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Full Research Paper

Investigating the Energy Consumption and Economic Indices for Sweet-Cherry and Sour-Cherry Production in Northeastern Iran

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Abstract

The aim of this study was to investigate the energy consumption and production costs of sweet-cherry and sour-cherry in Northeastern Iran. Required data were collected from 75 sweet-cherry and 42 sour-cherry producers. The total energy inputs in sweet-cherry and sour-cherry production were estimated as 37.76 and 31.03 GJha^{-1}, respectively. The energy efficiency of sweet-cherry production was greater than sour-cherry production. Chemical fertilizers and diesel fuel were the most highly consumed energies in both crops. The higher share of non-renewable energies consumed to produce sweet-cherry than sour-cherry revealed that sweet-cherry production was more dependent on non-renewable sources compared with the sour-cherry production. The economic analysis revealed that production costs for sweet-cherry were higher than sour-cherry but sweet-cherry was more profitable than sour-cherry because of premium prices for sweet-cherry. The modeling results showed that the human labor input had the most impact on costs of both crops. As a consequence, the main practical solutions could be saving in diesel fuel and fertilizer management, which could more properly overcome economic and energy problems in the two crops.

Keywords: Cherry, Cobb-Douglas, Energy modeling, Income, Production costs

Introduction

According to the Food and Agriculture Organization (FAO) annualy reports, around 2.4 tons of sweet-cherries and 1.2 tons of sour-cherries were produced in the world in 2017 (FAO, 2019). Additionally, based on the Iranian Agriculture Ministry (IAM), the allocated area of orchards for Sour-cherry and Sweet-cherry production is about 21181 and 38703 hectares, respectively in 2017. Iran with over 316 thousand tons of sweet-cherry and 116 thousand tons of sour-cherry is recognized as the third-largest sweet-cherry producers and the fifth-largest sour-cherry producers in the world. The average yield of sour-cherry and sweet-cherry was 6457 and 9497 kg ha^{-1}, respectively (Ministry of Agriculture, 2019).

For the agricultural sector, there are two important factors, which should be taken into account seriously: ensuring the food security, intensifying the foreign exchanges and attaining political and economic independence as well as contributing to the gross domestic product of the country. This is because maximizing income and production are the main objectives of the agricultural sector (Mahallati *et al.*, 2015). Modifying common agricultural practices and the optimization strategies related to land use and increasing production are inevitable (Chapagain and Riseman, 2014).

Over the past years, numerous studies have been conducted to evaluate and optimize energy flow and the economic analysis of producing orchard crops, with the aim of controlling the critical inputs and reduceing the environmental impacts at national and international levels. For instance, Tables 1 and 2 show the synopsis of the research findings reported on energetic and economic analysis for different orchard products in Iran and around the world.

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Considering the literature review, the significance of the energy and economic issues in the agricultural sector, and the paucity of comprehensive research on the analysis of input and output energy in the production of sweet-cherry and sour-cherry, this study investigates the aspects of econometrics and energetic of sweet-cherry and sour-cherry production in the North-Khorasan province, located in northeastern Iran.

Table 1- Synopsis of the research findings reported on energetic and economic analysis for different orchard products in Iran

Crop	Province	Analysis method	Result (hotspot in energy consumption)	Reference
Sour-cherry & Sweet-cherry	Alborz	Energetic	Fertilizer, Fuel, Electricity	(Haddadi *et al.*, 2015)
Pistachio	Kerman		Fertilizer, Fuel	(Mirzaei Khalilabadi *et al.*, 2014)
Walnut	Hamadan	Energetic & Economic	Fertilizers	(Banaeian and Zangeneh 2011)
Apple	West Azerbaijan		Packaging, Irrigation	(Fadavi *et al.*, 2011)
Apple	West Azarbayjan		Irrigation, Fuel	(Taghavifar and Mardani, 2015)
Peach	Chaharmahal va Bakhtiari		Fertilizers, Electricity	(Ghatrehsamani *et al.*, 2016)
Peach	Golestan	Energetic	Fuel	(Royan *et al.*, 2012)
Peach	Chaharmahal va Bakhtiari		Fuel, Electricity, Fertilizers	(Ghasemi-Varnamkhasti *et al.*, 2015)
Kiwifruit	Mazandaran	Energetic & Economic	Fertilizers, Fuel	(Mohammadi *et al.*, 210)
Kiwifruit	Gilan	Energetic	Fertilizers	(Nabavi-Pelesaraei *et al.*, 2016)
Kiwifruit	Gilan		Electricity, Fertilizers, Irrigation	(Soltanali *et al.*, 2017)
Citrus	Mazandaran	Energetic & Economic	Fertilizers, Fuel, Pesticides	(Aghkhani *et al.*, 2018)
Citrus	Mazandaran		Fertilizers, Pesticides	(Loghmanpour *et al.*, 2013)
Citrus	Mazandaran		Fertilizers	(Zarini et al., 2013)
Nectarine	Mazandaran		Fertilizers	(Qasemi-Kordkheili *et al.*, 2013)
Grape	Hamadan	Energetic	Fertilizers, Electricity	(Rasouli *et al.*, 2014)
Grape	Markazi		Fertilizers, Human labour,	(Mohseni *et al.*, 2019)
Prune	Tehran		Electrical, Irrigation, Irrigation	(Tabatabaie *et al*., 2013)
Hazelnut	Guilan		Electricity	(Nabavi-Pelesaraei *et al.*, 2013)
Pear	Tehran	Energetic & Economic	Fertilizers, Fuel	(Tabatabaie *et al.*, 2013)

