# Effect of drip irrigation subsidies on profitability and technical efficiency of maize production in Turkey: Case of Kahramanmaraş Province

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## Abstract

The study aims to determine the effect of drip irrigation support on producer profitability in maize production and empirically evaluate the factors that cause inefficiency. The study zone is Kahramanmaraş province of TR63 region (consist Hatay, Osmaniye, and Kahramanmaraş) in Turkey. The primary data used in the study were obtained through face-to-face surveys from a total of 90 maize producers, 45 of whom received drip irrigation support and 45 who did not receive drip irrigation support. In the study, the economic analysis of maize production was made, and the operating expenditures were determined by the budget analysis method and the alternative cost element method used for the production expenses. In addition, efficiency analysis was carried out with the Stochastic Frontier Analysis approach. Drip irrigation supports played a role in increasing the technical efficiency in maize production. In addition, it has been determined that the profitability of maize producers who took drip irrigation support was higher than those who did not. Enterprises receiving drip irrigation support will be able to reach maximum efficiency when they reduce their input amount by 9.1% without any changes in the output. On the other hand, it was observed that this rate was 20.7% in businesses that did not receive support.

**Keywords:** Drip irrigation supports. Cobb-Douglas. Maize. Stochastic frontier analysis

## 1. Introduction

Maize is a plant whose origin is America and has been cultivated for thousands of years. In the archaeological excavations carried out in the US state of Mexico, it has been determined that the maize kernels and maize cob pieces found in the shelters and caves made of rocks are about 5 thousand years old. On the other hand, in the archaeological studies carried out in Mexico in 1954, maize pollen, which was determined to be approximately 7 thousand years old, was found at a depth of 50-60 m in the soil (Geçit et al. 2009).

Maize is a species that can be cultivated in almost all parts of the world with tropical, subtropical, and temperate climates. Today, maize plants can be grown worldwide except in Antarctica (Geçit et al. 2009).

Maize production has increased significantly in the world and Turkey since the 1970s. There are several main reasons for the increase in maize production in Turkey. The first of these is the increase in yield provided by hybrid seed production, which started to be used in the 1980s. Afterward, the expanding production areas with the increasing demand, the developments in technological applications, and the policies implemented can be shown as the reasons for the improvement in the amount of production. The Southeastern Anatolia Project (GAP), which aims to increase irrigable areas, has pioneered the region to have maize cultivation potential. In addition to these changes, the rising demand with the increasing population is considered the factors that play an active role in enhancing the amount and area of maize production (Bozdemir, 2017).

According to the 2017 report of the International Grains Council (IGC), maize production in the world ranks second after wheat. Maize production is followed by paddy. While maize production in Asian countries comes after wheat and paddy, maize production ranks first in African and Latin American countries. Maize is used as animal feed and human nutrition in Turkey. While Turkey ranks 3rd in maize production, it takes seventh place in terms of cultivation area (IGC, 2018).

The leading countries in the world concerning production and cultivation area are the USA and China as of 2017. These countries are followed by Brazil, the EU, and Argentina, respectively. Turkey realizes 0.6% of the world's grain maize production. Besides, while the USA is the first with 11000 kg/ha in yield, Turkey is in second place with 10000 kg/ha. Canada and Egypt take place after the USA and Turkey in terms of yield. Moreover, Turkey's maize yield is well above the world average (5700 kg/ha) (IGC, 2018).

Turkey has a wide maize cultivation area with its convenient ecology. In addition, utilizing it for many different purposes in Turkey, such as animal feed and human food, can be shown as the reason for intensive maize production. As a result, maize consumption in Turkey reached 7.6 million tons while the production amount was 6.4 million tons in 2016. Imports met this supply gap caused by excessive consumption. Russia, Romania, Bulgaria, Ukraine, Serbia, and Hungary are among Turkey's importers, although it varies by year. In order to eliminate the supply gap, 1.4 million tons of maize were imported in 2016 (NGC, 2017).

Each part of the maize plant, which has a wide range of usage, has an economic value. Maize is part of a total of 4000 different products, either directly or indirectly. Animal feed produced from grain and green parts, fresh consumption, maize flour, canned food, chips, starch, candy, snacks, chewing gum, baby food, toothpaste, oil, alcohol, cleaning materials, salad dressings, ethanol, chocolate products, maize syrup, textile, and cosmetic products can be listed among the usage areas of maize (Özcan, 2009). In addition, the demand for breakfast cereal products has increased with the decrease in traditional and local food consumption due to the changes in consumer nutrition habits (Alexander, 1987). Grain maize used in producing such foods is dried, ground, and processed in the food industry (Jamin and Flores, 1998). Maize, a strategic product among the sectors it provides raw materials, is used in many different areas, and its place in the global market increases the competition between countries.

