The effect of soil analysis applications and soil analysis subsidies on the efficiency of wheat production enterprises in Turkey: case of Edirne Province

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Abstract

In this study, it was determined how the efficiency of agricultural enterprises producing wheat would change if soil analysis was done or not. In Edirne province, three laboratories were selected among the laboratories with the highest number of sample acceptances for soil analysis. Total of 60 producers who applied to the laboratories in 2015 and utilized from soil analysis subsidies, and total of 40 producers with similar characteristics who did not utilize from soil analysis subsidies and consequently, total of 100 producers were interviewed. Data Envelopment Analysis was used to measure efficiency in the enterprises. The average technical efficiency (pure technical efficiency) with variable return to scale was found to be

0.90, technical efficiency coefficient was 0.83 with constant return to scale and scale efficiency was 0.92 in enterprises that had soil analysis. Allocative efficiency was determined as 0.89 on average, and economic efficiency as 0.80 on average. In the enterprises that did not have soil analysis, the technical efficiency (pure technical efficiency) coefficient with variable return to scale was 0.86 on average, the technical efficiency coefficient was 0.78 with constant return to scale and scale efficiency was 0.89. It was determined that the average allocative efficiency for the enterprises that did not have soil analysis was 0.78, and the economic efficiency was 0.68 on average. According to the results of the efficiency analysis, it was determined that the enterprises that had soil analysis operated more effectively and were more successful in terms of input use compared to the enterprises that did not have the analysis.

Keywords: Data environmental analysis. Efficiency. Soil analysis. Wheat.

1. Introduction

For the continuation of life; it is an inevitable fact that there is a need for nutrition, food for nutrition, and fertile soils for healthy food. It is known that plant health affects human and animal health, especially in terms of element deficiency or excess, and causes various diseases. In terms of food safety, both yield decrease and product quality decrease will occur in plants grown in an environment without nutrient balance. (Güleç et al., 2018). Chemical fertilization, which is one of the most important agricultural applications, contributes to production on the one hand and can cause some negativities on the other hand. The amount and time of application are seen as important factors in the occurrence of these negativities. Considering the fact that it is not possible to avoid chemical fertilization on agricultural soils, it is necessary to correct the inaccuracy and especially to support it with organic fertilizers. When chemical fertilizers are applied with a fertilization program prepared based on the analysis results under expert control, their negative effects on the environment will be reduced and economic and high yield potential will be provided.

Soil analysis is a scientific method that reveals the fertilizer requirement of a field soil. The purpose of soil analysis is to reveal the type and amount of fertilizer required by the plants to be grown by determining the amount of plant nutrients in the soil. It is especially necessary to obtain high and quality products from the unit area and to ensure the continuity of soil fertility. If soil analysis is not done, more or less fertilizer can be applied than necessary, or a wrong type of fertilizer can be used. There may even be a timing error in the application (Çolak Esetlili and Anaç, 2014).The amount of plant nutrients in the soil is determined by analyzing the soil sample representing a certain field with various methods in the laboratory. Thus, in order to get a better and higher quality product from the plant to be grown in that soil, the required fertilizer amounts are determined by tdetermining he missing nutrients required by the plant.

In addition to direct income subsidy, the Ministry of Agriculture and Forestry started soil analysis subsidy to farmers who applied organic farming and had soil analysis, with the decision published in 2006, in order to encourage correct and sufficient fertilization and to have soil analysis done. Soil analysis subsidy continued until May 2016. With the decision published on 05.05.2016, it was determined that diesel and fertilizer support would be given to farmers within the field-based supports and soil analysis subsidy was not mentioned among the area-based supports. In accordance with the communiqué numbered 30183 published in the Official Gazette dated 17.09.2017, it was stated that the soil samples would be taken by the technical staff of the authorized soil analysis laboratories using a coordinate determining device.

Wheat is one of the most produced crops in the world and an indispensable crop in the nutrition, trade and crop rotation systems of many countries. Flour, bulgur, pasta, starch obtained from wheat products are used in human nutrition whereas the stems of the wheat plant are used in the paper-cardboard industry and animal nutrition. For this reason, when there is a decrease in wheat production for any reason, both in the world and in Turkey, both the prices of bread or the prices of foodstuffs made from flour directly affect everyone. Therefore, it is of strategic importance for each country to be sufficient in terms of wheat production and to have enough wheat products in their stocks (Süzer, 2022).

