

Economic Efficiency of the Organic Wheat Farming Program in Iraq for Season of 2024-2025

Diana M. Kaleel ^{1*} Zuhail R. Kadhim ² Mohammed J. Ali³
Department of Agricultural Economics, College of Agricultural Engineering Sciences,
University of Baghdad ^{1,2}
Ministry of Agriculture³

diana.majeed2308p@coagri.uobaghdad.edu.iq

zuhail.r.k@coagri.uobaghdad.edu.iq

mohammed.jassem1108a@coagri.uobaghdad.edu.iq

ABSTRACT

Study aimed to measure the technical and allocative efficiency, leading to overall economic efficiency of farmers who adopted organic for wheat production in Iraq, using a targeted sample of 78 wheat farms for the 2024–2025 season. The analysis was conducted using the Stochastic Frontier Analysis (SFA). The sample included farms from Baghdad, Salah al-Din, Mosul, Kirkuk, Anbar, Babil, Wasit, Diwaniyah, and Karbala within the framework of the organic farming program supervised by the Ministry of Agriculture. Results showed that the average technical efficiency for farmers using organic fertilisers (33 farms) was 68%, whereas it was 87% for farmers using biopesticides (45 farms). These findings suggest that farmers could increase production by 32% and 13%, respectively, without any additional economic burden. The study indicated that adopting organic inputs does not automatically lead to maximum efficiency for all farmers, as differences in their ability to manage inputs persist. The average allocative efficiency for users of organic fertilisers and biopesticides was 30% and 24%, respectively. It Farmers could reduce their production costs by 70% and 76% without altering current output levels. Low allocative efficiency may stem from suboptimal input allocation and limited experience with these technologies, which are still in early stages of adoption. Improving resource allocation, enhancing farmer training, and expanding access to organic inputs can significantly improve economic performance and reduce existing efficiency gaps.

Keywords: Economic efficiency, Organic farming, Organic fertilizers, Pesticides, Stochastic frontier analysis

Introduction

Food security, particularly wheat security, is an integral part of a country's national security. It is a vital entity that must be focused on because of its benefits for farmers and their incomes, on the one hand, and for national food security, on the other [15]. Competition between countries to increase production, whether through horizontal or vertical expansion using modern agricultural technologies, [7], and the successive increase in the population has failed to keep pace with the old method of exploiting resources and the needs of the growing population [5]. which necessitated the search for new means and methods to exploit limited agricultural resources by increasing the pace of intensifying the use of new technologies in agriculture and the use of chemical pesticides to control agricultural pests without paying attention to their risks, which resulted in this intensification of harmful consequences for the environment [9]. From this point of view, the inclusion of the concepts of sustainable development and organic agriculture is one of the most important for sustainability, as it helps preserve the environment, natural resources, and human health by adopting very small amounts of fertilisers, chemical pesticides, and radiation [12]. Therefore, organic materials are better than the chemicals used in cultivation processes for improving soil fertility and water retention, as reflected in growth and yield quality [8]. Organic agriculture helps prevent environmental hazards, specifically the protection and preservation of the environment from all types of pollution, which is an important global issue and poses a challenge to achieve the Sustainable Development Goals as a result of the wrong and unconsidered behaviour of humans towards the

environment [6]. Therefore, it has become necessary for agriculturists to provide Demand for chemical-free food crops has grown significantly [2]. Although the extensive application of fertilizers and chemical pesticides has improved agricultural productivity, it has also raised concerns about environmental sustainability and food safety.

it has also led to increased environmental hazards that necessitate the use of organic and biological alternatives to prevent environmental imbalances [4]. The transition from the traditional to the organic agricultural system means, in most cases, a radical and real change across the entire agricultural system [1]. All indications indicate that the local and global environment will be managed by the strength of the GATT agreement, which requires that the products of crops be free of chemical residues and the use of appropriate materials in agricultural transactions, provided that they comply with the conditions and specifications of environmental and health safety in application of the idea of sustainable development from which the international conventions for the protection of the environment have emerged [16]. Efficiency is a prominent concern for decision-makers at the farm level, who are keen to increase production capacity by optimally using resources, thereby achieving the highest output per [19].

