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TECHNICAL EFFICIENCY IN GRAPE PRODUCTION: A CASE STUDY OF DENIZLI, TURKEY

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Abstract

In many parts of the world, viticulture has become primary agricultural importance throughout history. The main reason for this is that it is economically productive with an assessment of grapes as fresh wine, dried fruit, fruit juice and other manufactured products. The aim of this was to determine the resource utilisation success of vineyard in Denizli province, which has an important share in Turkeys grape production. The primary material of the study was the data obtained from the grape producers in selected villages in Çivril, Çal and Buldan Districts of Denizli Province. The sample size was calculated by using proportional sampling method. Sample volume was found 96 farmers in 95% confidence interval and the 10% margin of error. Data envelopment method (DEA) was used in the research to measure technical efficiency in grape production. Data Envelopment Method is used to evaluate the efficiency of a certain number of production units. The technical efficiency, scale efficiency and pure technical efficiency calculated according to input and the results were calculated and compared to irrigated and non-irrigated vineyards. Interviewed producers were 49 years old, educated seven years, and their agricultural experience was 26 years. According to the findings, respondents were asked how much they could reduce their input on the efficiency limit, and some suggestions were made for inefficient vineyards.

Key words**:** *data envelopment, technical efficiency, economic loss, grape production, viticulture*

INTRODUCTION

Viticulture has been an important agricultural arm throughout history in many countries. The main reason is that it is economically able to evaluate the grapes as fresh food, wine, dried fruit, fruit juice and other processed products. Viticulture in the world is made between in 34^o - 49^o the northern and southern latitudes, which covers Turkey as favourable climate. Grape can be considered the most valuable foods as a raisin or other products. The grapevine leaves collected for use in food and processed in brine are widely considered as a second product. With these considerations, viticulture is considered one of the important economic activities of agriculture. Therefore, vineyards cover the widest field after the grain production in Turkey. Turkey's contribution to agricultural products outside the vineyard production is of vital importance regarding foreign trade and create employment in rural areas. According to data for 2017, Denizli has 9.77 percent of Turkey's vineyard and carries 11.27 percent of the production alone. In 2017; 4.2 million tons of grapes are produced about 417,000 hectares in Turkey [10]. Approximately 65,000 families earn their living from viticulture [2][11]. The grape production is the most shareholders in Turkey [6].

Approximately 50% of the grapes consume fresh, 38% are dried, and 11% is consumed as wine. Turkey, with about 6,000 a year more than 1,400 vine viticulture has a genotype of both culture and wild vine, vine country is considered one of the fatherland. According to data for 2017, Turkey ranks fifth regarding total vineyard area and sixth regarding production in the world [4].

Turkey's almost covers 2.97 percent of the total grape and raisin trade in the world [4]. 7-

10 percent of Turkey's export revenue consisted from the raisins in the 1930s so that, it counts the most important traditional export product. According to data from 2017, Turkey exports about 420 thousand tons of grapes (raisins to 51.53%) and has earned more than 677 million dollars [4]. This value constitutes 4% of the exports of agricultural products. Viticulture Turkey has very important potential regarding creating employment opportunities because almost every month of the year is one of the wine-growing areas that require labour-intensive agricultural activities as well as the economic benefits of foreign trade. Although it is accepted that 15% of the agricultural farms in Turkey operate in the field of viticulture, but not enough information has been reached about the employment rate it has created. When the general structure of farms is evaluated, it is accepted that market-oriented activity is essential in Aegean, Mediterranean and Marmara regions, whereas small family farms in other regions are predominant, but they are also an important source of income [3].

Since the vineyard areas can be established in areas that cannot be cultivated in fields, fruits and vegetables, it is an important source of livelihood for those living in such places. It also protects these areas from erosion. The determination of the efficiency in viticulture provides important information for the investors and establishment of policies that will guide the vineyard regarding the public. Modern vineyards are installed especially in recent years, which are require expensive investments. Therefore, making these investments more conscious is important for the more effective use of resources. The findings of the research provide useful information for these investments. Also, it can be said that the study will shed light on other studies. Briefly, the purpose of this study; was to determine the resource utilisation success of farms in the Denizli province, which has a significant share in Turkey's grape production. Many studies have been done related to grape varieties, and the cost of viticulture but none of them determines the efficiency of farms in Turkey despite the increase the importance of this paper. In the study, the calculated technical efficiency, scale efficiency and pure technical efficiency results for the input were calculated separately for the watery and dry land.