According to the 2019 report, grain maize is produced on an area of 638.829 ha in Turkey, while Kahramanmaraş contributes 3.76% to the total grain maize production to total production. On the other hand, it was observed that Kahramanmaraş has a share of 1.32% in the silage maize production made on a total area of 500.750 ha in Turkey in 2019. In Kahramanmaraş, 37% of grain maize production and 14.8% of silage maize production are carried out in Türkoğlu and Pazarcık districts (TURKSTAT, 2020). Türkoğlu and Pazarcık districts in Kahramanmaraş province are the places where 37% of grain maize production and 14.8% of silage maize production are made (TURKSTAT, 2020).

In the province of Kahramanmaraş, 156.772 tons of maize were produced in an area of 24.026 ha in 2019, and the average yield was observed to be 8.420 tons/ha. In the same year, 74,442 tons of maize was produced on an area of 8,882 ha in the Pazarcık and Türkoğlu districts, and the average yield was determined as 8,330 tons/ha (TURKSTAT, 2020).

Rural Development Investments Support Program (RDISP) is a rural development program that provides financial resources. It supports the investments of factual and legal people in their economic activities to ensure economic and social development in rural areas. In addition, it aims to encourage investments with projects based on equity funds, which will be made on pressurized irrigation systems (Anonymous, 2010).

The Support Program for the Purchase of Machinery and Equipment within the scope of RDISP aimed to provide financial support as a grant at special rates for the expenditures to be made to purchase specific agricultural machinery and equipment in rural areas. In this context, the supports given in this context have started to be given under Supporting Individual Irrigation Systems within the scope of Rural Development Supports as of 2016.

In recent years, the expansion of irrigated agricultural lands and the more rational use of existing water resources have become more and more important in Turkey. For this reason, pressurized irrigation systems that increase the efficiency of water use have been widely used. Among the pressure irrigation systems, the drip irrigation method is one of the most practical irrigation methods that can be used in conditions where water is scarce, in areas with poor topography, in soils with high water intake, and especially in irrigation of plants with high economic value and sensitive to moisture deficiency in the soil (Ayran, 2009). Thanks to various supports in our country, drip irrigation systems have become widespread. Researching the effectiveness of these supports is essential in understanding the usefulness of the supports and giving direction to future supports.

In this study, the economic analysis of maize production was made in agricultural enterprises that did not receive drip irrigation support, and that received support, and the efficiency of input use is analyzed using the Stochastic Frontier. Also, suggestions have been presented to enhance efficiency based on these findings, along with the factors leading to ineffectiveness have been determined.

## 2. Literature Review

Seyoum et al. (1998) examined the technical efficiency of maize producers in Eastern Ethiopia. In the study, producers were evaluated by dividing them into two sample groups. The producers operating within the scope of the Sasakawa-Global 2000 project were in the first group, and the producers apart from this project were in the second group. In the study, the Stochastic Frontier Analysis (SFA) method was used, and it was observed that there was a positive relationship between the technical efficiency values of the enterprises and socio-economic factors such as age and educational status.

Dhungana et al. (2004) calculated the economic efficiency of maize producer businesses operating in Nepal using the Data Envelopment Analysis (DEA) method. As a result of the study, they observed that the inputs of seeds, labor, fertilizer, and machinery equipment were used more than necessary in the enterprises. In addition, with the Two-Limit Tobit Regression Analysis, it was concluded that the gender and educational status of the business owners positively affected the relationship between their efficiency levels, and this relationship was statistically significant.

Liu (2006) used the Stochastic Frontier Analysis method to determine the technical efficiency of the maize producers in Kenya and the factors that directly lead it. In the study, the data obtained using six different Stochastic Frontier Analysis methods in the literature were compared with each other. The variables used were categorized under five groups: socio-economic variables, enterprise size, infrastructure, credit utilization, and land ownership.

Kaçıra (2007) carried out the efficiency analysis of maize produced in Şanlıurfa by using the Data Envelopment Method for non-parametric data and Stochastic Frontier Analysis for parametric data. The obtained technical efficiency, resource utilization efficiency, and economic efficiency degrees were 81%, 87%, and 77% with DEA, 84%, 78%, and 64% with Stochastic Frontier Analysis. As a result of the applied methods, it was observed that the inefficiency values were high in the agricultural enterprises examined. Moreover, it has been revealed that the number and frequency of irrigation in the enterprise led to statistically significant changes in the efficiency among the socio-economic factors.