Table 2- Synopsis of the research findings reported on energetic and economic analysis for different orchard products in the world

Crop	Country	Analysis method	Result (hotspot in energy consumption)	Reference
Organic mulberry	Turkey	Energetic	Irrigation	(Gokdogan *et al.*, 2017)
Lemon, Orange and mandarin	Turkey	Energetic	Fertilizer, Fuel	(Ozkan *et al.*, 2004)
Peach & Cherry	Turkey	Energetic & Economic	Machinery, Fuel, Fertilizers	(Aydın, and Aktürk, 2018)
Peach	Turkey	Energetic	Machinery	(Gündoğmuş, 2014)
Sweet-cherry	Turkey	Energetic &	Fertilizer, Electricity, Fuel	(Kizilaslan, 2009)
Apricot	Turkey	Economic	Fertilizer, Chemicals	(Esengun *et al.*, 2007)
Walnut	Turkey	Econometric	Fertilizers, Fuel, Chemicals	(Gundogmus, 2013)
Sweet cherry	Turkey	Energetic	Fertilizers, Fuel	(Demircan *et al.*, 2006)
Fig	Turkey	Energetic	Fertilizers	(Cobanoglu, 2010)
Banana	Turkey	Energetic	Electricity	(Akcaoz, 2011)
Pomegranate	Turkey	Energetic	Fertilizer, Chemicals	(Akcaoz *et al.*, 2009)
Open-field grape	Turkey	Energetic &	Fuel, Electricity, Chemicals	(Ozkan et al. 2007)
Greenhouse grape	Turkey	Economic	Electricity, Chemicals	(Ozkan *et al.*, 2007)
Sour-cherry and Sweet-cherry	USA	Energetic	Irrigation, Fertilizer	(Proebsting, 1980)
Mango	India	Energetic	Chemicals, Fuel, Electricity	(Verma *et al.*, 2018)
Apple	Greece	Energetic	Fuel, Machinery, Fertilizers	(Strapatsa *et al.*, 2006)
Pear	China	Energetic	Manure, Machinery	(Liu *et al.*, 2010)

Materials and Methods

Details of the studied area

The present study was conducted in the North-Khorasan province (37°09′42″N, 57°03′20.30″E). The province covers 1.72 percent of the total area of Iran, with an area of 28434 square kilometers. The statistical population in this study was all sweet-cherry and sour-cherry producers in the North-Khorasan province during 2016-2017. The random sampling method was used due to the large statistical population. Cochran has provided Equation 1 for calculating the number of samples required in the random sampling technique (Snedecor and Cochran, 1980).

$$n = \frac{N(t.s)^2}{Nd^2 + (t.s)^2} \quad (1)$$

Where N is the number of producers, t is reliability coefficient at 95% reliability, S^2 is the population variance, d is the desired probability and n is the sample size.

The data were collected through a questionnaire method and face-to-face interviews with 42 sour-cherry and 75 sweet-cherry producers. The content validity method was used to assess the validity of the questionnaire. Cronbach's alpha coefficient was used to assess the reliability of the scale. At first, the variance of scores of each questionnaire question and the total variance of the test for each sweet-cherry and sour-cherry questionnaire were determined and then its coefficient was obtained. The reliability of the test was 0.86 for sour-cherry and 0.85 for sweet-cherry questionnaires.

Energy analysis

In this study, seven inputs including human labor, agricultural machinery, diesel fuel, chemical fertilizers, chemical pesticides, water for irrigation, and electricity were considered as inputs. The output of this study was sweet-cherry and sour-cherry yields. Table 3 presents the energy equivalents for various inputs.

