the most logical and economic use of the system's production resources (Al-Taie, 2010: 93). The basic condition for achieving economic efficiency is the full utilization of economic resources and the effective allocation of these resources (Zidan, 2018: 13).The production of dates in Iraq has significant economic importance, as Iraq possesses a comparative advantage in date cultivation and production. However, the number of date palm trees has significantly declined in recent years, leading to a general decrease in date production (Sahan, 2016: 1). The aim of this study is to measure the economic efficiency and its components of date palm orchards in Salah al-Din Governorate, specifically in the Balad district, for the production season (2022-2023) using the Data Envelopment Analysis (DEA) method.

Research Hypotheses:

.1 The research is based on the hypothesis that the suboptimal utilization and scientific allocation of available economic resources negatively affect the productivity of the dunam of dates.

.2 The research assumes that there is a disparity in achieving economic efficiency among date orchards for the farmers in the sample.

Research Problem:

Date palm cultivation is economically significant; however, in recent times, we have observed a decline in the productivity of date crops and a decrease in the efficiency of date orchards. This decline is attributed to several factors, including a lack of government attention to this crop, limited expertise among many farmers, urban expansion leading to the clearing of many date orchards, and inefficient use of economic resources allocated for production.

Research Methodology:

A quantitative analysis approach was adopted, utilizing various quantitative analysis techniques. The non-parametric analysis method was applied using the DEAP software (Data Envelopment Analysis Program), which allows us to measure the technical, allocative, and economic efficiency of each orchard individually and as an average for the sample's efficiency. The method relies on linear programming. Data was collected through a questionnaire prepared for this purpose via personal interviews, with a total of 800 farmers in the study population, distributed across Salah al-Din Governorate, specifically in the Balad district. A random sample was selected, constituting 20%, resulting in a sample size of 160 farmers.

Theoretical Framework and Description of the Models Used

This section describes the standard model used to measure economic efficiency and its components for the research sample.Methods for estimating economic efficiency are important topics for researchers due to their significance in measuring the success of economic units, as well as in determining the initial steps toward achieving significant resource savings, which have implications for

ISSN 2072-3857

policy formulation and resource management. Optimal utilization is of great importance (Riegger and Brave, 1991: 18). Among these methods is Data Envelopment Analysis (DEA), which is a non-parametric method relying on linear programming to measure the efficiency and economic performance of organizations and to identify the optimal combination of input and output sets for the same units (Bahramz, 1996: 31).The interest in this method arises from its accuracy as a scientific tool that utilizes linear programming to measure the goal of utilizing a set of resources to produce a set of similar outputs. The performance of these units is assessed by identifying those that use more resources but produce outputs that are equal to or less than their peers. Decision-makers must then understand the reasons for declining performance and work to resolve these issues (Battal et al., 2017: 34).Before estimating the results of economic efficiency analysis and its components using the DEA method, it is essential to understand the relationship between variables and to formulate this relationship mathematically, which enables us to develop a model through which phenomena can be studied practically by identifying the dependent variable and the explanatory variables. This requires knowledge of the mathematical form of the equations and whether they are linear or non-linear. Since the DEA model is a non-parametric method based on linear programming applied to both the production function and the cost function, it can be described as follows:

Standard Description of the Model Used to Measure Economic Efficiency and Its Components According to Production Function Variables

To estimate technical efficiency from the input side for the crops in the study sample, the surrounding environmental conditions of the farm lead farmers to have more control over their inputs than their outputs. In other words, it is generally easier to reduce the quantity of inputs than to increase production. With the field statistical data represented by (K) inputs, which include (amount of fertilizers/g, pesticides/liter, human labor/hour, mechanical work/hour, irrigation/irrigation), these are explanatory variables that significantly influence the dependent variable (M), represented by the total production of the orchards under study (N).Using the duality theory in linear programming, the Data Envelopment Analysis (DEA) model used to estimate technical efficiency from the input side under variable returns to scale (VRS) is expressed as follows: (Coelli et al., 2005: 180.(

Min _(θ,) λ^θ

Subject to:

¬yi + yλ ≥ 0

θ_xi - Xλ ≥ 0

N_i λ = 1

λ ≥ 0

Where:

Xi = input vector.

Yi = output vector.

λ = outcome vector.

Ni = constants and weights associated with efficient orchards.

