EFFECT OF SUPPLEMENTARY IRRIGATION SYSTEM ON WHEAT PRODUCTION EFFICIENCY USING A STOCHASTIC FRONTIER ANALYSIS

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ABSTRACT

This study was aimed to director wheat production's technical efficiency grown under two irrigation systems(fixed and pivot sprinkler irrigation systems)using random border analysis.Samples were collected randomly from267farmers from Salah Al-Din Governorate/Iraq.The samples were divided into two groups;187farmers used a pivot sprinkler irrigation system with three categories of possession(80,60and120dunums),while the other group used a fixed sprinkler irrigation system with four categories of possession(40,30,20and10dunums).Transcendent production function was used to study the effect of production factors on wheat yield. The results indicated that the mechanization work and the amount of added irrigation water increased by 1% while the wheat yield increased by0.08and0.15%,respectively.The pivot sprinkler irrigation system's technical efficiency averaged0.86,while the fixed sprinkler irrigation system's efficiency was0.84.The technical efficiency and experience increased with the farmers' experience with supplementary irrigation, the cultivated area and age. On the other hand, technical efficiency and experience decreased with the family's size and wheat cultivating experience. Furthermore, farmers who owned mechanization were more efficient than the lessors. The sprinklers' highest productivity was in the pivot sprinkler irrigation system at120dunums and was 108,930 kg. The highest productivity per water unit was0.86in the fixed sprinkler irrigation system of10 and 40 dunums. The efficiency of water use was 86% when the cultivated area was120dunums with the pivot sprinkler irrigation system and87% at40 dunums with the fixed sprinkler irrigation system.

Keywords: transcendent production function, sprinklers' productivity, water use efficiency. Possession of a farm.

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تأثير انظمة الري التكميلي على كفاءة انتاج القمح باستخدام التحليل الحدودي العشوائي

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المستخلص

هدف البحث الى قياس الكفاءة التقنية لانتاج القمح المزروع تحت نظامي ري (الري الثابت والري المحوري) باستخدام التحليل الحدودي العشوائي , جمعت العينة بصورة عشوائية من 267 مزارعا من محافظة صلاح الدين / العراق قسمت العينة حسب نظام الري الى مجموعتين , 187 مزارعا تحت نظام الرش المحوري وبثلاث حيازات (60,80, 120) دونم , و88 مزارعا تحت نظام الرش الثابت وبأربع حيازات (10,20,30,40) دونم , قدرت دالة الانتاج المتسامية لمعرفة تاثير عوامل الانتاج على الكمية المنتجة من القمح وتبين ان زيادة العمل المكنني وكمية المياه المضافة بنسبة 1% فان انتاج القمح يزداد بنسبة 0.08 ,0.15 % على الترتيب وان الكفاءة التقنية للرش المحوري بلغ متوسطها 0.86 وللري الثابت بلغ متوسطها 0.84 , وارتبطت الكفاءة التقنية طرديا بالخبرة بالري التكميلي والمساحة المزروعة والعمر وعكسيا بحجم العائلة والخبرة في زراعة المحصول , وان المزارعين مالكي المكننة هم اكثر كفاءة من مؤجريها , وان اعلى انتاجية للمرشة كانت في نظام الري المحوري 120 دونم اذ بلغت 108930 كغم , وان اعلى انتاجية لوحدة المياه في الري الثابت بلغت اعلى ما يمكن في حيازات 10 , 40 دونم اذ بلغت 0.86 . وتناسبت كفاءة استخدام المياه طرديا مع حجم الحيازة فبلغت 86 % عند حيازة 120 دونم في نظام الرش المحوري و87 % عند 40 دونم في نظام الرش الثابت .

الكلمات المفتوحة: دالة الانتاج المتسامية, انتاجية المرشة, كفاءة استخدام المياه, الحيازة.