Wheat ranks first among cereals in terms of cultivation area and production amount in Turkey. Turkey's wheat cultivation area was approximately 6.9 million hectares in the 2020/21 production season, constituting 3.2% of the world wheat cultivation area and 44% of the total cultivated grain area in Turkey. There was an increase of 1.0% and 6.6%, respectively, in the wheat cultivation area and yield in the 2020/21 production season compared to the previous production season. Total wheat production, on the other hand, increased by 7.9% in the 2020/21 production season compared to the previous season and became 20.5 million tons. In the 2020/21 production season, 478,487 tons of wheat was produced in Edirne province, and the share of wheat production in Turkey was determined as 2.33% (Anonymous, 2022).

While increasing plant and animal production in the agricultural sector was the most important problem in the past, topics such as cost-reducing techniques, marketing of the produced products, rational planning of agricultural activities with minimum costs have started to gain importance at the present time. An extension approach that takes into account the principles of technical extension services as well as the principles of business economics in the adoption of innovations will both increase farmer incomes as a result of the effective use of production factors, and the adoption of innovation by the producer will be shorter and more permanent depending on the increasing farmer incomes (Yılmaz et al. Gürgen, 2008). Providing optimum input use in agriculture is only possible by measuring efficiency.

In terms of the dissemination and adoption of soil analysis applications, the evaluation of the results of the application of soil analysis subsidy with the data obtained from the field is important in terms of guiding the decisions to be taken on the subject. In this study, the effects of soil analysis on the performances of wheat producing enterprises in Edirne, where agricultural production is largely based on wheat production, were analyzed.

2. Literature Review

Various studies were carried out both in Turkey and in different countries on the determination of the efficiency of wheat production.

Hassan and Ahmad (2005) estimated the technical efficiency of the wheat farmers in the mixed farming system of the Punjab by using stochastic frontier production function, incorporating technical inefficiency effect model. The mean predicted technical efficiency of wheat farmers was 0.936 ranging between 0.58 and 0.985. The results of frontier model indicated that wheat production could be increased by increasing wheat area, weedicides, cultivations and fertilizer use.

Alemdar and Ören (2006a) estimated technical efficiencies of wheat growing farmers in Southeastern Anatolia region of Turkey using both parametric and non-parametric methods. According to the results of the data envelopment analysis model, mean efficiencies of wheat growing farmers were estimated to be 0.72 and 0.79 for constant and variable returns to scale assumptions respectively. Predicted technical efficiencies with stochastic frontier models varied widely among farms, ranging between 0.34 and 0.93 and a mean technical efficiency of 0.73.

Alemdar and Ören (2006b) analyzed technical efficiency of wheat growing farms in Southeastern Anatolia region of Turkey. Technical efficiency scores were calculated using an input oriented Data Envelopment Analysis and Tobit regression was used to identify determinant of technical efficiency. Mean efficiencies of wheat growing farmers were estimated to be 0.65 and 0.83 for constant and variable returns to scale assumptions respectively and scale efficiency was estimated as 0.78.

Javed et al. (2008) estimated technical, allocative and economic efficiency and subsequently investigated the determinants of technical, allocative and economic inefficiency of rice-wheat cropping system in Punjab, Pakistan. Technical, allocative and economic efficiencies were estimated by using data environmental analysis technique. The mean technical, allocative and economic efficiency scores of the sample farms were of the order 0.83, 0.477 and 0.402 respectively. Tobit Regression models indicated that farm size, age of farm operator, years of schooling, number of contacts with extension agents, access to credit and farm to market distance were significant determinants of technical efficiency whereas years of schooling,

Konyalı and Gaytancıoğlu (2008) aimed to measure and analyze the efficiency of the inputs used by the wheat-producing enterprises in the Thrace region by using the data environmental analysis method. As a result of their research, they determined that some wheat producers in the region were using excess input. They concluded that the amount of input used affected the yield, the prices of these inputs were higher than the price of wheat, and that the producers did not have enough knowledge of when and how much of a given input to use.

Kaur et al. (2010) analyzed the technical efficiency in wheat production across in different regions of the Punjab state, India. The mean technical efficiency of wheat production was found 87%, 94%, 86% and 87% in semi-hilly, central, south-western and Punjab state as a whole, respectively.

Al-Feel and Al-Basheer (2012) measured the farmer's technical efficiency of producing wheat and determined the main socio-economic factors affecting farmer's technical efficiency of wheat production in Gezira scheme. The study results showed that the mean technical efficiency of wheat production was 63%. The main socio-economic factors determining the farmer's technical efficiency appeared to be, the timing of the different agricultural operations, irrigation and land ownership.