θ = represents the technical efficiency value of the orchards, ranging between (0 – 1.(

Standard Description of the Model Used to Measure Economic Efficiency and Its Components According to Cost Function Variables

Using the economic efficiency estimation model from the cost function, both technical efficiency and allocative efficiency will be estimated, along with economic efficiency (cost efficiency), by using the prices of

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production inputs employed in the production process to reduce costs for the sample orchards. Assuming variable returns to scale, the linear programming model takes the following form:

Min λ , Xi^* wiXi

Subject to:

- $y_i + y\lambda \geq 0$

$\theta Xi^* - X\lambda \geq 0$

$\lambda \geq 0$

Where:

Xi = vector to minimize the cost of production unit i.

Wi = vector of input prices.

yi = output vector for production unit i.Economic efficiency (EE) is calculated as the ratio of the minimum cost to the actual cost through the following equation:

EE = (Wi Xi^*) / (Wi Xi(

EE = TE * AEAllocative efficiency can also be calculated by dividing economic efficiency by technical efficiency, as follows:

AE = EE / TE

Estimation of technical efficiency under stable and variable yield and energy efficiency of date crop.

The nature of the energy return for any orchard can be determined by measuring energy efficiency because efficient and inefficient orchards are directly identified in economies of scale, and scale efficiency is measured by dividing the technical efficiency under constant returns by its counterpart under variable returns. When observing Table (1), which shows the absorption efficiency and technical efficiency in light of the stability and change in the absorption yield of date crop producers for (160) orchards for the agricultural season (2022-2023), the results of estimating the absorption efficiency and technical efficiency in light of the stability and change in the yield for the sample of palm orchard farmers indicate that the average absorption efficiency reached (0.96). This value shows that the sample farmers can increase their production by 4% using the same amount of resources entering the production process, and the energy efficiency ranged between a maximum and a minimum (1-0.61) respectively. From Table (1), it is clear that the number of orchards that achieved full efficiency (100%) amounted to (110) orchards. These orchards can be considered references for the rest of the sample orchards that did not reach full efficiency and can continue according to the set of elements used despite the lack of economies of scale. They operate at the optimal size according to what is shown by the returns to scale index. This means that the total production increases by adding the same variable production factors. In this case, there is stability in the rate of increase in total production, which indicates the stability of the percentage of production elements used in the production process. As for the rest of the sample orchards that did not reach full efficiency, they amounted to (50). As for the technical efficiency, which was the basis for calculating energy efficiency, it is clear from the table that the technical efficiency, given the stability of the return for the sample of palm orchard farmers, ranged between the highest and lowest efficiency (1-0.47) respectively, with an average of (0.82), while the highest and lowest technical efficiency, given the change in the return, was (1-0.49) with an average of (0.88). It is clear from Table (1) that there is a variation in the efficiency ratios from one orchard to another, and this is due to the farmers' ability to implement agricultural policies and the expertise they possess in managing their agricultural orchards for the date crop

ISSN 2072-3857

Table (1) capacity efficiency and technical efficiency under fixed and variable capacity production factor for date crop.

Reference orchards	Capacity returns	Capacity efficiency)scale(	Technical efficiency under capacity change)vrste(	Technical efficiency under constant capacity)crste(	The orchard
46،152	-	1.000	0.819	0.819	1
72	-	1.000	0.761	0.761	2
124	-	1.000	0.625	0.625	3
100،153،78	Drs	0.975	0.953	0.929	4
153	-	1.000	0.582	0.582	5
6	Irs	0.859	1.000	0.859	6
123،71	-	1.000	0.592	0.592	7
8	Irs	0.920	1.000	0.920	8
100،153	Drs	0.741	0.970	0.719	9
153	-	1.000	0.867	0.867	10
153،46،100	-	1.000	0.819	0.819	11
100،153،45	Drs	0.910	0.687	0.625	12
46،45،153	-	1.000	0.861	0.861	13
153،45	Drs	0.889	0.786	0.699	14
152	-	1.000	1.000	1.000	15
153	-	1.000	1.000	1.000	16
71	-	1.000	1.000	1.000	17
124	-	1.000	1.000	1.000	18
100،46،153	Drs	0.963	0.497	0.479	19
153،78	-	1.000	0.614	0.614	20
153	-	1.000	0.816	0.816	21
100،45	-	1.000	1.000	1.000	22
46	-	1.000	1.000	1.000	23
45،153	-	1.000	0.872	0.872	24
45،153	Drs	0.870	0.932	0.811	25
45،153	Drs	0.742	0.705	0.523	26
100،153،46	Drs	0.946	0.697	0.659	27
153	-	1.000	0.806	0.806	28
46،153	-	1.000	0.929	0.929	29
53	Irs	0.970	1.000	0.970	30
100،153	Drs	0.892	0.970	0.865	31
153	-	1.000	0.867	0.867	32
153،45،46	-	1.000	0.819	0.819	33
153،45	Drs	0.850	0.687	0.584	34
153،100،78	Drs	0.944	0.861	0.813	35
100،153	-	1.000	0.786	0.786	36
60	-	1.000	1.000	1.000	37

