Determination and Evaluation of energy consumption for grape production in Eyvan county (Ilam province)

Faraidon Kamari, Bahram Ghamary*, and Amir Azizpanah

(Biosystem Engineering Department, Faculty of Agriculture, Pazhohesh Blvd, Ilam University, 69315- 516, Ilam, Iran)

Abstract: Grape is one of the most important fruits that has a long history of cultivation and production in our country. Effective use of energy in agriculture is one of the main reasons for the emergence of sustainable agriculture. It reduces environmental problems and pollution, prevents the destruction of natural resources and preserves fossil fuels. Energy analysis is also essential for the proper management of scarce resources to improve agricultural production and thereby identify efficient and economical production activities. In this research, the determination and evaluation of the energy consumption of grape production in Eyvan county (Ilam province) is conducted. In the present study, the required data were collected from the presence method and a questionnaire was collected from the grape producers in the county of Eyvan in 2019. The number of questionnaires was calculated using Cochran's equation and was 177. According to the collected data, the results showed that the weighted average of energy efficiency, energy efficiency, net energy and energy in the studied gardens were 5.44, 0.67 Kg mJ^{-1}, 126049.60 MJ ha^{-1} and 1.48 MJ kg^{-1}. The share of direct, indirect, renewable and non-renewable energy of total energy consumption were calculated as 54.68%, 45.32%, 22.47% and 77.53%, respectively. The results of sensitivity analysis of energy inputs to investigate the effect of increasing or decreasing inputs on product performance showed that 56.63% of total production costs were related to variable costs and 43.37% of total production costs related to fixed costs. The total amount of input and output energy were 28364.25 and 154413.86 MJ ha^{-1}, respectively. The net profit (net profit) for canola was 454963010 Rials, which showed that the production of canola in the region had economic justification.

Keywords: grape, eyvan, economic analysis, energy

Citation: Kamari, F., B. Ghamary, and A. Azizpanah. 2021. Determination and Evaluation of energy consumption for grape production in Eyvan county (Ilam province). Agricultural Engineering International: CIGR Journal, 23(3):173-181.

1 Introduction

Grape is one of the most important fruits that has a long history of cultivation and production in our country. The interest of the ancient Iranians in the consumption of various grape products, especially in the fresh, syrup, dried (raisin) state, was the due to the natural conditions of the country for the cultivation of vines. All edible grapes belong to the genus *vitis* (vine) of the vine family (vitaceae). This family has at least 11 known Genus and about 600 species (Einset and Dratt, 1975). Among them, *vitis* is the most important and the only genus whose fruit is edible and has 60 species and 10000 named varieties. *Vitis vinifera* is the only European species and the most important commercial species of grapes (Singleton and Esau, 1969). Iran is the seventh largest grape producer in the world, accounting for about 3.3% of total grape production in the world. In the year 2018, the area of country's gardens (both fertile and non-fertile) was about 2.91 million hectares, of which the production of horticultural was about 21 million tons,

Received date: 2020-04-18 **Accepted date**: 2021-03-09

* **Corresponding author: Bahram Ghamary,** Ph.D., Associate Professor of Department of Biosystem Engineering, Ilam University, 69315- 516, Iran. Email: b.ghamary@ilam.ac.ir. Tel: +98 9121013061, Fax: +98 84 3222 7032.

93.4% of which was irrigated and the rest cultivated by dry farming. Also, the highest fertility levels were in pistachio (15.9) and grape (11.7) percent, respectively. Also in 2018, the highest production share was in orange (15.1%) and then grapes (14.8%), (Ahmadi et al., 2019). In 2018, the level and production of horticultural products in Ilam province were 4966 hectares and 15409 tons, respectively.

Grape area and production in the country were 308419 hectares and 3030602 tons, respectively. Ilam province had the share of 1194 hectares and 5651 tons, respectively. Eyvan county with cultivated area of 420 hectares and average yield of 3500 tons, per years, is grape production pole in Ilam province (Ahmadi et al., 2019). Considering the energy situation in the world, agricultural efficiency and productivity at present are more dependent on energy consumption (Tabatabaeefar et al., 2009). One of the most important indicators of sustainability of grape production is energy flow analysis of its production. So far, studies have evaluated the production flow of these productions in various locations (Rajabi-Hamedani et al., 2011) and evaluated the energy production of grapes in Hamadan province.