Sohail et al. (2012) examined production efficiency of wheat producing farmers in District Sargodha in Pakistan using farm level data. In the first step, data envelopment analysis was used for the estimation of the farm level technical efficiency scores. Two outputs variables and nine inputs variables were used for estimation of efficiency scores. In the second step, the Tobit regression model was used to explore the impact of on efficiency variables. Technical efficiency was found as 0.87. The study revealed that farm's distance from market and size of farm effected farm's efficiency negatively while a significant positive impact of seed variety and location of water course was found.

Ali and Khan (2014) determined the technical efficiency of wheat production in district Peshawar, Khyber Pakhtunkhwa, Pakistan by using stochastic frontier analysis. The estimated results showed the technical efficiency ranged from 34 to 88%, meanwhile average technical efficiency was 62%. The result showed that the wheat production efficiency were increased with efficient usage of inputs such as fertilizer, tractor and labor. The wheat farmers' education level was also an important factor for wheat production efficiency.

Shahzad et al. (2016) analyzed technical efficiency of wheat farms using data envelopment analysis approach. The mean technical efficiency was estimated as 60.13% through variable return to scale and 56.61% through constant return to scale. It was concluded that the technical efficiency could be improved by educating the young farmers, building road infrastructure and providing access to essential inputs to farmers.

Khodaverdizadeh et al. (2019) estimated technical efficiency of wheat production in Urmia County using data envelopment analysis and stochastic frontier function methods. The results showed that average technical efficiency with DEA and SFA method was 75% and 51%, respectively.

Wana and Sori (2020) estimated the technical efficiency level of wheat production and factors affecting them in Horo district of Horoguduru Wollega Zone, Oromia Region, Ethiopia. The mean technical efficiency of sample household's was 63.9%. Land, seed, DAP and chemical were the variables that positively affected the production of wheat. Results of the factor model revealed that family size, experience in wheat production and extension contact positively and significantly affected technical efficiency. Total cultivated land had a significant negative effect on technical efficiency.

Uzundumlu et al. (2021) compared organic and conventional wheat production in Erzurum province in terms of efficiency and cost to reveal which branch of production was more advantageous. According to fixed and variable return, data envelopment analysis and Bootstrap efficiency values were determined. As a result of the study, according to fixed return, while efficiency was 83.4% in DEA and 80.4% in Bootstrap, respectively. According to the variable return, efficiency was 85.8% in DEA and 81.5% in Bootstrap, respectively.

3. Materials and Methods

The material of the research consisted of data obtained from primary and secondary sources. The primary data of the research consisted of the data obtained from the survey studies conducted with the producers who had soil analysis in 2015 in the laboratories that accepted the most sampling for soil analysis and gave fertilizer advice in Edirne province. Secondary data was obtained from the reports of Turkish Statistical Institute, TR Ministry of Agriculture and Forestry, domestic and foreign universities and extension services and from previous studies.

Three laboratories were selected among the laboratories with the highest number of sample acceptances for soil analysis. The number of surveyed producers was determined as 60 people benefiting from soil analysis subsidy, as 20 producers from each laboratory. Moreover, in the regions where the same laboratories are located, a survey was conducted with a total of 40 producers who did not benefit from soil analysis subsidies, thus total of 100 producers were interviewed.

In the analysis of the obtained data, descriptive statistics such as mean, standard deviation, percentage and cross tables were used. Non-parametric "Data Envelopment Analysis (DEA)" was used to measure the efficiency in the enterprises. Data envelopment analysis is a method that evaluates the relative efficiency for a set of non-parametric and comparable units with some specific mathematical programming models used for the estimation of production limits (Førsund and Sarafoglou, 2002). Data envelopment analysis was developed by the Frontier Production Function proposal put forward for the first time in 1957 by Farrell in response to the average performance criterion, and has taken the present form with the studies of Charnes, Cooper, Banker and Rhodes.

Data envelopment analysis can be used as input and output oriented. Input-oriented DEA models investigate how the most appropriate combination of inputs should be in order to produce a particular output combination most effectively. Output-oriented DEA models (Yolalan, 1993) on the other hand, investigate how much output combination can be obtained with a certain input combination.

Constant returns to scale (CRS) model is valid only when enterprises operate at optimum scale (Coelli et al., 1998). Since the enterprises in the study area are faced with the conditions of imperfect competition, a constraint providing convexity was added to the CRS model, and the model was transformed into a variable return-to-scale (VRS) model. Since the addition of this limiter to the model prevents the scale efficiency from being calculated, the scale efficiency was found by dividing the minimum cost in the CRS conditions by the minimum cost in the VRS conditions (Banker et al., 1984).