ISSN 2072-3857

153	-	1.000	1.000	1.000	38
71	-	1.000	1.000	1.000	39
124،72	-	1.000	1.000	1.000	40
45،153،46	-	1.000	0.497	0.497	41
78،153	-	1.000	0.614	0.614	42
153	-	1.000	0.816	0.816	43
45	-	1.000	1.000	1.000	44
45	-	1.000	1.000	1.000	45
78	-	1.000	1.000	1.000	46
100 153 ، 45	Drs	0.937	0.872	0.817	47
100 ، 153	Drs	0.839	0.932	0.782	48
153 ، 100	Drs	0.750	0.705	0.529	49
، 46 45 ، 153 100	Drs	0.927	0.697	0.646	50
153	-	1.000	806	0.806	51
46 ، 153	-	1.000	0.929	0.929	52
53	Irs	0.970	1.000	0.970	53
45 ، 153	-	1.000	0.970	0.970	54
153	-	1.000	0.867	0.867	55
،78 45 ، 153 100	Drs	0.960	0.819	0.787	56
45 153 ، 100	Drs	0.824	0.687	0.566	57
46 100 ، 153	Drs	0.922	0.861	0.794	58
153 ، 100	Drs	0.911	0.786	0.716	59
60	-	1.000	1.000	1.000	60
153	-	1.000	1.000	1.000	61
71	-	1.000	1.000	1.000	62
160	-	1.000	1.000	1.000	63
153 46 ، 100	-	1.000	0.497	0.497	64
78 ، 153	-	1.000	0.614	0.614	65
153 ، 100	Drs	0.892	0.687	0.613	66
، 153 100 ، 45 46	Drs	0.922	0.861	0.794	67
153 ، 45	-	1.000	0.786	0.786	68
60	-	1.000	1.000	1.000	69
153	-	1.000	1.000	1.000	70
71	-	1.000	1.000	1.000	71
72	-	1.000	1.000	1.000	72
78 45 ، 153	-	1.000	0.497	0.497	73
78 ، 153	Drs	0.960	0.614	0.589	74
153	-	1.000	0.816	0.816	75
100	-	1.000	1.000	1.000	76
100	-	1.000	1.000	1.000	77
78	-	1.000	1.000	1.000	78
153 ، 100	Drs	0.927	0.872	0.808	79
153 ، 45	Drs	0.829	0.932	0.773	80
45 ، 153	-	1.000	0.705	0.705	81

