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DETERMINING THE RESOURCE USE EFFICIENCY IN WHEAT (*TRITICUM AESTIVUM* L.) PRODUCTION: A CASE STUDY OF EDIRNE PROVINCE – TURKEY

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Abstract

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In this research, it is aimed to determine physical production inputs, which are used for wheat production, made in rain fed conditions in agricultural enterprises in Edirne, located in European Continent, Turkey, and to determine the resource use efficiency of previously mentioned activity. The data, used in this research were obtained from 90 agricultural enterprises in Edirne in 18 settlements, which have been marked through "Multi Stratified Random Sampling Method" by the means of questionnaire.

In the enterprises analyzed, it was determined that in wheat production 21.70 kg seed, 55.32 kg chemical fertilizer and 87.31 cc pesticide were required for the yield about 405.64 kg da^{-1} . Determination coefficient equation (R^2), acquired by using Cobb-Douglas type production function, is 0.965 and because of functional analysis, there is an increasing return to scale ($\sum\beta_{i\,=}$ 1.119).

All of the variables in production equation are significant at 5% level and their elasticity coefficients have positive valence. In the end of the research, it is proved that land value and pesticide factors are used actively in wheat production. However, for higher yield, an increase in the quantity of seed and fertilizer is required.

Key words: Wheat, input use, Cobb-Douglas production function, efficiency, Turkey

Introduction

Wheat ranks first among the agricultural products in Turkey, grown for contribution to economy due to its strategic position in nutrition, production amount and extensiveness of the wheat around the country in the respect of producer and value-added it creates. It also serves as staple food for human for the nutrition of people (Eraktan et al., 2008). The wheat production, which ranks first among field crops, in the aspects of cultivated area and the production quantity, is also of socio-economically importance (Ozcelik and Ozer, 2006).

Together with its vast production in Turkey, Central Anatolia, Thrace, Southern East Anatolia and Cukurova are important wheat production areas (Kumbasaroglu and Dagdemir, 2010). Located on Thrace Region, Edirne, which has the Turkey's important wheat production areas, average yield (372.4 kg da^{-1}) is 27.37% more than yield value of the world and 60.88% more than yield value of Turkey between the years 2005-09 (FAO, 2011; TURKSTAT, 2011).

In agricultural production, the efficient use of resource and productivity has a vital importance in the aspect of national economy and prosperity of producer. With the determination of optimal use level, reducing the production cost and increasing the productivity can provide a positive change in producer's income (Akcay and Uzunoz, 1999). Around the world, the studies have

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been made about the determination of input use and resource efficiency in wheat production (Negri and Anjos, 1980; Azhar and Chafoor, 1988; Philiph, 1989; Zuberi, 1989; Singh, 1990; Thakur et al., 1990; Yao, 1996). Similarly, there are some studies about of resource use level and activity in wheat production in Turkey (Ozcelik, 1989; Akcay et al., 1996; Gundogmus, 1998; Akcay and Esengun, 1999; Akcay and Uzunoz, 1999; Bayramoglu and Oguz, 2005).

However, the fact that similar studies have not been made in Edirne where wheat production is quite high and yield value is relatively higher than Turkey and world average has enabled the research to be an original one for the region.

In the previously mentioned conducted research, it has been aimed to determine elasticity coefficients of production factors in wheat production that has a significant role in Edirne's agriculture and economy, to determine marginal product (MP), marginal yield (MY), marginal income (MI) and marginal rate of technical substitution (MRTS) and to test efficiency in factor combinations.

Materials and Methods

The materials of the research consist of Edirne district data obtained from the project "Adaptation and Impacts of Improved Winter and Spring Wheat Varieties in Turkey" which is cooperated with the Ministry of Agriculture and Rural Affairs and General Directorate of Agricultural Research (GDAR) and International Centre for Agricultural Research in the Dry Areas (ICARDA) (Mazid at al., 2009). The data obtained from 90 wheat enterprises chosen according to "Multi-Stage Stratified Random Sampling Method" in 2006-2007 production periods has been used in this research. The climatic data applied in this research have been taken from General Directorate of State Meteorology Affairs (TSMS, 2009).

