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Technical Efficiency of Green Pepper Production in Greenhouses: The Case of Mersin Province, Turkey*

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Abstract

The main objectives of this research were to measure the technical efficiency of green pepper production in the greenhouse and to examine the determinants of technical efficiency in the Mersin province of Turkey. Data envelopment analysis was used to measure technical efficiency. 102 randomly selected farmers were visited to obtained data belong to the 2015 - 2016 production year. The results of the research showed that farmers may reduce their input use by 10.5% while maintaining current production under prevailing technology. The technical efficiency scores of the sample farms ranged from 0.748 to 1 (0.905 average). The variables of extension, off-farm income, cooperative partnership, credit usage, record keeping, and soil test positively affected technical efficiency. However, farm size had a negative relationship with efficiency. Therefore, this study proposes strategies such as providing better extension services, credit services, encouraging farmers to have agricultural insurance, soil tests, and co-operative formation, in order to improve technical efficiency.
Key words: Green Pepper; Data Envelopment; Technical Efficiency; Determinants of Efficiency; Greenhouse; Turkey

Plastik Serada Sivri Biber Üretiminin Teknik Etkinliği: Mersin İli Örneği, Türkiye

Özet

Bu çalışmanın temel amaçları, Türkiye'nin Mersin İlinde plastik serada sivri biber üretiminin teknik etkinliğinin ölçülmesi ve teknik etkinliğin belirleyicilerinin incelenmesidir. Teknik etkinliğin ölçülmesinde veri zarflama analizi kullanılmıştır. 2015 – 2016 üretim dönemine ait verilerin toplanması için rastgele seçilen 102 çiftçi ziyaret edilmiştir. Araştırma sonuçları, çiftçilerin hakim teknoloji altında mevcut üretim miktarlarını koruyarak girdi kullanımlarını %10.5 oranında azaltabileceklerini göstermiştir. Örnek işletmelerin teknik etkinlik skorları 0.748 ile 1 arasında değişmektedir (ortalama 0.905). Yayım, tarım dışı gelir, kooperatif ortaklığı, kredi kullanımı, kayıt tutma ve toprak analizi değişkenleri teknik etkinlik üzerine pozitif yönde etkilidir. Ancak, arazi genişliği etkinlik ile negatif ilişkilidir. Bundan dolayı, bu araştırmada teknik etkinliğin iyileştirilmesi için daha iyi yayım hizmeti sunucu, çiftçilerin krediye erişim imkanlarının iyileştirilmesi, çiftçilerin toprak analizi yaptırma ve kooperatif örgütlenmeye teşvik edilmesi gibi stratejiler önerilmektedir.
Anahtar kelimeler: Sivri Biber, Veri Zarflama Analizi, Teknik Etkinlik, Etkinliğin Belirleyicileri, Sera, Türkiye

1.INTRODUCTION

Every farmer who operates within the framework of the economic principle is occupied in getting at the highest income with a certain cost (Inan, 2006). When the necessity of better usage of the land, which is the most important production factor, gradual reduction of natural resources (Erkan et al., 2011), and the environmental problems caused by the unconscious and indiscriminate use of fertilizers and agrochemicals (Olhan, 1997) are considered together, the measurement of technical efficiency of agricultural production and inefficiency determinant can be easily understood by everyone.

Vegetable production has also increased its importance as response to improvement of both domestic demand and the foreign trade possibilities in Turkey. Vegetable production is create quite demand for labor not only in the production, but also in the other production stages such as the transportation, processing and marketing processes. Green pepper, with its export value of 90.94 million USA dollars, was located in Turkey's most exported vegetables in 2015. An important part of this export value was realized in the Mediterranean Region (Anonymous., 2016a). Vegetable production in greenhouse was an important source of income in Mediterranean region of Turkey due to climate and marketing opportunities. Turkey's total greenhouse production area was 647,594.00 decares in 2015. Green pepper produced in 8.00% (51,804.00 decares) of this area. 6.07% (385,548.00 tons) of total Turkish vegetable production in greenhouse was green pepper, and 49.30% of this was produced in Mersin province. In addition, 41.16% of the total greenhouse production area was engaged in green pepper in Mersin (Anonymous, 2016b).