ISSN 2072-3857

46 153 ، 45	-	1.000	0.697	0.697	82
153	-	1.000	0.806	0.806	83
46 ، 153	-	1.000	0.929	0.929	84
153	-	1.000	1.000	1.000	85
71	-	1.000	1.000	1.000	86
124	-	1.000	1.000	1.000	87
153 46 ، 100	Drs	0.963	0.497	0.479	88
78 ، 153	-	1.000	0.614	0.614	89
45 153 ، 100	Drs	0.842	0.687	0.579	90
153 45 ، 78	Drs	0.922	0.861	0.794	91
45 ، 153	-	1.000	0.786	0.786	92
60	-	1.000	1.000	1.000	93
153	-	1.000	1.000	1.000	94
71 ، 123	-	1.000	1.000	1.000	95
72	-	1.000	1.000	1.000	96
46 153 ، 45	-	1.000	0.947	0.497	97
46 153	Drs	0.614	0.589	0.589	98
153	-	1.000	0.816	0.816	99
100	-	1.000	1.000	1.000	100
153 ،78	Irs	0.987	0.913	0.902	101
153 ، 45	-	1.000	0.932	0.932	102
153 ،45	Drs	0.850	0.705	0.599	103
78 153 ، 45	Drs	0.927	0.697	0.646	104
153	Drs	0.897	0.806	0.723	105
46 ، 153	-	1.000	0.929	0.929	106
153	-	1.000	1.000	1.000	107
71 ، 123	-	1.000	1.000	1.000	108
72 ، 124	-	1.000	1.000	1.000	109
153 60 ،46	Irs	0.965	0.527	0.509	110
78 ، 153	-	1.000	0.614	0.614	111
153 ، 100	Drs	0.892	0.687	0.613	112
46 153 ، 45	-	1.000	0.961	0.861	113
153 ، 100	Drs	0.877	0.786	0.689	114
60	-	1.000	1.000	1.000	115
153	-	1.000	1.000	1.000	116
71	-	1.000	1.000	1.000	117
153 78 152	Irs	0.983	0.723	0.711	118
78 100 153	Drs	0.944	0.861	0.813	119
153 100	Drs	0.877	0.786	0.689	120
152	-	1.000	1.000	1.000	121
153	-	1.000	1.000	1.000	122
154	-	1.000	1.000	1.000	123
124	-	1.000	1.000	1.000	124
46 100 153	-	1.000	0.497	0.497	125
78 153	-	1.000	0.614	0.614	126
153	-	1.000	0.816	0.816	127

ISSN 2072-3857

45	-	1.000	1.000	1.000	128
153 100	Drs	0.927	0.872	0.808	129
100 153	-	1.000	0.932	0.932	130
45 153	-	1.000	0.705	0.705	131
46 153 45	-	1.000	0.697	0.697	132
153	Drs	0.897	0.806	0.723	133
78 153	-	1.000	0.929	0.929	134
153	-	1.000	1.000	1.000	135
71	-	1.000	1.000	1.000	136
72	-	1.000	1.000	1.000	137
153	-	1.000	1.000	1.000	138
71 123	-	1.000	1.000	1.000	139
72	-	1.000	1.000	1.000	140
78 45 153	-	1.000	0.497	0.497	141
153 46	Drs	0.960	0.614	0.589	142
45 153 100	Drs	0.824	0.687	0.566	143
78 153 45	-	1.000	0.861	0.861	144
153 100	Drs	0.911	0.786	0.716	145
60	-	1.000	1.000	1.000	146
153	-	1.000	1.000	1.000	147
71 123	-	1.000	1.000	1.000	148
45 153	-	1.000	0.687	0.687	149
46 153 45	Drs	0.922	0.861	0.794	150
153 100	Drs	0.911	0.786	0.716	151
60	-	1.000	1.000	1.000	152
153	-	1.000	1.000	1.000	153
154	-	1.000	1.000	1.000	154
72 124	_	1.000	1.000	1.000	155
100 153 78 45	Drs	0.963	0.497	0.479	156
153 46	-	1.000	0.614	0.614	157
153	-	1.000	0.816	0.816	158
71 123	-	1.000	1.000	1.000	159
124	-	1.000	1.000	1.000	160
		0.968	0.887	0.827	Average
		1	1	1	Maximum
		0.614	0.497	0.479	minimum

Source: Prepared by the researcher based on the outputs of the in-depth analysis of the program.

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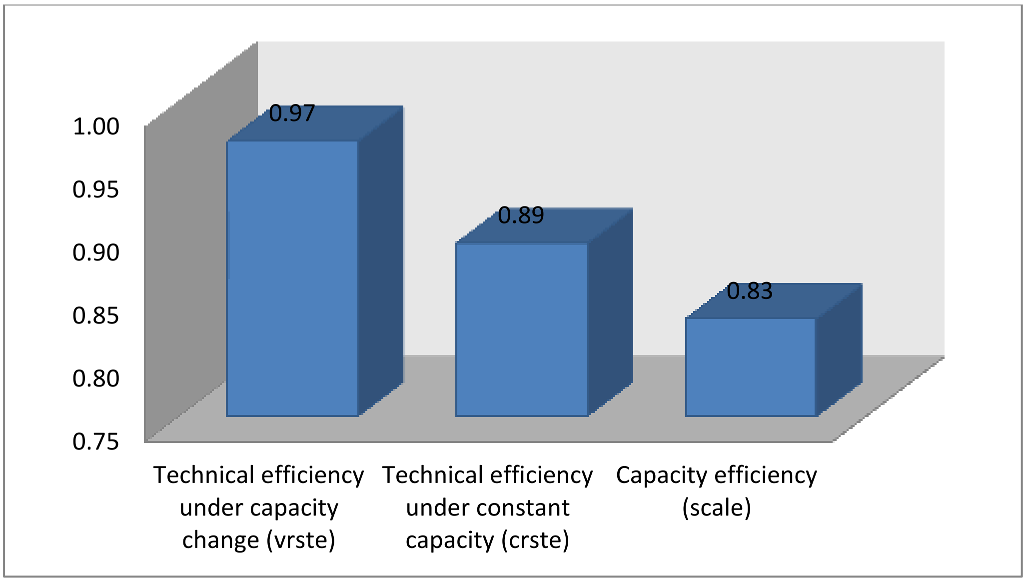