Mulinga (2013) estimated the level of technical efficiency in maize production. The Stochastic Production Frontier (SPF) analysis was used to estimate the technical efficiency of producing maize and determine the factors behind inefficiency such as age, educational level, marital status, family size, principal occupation, type of seeds, and extension services. The results indicated that the mean technical efficiency for maize production in both districts is 27% which means that farmers can increase their output by 34% through better use of available resources and existing technology if they are to be technically efficient. In addition, the study concluded that age, educational level, and access to credit were significant variables leading to technical inefficiency in Rwanda.

In the study conducted by Bozdemir (2017) in the province of Konya, the resource utilization efficiency of the agricultural enterprises producing maize was determined. It has been seen that the technical efficiency value of all the examined enterprises is higher than the economic efficiency value. According to the results obtained, the technical efficiency value ranged between 0.646 and 1.000, while the average technical efficiency value was determined to be 0.916. On the other hand, while the economic efficiency value varied between 0.095 and 1.000, the average economic efficiency value was found 0.350, and the resource utilization efficiency value, which was seen to be 0.380 as average, was changed between 0.111 and 1.000.

Paksoy and Ortasöz (2018) conducted a study on the economic analysis of silage and grain maize production activity in the Pazarcık district of Kahramanmaraş province. The share of variable costs in total expenses per hectare for grain maize production in enterprises was 81.80%, and fixed costs as 18.20%. It was determined that fertilization and labor took the most significant share in variable costs, followed by seed, irrigation, and labor from other variable costs. The average grain maize primary product yield in the region was found to be 10,804.3 kg/ha. Accordingly, the cost of 1 kg of grain maize was 0.102 $/kg, and the selling price was 0.113 $/kg, while the government support was 0.008 $/kg, and the net profit was

0.02 $/kg. Therefore, the share of variable costs in total expenses per hectare for silage maize production in enterprises was calculated as 83.44% and fixed costs as 16.56%. It was determined that fertilization and labor were the most substantial share in variable costs, followed by seed, irrigation and labor, and transportation costs.

Aydın et al. (2020) conducted an economic and productivity analysis and determined the technical effectiveness of silage maize in enterprises that benefited from drip irrigation support in Edirne and did not. As a result, total technical efficiency was found to be 0.894, and pure technical efficiency was 0.958 in the enterprises receiving support. On the other hand, in the enterprises that did not benefit from support, the total technical efficiency was 0.846, while the pure technical efficiency was 0.913. Moreover, the results of the economic analysis revealed that silage maize cultivation is more profitable in the supported enterprises. Besides, according to the evaluation of effectiveness analysis, it was seen that the companies that received support operated more effectively than those that did not receive support.

Doğan and Külekçi (2020) determined the efficiency of the enterprises producing silage maize in Iğdır province and the factors affecting the efficiency. According to the results obtained, it was seen that the general technical, pure technique, and scale efficiency of the enterprises producing silage maize were 0.42, 0.94 and 0.44, respectively. It has been examined that pesticide, labor, fertilizer, seed and other variable costs for active enterprises were 83.78%, 59.20%, 54.29%, 41.26% and 3.04% less, and marketing costs were 2.00% higher, respectively, compared to inactive ones. The only factor affecting the efficiency was determined as the age of the operator.

In the study conducted by Elham et al. (2020) in Afghanistan, technical efficiency (0.737), allocative efficiency (0.650) and economic efficiency (0.568). The inputs, including land, labor, seed, fertilizer and pesticide/weedicides, significantly impact maize production, and most of the farms exhibit an increasing return to scales. In addition, Tobit regression was applied to identify the influential factors of the production efficiencies for maize producers. The results indicated that education, family size, farm size, farming experience, contact to extension services, and access to credit have significantly influenced the efficiency level.

## 3. Material and Method

The material of this study consists of the primary data obtained by questionnaire from maize producers who received and did not receive drip irrigation support between 2012-2017 in Kahramanmaraş province. In addition, previous national and international studies and statistics on the subject of the study were also used.

The sample size was calculated according to a simple random sampling method using the following equation (Çiçek and Erkan, 1996).

$$n = \frac{N \times S^2 \times t^2}{(N-1)d^2 + (S^2 \times t^2)} \#(1)$$

where *n*, *S* and *N* are sample size, standard deviation, and the number of total enterprises, respectively, and *d* is the acceptable error (permissible error 10%), *t* is the reliability coefficient (1.645, which represents the 90% reliability).

According to the formula, the calculated sample size was determined to be 45 maize farms. Besides, forty-five producers, who did not utilize drip irrigation subsidies, were interviewed to compare the enterprises in the same region.