Green pepper production in greenhouse, which is intensive in labor and information, is an important source of livelihood in Mersin with the employment opportunities it creates. For this reason, analysis of the technical efficiency of green pepper production in greenhouse may contribute to improvement of the regional economy by providing more efficient use of scarce resources in Mersin province.

A great deal of studies has been done to measure the technical efficiency of agricultural production through data envelopment analysis and stochastic frontier analysis. In some of these studies performed in the world, the technical efficiency of pepper production has been analyzed (Adeoye et al., 2014; Dipeolu and Akinbode, 2008; Jaafar and Jusoh, 1997; Mohamed et al., 2015; Ogunbo et al., 2015; Radam and Ismail, 1999; Rosli, 2013; Rosli et al., 2013). Similarly, efficiency analysis studies have been applied in Turkey. However, only two studies focused on the technical efficiency of green pepper production in open field (Başaran and Engindeniz, 2015; Bozoglu and Ceyhan, 2007). As a result of the literature review, we did not find any study which focuses on technical efficiency of green pepper in greenhouse in Turkey. The analysis of the technical efficiency and inefficiency determinant in order to develop appropriate policies for increasing green pepper productivity through improved technical efficiency may be useful. Therefore, the purposes of this study were (i) to analyze farm level technical efficiency of green pepper production in greenhouse in Mersin, Turkey, and (ii) to investigate determinants of technical efficiency and (iii) to develop policy recommendations based on the results of technical efficiency analysis.

2.MATERIAL and METHOD

Sampling and data collection

Mersin province, which constitutes significant portion of Turkey's green pepper production in greenhouse, was chosen as research area. The main data of this study was obtained through face-to-face surveys conducted with 102 green pepper farms were selected by using random sampling technique with a precision level of 10% and 95% confidence interval based on the criteria of greenhouse area in the Kazanlı and Adanalıoğlu villages of Akdeniz district of Mersin province (Yamane, 1967). Kazanlı and Adanalıoğlu were selected via purposeful sampling because of these two villages constituted 85% of the total greenhouse area in pepper production in Mersin Province (Anonymous, 2016b). This study involves the data of the 2015 – 2016 production year. Various studies and reports were also used as a secondary data in the study.

Farm level data envelopment model and tobit regression

In this study, Based on suggestion by Charnes et al. (1978), we constructed a DEA model for green pepper farms assuming that each decision making unit, which is green pepper farm in this research, quantity of green pepper production using multiple inputs such as land, seed quantity, fertilizer, pesticide, labor and machinery power and that each farmer is allowed his/her own set of weights for both output and input. The data for all farmers are denoted by K x N input matrix (X) and M x N output matrix. Using current technology and input-oriented measure of TE can be calculated for each farmer the solution to linear programming (LP):

$$\begin{aligned} &\text{Minimize } \theta, \lambda \\ &\theta \text{ Subject to} - y_i + Y\lambda \geq 0 \qquad (1) \\ &\theta x_i - X\lambda \geq 0 \\ &\lambda \geq 0 \end{aligned}$$

In model, θ is the TE score having a value $0 \leq \theta \leq 1$. If θ is equals 1, farmer in on the frontier: the vector λ is an N x 1 vector of weights which defines the linear combination of the peers of the i-th farmer.

