Determination of resource use efficiency in table tomato (*Solanum lycopersicum)* production*:* Çanakkale province-Turkey sample

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Abstract

Turkey is one of the most prominent tomato producing countries in the world. Tomatoes are in fourth place in the ranking of countries in terms of production area and in third place in terms of quantity of production. According to data from the Food and Agriculture Organization of the United Nations for 2020, Turkey provides 3.60% of the tomato production area worldwide and 7.07% of its production. In this study, it has been aimed to determine the resource use effectiveness of the factors applied in table tomato production in Canakkale province, which is one of the most significant tomato production centers. The data used in the research have been obtained by applying a face-to-face survey from 99 agricultural enterprises identified by the Stratified Sampling Method. Determination coefficient of the estimation equation of table tomato production created with the help of Cobb-Douglas type function is 0.912 and this value has been found significant at a 1% significance level. In the study, the sum of elasticity coefficients of production factors included in the estimation equation prepared for tomato production has been calculated as 0.96. The calculated value indicates that in the production of table tomatoes, there seems to be a reduced return to the scale. The presence of autocorrelation of the equation has been tested by the "Durbin Watson Test". The Durbin Watson test statistic has been found as 1.914, and there seems no autocorrelation between the variables. When the production elasticity coefficients belonging to the arguments, which are included in the equation, have been examined; machine tensile strength and fuel consumption quantity variables have been found to be negative marked. In the estimation equation, seedling number of 1%, machine traction and labor factors have been found to be significant at the level of probability of production elasticity coefficients of 10%. When we consider the marginal efficiency coefficients of inputs used in table tomato production, it is seen that pure fertilizer (13.08), labor force (9.59) and number of seedlings (4.84) factors were found to be used below the economic optimum level, and the amount of use of specified inputs per unit area need to be increased. The marginal coefficient of effectiveness of the agricultural pest control drug used in tomato production is less than 1, and it has been recommended to reduce the use of this input. Other variables included in the estimation equation such as marginal efficiency coefficients related to machine traction power and diesel quantity are negatively marked and these inputs are used in the irrational region in tomato production. The study has revealed that production factors are not used effectively in the production of table tomatoes, which negatively affect the producer's income.

Keywords: Table Tomato Production. Efficiency. Elasticity. Marginal Yield. Marginal Income. Marginal Efficiency. Çanakkale, Turkey.

1. Introduction

Tomato is the most produced, consumed and traded agricultural product in the world. Tomatoes have an excellent source of lycopene (Osemwegi et al., 2010) which is known as a source of vitamins (John et al., 2010), essential minerals and antioxidants that help reduce the risk of breast cancer in women and prostate (Giovannucci, 1999). Also being low in calories and fat, tomatoes are a good storehouse of nutritional fiber without cholesterol (Bai and Lindhout, 2007). Tomatoes (Brasesco et al., 2019), which are used in large quantities in many traditional dishes such as soups, salads, sauces, which are an important component in the way of nutrition of many populations, are used as raw materials in the food industry as well as fresh consumption (Karadas and Ertürk, 2014). Tomatoes, which can be produced almost anywhere in the world, are an important source of employment and income for tomato cultivating countries and rural areas (Çetin and Vardar, 2008; Bayram and Gülser, 2018).

In recent years, the areas allocated to tomato production worldwide and the amount of production have tended to increase (Al-Remi et al., 2018). In parallel with the increase in production, the developments in production technology, the availability of different areas of use of tomatoes and the presence of studies on the positive effects of tomatoes on human health have gradually increased the interest in this sector (Sönmez and Ellialtioğlu, 2014; Gölükçü et al., 2016).

According to data from the Food and Agriculture Organization of the United Nations (FAO), the world tomato production area, which was 4581632 hectares in 2011, reached a total of 5051983 ha in 2020, with an increase of 10.27%. While the volume of world tomato production was 159466859 tons in 2011, it has reached a figure of 186821216 tons with an increase of 17.15% in 2020 (FAO, 2020). Turkey's tomato production area was 181018 ha in 2011, whereas this value reached the level of 181879 ha in 2020 with an increase of 0.48%. Turkey's tomato production amounting to 11003433 tons in 2011 increased to 13204015 tons in 2020 with an increase of 20.00% (FAO, 2020). Despite the limited increases in production areas between 2011-2020, Turkey has made a significant progress in the amount of tomato production depending on the yield obtained per unit area.

As of 2020, Turkey occupies 3.60% of the world's tomato production area and holds a share of 7.07% of total production and as such ranks third in world tomato production (FAO, 2020). Tomato production in the open field in Turkey is carried out in two forms: table and paste; 64.77% of the total tomato production area is reserved for paste and 65.52% of the production quantity is reserved for table tomato (TURKSTAT, 2021). The production of table tomatoes in the open field is important for Turkey's agriculture in terms of both the total production area and the share of the production quantity.