Studies have shown the significant role of organic farming in improving the quality of organic products, reducing costs, and ensuring successful and sustainable organic production [8]. They also highlighted the need to enhance farmers' human and social capital, and to expand training programs and

government support to ensure the sustainability of organic farming in areas near cities [17]. The organic agriculture program adopted by the Iraqi Ministry of Agriculture represents an important step toward achieving sustainable agricultural development through the use of biofertilizers, biopesticides, and organic inputs. This approach helps reduce the use of harmful chemicals, thereby lowering pollution levels in soil, water, and air. It also enhances human health and preserves biodiversity by promoting environmentally friendly farming practices. Through this program, the Ministry aims to implement sustainable practices, reduce pollution, and protect natural resources while ensuring food security.

In the last five years, the Department of Crop Protection, in cooperation with the Department of Agricultural Research in Iraq, has conducted numerous research projects

Materials and Methods

The data were obtained from primary sources, represented in the questionnaire, from which 33 forms were collected through personal interviews distributed among target wheat-growing farmers who used organic fertilisers for the wheat crop in the governorates of Baghdad, Salah al-Din, and Kirkuk. In addition, 45 questionnaire forms from farmers who used organic pesticides on wheat crops in the governorates of Karbala, Wasit, and Diwaniyah for the 2024-2025 productive agricultural season were analysed. The study used quantitative analytical methods to achieve the research objectives, including the Stochastic Frontier Analysis (SFA) method, using the 4.1 Frontier program to estimate the parameters of the random frontier production function to assess technical efficiency, and the $\ln Y_i = B_0 + X_i\beta_i + (v_i - u_i)$ where

that have yielded encouraging results, leading to the complete dispensing with chemical fertilisers and their replacement with organic products, while maintaining or even increasing production levels. The local organic fertilisers are manufactured in the laboratories of the Department of Organic Agriculture and the Department of Crop Protection, which are used in fertilising a group of crops, including wheat fields, and the biopesticides/organic pesticides are produced in special laboratories and used in the control of pests and insects that affect various crops. The organic farmers are distributed over several governorates and are followed up on within campaigns carried out by the Department of Crop Protection. The objective of the present analysis was to examine the wheat crop, given its strategic importance to the country's self-sufficiency and food security.

random border cost function to assess allocative efficiency. Efficiency is one indicator of the administration's ability to direct various economic resources [11]. Stochastic frontier production models use a composite error term that comprises inefficiency effects associated with the firm's inefficiency, measurement errors in production, and other uncontrolled effects [14]. Using the stochastic frontier production function and the program FRONTIER 4.1, this function is suitable for studying the production efficiency of sectors that may face certain problems and data variability, as is the case in the agricultural sector. The function includes two error components and takes the following form [10].

Ln: refers to the Natural Logarithm, which is used to transform data, reduce variance,

and make the relationship between variables more suitable for statistical analysis.

B0: represents the constant term (Intercept) in the model, meaning the value of production when all independent variables are equal to zero.

Xi: represents the independent variables included in the model

Bi: represent the regression coefficients, which indicate the extent of the effect of each independent variable on the dependent variable.

Yi: Total quantities of wheat produced

vi: Random error distributed normally and has an arithmetic mean equal to zero and a constant variance

ui: Random variable representing technical inefficiency

To estimate the model parameters and measure technical efficiency, the maximum likelihood method was used, and the stochastic function was transformed into the Translog (Transcendental Logarithmic) function. Therefore, the functional model used to measure technical efficiency using the stochastic frontier approach in the TL form is specified as follows [11].

$$\ln Y_i = B_0 + B_1 \ln X_1 + B_2 \ln X_2 + B_3 \ln X_3 + B_4 \ln X_4 + B_5 \ln X_5 + B_9 (\ln X_1) + B_{10} (\ln X_2) + B_{11} (\ln X_3) + B_{12} (\ln X_4) + B_{13} (\ln X_5) + B_{14} (\ln X_1 \ln X_2 \ln X_3 \ln X_4 \ln X_5) + (v_i - u_i)$$

Yi = production quantities (tons)

B1 to14: represent the regression coefficients, which reflect the effect of the independent variables and the interactions among them on the dependent variable.