The method applied during the data analyses

In recent years, it is observed that there is an increasing trend of obtaining economic criteria from production function that are compulsory and necessary for efficient use of sources in agriculture (Kumbasaroglu and Dagdemir, 2010). For this purpose, Cobb-Douglas production function is one of the most commonly used function type especially in agricultural economic studies (Kip and Isyar, 1976; Debertin, 1986). Cobb- Douglas production function is a kind of differentiable function type applied in industry and economy and has a bilateral logarithmic pattern (Tanriover and Genc, 2005; Gujarati, 2009). In this model every single coefficient of X variable measures the partial elasticity of Y dependent variable according to that (X) variable (Gujarati, 2009). Equation is generally shown as the following:

$$Y = \alpha X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} \ldots X_k^{\beta k} \quad (1)$$

In the equation, Y symbolizes output, X_i's symbolize factors used in production and β_i's symbolize elasticity coefficients of production factors. Cobb- Douglas production function is expressed as below after determining its bilateral logarithm:

$$\log Y = \log \alpha + \beta_1 \log x_1 + \beta_2 \log x_2 + \beta_3 \log x_3 + \ldots + \beta_k \log x_k \quad (2)$$

The advantages of Cobb- Douglas function are summarized below.

a) It shows compliance with the data obtained from the agricultural enterprises during a production period,

b) It provides convenience in practice,

c) It provides sufficient degree of freedom (Heady and Dillon, 1966).

In this research, Cobb- Douglas production function has been used to define the relation between wheat production quantity (Y) and inputs used in production activity (X). The variables in the created model are given below:

Log Y: Wheat production amount (kg)

Log X_1: Seed quantity (kg)

Log X_2: Chemical fertilizer quantity (kg)

Log X_3: Agrochemical (pesticide) (cc)

Log X_4: The quantity of the rainfall in wheat production period (mm)

Log X_5: Land value (USD).

In the research required tests have been made by calculating the function of statistics. After that relying upon the function, the predicament of elasticity coefficient (PEC), the marginal yield (MY), the value of marginal product (MPV), the marginal productivity coefficients (MPC) and the marginal rate of technical substitution (MRTS) of inputs used in wheat production have been made and economically interpreted.

In Cobb-Douglas type production function, the elasticity coefficient which has been used, is expressed by calculated coefficients and the formula of '*j*'s production factor (X_j) of elasticity coefficient has been given below. (Karagolge, 1973)

$$M_jY_{xj} = \beta_j * \frac{\overline{Y_G}}{\overline{Xi_G}} \quad (3)$$

$$e_{xj} = \frac{M_jY_{xj}}{AY_{xj}} = \frac{\beta_j * \Delta Y / \Delta X_j}{\overline{Y} / \overline{X_J}} = \beta_j \quad (4)$$

β_j coefficients of regression equation give the elasticity coefficient of inputs so it is possible to determine the marginal productivity of inputs with the help of these coefficients.

In Cobb-Douglas type production function, the total production elasticity ($\sum\beta_j$) indicates the relation among enterprises scale, production quantity and level of revenue. In the calculation of the marginal yield (MY) of any X_i input, used in wheat production, the following formula has been used (Karagolge, 1973):

$$M_jY_{xj} = \frac{\overline{Y}}{\overline{X_j}} * \beta_j \quad (5)$$

Due to the features of Cobb-Douglas model production function, geometric average has been used instead of arithmetic average. The marginal income (MI) of any production input (X_i) has been calculated with the help of following formula (Karagolge, 1973):

$$M_jI_{xj} = \beta_j \frac{\overline{Y_G}}{\overline{X_{jG}}} * F_y \quad (6)$$

Multiplication of marginal yield with product price gives the marginal income. In this state, it means that j's production factor is used in a way that makes the profit maximum or in the most economical way.

$$M_jY_{xj} = \beta_j \frac{\overline{Y}}{\overline{X_j}} = \frac{F_{xj}}{F_y} \quad (7)$$

The marginal efficiency coefficient (MEC), obtained by dividing of marginal income into factor price, shows which factor is active or which factor is used more, which one used less, in a more accurate way. The formula of the marginal efficiency coefficient is given below:

$$MEC = \frac{\text{Marginal Revenue of Factors}}{\text{Factor Price (Opportunity Cost)}} \quad (8)$$

