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Araştırma Makalesi

Determination of Efficiency and Factors Affecting Efficiency in Maize Production in Konya Province (Cumra District)

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ABSTRACT

The study aims to determine the efficiency of input use and to analyze the factors affecting technical efficiency in farms producing maize. Maize is among the most cultivated cereals in the world. Konya, on the other hand, ranks first in Turkey with a 10% share in maize production. The research area of Cumra district, which constitutes 15.76% of the maize production in Konya province, has been selected according to the purposive sampling method. In the study, the sample volume was determined as 77, with a 95% confidence interval and a 5% margin of error, according to the stratified sampling method. In the study, linear regression analysis was carried out to determine the factors affecting the technical efficiency of maize producers. According to the results of the research, gross production value (USD), total land size (ha), and age were found to be statistically significant at the 5% significance level. Variable costs and education were statistically significant at the 10% significance level. The DEA method, which is a non-parametric method, was used to determine the technical efficiency and scale efficiency of farms under the assumption of technical efficiency, VRS, and CRS. Farms should be informed about the optimum use of inputs. In addition, a farmer training program to be organized on this subject should be given to the farmers.

Key words: DEA, Konya, maize production, regression

Konya İli (Çumra İlçesi) Mısır Üretiminde Etkinlik Analizi ve Etkinliğe Etki Eden Faktörlerin Belirlenmesi

ÖZ

Çalışmanın amacı, mısır üretimi yapan işletmelerin girdi kullanım etkinliğinin belirlenmesi ve teknik etkinliğe etki eden faktörlerin tespit edilmesidir. Mısır dünyada en fazla tarımı yapılan tahıllar arasındadır. Konya ili ise mısır üretiminde %10'luk bir pay ile ilk sırada yer almaktadır. Araştırma alanı, Konya ili mısır üretiminin %15.76'sını oluşturan Çumra ilçesi gayeli örnekleme yöntemine göre seçilmiştir. Araştırmada örnek hacmi, tabakalı örnekleme yöntemine göre, %95 güven aralığı, %5 hata payı ile 77 olarak belirlenmiştir. Çalışmada mısır üretimi yapan işletmelerin teknik etkinliklerini etkileyen faktörleri belirlemek için doğrusal regresyon analizi yapılmıştır. Araştırma sonuçlarına göre gayri safi üretim değeri (USD), toplam arazi büyüklüğü (ha) ve yaş %5 önem düzeyinde istatistiksel olarak anlamlı bulunmuştur. Değişen masraflar ve eğitim, %10 anlamlılık düzeyinde istatistiksel olarak anlamlıydı. Teknik etkinlik, VRS ve CRS varsayımı altında çiftliklerin teknik etkinliği ve ölçek etkinliğinin belirlenmesinde parametrik olmayan bir yöntem olan VZA yöntemi kullanılmıştır. Çiftlikler girdilerin optimum kullanımı konusunda bilgilendirilmelidir. Ayrıca bu konuda düzenlenecek bir çiftçi eğitim programı çiftçilere verilmelidir.