Coelli et al. (2005) pointed out that the CRS model is only appropriate when the all farmers are operating at an optimal scale. But, factors such as imperfect competition and financial constraints may prevent a farmer operating at optimal scale in agriculture (Dinler, 2014). Since farmer in the Mersin Province conducted their activities under imperfect competition due to imperfect information about market condition and other factors. So that reason, we transformed equation (1) to the variable return to scale (VRS) technology model by adding the convexity constraint. Farmer that are efficient scales are of appropriate size and thus do not need to be reorganized to improve output or earnings. Scale efficiency was calculated as the ratio of TE score of the farmer under CRS technology to the TE score of the farmer VRS technology. Farmers research area were classified as efficient scale if SE = 1 or the $TE_{VRS} = TE_{CRS}$. Farmer level scale inefficiency was determined by comparing TE score under non-increasing returns to scale (NIRS) with TE score under CRS. İf SE < 1 and $TE_{NIRS} = TE_{CRS}$, farmer was classified as scale inefficient due to increasing returns to scale (IRS). If SE < 1 and $TE_{NIRS} > TE_{CRS}$, farmer was classified as scale inefficient due to decreasing return to scale (DRS) (Banker et al., 1984). In addition, at this stage of the study, the determinants of efficiency were analyzed by tobit regression analysis which technical efficiency scores calculated by data envelopment analysis were used as dependent variable (Greene, 1997).

Efficiency measures under CRS and VRS were calculated by using DEAP 2.1 (Coelli, 1996).

Description of data and variables

The amount of green pepper productions (kg) of the each farm was taken as a dependent variable in the data envelopment model established for estimating the technical efficiency. Eight inputs, (land as decares, labor as hours, machine power as hour, seedling as number, organic fertilizer as kg, chemical fertilizer as TL, agrochemical as TL and other capital as TL) were included in model as independent variables. Other capital consisted of water / electricity cost, the cost of materials used in heating, thread cost, cleaning plant residues cost, the fuel cost for transport of products to market.

The variables commonly used in previous studies to explain the efficiency of a sample farm size, schooling years, use of extension services, data recording, and credit use (Adeoye et al., 2014; Başaran and Engindeniz, 2014; Bozoglu and Ceyhan, 2007; Dipeolu and Akinbode, 2008; Jaafar and Jusoh, 1997; Mohamed et al., 2015; Ogunbo et al., 2015; Radam and Ismail, 1999; Rosli, 2013; Rosli et al., 2013). In this study, twelve explanatory variables (farmer's age as year, greenhouse land size as decares, total number of parcels, family size as person, schooling year, use of extension service, off-farm income, cooperative partnership, credit use, data record, insurance and soil test as dummy) were included in tobit regression model in order to investigated determinant of technical efficiency. Variables used in efficiency analysis and some basic characters of farm and farmers were presented in Table 1.

Table 1. Variables used in efficiency analysis and some basic characters of farm and farmers

Variables **Efficiency Model**	**Definition and Measurement**	**Mean**	**SD**	**Max.**	**Min.**
The amount of productions	as kg	214,970.71	140,378.12	504,400.00	40,000.00
Land	as decares	22.79	14.12	54.00	5.00
Labor	as hours	12,984.85	7,216.82	29,372.76	3,256.90
Machine power	as hours	77.90	49.00	183.97	15.67
Seedling	as number	47,015.83	27,086.50	101,304.00	11,570.00
Organic fertilizer	as kg	107,221.95	55,565.90	220,558.09	27,529.51
Chemical fertilizer	as TL	16,060.92	7,632.89	33,359.18	4,310.44
Agrochemical	as TL	17,506.37	9,443.65	39,521.34	4,674.21
Other capital	as TL	43,703.19	27,252.96	107,510.28	8,718.32
Determinant of Efficiency					
Age	Farmer's age as year	41.36	9.40	60.00	20.00
Land Size	Greenhouse land size as decares	22.79	14.12	54.00	5.0
Parcel	Total parcel number	1.33	0.55	3.00	1.00
Family size	Total number of family members	4.60	1.00	7.00	3.00
Schooling	Farmers' education (Year of schooling)	7.12	1.77	11.00	5.00
Extension	1 for use of extension service and 0 otherwise	0.38	0.49		
Off-farm income	1 for off-farm income and 0 otherwise	0.5	0.5		
Cooperative partnership	1 for cooperative partnership and 0 otherwise	0.42	0.5		
Credit	1 for credit use and 0 otherwise	0.41	0.49		
Record	1 for data record and 0 otherwise	0.33	0.47		
Insurance	1 for agricultural insurance and 0 otherwise	0.33	0.47		
Soil test	1 for soil test and 0 otherwise	0.44	0.50		

3.FINDINGS and DISCUSSION

Results of data envelopment analysis

The one of the main objectives of this paper was to estimate the farm level technical efficiency of pepper production on a sample of farms using DEA technique. A brief of the outcomes on the constant returns to scale (CRS) technical efficiency, variable returns to scale (VRS) technical efficiency and scale efficiency (SE) were presented in Table 2.