Technical efficiency is the success of an enterprise in producing as much output as possible by using the most appropriate combination of inputs. The success of the mentioned production activity in producing at the most appropriate scale is defined as scale efficiency. Economic efficiency is the ratio of the minimum cost of a particular product to the observed cost of the enterprise. Allocative efficiency is about the producers using the input combination that will give the most yield during production and achieving this with the lowest cost. Resource allocation efficiency was calculated by using the equation below (Coelli et al., 1998).

$$Allocative\ efficiency = \frac{Cost\ efficiency}{Technical\ efficiency}$$

Provided that the technical efficiency of a decision unit is maintained, it can be interpreted that its efficiency will increase when its scale is enlarged. This situation is expressed as increasing return to scale (IRS). When the scale of a decision unit is decreased by maintaining its technical efficiency, its efficiency will increase and it is expressed as Decreasing Return to Scale-DRS. The assumption that the intervals of increasing, decreasing and contant returns to scale can coexist at the production frontier is expressed with the concept of variable returns to scale (Coelli et al., 1998).

In efficiency analysis, enterprises with an efficiency coefficient with 1 can be classified as full efficient, those between 0.95 and 1 as efficient, those between 0.90 and 0.95 as less efficient, and those below 0.90 as inefficient (Charnes et al., 1978). The DEAP 2.1 package program developed by Coelli (1996) was used to estimate the efficiency measures.

In this study, a two-stage approach was used to determine the effects of various variables on efficiency. The two-stage method is recommended as it does not require any prior assumptions about the effect of the variables and can be used with more than one continuous or discrete variable. In the first step of this approach, efficiency coefficients are obtained for each enterprise. In the second stage, the relationship between the variables that may affect the efficiency and the efficiency is estimated by means of the appropriate regression model (Coelli et al., 1998).

Since the efficiency coefficients range from 0 to 1, the "tobit regression" was used in this study, since the classical least squares method would overestimate the coefficients. The Tobit model is an econometric method proposed by James Tobin to describe the relationship between a non-negative dependent variable and an independent variable or vector. It is known as the censored sample model, in which the information of the dependent variable is only available for some observations. It is a non-parametric alternative of the least squares regression (Liao, 1994).

Since producers tend to control their inputs more than outputs, the input-oriented efficiency measures of Farrell (1957) were used in this study. In the model, yield per decare was taken as output variable, and labor (h), fuel (l), nitrogen amount (kg), phosphorus amount (kg) and pesticides costs (TRY) were taken as basic inputs and consequently, a five input and single-output model was created.

4. Results and Discussion

Descriptive statistics of the variables used in the efficiency analysis are given in Table 1. In the enterprises that had soil analysis, it was stated that an average enterprise had a yield of 464.67 kg/da from wheat production, and 1.44 h/ha of labor, 7.42 l/da of fuel, 20.88 kg/da of nitrogen, 4.76 kg/da of phosphorus were used and 39.82 TRY/da of pesticides was spent in order to obtain the yield.

On the other hand, in the enterprises that did not have soil analysis, it was stated that an average enterprise had a yield of 434.02 kg/da from wheat production, and 1.73 h/ha of labor, 8.10 l/da of fuel, 22.11 kg/da of nitrogen, 5.10 kg/da of phosphorus were used and 43.51 TRY/da of pesticides was spent in order to obtain the yield.

Table 1: Descriptive statistics of the variables used in efficiency analysis in wheat production.

Variables	Soil Analysis		No Soil Analysis	
	Mean	Standard deviation	Mean	Standard deviation
Yield (kg/da)	464.67	74.30	434.02	85.15
Labor (h/da)	1.44	0.44	1.73	0.91
Fuel (l/da)	7.42	2.90	8.10	2.85
Nitrogen (kg/da)	20.88	4.90	22.11	4.78
Phosphorus (kg/da)	4.76	1.99	5.10	2.73
Pesticides costs (TRY/da)	39.82	16.12	43.51	14.32

Descriptive statistics of the efficiency scores are given in Table 2. Technical efficiency scores with variable returns to scale (pure technical efficiency) ranged from 0.66 to 1, with an average of 0.90 in the enterprises that had soil analysis. This value indicated that inefficient enterprises could reduce their inputs by 10% without a reduction in output. It was determined that 41.67% of the enterprises had a lower value than the calculated average technical efficiency. With constant return to scale, the technical efficiency coefficient was 0.83 and the scale efficiency was 0.92. Scale efficiency indicated whether the enterprises were at the optimal scale. It was determined that 36.67% of the enterprises had a lower value than the calculated average scale efficiency value. Allocative efficiency for the enterprises that had soil analysis varied between 0.43 and 1, and it was found as 0.89 on average. This value showed that the enterprises spent 11% more than the minimum cost input combination. It was determined that 41.67% of the enterprises had a lower value than the calculated average allocative efficiency value. It was determined that the economic efficiency varied between 0.43 and 1, with an average of 0.80. This value pointed out that other enterprises with economic inadequacy should reduce their operating costs by 20% in order to reach the level of similar and economically efficient enterprises. It was determined that 45% of the enterprises had a lower value than the calculated average economic efficiency coefficient.