According to the data of the Turkish Statistical Institute, 8656435 tons of table tomatoes were produced in the area of 111658 ha in 2020. Çanakkale province ranks fifth in the country with its share of 4.82% from table tomato production area and fourth place with 4.57% share of tomato production (TURKSTAT, 2021). Table tomato production activity is in the first place in terms of return to the economy of Çanakkale province. The vegetable production value of the province is about $174 million, and a very significant part of this vegetable production value, a share of 53.58%, is due to the tomato production value. In Çanakkale province, 67.82% of the revenue from tomato production ($93 million) consists of table tomato production (TOB, 2020).

The central district (TURKSTAT, 2021), which has a quarter of the production area and production volume in table tomato production of the province, is of particular importance in terms of its proximity to the market, ease of transportation and potential to create economic value. Therefore, the central district of Çanakkale province has been designated as the research area.

In the literature review, a great number of studies examining tomato production costs and profitability have been encountered (Karkacıer and Yılmaz Altuntaş, 1998; Engindeniz, 2007; Özkan et al., 2011; Galinato and Miles, 2013; Chile and Gündüz, 2014; Testa et al., 2014; Duhan, 2016; Kumar et al., 2016; Örük and Örük Engindeniz, 2019). However, it has been understood that there is not a satisfactory and sufficient number of studies on the effective use of resources in tomato production.

Effective use of resources in agricultural production is of great importance for the country's economy and producer welfare (Saini, 1969; de Wit, 1992; Bhale and Wanjari, 2009; Awunyo-Vitor et al., 2016). Indeed, optimal use of production factors could also significantly reduce production costs (Haque, 2006; Tian et al., 2018; Semerci, 2022a).

Effective use of resources also leads to increased productivity in agricultural production (Nimoh et al., 2012; Anim et al., 2015; Dhakal et al., 2015; Semerci, 2022b).

In this research, the relationship between the inputs used in table tomato production and the amount of production in the central district, which accounts for one quarter of the open field table tomato production in Canakkale province, has been investigated using efficiency measures. In this context, the relationship between inputs and output used in table tomato production has been analyzed with the help of Cobb-Douglas type function.

2. Literature Review

Başsevinç and Esengün (1995) aimed to determine the functional relationship between inputs and output and production costs used in tomato production in Tokat province with data obtained from 81 agricultural enterprises. The Cobb-Douglas production function has been used to determine the relationship between inputs and output used in tomato production. Tomato yield dependent variable in the estimation equation; irrigation labor, hoe labor, plowing labor, plough pull force, disc harrow pull power, furrow pull force, fertilizing labor, spraying labor, pure nitrogen content, pure phosphorus content, pure potassium quantity, anthracol quantity and planting labor all have been considered as independent variables.

In their studies Dileep et al. (2002) aimed to reveal the resource use activities of agricultural enterprises engaged in contract tomato production. With this purpose, the functional relationship between inputs and output used in tomato production was analyzed by collecting data from 100 agricultural enterprises, 50 of which carried out contracted production and 50 of which did not produce contract production. The Cobb-Douglas production function was used in the determination of the functional relationship between input and output and it was examined separately for enterprises which were engaged in contract production and the enterprises which were not. The dependent variable of the estimation equation has been determined as the amount of production and the independent variables have been determined as the amount of labor, machine pulling power, fertilizing costs, plant protection costs and irrigation costs.

In their study, Oğuz and Arısoy (2002) aimed to perform functional analysis of the production of greenhouse tomatoes in Konya province with the data obtained from 24 agricultural enterprises and to calculate their production costs. The functional relationship between inputs and outputs used in the production of greenhouse tomatoes was analyzed with the Cobb-Douglas production function. While gross production value in the function is the dependent variable, seed value, fertilizer value, drug value and labor value are independent variables.

Zakariya and Ogungbile (2010) in their study aimed to investigate the resource utilization efficiency and efficiency of tomato production under different irrigation programs. Data were obtained from a total of 280 agricultural enterprises, 141 of which carried the special irrigation program and 139 of which followed the government irrigation program. The Cobb-Douglas production function was used to measure the effect of different irrigation programs on the amount of production. The amount of tomato production constitutes the dependent variable of the estimation equation. The independent variables of the equation are production area, labor quantity, fertilizer quantity, pesticide amount and irrigation time.

In their study conducted in Bangladesh, Sarkar et al. (2011) aimed to determine the effectiveness of resource use in contract tomato production with data from 60 agricultural enterprises. Determination of the functional relationship between inputs and output in tomato production was determined by Cobb-Douglas production function. The dependent variable of the function consists of gross income whereas its independent variables consist of labor cost, pulling power cost, seed cost, organic fertilizer cost, chemical fertilizer cost, plant protection drug cost, irrigation cost and cost of staking sticks and gunny thread.

In their study, Ibiyote et al (2015) aimed to determine the effectiveness of resource use in tomato production with the data obtained from 240 agricultural enterprises. The Cobb-Douglas type function has been used to determine whether resources were used effectively or not. The amount of tomato production is the dependent variable of the estimation function and the independent variables have been determined as agricultural pesticides, labor force, seed quantity, production area and fertilizer.