Under the constant returns to scale, technical efficiency of farms ranged between 0.720 to 1.000 with mean efficiency score of 0.874 and standard deviation of 0.076. Variable returns to scale technical efficiency score ranged from 0.748 to 1.000 with mean efficiency score of 0.905 and standard deviation of 0.072. Similarly the scale efficiency score ranged from 0.735 to 1.000 with mean efficiency score of 0.966 and standard deviation of 0.041. About 42 farms under constant returns to scale and 62 farms under variable returns to scale had technical efficiency score greater than 0.90. This emitted that about 41.18% of the farms fall under the category of relatively efficient farmers (technical efficiency above 90%) with the assumption of constant return to scale, whereas sample farms falling under least efficient category (70 – 79.9 percent) constitutes only 20.29% of sample farms (Table 2).

Table 2. Number of Farms under Different Component of Efficiency

Efficiency Level	Number of Farms Under CRS-TE		Number of Farms Under VRS-TE		Number of Farms Under SE	
	Frequency	%	Frequency	%	Frequency	%
0.70 - 0.799	21	20.59	8	7.84	2	1.96
0.80 - 0.899	39	38.24	32	31.37	2	1.96
0.90 - 1.00	42	41.18	62	60.78	98	96.08
Total No. of Farms	102	100	102	100	102	100
Mean	0.874		0.905		0.966	
Max.	1.000		1.000		1.000	
Min.	0.720		0.748		0.735	

The mean technical inefficiency under CRS was estimated as 12.6%. This result showed that sample farms were not using their production resources technically efficient and that they may reduce their input usage levels by 12.6% while maintaining the current production quantities by adopting the best agricultural practices. A proportion of farms operated far from the technical efficient frontier, meaning an important extent for improving productivity by efficient use of the existing level of inputs and resources. With the assumption of VRS the estimated mean technical efficiency score was 0.905, and this indicates that there existed a potential for technical efficiency improvement in green pepper farms and total production can be increased up to 9.95% by adopting the technology and the techniques used by the efficient farms. The scale efficiency of the sample farms was estimated as 0.966. This result showed that the sample farms had little potential to improve their efficiency. Sample farms can increase their efficiency only 0.034 by adoption of the best farming techniques and moving to the optimal scale.

Whilst, 3.92% of farmers had CRS that increased in inputs cause the same proportional increase in output, 89.91% of farmers had IRS, which the output increases by a larger proportion than the increase in inputs. 6.86% of the farmers had DRS, which means the proportion of output is less than the desired increased input (Table 3). Since scale refers to size, the descriptive statistics of variables such as number of farms, yield (kg/da), labor (hour/da), seedling (number/da), organic fertilizer (kg/da), chemical fertilizer (TL/da), agrochemical (TL/da), other capital (TL/da) were presented in Table 3. As shown in Table 3, the 4 scale-efficient farmers were large in terms of only yield, whereas, the 91 farmers who had IRS were large in terms of labor, seedling, organic fertilizer, chemical fertilizer, agrochemical and other capital. In addition, scale-efficient farmers had less labor compared to inefficient farmers (Table 3).