The technical efficiency scores with variable returns to scale (pure technical efficiency) varied between 0.52 and 1, with an average of 0.86 in the enterprises that did not have soil analysis. This value indicated that inefficient enterprises could reduce their inputs by 14% without a reduction in output. It was determined that 42.50% of the enterprises had a lower value than the calculated average technical efficiency. With constant return to scale, the technical efficiency coefficient was 0.78 and the scale efficiency was 0.89. It was determined that 42.50% of the enterprises had a lower value than the calculated average scale efficiency value. In the study conducted by Alemdar and Ören (2006a) in the Southeastern Anatolia region, technical efficiency, pure technical efficiency and scale efficiency scores were found as 0.72, 0.79 and 0.92, respectively. In the study conducted by Alemdar and Ören (2006b), technical efficiency, pure technical efficiency and scale efficiency were found as 0.65, 0.83 and 0.78 in wheat production, respectively. In the study carried out by Shahzad et al. (2016) in Pakistan, technical efficiency, pure technical efficiency and scale efficiency were found as 0.57, 0.64 and 0.90, respectively. In the study conducted in Iran by Khodaverdizadeh (2019), technical efficiency was found to be 0.75 in wheat production. Compared to previous studies, it is possible to say that wheat producers in the research region performed better technically.

Allocative efficiency for the enterprises that did not have soil analysis varied between 0.58 and 1, with an average of 0.78. This value indicated that the enterprises spent 22% more than the minimum cost input combination. It was determined that 50% of the enterprises had a lower value than the calculated average allocative efficiency value. It was determined that the economic efficiency varied between 0.40 and 1, with an average of 0.68. This value indicated that other enterprises with economic inadequacy should reduce their operating costs by 32% in order to reach the level of similar and economically efficient enterprises. It was determined that 55% of the enterprises had a lower value than the calculated average economic efficiency coefficient.

Table 2: Descriptive statistics of efficiency scores in wheat production.

Efficiency Scores	Soil Analysis				No Soil Analysis			
	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
Technical efficiency	0.83	0.15	0.49	1.00	0.78	0.19	0.35	1.00
Pure technical efficiency	0.90	0.11	0.66	1.00	0.86	0.13	0.52	1.00
Scale efficiency	0.92	0.10	0.60	1.00	0.89	0.14	0.43	1.00
Allocative efficiency	0.89	0.11	0.43	1.00	0.78	0.11	0.58	1.00
Economic efficiency	0.80	0.16	0.43	1.00	0.68	0.16	0.40	1.00

It was determined that 33.33% of the enterprises that had soil analysis in the research area had a constant return to scale, 61.67% had an increasing return to scale, and 5% had a decreasing return to scale (Table 3). It was determined that the yield obtained by the enterprises with increasing returns to scale was considerably lower than the enterprises with decreasing returns to scale and constant returns to scale. It was determined that the enterprises with constant returns to scale obtained 475.50 kg/da of wheat, but the amount of labor and fuel and the pesticides costs they spent were lower than the enterprises with increasing and decreasing returns to scale.

It was determined that 30% of the enterprises that did not have soil analysis had a constant return to scale, 67.50% had an increasing return to scale, and 2.50% had a decreasing return to scale. It was determined that the efficiency obtained by the enterprises with increasing returns to scale was considerably lower than the enterprises with decreasing returns to scale and constant returns to scale. It was determined that the enterprises with a constant returns to scale obtained 494.22 kg/da of wheat, the amount of labor, fuel and nitrogen and the pesticides costs they spent were lower than the enterprises with increasing and decreasing returns to scale.

Table 3: The results of scale efficiency analysis in wheat producing enterprises.