The results showed that chemical fertilizers and energy consuming inputs in production and total energy consumption was 42213 MJ ha^{-1}. Khoshroo et al. (2013) also evaluated the energy consumption trend of grape production in Fars province and reported two electricity and irrigation water inputs as the most consumed energy sources in production. Mardani and Taghavifar (2016) studied the energy flow of grape production in the west Azerbaijan province. Their results showed that consumed nitrogen fertilizer with 36% of total energy consumed, was the most consumed energy source. Also, total energy efficiency and energy proficiency were 5.47 and 0.46 Kg MJ^{-1}, respectively. Ozkan et al. (2007) in the study of energy consumption in grape production at the research farm of Akdeniz university in Turkey, reported that the energy consumption in grape production was 245.3 MJ, greenhouse per hectare and in the field 23640.9. The output energy of the greenhouse production was lower than that of the farm and as a result the energy ratios in the production of greenhouse grapes were 2.99 and 5.1. A review of the sources revealed that so far the energy flow in grape production in Ilam province had not been investigated. Therefore, the purpose of this study was to determinate and evaluate the energy consumption of grape production in Eyvan county (Ilam province).

2 Material and methods

2.1 Study area and sampling method

This study was carried out in Eyvan county (Ilam province) in the year 2018 – 2019 (Figure 1). The number of people studied was determined by Cochran's relation (Cochran, 1977), so that the limitation questionnaires were initially distributed among the local gardeners. Then the standard deviation was calculated and then the number of samples was calculated using the Equation 1. Accordingly, 177 samples were determined.

$$n = \frac{Nt^2 S^2}{Nd^2 + t^2 S^2} \qquad (1)$$

In this relation (N), the size of statistical population or the number of grape growers, (t), is acceptable reliability coefficient assuming the normal distribution of the trait to be obtained from the Students' t-table, (S²), estimates the variance of the trait studied in the population, which is the variance of the energy ratio in the study area, (d), is the optimal probability accuracy and (n), is the sample volume.

Figure 1 Location of the study area of county (Ilam province)

Required information was collected through the questionnaires and in-person interviews with gardeners. The questionnaires contained questions about inputs and outputs needed for grape production in Eyvan county (Ilam province). The questionnaires included data about general information of the farmer, general information of the farm (i.e. situation, number of trees, age of tree, type of the farm etc.), irrigation, human force, machinery, operations, electricity and yield. Then the energy content of inputs and outputs were obtained using the equivalent energy coefficients.

2.2 Energy flow

The energy consumed was calculated using the energy equivalence of each unit of input or output shown in Table 1 and multiplied by the amount of input or output produced. Input energies are divided into two groups: direct and indirect, in the form of renewable and non-renewable energy (Khojastehpour et al., 2015). Direct energies include: Human labor, diesel fuel and electricity, while indirect energies included machinery, fertilizers and pesticides. On the other hand, renewable energies included manpower and non-renewable energies, including, machinery, diesel fuel, chemical.

$$energy\ ratio = \frac{\text{input energy}(\frac{\text{MJ}}{\text{hr}})}{\text{output energy}(\frac{\text{MJ}}{\text{hr}})} \quad (2)$$

$$energy\ efficiency = \frac{\text{operation}(\frac{\text{kg}}{\text{hr}})}{\text{input energy}(\frac{\text{MJ}}{\text{hr}})} \quad (3)$$

$$energy\ intensity = \frac{\text{input energy}(\frac{\text{MJ}}{\text{hr}})}{\text{operation}(\frac{\text{kg}}{\text{hr}})} \quad (4)$$

$$NT = \text{output energy} - \text{input energy} \quad (5)$$

Table 1 Equivalence of energy inputs and outputs in agricultural production

Input	(UNIT)	Energy coefficienets (MJ.Unit)	Reference
Human labor	Hr	1.96	Pahlavan et al., 2012
Animal excreta	Kg	0.3	Pahlavan et al., 2012
Chemical fertilizer	Kg	120	Pahlavan et al., 2012
Pesticide	Kg	101.2	Mandal et al., 2009
Insecticides	Kg	199	Helsel, 1992
Fungicides	Kg	92	Kitani, 1999
Herbicide	Kg	238	Esengun et al., 2007
Machinery	Kg	62.7	Mandal et al., 2009
Ssprayer	Kg	129	Kitani, 1999
Fuel	L	47.8	Kitani, 1999
Electricity	KW.hr	11.93	Pahlavan et al., 2012
Watering	M^3	1.02	Pahlavan et al., 2012
Output	Kg		
Grape	Kg	11.8	Pahlavan et al., 2012

