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Original Research Article

On the study of energy and cost analyses of orange production in Mazandaran province

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ABSTRACT

The objective of this study is to determine energy balance between inputs and output for orange production in Mazandaran province which is one of the most important citrus production centers in Iran. Data is collected by administering a questionnaire in face-to-face interviews. The total energy input and energy output were calculated as 48,900.5 MJ ha^{-1} and 32,938 MJ ha^{-1}, respectively, therefore the energy productivity and net energy value are estimated as 0.36 kg MJ^{-1} and −15,962 MJ ha^{-1}, respectively. The results show that the highest share of energy is consumed by chemical fertilizers (26.9%) and chemicals (26.1%). The ratio of energy outputs to energy inputs is approximately 0.67. The shares of renewable and non-renewable energy were 24% and 76%, respectively from total energy input. The Cobb–Douglas production function is applied to test the relationship among different forms of energy consumption. The net return and productivity from orange production were found to be 3343.9 \$ ha^{-1} and 2.1 kg \$$^{-1}$, respectively. The findings suggest that the orange producers must optimize their use of indirect and non-renewable energy resources since they are excessively using the energy inputs which results in an inverse effect on yield in addition to increasing risks to natural resources and human health.

Introduction

Over the past 20 years there has been a growing consumer's interest, in minimally processed fruit and vegetables for their freshness and convenience. The benefits of fruit and vegetable consumption are now widely reported in the literature, as they represent a source of vitamin C and phenolic antioxidants, which intake is reported to decrease the risk of developing degenerative diseases, such as cancer, diabetes, cardiovascular and neurological diseases. Among fruits, oranges have the ideal characteristics to be minimally processed as they are a non climacteric fruit that can be stored for long periods without apparent bio-chemical changes [1]. Orange juice is probably the best known and most widespread fruit juice all over the world, particularly for its flavor and highest value for its vitamin C and natural antioxidants contents [2].

Citrus fruits are the main horticultural products with an annual production of over 88 million tons, where 33% of the fruits such as oranges, etc. are industrially processed for juice production [3].

Many studies have been conducted to determine the energy efficiency of plant production, such as energy use pattern in a typical village in arid zone; soybean and wheat crops in India, sunflower in Greece, citrus fruits, sweet cherry, some field crops and vegetable in Turkey and maize and sorghum in the United States [4]. Crop production in general requires high input of fossil fuels, which is consumed as direct and indirect energies. The latter systems are characterized by the heavy use of fertilizers, pesticides, labor-saving and high-power machines [5]. Mathematical function needs to be specified to obtain a relationship between inputs and yield [6]. Agriculture uses large quantities of locally available non-commercial energies, such as seed, manure and animate energy, and commercial energies directly and indirectly in the form of diesel, electricity, fertilizer, plant protection, chemicals, irrigation water, machinery, etc. Efficient use of these energies helps to achieve increased production and productivity and contributes to economy, profitability and competitiveness of agricultural sustainability to rural living requirements [7]. Renewable energy sources coming from agricultural crops play an important role to supply the energy requirement and in terms of environmental effects [8]. Energy input–output relationships in cropping systems vary with the crops grown in a sequence, type of soils, nature of tillage operations for seed bed preparation, nature and amount of organic manure and chemical fertilizers, plant protection measures, harvesting and threshing operations, yield levels and biomass production [9].

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Energy is a fundamental ingredient in the process of economic development, as it provides essential services that maintain economic activity and the quality of human life. Thus, shortages of energy are a serious constraint on the development of low income countries. Shortages are caused or aggravated by widespread technical inefficiencies, capital constraints and a pattern of subsidies that undercut incentives for conservation [10]. Hetz [11] studied the utilization of energy in the production of fruits in Chile in order to improve the efficiency of energy use; from the results of this study it was found that the energy ratio of fruit production was in 0.44–2.22 range. As seen in previous research, several studies on the subject of energy utilization, energy input–output analysis and their relationships have been conducted on agricultural productions [12].

Energy has a key role in economic and social development but there is a general lack of rural energy development policies that focus on agriculture; since, has a dual role as user and supplier of energy. This energy function of agriculture offers important rural development opportunities as well as climatic change mitigation by substituting bio-energy for fossil fuels [13]. The amount of energy used in agricultural production, processing and distribution needs to be adequate in order to feed the rising population and to meet other social and economic goals. Sufficiency and efficiency of energy use are prerequisites for improved agricultural productions. It was realized that crop yields and food supplies are directly linked to energy. In developing countries, rise in crop yields were mainly attributed to rise in use of improved commercial energy inputs in addition to improved crop varieties [13].