Anahtar kelimeler: Mısır, VZA, GSÜD, regresyon analizi, Konya

INTRODUCTION

Cereal crops are considered one of the most strategic food crops in the world. The most cultivated cereals in the world are wheat, paddy rice, and maize. Maize is consumed as a staple food for humans and as fodder for animals, and also serves as a basic raw material in the production of alcoholic beverages, textiles, pharmaceuticals, cosmetics, protein, food flavorings, and bioplastics (Manal, 2018; Doğan and Külekçi, 2020). World maize production is 1.1 billion tons and Turkey meets 0.55% (6 million tons) of world maize production (FAO, 2021; TURKSTAT, 2021). Maize is the third most important crop for Turkey after wheat and barley. Turkey's total maize cultivation area in 2020 is 1,217,893 hectares (ha), its production amount is 33,813,091 tonnes, its maize yield is 223 kg/ha, and its maize (silage) yield is 523 kg/ha. Konya is a very important agricultural city with 2,617,908 hectares of agricultural land, constituting 10.00% of Turkey's agricultural land. In terms of maize production, Konya ranks first with a share of 10.77% (3 641 610 tons) (TURKSTAT, 2021). Maize, which has an important place among cereal crops and has a wide production and usage area, has a very important role in nutrition. Great success has been achieved recently in increasing agricultural production and food security in the world. More than 7 billion people are fed by limited arable land. Yield increased from 1.2 to 3.7 tonnes from 1961 to 2017 (FAO, 2017). But the world also faces great challenges. Hunger and malnutrition are among the biggest problems in the world. A large part of the population in Asian and African countries derives their livelihood from traditional agricultural production (Fusuo et al., 2013). Today, more than half of the nitrogen fertilizer used in agriculture is lost to the environment, and scarce resources are wasted. In addition, the use of wrong techniques in agricultural production poses a threat to air, water, soil, and biodiversity (Lassaletta et al., 2014). In order to reduce these negative effects and support the sustainable development of agricultural production, it is necessary to increase the use of modern technologies and to raise the awareness of farmers (Smetanová et al., 2013; Hašková, 2017; Maroušek et al., 2017; Ren et al., 2019). The rate of technology used in the agricultural sector is far behind that of other sectors. Traditional agriculture cannot show the desired effect in terms of maximum yield or minimum production cost (Tey and Brindal, 2012; Adnan et al., 2019). Effective use of scarce resources used in production is very important to ensure the sustainability of farms. There are studies on efficiency in farms, aiming to contribute to the more efficient operation of farms (Thiombiano, 2017; Oğuz and Yener, 2018; Hajihassaniasl, 2019; Oğuz et al., 2019; Oğuz and Yener, 2019; Kaur and Bhaskar, 2020; Tümer et al., 2020; Parlakay and Çimrin, 2021). In the globalizing world, the optimum use of scarce resources is becoming an increasingly important issue. Whether the resources are used optimally or not can be determined by efficiency studies. In this study, it is aimed to calculate the efficiency of farms growing maize and to determine the factors affecting technical efficiency.

MATERIAL AND METHOD

The method used to determine the sample volume

In the selection of the sample district, Çumra district, which constitutes 15.76% of the maize production in Konya province, was selected according to the purposive sampling method (Table 1). The study was conducted in 2022. In the research, a stratified sampling method was used (Güneş and Arıkan, 1985) to increase the accuracy of the findings to be collected from the farms and to ensure adequate representation of different parts of the population. In the study, the sample size was determined as 77 with a 95% confidence interval and a 5% permisable error. The number of samples to be studied according to the stratified random sampling method was calculated using the formula below (Yamane, 1967).

$$n = \frac{\sum(N_h S_h)^2}{N^2 D^2 + \sum N_h S_{h^2}} \qquad D^2 = {d^2}/{z^2}$$

In the formula; n: Number of samples, N: Number of farms in the population, N_h: Number of farms in the *h*th layer, S_h^2: Variance of the *h*th layer, d: Allowable margin of error from the population mean, z: Refers to the z value in the standard normal distribution table according to the error rate.

Table 1. Distribution of farms producing maize (Sample Volume)

Size Groups of Farms (ha)	Sample Volume (n)
0-2.9	4
3-9.9	28
10-+	45
Total	77

The method used to determine the activities in the farms producing maize

In the study, the DEA method, which is a non-parametric method, was used to determine the technical efficiency and scale efficiency of the maize producers under the assumptions of technical efficiency, CRS, and VRS. In the DEA method, it is recommended that the number of decision-making units be equal to the product of the number of inputs to be used and the number of outputs or three times the sum of the number of inputs and outputs (Cooper et al., 2007). Therefore, 77 farms are enough for the DEA method. Maize yield was included in the model as the only output variable. The DEA method is included in non-parametric models and measures the relative efficiency of "n" Decision Making Units (DMU). The model was used in the study to determine the efficiency of the maize-producing farm by ranking them according to their performance. In the model, maize production value USD/hectare was taken as the output variable. 7 inputs were used as input variables. Inputs are seed cost (USD/ha), fertilizer cost (USD/ha), pesticide cost (USD/ha), labor cost (USD/ha), marketing cost (USD/ha), fuel cost (USD/ha), and water cost (USD/ha). In farms, producers control the efficiency of commonly used inputs. Therefore, input efficiency measures were used in the study (Farrel, 1957). In the study, 2 models of the DEA method were used to calculate the maize production efficiency of the farms. These are the CCR (Charnes-Cooper-Rhodes) fixed return to scale (Banker et al., 1984) and BCC (Banker-Charnes-Cooper) increasing returns to scale (Charnes et al., 1978) models. In DEA, inefficient decision units can be made effective symmetrically, both by realizing the same output level (input-oriented) with minimum input, and by maximizing output levels (output-oriented), provided that the inputs are kept constant. Maize production is produced with insufficient and scarce resources. Therefore, the application of the input-oriented DEA method is considered more appropriate to reduce the inputs used in the production process. Maize production value (USD/ha) was used to calculate the technical, pure technical, and scale efficiency of the farms to define the efficient and ineffective farms. Technical Efficiency (TE) can be defined as the decision unit's ability to produce maximum output from available technology and a given set of inputs. In the case of multiple input and output factors, the TE score (ø) is found as follows (Banker et al., 1984; Coelli et al., 2002):