According to the findings, the question of how much can be reduced in proportion to the amount of electricity, labour, depreciation, overheads and other inputs used to obtain the income in question, according to the farms that produce over the efficiency limit, without any change in the production. According to the findings, the question of how much can be reduced in proportion to the amount of electricity, labour, depreciation, overheads and other inputs used to obtain the income in question, according to the enterprises that produce over the efficiency limit, without any change in production. In the end, a number of recommendations were made for ineffective farms.

MATERIALS AND METHODS

The main material of the study was the data obtained from the grape producers in the villages of Çivril, Çal and Buldan in Denizli. The data were obtained from face-to-face interviews using a pre-prepared questionnaire. Also, various statistics, research reports, theses and papers were used as secondary data sources. In 2017; 4.2 million tons of grapes are produced in Turkey, and 11.25% of this quantity are covered by Denizli [10]. Especially in Denizli province, fresh grape and wine grape varieties are at the forefront. Denizli Province produces 205,788 tons of fresh seedless grapes in 2017. Buldan has a share of 32.33 per cent, Çal has a share of 26.53 per cent, and Çivril has a share of 0.084 per cent. However, regarding wine grapes, Çal ranks first with a share of 43.58 percent of Denizli and 8.44 percent of Turkey. In addition regarding raisins, Buldan was shining out with 14,703 tonnes of production quantity and its share of 18.25 percent of Denizli and 1.13 percent of Turkey. Çal (56,257 tons) and Çivril (1,188 tons) districts are other important production places in the production of dried seedless grapes. With the production of 31,711 tonnes in Buldan district came to the fore in 2018 in the production of table

seedless grapes. For this reason, Buldan, Çal and Çivril districts, which represent approximately 60% of the total grape production, were selected for representing Denizli district. Buldan district is located in the inner part of the Aegean Region, and neighbour with Güney District from the east; Kuyucak (Aydın Province) from the west, Sarıgöl (Manisa Province) from north and Sarayköy District from the south [7]. Çivril is a district located on the Denizli-Uşak highway in the northern part of Denizli and 90 km northeast of Denizli, in the western part of Denizli province [9]. Çal district is located on the eastern skirts of the Çekelez Mountain in the east of Denizli. On the western skirt of the mountain is the famous Pamukkale.

Table 1. Vineyard area and production quantity of Denizli, Turkey and researched districts

		Fresh with seed	Fresh seedless	Wine grape	Dried with seed	Dried seedless	Total
Çal	Vineyards (ha)	2,000.00	5,833.00	3,955.90	1,996.50	5,880.00	19,665.40
	Share in Denizli province (%)	25.76	47.86	39.44	60.40	79.07	48.29
	Production quantity (tonnes)	16,434.00	54,588.00	41,203.00	19,728.00	56,257.00	188,210.00
	Share in Denizli province (%)	**24.44**	**26.53**	**43.58**	**70.99**	**72.97**	**39.83**
Buldan	Vineyards (ha)	350.00	2,559.60	48.70	256.20	660.00	3,874.50
	Share in Denizli province (%)	4.51	21.00	0.49	7.75	8.88	9.51
	Production quantity (tonnes)	3,515.00	66,539.00	366.00	1,055.00	14,073.00	85,548.00
	Share in Denizli province (%)	5.23	**32.33**	0.39	3.80	**18.25**	**18.11**
Çivril	Vineyards (ha)	207.50	263.90	101.40	113.10	173.20	859.10
	Share in Denizli province (%)	2.67	2.17	1.01	3.42	2.33	2.11
	Production quantity (tonnes)	1,478.00	1,729.00	1,056.00	727.00	1,188.00	6,178.00
	Share in Denizli province (%)	2.20	0.84	1.12	2.62	1.54	1.31
Denizli	Vineyards (ha)	7,762.50	12,187.30	10,030.80	3,305.50	7,436.10	40,722.20
	Share in Turkey (%)	4.06	37.16	15.75	5.92	10.10	9.77
	Production quantity (tonnes)	67,250.00	205,788.00	94,555.00	27,789.00	77,092.00	472,474.00
	Share in Turkey (%)	4.67	**30.81**	**19.38**	7.66	6.22	**11.25**
Turkey	Vineyards (ha)	191,034.10	32,795.60	63,679.50	55,804.70	73,592.90	416,906.80
	Production quantity (tonnes)	1,441,000.00	668,000.00	488,000.00	363,000.00	1,240,000.00	4,200,000.00

Source: TÜİK, 2018 [10].

In the selection of villages, the villages that were thought to represent the research area were selected, and the selection of villages was homogenous. While determining the number of producers interviewed in the study, the following proportional sample volume formula was used.