Table 3- Energy equivalent for energy inputs and outputs

Energy source	Unit	Energy equivalent (MJ unit^{-1})	Source
Human labor	h	1.96	(Yaldiz *et al.*, 1993)
Machinery	h	62.7	(Yaldiz *et al.*, 1993)
Diesel	L	47.8	(Cervinka, 1980)
Chemicals			
a) Insecticide		199	(Yaldiz *et al.*, 1990a,b)
b) Fungicides	kg	216	(Pathak and Bining, 1985)
c) Herbicide		238	(Helsel, 1992)
Fertilizer			
a) N		78.1	(Mudahar *et al.*, 1987)
b) P_2O_5	kg	17.4	(Mudahar *et al.*, 1987)
c) K_2O		13.7	(Mudahar *et al.*, 1987)
Water	m^3	1.02	(Acaroglu, 1998)
Electricity	kWh	12	(Cervinka, 1980)
Sour-Cherry	kg	2.93	(Proebsting, 1980)
Sweet-Cherry	kg	2.93	(Proebsting, 1980)

To compare the energy flow of sweet-cherry and sour-cherry productions, energy indicators such as energy efficiency, energy productivity, specific energy and net energy were calculated according to the following equations:

$$\text{Energy Efficiency} = \frac{\text{Energy Output (MJ ha}^{-1}\text{)}}{\text{Energy Input (MJ ha}^{-1}\text{)}} \quad (2)$$

$$\text{Energy productivity} = \frac{\text{Yield (kg ha}^{-1}\text{)}}{\text{Energy Input (MJ ha}^{-1}\text{)}} \quad (3)$$

$$\text{Specific energy} = \frac{\text{Energy Input (MJ ha}^{-1}\text{)}}{\text{Yield}\left(\text{kg ha}^{-1}\right)} \quad (4)$$

$$\text{Net energy} = \text{Output energy(MJ ha}^{-1}\text{)} - \text{Input energy(MJ ha}^{-1}\text{)} \quad (5)$$

Economic analysis

To have an economic evaluation of the sweet-cherry and sour-cherry production in

North-Khorasan province, economic indicators, such as total production value, gross income, net income, benefit-cost ratio and economic productivity were calculated according to Equations (6) to (10).

$$\text{Total production value} = \text{Crop yield } (\text{kg ha}^{-1}) \times \text{Crop price } (\$ \text{ kg}^{-1}) \quad (6)$$

$$\text{Gross income} = \text{Total production value } (\$ \text{ ha}^{-1}) - \text{Variable production cost } (\$ \text{ ha}^{-1}) \quad (7)$$

$$\text{Net income} = \text{Total production value } (\$ \text{ ha}^{-1}) - \text{Total production cost } (\$ \text{ ha}^{-1}) \quad (8)$$

$$\text{Benefit -cost ratio} = \frac{\text{Total production value } (\$ \text{ ha}^{-1})}{\text{Total production cost } (\$ \text{ ha}^{-1})} \quad (9)$$

$$\text{Economic productivity} = \frac{\text{Crop yield } (\text{kg ha}^{-1})}{\text{Total production cost } (\$ \text{ ha}^{-1})} \quad (10)$$

Energy modeling

Cobb-Douglas function was used to estimate the relationships between input energies and the yield, input costs and income (Tabatabaie *et al*., 2013; Nikkhah *et al*., 2016; Gundogmus, 2013). The Cobb-Douglas function is expressed in Equation (11) (Cobb and Douglas, 1928):

$$Y = f(x)\exp(u) \quad (11)$$

which can be further written as

$$\ln Y_i = a + \sum_{j=1}^{n} \alpha_j \ln(X_{ij}) + e_i \quad i=1,2,\ldots,n \quad (12)$$

Where Y_i is the yield of the i_{th} farmer, X_{ij} is the vector of inputs used in the production process, a is a constant, e_i is the error term, and a_j is coefficients of inputs which are estimated from the model. With the assumption that the yield is the function of inputs, Equation (12) can be written as:

$$\ln Y_i = a_0 + \alpha_1 \ln X_1 + \alpha_2 \ln X_2 + \alpha_3 \ln X_3 + \ldots + \alpha_8 \ln X_8 + e_i \quad (13)$$

Where $x_1, x_2, x_3, x_4, x_5, x_6$ and x_7 are human labor, agricultural machinery, diesel fuel, fertilizers, chemicals, irrigation water, electricity, respectively.

Moreover, the impacts of direct (DE), indirect (IDE), renewable (RE) and non-renewable (NRE) energies on sweet-cherry and sour-cherry yields were examined by Equations (9) and (10).

$$\ln Y_i = a_0 + \beta_1 \ln DE + \beta_2 \ln IDE + e_i \quad (14)$$

$$\ln Y_i = a_0 + \gamma_1 \ln RE + \gamma_2 \ln NRE + e_i \quad (15)$$

Where β_i and γ_i are the regression coefficients.

Returns to scale was used to determine the proportional change in output due to proportional increase in all inputs by the same factor. It was calculated by summing the regression coefficients of models of Equations (13)-(15). If the sum of the coefficients is greater than, equal to, or less than 1, it indicates that the return to scale is increasing, constant or decreasing, respectively.