In another study Umar and Abdulkadir (2015) investigated the resource utilization efficiency of tomato production with data from 210 agricultural enterprises. Having used the Cobb-Douglas production function in the study, tomato yield was determined as a dependent variable. The independent variables of the model are production area, number of seedlings, labor force, chemical fertilizer and organic fertilizer quantities.

In their study Kavoi and Mbeche (2016) aimed to determine the technical effectiveness of tomato production in the open field with data from 75 agricultural enterprises. In the study, the Cobb-Douglas type function was used to determine the effectiveness, and the "*Stochastic Frontier Approach"* method was adopted. The dependent variable of the estimation model is the amount of tomato production, and its independent variables are labor force quantity, seed quantity, fertilizer quantity, pesticide quantity and production area.

In their study Muhammad et al. (2017) aimed to determine the resource use effectiveness of tomato producers with the data obtained from 115 agricultural enterprises. In order to determine the effectiveness of resource utilization, Cobb-Douglas type function has been used. The dependent variable of the function consists of tomato yield, whereas the independent variables are farm fertilizer, seed quantity, labor force, number of irrigation, agricultural struggle drug, chemical fertilizer and machine pulling power.

In their study Ahmad et al. (2019) aimed to determine the resource use effectiveness of tomato producers with the help of data obtained from 105 agricultural enterprises. The Cobb-Douglas type function was used in order to estimate the functional relationship between inputs and output used in tomato production. The dependent variable of the estimation model was determined as the yield of tomatoes and the independent variables were determined as labor hours, number of irrigation, chemical pesticides, DAP, nitrate, urea, nitro-phase and farm fertilizer amounts.

Ali et al. aimed to determine the technical effectiveness of tomato producers with data obtained from 90 agricultural enterprises in their studies (2019). In the study in which the Cobb-Douglas type function has been used, tomato yield has been determined as the dependent variable whereas the independent variables have been determined as seeds, pulling power, labor force, urea quantity, farm fertilizer quantity, irrigation number and the amount of pesticides used.

In their study Rijal and Bhatta (2020) aimed to determine the resource use effectiveness of tomato producers with the help of data obtained from 80 agricultural enterprises. In order to determine whether resources were used effectively the Cobb-Douglas type production function was used. Income obtained from vegetable farming is the independent variable of the estimation function whereas preparation cost, seed cost, labor cost, chemical fertilizer cost, farm fertilizer cost, marketing cost, pesticide cost and fixed cost all constitute the independent variable.

Subedi et al. (2020) , in their study, aimed to determine the economic analysis of tomato production and resource use efficiency with data obtained from 90 agricultural enterprises. In order to determine the effectiveness of resource use, Cobb-Douglas type function has been used. The dependent variable of the production function has been determined as gross income whereas the independent variables have been determined as labor force cost, fertilizer cost, seed cost, plowing and maintenance cost.

In their study, Nakana et al. (2021) aimed to analyze the allocation effectiveness of small-scale tomato producers with data obtained from 68 agricultural enterprises. In order to determine the effectiveness of resource use, Cobb-Douglas type function has been used. Tomato production quantity is the dependent variable of the estimation variable while production area, tractor pulling force, work force hours, amount of fertilizer, number of seedlings, pesticide quantity and water quantity constitute the independent variables.

In their study Ajibare et al. (2022) aimed to determine the efficiency of tomato production and resource use with the data obtained from 100 agricultural enterprises. The Cobb-Douglas type function has been used to determine whether resources are used effectively or not. Tomato production quantity has been determined as the dependent variable of the estimation equation while household size, production area, extension visit, seed, fertilizer, pesticide and labor force constitute the independent variables.

Khanal et al. aimed to determine resource use effectiveness in tomatoes with data from 180 agricultural enterprises in their study (2022). Resource use efficiency was estimated using the Cobb-Douglas type production function. In the estimation equation, the dependent variable was income from tomato production while plowing cost, farm fertilizer cost, urea cost, diammonium phosphate (DAP) fertilizer cost, potassium fertilizer cost, seed cost, irrigation cost and labor force cost were determined as independent variables.

3. Materials and Methods

3.1. Materials

The primary data of the research are the data obtained by survey from 99 agricultural enterprises that produce table tomatoes in the central district of Çanakkale province, located in Marmara Region of Turkey and these enterprises are determined by using the "Stratified Sampling Method". The secondary data of the study are data obtained from the Food and Agriculture Organization of the United Nations (FAO), the Turkish Statistical Institution (TURKSTAT) and the Canakkale Provincial Directorate of Agriculture and Forestry Ministry of Agriculture and Forestry. In addition to this, publications, reports, articles and dissertations related to the subject have been referred to at both national and international level.