A number of studies have been conducted on agricultural energy use and energy input–output analysis in Iran and other countries [4–8,10–12]. In all of these related studies, energy ratio (energy use, efficiency) and energy productivity were measured. However, none of these studies report energy inputs and output in orange production in Iran.

The main objective of this study is to perform the energy and sensitivity analyses of orange production in Mazandaran province of Iran. Also sensitivity analyses of the energy inputs of the orange yield is conducted, in order to specify a relationship between input energies and yield. This study is particularly important because there has not been any previous study focusing on orange production, one of the most important citrus production centers, in Iran.

Materials and methods

Data acquisitioning

This study is conducted in Mazandaran province, located in the northern part of Iran, around 36°40′ north latitude and 52°50′ east longitude. The total area of Mazandaran province is 143,100 hectares of which 102,000 hectares are farm land (71.3% of total area). The orange orchards consist of 70% of total farming land in the province, the orange orchards constitute 58 farms which represent the large percentage of the available farms [14].

Data is collected from farmers by using a face-to-face questionnaire performed from June to August 2011.

For estimating the size of required sample, Cochran formula [15] is used and eventually statistical sample method is executed by 50 orchards of orange:

$$n = \frac{N(t \times S)^2}{(N-1)d^2 + (t \times S)^2} \quad (1)$$

where n is the required sample size; N is the number of holdings in target population; t is the reliability coefficient (1.96 which represents the 95% reliability); S^2 is the variance of studied qualification in the population; d is the precision (x–X). The permissible error in the sample size is defined to be 5% for 95% confidence. Thus the sample size was calculated to be equals 50, then selection of 50 orange producers from the population were randomly carried out.

Energy analysis

In the orchards of this region, energy sources are human labor, machinery, diesel fuel, farmyard manure, electricity, fertilizers (N, P, K), chemicals and irrigation water.

Machinery, implements and tools

Energy equivalent for machinery is calculated by Eq. (2):

$$ME = E\frac{G}{T} \quad (2)$$

where ME is the machinery energy (MJ h^{-1}), E (=62.7 MJ kg^{-1}) [16] the production energy of machine, G the weight of machine (kg), and T is the economic life of machine (h).

Based on the energy equivalents of the inputs and output (Table 1), the surveyed data including various energy and economic indicators, specifically, energy ratio (energy use efficiency), specific energy, energy productivity, net energy and energy intensiveness are calculated. For the economic analyses, net profit, gross return, net return, benefit to cost ratio and productivity are also computed.

Form of direct, indirect, renewable and non-renewable

For the purpose of growth and development energy demand in agriculture is divided into direct and indirect energies or renewable and non-renewable energies. Direct energy (DE) covers human labor, diesel and electricity, while indirect energy (IDE) includes energy embodied in fertilizers, chemicals, water for irrigation, farmyard manure, and machinery used in the orchard fruit productions. Renewable energy (RE) consists of human labor, farmyard manure and water for irrigation, whereas non-renewable energy (NRE) includes machinery, diesel fuel, electricity, fertilizer and chemicals.

Econometric model development

Production function summarizes the process of conversion of factors into a particular commodity. It is important that the production function describes technology and not economic behavior. Production functions are used to determine the efficient allocation of resources. For this purpose Cobb–Douglass (CD) production function is chosen as the best function in terms of statistical significance and expected signs of parameters. The CD production function is expressed as:

Table 1
Energy equivalents of inputs and output in agricultural productions.

Particulars	Unit energy	Equivalent (MJ unit^{-1})	References
A. Inputs			
1. Human labor	h	1.96	[17]
2. Machinery	h	62.7	[17]
3. Diesel fuel	L	47.8	[18]
4. Chemical fertilizers	kg		
(a) Nitrogen (N)		78.1	[18]
(b) Phosphate (P_2O_5)		17.4	[18]
(c) Potassium (K_2O)		13.7	[18]
5. Farmyard manure	kg	0.3	[17]
6. Chemicals	kg	120	[17]
7. Water for irrigation	m3	1.02	[17]
8. Electricity	kWh	3.6	[18]
B. Output			
1. Orange	kg	1.9	[17]

$$Y = f(x)\exp(u). \tag{3}$$

This methodology has been applied to investigate theoretical assumptions for signs of energy input in determining the optimal output levels. The Cobb–Douglass function has been used by several authors to investigate the relationship between various energy inputs and output of agricultural crops [19–21]; it is a power function that can be specified in a mathematical form as follows [20]:

$$Y_i = a\prod_{j=1}^{k} X_{ij}^{\alpha_j} e^{e_i}\ (i = 1, 2, \ldots, n\ j = 1, 2, \ldots, k) \tag{4}$$