Table 3. Summary of returns to scale results

Variables	IRS	CRS	DRS
Number of farms	91	4	7
Yield (kg/da)*	9,150.2	10,650.00	9,804.28
Labor (hour/da)*	604.87	530.79^{a}	544.01^{a}
Seedling (number/da)**	2147^{a}	2039^{a,b}	1923b
Organic fertilizer (kg/da)*	5,123.89	4,383.63^{a}	4,150.86^{a}
Chemical fertilizer (TL/da)*	796.19^{a}	708.41^{a,b}	568.49^{b}
Agrochemical (TL/da)*	826,44^{a}	744.36^{a,b}	706.20^{b}
Other capital (TL/da)*	1,916.41^{a}	1,885.88^{a}	1,920.52^{a}

Returns to scales with same letter(s) are not significantly different
**Games-Howell coefficient*
***Tukey HSD coefficient*

Determinants of technical efficiency

Based on the results of the tobit regression analysis, some exogenous variables had a significant coefficient. Most of the signs of coefficients were in accordance with our expectations. The results of regression analysis showed that factors as extension, off-farm income, cooperative partnership, credit use, data record, and soil test had positively relationships with technical efficiency, while greenhouse land area negatively influenced it. According to results, schooling, farmers' age, total number of parcels, agricultural insurance, and family size had not significant relationship with technical efficiency of green pepper production (Table 4.).

The age variable included in the tobit regression model to test the hypothesis that younger farmers were more likely to innovations or had more experience so more technically efficient. But result of regression analysis showed that age had not statistically significant influenced on technical efficiency. As distinct from expected outcomes, total parcel number, family size and schooling variables had not statistically significant influence on technical efficiency.

Farms size, as decares, was included in tobit regression model in order to investigate the relationship between greenhouse land area and technical efficiency. According to results of regression analysis, farm size had a negative and statistically significant coefficient. This implied that farm size had negatively influence on technical efficiency. Agricultural practices in green pepper production like fertilization, spraying, harvesting, heating, irrigation need to be applied many times in a production period. Failure to do some agricultural practices, especially such as spraying and heating, on time and even a few hours delaying them can lead to important losses in the production of green peppers. Agricultural activities are spread over time in large farms. Thus, it may be more difficult for large farms than small farms to carry out their agricultural activities (like spraying, heating, harvest etc) at the right time. And this may be reason for inefficient input uses. Our result was similar to Amara et al. (1999), Bozoglu and Ceyhan (2007) and Cinemre et al. (2006), was inconsistent with our Parlakay (2011) and Tiruneh and Geta (2016).

It was expected that contact with extension service will increase the farmer's possibility of adoption of developed vegetable seedling, fertilizer and growing technologies which may increase the technical efficiency level of green pepper production. In accordance with this expectation, an important finding was that extension variables had a positive and significant sing. This result showed that contacts with extension service were able to improve technical efficiency in green pepper production because farmers may improve agricultural practices and managerial skills based on suggestions of extension service. This finding was agreed with Bozoglu and Ceyhan (2007), Ceyhan and Hazneci (2010), Cinemre et al. (2006) and Rosli et al. (2013) who reported farmers with a high information score as a variable of frequency of contact with extension and other information sources were more efficient. However, there were also studies reported conflicting results to our findings (Amoah et al. 2014; Tiruneh and Geta 2016).

Financing of agricultural enterprises at exactly time and the required amount is very important for increasing the production amount, productivity, input use efficiency and eventually agricultural income (Hazneci and Ceyhan, 2015; Terin et al., 2014). Although well-motivated and educated, a farmer lacking sufficient financial resources does not have the potential making modernize agriculture. Modern agriculture requires the use of inputs such as fertile seeds, fertilizers, agricultural medicines, concentrated animal feed, specialist labor in certain settings (Agbo et al., 2015). In order to be able to supply these at the right time and in sufficient quantity, a continuous cash outflow is required. However, due to the structure of agriculture, farmers are able to earn one or few times a year depending on the harvesting period, although they face a constant cash outflow. Therefore, farmers' to achieve to off-farm income and credit sources was hypothesized to have influence on technical efficiency positively. In line with our previous expectation, we found that access to off-farms income and to credit have a positive effect on technical efficiency. Another important result showed that credit usage increased technical efficiency, a result similar to the findings of Ceyhan and Hazneci (2010), Cinemre et al. (2006) and Hazneci and Ceyhan (2015), but different to the finding of Külekci (2010).