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INTRODUCTION

Rainfed regions in Iraq are classified under arid and semi-arid. In addition to water losses as a result of using the wrong irrigation methods, farmers tend to waste irrigation water as a result of their incorrect perceptions about how much water crops need and their expectations about the amount of rain, as well as the lack of necessary legislation and laws to manage water resources. All of this had a negative impact on grains yield (wheat) and irrigation water use efficiency as well. The total area of rainfed regions 14.6 million dunams classified depending on the average amount of precipitation into guaranteed precipitation region (>450 mm) with 1.8 million dunams, semi-guaranteed precipitation region (350-450 mm) with 4.4 million dunams, and non-guaranteed precipitation region (100-350 mm) with 8.4 million dunams which representing 12, 30 and 58%, respectively. Rainfed farming is the main source of grain crop yield (wheat and barley) in Iraq (3). Statistics studied indicated that about 85% of wheat production and 48% of barley production fell under rainfed cultivation conditions during the past four decades. Still, the productivity of wheat and barley in this region was very low. This decrease in grain crop productivity rates has led to low self-sufficiency ratios of the major grain crops in Iraq. Because the agriculture sector consumes 80%–90% of the water available for irrigation purposes, any water-saving must come from the agricultural sector. This requires increasing the efficiency of water use. Therefore, the focus is on producing a yield greater than the available water resources or using less water to achieve the same outcomes. In Iraq, grain production in the rainfed regions with a high risk depends on fluctuating climatic conditions. The grain will be subject to these fluctuations and instability as well. Water precipitation is a reliable source for food production in such environments. In general, the annual precipitation rates are way less than water crops' needs for obtaining an economic yield, and the soil water storage in the root zone is insufficient to secure the water crops' needs during the growing season (12). Modern technology, through its various tools, has produced significant positive changes to increase the productivity of the available and limited yield elements, especially in rainfed agriculture, in a way that enables greater output from the same resources or the same product with fewer resources (7)(16). Supplementary irrigation is a technique defined as adding water to rainfed crops when precipitation does not secure enough moisture for the plants to grow normally to improve crop yields and stability (18). In light of the unstable productive conditions of rainfed agriculture, which is the main source of grain production (wheat and barley), and the deterioration of productivity in many agricultural systems suffering from fluctuating precipitation rates, many Arab countries have tended to apply supplementary irrigation technology to secure the water crops' needs, reduce dependency on precipitation and reduce risk). Improving irrigation use efficiency is an essential factor in improving wheat production in Iraq, which suffers from a large food gap (11). Supplementary irrigation technology has recently been introduced and used in agricultural activities to increase and stabilize crop yields, improve water use efficiency, and increase farm income. Therefore, most developed countries have taken this modern method to establish other components' productivity and increase productivity and yield for this important strategic crop. Wheat is an important strategic crop and a major dietary component. This crop yield rate and productivity have declined in Salah Al-Din Governorate, which does not reflect a rational use of available resources due to not using scientific methods, a low technical level and inefficient use of resources resulting in higher costs and lower achieved economic returns. This could be related to the ability to maintain increasing wheat crop yield by increasing agricultural resource productivity to higher levels through the adoption and spread of modern technologies in the cultivation of the wheat crop, like using modern irrigation methods. Low yield levels of the wheat crop in Salah Al-Din Governorate are an indicator that reflects the inefficiency in resource use, the accompanying waste in the use of those resources and the inefficiency in yield. This could lead to a discrepancy in the actual yield and may not be achieved on the ground due to a lack of technical capacity. That means that wheat-producing farms have less than planned-for technical competence, and the estimation of technical efficiency exceeds problems faced by the farmers in this study. The results indicated that irrigation methods used are in a lack of production as compared to used economic resources, which is considered one of the main reasons to conduct such a study and lack of quantitative studies that guide wheat farmers to make the right decisions. The study aimed to measure the technical efficiency regarding the water-use efficiency, using fixed and pivot sprinkler irrigation systems, on the efficiency of wheat yield by estimating the Stochastic Frontier Production Function and by focusing on yield inputs to identify the amount of the inefficiency parameter for each farm, represented by the random variable ui.

MATERIALS AND METHODS

Study area and aata collection

This study was based on primary data collected from wheat crop growers who used the supplementary irrigation methods (fixed and pivot sprinkler irrigation systems) at Salah Al-Din Governorate/Iraq for the growing seasons 2019 and 2020. Salah Al-Din Governorate is a governorate in Iraq, north of Baghdad. The capital is Tikrit; the governorate also contains the significantly larger city of Samarra. The province located on a longitude of 43.35° east and latitude of 34.27° north. The governorate has an area of 24,363 square kilometers (9,407 sq mi). The estimated population is 1,042,200. The governorate has a semi-arid climate, high temperatures, high evaporation, high humidity, high wind speed and fluctuating precipitation rates. Collecting data from farmers relied on a direct questionnaire form, prepared for the study, and composed a personal interview style with each farmer to obtain the required data. Data were collected randomly from each agricultural division compared to the community's size in the farming division. The questionnaire has conducted from 87 farmers who used a fixed sprinkler irrigation system with four categories of possession: 10, 20, 30, and 40 dunums, and 180 farmers who have used a pivot sprinkler irrigation system with three categories of possession: 600, 80 and 120 dunums. The total sample was 267 farmers. The study used the quantitative and econometric approach to estimate the stochastic frontier production function and the farmers' technical efficiency. Logarithmic Transcendent production function frontiers are one of the most widespread functional formulas and homogeneous. This functional form can be used in the empirical analysis of multiple-output and multiple-input technologies. Those functions can deal with more than two productive factors. The other functions like the Cobb-Douglas production function, the elasticity of substitution is constant and equal to unity won't be a good fit. The limitation of these functions led to the development of many formats, like logarithmic transcendental production function frontiers, to test the hypotheses of separability, substitution, symmetry, and economies of scale rather than presupposing them. A stochastic frontier analysis (SFA) method is suitable for studying farmers' efficiency that suffers from problems and significant variations in the data. It also has the ability to interpret covariance in terms of independent variables within linear and quadratic variables and with arbitrary numbers of production factors (4).