2.3 Energy sensitivity analysis

A function and its intended variables should be such that the nature of the subject and purpose of the research can be explained. In examining the relationship between inputs and outputs in agricultural production, there are a variety of different functions, including the Cobb-Douglas function (Hatirli et al., 2006; Mohammadi et al., 2010; Rafiee et al., 2010). The production functions defined as follows:

$$Y_i = a_0 \sum_{j=1}^{n} x_{ij}{}^{aj} u^{ei} \text{=1,2,…,k: j=1,2,…,n)} \quad (6)$$

In general, to estimate the coefficients of the Cobb-Douglas production function, it must firstly be logarithmically transformed into a linear relation that is Equation 7(Hatirli et al., 2006; Mohammadi et al., 2010; Rafiee et al., 2010).

$$lnY_i = a_0 + \sum_{j=1}^{n} a_j\, ln(X_{ij}) + e_i \quad (7)$$

Where, Yi: field output energy

X_{ij}: inputs used in production

a_0:fixed coefficient

e_i:error coefficient

a_j:regression coefficient of inputs

Independent variables, inputs and dependent variables are the operation per hectares. Independent variables include, fuel energy, machinery, fertilizer, irrigation, Human labor, poison and electricity in examining the relationship between inputs and performance.

Sensitivity analysis of energy inputs is used to evaluate the effect of an increase or decrease in the amount of inputs on a products performance, the final physical output index of MPP is used for this purpose. The MPP value is calculated from Equation 8.

$$MPP_{xj} = \frac{GM(Y)}{GM(X_j)} \times a_j \quad (8)$$

Where:

MPP_{xj}: the ultimate physical production of i

$GM(Y)$: geometric mean of product performance

$GM(X_j)$: geometric mean of input i

a_j: regression coefficient of input i

To obtain the relationship between imported, inputs and grape operation, the Cobb-Douglas relation function model Equation 9 was used.

$$Y = f(x)\exp(u) \quad (9)$$

this function is expressed linearly.

$$\ln Y_i = a + \sum_{j=1}^{n} \mathrm{a}_j \ln X_{ij} + e_i \quad (10)$$

Y_i: is the function of the farmer, X_{ij}: is the equivalent energy input of production, $e_i: is\ the\ error.$

Also, the effect of direct, indirect, renewable and non-renewable energies on product performance using the Cobb-Douglas function model Equation 11 and 12 was used.

$$LN\,Yi = \beta_0 + \beta_i \ln DE + \ \alpha\beta_2 lnIDE + e_i \quad (11)$$

$$LN\,Yi = y_0 + y_i lnRE + y_2 lnNRE + e_i \quad (12)$$

Here, Yi is the i field performance, $\beta_{0,}$ constant value,y_0, constant value and $\beta_{i\ and} y_i$, coefficients of the independent variables and DE, IDE, RE and NRD in the form of direct, indirect, renewable and non-renewable energy, respectively.

In the final part of this study, based on the Equation 13 average productivity values of the product is calculated.

$$\mathrm{App}_{xj} = \frac{GM(Y)}{GM(X_J)} \quad (13)$$

In which App_{xj}, the average productivity is related to “J” input, $GM(Y)$, the geometric mean of product performance, $GM(X_J)$, the geometric mean of J input, $Ja,$ is the demand elasticity of input J.

In first, raw data extracted form questionnaires were entered into Excel 2010 software. Data were analyzed using SPSS software, Version 23.

3 Results and discussion

In this work, the energy consumption of grape production was studied in a county in the west of Iran. It was observed that the highest and lowest energy inputs were electricity and machinery with amounts of 5443.65 and 690 MJ ha^{-1}, respectively. The energy input for fertilizers came the second and had the amount of 5286.96 MJ ha^{-1}. Energy efficiency of grape production in this province amounted to 0.67 kg MJ^{-1}. Based on the Cobb- Douglas function, the input coefficients for herbicide, sprayer and fuel inputs were negative and smaller than 1.