The marginal physical productivity (MPP)

The MPP shows the rate of change induced in the performance, assuming that the other factors of production remained unchanged, by increasing one unit in one of the energy inputs. The MPP positive value indicates that any increase in the input will increase the yield output. The MPP negative value indicates that each additional input unit reduces performance. The MPP was calculated by Equation (16):

$$MPP_{xj} = \frac{GM(Y)}{GM(X_j)} \times \alpha_j \quad (16)$$

Where MPP_{xj} is marginal physical productivity of j^{th} input; GM(Y) is the geometric mean of yield; $GM(X_j)$ is geometric mean of j^{th} input energy on per hectare.

Data analysis was performed in Minitab17 and JMP8 statistical software programs. Regression relationships between the inputs and yield were established through a linear regression method. Figures were prepared by Origin 2018.

Results and Discussion

Distribution of energy inputs

The consumed inputs in sour-cherry and sweet-cherry production and their energy equivalents are summarized in Table 4. The results indicated that the total energy consumed in sour-cherry production was less than sweet-cherry production. The total output energy of sweet-cherry was higher than sour-cherry because more sweet-cherry is yielded in comparison with sour-cherry. The total input energy for producing sweet-cherry was 29.20 GJ ha^{-1} in Isparta province (Demircan *et al*., 2006), 33.60 GJ ha^{-1} in Çanakkale province (Aydın and Aktürk, 2018) 18 GJ ha^{-1} and 17.53 GJ ha^{-1} for sour-cherry and sweet-cherry in Alborz province (Haddadi *et al.*, 2015), which showed that energy used for producing sweet-cherry in the North-Khorasan province was much higher than the Alborz province and Turkey.

Table 4- Amounts of inputs and output with their equivalent energy in sour-cherry and sweet-cherry production

Energy source	Sour-cherry		Sweet-cherry	
	Quantity used per unit area (ha)	**Energy equivalent (MJ ha^{-1})**	**Quantity used per unit area (ha)**	**Energy equivalent (MJ ha^{-1})**
Human labor (h)	2106.74	4129.20	2232.5	4374.83
Machinery (h)	56.05	3514.53	83.98	5265.81
Diesel (L)	113.54	6528.58	144.23	8293.10
Chemicals		679.98		725.03
a) Insecticide	1.40	278.60	1.45	288.55
b) Fungicides	1.12	241.92	1.58	341.28
c) Herbicide	0.67	159.46	0.40	95.2
Fertilizer		13179.65		15414.78
a) Nitrogen (kg)	149.13	11647.05	174.97	13665.16
b) Phosphorus (kg)	50.50	878.70	55.91	972.83
c) Potassium (kg)	47.73	653.90	56.70	776.79
Irrigation Water (m^3)	514.65	524.95	724.06	738.54
Electricity (kWh)	205.79	2469.48	245.54	2946.49
Total energy input (MJ ha^{-1})		31026.37		37758.57
Total energy output (MJ ha^{-1})	4287.55	12562.53	5472.39	16034.09

As Figure 1 shows, the chemical fertilizers have the largest share of energy consumption in the production of sour-cherry (41%) and sweet-cherry (39%). Nitrogen is the most used energy in both products when is compared to the other fertilizers. Similar results were observed in producing Pistachio (Mirzaei Khalilabadi *et al*., 2014), Walnut (Banaeian and Zangeneh, 2011), Kiwifruit (Mohammadi *et al*., 210), Sweet-cherry (Kizilaslan, 2009; Demircan *et al*., 2006), Citrus (Zarini *et al.*, 2013) and Plum (Tabatabaie *et al.*, 2012).

The second most energy-intensive input was diesel fuel for both crops, despite the lack of diesel fuel consumption at the harvesting operation, relatively large amounts of fuel were consumed at the stages of tillage and spraying. The reason for the high consumption of this source could be due to the old machines, lack of gas regulation and proper use of gear by most farmers.

The agricultural machinery input was the third most energy consumed input in sweet-cherry production and it was the fourth energy consumed input in sour-cherry production. Tillage and transportation operations had the highest and lowest energy consumption, respectively. Meanwhile Akcaoz (2011) found that the agricultural machinery input in banana in Turkey was the third most used input and transportation operation had the most share in the agricultural machinery input. Besides, the share of agricultural machinery input was reported around 7-8% in the Alborz province for sweet-cherry and sour-cherry (Haddadi *et al.*, 2015). In the North Khorasan due to high consumption of the input in tillage and spraying operation, and despite the absence of this input at the harvesting operation, this input was considered as one of the most energy-consuming inputs in the production of both crops.

The human labor input in the sour-cherry production and the sweet-cherry production was the lowest consumed inputs, respectively. Harvesting operation had the highest share of energy consumption in this input. A similar result was observed in producing sweet-cherry in Turkey, in which the human labor input with 13% of the share of total energy consumed was reported as the third most consumed input. Notwithstanding these results, the share of energy consumed by human labor was 4% for pomegranate (Akcaoz *et al.*, 2009), 6% for peach (Royan *et al.*, 2012) and 7% apple (Rafiee *et al.*, 2010). Sweet-cherry and sour-cherry are small fruits, and consequently, harvesting them is of difficulty and it needs more human labor. However, timely pruning trees has also a significant contribution to the deceasing of human labor in a harvesting operation.