Figure (1) Average capacity efficiency and technical efficiency under constant and variable returns.

Source: Prepared by the researcher based on data in Table (1) using Excel .

Estimating the economic efficiency and its components (technical and allocation) of the date crop according to the variables of cost functions.

Table (2) shows the technical efficiency, allocative efficiency, and economic efficiency (cost efficiency) that can be obtained using the quantities of resources and the costs of these resources involved in the production process, assuming a change in the yield to the production capacity of the date crop for (160) orchards for the agricultural season (2022-2023), where it is clear that the average technical efficiency reached (0.96). This is the same result obtained in calculating energy efficiency under change in yield, which indicates that these orchards can increase their production by 4% with the resources used, and also indicates that they allow the loss of some of their resources due to inefficiency, which leads to an increase in costs by 4%, and technical efficiency was used in calculating cost efficiency. As for the allocative efficiency, the table shows that it ranged between the highest efficiency, which is one, and the lowest efficiency, which is (0.65) at the sample level, with an arithmetic average of (0.85). This indicates the possibility of increasing production by adopting modern technology, through which the optimal utilization of resources can be achieved by (15%). Thus, the reallocation of economic resources would save (15%) of the costs of economic resources while maintaining the same level of production. Thus, these orchards can reach the optimal production point, which is represented by the tangent of the cost line to the equal-yield curve. It is also clear that the total number of orchards that achieved 100% allocative efficiency Three orchards, in this case there is no surplus of inputs in these orchards because they consume all inputs at the optimal volume to reach the optimal production, i.e. the stagnant values are equal to zero, and it is also clear that some orchards that achieved full technical efficiency were unable to achieve full allocative efficiency, because the costs of the resources involved in production are high at a level that led to a decrease in allocative efficiency below the optimal level, and this indicates that

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production At the point where it is technically efficient and allocatively inefficient, when the costs of the orchard fall to a level where the cost line is tangent to the isoquant, the orchard will be allocatively and economically efficient, because improving technical efficiency by a small amount will increase allocative efficiency by one unit, and this will cause the rate of technical change to continue to rise until it reaches its maximum. The table also shows the results of estimating the economic efficiency of the date crop, where the average economic efficiency reached (0.81), which is a fairly good level, and is the product of both technical efficiency and allocative efficiency, indicating that these orchards can reduce costs by 19% and achieve the same level of production, or that these orchards can obtain the current production using 81% of the resources to become economically efficient.

Table (2) Measuring the economic efficiency, allocative efficiency, and technical efficiency of the date crop according to the cost function variables in Salah al-Din Governorate - Al-Dhuluiyah District for the agricultural season (2022-2023) for the research sample

Economic efficiency EE)(	allocation efficiency AE)(	Technical competence)TE(	T
0.829	0.849	0.977	1
0.945	0.945	1.000	2
0.849	0.849	1.000	3
0.835	0.893	0.936	4
0.882	0.882	1.000	5
0.848	0.848	1.000	6
0.734	0.734	1.000	7
0.655	0.655	1.000	8
0.641	0.854	0.750	9
0.889	0.889	1.000	10
0.801	0.801	1.000	11
0.791	0.889	0.889	12
0.909	0.909	1.000	13
0.804	0.950	0.846	14
0.887	0.887	1.000	15
0.771	0.771	1.000	16
0.776	0.776	1.000	17
0.755	0.755	1.000	18
0.734	0.814	0.901	19
0.940	0.940	1.000	20
0.820	0.820	1.000	21
0.822	0.822	1.000	22
0.963	0.963	1.000	23
0.862	0.862	1.000	24