In the study, primarily, some important descriptive statistical parameters such as mean, minimum, maximum values, and percentages were used. Also, an economic analysis of maize production was made. Operating expenses were examined by the budget analysis method, and production expenses were determined by the alternative cost element method. Variable costs in the study consist of fertilizer, pesticide, labor, draft power, seeds, fertilizer, pesticide, irrigation costs, and capital enterprises interest. Half of the loan interest rate (3%) determined by the Republic of Turkey Ziraat Bank for crop production in 2018 was used to calculate the capital enterprise interest.

Fixed costs include general administrative expenses, land rent, irrigation equipment-machinery capital depreciation and interest, irrigation systems investment expenses depreciation and interest in enterprises taking advantage of drip irrigation support. On the other hand, in enterprises that do not receive drip irrigation support, fixed costs consist of general administrative expenses and land rent. On the other hand, three percent of variable costs have been taken to calculate general administrative expenses. The tool machine interest was calculated by applying interest to half the machine value. Tool and machinery depreciation was taken as 10% of the total capital (Kıral et al., 1999).

In addition, the costs of the products, gross profit, net profit, and relative profit rates were determined, and economic comparisons were made. In the calculation of these indicators;

$$Gross\ profit = Gross\ production\ value - Variable\ costs \#(2)$$

$$Relative\ (Proportional)\ profit\ = \frac{Gross\ production\ value}{Production\ costs} \#(3)$$

formulas were used (Açıl and Demirci, 1984; Kıral et al.,1999; Tanrıvermiş, 2000).

Stochastic Frontier Model, one of the parametric methods, was used to measure technical efficiency (Coelli et al. 1998). In addition, a separate technical efficiency model has been created for agricultural enterprises that received support and those that did not. The general structure of the Stochastic Frontier Model used in the research was given below (Battese and Coelli, 1995; Coelli et al., 1998).

$$\mathrm{In}(T_i)\ = \mathrm{In}(X_i)\beta + V_i - U_i\ldots\ldots\ (i = 1,\ldots\ldots n)\#(4)$$

In the formula, *Ti* is the output of the ith enterprise; *Xi* represents the inputs of the ith entity; *β* is the parameters that show the relationship between the inputs and the output; *Ui* denotes the non-negative error variable ranges from 0 to 1 and indicates technical efficiency. *Vi* in the formula represents the error term with zero mean, which is not under the control of the enterprise, such as measurement error, climatic conditions, and is independent of *Ui*. According to this method, the technical efficiency for each enterprise was found by dividing the observed production value with the required production value. The following equation was used to calculate the technical efficiency.

$$TE_i = \frac{Y_i}{Y_i^{*\ldots\ldots}}\#(5)$$

In the formula, *TEi* is the technical efficiency of the ith enterprise; *Yi* is the observed production value; *Yi** represents the estimated and expected production value.

The following equation was used to estimate the factors affecting the technical inadequacy of the enterprises.

$$1 - U_i = zi\delta\#(6)$$

In the equation, *zi* represents the vector of independent variables explaining the technical efficiency at the enterprise level, and *δ* represents the parameters to be estimated.

In this study, efficiency was estimated using the Cobb-Douglas type function with discrete normal distribution, the maximum probability method developed by Battese and Coellli (1995). On the other hand, Stochastic Frontier estimates were made using FRONTIER 4.1 developed by Coelli (2007). The SFA Inefficiency Factors model was used to determine the factors causing technical inefficiency.

Maize yield (kg/ha) was used as output in the single output multi-input model. The inputs (explanatory variables) used to obtain this output are drug cost ($/ha), labor cost ($/ha), and fuel (lt/ha).

In determining the factors causing technical inefficiency, seven variables in the data obtained from the enterprises through questionnaires were used. These variables are age (years), education level (years), family size (person), farming experience (years), land size (ha), agricultural income ($), non-agricultural income (if yes 1, if no 0).

## 4. Results and Discussion

### 4.1. Economic analysis results

Maize production costs per unit area in the examined enterprises were given in Table 1. As a result, total production costs were determined as $2183.7/ha in the enterprises receiving support. On the other hand, it has been observed that 61.94% of total production costs were variable costs while and 38.06% were fixed costs. In addition, the most important item of production costs was power costs (19%). Furthermore, it was found that the share of labor costs, which are included in the variable costs, in the total production costs was 9.98%, the share of irrigation costs was 8.55%, the share of seed costs was 7.79%, the share of the annual maintenance and repair fee of the irrigation system was 6.75%, the share of fertilizer costs was 5.18%, and the share of pesticide costs was 2.90%. Finally, it has been determined that the cost item with the highest share in fixed costs was land rent, and its share in total production costs has been observed to be 23.75%.