3.2. Methods

3.2.1. Method used in sampling

In determining the sample volume, the statistical formula proposed by Neyman, one of the Stratified Sampling Methods, was used (Neyman, 1934; Yamane, 1967). And in determining the number of enterprises to count as the sample, the agricultural enterprises that produce table tomatoes in the open field registered in the Farmer Registration System of the Canakkale Provincial Agricultural and Forestry Directorate are considered the main mass. Neyman Allocation is also known as Optimum Allocation. In this method, each layer is proportional to the standard deviation of the variable distribution. In order to generate the lowest possible sampling variance, larger samples are taken from the layer with the highest variability. The objective here is to maximize the accuracy of results with a constant sampling size (Benedetti et al., 2008; Gonzalez and Eltinge, 2010; Singh and Masuka, 2013). Determination of the sample volume has been carried out within 95% confidence interval and 1% error limits. The number of surveys which will be applied as a result of the sampling study has been determined as 99. The Neyman Allocation has been formulated as given below (Ekwere and Erdem, 2014; Anigbogu and Uzondu, 2019):

$$n = \frac{[\sum(N_h S_h)]^2}{N^2 D^2 + \sum N_h (S_h)^2}$$

$$D^2 = (\frac{d}{t})^2$$

The followings are given in the equation;

n= sample volume,

N_h= the number of enterprises in the sampling frame belonging to the layer h.

S_h= standard deviation of data in the layer h.

S_h^2= variance of data in layer h.

t= the table value of t for a certain confidence interval,

N= Total Number of Enterprises per Sampling Frame

d= Represents a certain % deviation from the mean.

The number of enterprises entering each layer has been determined by taking into account the standard coefficient of deviation and variation (C.V.). The coefficient of variation refers to how many percent the standard deviation has varied in relation to the average. Low coefficient of variation means that unit values have less deviations from the average. In other words, it is indicated that the units studied are more homogeneous in terms of properties. A sample with a coefficient of variation greater than 33% does not represent a normal population and indicates large differences between the data. The coefficient of variation is formulated as follows (Dalenius and Hodges, 1959; Horgan, 2006; Oguz and Karakayacı, 2017).

$$C.V. = \frac{S}{\bar{X}}$$

In the equation, C.V. refers to the coefficient of variation, S refers to standard deviation and $\bar{x}$ refers to average.

3.2.2. Method applied in functional analysis of table tomato production

The Cobb-Douglas production function has been used in the study for functional analysis (Douglas, 1976; Miller, 2008). It appears that the Cobb-Douglas production function is often used in various studies on agricultural activities (Hayami, 1970; Dawson and Lingard, 1982; Hatirli et al., 2005; Atis, 2006; Armagani and Ozden, 2007; Oguz and Kaya, 2016; Ghoshal and Goswami, 2017; Dahal and Rijal, 2019; Vasyl'yeva, 2021). In different studies it is also reported that the Cobb-Douglas type production function is suitable for functional analysis of agricultural production activities (Davis, 1981; Biddle, 2011; Semerci, 2013; Mazid et al., 2015; Zhang et al., 2017). Besides, the Cobb-Douglas type production function has been preferred since it provides ease of calculation, statistical tests of production flexibility, ensures sufficient degrees of freedom even with insufficient data, etc., (Ibach, 1953; Dhrymes, 1965; Felipe and McCombie, 2010). The equation for the function is shown as follows (Zellner et al., 1966; Rahim et al., 2019):

$$Y = AX_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} \ldots X_n^{\beta_n}$$

Regarding the parameter estimation of the Cobb-Douglas production function, the common method is to turn the model into a linear form after its logarithm has been calculated (Chen et al., 2009; Alrefaei and Diabat, 2009; Anagnostopoulos and Kotsikas, 2010). When the logarithm of both sides of the equation is taken;

$$\log Y = \log A + \beta_1 logX_1 + \beta_2 logX_2 + \beta_2 logX_3 + \ldots + \beta_k logX_k + e^u$$

it forms into this. In both equations, X_i (i= 1,2,3,..., n) indicates the input of the ith factor and Y the output;β_i (i=1,2,3..., n) X_i shows the production elasticity of the factor, A shows the level of technical progress, log shows the common logarithm, e^u error term.

With the help of an appropriate statistical package program, the coefficient of determination of regression equation (R^2), production elasticity of independent variables (β_i), standard errors ($s\beta_i$), significance levels ($t\beta_i$), geometric averages of variables (X_{iG}, Y_G), test of the presence of autocorrelation and multicollinearity, standard equation deviation (S) and significance level (F value) have been analyzed (Dawson and Lingard, 1982). The methods used in the interpretation of the estimation function prepared in the study are given below.

Production elasticity: At a given level of production, the percentage change that occurs in any of the production factors (X_i) is the percentage change that occurs in the amount of production (Y). In line with the feature of the Cobb-Douglas type production function', the coefficients belonging to the independent variables involved in the function indicate the marginal production elasticity of the production factors with which they are related (Shih et al., 1977). Considering the sum of production elasticity ($\sum\beta_i$); if $\sum\beta_i >1$; it is an increased return to the scale, if $\sum\beta_i <1$, it is a decreased return to the scale and if $\sum\beta_i =1$, it is a fixed return to the scale (Dillon, 1966).