Stochastic Frontier Production Function

Stochastic frontier analysis (SFA) is a method of economic modelling that considers random error and requires predetermination of the model used. The possibility of inefficiency when describing the model is inaccurate as it requires econometrics as a method of estimation (12). It has starting point in the stochastic production frontier models simultaneously introduced by Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977). The first term is a random error with zero means, assumed to be involved in the traditional linear regression model. The second term is a non-negative random variable taken to account for technical inefficiency in the observation period(15). Technical efficiency (TE) was estimated using the SFA method according to the highest logarithmic transcendent production function (TL) for wheat farmers to evaluate the achieved efficiency using supplementary irrigation technology. In this case, the focus will be on the main inputs in production that the farmers used in the research sample. It was used to calculate and estimate the technical proficiency software Frontier 4.1 to estimate the random production limits and obtain estimates of the function's maximum parameters. The estimation process goes through three steps (14) by using the Translog function to estimate technical efficiency is assumed to be defined by (19,6):

Y_{it}=exp= (BLnx_{it}+v_{it}-u_{it}) ………….(1)

$LnY_i = \beta o + \beta_1 \ Ln \ X_1 + \beta_2 \ Ln \ X_2 + \beta_3 LnX_3 + \beta_4 LnX_4 + \beta + \beta_{11} (Ln \ X_1)^2 + \beta_{22}(Ln \ X_2)^2 + \beta_{33} (Ln \ X_3)^2 + \beta_{44}(Ln \ X_4)^2 \beta_{55} (Ln \ X_5)^2 + \beta_{66}(Ln \ X_6)^2 + \beta_{77} (Ln \ X_7)^2 + \beta_{1\rightarrow 7} Ln \ X_1 \ Ln \ X_2 \ Ln \ X_3 \ Ln \ X_4 lnX_5 + LnX_6 \ Ln \ X_7 + (V_i - U_{it})$ ………………………….... (2)

$U_{it} = \delta z_{it} + w_{it}$……… (3)

Where:

Y: dependant variable represents wheat production in kg

βo: constant

β_m: parameters

X_m: independent variants include

X_1: Area of irrigated land (dunums).

X_2: Amount of pesticides (litres).

X_3: Hours of family labour and hired labour (hours).

X_4: Hours of mechanized work (hours).

X_5: Amount of added water (m^3).

X_6: Quantity of seeds (kg).

X_7: Amount of fertilizer (kg).

V_i: A random variable or measurement error related to variables beyond the farmers' control, such as precipitation, or sometimes called a specification error, a normal distribution with mean zero and variance δ.

U_i: Non-negative random variable refers to the inefficiency variables, a one-sided distribution of zero with mean δz_{it} and variance of n (δz_{it}, δ) …… δ2. (9).

Z_{it} = Explanatory variables that correlate with inefficiency

The inefficiency model is defined by:

$U_{it}=D_0+D_1Z_1+D_2Z_2+D_3Z_3+D_4Z_4+D_5Z_5$… (4)

Where:

D_1- D_5: Parameters of the inefficiency model

Z_1 - Z_5: Management variables include.

Z_1: Family size

Z_2: Educational level, expressed as [1 (illiterate), 2 (elementary), 3 (intermediate), 4 (high school), 5 (college), 6 (higher)].

Z_3: Experience in supplemental irrigation (year).

Z_4: Age of farmer (year).

Z_5: Experience in farming (year).