The energy consumption of each of the inputs for grape production and the results of the calculations of energy consumption by the different inputs are presented in Table 2. According to the table, the highest energy consumption related to electricity was 5443.65 MJ ha^{-1}. The overuse of electricity is due to the use of pumping stations to supply garden water. Khoshroo et al. (2013) worked on the use of a non-parametric data envelopment analysis for improving energy efficiency of grape production. It was reported that the main difference between efficient and inefficient farmers was in the use of chemicals, diesel fuel and water for irrigation. Tian et al. (2019) studied the energy consumption and energy efficiency in two-harvest-a-year grape cultivation. It was observed that the energy input structures in two production seasons were quite similar because they both consumed large proportions energy of chemical fertilizer and pesticide. Mohseni et al. (2019) made the energy consumption analysis in Arak city, Iran. They observed that among all input energies, chemical fertilizers held the first rank with an amount of about 704 MJ ton^{-1}. It accounted for 38% of the total energy used in the production season. Energy use efficiency, which was a ratio between output and input energy, was calculated as 5.75.

The results also showed that, on average 5 hours of tractor work per hectare was required to prepare the garden. Fertilizer application in orchards requires an average of 524.47 kg ha^{-1}. On average 88.86 liters of fuel were consumed per hectare, which increased with increasing cultivation area. The average yield of grapes was 13085.92 kg ha^{-1}. The energy consumption of chemical fertilizer and animal manure was 5286.96 and 1133.8 MJ ha^{-1}, respectively. The last column of the table showed the percentage of energy of each input relative to the total input energy. Total energy input of consumable inputs, included (manpower), animal manure, chemical fertilizer, insecticides, fungicides, herbicides, tractors, spraying, fuel, electricity and water, were obtained 28364.24 MJ ha^{-1}. Electricity, fertilizer, fuel and fungicides had the highest energy consumption, respectively, which is the share of each respectively, with 19.19, 18.64, 14.98 and 14.60 (Table 2). The lowest energy consumption was obtained for insecticides, tractors, manpower and spraying, which accounted for 1.91, 2.43, 3.33 and 3.74, respectively (Table 2).

Table 2 Physical quantities of inputs and outputs, and the amount of input and output energy in the grape product

A: outputs(unit)	Amount (unit ha^{-1})	Energy (MJ ha^{-1})	Share of each input (%)
Human labor	474.54 (h ha^{-1})	945.77	3.33
Animal excreta	3776.95 (h ha^{-1})	1133.08	3.99
Chemical fertilizer	524.48 (Kg ha^{-1})	5286.96	18.64
Insecticides	4 (Kg ha^{-1})	542.64	1.91
Fungicides(sulfur)	45.01 (h ha^{-1})	4140.93	14.60
Herbicide	12 (Kg ha^{-1})	2856.00	10.07
Machinery	5 (h ha^{-1})	690	2.43
Sprayer	8.22 (Kg ha^{-1})	1059.77	3.74
Fuel	88.86 (L ha^{-1})	4247.59	14.98
Electricity	546.30 (KW ha^{-1})	5443.66	19.19
Water	1978.27 (m^3 ha^{-1})	2017.83	7.11
Total energy input	-	28364.25	100
outputs(unit)	Amount(Kg ha^{-1})	Energy(MJ ha^{-1})	Share of each output(%)
Product(grape)	13085.92	154413.86	100
Total energy output	-	154413.86	100