Inputs of chemicals and water for irrigation and electricity had the lowest energy consumption in both crops. Fungicides were the most energy consumed input in comparison with other pesticides. Similar results in using chemicals in producing nectarine in the Sari region (Qasemi-Kordkheili *et al.*, 2013), apple in Turkey (Akdemİr *et al.*, 2012) were reported. The irrigation water energy was also one of the lowest energy consumed inputs in producing sweet-cherry and sour-cherry productions in the Alborz province (Haddadi *et al.*, 2015), peach in the Golestan province (Royan *et al.*, 2012) and apple in the Isfahan province (Sami *et al.*, 2011).

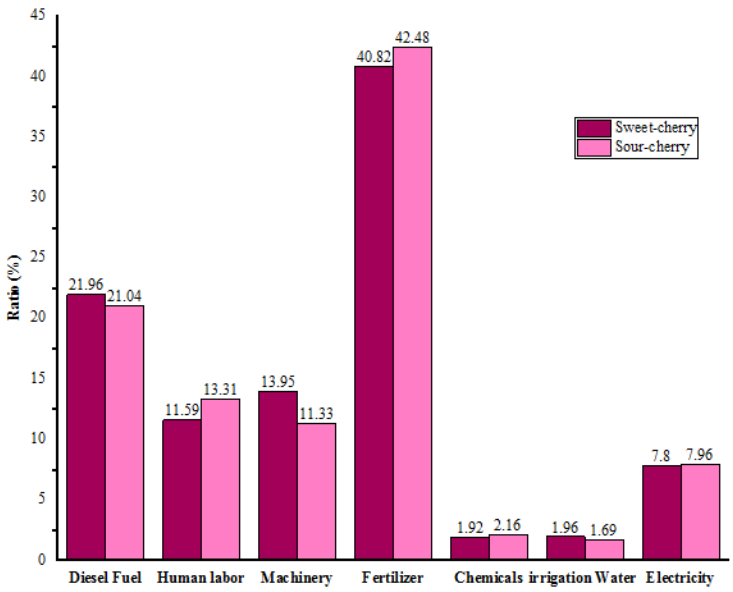

Fig.1. The anthropogenic energy input ratios in energy in sour-cherry and sweet-cherry production

Assessment of energy indicators

Table 5 presents the energy indicators in the sweet-cherry and sour-cherry production. The energy efficiency and energy productivity of sour-cherry were not greater than sweet-cherry, suggesting that the sweet-cherry production was more efficient than sour-cherry production in terms of energy consumption.

The other studies showed that energy efficiency was 1.48 for sour-cherry, 1.25 for sweet-cherry in the Alborz province (Haddadi *et al.*, 2015), 1.23 for sweet-cherry in the Isparta province (Demircan *et al.*, 2006), 0.78 for sweet-cherry in Çanakkale province (Aydın and Aktürk, 2018). Energy productivity was 1.45 for sweet-cherry and

1.83 for sour cherry in Alborz (Haddadi *et al.*, 2015), 0.32 for sweet-cherry in the Isparta province (Demircan *et al.*, 2006), 0.32 for sweet-cherry in the Çanakkale province (Aydın and Aktürk, 2018), 0.51 for sweet-cherry and 0.20 for sour-cherry in the US (Proebsting, 1980). The comparison of the results of this study with other studies shows that sweet-cherry and sour-cherry production elsewhere were more efficient than both crops production in the North-Khorasan province. The main reasons for low energy efficiency and productivity in the North Khorasan province are the inefficient use of energy inputs and the low yield of sour-cherry and sweet-cherry than elsewhere.

Reducing fertilizer and fuel consumption not only prevents environmental pollution (water, soil and air) but also reduces energy consumption in production. Providing proper training in the regulation and the proper use of machineries as well as soil testing can help farmers use inputs more appropriately. Thus allow to achieve more sustainable and profitable agriculture, energy efficiency and improved productivity. It also suggests that pruning and using higher productive varieties help farmers boost energy use efficiency and income.