RESULTS AND DISCUSSION

Estimation of the logarithmic transcendent production function (TL) according to stochastic frontier analysis (SFA):

The estimated model, according to stochastic frontier analysis (SFA), is a dependent variable as the quantity of wheat production, and the independent variables are area, amount of pesticides, the hours of family labour and hired labour, hours of mechanization work, amount of added water, amount of seeds and amount of fertilizers. The inefficiency variables were represented by the management variables and included family size, educational level, experience in supplementary irrigation, age of the farmer and experience in farming. Parameter estimates for this stochastic frontier production function are obtained using the Frontier 4.1 software using coefficients estimated by the maximum likelihood (ML) model based on the assumption that values follow an asymptotic standard normal distribution. Coefficients with nonlinear regression cannot be estimated by OLS. However, it is used as a step in the estimation because it gives the best non-biased linear estimate of the coefficients except for the disconnected part of the y-axis B_0. Then we used the COLS method as a second step to obtain unbiased linear parameters. In the third step, the model estimates the ML method to obtain maximum likelihood estimates for the production function parameters. The logarithmic transcendent production function (TL) results were according to the (ML) method and according to stochastic frontier analysis (SFA) shown in Table (1).

Table 1. Estimated logarithmic transcendent production function (TL) using Maximum Likelihood (ML) method.

param.	Cof.	st.	t-r.
Beta0	5.705747	0.89461	6.377887***
Beta1	0.796654	0.11782	6.761548***
Beta2	0.074872	0.08068	0.928073
Beta3	0.046335	0.02955	1.567808**
Beta4	0.085017	0.02979	2.85401***
Beta5	0.150022	0.10857	1.381777*
Beta6	-0.03938	0.06622	-0.59471
Beta7	0.058914	0.04384	1.343722*
TE EFFECTS MODEL (inefficiency)			
Delta0	-1.12727	1.1344	-0.99372
Delta1	-0.0429	0.03699	-1.15958**
Delta2	0.025467	0.05958	0.427483
Delta3	0.003093	0.01028	0.300952
Delta4	0.023332	0.01346	1.73348**
Delta5	0.019959	0.01922	1.038437*
sigma-squared	0.046428	0.01794	2.587611***
Gamma	0.837111	0.07112	11.76983***
log-likelihood function	0.135		

Source: Researchers using Frontier 4.1 software

Area (X_1): This variable's elasticity value indicates the positive relationship between the area of land and the wheat yield. This means that increasing the area cultivated with wheat crop by 1% leads to an increase in yield by 0.796654%, and this is consistent with the expectations and concepts of economic theory. It is the most influential variable in the yield's size due to the importance of the area in increasing yield. It is also important in supplementary irrigation, especially in pivot-sprinkler irrigation systems, as it needs large areas.

The amount of pesticides (X_2): The variable's tendency was positive and reached 0.074872 with a slight effect. This might be related to the lack of farmers' knowledge of using pesticides, the pesticides' incompatibility and conformity with the pathological symptoms that may appear on the crop, and their use in an unscientific and non-logical way. On the other hand, the absence of agricultural guidance and counselling that must be provided negatively affected this resource because the farmers wanted to buy more pesticide quantities for field control operations requiring them. Still, the high prices in the markets on the one hand and the lack of knowledge of the farm owners of diseases, on the other hand, that affect their crops and the way to prevent that. The hours of family labour and hired labour (X_3): The hours of family labour and hired labour tendency (0.046) coincided with the economic logic, indicating the positive relationship between the hours of family labour and hired labour and yield a clear indication of two things. The first is that wheat yield depends heavily on family labour, especially in small areas due to the abundance of family labour. The second one is that wheat production depends mainly on mechanized work, which has reduced the number of family labour and hired labour and increased family labour and hired labour hours by 1%, so wheat yield will increase by 0.045%. The hours of mechanized work (X_4): The results indicated that the mechanized work hours significantly affect the wheat crop yield. The results showed an elasticity of 0.085, and it conforms to the logic of the economic theory. This indicated an increase in the resource by 1%, which leads to an increase in yield by 0.085%. The effect of mechanization work is evident as wheat production depends on mechanization work. The Amount of Added Water (X_5): The results showed a direct correlation between wheat production and added water with an elasticity value. This indicated an increase in the amount of irrigation water given to the wheat crop from water by 10% will increase wheat production by 1.5. This reflects the effect of the amount of added water on wheat yield and the importance of supplementary irrigation. The Quantity of Seeds (X_6): The results showed an inverse correlation between wheat production and seeds quantity, contrary to the logic of the economic theory, which confirmed the negative impact of this variable. An increase of 1% of seeds will lead to a decrease in yield by 0.0393%. This confirms wasted use of the resource and most farmers' dependence on traditional wheat species due to low prices resulting from insufficient financing. Most of the farmers scatter large quantities of seeds and do not depend on the amounts recommended, and this leads to plant growth density and a struggle to obtain light and food, thus reflecting a decrease in production. The Amount of Fertilizer (X_7): The results showed a positive effect (0.058) between wheat yield and fertilizer. This indicated an increase in the amount of fertilizers by 1% increased wheat production by 0.058%. Regarding the significance of the variables, although the statistical significance is not essential in the ML method's functions, the estimated parameters are efficient and consistent with the limits of error (Ui) with a small sample size (15). Nevertheless, the cultivated area variables and mechanization work hours were significant at the 1% level. Family labour and hired labour hours were significant at the level of 1%. The amount of added water and fertilizer was significant at 10%, while seeds quantity was insignificant. This method can create a model that explains the relationships and limitations of inefficiency in one stage and can measure the level of technical and allocation efficiency of the farm and economic efficiency (8). The inefficiency is conditionally estimated depending on the residuals and the distribution of the residuals. The error resulting from the inefficiency has a one-sided distribution, which comes in the fact that the inefficiency comes from the negative deviation from the borderline efficiency curve. The analysis of inefficiency reflects the levels of management processes and that inefficiency has three models:

The first model, presented by Colli and Battese (1996)(10), depends on the effect of time variation on inefficiency as below:

$$U_{it} = \exp[-\eta(t-T)] \quad \ldots\ldots\ldots\ldots\ldots (6)$$

Where:

Ŋ = Unknown parameters.

t-T = Time variation

The second model, presented by Ziu and Hnauy (1994)(21) to calculate the overlap between the explanatory variables in the inefficiency model, can be defined as:

$$U_{it} = \Sigma z_{it} + \delta z_{it} + w_{it} \quad \ldots\ldots\ldots\ldots\ldots (7)$$

The third model's panel data, presented by Colli and Battese (1995), can be defined as:

$$U_{it} = \delta z_{it} - w_{it} \quad \ldots\ldots\ldots\ldots\ldots (8)$$

Where w_{it} is a random non-perspective variable.

This article used the second model to estimate the impact of economic and social factors (management factors). The results are as follows:

The effect of family size (D_1): The effect was negative and significant at a level of 5%. This indicates that technical efficiency increases when the family's size increases and the family's size is efficient technically. Inefficiency decreases over time, and large families are more efficient than small families. Educational level (D_2): Positive and insignificant. This indicates that farmers with lower educational levels are more technically efficient than educated farmers. The study showed that wheat farmers in the Salah al-Din Governorate do not have complete technical efficiency as wheat farmers depend on experience and agricultural operations rely more on local experience than education. Experience in supplemental irrigation (D_3): Experience in supplemental irrigation was positive. This mean experience has no effect on efficiency because supplemental irrigation was recently introduced and adopted a few years ago, and farmers are still in the early years of experience that affect inefficiency. Age of farmer (D_4): This is positive and about 0.02, which means that the old has been negatively reflected in terms of technical efficiency in the sense that young farmers are more efficient because they can adopt modern knowledge and technology more than the older farmers. Young farmers can change and adapt to new technologies. Experience in wheat crop cultivating (D_5): This is positive and significant at the level of 10%. This indicates that old farmers are less efficient than young farmers, less resourceful, and have poor access to advanced technology. Population variance (σ^2): Population variance was 0.046 and significant at the 1% level. This indicates the validity of the assumed distribution of the composite error. The value of Γ 0.837 was significant at the level of 1%. This indicates that most of the deviation of values from the boundary outcome (the variance of values) of production deviations is due to production inefficiency. The results showed the significance of the logarithm square of the independent variables. The logarithmic function for the maximum likelihood was 0.135, indicating that technical changes positively affect the random variable, then the agricultural yield, and ultimately, the technical efficiency (Table 2). Table 2 showed that the highest value of technical efficiency reached 96% at farm no. 262. That indicated the farm was close to the level of total efficiency as it was able to achieve the highest production among the farms with a limited number of inputs. In other words, this farm produces this amount of production using only 96% of the inputs or less. In comparison, the lowest level of efficiency reached 21% at farm no. 214. This farm reached efficiency and produces the current production or more by using only 21% or less of the current inputs. The average technical efficiency was 85%. This indicated that farmers can increase their production by 15% without increasing their economic resources.Also this means the loss of some economic resources and thus incurred additional costs equal to 15%. In terms of resource costs, it also means that the farmer can produce the exact previous production with less resources, which is approximately 15% less of used resources. The average efficiency indicated a deviation in actual production at optimum production by 15% and that farmers can achieve it if the available economic resources are used optimally. The farm did not achieve 100% of total economic efficiency. Therefore, all farms did not produce the potential production and diverge from it in different percentages. This means these farms have the opportunity to reduce the amounts of economic resources used to obtain the same level of production or to use the amounts of resources used to obtain a higher level of production.