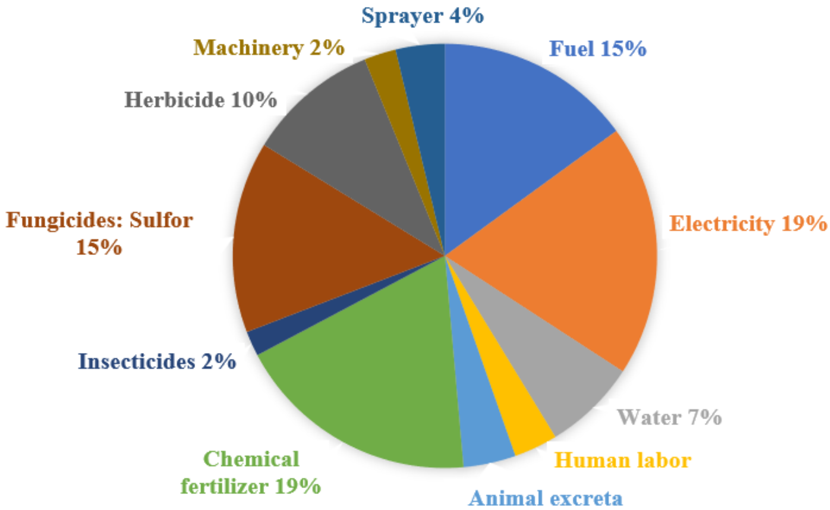

Figure 2 percentage of different inputs in grape production

According to Figure 2, electricity accounted for 19.19 percent of total energy consumption in grape production. In addition, chemical fertilizer energy ranked the second with 18.64 percent. Insecticides also had the lowest energy consumption in grape production with 1.91 percent. In this part of the study, energy indices in grape production were studied. Indicators are defined and applied to determine the relationship between inputs and outputs for agricultural product. Some of the important energy indicators that make it possible to compare different production system in agriculture, including energy ratio, energy efficiency, energy intensity and net energy.

Table 3, showed the indicators of energy ratio, energy intensity, net energy and energy efficiency. Accordingly, the energy ratio was 5.44. Energy efficiency in grape production was 0.67 kg MJ^{-1}, which meant one MJ of energy consumed per 0.67 kg of grape production. An energy intensity of 1.48 MJ kg^{-1} was calculated, which meant consuming 1.48 MJ kg^{-1} of grape production. According to Table 3, the percentages of direct, indirect, renewable and non-renewable energies were 54.68, 45.32, 22.47 and 77.53, respectively. Because of high fertilizer and water consumption, direct energy was more than indirect energy. Energy efficiency is kg per megawatt and was mostly used to compare two identical crops in agricultural systems and indicated the efficiency of each system (Maleki et al., 2011). The amount of renewable energy for grape production in the study area was 2963.61 MJ ha^{-1}. Renewable energy included the labor force. The amount of non-renewable energy for grape production in the study area was 10224.555 MJ ha^{-1}. Non-renewable energy includes machinery, fuel, electricity, fertilizer, chemical pesticides and water. The amount of direct energy for grape production in the study area was 7211.20 MJ ha^{-1}. Direct energy includes labor, fuel, electricity and water. Indirect energy yield for grape production in the study area was 5976.96 MJ ha^{-1}.

Table 3 Energy indices and different form and different forms of energy in grape production

Energy indices/different energy	Unit	Amount	Percentage
Energy ratio	-	5.44	-
Energy efficiency	Kg MJ^{-1}	0.67	-
Energy intensity	MJ Kg^{-1}	1.48	-
Net energy	MJ ha^{-1}	126049.60	-
Direct energy	MJ ha^{-1}	7211.20	54.68
Indirect energy	MJ ha^{-1}	5976.96	45.32
Renewable energy	MJ ha^{-1}	2963.61	22.47
Non-renewable energy	MJ ha^{-1}	10224.55	77.53
Total input energy	MJ ha^{-1}	28364.25	-

Indirect energy includes machinery, fertilizers and pesticides. Electricity input had the highest impact on the direct energy with 19.19 and labor force input had the lowest effect on direct energy with 3.33. Fertilizer input with 18.64 had the highest impact and tractor with 2.43 had the least impact on indirect energy. Electricity input 19.19 and tractor 2.43 had the least impact on non-renewable energy. Energy intensity is the opposite of energy efficiency and varies depending on the type of crop, location and time, and can be an in director for evaluating energy efficiency in different crop production systems. Energy intensity indicated the energy consumption to produce one unit of product (Maleki et al., 2011). The net added energy is in megacycles per hectare.

The negative of this indicator, indicates the negative energy balance and occur when the output energy is lower than the input energy. Net energy surplus can determine the amount of potential energy development that depends on how the crop is managed in different climates (Maleki et al., 2011). The net energy gain for the grape yield in the study area was 126049.60 MJ ha^{-1}, which is the positive value indicating that the output energy is higher than the input energy. In grape production 51% of total input energy was direct energy (Human lober, fuel, water and electricity) and 49% was indirect energy (machinery, fertilizer and pesticides) Figure 3. Non-renewable energy consumption was also greater than that of renewable energy consumption (Figure 4). 21% were renewable and 79% non-renewable (Figure 4).