The estimated coefficient of cooperative partnership had positive and significant sing related to technical efficiency. This finding emitted that it improved technical efficiency of green pepper production in research area. The rationale of this coefficient may be that the farmers' technical knowledge and management skills provided from the cooperative partnership improve the use of inputs in green pepper production. This result line with Alwarritzi et al. (2015), Rosli et al. (2013) and Tipi et al. (2009), but contradict to Mohamed et al. (2015).

As a result of our literature review, we found only one study that examined the relationship between participation in the insurance program and technical efficiency. Amara et al. (1999) reported that there was no correlation between participation in insurance program and technical efficiency of potato production. Participation in insurance program as an independent variable was included in tobit regression model in this case. According to our result, the correlation between participation in insurance program and technical efficiency was positive but not statistically significant.

Soil test and data record are important practices in order to enhance economic and agronomic sustainability (Rodriguez et al., 2009). We hypothesized that soil tests and data record may be provide monitoring input usage in the appropriate amount and time, and may improve technical efficiency. In order to test this, two variables, soil test and data record, included in the tobit regression model. These findings showed that the data record and soil test variables improve the technical efficiency. Hazneci (2015) reported that data record improve technical efficiency in sugar beet and wheat seed production. But result of Hazneci and Ceyhan (2015) showed that there was no correlation between data record and technical efficiency. In this study, there was a positive correlation between soil test and technical efficiency. Güldal and Özçelik (2017) reported that the cost of wheat in farms those doing soil test was lower than farms those not doing soil test in Turkey.

Table 4. Results of tobit regression analysis

Variables	Coef.	Std. Err.	t	P > |t|	95% Conf. Interval	
Age	0.000076	0.000485	0.16	0.876	-0.000888	0.001040
Land Size	-0.001482	0.000485	-3.05	0.003	-0.002446	-0.000418
Parcel	-0.008801	0.008920	-0.99	0.326	-0.026522	0.008919
Family size	0.010201	0.006491	1.57	0.120	-0.002695	0.023096
Scholling	0.002966	0.002864	1.04	0.303	-0.002724	0.008656
Extension	0.021091	0.010994	1.92	0.058	-0.000751	0.042933
Off-farm income	0.036395	0.009827	3.70	0.000	0.016872	0.055918
Cooperative partnership	0.035109	0.009758	3.60	0.001	0.015723	0.054495
Credit	0.029548	0.010160	2.91	0.005	0.009364	0.049732
Record	0.027797	0.011294	2.46	0.016	0.005359	0.050234
Insurance	0.015893	0.011380	1.40	0.166	-0.006715	0.038502
Soil test	0.034155	0.010480	3.26	0.002	0.013335	0.054976
Constant	0.080100	0.040013	20.02	0.000	0.072151	0.880490
Sigma	0.003785	0.002876			0.032133	0.043558
Log Likelihood				15,551.917		
Number of obs				102		
LR chi2(12)				144.17		
Prob > chi2				0		
Pseudo R2				-0.864		

4.CONCLUSIONS

The results of the research showed that farmers may reduce their input use by 10.5% by maintain current production under prevailing technology. The technical efficiency of the sample farms ranged from 0.748 to 1 (0.905 average). According to the results of this study, the variables of extension, off-farm income, cooperative partnership, credit usage, record keeping, agricultural insurance and soil test positively affected technical efficiency. However, farm size had a negative relationship with efficiency. Based on results of this study, it is obvious that the inputs used in production can be reduced without a reduction in the amount of production under current technology. Under findings of this study, we recommended that policy makers should focus on (i) improving access to information through effective extension and training programs, (ii) since the results of the research show that the use of credit has a positive effect on the technical efficiency, the enhancing farmers' facilities of access to credit, (iii) encouraging and guiding farmers for carry out soil testing to guide fertilization, and co-operative formation.

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