Soil Analysis

Return to Scale	Frequency	%	Yield (kg/da)	Labor (h/da)	Fuel (l/da)	Nitrogen (kg/da)	Phosphorus (kg/da)	Pesticides (TRY/da)
CRS	20	33.33	475.50	1.37	6.53	19.95	4.37	36.03
DRS	3	5.00	566.67	2.26	12.81	19.89	4.33	40.56
IRS	37	61.67	450.54	1.41	7.46	21.46	5.00	41.81
No Soil Analysis								
Return to Scale	Frequency	%	Yield (kg/da)	Labor (h/da)	Fuel (l/da)	Nitrogen (kg/da)	Phosphorus (kg/da)	Pesticides (TRY/da)
CRS	12	30.00	494.22	1.35	5.66	20.79	6.51	36.67
DRS	1	2.50	500.00	2.00	7.14	26.04	4.00	50.00
IRS	27	67.50	404.81	1.90	9.22	22.55	4.52	46.31

CRS: Constant return to scale, DRS: Decreasing return to scale, IRS: Increasing return to scale

The classification of the enterprises according to technical efficiency is given in Table 4. It was determined that 43.33% of the enterprises that had soil analysis were technically fully efficient. In addition, it was determined that 5% of the enterprises operated effectively, 10% were less efficient, and 41.67% were not technically efficient. It was determined that 45% of the enterprises operated at the optimal scale, in other words, their scale efficiency scores were equal to 1. Besides, it was concluded that 6.67% of the enterprises operated close to the optimal scale.

It was determined that 32.50% of the enterprises that did not have soil analysis were technically fully efficient. In addition, it was determined that 10% of the enterprises operated effectively, 5% were less efficient, and 52.50% were not technically efficient. It was concluded that 40% of the enterprises operated at the optimal scale whereas 10% of the enterprises operated close to the optimal scale.

Table 4: Classification of wheat producing enterprises according to their technical efficiency.

Soil Analysis						
Efficiency Status	Technical Efficiency		Pure Technical Efficiency		Scale Efficieny	
	Frequency	%	Frequency	%	Frequency	%
Full efficient	18	30.00	26	43.33	27	45.00
Efficient	1	1.67	3	5.00	4	6.67
Less efficient	4	6.67	6	10.00	9	15.00
Inefficient	37	61.67	25	41.67	29	48.33
Total	60	100.00	60	100.00	60	100.00
No Soil Analysis						
Full efficient	11	27.50	13	32.50	16	40.00
Efficient	1	2.50	4	10.00	4	10.00
Less efficient	1	2.50	2	5.00	3	7.50
Inefficient	27	67.50	21	52.50	17	42.50
Total	40	100.00	40	100.00	40	100.00

The classification of the enterprises in terms of allocative efficiency and economic efficiency is also performed (Table 5). According to the results obtained, it was determined that 18.33% of the enterprises that had soil analysis were fully efficient, 21.67% efficient and 15% less efficient in terms of resource distribution. It was determined that 45% of the enterprises did not distribute the resources effectively, that is, considering the current technology level and current input prices, a large part of the enterprises produced with the wrong input combination. It was determined that 5% of the enterprises that did not have soil analysis were fully efficient in terms of resource distribution, 2.50% were efficient, 10% were less efficient, and 82.50% did not distribute resources effectively.

It was determined that 18.33% of the enterprises that had soil analysis and 5% of the enterprises that did not have a soil analysis operated fully economic, that is, they continued their production with a minimum cost input combination. It was determined that 11.67% of the enterprises that had soil analysis operated efficient, 5% of them were less efficient, and 65% of them were inefficient. It was determined that 2.50% of the enterprises that did not have soil analysis were efficient, 7.50% were less efficient, while 85% were inefficient economically.

Table 5: Classification of wheat producing enterprises according to resource distribution efficiency and economic efficiency.

Efficiency Status	Allocative Efficiency		Economic Efficiency	
	Frequency	%	Frequency	%
Soil Analysis				
Full efficient	11	18.33	11	18.33
Efficient	13	21.67	7	11.67
Less efficient	9	15.00	3	5.00
Inefficient	27	45.00	39	65.00
Total	60	100.00	60	100.00
No Soil Analysis				
Full efficient	2	5.00	2	5.00
Efficient	1	2.50	1	2.50
Less efficient	4	10.00	3	7.50
Inefficient	33	82.50	34	85.00
Total	40	100.00	40	100.00

The average and optimum input levels and potential improvement rates of the economically inefficient enterprises were also determined (Table 6). According to the results obtained, in order for the enterprises that had soil analysis to become economically efficient, it was determined that the enterprises should make a reduction in the ratios of 6.12% in the labor, 6.05% in the fuel, 18.51% in the nitrogen amount, 15.79% in the phosphorus amount and 47.40% in the pesticide costs.

In order for the enterprises that did not have soil analysis to become economically efficient, it was determined that the enterprises should make a reduction in the ratios of 25.71% in the labor, 14.54% in the fuel, 20.26% in the nitrogen amount, 57.57% in the pesticide costs and an increase of 8.10% in the phosphorus amount.

Table 6: Average actual and optimum input levels and potential improvement rates of wheat producing businesses that are not economically efficient.