Table 5- Total energy consumption distributed by energy sources in sweet-cherry and sour-cherry production

Indicators	Unit	Sour-cherry	Sweet-cherry
Energy efficiency	-	0.41	0.43
Energy productivity	kg MJ^{-1}	0.14	0.15
Specific energy	MJ kg^{-1}	7.24	6.92
Net energy	MJ ha^{-1}	-20732.55	-21634.60
Direct energy	MJ ha^{-1}	13652.21	16352.96
Indirect energy	MJ ha^{-1}	17374.16	21405.62
Renewable energy	MJ ha^{-1}	4654.15	5113.37
Non-renewable energy	MJ ha^{-1}	26372.23	32645.20
Total energy input	MJ ha^{-1}	31026.37	37758.57
Total energy output	MJ ha^{-1}	12562.53	16034.09

The share of direct, indirect, renewable, and non-renewable energies in the production of sweet-cherry and sour-cherry are shown in Figure 2. For both crops, the share of indirect and non-renewable energy was higher than direct and renewable energy. In sweet-cherry production, the use of diesel fuel, agricultural machinery, chemical fertilizers and chemical pesticides were higher than those of in sour-cherry production. For this reason, the share of indirect energy in sweet-cherry production was more than sour-cherry production. According to Figure 2, the share of non-renewable energy in sweet-cherry production was higher than sour-cherry, so sweet-cherry production was more dependent on non-renewable energy than sour-cherry. Aydın and Aktürk (2018) that reported the share of non-renewable energy in sweet-cherry production was 96.41% in the Çanakkale province, while this share was 73.05% in sweet-cherry production in the Isparta province, which shows sweet-cherry production in the North- Khorasan province was more dependent on non-renewable energy than the Çanakkale province and sweet-cherry production in the Isparta province was more sustainable.

Association of inputs and the yield

Table 6 shows the results of applying Cobb Douglas function to determine the relationship between the inputs and yield for both crops. The return to the scale implies that increasing 1% in the energy of all inputs can increase the yield in the sour-cherry when compared with sweet-cherry. Regression coefficients in Table 4 shows the influence of diesel fuel, and human labor and water were more significant than other inputs on the yield of both crops.

According to the results of sensitivity analysis by increasing 1 MJ in the energy of water for irrigation, chemical pesticides, human labor, diesel fuel and chemical fertilizers, the sour-cherry yield was increased to 1.241, 0.766, 0.237, 0.152, and 0.042, respectively, while by increasing 1 MJ in the energy of water for irrigation, human labor, diesel fuel, agricultural machinery and chemical fertilizers, the sweet-yield was increased to 0.941, 0.290, 0.127, 0.086 and 0.021 kg, respectively.

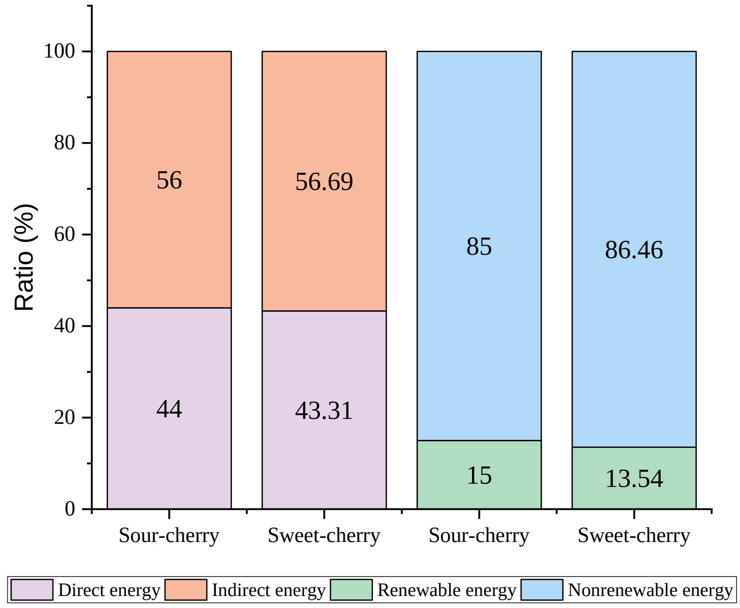

Fig.2. The share of total mean energy inputs as direct, indirect renewable and non-renewable forms in sweet-cherry and sour-cherry production

Table 6- Energetic estimation results of energy inputs with yield

Energy source	Sour-cherry				Sweet-cherry			
	Coefficient	**t-ratio**	**P-value**	**MPP**	**Coefficient**	**t-ratio**	**P-value**	**MPP**
Model: $Lny_i = a_0 + \alpha_1 lnx_1 + \alpha_2 lnx_2 + \alpha_3 lnx_3 + \cdots + \alpha_8 lnx_8 + e_i$								
Diesel fuel	0.227	4.09^{**}	0.001	0.152	0.188	3.26^{*}	0.000	0.127
Human labor	0.228	4.33^{**}	0.001	0.237	0.232	3.87^{**}	0.001	0.290
Machinery	-0.008	-1.11^{ns}	0.899	-0.010	0.083	2.02^{*}	0.000	0.086
Fertilizer	0.108	2.27^{*}	0.000	0.042	0.049	1.06^{*}	0.000	0.021
Chemicals	0.097	2.41^{*}	0.000	0.766	-.063	-1.42^{ns}	0.397	-0.591
Irrigation water	0.152	3.81^{**}	0.001	1.241	0.127	2.39^{*}	0.000	0.941
Electricity	-0.018	-1.35^{ns}	0.249	-0.104	-0.009	-0.98^{ns}	0.716	-0.056
R^2	0.92				0.89			
Durbin-Watson	2.01				2.06			
Return to scale	0.786				0.607			

*Significant at 1% level, **Significant at 10% level and ^{ns} non-significant

The results of using Cobb Douglas function were shown in Table 7 to determine the relationship between types of input energies and the yield of sweet-cherry and sour-cherry. The Durbin-Watson statistics indicated no auto-correlation at the 5% significance level and the effect of both energy types on the yield was positive.