X1 = Seed quantities (kg)

X2 = Fertiliser quantities (kg)

X3 = Pesticide quantities (kg)

X4 = Total number of hours of manual work (h)

X5 = Total number of hours of mechanical work (h)

Vi = Random variable (uncontrolled errors)

Ui =A random variable representing technical inefficiency: $U_i = \alpha_0 + \alpha_i z_i$

Zi is including: (Z1- Farm Size, Z2 -Farmer Experience, Z3 -Educational level)

Through the stochastic frontier cost function, allocative efficiency can be obtained [2]:

$$\ln C = X_i \beta + (v_i - u_i)$$

$$\ln C = B_0 + B_1 \ln P_1 + B_2 \ln P_2 + B_3 \ln P_3 + B_4 \ln P_4 + B_5 \ln P_5 + B_6 \ln Y + (v_i - u_i)$$

C = Total production costs (Thousand JDs)

Y = Production quantities (Tons)

P1 = Seed prices (one thousand dinars)

P2 = Fertilizer prices (one thousand dinars)

P3 = Pesticide prices (one thousand dinars)

P4 = Manual work item prices

P5 = Mechanical work prices

Vi = Random variable (uncontrolled errors)

Ui=A random variable representing technical inefficiency: $U_i = \alpha_0 + \alpha_i z_i$

Zi is including (Z1-Farm Size, Z2 -Farmer Experience, Z3-Educational

Results and Discussion

Estimation of the Technical Efficiency of the Use of Organic Fertilizers for the Study Sample for the Agricultural Season 2024-2025.

The model was estimated using stochastic frontier analysis (SFA), in which wheat production was specified as the dependent variable. The explanatory variables included the quantities of seeds, organic fertilizers, pesticides, and human labor hours. The Efficiency effects were modeled using farm management variables, namely the educational level of the farmer, experience

in organic agriculture, and farm size. The model was estimated using the Frontier software based on the Maximum Likelihood (ML) method. The estimation results of the Translog (TL) production function and the technical inefficiency model obtained from

the stochastic frontier analysis are presented in Table 1.

Table 1. Results of the superior logarithmic (TL) production function and the inefficiency model

t- ratio	Standard Erorr	Coefficient	Parameter
-0.10417260	0.34108668	-0.5531888	Beta0
0.11935191	0.10665761	0.12729789	Beta1
0.35430365	0.13154993	0.46608619	Beta2
0.20407496	0.76987944	0.15711311	Beta3
-0.10369830	0.34882627	-0.36171643	Beta4
0.84840931	0.33231829	0.28194194	Beta5
TE EFFECTS MODEL(inefficiency)			
0.11614525	0.55347874	0.55837493	Delta0
-0.13491652	0.13551189	-0.22797063	Delta1
0.34196030	0.52155177	0.91973996	Delta2
0.13852275	0.99218255	0.16066555	Delta3

Source: The researcher's work using Frontier 4.1

Table 1 shows the following data:

Seed quantity x1 : The seed quantity variable signal of 0.12729789 corresponds to the economic logic, indicating the positive relationship between the quantity of seeds used and the output, i.e. increasing the use of the amount of seeds by 1% will lead to an increase in the output by 0.1272%, which reflects a positive effect of this input, but it is limited, and this result is consistent with the agricultural reality, as farmers usually use quantities of seeds close to the optimal level, so the increase in the quantity

of seeds does not achieve a significant increase in the amount of seeds Production,

Amount of organic fertilizers x2: The indicator of the organic fertilizer variable 0.46608619 which is in line with the economic logic indicates the positive relationship between the amount of organic fertilizers used by farmers within the organic agriculture program and the output, i.e. an increase in the use of biological fertilizers by 1% will lead to an increase in the output by 0.4660This reflects the important role of

organic fertilizers in improving soil fertility and increasing productivity, and this is in line with modern trends in sustainable agriculture that emphasize the adoption of organic fertilizers as an alternative to chemical fertilizers,

Pesticide quantity x3: The variable indicated that the amount of pesticides was positive, which is in line with economic logic, and reached 0.15711311, which means that an increase in the use of pesticides by 1% will contribute to increasing production by 0.1571%, and this means that pesticides contribute to reducing crop losses resulting from pests and weeds, and thus reflect positively on the amount of production.