ISSN 2072-3857

0.773	0.914	0.846	25
0.655	0.916	0.715	26
0.692	0.778	0.889	27
0.730	0.730	1.000	28
0.970	0.970	1.000	29
0.810	0.810	1.000	30
0.787	0.886	0.889	31
0.826	0.826	1.000	32
0.799	0.799	1.000	33
0.726	0.858	0.846	34
0.754	0.848	0.889	35
0.747	0.747	1.000	36
0.754	0.754	1.000	37
0.956	0.956	1.000	38
0.837	0.837	1.000	39
0.830	0.830	1.000	40
0.910	0.910	1.000	41
0.889	0.889	1.000	42
0.710	0.710	1.000	43
0.741	0.741	1.000	44
0.931	0.931	1.000	45
0.976	0.976	1.000	46
0.819	0.921	0.889	47
0.700	0.875	0.800	48
0.621	0.853	0.727	49
0.668	0.864	0.773	50
0.909	0.909	1.000	51
0.808	0.808	1.000	52
0.869	0.869	1.000	53
0.876	0.876	1.000	54
0.875	0.875	1.000	55
0.781	0.852	0.916	56
0.680	0.851	0.799	57
0.649	0.806	0.806	58
0.738	0.831	0.889	59
1.000	1.000	1.000	60
0.830	0.830	1.000	61
0.781	0.781	1.000	62
0.720	0.720	1.000	63
0.759	0.759	1.000	64
0.945	0.945	1.000	65

ISSN 2072-3857

0.771	0.868	0.899	66
0.786	0.969	0.811	67
0.831	0.831	1.000	68
0.853	0.853	1.000	69
0.808	0.808	1.000	70
0.857	0.857	1.000	71
0.945	0.945	1.000	72
0.889	0.889	1.000	73
0.797	0.942	0.846	74
0.669	0.669	1.000	75
0.693	0.693	1.000	76
0.732	0.732	1.000	77
0.979	0.979	1.000	78
0.779	0.877	0.889	79
0.723	0.921	0.786	80
0.770	0.770	1.000	81
0.929	0.929	1.000	82
0.745	0.745	1.000	83
0.928	0.928	1.000	84
0.821	0.821	1.000	85
0.797	0.797	1.000	86
0.766	0.766	1.000	87
0.736	0.817	0.901	88
0.929	0.929	1.000	89
0.736	0.899	0.820	90
0.755	0.937	0.806	91
0.802	0.802	1.000	92
0.962	0.962	1.000	93
0.822	0.822	1.000	94
0.843	0.843	1.000	95
0.906	0.906	1.000	96
0.841	0.841	1.000	97
0.762	0.901	0.846	98
0.763	0.763	1.000	99
0.857	0.857	1.000	100
0.926	0.926	1.000	101
0.881	0.881	1.000	102
0.740	0.874	0.846	103
0.682	0.882	0.773	104
0.679	0.764	0.889	105
0.746	0.746	1.000	106

ISSN 2072-3857

0.963	0.963	1.000	107
0.785	0.795	1.000	108
0.830	0.830	1.000	109
0.954	0.954	1.000	110
0.941	0.941	1.000	111
0.707	0.796	0.889	112
0.882	0.882	1.000	113
0.752	0.940	0.800	114
0.729	0.729	1.000	115
0.656	0.656	1.000	116
0.767	0.767	1.000	117
0.920	0.920	1.000	118
0.778	0.875	0.889	119
0.774	0.967	0.800	120
0.879	0.879	1.000	121
0.832	0.832	1.000	122
0.953	0.953	1.000	123
0.824	0.824	1.000	124
0.825	0.825	1.000	125
0.932	0.932	1.000	126
0.841	0.841	1.000	127
0.750	0.750	1.000	128
0.776	0.873	0.889	129
0.816	0.816	1.000	130
0.863	0.863	1.000	131
0.795	0.795	1.000	132
0.835	0.940	1.000	133
0.784	0.784	1.000	134
0.712	0.712	1.000	135
0.745	0.745	1.000	136
0.953	0.953	1.000	137
0.859	0.859	1.000	138
0.830	0.830	1.000	139
0.964	0.964	1.000	140
0.890	0.890	1.000	141
0.715	0.875	0.817	142
0.662	0.832	0.795	143
0.817	0.817	1.000	144
0.768	0.865	0.889	145
0.780	0.780	1.000	146
0.727	0.727	1.000	147