$$TE_j = \frac{U_1 Y_{j1} + U_2 Y_{2j} + \cdots \dots \dots \dots + U_n Y_{nj}}{V_1 X_{j1ji} + V_2 X_{2j} + \cdots \dots \dots \dots + V_n X_{nj}} = \frac{\sum_{r-1}^{n} + U_r Y_{rj}}{\sum_{s-1}^{m} + V_s X_{sj}}$$

where U_r is the weight given to output "n", Y_r is the amount of output "n", "V_s" is the weight given to input "n", X_s is the amount of input "n", "r" is several outputs (r=1, 2, …., n), "s" is several inputs (s=1, 2, …, m) and "j" represents the j[th] DMU (j =1, 2, …, k). Following linear programming, the equation can be solved as follows:

$$Maximize\ TE = a_0 + \sum_{r-1}^{n} U_r Y_{rj}$$

$$\sum_{r-1}^{n} U_r Y_{rj} - \sum_{s-1}^{m} V_s X_{sj} \leq 0$$

$$\sum_{s-1}^{m} V_s X_{sj} = 1, U_r \geq 0, V_s \geq 0\ and\ (\text{“i”}\ and\ \text{“j”} = 1,2,3, \dots \dots k)$$

The CCR model calculates only TE, while the BBC model calculates TE, scale efficiency (SE), and pure technical efficiency (PTE). The BBC model assumes a variable return to scale, which represents a change in the product at a different rate for a one-unit change in inputs. The scale efficiency (SE) is associated with the most efficient scale of farms that act with the sensitivity of maximizing average productivity. It can be calculated as follows:

$$Maximize\ Z = uy_i - u_i$$

$$Subjected\ to\ vx_i = 1$$

$$-\text{vX} + \text{uY} - u_0\, e \leq 0$$

$$v \geq 0, u \geq 0$$

where "Z" and "u_0" are scalar and free in sign, "u" and "v" are output and input weight matrices, respectively, and "Y" and "X" are the corresponding output and input matrices, respectively. "xi" and "yi" refer to the inputs and output of the DMU, respectively. In addition, in the efficiency analysis, farms with a TE coefficient of 1-0.95 are classified as efficient, farms with 0.95-0.90 as less efficient, and farms below 0.90 as inefficient (Charnes et al., 1978). The scale efficiency (SE) is associated with the most efficient scales of farms that act with the sensitivity of maximizing average productivity. It can be calculated as follows:

$$SE = TE\ /\ STE$$

It gives information about the quantity on the SE scale characteristics (Chauhan et al., 2006). Deap 2.1 software was used to calculate TE scores.

The method used to determine the factors affecting the total technical efficiency in maize producers

In the study, linear regression analysis was carried out to determine the factors affecting technical efficiency of maize producers. Linear regression analysis measures the dependence of a single dependent variable with more than one explanatory variable. The coefficient of determination of the variables shows the strength of the interaction and the "t" test shows the interaction between the dependent and independent variables. The coefficient of determination is the square of the correlation coefficient (R^2). Projection equations consist of a dependent variable and the independent variables that determine this variable. In addition, these equations are established by the least-squares method (Gujarati and Porter, 2009). The dependent and independent variables used in the study are given below. $Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8$

Y= TE value obtained in maize producing farms, β_0= Fixed value, X_1= crop production value (USD), X_2= Land assets (ha) X_3= Variable costs (USD/ha) Social Security, X_4= Age, X_5= Education, X_6= Technology Index, X_7= Insurance status X_8=Information and Communication Technologies