Average yield, marginal physical yield and marginal income: At a given level of production, the production amount corresponding to the unit production factor is called as average yield. Since logarithmic transformation is used in the Cobb-Douglas type production function or logarithmic production function, calculations are made through geometric means (GM). Because, the mean of the data transformed logarithmically will be the geometric mean (Griliches, 1963; Humphrey, 1997). The amount of production from the use of the last unit of a production factor is called marginal physical efficiency (Marginal Physical Productivity-MPP) (Doll, 1974; Khatun and Afroze, 2016). The demonstration of marginal physical efficiency in Cobb-Douglas production function is as follows;

$$MPP_{X_i} = \beta_i \frac{GM_Y}{GM_{X_i}}$$

The equation shows the marginal physical efficiency MPP_{X_i} of theβ_i input, the regression coefficient of the input, the geometric mean of theGM_Y dependent variable and the geometric mean GM_{X_i} of the inputs (Singh et al., 2004).

Marginal revenue (MR) is obtained by multiplying the marginal yield with the product price. The formula used in order to calculate marginal income is shown below (Mobtaker et al., 2010).

$$MR_{X_i} = \beta_i \frac{GM_Y}{GM_{X_i}} F_Y$$

In the equation, the marginal income of the production factor shows the regression coefficient of the input, the geometric mean of the dependent variable, the geometric mean of the inputs and the product price (Reder, 1943).

The formula used to calculate the Marginal Income (MI) of the production factors which are applied in the production of paddy in the surveyed enterprises is shown below.

Marginal efficiency coefficients (MEC): The determination of the extent to which the production factor is used effectively is determined by the efficiency coefficient of its factor. The concept of activity refers to the maximum use of factors. Effective use of the factor is possible at the point where the marginal income of the relevant factor is equal to its marginal expense. Within this framework, it is necessary to divide the marginal income of the factors by the factor price (Marginal Factor Cost - MC) in order to calculate the effectiveness coefficient of the factor. The equation used in the calculation of the marginal activity coefficient is shown below (Rafiee et al., 2010; Semerci, 2012).

$$MEC = \frac{MR_{X_i}}{MC_{X_i}}$$

The following rules have been taken into account in the interpretation of the calculated marginal activity coefficients for production factors (Hopper, 1965; Timmer, 1971; Taru et al., 2008; Semerci, 2013):

If MEC = 1 (MR=MC), the factor is used effectively.

If MEC > 1, factor is used less and should be increased (MR>MC),

If MEC < 1, the factor is overused and should be reduced (MR<MC).

4. Results and Discussion

Within the scope of the research, the functional relationships between number of seedlings, pure fertilizer quantity, agricultural struggle drug quantity, machine pull power, diesel quantity and labor force use have been analyzed with the help of Cobb-Douglas production function (Neill, 2002). The variables involved in the production function of table tomatoes in the research and their definitions are given below.

Dependent variable;

Y= Table tomato production quantity (kg/enterprise),

Independent variables;

X_1 = Number of seedlings (pcs/enterprise),

X_2 = Pure fertilizer quantity (kg/enterprise),

X_3 = Amount of agricultural struggle drug (cc/enterprise),

X_4 = Machine pulling power (hour/enterprise),

X_5 = The amount of diesel fuel (l/enterprise),

X_6 = Labor force (hours/enterprise).

In the present study, functional correlation between the variables involved in production

$$Y = 1.415\, X_1^{0.742} X_2^{0.097} X_3^{0.039} X_4^{-0.129} X_5^{0.038} X_6^{0.249}$$

has been determined in the form of *(S=0.115; R=0.955; R^2=0.912; F=158.65).*

Multiple correlation and determination coefficients of equation ($F_{calc.} > F_{table}$) has been found to be significant at 1% probability level. The presence of autocorrelation in the created equation has been tested by the "Durbin Watson (DW) Statistical Test" (Table 1).

Table 1: Basic statistics of table tomato production prediction equation

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	0.955[a]	0.912	0.906	0.1145	0.912	158.65	6	92	0.000	1.914

a. Predictors: (Constant), human labor, pure fertilizer, pesticide, machine labor, diesel fuel, seedling.
b. Dependent Variable: tomato production.

Since the value of the statistic $DW_{C\ of\ equation\ (calc.)}$ is higher than the table top value (0.05; n=99; k'=6), it has been understood that there is no autocorrelation problem for the function ($DW_{calc.}$ 1.914> $DW_{U(0.05)}$ 1.670). (Table 1 and 2)

Table 2: Table tomato production function variance analysis table

	Degrees of freedom	Sum of squares	Mean of squares	F value	P value
Degrees of freedom	6	12480	2080	158.653	0.000
Residue	92	1206	0.013		
Total sum	98	13686			

After testing the presence of autocorrelation in the model and the significance of the model, the explanation of the estimation equation has been interpreted. The determining coefficient of the model (R^2) has been found as 0.912. With another expression, 91.20% of the changes that occur in the dependent variable could be explained by independent variable included in the model (Table 1).