Mechanical working hours x5: It is noted that the variable of the number of mechanical working hours showed its elasticity signal of -0.36171643 which is contrary to the logic of economic theory, and it is negative and indicates that the increase of this resource by 1% leads to a decrease in production by 0.3617%, although the production of wheat depends heavily on mechanical work, but this means that there is a waste in the use of this resource.

Human working hours x4: The reference to the number of human working hours amounting to 0.28194194 came with the economic logic, pointing to the positive relationship between human labor and production, with a clear indication of two things, the first is that the production of wheat depends heavily on family work, especially in small areas due to the availability of family work, and the second thing is that the production of wheat depends heavily on mechanized labor, which led to a reduction in the contribution of human labor, and that the increase in human working hours by 1% is the production of

wheat. It will increase by 0.2819%, which means that human labor still plays a pivotal role in the production process, especially in small farms.

As for the inefficiency model, it includes the following variables: Effect of Farm Size (D1) Negative Appear, which indicates that technical efficiency increases when the size of the farm increases, and the size of the farm is likely to be technically efficient and that large farms are more efficient than small farms, due to the ability of large farms to absorb modern technologies and take advantage of economies of scale in the purchase of agricultural inputs and operations. As for the educational level (D2) It appeared positive, and this indicates that farmers at lower educational levels are more technically competent than educated farmers, i.e. it has an impact on incompetence as wheat farmers in the research sample do not have full technical competence, i.e. farmers with higher scientific levels did not register more technical competence than others, in some cases the farmer who has higher technical experience in the field of wheat cultivation is more efficient than those who The educated farmer. It is clear that the experience in the use of organic fertilizers (D3) parameter came with a positive sign, which means that experience has no effect on efficiency, because the technology of organic (biological) fertilizers has recently been introduced, and it has not yet contributed to raising the efficiency of farmers due to the novelty of its use and the weakness of farmers' experience in applying it optimally.

The production function (TL) was then used to estimate the technical efficiency and the results of the estimate were confirmed in Table 2, where it is clear from the table 2 below that the highest value of technical

efficiency was 96% at the farm sequence 15, which means that the farm approached the level of full technical competence as it was able to achieve the highest output among the farms of the research sample with the same resources more effectively, i.e. this farm produces this amount of production using only 96% of the inputs or less, while less. The level of efficiency reached 36% at the farm sequence 2, as the farm achieving this value must reach the efficiency stage and produce the current amount of output or

more using only 36% or less of the inputs currently used, while the average technical efficiency at the sample level reached 68%, this result indicates that farmers can increase their production by 32% without increasing any amount of economic resources used in the production process, and this indicates that the use of organic fertilizers. It does not necessarily achieve the highest possible efficiency for all farmers, but there is a disparity in the ability to optimally exploit these input.

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

Firm	Technical Efficiency	Firm	Technical Efficiency
1	0.37023204	18	0.89930569
2	0.36312143	19	0.80234274
3	0.40827237	20	0.59979668
4	0.87551496	21	0.38566355
5	0.93101107	22	0.54068561
6	0.52022452	23	0.75784578
7	0.43250414	24	0.83368593
8	0.83587520	25	0.72842213
9	0.59817667	26	0.47771876
10	0.91891763	27	0.42577390
11	0.71819219	28	0.82391353
12	0.58863524	29	0.65811682
13	0.80504420	30	0.53277900
14	0.65878959	31	0.87477094
15	0.96581824	32	0.90094567
16	0.63180875	33	0.93315785
17	0.86255401		

Source: The researcher's work using Frontier 4.1

Estimation of the function of random boundary costs of farms that used organic

(biological) fertilizers for the season 2024-2025:

Table 3. Results of the logarithmic cost function (TL) and inefficiency mode

t- ratio	Standard Errorr	Coefficient	Parameter
-0..35571981	0.47939246	-0.17052940	Beta0
0.45945333	0.83465469	0.38348488	Beta1
0.10241763	0.72582717	0.74337497	Beta2
0.83846759	0.47461889	0.39795256	Beta3
0.11611468	0.46377518	0.53851106	Beta4
0.20870328	0.36006120	0.75145953	Beta5

Source: The researcher's work using Frontier 4.1

Table 3 shows the following data:

Seed prices p1: The signal of the wheat seed parameter appeared positive, which means that there is a direct relationship between seed prices and total production costs, i.e. by increasing seed prices by one unit, the total costs increase by 38%, and this is due to the fact that seeds are one of the main inputs in the production process, and therefore any change in their prices is directly reflected on the total costs, and this value shows that the total costs are less sensitive to seed prices compared to other inputs, so policies should be developed to support or support the stability of seed prices because of the impact of reducing the burden of costs and improving the efficiency of farmers.

organic fertilizer prices P2: The organic fertilizer parameter signal was positive, that is, the increase in the prices of this resource will lead to an increase in the total cost of wheat by 0.74%, that is, the increase in organic (biological) fertilizers contributes to the increase in total costs, and this means that organic fertilizers constitute a substantial part of the total costs of farms and any change in their prices will be directly reflected on the total costs, so we

must focus on managing the costs of organic fertilizers to achieve better economic efficiency, and subsidy policies Reductions in the prices of organic fertilizers may have a tangible impact on reducing costs,

Pesticide prices P3: The price of pesticide supplier parameters indicated positive and has a direct relationship with total costs, and that increasing the price of pesticides by one unit or using an additional unit of this resource will lead to an increase in the total costs of wheat production by 35%, and this reflects that pesticides have an impact on the total cost of production of the crop, but their effect is relatively limited on reducing or increasing the total costs of production.

Mechanical Labor Prices P4: The signal of the mechanical labor element was positive, i.e. with an increase in the price of mechanical labor by 1%, the total cost will increase by 39%, and this means that the labor element contributes to raising the total costs of wheat crop production due to the dependence of this crop on mechanical labor by a large percentage

Manual Labor prices P5: The price signal of the manual labor supplier appeared

positive, and this reflects the direct relationship between the total costs of wheat production and the prices of manual labor used in the production process, i.e. if the price of manual labor increases by one unit, the total cost will increase by 75%, and this reflects the great impact of this resource due to the dependence of a large percentage of these farmers on manual and family labor in special agricultural operations in the production of the wheat crop.

Wheat Production Quantity Y: The value of the explanatory variable represented by the quantity of production is positive, and this means that the relationship between the total quantities of wheat produced and the total production costs appears, as by increasing the production quantities by one unit, the total costs will increase by 37%, meaning that the producer still has the opportunity to achieve the same returns and at a higher cost, i.e. the farmer

can achieve some volume savings or increase efficiency in production.

It is clear from the table 4 below that the highest value of allocation efficiency reached 88% at the farm sequence 23, which means that the farm approached the level of full allocation efficiency, as it was able to achieve the lowest cost among the farms of the research sample, which reflects the optimal use of agricultural inputs, while the lowest level of efficiency was 11% at the farm sequence 11, which is very far from the level of efficiency that achieves the lowest cost for the farmers, which means that there is a waste of resources or an in optimal use of inputs, which leads to A significant increase in costs without a significant improvement in production, while the average allocation efficiency at the sample level reached 30%, this result indicates that farmers can reduce their cost by 70% without increasing any amount of economic resources used in the production process.

Table 4. Allocative efficiency (TE) of the study sample according to the stochastic frontier analysis (SAF)

Firm	Technical Efficiency	Firm	Technical Efficiency
1	0.48260065	18	0.59329812
2	0.17233446	19	0.26757235
3	0.39995320	20	0.35759508
4	0.20612413	21	0.21208978
5	0.21926731	22	0.74037024
6	0.19726188	23	0.88618923
7	0.36383903	24	0.15842511
8	0.25662646	25	0.15671101
9	0.15624495	26	0.86338821
10	0.22541550	27	0.13006399
11	0.11309824	28	0.18509052
12	0.26692091	29	0.34221473
13	0.22575435	30	0.41326148
14	0.23863003	31	0.20767968
15	0.59946709	32	0.15430282
16	0.28637247	33	0.81917108
17	0.76098811		

Source: The researcher's work using Frontier 4.1

Estimation of the technical efficiency of the use of organic (biological) pesticides for the study sample for the agricultural season 2024-2025