A "technology usage index" was created according to the current technology use cases of the farms. Current technologies used by the farms are the disc tractor plow, disc stubble plow, soil mill (rotovator), disc harrow, combicure (mixed harrow), combined grain sowing machine, farm manure spreader, chemical fertilizer spreader, motorized sprayer, electropump, motor pump (thermic), centrifugal pump, deep well pump, sprinkler plant, water tanker (used in agriculture), bottom boiler (subsoiler), rototiller, pneumatic sowing machine, universal sowing machine (mechanical) (including beet seeder), stubble planter and drip irrigation plant. In order to calculate the factors affecting the technology adaptation of the producers in the research area, the technologies related to the farms producing maize were determined and a score varying between "0 and 1" was given to each technology. This scoring was converted into an index. The technology usage index was calculated as follows (Spielman and Birner, 2008; Knickel et al., 2009; OECD, 2013; Läpple et al., 2015; Läpple et al., 2016; Yener, 2017; Ögür et al., 2021). Technology Usage Index = (TSNR/MSMR)*100 TSNR: Total score the manufacturer received. MSMR: Maximum score the manufacturer can receive (Yener, 2017; Ögür et al., 2021).

RESEARCH FINDINGS

The age of farmers between the ages of 15-49, which is the main source of the business, is examined, it constitutes 33.77% of the farmers. When the education level of the individuals in the examined farms is examined, it has been determined that 45.45% of them are high school graduates, and the rate of university graduates is 3.90%. The average land width in the examined farms was found to be 30.33 ha, of which 70.02% is owned land and 29.98% is rented land. According to the 2020 data in Turkey, 23.1 million hectares of agricultural land and 8.03% of this agricultural land area is in the province of Konya. Total maize land planted in Turkey is 12,178 hectares, and 11.92% of this land is in Konya (TURKSTAT, 2021).

Chart 2. Land Use Status of the Investigated Farms

	1st Layer		2nd Layer		3rd Layer		Farms Average	
	ha	%	ha	%	ha	%	ha	%
Maize	1.94	8.61	5.85	31.87	21.37	55.53	14.72	48.51
Sugar beet	0.63	2.78	5.92	32.22	4.97	12.93	5.09	16.79
Wheat	13.63	60.56	3.25	17.70	5.35	13.89	5.01	16.53
Barley	3.13	13.89	2.29	12.48	3.80	9.89	3.22	10.61
Bean	2.25	10.00	0.40	2.18	1.18	3.07	0.95	3.14
Maize (Silage)	0.00	0.00	0.18	0.97	1.09	2.83	0.70	2.31
Sunflower	0.94	4.17	0.47	2.58	0.72	1.86	0.64	2.11
Total	22.50	100.00	18.37	100.00	38.47	100.00	30.33	100.00

The gross production value (GPV) of the examined farms was found to be 63,509.26 USD (Chart 3). Of this value, 57.50% is maize and 2.06% is maize (silage). The highest percentage was obtained from maize in the 3rd layer with a maximum rate of 64.82% in crop production value.

Chart 3. Gross Production Value of the investigated farms (USD)

	1st Layer		2nd Layer		3rd Layer		Farms Average	
	USD	%	USD	%	USD	%	USD	%
Maize	4,808.16	20.85	14,526.40	36.42	53,021.40	64.82	36,518.64	57.50
Sugar beet	2,062.85	8.94	19,532.29	48.97	16,418.49	20.07	16,805.03	26.46
Barley	3,237.75	14.04	2,375.58	5.96	3,941.71	4.82	3,335.64	5.25
Bean	5,862.85	25.42	1,042.28	2.61	3,074.74	3.76	2,480.50	3.91
Wheat	5,646.64	24.48	1,346.90	0.42	2,215.37	2.71	2,077.81	3.27
Maize (Silage)	0.00	0.00	332.36	0.83	2,026.66	2.48	1,305.27	2.06
Sunflower	1,447.22	6.27	730.50	1.83	1,104.60	1.35	986.36	1.55
Total	23,065.47	100.00	39,886.32	100.00	81,802.98	100.00	63,509.26	100.00

*Note: CBRT 2020 data is calculated as 1USD=8.06 USD according to the annual average rate.