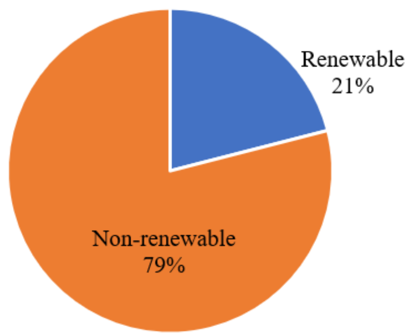

Figure 3 contribution of each renewable and non-renewable energy to grape production.

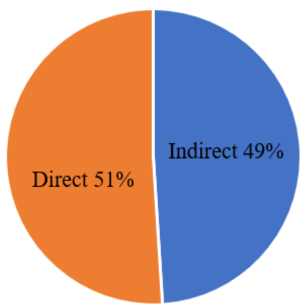

Figure 4 contribution of each direct and indirect energy to grape production.

In the production of grape in Eyvan county average yield was 13085.192 kg ha^{-1}. Regression method was used to estimate the most effective inputs. Economic models were used to estimate the relationship between energy input and crop production using the Cobb-Douglas function. Grape yield (dependent variable) was considered a function of Human labor, animal manure, chemical fertilizer, insecticides, fungicides, herbicides, tractor, sprinklers, fuel, electricity and water (independent variables). The regression results are shown in Table 5. In the Cobb- Douglas function, the input coefficients represent the elasticity. According to Table 5, in Eyvan area, herbicide, sprayer and fuel inputs with negative coefficients of 0.48, 0.076, 0.0136, were negative and smaller than 1, respectively, and that meant, these inputs were used more in production and their final productivity was lower than average output and the amount of these inputs should be reduced. Also, the elasticity of inputs of manpower, animal manure, chemical fertilizer, insecticides, fungicides, tractors, electricity and water with coefficients of 0.333, 0.339, 0.581, 0.395, 0.122, 0.605, 1.085, 0.076 are positive, so the consumption of these inputs by area gardeners is economic. In the present study, only the effect of tractor independent variable was significant and the effect of other independent variables on grape yield was not significant. The values of Durbin-Watson, R^2 and RTC (return to scale) based on Table 5, in the region were 2.11, 0.848, 2.84, respectively. Given that the input coefficients of the Cobb-Douglas production function (RTC) are greater than the one of the incremental or ascending function, the product will increase in greater proportion if we increase the input consumption by one percent. The R^2 tensile coefficient is obtained as 0.848, which means that if a change in unit value of "X" causes an increase of 0.848 units in product yield "Y".

Table 5 Results of sensitivity analysis of grape production inputs in Eyvan county

Variables	Regression coefficients	T statistic	P-Value	APP	MPP
x_1 Human labor	0.333	0.664	0.508	22.37	4.38
x_2 Animal excreta	0.339	0.762	0.447	17.67	3.62
x_3Chemical fertilizer	0.581	0.933	0.352	0.22	0.12
x_4 Insecticides	0.395	1.006	0.316	39.71	8.55
x_5 Fungicides	0.122	1.287	0.2	3.97	0.35
x_6 Herbicide	- 0.136	- 0.206	0.837	6.46	-0.60
x_7 Machinery	0.605	1.022	0.000**	32.30	10.96
x_8 Sprayer	- 0.076	- 1.293	0.198	19.49	- 0.88
x_9 Fuel	- 0.48	- 0.167	0.868	4.14	- 1.41
x_{10} Electricity	1.085	1.085	0.707	3.15	0.20
x_{11} Waret	0.076	1.431	0.195	11.95	0.58
R^2	0.848				
DurbinWatson	2.11				
RTC	2.84				

Note: ** significance at the one percent level

Table 6 Results of sensitivity analysis of direct, indirect, renewable, non-renewable energies of Eyvan grape production

Variables	Regression coefficient	T statistic	P-Value	APP	MPP
Direct energy	0.171	1.254	0.211	2.31	0.3
Indirect energy	0.458	3.366	0.001**	0.2	0.09
R2	0.379				
Durbin Watson	2.087				
Renewable energy	0.11	1.346	0.18	6.76	0.5
Non-renewable energy	0.552	7.444	0.000**	0.19	0.1
R2	0.38				
Durbin Watson	2.077				

Note: ** significance at the one percent level

Also, the regression coefficient of direct, indirect and non-renewable energies is shown in Table 6. Accordingly, the direct and indirect energy tensile coefficients were 0.171 and 0.458 in the region, respectively. The indirect energy was significant at the 1% level but the direct energy was not significant. Also, the coefficients of renewable and non-renewable energy were equal to 0.11 and 0.552, which were significant at the 1% level. Also, the values of Durbin-Watson and R^2 based on Table 6, for direct and indirect energies were 2.077 and 0.38, respectively.