Table 2. Technical efficiency (TE) of the study sample according to stochastic frontier analysis (SFA).

Farm	TE	Farm	TE	Farm	TE	Farm	TE	Farm	TE	Farm	TE
1	0.92	46	0.89	91	0.821	136	0.955	181	0.881	226	0.922
2	0.716	47	0.927	92	0.933	137	0.897	182	0.934	227	0.951
3	0.792	48	0.931	93	0.904	138	0.955	183	0.891	228	0.941
4	0.902	49	0.925	94	0.911	139	0.918	184	0.918	229	0.881
5	0.945	50	0.738	95	0.917	140	0.836	185	0.805	230	0.813
6	0.879	51	0.877	96	0.905	141	0.926	186	0.809	231	0.931
7	0.889	52	0.886	97	0.951	142	0.778	187	0.747	232	0.948
8	0.925	53	0.868	98	0.943	143	0.914	188	0.837	233	0.93
9	0.81	54	0.822	99	0.919	144	0.957	189	0.762	234	0.729
10	0.801	55	0.841	100	0.958	145	0.885	190	0.887	235	0.885
11	0.694	56	0.702	101	0.729	146	0.935	191	0.904	236	0.634
12	0.766	57	0.777	102	0.895	147	0.907	192	0.911	237	0.715
13	0.815	58	0.875	103	0.882	148	0.926	193	0.785	238	0.898
14	0.785	59	0.887	104	0.911	149	0.878	194	0.892	239	0.958
15	0.909	60	0.75	105	0.855	150	0.912	195	0.812	240	0.814
16	0.897	61	0.789	106	0.925	151	0.96	196	0.743	241	0.873
17	0.938	62	0.723	107	0.872	152	0.801	197	0.874	242	0.918
18	0.757	63	0.885	108	0.869	153	0.881	198	0.793	243	0.761
19	0.719	64	0.917	109	0.787	154	0.928	199	0.94	244	0.96
20	0.868	65	0.729	110	0.745	155	0.878	200	0.951	245	0.896
21	0.621	66	0.808	111	0.906	156	0.69	201	0.966	246	0.802
22	0.682	67	0.94	112	0.653	157	0.901	202	0.876	247	0.895

23	0.688	68	0.911	113	0.679	158	0.822	203	0.722	248	0.92
24	0.875	69	0.718	114	0.848	159	0.902	204	0.811	249	0.948
25	0.92	70	0.75	115	0.913	160	0.873	205	0.887	250	0.896
26	0.733	71	0.776	116	0.957	161	0.957	206	0.787	251	0.918
27	0.88	72	0.821	117	0.961	162	0.881	207	0.929	252	0.941
28	0.965	73	0.58	118	0.742	163	0.813	208	0.921	253	0.902
29	0.744	74	0.68	119	0.896	164	0.914	209	0.893	254	0.902
30	0.889	75	0.541	120	0.942	165	0.886	210	0.812	255	0.807
31	0.884	76	0.81	121	0.917	166	0.689	211	0.843	256	0.752
32	0.909	77	0.795	122	0.848	167	0.826	212	0.866	257	0.912
33	0.876	78	0.966	123	0.94	168	0.814	213	0.967	258	0.863
34	0.794	79	0.961	124	0.912	169	0.717	214	0.213	259	0.948
35	0.691	80	0.866	125	0.789	170	0.679	215	0.884	260	0.889
36	0.946	81	0.788	126	0.94	171	0.838	216	0.838	261	0.916
37	0.931	82	0.914	127	0.961	172	0.881	217	0.851	262	0.967
38	0.875	83	0.898	128	0.932	173	0.958	218	0.925	263	0.894
39	0.675	84	0.884	129	0.961	174	0.905	219	0.776	264	0.929
40	0.776	85	0.792	130	0.73	175	0.842	220	0.925	265	0.876
41	0.71	86	0.697	131	0.725	176	0.847	221	0.899	266	0.955
42	0.723	87	0.906	132	0.858	177	0.951	222	0.767	267	0.9
43	0.93	88	0.884	133	0.759	178	0.961	223	0.735	MEAN	0.853
44	0.939	89	0.887	134	0.78	179	0.902	224	0.896		
45	0.756	90	0.898	135	0.631	180	0.95	225	0.914		