To stay in a certain production level, when the quantity used in X_j factor is increased one unit, from any point on, required decrease in the quantity of x is called as 'Marginal Rate of Technical Substitution' (MRTS) in the point of X_i in relation to X_j (Dilmen, 1985). The formula of MRTS used in the research could be written as:

$$MRTS_{(i \text{ in relation to } j)} = \frac{\text{Marginal Yield of } X_j}{\text{Marginal Yield of } X_i} \quad (9)$$

In order to understand to which extent the factor combinations approach the optimum level or which factors need to be increased and decreased or to make the combination between two factors economical, it is required to take into consideration the factor prices, more precisely price ratios, apart from the substitution rate. The formula applied for testing whether the factor combinations have been used in economic optimum level or not is given as:

$$MRTS(X_i / X_j) = \frac{\beta_j \ \overline{X_i}}{\beta_i \ \overline{X_j}} = \frac{F_{xj}}{F_{xi}} \quad (10)$$

Results

Input use in wheat production

21.7 kg seed, 87.3 cc pesticide and 55.3 kg fertilizer have been used in return for 405.6 kg da^{-1} wheat yield in the analyzed enterprises in the scope of the research. The related information about the yield and seed value, fertilizer and pesticide use per unit area in the research area enterprises are provided in Table 1 on the basis of the enterprise size.

In the enterprises, the average yield value of wheat production is higher in the enterprises which are 100 decares and more in proportion to other enterprises group. In the wheat production, the highest seed use per unit area belongs to enterprises between 3-49 da with 22.27 kg da^{-1} and in pesticide use with 105.50 cc, in chemical fertilizer with 56.63 da^{-1} belong to 100 decares and more enterprises.

In the research, to determine the differences among inputs used among enterprises group in wheat production, "Tukey HSD Test'' has been used (Green et al., 2000; Ural and Kılıc, 2006; Altunisik et al., 2007;). For this aim, the enterprises have been evaluated in 3 groups as 1-49 da (28 enterprises), 50-99 da (30 enterprises), 100 da and more (32 enterprises). In the analyses the differences of the factors among the enterprises group in wheat production have been examined and proved that there is no significant difference.

Seed use

In wheat production, the factors that affect quality of seed, which will be used per unit area, are generally seed quantity per m^2, the weight of seed per 1000 grain, seed purity and biological values (Kun, 1988). In the research, it has been determined that the planting frequency of wheat, varies between 450-650 grain per m^2 in Turkey's condition (Sencar et al., 1991; Akkaya, 1994; Sade et al., 1999). In another research, which has been conducted in research area conditions, it has been proved that the most suitable planting frequency is 550 grain per m^2 (Genctan et al., 1987)

In the research area, it has been determined that in the enterprises where the questionnaire has been conducted, seed quantity is taken into account instead of m^2 per unit area about seed use. Another research, made on this subject has shown that the quantity of seed use per unit area can change between 22-26 kg da^{-1} in the wheat production (Gundogmus, 1988; Ozcelik, 1989; Sade et al., 1999).

Nutrient requirement of wheat

In the enterprises, which have been analyzed in the extent of research, it has been determined, that quantity of total fertilizer use in wheat production is around 55.3 kg da^{-1}. In another research, which has been made in Iran, it has been proved that the total fertilizer quantity, used in wheat production is 32.61 kg da^{-1} (Shahan et al., 2008). In the research about the level of fertilizer

Table 1
Mean, standard deviation and standard error values of factors used in wheat production on the basis of enterprise size

Variables	Enterprise size, decare*	Mean	Standard deviation	Standard error
Yield, kg da^{-1}	3-49	386.641	62.318	11.778
	50-99	408.811	70.716	12.911
	100+	419.298	60.972	10.778
	Mean	405.642	65.472	6.901
Seed quantity, kg da^{-1}	3-49	22.265	2.644	0.500
	50-99	21.702	2.228	0.407
	100+	21.207	2.422	0.428
	Mean	21.701	2.443	0.257
Pesticide quantity, cc da^{-1}	3-49	64.979	78.139	14.770
	50-99	88.762	78.020	14.245
	100+	105.499	106.515	18.829
	Mean	87.314	89.800	9.466
Fertilizer quantity, kg da^{-1}	3-49	53.488	8.469	1.600
	50-99	55.640	7.603	1.388
	100+	56.628	7.799	1.379
	Mean	55.322	7.968	0.840

*1 hectare = 10 decares (da).

use in wheat production in Turkey, it has been seen that chemical fertilizer is used between 29.09-32.21 kg da^{-1} per unit area (Ozcelik, 1989; Gundogmus, 1998;).