Rajabi-hamedani et al. (2011), in assessing grape production energy in Hamadan province, concluded that chemical fertilizers and electricity were the most energy consuming inputs in production, and total energy consumption was 42213 MJ ha^{-1}. Also, Rasouli et al. (2014) in modeling and analysis of grape production energy assessment in Iran concluded that the total energy input was 33873.78 MJ ha^{-1}. Also, the energy efficiency and energy productivity were 1.73, 0.15 kg MJ^{-1} and net energy 24787.62 MJ ha^{-1}, respectively. Khoshroo et al. (2013) in assessing the energy consumption trend of grape production in Fars province concluded that two inputs of electricity and irrigation water were the most consumed energy source in production. Mardani and Taghavifar (2016) studied the energy flow of grape production in west Azerbaijan province. Their results showed that consumed nitrogen fertilizer with 36% of total energy consumption was the most consumed energy source. Also, energy efficiency and energy productivity were 5.47 and 0.46 kg mJ^{-1}, respectively. Ozkan et al. (2007) in the study of energy consumption in grape production at the research farm of Akdeniz university in Turkey reported that the energy consumption in greenhouse grape production and in the field were 245.3 and 23640.9 MJ ha^{-1}, respectively. Baran et al. (2017) in a case study of measuring energy consumption in organic grapes concluded in Adi Baman Province, Turkey, found that two inputs of irrigation water and machinery as the most consumed inputs and the total input and output energies were 24875 and 163430 MJ ha^{-1}, respectively. Tian et al. (2019) in the study of grape energy consumption in China concluded that the two pesticide inputs and energy as the most consumed input and the total input and output energy were 67630 and 50462 MJ, respectively. Murat and Engindeniz (2009) conducted a case study of grape energy production in Manisa (western Turkey) that two fuel and electricity inputs were identified as the most consumed inputs, and a total input energy of 37488 MJ ha^{-1} was obtained.

This study aimed to determine and evaluate the energy consumption of grape production in Eyvan county (Ilam province). The most important results of this study are as follows:

The largest share of inputs was related to electricity, fertilizer, fuel and fungicide, respectively, which were 19.19, 18.64, 14.98 and 14.60 percent, respectively. In addition, the average input energy was 28364.25 and the output energy was 154413.86 MJ ha^{-1}, that indicating the energy efficiency of grapes in the region. The issue of energy is an important issue in the discussion of energy efficiency, sustainability and economic use. The total energy used to produce one hectare of grapes was 28364.25 MJ and its energy efficiency was 5.44, so the energy efficiency in grape production was low due to the high consumption of electricity, chemical fertilizers and low fuel. Therefore, proper management can be used to reduce energy consumption in the system, thus increasing energy efficiency. In grape production, electricity accounted for the largest share of energy consumption, with fertilizers and fuel being ranked next. In large production, 51% of total input energy was direct energy (Human labor, fuel, water and electricity) and 49% indirect energy (machines, fertilizers and pesticides). non-renewable energy consumption was also higher than that of renewable energy, with 21% being renewable and 79% nonrenewable.

References

Ahmadi, K., H. R. Ebadzadeh, R. Hoseinpour, F. Hatami, and H. Abdeshah. 2019. *Agricultural Statistics, Volume III: Horticultural Products*. Location: Ministry of Jihad-e-Agriculture.

Baran, M. F., F. Lule, and O. Gokdogan. 2017. Energy input-output analysis of organic grape production: A case study from Adiyaman province. *Erwerbs-Obstbau*, 59(1): 275–279.

Cochran, W. G. 1977. *Sampling Techniques*. **3rd ed.** New York: John Wily and Sons.

Einset, J., and C. Dratt. 1975. Grape. In *Advances in Fruit Breeding*, eds. J. Janick, and J. N. Moore. West Lafayette: Purdu University Oress.