If the size of the population is unknown;

$n = t^2\ pq\ /\ d^2$

n: Sample size

p: Probability of occurrence

q: 1-p (or probability of incidence)

d: accepted ± sampling error rate

t (α, sd): The critical value of t table according to the degree of freedom at the level of α significance

Accordingly, 95 percent confidence interval and a 10 percent margin of error sample size were calculated as 96 producers. The villages included in the study and the number of producers interviewed in these villages were given in Table 2.

Table 2. Numbers of interviewed producers in research villages

	Village	Number of producers	Total
Buldan	Yenicekent	29	48
	Oğuzköyü	19	
	Ortaköy	10	
	Selcen	8	
Çal	Bahadınlar	6	35
	İsabey	6	
	Kabalar	5	
Çivril	İmralı	6	13
	Koçak	7	

Source: own calculation

In the research, data envelopment method (DEA) was used to measure the technical efficiency of grape production. Efficiency score was determined by considering the following variables. Data Envelopment Method is used to evaluate the effectiveness of a certain number of production units. It can determine production technology in the case of multiple outputs and inputs based on distance functions [8]. Efficiency score was calculated by considering the following variables.

Y: Grape production quantity (1,000 tons)

X1: Vineyard size (ha)

X2: Labour hours (Adult male equivalent-AME)
X3: Machinery power (hours)
X4: Fertiliser (TRY)
X5: Pesticides (TRY)

The amount of grapes produced was the amount of grapes produced in each farm and was included as a dependent variable in the analysis. The size of the vineyard, was the width of the land, indicates the size of the grape produced area regarding hectares (ha).

The labour force was included in the analysis as the expression of the workforce spent during the grape production regarding adult male equivalent (AME). Labour force includes both family power and foreign labour. It was thought that it would be more appropriate to include the labour force in quantity, not in monetary terms.

Machinery costs were obtained separately from the hours spent for each process, from the first to the harvest, which the farms spent on producing grapes. Since different fertilisers used in grape production contain different amounts of nutrients (N, P, K) or they have different properties, it was decided to treat them as fertiliser costs in TRY. Similarly, it was decided that it should be included in the model in monetary terms because it was considered a large number of chemicals in grape production.

When determining the efficiency score, the observed and optimal values of the inputs and outputs used were compared. This comparison can be considered as the ratio of the observed output to the maximum output available from the current input, or the ratio of the minimum potential input required producing a certain amount of output to the observed input, or a combination of the two.

Efficiency component has not been taken into consideration in efficiency studies for many years. The activity is, in fact, one of the components that provide efficiency change [8].

If agricultural production is not done effectively, agricultural production can be increased by better utilisation of resources. When we look at the subject, in theory, it will be shifted from a point below the production possibilities curve to the production possibilities curve where maximum potential production is realised [5] [8].

RESULTS AND DISCUSSIONS

Table 3 presents the general characteristics of the producers interviewed. The average age of the interviewed producers was 49 years, the training period was seven, and the agricultural experience was 26 years. When compared to producers according to the land structure, it was determined that the producers who produce in the irrigated land be younger and more educated, but their experience period was shorter than the non-irrigated vineyards. When farms were evaluated regarding households, it was seen that the farms were composed of four persons.

Table 3. Farmers' characteristics according to the land structure in interviewed farms

General characteristics	Irrigated (N=56)		Dry (N=40)		Total (N=96)	
	Mean	Std. Dev.	Mean	Mean	Std. Dev.	Mean
Age (year)	44.30	9.71	56.45	9.13	49.36	11.18
Education (year)	7.70	3.13	6.00	2.28	6.99	2.91
Household population (person)	4.09	1.16	3.90	2.38	4.01	1.77
Experience (year)	21.26	8.56	32.80	13.42	26.17	12.26

Source: own calculation

Table 4 shows the distribution of the vineyards according to their owned status and land structure. According to the results of the research, it was determined that the farms have 4.52 hectares of vineyard. It was determined that 4.1 hectares be owned by the property, 0.25 hectares were rented, 0.26 hectares was mutual property. The vineyards were found to have an average of 4.8 plots. When the ownership status of the vineyards according to the land structure was evaluated, it was determined that the irrigated vineyards were larger, less fragmented and the property rate was higher.