Soil Analysis				
Variables	Actual	Optimum	Difference	PI (%)
Labor (h/da)	1.47	1.38	-0.09	-6.12
Fuel (l/da)	7.77	7.30	-0.47	-6.05
Nitrogen (kg/da)	21.18	17.26	-3.92	-18.51
Phosphorus (kg/da)	4.75	4.00	-0.75	-15.79
Pesticides (TRY/da)	41.08	21.61	-19.47	-47.40
No Soil Analysis				
Variables	Actual	Optimum	Difference	PI (%)
Labor (h/da)	1.75	1.30	-0.45	-25.71
Fuel (l/da)	8.32	7.11	-1.21	-14.54
Nitrogen (kg/da)	22.21	17.71	-4.50	-20.26
Phosphorus (kg/da)	5.06	5.47	0.41	8.10
Pesticides (TRY/da)	44.36	18.82	-25.54	-57.57

PI: Potential improvement rate

Descriptive statistics of the variables used in the Tobit model are given in Table 7. The average age of the farmer was 56.78 years, the average education period was 9.03 years, the average family size was 4.45, and the average agricultural experience was 31.63 years in the enterprises that had soil analysis. The average parcel size where they cultivated wheat was found to be 66.42 da, their farm land average was 606.48 da and the number of membership agricultural organizations was 2.05. It was determined that 57.50% of the producers had non-agricultural income, 75.83% had agricultural insurance, 54.17% used credit in the last three years and 95% used certified seeds. It was determined that 38.33% of the producers encountered risks in agriculture in the last three years and 10.83% of them made contracted production.

The average age of the farmer was 56.13 years, the average education period wass 7.83 years, the average family size was 3.43, and the average agricultural experience was 34.53 years in the enterprises that did not have soil analysis. The average parcel size where they cultivated wheat was found to be 33.31 da, their farm land average was 221.53 da, and the number of membership agricultural organizations was 2.13. It was determined that 55% of the producers had non-agricultural income, 63.75% had agricultural insurance, 56.25% used credit in the last three years and 83.75% used certified seeds. It was determined that 37.50% of the producers encountered risks in agriculture in the last three years and 6.25% of them made contracted production.

Table 7: Descriptive statistics of the variables used in the Tobit model.

Variables	Soil Analysis		No Soil Analysis	
	Average	Standard deviation	Average	Standard deviation
Farmer's age (years)	56.78	12.03	56.13	12.12
Education period (years)	9.03	4.26	7.83	3.23
Family size (person)	4.45	1.85	3.43	1.34
Agricultural experience (years)	31.63	13.49	34.53	12.60
Wheat land (da)	66.42	72.18	33.31	39.60
Total land (da)	606.48	619.60	221.53	205.70
Number of membership organizations	2.05	1.10	2.13	1.28
Non-agricultural income[1]	1.00		1.00	
Agricultural insurance[1]	1.00		1.00	
Credit use in the last three years[1]	1.00		1.00	
Encountering risks in the last three years[1]	0.00		0.00	
Contract production[1]	0.00		0.00	
Seed type[2]	1.00		1.00	

* As a measure of central tendency, the arithmetic mean was used in the range and ratio data, the median in the rank data, and the mode in the classified data.
[1] Included in the model as; no: 0, yes: 1.
[2] Included in the model as; certified seed type: 1, conventional seed type: 2.

The results of Tobit model, which was performed to determine the factors affecting economic efficiency in wheat production, are given in Table 8. In the model, the signs of the majority of the variables were as expected. The agricultural experience of the producer, the status of having non-agricultural income and having agricultural insurance affected the economic efficiency positively whereas the number of the membership organizations, the credit of credit in the last three years and the type of seed affected negatively in the enterprises that had soil analysis. On the other hand, in the enterprises that did not have soil analysis, the land size affected the economic efficiency positively and the age of the farmer, the size of the parcel where they cultivated wheat, the number of the membership organizations, the status of having non-agricultural income, and the use of credit in the last three years affected negatively. These variables were statistically insignificant ($p<0.10$).

The farmer's age had a positive effect on economic efficiency in the enterprises that had soil analysis (p=0.0816). As the age of the farmer increased, economic efficiency increased. This situation can be interpreted as older people were more experienced and could earn more income by using this experience. The education period of the producer affected the economic efficiency positively in both groups, and as the education period increased, the economic efficiency increased. This situation can be interpreted as producers with higher education levels were more conscious and therefore earned more income. In the study conducted by Alemdar and Ören (2006b), it was determined that the age of wheat producers positively affected the technical efficiency, and it was similar to the research result.

In both groups, the family size positively affected economic efficiency. As family size increased, economic efficiency decreased.