Total production costs in enterprises that did not receive support were determined as 1772.2 $/ha. The share of variable costs in total production costs was determined as 68.67%, while the share of fixed costs was determined as 31.33%. According to the results, the share of draft power costs, which is considered as variable costs, in total production costs was found 22.83% while the share of labor costs was 12.88%, the share of irrigation costs was 10.71%, the share of seed costs is 9.72%, the share of fertilizer costs was 6.61%, and the share of pesticide costs was 3.92%. It has been determined that the most critical expense element in fixed costs was land rent, and its share in total production costs was determined as 29.27%.

**Table 1: Grain maize production costs ($/ha)**

| Expenses | With Support | | Without Support | |
|---|---|---|---|---|
| | $/ha | % | $/ha | % |
| Labor | 217.8 | 9.98 | 228.2 | 12.88 |
| Power | 414.9 | 19.00 | 404.6 | 22.83 |
| Seed | 170.1 | 7.79 | 172.2 | 9.72 |
| Fertilizer | 113.1 | 5.18 | 117.2 | 6.61 |
| Pesticide | 63.3 | 2.90 | 69.5 | 3.92 |
| Irrigation | 186.7 | 8.55 | 189.8 | 10.71 |
| Irrigation system annual maintenance and repair fee | 147.3 | 6.75 | 0.00 | 0.00 |
| Capital fund interest | 39.4 | 1.80 | 35.4 | 2.00 |
| *Variable cost* | *1352.7* | *61.94* | *1217.0* | *68.67* |
| General administrative expenses | 40.6 | 1.86 | 36.5 | 2.06 |
| Land rent | 518.7 | 23.75 | 518.7 | 29.27 |
| Irrigation equipment-machine capital depreciation | 46.7 | 2.14 | 0.00 | 0.00 |
| Irrigation tool-machine capital interest | 62.2 | 2.85 | 0.00 | 0.00 |
| Depreciation of irrigation systems investment costs | 95.4 | 4.37 | 0.00 | 0.00 |
| Irrigation systems investment costs interest | 67.4 | 3.09 | 0.00 | 0.00 |
| *Fixed costs* | *831.0* | *38.06* | *555.2* | *31.33* |
| *Total production costs* | 2183.7 | 100.00 | 1772.2 | 100.00 |

In the study conducted by Paksoy and Ortasöz (2018), the share of variable costs in the total cost per hectare in grain maize production was 81.80% and fixed costs of 18.20%.

The economic analysis results of grain maize production were given in Table 2. The average yield was 15,322.5 kg/ha in enterprises receiving support and 12,781.8 kg/ha in which did not. The average grain maize sales price in the research region was determined as 0.15 $/kg. The gross production value per unit area, obtained by multiplying the production amount and the sales price, was calculated in the enterprises that received and did not as 2,257.0 $/ha and 1,882.8 $/ha, respectively. Thus, along with the drip irrigation support, the gross production value in the enterprises that received the support reached 3024.7 $/ha.

**Table 2: Cost and profitability indicators in grain maize production**

| Indicators | With Support | Without Support |
|---|---|---|
| Yield (kg/ha) | 15322.5 | 12781.8 |
| Cost of one kg maize ($/kg) | 0.14 | 0.14 |
| Sales price ($/kg) | 0.15 | 0.15 |
| GDP ($/ha) | 2257.0 | 1882.8 |
| GDP + support amount ($/ha) | 3024.7 | |
| Gross profit ($/ha) | 1672.0 | 665.8 |
| Net profit ($/ha) | 841.0 | 110.6 |
| Relative profit | 1.39 | 1.06 |

The unit grain maize costs, calculated by dividing the total production cost by the production amount, were similarly found to be 0.14 $/kg in the enterprises that received support and those that did not. Gross profit values, showing the difference between production value and variable costs, were calculated in enterprises that received and did not as 1,672.0 $/ha and 665.8 $/ha, respectively. The net profit values per unit area were determined in the businesses that took advantage of the support and did not as 841.0 $/ha and 110.6 $/ha, respectively. It was observed that the relative profit ratio in the enterprises that received support and did not was 1.39 and 1.06, respectively. Hence, it was concluded that grain maize cultivation was profitable. Despite this profitability in both business groups, it was seen that this rate was higher in grain maize cultivation in supported enterprises.

In the study conducted by Selvi (2019), it was seen that the product cost in enterprises producing organic silage maize was 0.015 $/kg, and for those enterprises producing conventional silage maize was 0.018 $/kg. Considering the state support, these values were determined as 0.007 $/kg and 0.013 $/kg, respectively. In the study, it has been shown that organic silage maize cultivation is more profitable than the conventional one.