Nitrogen requirement

Because of 23 researches, which have been made in USA, it has been reported that the quantity of pure nitrogen required in wheat production, varies between 3-5 kg for 100 kg grain yield (Halvorson et al., 1987). In a similar research, made in Turkey, it has been observed that the nitrogen requirement for wheat is 15 kg da^{-1} (Eker and Cagatay, 1989). Also in Edirne, where the research has been conducted, it has been determined that the highest yield (616.1 ± 23.4 kg da^{-1}) has been obtained by using 16 kg da^{-1} pure nitrogen per unit area, and an increase in the quality of bread-wheat flour has been observed (Ozturk and Gokkus, 2008).

Phosphorous requirement

Deficiency of phosphorous for plant is one of the factors, which affects the yield and the quality negatively (Zabunoglu and Karacal, 1992). Halvorson (1987) stated that the quantity of pure phosphorous (P), required for vegetative improvement and kernel yield of wheat is between 2.5-4 kg for 100 kg. In the condition of Turkey, it is suggested that 2 kg of P_2O_5 should be given for 100 kg grain product (Sencar et al., 1991).

In the enterprises analyzed in the scope of this research, it has been determined that average use of pure phosphorus fertilizer is 5.57 kg da^{-1} and this is below the recommended quantity. When the average yield value (405.6 kg da^{-1}) is taken into consideration in the enterprises where the questionnaire has been conducted, it is understood that use of phosphorus fertilizer in wheat production is low and between 25-30%.

Water requirement

Wheat (*Triticum astivum* L.) is generally produced in dry farming areas in Turkey and in the world (Akkaya, 1994). It has been determined that the wheat production is made in rainfed conditions in the enterprises, which are analyzed in the research area. In accordance with a research conducted in five provinces of Turkey, it has been observed that yield of wheat produced in rain fed conditions is 269.2 kg da^{-1} while the amount of the yield of wheat produced in irrigated conditions is 405.4 kg da^{-1} (Mazid et al., 2009). The yield values obtained from the research clearly prove the significance of the wheat production in irrigated conditions.

Weed, disease and pest control

In wheat production, weed, disease and pest control issues are considered important due to the lowness in the yield quantity and their impairing effects on the product quality. It has been tested that the level of the pesticide used in the enterprises, which are analyzed in the research area, is 87.3 cc da^{-1}. Two different researches have been made in order to determine the level of input use in wheat production and the use level of pesticide has been respectively determined as 169 cc da^{-1} and 200 cc da^{-1} (Ozcelik, 1989; Gundogan, 1998).

Functional Analyses of Wheat Production

Cobb-Douglas production function is one of the most commonly used functions applied for determining resource use efficiency in agricultural production. In this research, production function has been applied for determining the relation between wheat production and the factors applied in production. The estimating equation of the production function is given below:

$$\text{Log } Y = 4.335 + 0.459 \text{ Log}X_1 + 0.354 \text{ Log}X_2 + 0.049 \text{ Log}X_3 + 0.085 \text{ Log}X_4 + 0.172 \text{ Log}X_5$$

Determination coefficient (R^2) of the equation is 0.965 and it has been understood that the value of the function "F calculation" is found to be different than zero (0) significant at 1% level ($F_{calculation}$ 486.68 > F_{table} 3.65). Total amount of the independent variables in wheat production equation have the capacity of explaining 96.5% variations in production quantity. Determination coefficient of the estimating equation shows that the explanation level is sufficient for horizontal cross section data (Miran et al., 2002). In the conducted research, "DW (d) Test" has been applied for determining the existence of internal relation. "DW (d) Statistic" value has been found as 1.723 in the research (K=6; n=90). In this study, "DW (d) Statistic" calculation value has been compared with table value and it has been concluded that there is not negative or positive correlation in the model significant at 1% level ($d_{table\ L\ 1.383\ -\ U1.661}$). In this research, "Student

Test" method has been applied in order to determine whether there is a correlation between the independent variables or not and partial regression coefficients of the variables have been calculated. The production elasticity coefficients, partial correlation coefficients and significance level of variables in function analysis of wheat production have been given in Table 2.