Oğuz and Arısoy (2002) calculated the value of the prediction equation (R^2) as 0.90 and found the statistical value F to be significant at the level of significance of 1%. In a study, the value of the prediction equation (R^2) has been found 0.790, and the F statistical value has been significant at the significance level of 1% (Sarkar et al., 2011). In another study, the value of the prediction equation (R^2) is 0.914, and the F test is significant at a significance level of 1% (Ahmad et al., 2019).

In the study carried out by Rijal and Bhatta (2020), the value of the prediction equation (R^2) was calculated as 0.652 and the F test statistic was considered significant at 1% significance level. In their study Subedi et al. (2020) have calculated the (R^2) value of the estimation equation as 0.650 and have found the F statistical value as meaningful at a 1% significance level.

In their study Khanal et al. (2022) have calculated the (R^2) value of the estimation equation as 0.840 and have found the F statistical value as meaningful at a 1% significance level. The F statistical values of the studies above are similar to the value calculated in this study and there are differences in terms of determining coefficients (R^2).

While the (R^2) values of the studies conducted by Oğuz and Arısoy(2002) and Ahmad et al. (2019) show similarities with the (R^2) values obtained in this study, it is seen that the (R^2) values of the other studies are lower than the (R^2) values obtained in the present study.

When the production elasticity of the independent variables are examined; it is seen that the production elasticity coefficients of machinery, pulling power and diesel use factors are negative, whereas the number of seedlings, the amount of pure fertilizer, the agricultural pesticide drugs and the production elasticity coefficients related to labor variables have been found to have a positive character. The sum of production elasticity of the factors involved in the function (($\sum\beta_i$) is 0.96 and the calculated value represents the reduced yield to the scale in the production of table tomatoes. In other words, the sum of production elasticity coefficients refers to the fact that if the variables in table tomato production are increased by 1%, an increase in production by 0.96% could be expected (Table 3).

Table 3: Production elasticity of table tomato production factors

	X_1 (Seedling)	X_2 (Pure fertilizer)	X_3 (Pesticide)	X_4 (Machine labor)	X_5 (Diesel fuel)	X_6 (Human labor)	($\Sigma\beta_i$)
Production elasticity (βi)	0.742	0.097	0.039	-0.129	-0.038	0.249	0.96
Standard error (SβI)	0.162	0.072	0.057	0.079	0.112	0.164	-
Tβi	5.375*	1.332	0.639	1.679**	-0.347	1.686**	-

(*): Significant at 1% probability level
(**): Significant at 10% probability level

In the equation, the production elasticity coefficient of number of seedlings (X_1) is 1%, and the production elasticity coefficients of machine pulling force (X_4) and labor force

(X_6) inputs have been found to be significant at 10% probability level. When theoretically analyzed, it could be claimed that a 1% increase in seedling input used in table tomato production would increase production by 0.742 percent, 1% increase in pure fertilizer use by 0.097%, an increase in agricultural pesticide drug by 0.039% and a 1% increase in labor use would increase production by 0.249%. The increase in the amount of machine pulling force and diesel fuel will result in a decrease in production (Table 3). However, in practice, it would be more appropriate to interpret the increase in the use of qualified input in table tomato production as an increase in the level of table tomato production up to a certain stage (Ahuja, 2016).

In a study examining how private irrigation and government irrigation programs affect resource utilization efficiency in tomato production, it has been determined that the total of production elasticity of the estimation equation for the special irrigation program is 0.70, while for the government irrigation program this value is 0.98. The production elasticity coefficients of the variables in the estimation equation generated for the specific irrigation program have been calculated as 0.11 for production area, 0.18 for labor force, 0.36 for irrigation time, 0.033 for fertilizing, and -0.015 for pesticide. The production elasticity coefficients of the variables have been determined to be significant at 1% importance level for production area, labor force, irrigation. Production elasticity coefficients of fertilizer and pesticide variables have been found statistically insignificant. The production elasticity coefficients of the variables in the estimation equation generated for the specific irrigation program have been calculated as 0.17 for production area, 0.28 for labor force, 0.15 for irrigation time, 0.87 for fertilizing, and -0.29 for pesticide. Production elasticity coefficients of variables have been determined to be significant at 1% importance level for production area, labor, fertilization, 5% importance level for irrigation and 10% significance level for pesticide (Zakaria and Ogungbile, 2010).

In another study, the sum of production elasticity coefficients of the estimation model has been calculated at 1.76, which indicates the presence of increased return to the scale. In the same study, it was estimated that a 1% increase in land, seed quantity, labor force, chemical and organic fertilizer could increase the yield of tomatoes by 0.23%, 0.57%, 0.28%, 0.34% and 0.34% units respectively. In the research conducted, while the amount of land, seed quantity, production elasticity coefficients of chemical fertilizer variables were found to be significant at the level of 1%, the coefficient of production elasticity belonging to the labor force was found as 5% and the production elasticity coefficient of organic fertilizer was significant at 10% (Umar and Abdulkadir, 2015).