The model was characterized according to random boundary analysis, where the dependent variable was the amount of wheat production, while the explanatory variables

were (the amount of seeds, the amount of fertilizers, the amount of organic pesticides, human working hours, and the inefficiency variables, represented by the management variables represented (educational level, experience in organic agriculture, farm size), and the Frontier 4.1 program and the ML method were used to estimate the model, as shown in the table below:

Table 5. Results of the superior logarithmic (TL) production function and the inefficiency model

t-ratio	Standard Error	Coefficients	Parameter
0.15789637	0.30800912	0.48633521	Beta0
0.10290961	0.10227605	0.10525188	Beta1
-0.55883170	0.86010567	-0.48065432	Beta2
-0.94354826	0.46959163	-0.44308236	Beta3
0.83225733	0.96591526	0.80389006	Beta4
0.52619128	0.99431135	0.52319796	Beta5
T E EFFECTS MODEL(inefficiency)			
0.11614525	0.15722346	0.18260758	Delta0
-0.13491652	0.21908266	-0.29557872	Delta1
0.34196030	0.28615291	0.97852936	Delta2
0.13852275	0.33687973	0.46665506	Delta3

Source: The researcher's work using Frontier 4.1

Table 5 shows the following data:

Quantity of seeds x1: The variable elasticity signal was positive and in line with the logic of economic theory, confirming the positive effect of this variable, meaning that increasing the number of seeds by 1% will lead to an increase in the amount of production by 0.10525%, which means that seeds represent one of the main inputs, but

they are not the most influential factor on production, even with the use of high-quality seeds or an increase in quantity, production does not improve unless other inputs are fully optimized.

Amount of fertilizers x2: The signal of the fertilizer variable of -0.480654 is contrary to economic logic, pointing to the inverse relationship of this variable,

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meaning that increasing fertilizers by 1% will lead to a decrease in the amount of production by 0.480654%, meaning that the amount of fertilizers used by farmers exceeds the required level, which confirms that there is a waste in the use of the resource, and also indicates that most farmers use large quantities of fertilizers and do not rely on the recommended quantities, and this leads to plant growth, density and nature. The access to light and food thus reflects in the decrease in production.

Amount of organic pesticides x3: The variable signal came negative and the amount of pesticides is negative, which does not agree with economic logic, and reached 0.4430823, and the reason for this may be due to the farmers' lack of knowledge of the appropriate methods to use these biological pesticides, in addition to their use in an unscientific and systematic manner, which reduces the effectiveness of these pesticides, and on the other hand, and at the same time, the absence of agricultural guidance and extension that must be provided, which in turn reflected negatively on the use of this technology, where it should be focused on determining the optimal quantities for the process of control and improvement of methods of use to reach maximum production without damaging the crop or soil.

Mechanical working hours x5: It is noted that the variable of the number of hours of mechanical work has a significant effect on the production of the wheat crop, as its elasticity signal of 0.8038 showed that it is in accordance with the logic of economic theory, which is positive and indicates an increase in the resource by 1%, which leads to an increase in production by 0.8038%, and the important effect of mechanical work in improving productivity is evident, as the production of wheat

depends heavily on mechanized work, as investing in mechanical work and calculating its methods of operation can It leads to a significant increase in production and thus improves production efficiency.

Human working hours x4: The signal of the number of human working hours, which amounted to 0.52319, corresponded to the economic logic, pointing to the positive relationship between human labor and production, with a clear indication of two things: the first is that wheat production depends heavily on family work, especially in small areas due to the availability of family work, and the second thing is that wheat production depends heavily on mechanized work, which led to a reduction in the contribution of human labor, and an increase in human work hours by 1%, wheat production. It will increase by 0.52319%.

As for the inefficiency model, it includes the following variables:

The effect of farm size (D1) Its signal came negative, and this indicates that technical efficiency increases when the size of the farm increases, and the size of the farm is likely to be technically efficient and that large farms are more efficient than small farms due to the increase in experience and in the farmers benefiting from the advantages of large production and economies of scale. As for the educational level (D2) positive, which means that farmers at lower educational levels are more technically competent than educated farmers, i.e. it has an impact on incompetence where, this is in line with the technical reality of wheat producers, as wheat farmers rely on experience and agricultural operations need local expertise more than certification. It is clear that the experience parameter in the use of biopesticides (D3) came with a positive

sign, which means that experience has no effect on efficiency, because the use of organic (biological) pesticide technology has recently been introduced and the wheat farmers in the research sample are still in the early years of experience that affects inefficiency.