The variable costs of crop production in the examined agricultural farms were calculated as 8,123.88 USD on average (Chart 4). The variable cost item, which has the highest share in this value, is fertilizer with 29.87% and irrigation with 25.65%, respectively. The reason for the high irrigation costs is the result of the high water consumption of the maize and sugar beet crops.

Chart 4. Variable costs of crop production of the surveyed farms (USD)

	1st Layer		2nd Layer		3rd Layer		Farms Average	
	USD	%	USD	%	USD	%	USD	%
Seed	305.25	10.84	633.60	11.29	1056.90	10.40	863.93	10.63
Fertilizer	646.77	22.97	1573.29	28.04	3116.20	30.67	2426.86	29.87
Biocides	186.83	6.63	215.96	3.85	254.15	2.50	236.76	2.91
Fuel-Oil	390.29	13.86	609.36	10.86	975.83	9.61	812.15	10.00
Irrigation	604.94	21.48	1376.95	24.54	2654.91	26.13	2083.71	25.65
Labor	521.14	18.50	999.52	17.81	1809.25	17.81	1447.89	17.82
Marketing	161.05	5.72	202.93	3.62	291.63	2.87	252.59	3.11
Total	2816.28	100.00	5611.61	100.00	10158.87	100.00	8123.88	100.00

*Note: CBRT 2020 data is calculated as 1USD=8.06 USD according to the annual average rate.

The gross profit of the farms examined was calculated as 55,380.01 USD according to the operating average (Chart 5). Variable costs account for 12.79% and gross profit for 87.20% of the crop production value. Gross profit is an important criterion that shows the success of the business organization.

Chart 5. Gross profit of the farms examined (USD)

	1st Layer	2nd Layer	3rd Layer	Farms Average
Crop Production Value	23,063.24	39,882.46	81,795.06	63,503.11
Variable Costs	2,816.01	5,611.06	10,157.88	8,123.10
Gross profit	20,247.23	34,271.40	71,637.17	55,380.01

*Note: CBRT 2020 data is calculated as 1USD=8.06 USD according to the annual average rate.

The aim of ensuring technical efficiency in agricultural production is to prevent waste of resources. Farms that ensure technical efficiency, on the one hand, reduce their costs, and on the other hand, minimize the damage to the environment. Internal costs and external costs should be considered, especially when making a production decision. Today, determining the environmental effects of production and showing these effects in costs is very important in modern economics (Doğan and Külekçi, 2020). Success in production is measured by “scale efficiency”. If the farms are operated at full capacity, more output can be produced from one unit of input with one unit of input. The average TE of the farms was calculated as 0.545. Accordingly, to achieve the same production level, the amount of input should be reduced by 45.5%. In the farms producing maize, 31.17% are efficient in the use of varying costs per hectare, 7.79% are less efficient and 61.04% are inefficient.

Chart 6. Efficiency scores of the surveyed farms

	Lowest	Highest	Average	Efficient Farm	Increasing Returns to Scale	Decreasing Returns to Scale
Technical Efficiency (CRS)	0.528	1	0.843	22	3	52
Pure Technical Efficiency (VRS)	0.531	1	0.870	26	13	38
Scale Efficiency (SE)	0782	1	0.968	61	12	4
Technical Efficiency (TE)	0.531	1	0.843	21	2	54

Efficiency scores ranged from 0.528 to 1 for the CRS and 0.531 to 1 for the VRS. The average TE level for maize producers under the assumptions of CRS and VRS was estimated by DEA analysis as 84.3% and 87.0%, respectively. This indicates that there is potential to improve current efficiency levels among maize producers. According to the CRS assumption, the farms are used inefficiently at an average of 15.7% and according to the VRS assumption at a rate of 13%. In chart 6, it is understood that 22 of 77 maize producers for CRS are efficient and 26 for VRS. The scale efficiency (SE) in the maize producers varies between 0.782 and 1 and the average was calculated as 0.968. In the study, the VRS technical efficiency score was estimated lower than the SE score. This result is due to the inefficiency in corn producing farms, the wrong input use of the farmers and the lack of technical knowledge. The technical efficiency of the maize producers varies between 0.531 and 1 and the average was calculated as 0.843.