In the enterprises that did not have soil analysis, the agricultural experience of the producer affected the economic efficiency positively (p=0.0064). This situation can be interpreted as the producers with high experience took more accurate decisions than the other producers in terms of both the level of input usage and the application of production techniques.

The size of the wheat parcel and the total land size affected the economic efficiency positively in the enterprises that had soil analysis. As the size of the land increased, the yield also increased, which caused an increase in the income and thus the economic efficiency. In the study conducted by Alemdar and Ören (2006b), the wheat parcel size and in the study conducted by Shahzad et al. (2016) in Pakistan, the total land size affected the technical efficiency positively, which were similar to the research result.

In the enterprises that did not have soil analysis, the status of having agricultural insurance affected the economic efficiency positively (p=0.0208) whereas and the type of seed affected negatively (p=0.0289). Besides, it was observed that the use of certified seeds by producers had a positive effect on economic efficiency.

In both groups, it was determined that encountering risks in agriculture in the last three years had a negative effect on economic efficiency. It is possible to say that any negativity encountered in agriculture (frost, hail, flood, etc.) had a negative impact on the yield and income. In both groups, it was determined that the application of contract production affected the economic efficiency positively.

Table 8: Results of Tobit analysis: Factors affecting economic efficiency in wheat production.

Variable	Soil Analysis			No Soil Analysis		
	Coefficient	Standard error	P	Coefficient	Standard error	P
Farmer's age	0.004572	0.002626	0.0816*	-0.005856	0.004079	0.1511
Education period	0.009575	0.004765	0.0445**	0.025326	0.008990	0.0048***
Family size	0.025787	0.010689	0.0158**	0.049023	0.015437	0.0015***
Agricultural experience	0.000802	0.002499	0.7481	0.010603	0.003890	0.0064***
Wheat land	0.000654	0.000275	0.0175**	-0.000433	0.000527	0.4108
Total land	7.62E-05	3.86E-05	0.0484**	3.96E-06	0.000119	0.9735
Number of membership organizations	-0.021739	0.017204	0.2064	-0.018700	0.018384	0.3091
Non- agricultural income	0.028671	0.034881	0.4111	-0.064101	0.051563	0.2138
Agricultural insurance	0.042232	0.054350	0.4371	0.104586	0.045230	0.0208**
Credit use in the last three years	-0.018311	0.039220	0.6406	-0.041871	0.040578	0.3021
Encountering risk in the last three years	-0.084995	0.038811	0.0285**	-0.127023	0.053604	0.0178**
Contract production	0.116633	0.049564	0.0186**	0.349516	0.137512	0.0110**
Seed type	-0.045967	0.066967	0.4925	-0.111671	0.051113	0.0289**
Likelihood rate	10.95445 ***			8.944293 ***		

Significant at * %10 significance level, ** %5 significance level, *** %1 significance level

5. Conclusion

In this study, the effect of soil analysis on the efficiency of wheat production agricultural enterprises was examined. It was determined that the producers who had soil analysis were more educated than the producers who did not have the analysis, and the size of the land they cultivated was higher. It was determined that the rates of having agricultural insurance and contracted production in the producer group who had soil analysis were higher than the producer group who did not have the analysis.

The contribution of soil analysis was evaluated in terms of technical and economic aspects. When the enterprises were evaluated from technically, it was calculated that the technical efficiency scores of the wheat enterprises that had soil analysis were 4.65% higher than those that did not. When the enterprises were evaluated economically, it was calculated that the economic efficiency scores of the wheat enterprises that had soil analysis were 17.65% higher than those that did not. The relevant profitability difference can be shown as the effect of soil analysis subsidies, as well as showing that the inputs were used more effectively.

Technical efficiency scores were found to be higher than economic efficiency scores in both enterprise groups. This result indicated that the producers required more information about choosing the appropriate input combination at the given price level, rather than technical information. Considering the efficiency of resource use, considering the current technology level and current input prices, the rate of producing with the wrong input combination in the enterprises that did not have soil analysis was found to be higher than the enterprises that had soil analysis, and it was seen that the enterprises that had soil analysis used the resources more effectively.

The input use in wheat production in the enterprises that had soil analysis in the research region was higher than the enterprises that did not have soil analysis. This is due to the fact that the producers who had soil analysis applied less fertilizer, which had an important place among the inputs. When chemical fertilizers are applied with a fertilization program prepared based on the analysis results under expert control, their negative effects on the environment will be reduced and economic and high yield potential will be provided. All producers should be obliged to do soil analysis, the subsidies should be conditional on soil analysis, and the necessary opportunities should be created for free soil analysis.

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