Table 4. The land presence and tenure in interviewed farms according to the land structure

	Irrigated (N=56)		Dry (N=40)		Total (N=96)	
	Mean	Std. Dev.	Mean	Mean	Std. Dev.	Mean
Vineyard size (ha)	5.09	42.39	3.72	30.38	4.52	38.28
Personal vineyard (ha)	4.55	42.27	3.26	24.05	4.10	36.24
Rented vineyard (ha)	0.15	5.70	0.39	15.38	0.25	10.83
Mutual vineyard (ha)	0.39	13.04	0.08	4.74	0.26	10.49
Mean plot (number)	3.91	2.09	6.03	4.99	4.79	3.72

Source: own calculation

The average yield of grapes was 13,343 kg per hectare, and the average vineyard was 4.52 hectares (Table 5). In grape production, producers use an average of 692 hours of labour (AME), 534 hours of machinery power, 891 TRY of fertiliser and 360 TRY of pesticides. In irrigated vineyards, the average grape yield was 17,858 kg per hectare, and the average vineyard size was 5.09 hectares. In irrigated conditions, it was determined that the producers use 794 hours of labour (AME), 517 hours of machinery power, 955 TRY of fertiliser and 359 TRY or pesticides. In dry conditions, it was noteworthy that the vineyards produce much lower efficiency than the aqueous conditions. The average yield of vineyard in dry conditions was 4,695 kg per hectare. Producers producing grapes in dry conditions need 495 (EİG) 692 hours of labour (AME), 567 hours of machinery power, and 767 TRY fertiliser and 363 TRY agricultural pesticides.

Table 5. Grape production and input use quantities in interviewed farms according to the land structure

General features	Irrigated (N=56)		Dry (N=40)		Total (N=96)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Yield (kg ha^{-1})	17,858	1,125.34	4,695	322.71	13,343	1,136.55
Vineyards (ha)	5.09	42.39	3.72	30.38	4.52	38.28
Labour (man power ha^{-1})	794	42.91	495	34.99	692	43.59
Machinery (hour ha^{-1})	517	25.18	567	25.87	534	25.47
Fertilisers (TRY ha^{-1})	955	50.56	767	48.94	891	50.07
Pesticides (TRY ha^{-1})	359	43.51	363	41.24	360	42.37

Source: own calculation

The gross production value of the grape production in the interviewed vineyards was determined to be TRY 11,209.5; the total variable cost per hectare was 5,666 TRY (Table 6). It was seen that labour costs were the most significant share among variable expenses. The gross margin of the vineyard was determined to TRY 5,543. When comparing according to the land structure, it was seen that the gross production value was higher in the irrigated vineyards. According to Table 6, the total variable costs, fertiliser, labour force, machinery power and other costs were higher in the irrigated vineyards than non-irrigated vineyards.

Within the scope of the research, data envelopment method was applied all the vineyards interviewed to evaluate the results of the input efficiency. Moreover, according to the land structure, the vineyards were separated as irrigated and non-irrigated vineyards and evaluated independently. The study examined the question of how much input quantities can be reduced proportionally without changing the amount of grapes produced in the vineyard. Table seven presents the results of input efficiency score in general and according to the land structure of the examined vineyards.

Table 6. Gross production value, variable costs and gross margins in interviewed farms according to the land structure

	irrigated (N=56)		Dry (N=40)		Total (N=96)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Gross production value (TRY ha^{-1})	12,605.0	836.01	8,538.0	647.89	11,209.5	815.26
Variable costs (TRY ha^{-1})						
Fertilizers (TRY ha^{-1})	955	50.56	767	48.94	891	50.07
Pesticides (TRY ha^{-1})	359	43.51	363	41.24	360	42.37
Labour (TRY ha^{-1})	3,988	222.53	2,330	186.57	3,419	229.33
Machinery power (TRY ha^{-1})	425	11.00	380	17.97	409	14.40
Irrigation (TRY ha^{-1})	309	12.28	-	-	203	18.81
Other costs (TRY ha^{-1})	421	22.03	311	15.14	384	20.15
Total (TRY ha^{-1})	6,457	245.54	4,151	205.30	5,666	262.88
Gross margin (TRY ha^{-1})	6,147	788.44	4,386	521.35	5,543	706.45

Source: own calculation

The lowest value of the total technical efficiency for the input was 0.020, and the average score was 0.374. When an evaluation made according to the average efficiency, it was possible to realise the same production even if the examined vineyards can reduce the amount of input they use by 62.6%. When looking at the source of inefficiency in input usage, it seen that this was a problem due to not being able to realise the current production using minimum input and deviation from the optimum scale. The number of reference vineyards with a total technical efficiency value of one or which constitutes the effective limit was determined as three and these vineyards constitute only 5.36% of all vineyards.