Chart 7. Descriptive statistics of variables used in the analysis of factors affecting technical efficiency

	Minimum	Maximum	Mean	Std. Deviation
Technical Efficiency	.53	1.00	.8561	.12932
Crop Production Value (USD)	6555.13	179960.00	51183.5055	37271.54926
Land Presence in Maize (ha)	1.25	62.50	14.7156	12.67937
Variable Costs	7965.42	314975.83	65472.1660	56869.95824
Age	20.00	76.00	51.3896	13.55608
Education	1.00	4.00	2.2208	.91225
Social Security	.00	3.00	1.8571	.75593
Technology Index	.02	1.00	.4616	.32827
Insurance	.00	1.00	.6623	.47601
Information Communication Technologies	1.57	3.95	2.7044	.53314

Descriptive statistics of dependent and independent variables used in the analysis of factors affecting technical efficiency are given in chart 7.

Chart 8. Analysis of factors affecting technical efficiency

	B	Std. Error	Beta	t	Sig	VIF
(Constant)	1.111	.117		9.526	<.001	
Crop Production Value (USD)	4.578E-7	.000	1.320	3.185	.002*	18.004
Land Presence in Maize (ha)	-.001	.000	-.628	-2.561	.013*	6.296
Variable Costs	-1.245E-6	.000	-.510	-1.830	.072*	8.129
Age	.003	.001	.262	2.179	.033*	1.519
Education	.029	.016	.205	1.820	.073*	1.328
Social Security	.011	.020	.066	.572	.569	1.391
Technology Index	-.046	.042	-.116	-1.079	.284	1.205
Insurance	.023	.028	.085	.823	.414	1.122
Information Communication Technologies	.057	.025	.237	2.288	.025*	1.122

R^2= 0.361 R^2 (adj)= 0.275 F=4.206 Durbin Watson= 1.277

Factors affecting technical efficiency were determined by regression analysis (Chart 8). According to the regression analysis, R^2 was determined as 36.1. The studies in the literature were examined and it was determined that the R^2 values were appropriate (Below et al., 2012; Danso-Abbeam et al., 2018; Harniati and Anwarudin, 2018). According to the results of the analysis, crop production value (USD), land availability (ha), age, and information and communication technologies were found to be statistically significant at the 5% significance level. Variable costs and education were statistically significant at the 10% significance level.

CONCLUSION AND RECOMMENDATIONS

Input usage efficiencies were calculated by analyzing the crop production value of the farms producing maize in Konya province and their varying costs. The average TE level for maize producers under the assumptions of CRS and VRS was estimated by DEA analysis as 84.3% and 87%, respectively. In other words, maize farms will be able to achieve the same level of output by using 15.7% and 13% fewer inputs. The scale efficiency has been determined as 96.80% in the average of the farms and the farms are not at an economically appropriate scale. The reason for the low scale efficiency shows that the farms do not use their resources rationally and their management ability is low. In the study, the VRS score was estimated lower than the SE score. This result is due to the inefficiency in corn producing farms, the wrong input use of the farmers and the lack of technical knowledge. Technical efficiency in the examined farms was determined as 84.43%. Accordingly, farms producing maize use 15.57% of their resources inefficiently. In the farms producing maize, 27.27% are efficient in the use of varying costs per hectare, 2.60% are less efficient and 70.13% are inefficient. According to the results of the regression analysis, crop production value (USD), age, information, and communication technologies usage status were found to be statistically significant in the positive direction, while the land availability (ha) was found to be statistically significant at the 5% significance level in the negative direction. On the other hand, education was found to be statistically significant at the 10% significance level, in the positive direction, and the variable costs in the negative direction. As the crop production value increases, the efficiency in the farm increases. Land availability, on the other hand, has the opposite effect. Efficiency decreases as the presence of land increases in farms. This situation is explained by the increase in land fragmentation and product diversity because of the increase in the presence of land in the farms. The land fragmentation situation and the increase in product diversity affect the changing costs and cause the changing costs to increase. This situation leads to a decrease in efficiency because of the increase in variable costs. It has been determined that as the age of the farmers increases in the farms, the efficiency decreases. It has been determined that as the level of education in farms increases the efficiency increases. As the education level increases, the rate of using information and communication technologies increases, and the efficiency levels increase. This is explained by the fact that young farmers are more active in maize production than the old ones, they are open to innovations, their education level is higher, and they use information and communication tools more effectively. It is necessary to inform the farmers about the optimum use of inputs. In addition, technical and economic information about maize production should be provided to the farmers and a farmer training program should be organized on this issue. Thus, it will be possible to reduce the variable costs used and to make effective use of the resources used. Young farmers should be given more place in farmer training programs and effective and successful farms should be increased by training these farmers.