All the variables in the function are considered to be significant at 5% level statistically. When the values in Table 2 is examined, it is determined that due to the high determination coefficient, explanatory variables' being below significant at 5% level and low partial coefficient, there is no multicollinearity among variables in the research (Gujarati, 2009)

The simple correlation coefficients, which show the relations among factors, are given in Table 3. From the table, it can be concluded that there is an important relation among the same inputs used in wheat production. This shows that there could be a multicollinearity relation among independent variables. This relation can lead to difficulties in understanding the individual effect of independent variables over depended ones. This fact requires being careful while making the marginal analyses and economic interpretation (Zoral, 1974).

In addition, if the multicollinearity does not affect the coefficient estimate importantly, multicollinearity can be ignored to some extent even if the least square loses its integrity of estimate partially (Ozcelik, 1994).

Marginal production elasticity of production factors

The marginal production elasticity of variables in estimate equation about wheat production activity is given Table 4. When the marginal production elasticity of variables in equation has been examined, it has been observed that all of the coefficients have positive character. The highest marginal production elasticity coefficient among estimated variables is seed input. The marginal yield value of production factor has been calculated with the help of production elasticity factor and geometric mean.

As it can be understood from Table 4, the highest marginal yield value belongs to seed input (X_1). On the condition that the use level of other inputs stay at the same level, one unit increase in seed quantity enables

Table 2
Parameters and related tests of production function in analyzing the wheat production activities

Variables	Elasticity coefficients, β_i	Partial correlation	"t- value"	Significance level
X_1 (Seed, kg)	0.459	0.420	4.247	0.001
X_2 (Fertilizer, kg)	0.354	0.337	3.280	0.002
X_3 (Pesticide, cc)	0.049	0.220	2.069	0.042
X_4 (Precipitate, mm)	0.085	0.402	4.021	0.000
X_5 (Land Value, USD)	0.172	0.214	2.005	0.048
R^2: 0.965 ; $F_{calculation}$ = 468.68 ; DW: 1.723				

Table 3
The correlation matrix among the factors in wheat production

Variables	Production quantity, kg Y	Seed quantity, kg X_1	Fertilizer quantity, kg X_2	Pesticide quantity, cc X_3	Precipitate, mm X_4
X_1(Seed, kg)	0.972*	-	-	-	-
X_2 (Fertilizer, kg)	0.971*	0.979*	-	-	-
X_3 (Pesticide, cc)	0.522*	0.474*	0.496*	-	-
X_4 (Precipitate, mm)	0.172	0.258*	0.262*	0.078	-
X_5 (Land Value, USD)	0.960*	0.966*	0.966*	0.505*	0.245*

* Significiant at 5% level.

8.62 kg increase in wheat production. On the condition that the production inputs remain stable, one unit increase in precipitate (rainfall amount) leads to 4.29 kg increase in production quantity and fertilizer, pesticide and land value respectively lead to 2.62 kg, 1.67 kg and 0.07 kg increase in wheat production quantity.

Total production elasticity coefficients ($\sum\beta_i$) placed in estimating equation of wheat production has been determined as 1.119. On the condition that the combinations of the variables remain stable, this value can be interpreted as 1% increase in input quantity will lead to approximately a 0.15% increase in wheat production quantity. In other words, the calculated value means increasing returns to scale in wheat production. Marginal production elasticity of the variables in wheat production has been briefly expressed below.

X_1 (Seed Quantity- kg): Production elasticity coefficient of seed factor is positive and is significant in explaining the quantity of production. On the condition that other factors stay at the same level, 1% increase in seed quantity enables 0.459 % increase in production quantity.

X_2 (Fertilizer- kg-): Fertilizer factor is significant in explaining the production quantity. On condition that other factors stay at the same level, 1% unit increase of fertilizer quantity leads to 0.354 % increase in production quantity.

X_3 (Pesticide-cc): Production elasticity coefficient of pesticide is positive and on the condition that other factors stay at the same level, 1% increase of pesticide leads to 0.049% increase in wheat production quantity.