The production function (TL) was then used in estimating the technical efficiency and the results of the estimate were confirmed in Table 6 It is clear from the table below that the highest value of technical efficiency was 97% at the farm sequence 2, meaning that the farm was able to achieve the highest output among the farms of the research sample with the number of productive

resources used, i.e. this farm produces this amount of production using only 97% of the inputs or less, while the lowest level of efficiency was 66% at the farm sequence 16 In order to reach the efficiency stage and produce the current amount of output or more, the farm must use only 34% or less of the inputs currently used, while the average technical efficiency at the sample level is 87%, which is a good percentage, and farmers can increase their production by 13% without increasing the amount of economic resources involved in the production process, and the average efficiency indicates that pesticides can contribute to increasing production when used optimal.

Table 6. Technical efficiency (TE) of the study sample according to the stochastic frontier analysis (SAF)

Firm	Technical Efficiency	Firm	Technical Efficiency
1	0.82825818	24	0.88705014
2	0.97176422	25	0.78031786
3	0.91999432	26	0.84287880
4	0.85389521	27	0.84287880
5	0.71523183	28	0.85343910
6	0.71585606	29	0.79634138
7	0.84310331	30	0.78325195
8	0.72080148	31	0.84749286
9	0.93968995	32	0.82435834
10	0.80293079	33	0.88140458
11	0.86981014	34	0.86052408
12	0.81203337	35	0.69274298
13	0.95461198	36	0.86517962
14	0.76153145	37	0.83015021
15	0.82087574	38	0.77507646
16	0.66878625	39	0.67211220
17	0.90949703	40	0.95583618
18	0.92148156	41	0.88957506
19	0.82970022	42	0.78015351
20	0.98655416	43	0.61765221
22	0.76099920	45	0.96494168
23	0.84283592		

Source: The researcher's work using Frontier 4.1

Estimation of the Random Boundary Cost Function of Farms that Used Organic (Bio) Pesticides for the Season 2024-2025:

Table 7 indicates the results of the Random Boundary Costs function using the Greatest Possibility method as shown

Table 7. Results of the logarithmic cost function (TL) and inefficiency mode

t- ratio	Standard Error	Coefficient	Parameter
-0.15111756	0.14303777	-0.21615519	Beta0
0.27701946	0.92238027	0.25551729	Beta1
-0.15181196	0.11721642	-0.17794855	Beta2
-0.96273626	0.80262328	-0.77271453	Beta3
0.11884631	0.72760864	0.86473606	Beta4
0.47959627	0.72283678	0.34666982	Beta5
0.20988106	0.75697175	0.15887404	Beta6

Source: The researcher's work using Frontier 4.1

Table 7 shows the following data:

P1 Seed prices: The signal of this parameter is positive, i.e. the direct relationship between wheat seed prices and total production costs is positive, i.e. by increasing seed prices by 1%, the total total cost of producing this crop will increase by 25%, but this effect of seed prices on the production costs of wheat is still limited, and farmers can better absorb price fluctuations from other less influential variables.

P2 Fertilizer Prices: The Fertilizer Price Supplier Signal is negative, which means that the increase in the prices of fertilizers used in the cultivation of this crop will lead to a reduction in production costs by 17%, as the negative signal of this parameter reflects that farmers may take fewer measures to reduce the use of fertilizers when their prices rise.

P3 Organic Pesticide Prices: The price signal of the biopesticide supplier appeared negative, and this is due to the inverse relationship between the prices of pesticides used and the total production costs, as by increasing the prices of pesticides by one unit, it leads to a reduction in the production cost by an estimated 77%, that is, a slight increase in the prices of pesticides may be directly reflected on the production costs, which makes their effective management important in improving the economic efficiency of the study sample, and that the increase in pesticide prices may increase the total cost of the crop if it is not The amount and method of use are adjusted.

P4 Mechanical Work Prices: The indicator of the price of the mechanized labor resource was positive, and this

indicates the direct relationship between automated labor and the total production costs, as increasing the price of automated labor hours by one unit, the total cost will increase by 86%, as improving the efficiency of its use or controlling its cost can lead to a reduction in costs, and it also indicates that farmers rely heavily on mechanized labor in the production process.