0.709	0.709	1.000	148
0.792	0.792	1.000	149
0.709	0.880	0.806	150
0.809	0.910	0.889	151
1.000	1.000	1.000	152
1.000	1.000	1.000	153
0.956	0.956	1.000	154
0.811	0.811	1.000	155
0.782	0.894	0.875	156
0.833	0.833	1.000	157
0.764	0.764	1.000	158
0.873	0.873	1.000	159
0.825	0.825	1.000	160
0.814	0.851	0.959	Average
1	1	1	Maximum
0.621	0.655	0.715	Minimum

Source: Prepared by the researcher based on the outputs of the Deep program analysis

ISSN 2072-3857

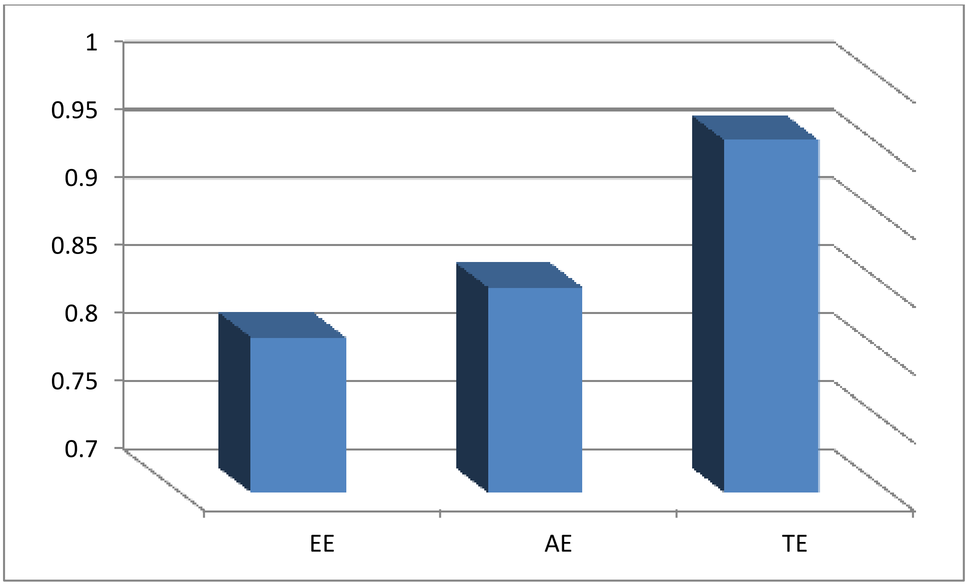

Figure (2) Average technical efficiency, allocative efficiency and economic efficiency of the date crop.

Source: Prepared by the researcher based on data in Table (2) using Excel.

Average capacity efficiency and technical efficiency in light of stability and change in capacity return for palm orchard farmers in Salah al-Din Governorate - Al-Dhuluiyah District for the agricultural season 2022-2023

Table (3) shows a comparison between the technical capacity efficiencies of farmers in palm groves in Salah al-Din Governorate, where the average capacity efficiency indicates that farmers are working near the maximum limits of productivity.In terms of available energy, this means that they are making good use of their resources, which is (0.97), and the average technical efficiency under energy change is (0.89), This value reflects the ability of farmers to use available inputs efficiently, despite changes in capacity. There is still room for improvement in technical efficiency, indicating the potential for improving agricultural operations or resource management. Average technical efficiency with constant capacity (0.83), This value reflects the farmers' efficiency in achieving the highest yield while maintaining constant energy. The result here indicates that there is a greater opportunity to improve technical efficiency in this context, which means that farmers may not be exploiting the full potential available to them.