In another study examining the technical efficiency of open field table tomato production, the sum of production elasticity coefficients of the independent variables included in the model was calculated as 0.96. This value refers to a decreased return to the scale and is a value close to the fixed return to the scale (Kavoi and Mbeche, 2016). In the study conducted by Kavoi and Mbeche (2016), it was reported that the production elasticity coefficient of the fertilizer variable had been found as 0.29, the production elasticity of the labor force as 0.29, the production elasticity of the pesticide as 0.12. Besides, the coefficients had a significance level of 1%, 5% and 10% respectively. In the same study, the production elasticity of seed input was found as 0.07 and the coefficient of elasticity related to the production area was determined as 0.18, and both factors were statistically found insignificant.

In a study conducted by Muhammad et al. (2017), the sum of production elasticity coefficients of the independent variables in the estimation model was found as 1.51 and this values represents an increased return to the scale. The production elasticity coefficients of the variables included in the model have been found as 0.02 for farm fertilizer, 0.27 for seed quantity, 0.19 for labor force, 0.25 for the number of irrigation, 0.15 for chemical fertilizer and 0.15 for the machine pulling force. Production elasticity coefficients of variables were found to be significant at seed quantity, irrigation number, chemical spray, 1% for machine pulling force and 5% significance level for labor force and chemical fertilizer (Muhammad et al., 2017).

In the literature reviewed, the production elasticity coefficient of Kavoi and Mbeche's (2016) estimation equation is similar to the present study, and the production elasticity coefficient of the estimation function prepared for the government irrigation program of Zakaria and Ogungbile (2010) shows proximity to the present study's data. The production elasticity coefficients belonging to the estimation function of Umar and Abdulkadir (2015) and Muhammad et al. (2017) shows an increased return to the scale. In addition to this, the production elasticity coefficient and significance levels of each variable in the studied literature differ from each other.

Marginal product values and marginal activity coefficients of production factors that are effective in the quantity of table tomato production in the research are shown in Table 4. In the determination of marginal product values, unit prices of the inputs which are formed in the free market and used as factor prices have been taken into consideration. As it could be seen in Table 4, the factors related to machine pulling power and diesel quantity in the inputs used in table tomato production have been marked as negative. Therefore, when estimating for all factors, only economic and technical interpretations about these two variables have not been made.

Table 4: Marginal value and efficiency coefficients of coefficients in table tomato production model

	X_1 (Number of seedlings)	X_2 (Pure fertilizer)	X_3 (Agricultural pesticides)	X_4 (Machine pulling power)	X_5 (Diesel)	X_6 (Workforce)	Y
Geometric mean	14165.42	684.88	19772.44	497.57	435.31	2397.85	92373.49
Marg. product value ($)	0.35	31.31	6.99	-0.78	7.44	103.28	-
Factor prices ($)	0.073	2.39	38.36	4.39	0.92	10.77	-
Marg. efficiency coeff.	4.84	13.08	0.18	-0.18	-8.06	9.59	-

Among the variables included in the equation, the highest marginal efficiency coefficient belongs to the pure fertilizer variable (X_2) with 13.08, and it is followed by the labor force factor (X_2) with a coefficient of 9.59. According to marginal efficiency coefficients, it is clear that pure fertilizer, labor and seedling use inputs are used below the economic optimum level. Therefore, it is necessary to increase the use of these factors, which have a high coefficient of marginal effectiveness. The marginal coefficient of effectiveness of the agricultural pest control drug (X_3) is 0.18, and there seems an excessive use of input. Therefore, it is necessary to reduce the use of agricultural pest control drugs.

In a study of economic analysis of tomato cultivation, 13 variables were included in the estimation function; and marginal efficiency coefficients of planting labor, plowing, disc harrow, potassium sulfate (K_2O) and spraying labor variables were found as negatively marked. The marginal efficiency coefficient was calculated as 6.81 for groove retrieval labor, 4.59 for fertilizer labor, 4.11 for fungicide usage and 1.45 for plough labor. These values indicate that the factors have been used below the economic optimum level. In addition to this, in the same study, the marginal efficiency coefficients of irrigation labor, diammonium phosphate (P_2O_5) fertilizer, hoeing labor and nitrogen (N) fertilizer have been calculated as 0.98, 0.75, 0.35 and 0.25, respectively, and the determined values indicate that the relevant factors are used in tomato production at an extreme level (Başsevinç and Esengün, 1995).