Indirect energies had a greater impact than direct energies. Similar results were obtained in various studies in Iran (Mohammadi *et al.*, 2010; Tabatabaie *et al.*, 2013; Royan *et al.*, 2012).

Findings highlighted that the impact of both renewable and non-renewable energies on the yield was positive. The amount of non-renewable energy consumed during the production of sweet-cherry and sour-cherry was about six times higher than renewable energy. The use of non-renewable energy as a resource-depletion can affect the environment. Carbon dioxide emissions from the energy required to produce fertilizers and pesticides as well as fuel can have adverse effects on the environment. Therefore, using biodiesel as fuel or by-products as fertilizers can reduce the need for non-renewable resources and increase energy efficiency.

Table 7- Estimation of impacts of direct energy vs. indirect energy and renewable energy vs. non-renewable energy on yield

Energy source	Sour-cherry			Sweet-cherry		
	Coefficient	**t-ratio**	**P-value**	**Coefficient**	**t-ratio**	**P-value**
$\ln Y_i = \beta_1 \ln DE + \beta_2 \ln IDE + e_i$						
Direct energy	0.358	3.78**	0.001	0.317	3.54**	0.001
Indirect energy	0.324	3.79**	0.001	0.369	4.12*	0.001
R^2	0.72			0.81		
Durbin-Watson	1.90			1.78		
Return to scale	0.682			0.686		
$\ln Y_i = \gamma_1 \ln RE + \gamma_2 \ln NRE + e_i$						
Renewable energy	0.456	7.22**	0.001	0.419	5.09**	0.001
Nonrenewable energy	0.365	6.69**	0.001	0.89	3.49**	0.001
R^2	0.83			0.74		
Durbin-Watson	1.77			1.86		
Return to scale	0.821			0.708		

*Significant at 1% level, **Significant at 10% level and ns non-significant

Production costs and economic indicators

It is very important to reduce the production cost in agricultural sector while increasing yield. For this purpose, economic analysis should be done. Table 8 shows the econometric analysis in the production of sour-cherry and sweet-cherry products. The costs of the total production for sweet-cherry were more than those of sour-cherry. Also, the gross value of sweet-cherry was more than sour cherry because the price of sweet-cherry was more than sour-cherry in the market.

The economic productivity in sour-cherry production was found to be more than sour-cherry production which means that with each dollar expense we can produce more weight of sour-cherry than sweet-cherry. While the benefit-cost ratio of sweet-cherry was more than sour-cherry, indicating a higher profitability of sweet-cherry production compared to sour-cherry.

The human labor input had the highest expense in the production of both crops. This was due to lack of mechanization in the horticulture sector, pruning, and fertilization, and harvesting operations are carried out by human labor, thus, human labor expense had the highest share from total cost.

The agricultural machinery was the second most expensive input in the production of both crops. Water irrigation was ranked third in the production costs of both crops. According to Table 6, the total contribution of the other inputs was less than 3%. Improvement in management practices (e.g. the efficient use of fertilizers and fuel) reduces the production costs. A compromise should be made between the economic interests of the farmers and the sustainability of local environmental systems is the key to achieve new and sustainable farming techniques and management systems.

Association of inputs and the income

Table 9 illustrates the econometric estimation results of input costs and the income using Cobb-Douglas production function. The return to the scale for sour-cherry and sweet-cherry was determined to be 0.698 and 0.592, respectively. Therefore, there is an increasing rate of return to the scale for both products. In the production of sour-cherry and sweet-cherry, the human labor cost the had the highest effect on the income at 1% probability level.