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REFERENCES

Adnan, N., Nordin, S.M., Bahruddin, M.A. and Tareq, A.H.A. 2019. State-of-the-art review on facilitating sustainable agriculture through green fertilizer technology adoption: Assessing farmers behavior. *Trends in Food Science & Technology,* 86**,** 439-452.

Banker, R.D., Charnes, A. and Cooper, W.W. 1984. Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management science,* 30**,** 1078-1092.

Below, T.B. 2012. Mutabazi K.D., Kirschke D., Franke C., Sieber S., Siebert R., Tscherning K. Can farmers' adaptation to climate change be explained by socio-economic household-level variables? *Global Environmental Change,* 22**,** 223-235.

Charnes, A., Cooper, W.W. and Rhodes, E. 1978. Measuring the efficiency of decision making units. *European journal of operational research,* 2**,** 429-444. 1978.

Chauhan, N.S., Mohapatra, P.K. and Pandey, K.P. 2006. Improving energy productivity in paddy production through benchmarking—An application of data envelopment analysis. *Energy conversion and Management,* 47**,** 1063-1085.

Coelli, T., Rahman, S. and Thirtle, C. 2002. Technical, allocative, cost and scale efficiencies in Bangladesh rice cultivation: a non-parametric approach. *Journal of Agricultural Economics,* 53**,** 607-626.

Cooper, W.W., Seiford, L.M. and Tone, K. 2007. Data envelopment analysis: a comprehensive text with models, applications, references and DEA-solver software. In Secondary Data envelopment analysis: a comprehensive text with models, applications, references and DEA-solver software.

Danso-Abbeam, G., Ehiakpor, D.S. and Aidoo, R. 2018. Agricultural extension and its effects on farm productivity and income: insight from Northern Ghana. *Agriculture & Food Security,* 7**,** 1-10.

Doğan, K. and Külekçi, M. 2020. Iğdır İli Silajlık Mısır Üretiminde Etkinliğin ve Etkinliğe Etki Eden Faktörlerin Belirlenmesi. *Journal of the Institute of Science and Technology,* 10**,** 1338-1349.

FAO. 2017. FAO Statistical Databases. web (Food and Agriculture Organization of the United Nations): FAOSTAT.

FAO 2021. https://www.fao.org/faostat/en/ (Accessed of date, 11.12.2021).

Farrel, J. 1957. The measurement of productive efficiency. Journal of the Royal Statistical Society. Series A, General 125. *Part***,** 252. 1957.

Fusuo, Z., Xinping, C. and Vitousek, P. 2013. Chinese agriculture: An experiment for the world. *Nature,* 497**,** 33-35.

Gujarati, D.N. and Porter, D.C. 2009. Basic econometrics (international edition). *New York: McGraw-Hills Inc*.

Güneş, T. and Arıkan, R. 1985. Agricultural Economics Statistics. *Ankara University Publication,* 924.

Hajihassaniasl, S. 2019. Efficiency, Analysis in the Agricultural Sector in Iran: The Case of West Azerbaijan Sunflower Producers. *International Journal of Management, Accounting and Economics,* 6**,** 389-399. 2019.

Harniati, H. and Anwarudin, O. 2018. The interest and action of young agricultural entrepreneur on agribusiness in Cianjur Regency, West Java. *Jurnal Penyuluhan,* 14.

Hašková, S. 2017. Holistic assessment and ethical disputation on a new trend in solid biofuels. *Science and engineering ethics,* 23**,** 509-519.

Kaur, R. and Bhaskar, T. 2020. Potential of castor plant (Ricinus communis) for production of biofuels, chemicals, and value-added products. In *Waste biorefinery*, 269-310. Elsevier.

Knickel, K., Tisenkopfs, T. and Peter S. 2009. Innovation processes in agriculture and rural development. *Results of a cross-national analysis of the situation in seven countries, research gaps and recommendations. In-Sight project report*. 2009.