In a study which examined the economic effectiveness of producers who produce tomatoes with and without contract, the marginal efficiency coefficients of machine pulling force and agricultural pest control drugs were found negative in the estimation equation for contract tomato production. In the same study, the marginal efficiency coefficient of fertilization variable was 65.09 and the marginal efficiency coefficient of irrigation variable was 54.96. Whereas, the values determined indicate that these inputs were used below the optimum level in tomato production and should be increased. The marginal efficiency coefficient of the labor force variable is 0.21 and it seems to be overused. In the estimation equation created for uncontracted tomato production, the marginal efficiency coefficient of irrigation was 52.23, the marginal efficiency coefficient of agricultural pesticide was 39.82, the marginal efficiency coefficient of fertilization was 16.62, the marginal efficiency coefficient of labor force was 1.70. The research revealed that these inputs were used at an insufficient level. In the present study, the marginal efficiency coefficient of machine pulling power was calculated as 0.09, and the calculated value showed that the machine pulling force was overused in the production of tomatoes (Dileep et al., 2002).

In another study examining the resource use efficiency of tomato production, marginal efficiency coefficients of production area and labor force variables included in the estimation equation were 15.20 and 1.20 respectively. It was interpreted that the specified variables were used below the economic optimum point. In the same research, the amount of seeds included in the estimation equation, the marginal efficiency coefficients for agricultural pest control drug and fertilizer use were calculated as 0.30, 0.20 and 0.05 respectively. It is understood that the specified production factors have been used at an extreme level in tomato production (Ibiyote et al., 2015).

In the present study, it has been determined that the amount of pure fertilizer and labor force are used below the economic optimum level in tomato production. This finding seems to coincide with the findings obtained by Dileep et al. (2002) and Ajibare et al. (2022). Again in this research, the marginal efficiency coefficient of machine pulling power in tomato production was found as negatively marked. The calculated value coincides with the findings obtained by Başsevinç and Esengün (1995) and Ali et al. (2019). In this study, it has been concluded that the agricultural pest control drug is overused in the production of tomatoes. Ibiyote et al. (2015) achieved a similar result in their study.

When we make a general evaluation of the findings obtained in this research and other research findings, it could be said that the production factors used in table tomato production vary from country to country and from region to region. In the present study, it has been found that machine pulling power and labor force use, which are the two inputs used in table tomato production, are statistically significant in other studies, as it is in this study, and the marginal activity coefficient of pulling force is negative in some studies, and the marginal activity coefficient of labor force is greater than 1. The marginal efficiency coefficients of pure fertilizer and agricultural pest control use also show similarity with the other studies in the literature.

5. Conclusion and Recommendations

Turkey is one of the world's leading tomato producing countries. Tomato is in the fourth place in the ranking of countries in terms of production area and in third place in terms of quantity of production. In Turkey, 65.52% of tomato production is made in table tomato form and it is the main source of livelihood of many producers. In this study, the relationship between the quantity of table tomato production and the inputs used in the production of tomatoes in Çanakkale, one of the leading provinces of Turkey, has been analyzed functionally.

The relationship between table tomato production quantity and seedlings, pure fertilizer quantity, agricultural pest control drug, machine pull power, diesel and labor use quantity have been investigated with the help of Cobb-Douglas type function. In the study, the function of table tomato production shows that; the number of production elasticity of the number of seedlings is 1% and the coefficients of production elasticity of the machine pulling and labor force are found to be significant at the level of 10% probability. The sum of the coefficients of production elasticity of the independent variables included in the estimation equation is 0.96, and the calculated value indicates that there is a reduced return to the scale in the production of table tomatoes in the open field.

In the study, it has been also determined that the marginal efficiency coefficients of machine pulling power and diesel use quantity variables included in the estimation equation of table tomato production are marked negatively. Being among the other variables included in the estimation equation, the marginal efficiency coefficient of pure fertilizer variable is 13.08, the labor force value is 9.59, the value of the number of seedlings has been calculated as 4.84. It has been determined that the specified variables are used below the economic optimum. In the study, the marginal efficiency coefficient for the agricultural pest control drug factor used in tomato production has been determined as 0.18. The calculated value indicates that the specified factor is overused in production. In the present research, it has been recommended to increase the use of pure fertilizer, labor force and seedling factors with high marginal efficiency coefficient in the unit area, and to reduce the use of agricultural pest control drugs.

The results obtained as a result of the research show that in order to obtain higher yields from the unit area in the enterprises studied; the use of qualified labor in table tomato production should be motivated and fertilization should be carried out in accordance with the results of soil analysis.

The conducted research showed that the use of input in the production of table tomatoes in the open field in the enterprises studied is not carried out by taking the economic optimum level into consideration. The use of input in agricultural production must be at a level where the marginal value is equal to the marginal factor cost or at the level where they coincide (Hassan and Ahmad, 2005; Shaheen, 2011; Ali and Khan, 2014). At this point, the possibility of maximum use of each input used could be obtained. Thus, with the rational use of resources in agricultural production activity, the yield and income from the unit area will also rise (Nakana et al., 2021; Ajibare et al., 2022). In enterprises with a structure suitable for the specified situation, besides the increase in the revenue generated from the unit area, the product cost could be reduced. And as such, a more advantageous position in the competition among the enterprises suitable for this structure.

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