Source: Researchers based on the results of technical efficiency obtained by the SAF method

The results showed that 0.37% of farmers had limited technical efficiency between 21 and 50 when dividing technical efficiency levels into different level groups. Given the good use of resources, especially family labour, seeds, and the amount of fertilizer compared to other farms, two farms achieved efficiency between 51 and 60. This accounted for 0.74% of the farmers, and 5.99% achieved technical efficiency levels between 70 and 61. In contrast, 20.97% of farmers achieved between 71 and 80 technical efficiency. The highest technical efficiency level more than (81) has been achieved by 71.91% of the farmers (192 farmers). In general, 248 farms have achieved farmers' technical efficiency by 71%. This reflects the good use of resources (table 3)

Table 3. Levels of technical efficiency and numbers of farmers at each level

The level of technical efficiency	Number of farmers	%
50 – 21	1	0.37
60 – 51	2	0.74
70 – 61	16	5.99
80 – 71	56	20.97
>81	192	71.91

Source: Researchers based on the results of technical efficiency obtained by the SAF method

Relationship between size of possessed farm area and technical efficiency

There have been many attempts to determine the extent of economic size's influence on various economic events in the economic literature. However, sufficient and accurate information was not available on the farms' different sizes possession's economic efficiency. A few studies that dealt with this subject in light of particular hypotheses and data showed the effect of some variables of the economic aspect in the size of the farm on the productivity of the area and the achieved returns. There is no doubt that the economic and social relations from the forms of possession and land management are the main pillar in agricultural economic development in many third world countries, including Iraq. Studying the agricultural possession system's economic emergence and development helps identify the roots of agriculture's problems, especially agricultural ownership. This hinders agricultural development and will also help connect the changes in agricultural investment and what is related to land over time with the economic theory (5). To explain the economic relationship between capacity and productivity of resources that does not go beyond the two sides of the same theory and express by farm's size associated with the owner and lessor of the land. It shows the economic relationship between farm size and resource productivity, defining the concept of the optimal size and the possibilities of achieving efficiency within the limits of what is available and the necessary improvement in the development of this sector measured by the value of what is achieved from the total resources used within an accurate diagnosis that is difficult to measure. This brought around those interested in land use despite all the disadvantages and influence on the offer of labour and capital (2). There is a relationship between farm size and economic efficiency, either because of the production function's economies of capacity or because of relatively low prices and reduced costs resulting in increasing the farm size. The efficiency that accompanies economies of capacity is technical efficiency, while the efficiency that accompanies adjustment of resource prices and the combination of output prices is price efficiency. Therefore, economic efficiency is a function of price efficiency and technical efficiency (13). Some researchers have studied this topic, even from various points. Showed (17) that small farms use land more intensively than large farms. There is an inverse relationship between yield and farm size. (5) have proven that relatively large areas are more efficient by utilizing the available elements for every dinar spent on every item. Ahmed and Sarpras (1) confirmed no relationship between large sizes and efficiency, and Tomas (20) supported these results when he found that small farms are more efficient and productive than large farms, while Al-Azzi (2) proved that the volume of achieved profits is not related to the available land area. In this paper, to explain the relationship between the size of the possession and the technical efficiency, we need to know which efficiency achieved the highest levels. The possession was divided into seven categories: four for fixed sprinkler irrigation systems of 40, 30, 20, and 10 dunums and three categories for irrigation with pivot sprinkler irrigation systems of 120, 80, and 60 dunums as shows in Table 4. Table 4 showsd that the technical efficiency at 10 dunums was 0.71–0.95 with an average of 0.88. This indicated these farmers can still expand the yield and increase it by 0.12%. Maybe because of the improvement in technical efficiency levels within this category (10 dunums) due to the farmer's interest in technical factors like mechanized work in the production process and adopting it by using more human work , while the technical efficiency of the two categories (30 and 20 dunums) decreased in averages of 0.84, 0.85. We concluded from the technical efficiency results that this category's farms could increase their current yield by 0.16 and 0.15% without increasing the resources to produce the potential yield curve, whereas the technical efficiency of 40 dunums increased by 0.73 – 0.96 in an average of 0.87. This indicated the optimal use of the available resources by the farmers in this category. This means that the technical efficiency is directly related to the farm's size under the fixed sprinkler irrigation systems. The category of 40 dunums achieved the highest efficiency and approached the potential yield curve by 13%.