X_4 (Precipitate –mm-): Precipitate factor is important for explaining the production quantity. On the condition that other factors stay at the same level, 1% unit increase in precipitate leads to 0.085% increase in production quantity.

X_5 (Land Value- USD-): Production elasticity coefficient of land value factor is positive and on the condition that other factors stay at the same level, 1% unit increase in land value enables 0.172% increase in wheat production quantity.

Efficiency coefficient of production factors

The geometric mean, standard deviation, standard error and the marginal revenue values of factors used in wheat production are given in Table 5. According to marginal income values of input use in wheat production; one unit increase in seed use leads to 3.32 USD increase in wheat revenue and respectively 1.66 USD in

Table 4
Marginal production elasticity of the estimated equation

Variables	Marginal production elasticity, β_i	Marginal yield
X_1(Seed, kg)	0.459	8.61945
X_2 (Fertilizer, kg)	0.354	2.61803
X_3 (Pesticide, cc)	0.049	1.67105
X_4 (Precipitate, mm)	0.085	4.29432
X_5 (Land Value, USD)	0.172	0.07038

Table 5
Geometric mean and marginal revenue values of factors

Variables	Geometric mean	Standard deviation	Standard error	Marginal income, USD
Y (Production)	26434.29	0.40157	0.04233	-
X_1 (Seed Quantity)	1407.67	0.37895	0.03994	3.32366
X_2 (Fertilizer Quantity)	3574.35	0.40093	0.04226	1.00951
X_3 (Pesticide Quantity)	775.13	1.14363	0.12055	0.64436
X_4 (Precipitate)	523.23	0.01819	0.00192	1.65589
X_5 (Land Value)	64604.00	0.39410	0.04154	0.02714

precipitate, 1.01 USD in fertilizer, 0.64 USD in pesticide and 0.03 USD increase in land value factor.

Although the elasticity coefficient signs of production factors give information about use cases of relevant factors, it could be said that the efficiency coefficients give loud and clear information about use cases. Because the marginal production value's being, high or low has no meaning separately. At this point, when efficiency coefficients are considered, there could be found an answer to the question whether the use quantity is increased or decreased by depending on current use cases of any production factor (Akcay and Uzunoz, 1999).

The marginal revenue, factor price and marginal coefficient of production factors in wheat production are given in Table 6. When marginal efficiency coefficient factors in Table 6 are considered, it is seen that the inputs are no used at an economic optimum level.

Marginal product value is divided into factor price and marginal efficiency coefficients have been obtained. When these coefficients are evaluated, it is understood that marginal efficiency coefficients are used below the economic optimum level of pesticide (X_3) and land factor (X_5). It is also understood that marginal efficiency coefficients are used above the economic optimum level of seed (X_1) and fertilizer (X_2) (Table 6). When marginal efficiency coefficients of inputs used in wheat production are analyzed, it reveals that pesticide factors and land value are used efficiently but it is required to make an increase in seed and fertilizer factors used per unit area in order to create an increase in production.

Marginal rate of technical substitution and price ratio

Marginal rate of technical substitution is calculated via utilizing from the estimating equation of wheat production. Marginal rate of technical substitution and price ratio of inputs that show the use case of production factors in proportion to each other have been shown at Table 7. Marginal rate of technical substitution and price ratio of the factors are analysed, it is understood that there is not factor combination that has economic optimum level among the inputs used in wheat production.

When the use cases of factors in proportion to each other are examined, it is proved that seed, fertilizer, and pesticide quantity should be increased despite staying at the same land size to reach an optimum level (Table 7). In the enterprises analyzed, it is seen that increasing the use of seed, which is improved for Thrace Region where Edirne locates and which has the certificated quantity, will create an increase in wheat production.

In the research, cooperated with the Ministry of Agriculture and Rural Affairs and ICARDA, which has been conducted in 5 cities of different regions (Konya, Ankara, Adana and Diyarbakir) including Edirne, it is seen that wheat producers concentrate on newly developed wheat varieties. The basic reason for this is that newly developed products show higher performance than old and local types in the aspect of yield and water yield criteria and their contribution to producer prosperity (ICARDA, 2009).