### 4.2. Activity analysis results

Descriptive statistics of dependent and independent variables in the model prepared for efficiency analysis in supported enterprises were given in Table 3. While the average yield in the enterprises is 15,322.5 kg/ha, it has been determined that the average pesticide cost was 63.3 $/ha, the average labor cost was 217.8 $/ha, and the average amount of fuel used was 85.5l.

**Table 3: Summary statistics of the variables used in the Stochastic Frontier Model in supported businesses**

| **Output** | **Minimum** | **Maximum** | **Average** | **Standard Deviation** |
|---|---|---|---|---|
| Yield (kg/ha) | 13000.00 | 18000.00 | 15322.50 | 1739.4 |
| **Production function variables** | | | | |
| Pesticide ($/ha) | 51.0 | 78.0 | 63.3 | 9.3 |
| Labor ($/ha) | 171.0 | 254.0 | 217.8 | 23.1 |
| Fuel (l/ha) | 59.5 | 108.5 | 85.5 | 15.7 |
| **Variables explaining ineffectiveness** | | | | |

| | | | | |
|---|---|---|---|---|
| Age of operator | 27.00 | 70.00 | 50.02 | 9.04 |
| Education level of operator | 5.00 | 15.00 | 8.80 | 2.87 |
| Family size | 2.00 | 8.00 | 4.82 | 1.84 |
| Experience of the operator | 6.00 | 43.00 | 24.67 | 8.36 |
| Land size (ha) | 6.50 | 84.00 | 24.50 | 17.55 |
| Agricultural income ($) | 5186.72 | 72614.11 | 15698.48 | 12940.56 |
| Non-agricultural income (%) | 0.00 | 1.00 | 0.51 | 0.50 |

On the other hand, it has been observed that the average age of the enterprises receiving support was 50.02, the average education period was 8.80 years, and the average number of individuals in the family was 4.82. Moreover, it was determined that the agricultural experience of the enterprises in question was 24.67 years on average and the total irrigated land size was 24.50 hectares. The annual income of the producers receiving support from plant production was 15,698.48 $, and it was concluded that 51% of them have non-agricultural income.

Descriptive statistics of dependent and independent variables in the model formed for efficiency analysis in businesses that did not receive support were given in Table 4. According to the analysis results, it was observed that the average yield was 12,781.8 kg/ha while the average pesticide cost was 69.5 $/ha, the average labor cost was 228.2 $/ha, and the average fuel used was 83.4 l/ha.

On the other hand, it has been determined that the average age of the mentioned enterprises was 49.04 while the average education period was 7.40 years, and the average household size was 3.44. Moreover, their agricultural experience average was 28.73 years, and the total irrigated land size was 16.86 hectares. The annual income of the producers who did not receive support from plant production was 12,816.97 $, and it was observed that 58% of them have non-agricultural income.

**Table 4: Summary statistics of the variables used in the Stochastic Frontier Model in businesses that did not receive support**

| **Output** | **Minimum** | **Maximum** | **Average** | **Standard Deviation** |
|---|---|---|---|---|
| Yield (kg/ha) | 12000.0 | 15500.0 | 12781.8 | 795.9 |
| **Production function variables** | | | | |
| Pesticide ($/ha) | 52.0 | 85.0 | 69.5 | 10.2 |

| | | | | |
|---|---|---|---|---|
| Labor ($/ha) | 176.0 | 282.0 | 228.2 | 38.7 |
| Fuel (l/ha) | 62.0 | 101.0 | 83.4 | 14.7 |
| **Variables explaining ineffectiveness** | | | | |
| Age of operator | 40.00 | 65.00 | 49.04 | 5.72 |
| Education level of operator | 5.00 | 11.00 | 7.40 | 2.53 |
| Family size | 2.00 | 7.00 | 3.44 | 1.44 |
| Experience of the operator | 8.00 | 40.00 | 28.73 | 6.21 |
| Land size (ha) | 4.50 | 75.00 | 16.86 | 15.83 |
| Agricultural income ($) | 3112.03 | 41493.78 | 12816.97 | 9507.82 |
| Non-agricultural income (%) | 0.00 | 1.00 | 0.58 | 0.50 |

The coefficient estimates of the stochastic Cobb-Douglas efficiency frontier analysis and the inefficiency model were given in Table 5.

The variance parameters were statistically significant in the frontier model obtained for grain maize production in the farms that received and did not receive drip irrigation support. This result indicates that technical efficiency affects grain maize production. The $\gamma$ parameter took the value of 0.999 in both business groups, and it was statistically significant. Therefore, it was determined that 99.9% of the variation in yield value obtained from grain maize production in both farm groups was due to technical inefficiency.