Table 8- Economic analysis of sour-cherry and sweet-cherry production

Inputs (unit)	Sour-Cherry		Sweet-cherry	
	Cost	Ratio (%)	Cost	Ratio (%)
Human labor ($ ha^{-1})	2508.0	76.96	2657.2	72.05
Machinery ($ ha^{-1})	293.6	9.01	439.9	11.93
Fertilizers ($ ha^{-1})	78.7	2.42	92.1	2.50
Chemicals ($ ha^{-1})	49.44	1.52	53.1	1.44
Diesel fuel ($ ha^{-1})	8.1	0.25	10.3	0.28
Irrigation water ($ ha^{-1})	242.7	7.44	341.4	9.26
Electricity ($ ha^{-1})	78.4	2.40	93.5	2.54
Variable production cost ($ ha^{-1})	3259.0	100	3687.64	100
Fix production cost ($ ha^{-1})	423.7		479.4	
Total production costs ($ ha^{-1})	3682.7		4167.1	
Crop price ($ kg^{-1})	1.42		2.26	
Gross production value ($ ha^{-1})	6696.7		12378.0	
Economic indicators				
Benefit-cost ratio (-)	1.82		2.97	
Economic productivity (kg S^{-1})	1.16		1.03	
Gross income ($ ha^{-1})	3437.7		8690.4	
Net income ($ ha^{-1})	3014.1		8210.0	

Table 9- Econometric estimation results of energy inputs

Energy source	Sour-cherry			Sweet-cherry		
	Coefficient	t-ratio	P-value	Coefficient	t-ratio	P-value
Model: $Lny_i = a_0 + \alpha_1 lnx_1 + \alpha_2 lnx_2 + \alpha_3 lnx_3 + \cdots + \alpha_8 lnx_8 + e_i$						
Diesel fuel	0.193	3.84^{**}	0.001	0.138	2.58^{*}	0.001
Human labor	0.223	4.15^{**}	0.001	0.214	3.67^{**}	0.000
Machinery	-0.021	-1.17^{ns}	0.889	0.081	1.26^{*}	0.000
Fertilizer	0.094	2.11^{*}	0.000	0.109	1.43^{ns}	0.350
Chemicals	0.119	2.67^{ns}	0.010	-0.041	-1.68^{*}	0.000
Irrigation water	0.138	3.61^{*}	0.000	0.038	1.02^{*}	0.000
Electricity	-0.048	-1.71^{ns}	0.290	0.053	1.19^{ns}	0.359
R^2	0.84			0.79		
Durbin-Watson	2.11			1.82		
Return to scale	0.698			0.592		

*Significant at 1% level, **Significant at 10% level and ^{ns} non-significant

Conclusions

The purpose of this study was to compare the energy consumption and income of sour-cherry and sweet-cherry production. The results of this research would be very productive for any construction of orchard of sweet-cherry and sour-cherry. According to the analysis, the following results were obtained:

1. Total energy consumption for sweet-cherry production was 1.22 times higher than sour-cherry production. Furthermore, the yield of sweet-cherry production was more than the sour-cherry production. It was concluded that the use of inputs in production was accompanied by the same results in the yield.
2. In the production of both crops, fertilizers were the energy-intensive input whereas human labor and agricultural machinery were the costliest inputs.
3. The economic analysis revealed that the production costs for sweet-cherry were higher than sour-cherry but sweet-cherry was more profitable than sour-cherry due to the premium prices for sweet-cherry.
4. Accurate fertilizer management (especially nitrogen) and saving fuel by the proper tractor selection and management, precise and timely pruning, using high yield varieties were suggested to decrease energy consumption and increase income.

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مقاله علمی-پژوهشی

بررسی مصرف انرژی و شاخص‌های اقتصادی تولید آلبالو و گیلاس در شمال شرق ایران

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چکیده

هدف این تحقیق بررسی مصرف انرژی و هزینه‌های تولید آلبالو و گیلاس در شمال شرق ایران بود. اطلاعات از طریق ۷۵ تولیدکننده گیلاس و ۴۲ تولیدکننده آلبالو جمع‌آوری شدند. انرژی کل نهاده‌ها برای تولید گیلاس و آلبالو به‌ترتیب ۳۷/۷۶ و ۳۱/۰۳ $GJha^{-1}$ تخمین زده شد. در حالی‌که بازده انرژی گیلاس بیشتر از آلبالو بود. در هر دو محصول کود شیمیایی و سوخت دیزل بیشترین مصرف انرژی را داشتند. سهم انرژی‌های تجدیدپذیر در تولید گیلاس بیشتر از آلبالو بود که نشان می‌دهد تولید گیلاس در این منطقه به منابع تجدیدناپذیر وابسته‌تر است. تحلیل اقتصادی نشان داد که هزینه تولید گیلاس بیشتر از آلبالو بود اما به‌دلیل قیمت بالاتر گیلاس، سود گیلاس بیشتر بود. نتایج مدل‌سازی نشان داد که نیروی انسانی بیشترین تاثیر را روی هزینه تولید هر دو محصول داشت. در نهایت، صرفه‌جویی در مصرف سوخت دیزل و مدیریت کوددهی به‌عنوان راه‌حل‌های اصلی برای حل مسایل اقتصادی و انرژی هر دو محصول توصیه شد.

واژه‌های کلیدی: آلبالو، درآمد، کاب داگلاس، گیلاس، مدل‌سازی انرژی، هزینه تولید

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