P5 Manual (Human) Labor Prices:

This parameter of the price of the manual labor resource was positive and indicates the direct relationship between the prices of human labor and the total cost of production, as by increasing the price of human labor hours by one unit, the total total costs of the wheat crop will increase by 34%, and this indicates that human labor is less important than mechanical labor in the production process of this crop due to the reliance of most agricultural processes of the wheat crop on the use of mechanical labor.

Quantities of wheat produced Y: The value of the explanatory variable represented by the production quantities of the wheat crop appeared positive, which represents the direct relationship between the quantities produced of this crop and the total cost of

Production, as an increase in production quantities by 1% will increase the total costs by 15%, meaning that the farmer can achieve returns at a higher rate than the costs, and that the increase in production leads to a slight increase in costs due to the benefit of economies of scale and the advantages of large production.

It is clear from the table 8 below that the highest value of allocation efficiency reached 98% at the farm sequence 6, meaning that the farm approached the full efficiency level, as it was able to achieve the output with a limited number of inputs and the lowest cost, while the lowest efficiency level reached 11% at the farm sequence 13. The average allocation efficiency was 24%, which is low and means that farmers do not achieve the optimal level of available resources according to the prevailing prices, and this may be due to the lack of experience in the use of these pesticides, as this technology is in the adoption stage and farmers are in a trial period, which reduces their ability to use the optimal and economically efficient use, and that there is a large gap of 76% that can be improved through training, improving access to this type of pesticide and enhancing the economic awareness of farmers.

Table 8. Allocative efficiency of the study sample according to the stochastic frontier analysis (SAF)

Firm	Technical Efficiency	Firm	Technical Efficiency
1	0.19840036	24	0.24238533
2	0.42031835	25	0.11853269
3	0.46359476	26	0.11843510
4	0.53599372	27	0.14635211
5	0.39623393	28	0.11672911
6	0.98528299	29	0.11239804
7	0.16174428	30	0.15733921
8	0.45011935	31	0.49071061

9	0.20336357	32	0.71918989
10	0.14908267	33	0.31826878
11	0.16897813	34	0.14263693
12	0.29402011	35	0.28286901
13	0.11025231	36	0.30888605
14	0.10763853	37	0.56922040
15	0.19379758	38	0.10828147
16	0.99862752	39	0.75626620
17	0.37029841	40	0.63466896
18	0.41755036	41	0.43558961
19	0.17654160	42	0.11515813
20	0.25991499	43	0.28020120
21	0.32886471	44	0.14063275
22	0.64574189	45	0.14997723
23	0.16644272		

Source: The researcher's work using Frontier 4.1

Conclusion

The research results concluded that farmers who use organic fertilizer technology achieve better outcomes. for the wheat crop did not adopt the scientific method in choosing the optimal combination, as their average technical efficiency reached 68%, which means that there is a waste in the use of productive resources by 32%, while the allocation efficiency for them reached 30%, which is a low percentage, which means that farmers do not achieve the optimal level of available resources according to the prevailing prices, and this may be due to the lack of experience in the use of these pesticides Creating this technology in the adoption phase and farmers in a pilot period, which reduces their ability to use it economically efficiently. As for the farms that used biopesticide technology, their average technical efficiency was 87%, which is a good percentage compared to the farmers who used organic fertilizers, and that there is a waste in the use of resources by only 13%, while the allocation efficiency reached 24 shares, this result is that farmers can reduce their cost by 70% without

increasing any amount of economic resources used in the production process, and the reason for their low efficiency is allocation, and not allocating their inputs in an optimal way and can be achieved. Significant cost savings if resource allocation is optimized in line with the minimum possible costs to produce the same level of output.

Therefore, the research recommends the need to raise the efficiency of the extension system and publish guidance boards for modern technologies in order to spread these technologies over wider areas and then re-evaluate them economically, and emphasize the need to adhere to the recommended quantities and concentrations, whether for organic fertilizers or biopesticides, and focus on increasing government support related to the dissemination of modern and environmentally friendly technologies that achieve the goals of sustainable development, and facilitate farmers' access to them by providing them over a wider range and at state-subsidized prices.

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