Although in the enterprises, which have been analyzed, it has been determined that nitrogenous fertilizer quantity in wheat production is sufficient, the opinion that especially phosphorous fertilizer use is insufficient in production and it must be increased, has been proved in the light of research. In addition to this, another result concluded from Table 7 is that it is required to concentrate on agricultural control studies against weed, diseases and pests in wheat production.

Table 6
The marginal revenue, factor price, and the marginal efficiency coefficient of variables

Variables	Marginal revenue, USD	Factor price, USD	Marginal efficiency coefficient, MR FP
X_1(Seed Quantity)	3.32366	0.51949	6.39793
X_2 (Fertilizer Quantity)	1.00951	0.41662	2.42310
X_3(Pesticide Quantity)	0.64436	2.35386	0.27374
X_5 (Land Value)	0.02741	1002.28314	0.00003

Table 7
Marginal rate of technical substitution and price ratio of factors

Variables	Marginal rate of technical substitution / Price ratio, MRTS PR	X_2, Fertilizer quantity	X_3, Pesticide quantity	X_5, Land value
X_1(Seed Quantity)	dx_1/dx_j Fx_j/Fx_1	0.37873	0.042787	0.0000042
X_2 (Fertilizer Quantity)	dx_2/dx_j Fx_j/Fx_2	-	0.11297	0.0000112
X_3(Pesticide Quantity)	dx_3/dx_5 Fx_5/Fx_3	-	-	0.0000989

Discussion

When the quantity of seed use per unit area is compared with other research findings, it is seen that seed use is lower in the enterprises. The basic reason of this is that in production, the quantity of seed use per unit area has been abandoned in time and concentrated on seed use, which depends on the principle of seed plant number per m^2.

When the data has been compared, it has been determined that the quantity of nitrogenous fertilizer use per unit area is more than other research findings and phosphorous fertilizer use is lower than recommended quality. The acquired data shows that phosphorous fertilizer use is required to be increased. It is thought that the reason of this diversity in the region about fertilizing in wheat production stems from low ratio of soil testing and the lack of fertilizing applications based on the result of analyses because in the studies which have been conducted in the research area before it has been proved that the ratio of soil testing is rather low in the area (Semerci, 1998).

In the analyzed enterprises, wheat production is made under rainfed conditions. The basic reason for this stems from the opinion that precipitate in production period (500-550 mm) is enough for wheat growing. However, to have a higher yield and revenue, wheat production must be made under irrigated conditions.

In the research it has been observed that there is a difference between the findings of enterprises which have been analyzed and other research findings in terms of the pesticide use quantity because pesticide, which is recommended to be used at 1gr per unit area, has been begun to be used in growing quantity in Edirne. For this reason, the fact that pesticide use level in the enterprises is lower than the other research findings does not mean that these enterprises give no importance to agricultural protection in wheat production.

Determination coefficient (R^2) of estimating equation of the research has shown parallelism with the other research results related with the topic and it is concluded that there is not multicollinearity in the function.

Because of the conducted analysis, it has been understood that pesticide and land factors, variables in estimating equation of wheat production are used efficiently in the basis of marginal efficiency coefficients but seed and fertilizer variables are below the economic optimum level. When the rate of technical substitution and price ratio are taken into consideration according to factor combinations, it reveals that use levels of seed, fertilizer and pesticide are not sufficient and these inputs must be raised in order to create increase in wheat production.

Conclusion

Nowadays, terms of productivity and efficient use of resources rank at the top of topics that are principally targeted in all branches of activity. Also in agricultural sector, it has been observed that there has been increase in the researchers conducted on determining efficiency level of inputs that are used in production activities. In this research, conducted in Edirne, which is one of the most important wheat producers of Turkey, the relations between production quantity and inputs that are used in wheat production have been analyzed. In this research, Cobb-Douglas production function has been applied for analysing wheat production activity and in the light of research results, it has been seen that this function is suitable for the available data. In the enterprises analysed within the scope of this research, it has been understood that there is not statistically difference in the use of seed, fertilizer and pesticide according to the enterprise size. Total of production elasticity in estimating equation obtained from function analysis has revealed that there is increasing return to scale in wheat production. In this research, it is concluded that seed and fertilizer inputs, the use level and efficiency coefficients of which are insufficient, need to be raised in order to increase wheat production in analyzed enterprises.

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