Average capacity efficiency (scale)	Average technical efficiency under changing capacity returns (vrste)	Average technical efficiency under constant power returns (crste)	The orchards
0.97	0.89	0.83	Average

Source: Prepared by the researcher based on questionnaire data and DEAP program results

ISSN 2072-3857

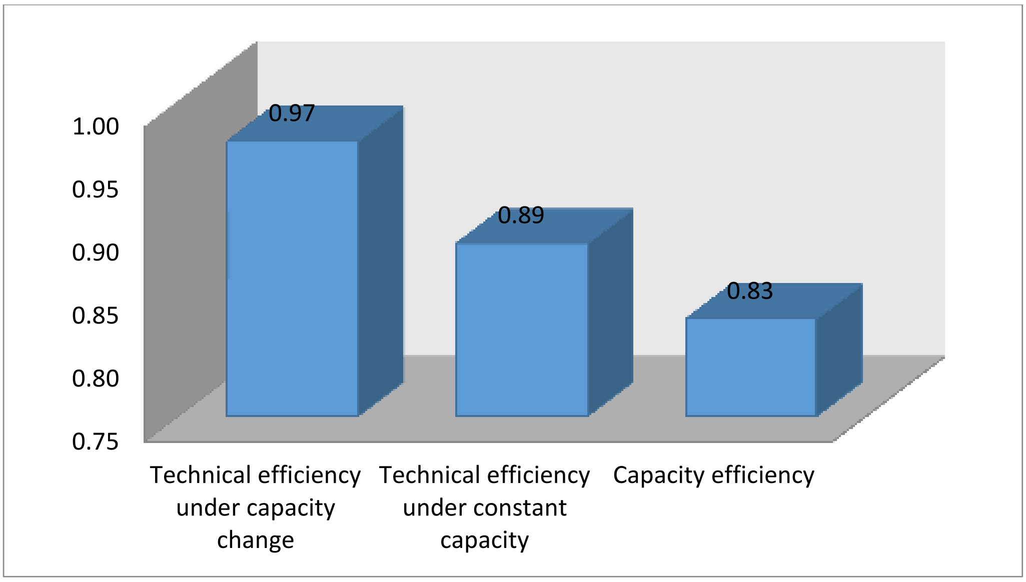

Figure (3) Average energy efficiency and technical efficiency under fixed and variable returns.
Source: Prepared by the researcher based on data in Table (3) using Excel.

Conclusions:

-1

The research concluded, through measuring energy efficiency, that it is possible to expand the production of dates for a sample of date orchard farmers by (18%, 15%) respectively to reach the optimal production capacity.

-2From the average value of technical efficiency (TE) for the total sample, which amounted to (95%), we conclude that palm grove farmers in the research sample have acquired a fair amount of experience in the technical aspect represented by agricultural operations and the process of integrating production elements and avoiding significant waste in them.

-3From the average value of economic efficiency (EE) for the total sample, which amounted to (85%), we conclude that the opportunity to achieve a greater output from the same resources or produce the same output with fewer resources exists and is possible as long as the value of technical efficiency is high and experience is available, and the matter depends only on what raises the value of allocative efficiency, which is supporting the inputs or outputs or both together to reach profitable economic efficiency.

-4The low value of the average allocative efficiency (AE) for the total sample, which amounted to (85%), is due to the high prices of production elements that crop farmers obtain from the market as a result of the lack of government support for these elements. This was confirmed by all farmers in the sample through the questionnaire, which led to a large waste in the costs of production elements estimated at about (15%.(

Recommendations:

.1

Encourage investment in palm cultivation by providing financial incentives, such as facilitated loans or tax exemptions, to enable farmers to expand their production by 15% to 18% to reach optimal capacity.

ISSN 2072-3857

.2 The government should provide financial support to farmers to reduce the prices of essential production inputs, such as fertilizers and pesticides, which contributes to enhancing allocative efficiency and reducing costs.

.3 Develop pricing policies that align with market costs and ensure fair prices for inputs, encouraging farmers to invest in palm cultivation.

.4 Work on improving distribution and marketing networks for dates, including the development of local and international sales channels. Effective marketing strategies can help increase revenues.

.5 Support the establishment of agricultural cooperatives that allow farmers to access inputs at reduced prices and provide technical support, helping to lower production costs and increase efficiency.

.6 Implement training programs for farmers to improve their technical and managerial skills, contributing to enhanced technical efficiency and boosting their expertise in date cultivation.

.7 Invest in agricultural research to develop improved varieties of dates and enhance farming methods, which will increase productivity and expand agricultural opportunities.

.8 Stimulate innovations in production and marketing technologies, such as the use of smart farming techniques or sustainable agriculture, which will help improve economic efficiency.

.9 Establish a system for periodic performance evaluation of farmers to measure economic and technical efficiency and identify areas needing improvement.

sources:

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