For the companies receiving drip irrigation support, the estimated elasticity coefficients for the pesticide, labor, and fuel variables used in grain maize production were -0.135, 0.121 and 0.586, respectively. Among these variables, the results of the pesticide and labor variables were found to be statistically insignificant. On the other hand, the fuel ($p<0.01$) variable was statistically significant. This data shows that the enhancement in the yield value is related to the increase in fuel consumption. In other words, a 10% increase in fuel consumption will result in an improvement of 5.86% in yield.

For the enterprises that did not receive drip irrigation support, the estimated elasticity coefficients for the pesticide, labor and fuel variables used in grain maize production were 0.102, -0.365 and 0.399, respectively. Among these variables, the result of the pesticide variable was found to be statistically insignificant, while labor and fuel ($p<0.10$) variables were found to be statistically significant. On the other hand, it was taught that a 10% increase in these variables would cause a decrease of 3.65% due to labor wages and an increase of 3.99% due to the amount of fuel.

The sum of the coefficients of the explanatory variables was found to be 0.572 in the enterprises that received drip irrigation support and 0.136 in the enterprises that did not. On the other hand, it was found that both business groups had decreasing returns to scale. According to these results, each 1% increase of each coefficient (input) for both business groups will improve the yield by less than 1%.

The average technical efficiency was calculated as 0.909 for businesses that received support and 0.793 for those that did not. This data indicates that the technical inadequacy was lower in the enterprises that receive drip irrigation support. However, as long as the output is preserved, enterprises receiving drip irrigation support will reach maximum efficiency only if they provide an average of 9.1% reduction in input amounts, and those that did not receive support by 20.7%. In the study conducted by Kaçıra (2007), the technical efficiency in maize production was found to be 84% with the Stochastic Frontier. Bozdemir (2017), on the other hand, found the technical efficiency value as 0.916 in maize-producing enterprises. In another study, Aydın et al. (2020) found that technical efficiency in silage maize production in Edirne province was 0.958 in enterprises receiving support and 0.913 in enterprises that did not. In the study conducted by Doğan and Külekçi (2020), it was determined that the technical efficiency level in the enterprises producing silage maize in Iğdır province was 0.94. Finally, Elham et al. (2020) determined the technical efficiency as 0.737 in maize-producing enterprises.

Efficiency analysis results indicate that enterprises that received support were more successful than those that did not and that inputs were used more effectively in grain maize production.

**Table 5: Estimated parameters for frontier and inefficiency models**

| Variables | Parameters | With Support | | Without Support | |
|---|---|---|---|---|---|
| | | Coefficient | Standard Error | Coefficient | Standard Error |
| *Stochastic Frontier Analysis* | | | | | |
| Constant | $\beta_0$ | 6.384*** | 0.465 | 7.197*** | 0.469 |
| Ln (Pesticide) | $\beta_1$ | -0.135 | 0.143 | 0.102 | 0.086 |
| Ln (Labor) | $\beta_2$ | 0.121 | 0.116 | -0.365*** | 0.105 |
| Ln (Fuel) | $\beta_3$ | 0.586*** | 0.060 | 0.399*** | 0.085 |
| Return to Scale | | 0.572 | | 0.136 | |
| *Technical Inefficiency Model* | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Constant | $\delta_0$ | -0.468* | 0.324 | 0.445*** | 0.147 |
| Age | $\delta_1$ | 0.001 | 0.004 | -0.0023* | 0.0014 |
| Education | $\delta_2$ | 0.034 | 0.027 | -0.016** | 0.008 |
| Family size | $\delta_3$ | 0.017*** | 0.005 | 0.0025 | 0.0016 |
| Experience | $\delta_4$ | 0.002 | 0.018 | -0.018** | 0.009 |
| Irrigated land size | $\delta_5$ | -0.001*** | 0.0004 | -0.0001 | -0.0001 |
| Agricultural income | $\delta_6$ | 0.0001** | 0.0007 | 0.00007** | 0.00003 |
| Non-agricultural income | $\delta_7$ | -0.073 | 0.089 | 0.0033*** | 0.0009 |
| *Variance Parameters* | | | | | |
| Sigma square | $\sigma^2$ | 0.0063* | 0.0034 | 0.0033** | 0.0009 |
| Gamma | $\gamma$ | 0.999*** | 0.090 | 0.999** | 0.489 |
| Log possibility function | | 22.763 | | 38.863 | |
| Log possibility ratio (LR) test | | 12.011 | | 14.119 | |
| Average technical efficiency | | 0.909 | | 0.793 | |

Significance levels were shown as *: p<0.1; **: p<0.05; ***: p<0.01.