Table 4. The relationship between possession size and technical efficiency

Possession size	Technical efficiency Mean	Min	Max
10	0.88717	0.715	0.951
20	0.85515	0.213	0.967
30	0.84965	0.722	0.96
40	0.87931	0.735	0.967
60	0.85335	0.541	0.965
80	0.83321	0.58	0.966
120	0.86644	0.675	0.961

Source: Researchers based on the results of technical efficiency obtained by the SAF method

The relationship between levels of technical efficiency and some economic variables

To determine the relationship between the size of the family and the technical efficiency, we found that the technical efficiency average in large families is higher than in small families, but there were no significant differences. Table (5) showed a direct relationship between years of experience in supplementary irrigation and technical efficiency levels, which means that more years of experience in supplementary irrigation led to the higher efficiency of wheat growers. As for farmers' experience in cultivating the crop, we found that the category of 18 years or more achieved the highest level of efficiency. When connecting technical efficiency levels together with the variable of age, we found that older farmers achieved higher technical efficiency levels than the youth group. This came from the experience in growing the crop and the farmers of this age group owning capital, which enabled them to use modern technologies in wheat crop cultivation. Education has an important role in building up and developing the rural social structure in developing the capacity for education and scientific thinking. It also enables farmers to use modern scientific methods in agriculture because it aims to develop human capabilities and provide them with the necessary information to work efficiently. The farmers in this study were divided into different educational levels to connect with efficiency levels. We found that farmers who had a high school level had higher technical efficiency because of their combined knowledge and experience. The illiterate level category had a technical efficiency of 0.86 due to the experience factor gained from practicing farming for many years and their specialization in producing wheat crops. As for the type of variable mechanized ownership, the ownership category achieved technical efficiency that outperformed the leasing category. This indicates that wheat farmers own the mechanized device. Regarding the sprinklers' productivity, the results obtained in table (5) showed an inverse relationship between technical efficiency and sprinkler productivity. The possession groups of fixed sprinklers achieved higher technical efficiency than pivot sprinklers due to technical reasons related to the sprinklers' work and weather factors, especially temperature and wind. This leads to an increase the evaporation losses, which affects mainly technical efficiency. Despite its stability in the study, the water unit's productivity achieved the highest technical efficiency in the possession categories 120 and 40 dunums and an efficiency of 0.87 and 0.86. The efficiency of water use achieved good technical efficiency in the possession category 10 dunums.

Table 5. The relationship between technical efficiency and some economic variables

Variables	Technical efficiency
Family size	
Small (1-5)	0.84
Big (>5)	0.85
Experience in supplemental irrigation (year)	
1-10	0.84
11-20	0.86
21 and over	0.87
Experience in the cultivation of wheat crop (year)	
(6 - 1)	0.86
(17 - 7)	0.84
18 فأكثر	0.88
Age (years)	
Youth (1-45)	0.84
elderly (45 and over) The	0.86
Educational level	
illiterate	0.86
elementary	0.85
intermediate	0.85
school high	0.87
college	0.85
higher	0.85
Type of mechanized	
ownership	0.89
Leasing	0.83
sprinkler productivity (kg)	
8,602	0.88
18,171	0.86
25,663	0.85
34,428	0.87
54,222	0.85
73,011	0.83
108,930	0.86
water unit's productivity (kg/m(^{3}	
0.48	0.88
0.46	0.86
0.47	0.85
0.48	0.87
0.49	0.85
0.52	0.83
0.51	0.86
Water use efficiency	
0.79	0.88
0.8	0.85
0.82	0.85
0.82	0.87
0.81	0.85
0.83	0.83
0.8	0.86

Source: Researchers based on the questionnaire form

CONCLUSIONS

By estimating the stochastic frontier production function, the area is one of the most influential wheat production variables. Wheat production under fixed and pivot sprinkler irrigation systems needs specific areas compatible with the irrigation system's size. The inefficiency model included management variables reported that family size is the most influencing variable on the inefficiency. Small families are more efficient than large families. There is a direct relationship between years of experience in supplementary irrigation and technical efficiency levels. The more years of experience in supplementary irrigation, the higher the wheat farmers' efficiency. The sprinkler's productivity in the fixed sprinkler irrigation systems was 34428 kg with a technical efficiency of 0.87. While the pivot sprinkler irrigation systems, the sprinkler's highest productivity in the 120 dunums reached 930108 kg technical efficiency of 0.86. The productivity of the water unit was in direct relationship with the area and technical efficiency. The study recommends providing adequate spaces to use sprinkler irrigation techniques, taking advantage of the large yield and providing the necessary financial support. We recommend building receiving centres close to farms for marketing and maximizing farmers' profits, encouraging marketing, and benefiting from price support.

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