Esengun, K., O. Gunduz, and G. Erdal. 2007. Input–output energy analysis in dry apricot production of Turkey. *Energy Conversion Management*, 48(2): 592–598.

Hatirli, S. A., B. Ozkan, and C. Fert. 2006. Energy inputs and crop yield relationship in greenhouse tomato production. *Renewables Energy*, 31(4): 427- 438.

Helsel, Z. R. 1992. Energy and alternatives for fertilizer and pesticide. In *Energy in World Agriculture*, ed. R. C. Fluck, vol. 6, 177–210. Amsterdam: Elsevier Science Publishing.

Khojastehpour, M., A. Nikkhah, and D. Hashemabadi. 2015. A comparative study of energy use and greenhouse gas emissions of canola production. *International Journal of Agricultural Management and Development*, 5(1): 51-58.

Khoshroo, A., R. Mulwa, A. Emrouznejad, and B. Arabi. 2013. A non-parametric Data Envelopment Analysis approach for improving energy efficiency of grape production. *Energy*, 63(dec.15): 189-194.

Kitani, O. 1999. *Energy and Biomass Engineering. CIGR Handbook of Agricultural Engineering.* St. Joseph. MI: ASAE Publication.

Maleki, A., F. Yousefi, and M. Nowruzi. 2011. Evaluation of energy efficiency and analysis of energy consumption and production of wheat in ilam province. In *First National Conference on Sustainable Agriculture and Environment*. Hamadan, Iran, Hamadan Azad University, Feb. 2018.

Mandal, K. G., K. P. Saha, P. K. Ghosh, K. M. Hati, and K. K. Bandyopadhyay. 2009. Bioenergy and economic analysis of soybeanbased crop production systems in central India. *Biomass Bioenergy*, 23(5): 337-345.

Mardani, A., and H. Taghavifar. 2016. An overview on energy inputs and environmental emissions of grape production in West Azerbayjan of Iran. *Renewable and Sustainable Energy Reviews*, 54(1): 918-924.

Mohammadi, A., S. Rafiee, S. S. Mohtasebi, and H. Rafiee. 2010. Energy inputs – yield relationship and cost analysis of kiwifruit production in Iran. *Renewable Energy*, 35(5): 1071-1075.

Mohseni, P., A. M. Borgheei, and M. Khanali. 2019. Energy consumption analysis and environmental impact assessment of grape production in Hazavah region of Arak city. *Journal of Agricultural Machinery*, 9(1): 177-193.

Murat, K. O., and S. Engindeniz. 2009. Energy and cost analysis of sultana grape growing: A case study of Manisa, west Turkey. *African Journal of Agricultural Research*, 4(10): 938-943.

Ozkan, B., C. Fert, and C. F. Karadeniz. 2007. Energy and cost analysis for greenhouse and open-field grape production. *Energy*, 32(8): 1500-1504.

Pahlavan, R., M. Omid, and A. Akram. 2012. Energy input-output analysis and application of artificial neural networks for predicting greenhouse basil production. *Energy*, 37(1): 171-176.

Rafiee, S., S. H. Mousavi-Aval, and A. Mohammadi. 2010. Modeling and sensitivity analysis of energy inputs for apple production in Iran. *Energy*, 35(8): 3301-3306.

Rajabi-Hamedani, S. R., A. Keyhani, and R. Alimardani. 2011. Energy use patterns and econometric models of grape production in Hamadan province of Iran. *Energy*, 36(11): 6345-6351.

Rasouli, M., M. Namdari, and S. H. Mousavi-Avval. 2014. Modeling and analysis of energy efficiency in grape production of Iran. *International Journal of Agricultural Technology*, 10(3): 517-532.

Singleton, V. L., and P. Esau. 1969. Phenolic substances in grapes and wine and their significance. *Advances in Food Research*, 1(1): 159-166.

Tabatabaeefar, A., H. Emamzadeh, M. G. Varnamkhasti, R. Rahimizadeh, and M. Karimi. 2009. Comparison of energy of tillage systems in wheat production. *Energy*, 34(1): 41-45.

Tian, D., M. Zhang, Ch. Xiong, W. Mu, and J. Feng. 2019. Measuring the energy consumption and energy efficiency in two-harvest-a-year grape cultivation. *Energy*, 189(PT.1): 116258-116264.