Läpple, D., Renwick, A., Cullinan J. and Thorne, F. 2016. What drives innovation in the agricultural sector? A spatial analysis of knowledge spillovers. *Land use policy,* 56**,** 238-250.

Läpple, D., Renwick, A. and Thorne, F. 2015. Measuring and understanding the drivers of agricultural innovation: Evidence from Ireland. *Food policy,* 51**,** 1-8. 2015.

Lassaletta, L., Billen, G., Grizzetti, B., Anglade, J. and Garnier, J. 2014. 50 year trends in nitrogen use efficiency of world cropping systems: the relationship between yield and nitrogen input to cropland. *Environmental Research Letters,* 9**,** 105011.

Manal, M.S. 2018. Expected Economic Effects of Applying a Proposed Class Map for Maize Crop in Egypt. Egypt. *J. Agri. Eco,* 28**,** 269-304. 2018.

Maroušek, J., Kolář, L., Vochozka, M., Stehel, V. and Maroušková, A. 2017. Novel method for cultivating beetroot reduces nitrate content. *Journal of Cleaner Production,* 168**,** 60-62.

OECD. 2013. Agricultural Innovation Systems: A Framework for Analyzing the Role of the Government. Paris. web (Organisation for Economic Co-operation and Development): OECD Publishing.

Oğuz, C. and Yener, A. 2018. Productivity analysis of dairy cattle farms in Turkey: case study of Konya Province. *Custos e Agronegocio,* 14**,** 298-319.

Oğuz, C., Öğür A.Y. and Ayhan, A. 2019. Input Use Efficiency in Sunflower Production; A Case Study of Konya Province (Karatay District). *Turkish Journal of Agriculture-Food Science and Technology,* 7**,** 2012-2017.

Oğuz, C. and Yener, A. 2019. The use of energy in milk production; a case study from Konya province of Turkey. *Energy,* 183**,** 142-148.

Ögür, A.Y., Kaygusuz M., Bilik Ş. and Alp, M. 2021. The Effect of Climate Change and The Information Sources Used In The Farms Producing Sunflowerseed. In *Secondary.* Agrosym 2021 329-335.

Parlakay, O. and Çimrin, T. 2021. Determination of technical efficiency in broiler production using Data Envelopment Analysis method: a case study of Hatay Province in Turkey. *CUSTOS e Agronegocio Online,* 17**,** 239-250.

Ren, C., Liu, S., Van Grinsven, H., Reis, S., Jin, S., Liu, H.and Gu, B. 2019. The impact of farm size on agricultural sustainability. *Journal of Cleaner Production,* 220**,** 357-367.

Smetanová, A., Dotterweich, M., Diehl, D. and Ulrich, U. 2013. Dotterweich N.F. Influence of biochar and terra preta substrates on wettability and erodibility of soils. *Zeitschrift für Geomorphologie, Supplementary Issues,* 57**,** 111-134.

Spielman, D.J. and Birner, R. 2008. How innovative is your agriculture? Using innovation indicators and benchmarks to strengthen national agricultural innovation systems. World Bank Washington, DC.

Tey, Y.S. and Brindal, M. 2012. Factors influencing the adoption of precision agricultural technologies: a review for policy implications. *Precision agriculture,* 13**,** 713-730.

Thiombiano, B.A. 2017. Maize and Livestock Production Efficiencies and Their Drivers in Heterogeneous Smallholder Systems in Southwestern Burkina Faso. 2017.

TURKSTAT. 2021. https://data.tuik.gov.tr/Kategori/GetKategori?p=tarim-111&dil=1 (Accessed of date, 11.12.2021).

Tümer, E.İ., Ağır, H.B. and Aydoğan, İ. 2020. Evaluating technical efficiency of hair goat farms in Turkey: the case of Mersin Province. *Tropical Animal Health and Production,* 52**,** 3707-3712.

Yamane, T. 1967. Elementary Sampling Theory. In Secondary Elementary Sampling.

Yener, A. 2017. Konya ilinde süt sığırcılığı yapan aile işletmelerinde yeniliklerin benimsenmesi ve yayılmasına etki eden faktörler. Selçuk Üniversitesi Fen Bilimleri Enstitüsü.