When the vineyards evaluated according to the land structure, the technical efficiency score in the irrigated conditions was determined as 0.050, and the average value was 0.533. These coefficients were

determined as 0.112 and 0.470 in the non-irrigated vineyards. While the number of active vineyards in water conditions was 11 and 19.64% of total vineyards, the number of active vineyards in dry conditions was six, and it has a share of 10.71% in total. The high number of vineyards that provided pure technical efficiency in both land structures shows that there were losses due to scale inefficiency in vineyards. According to the results of the analysis, although it was not an active agricultural activity in both land structures, it was seen that resource utilisation was more successful in irrigated conditions.

Table 7. The results of the input efficiency according to the land structure in the interviewed farms

Irrigated vineyards (N=56)			
Efficiency	Technical effi.	Pure effi.	Scale effi.
Max.	1.000	1.000	1.000
Min.	0.050	0.124	0.050
Mean	0.533	0.749	0.742
Std. Dev.	0.304	0.287	0.288
Var. Coefficient.	0.173	0.110	0.112
%100 efficient farms	11	26	11
Share in total (%)	19.64	46.43	19.64
Dry vineyards (N=40)			
Efficiency	Technical effi.	Pure effi.	Scale effi.
Max.	1.000	1.000	1.000
Min.	0.112	0.163	0.112
Mean	0.470	0.826	0.612
Std. Dev.	0.310	0.297	0.316
Var. Coefficient.	0.205	0.107	0.163
%100 efficient farms	6	27	6
Share in total (%)	10.71	48.21	10.71
Total (N=96)			
Efficiency	Technical effi.	Pure effi.	Technical effi.
Max.	1.000	1.000	1.000
Min.	0.020	0.020	0.020
Mean	0.374	0.374	0.374
Std. Dev.	0.316	0.316	0.316
Var. Coefficient.	0.266	0.266	0.266
%100 efficient farms	3	3	3
Share in total (%)	5.36	5.36	5.36

Source: own calculation

The loss of inputs resulting from inefficiency in the vineyards has calculated by subtracting the targeted input usage amounts from the current use of the vineyards that have not been able to ensure their efficiency in production. In other words, in each group, inefficient vineyards were determined how much they need to save more labour force, machinery power, pesticides and fertiliser costs compared to reference vineyards that produce over activity limit. In grape production, producers overuse 111 hours of the workforce, 94.3 hours of machinery power, 193 TRY of fertilisers and 46.5 TRY of pesticides due to inefficiency in production. If the loss of inputs due to inefficiency in the interviewed vineyards was expressed in monetary terms, 15.19 percent of the variable costs were wasted. Considering that the area where the vineyards in Denizli was more than 40 thousand hectares, the total loss of input will be 35 million TRY. These input losses were very important regarding increasing the producer's income and decreasing the product costs and increasing consumer welfare. It was determined that although irrigated vineyards were more effective, the input losses were more. It was possible to say that the amount of loss was less because non-irrigated vineyard was more extensible.

Table 8. Input losses according to the land structure in interviewed farms

	Irrigated vineyards (N=56)	Dry vineyards (N=40)	Total (N=96)
Labour (TRY ha^{-1})*	807.2	120.3	548.3
Machinery power (TRY ha^{-1})**	77.2	42.5	72.6
Fertilisers (TRY ha^{-1})	233.6	85.1	193.2
Pesticides (TRY ha^{-1})	61.1	22.7	46.5
TOTAL	1179.1	270.6	860.6
Share in the variable cost (%)	18.26	6.52	15.19

* 1 unit of men power hourly rate was calculated as 5.02 TRY in irrigated farms, 4.70 TRY in dry farms and 4.94 TRY in general. ** The hourly rate of the machinery power was calculated as 0.82 TRY in irrigated farms, 0.67 TRY in dry farms, and 0.77 TRY in general.
Source: own calculation

CONCLUSIONS

The results of this study, which shows the technical efficiency of grape production in Denizli province, can be summarised as follows:

Total technical efficiency value was determined as 0.374. This indicates that the production of grapes in Denizli was not effective and generally shows that 62.6% of the producers use excess input. It was determined that ineffectiveness be mostly due to the inability of the farms to operate on an appropriate scale. The primary reason for this was the fact that farms, which were the main problems of the Turkish agricultural structure, were mostly fragmented. The number of active farms was determined as only three, and it was determined that it constitutes only 5.36% of the total farms. According to the land structure, it was determined that the irrigated farms be more effective regarding the amount of input, but because of the intense production, they have a higher monetary value than the ones producing in dry conditions. Because of the research, it was necessary to increase the mechanisation of viticulture, in other words, in order to make the production of grapes more efficient.

Grape was a very important traditional product regarding Turkish agriculture, and grape production was made in many regions of Turkey. In this regard, more efficient work of the research institutions and ensuring that innovations were delivered to the farmers will contribute to the increase of efficiency in both Denizli and other regions.

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