### 4.3. Technical Inefficiency Model

In the inefficiency effects model, the positive sign on the parameters demonstrates the adverse effects on the technical efficiency of maize yield.

The coefficient of the 'age of the operator' variable was positive and statistically insignificant in the enterprises receiving support. On the other hand, the coefficient of the same variable was negative and statistically significant (p<0.10) in businesses that did not receive support. In other words, the probability of efficient production enhances as the age of the operator increases. Moreover, it has been concluded that older producers are more experienced in agricultural activities and work more effectively in enterprises that did not receive support. These data are supported by the study results of Seyoum et al. (1998), Mulinga (2013), and Doğan and Külekçi (2020).

The coefficient of the 'education' variable of the business owner in the enterprises receiving support was positive and statistically insignificant. On the contrary, in enterprises that did not receive support, the coefficient of the 'education' variable of the operator was negative and statistically significant (p<0.05). These results indicate that the probability of effective production rises as the education level of the business owner increases. Moreover, these outcomes are consistent with the research results of Seyoum et al. (1998), Dhungana et al. (2004), and Mulinga (2013).

The coefficient of the ‘family size’ variable was positive and statistically significant (p<0.01) in the businesses that received support. Thus, as the family size increases in these enterprises, the production efficiency decreases. The coefficient of the ‘family size’ variable is also positive in the businesses that did not receive support, but it was statistically insignificant.

The coefficient of the agricultural ‘experience’ variable of the operator in the enterprises receiving support was positive and statistically insignificant. On the contrary, the coefficient of this variable was negative and statistically significant (p<0.05) in businesses that did not receive support. Thus, as the experience of the owner increases, the production efficiency also rises. This result is compatible with the outcome of Elham et al. (2020).

The coefficient of the ‘irrigated land size’ variable in the enterprises receiving support was negative and statistically significant (p<0.01). As can be understood from this result, technical efficiency increases as the irrigated lands expand. On the other hand, the coefficient of the same variable in the enterprises that did not receive support was negative and statistically insignificant.

In both farm groups, the coefficient of the ‘agricultural income’ variable was positive and statistically significant (p<0.05). Thus, in both groups, it was seen that producers with high agricultural incomes were in animal husbandry activities. Therefore, they were less likely to perform effective production as they cannot spare time for agricultural activities as much as producers engaged in only plant production.

The coefficient of the ‘non-agricultural activity variable of the business owner in the supported enterprises was negative and statistically insignificant. The coefficient of this variable was positive in businesses that did not receive support, and it was statistically significant (p<0.01). This result indicates that any non-agricultural activity of the owner will reduce the possibility of effective production.

## 5. Conclusion

Pressurized irrigation systems such as drip irrigation are used extensively in maize, cotton, red pepper, fruit growing, and greenhouse cultivation in Kahramanmaraş. Farmers adopt drip irrigation support as a supportive tool that has high satisfaction and is desired to continue. Regarding limited water resources, it has been observed that the level of awareness of producers about such irrigation systems is relatively high. Although drip irrigation support does not affect directing the production, it can be said that it plays an active role in changing irrigation methods and evolving into a more effective one.

Efficiency scores were considered in the technical evaluation of the contribution of drip irrigation supports. The fact that the technical efficiency score is high and close to 1 indicates the success of producing the highest possible output by using the input combination of the enterprise in the most appropriate way and the inputs used in product cultivation. In this respect, the evaluation of the technical efficiency scores of the enterprises demonstrates that the producers who receive drip irrigation support work technically 14.63% more effectively than those who do not.

Gross profit has been taken into consideration in the economic evaluation of the contribution of drip irrigation supports. Gross profit is a measure of success used to compare businesses or production activity. Moreover, it provides an opportunity to comment on the comparative competitiveness and sustainability of the enterprise or production activity. A positive gross profit can indicate that an enterprise can meet its changing costs and be successful in management. In this respect, according to the gross profit evaluations of the enterprises examined, it was calculated that the producers who received drip irrigation support earned 151.12% more gross profit than those who did not.

It has been determined that the profitability and efficiency of the enterprises that receive drip irrigation support in Kahramanmaraş are higher than those that use the flood irrigation method. On the other hand, when the total production costs are examined, the total costs of the drip irrigation system are higher than the flood irrigation system. The main reason for this situation is the maintenance and depreciation costs of drip irrigation systems. However, the drip irrigation system provides an advantage in labor costs. While the average yield of maize producers receiving drip irrigation support was calculated as 15,322.5 kg/ha, it was calculated as 12,781.8 kg/ha in those using flood irrigation and did not take support. Although there was no variation in the sales price of grain maize produced in drip irrigation and flood irrigation systems, the difference in profitability and efficiency was due to yield.

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