Using a linear presentation, the function to be estimated could be written as:

$$\text{Model I}: \ln Y_i = a + \sum_{j=1}^{n} \alpha_j \ln(X_{ij}) + e_i \quad i = 1, 2, 3 \ldots 50 \tag{5}$$

where Y_i denotes the yield level of the i'th farmer, X_{ij} is the vector inputs used in the production process that stands for energy of human labor (X_1), machinery (X_2), diesel fuel (X_3), chemical fertilizers (X_4), farmyard manure (X_5), chemicals (X_6), water for irrigation (X_7) and electricity (X_8), a is the constant term, α_j represents coefficients of inputs which are estimated from the model and e_i is the error term. In this study, it is assumed that if there is no input energy, the output energy is also zero. Making this assumption excludes the constant term a from Eq. (5), and the equation reduces to:

$$\ln Y_i = a_1 \ln X_1 + a_2 \ln X_2 + a_3 \ln X_3 + \ldots + a_8 \ln X_8 \tag{6}$$

Eq. (6) is expanded in accordance with the assumption that yield is a function of energy inputs and income is a function of expenses input. More specifically, Eq. (6) can be expressed in the following form by using standardized coefficients.

Similarly, the effect of direct, indirect, renewable and nonrenewable energies on production yield was modeled using the following equations [6]:

$$\text{Model II}: \ln Y_i = \beta_1 \ln \mathrm{DE}k + \beta_2 \ln \mathrm{IDE} + e_i \tag{7}$$

$$\text{Model III}: \ln Y_i = \gamma_1 \ln \mathrm{RE} + \gamma_2 \ln \mathrm{NRE} + e_i \tag{8}$$

Eqs. (7) and (8) are expressed by using standardized coefficients. Where Y_i is the ith grower's yield, β_i and γ_i are coefficient of exogenous variables.

In addition to the influence of each variable on the yield level, the impact of expenses on yield is also investigated. For this purpose, Cobb–Douglas function was specified in the following form Eq. (9):

$$\text{Model IV}: \ln Y_i' = a_1' \ln X_1' + a_2' \ln X_2' + a_3' \ln X_3' + \ldots + a_8' \ln X_8' \tag{9}$$

where Y_i' is the ith farm's income and a_i' is the coefficient of exogenous variables. Eqs. (6)–(9) are estimated using ordinary least square technique.

Sensitivity analysis

The Marginal Physical Productivity (MPP) method based on the response coefficients of the inputs is utilized to analyze the sensitivity of energy inputs on orange yield. Sensitivity analysis is especially useful in pinpointing the assumptions are appropriate for additional data collection to narrow the degree of uncertainty in the results. Typically, in a sensitivity analysis in which the exogenous parameters are generally varied by a linear proportion, the endogenous variable must linearly depend on those parameters. Also, as the parameters are varied one at a time, different model parameters must not interact in their influence on the endogenous variable [22]. Therefore, the sensitivity analysis of an input imposes the change in the output level with a unit change in the input in model, assuming that all other inputs are constant at their geometric mean level. The MPP of the various inputs was computed using the α_j of the various energy inputs as [20]:

$$\mathrm{MPP}_{xj} = \frac{\mathrm{GM}(y)}{\mathrm{GM}(x_j)} \times \alpha_j \tag{10}$$

In orange production process, returns to scale refer to changes in output subsequent to a proportional change in all inputs (where all inputs increase by a constant factor). The Cobb–Douglas production function is indicated by the sum of the elasticity derived in the form of regression coefficients. If the sum of the estimated coefficients is greater than unity ($\sum_{i=1}^{n}\alpha_i > 1$), then it could be concluded that the increasing returns to scale, on the other hand if the latter parameter is less than unity ($\sum_{i=1}^{n}\alpha_i < 1$), then it is indicated that the decreasing returns to scale; and if the result is unity ($\sum_{i=1}^{n}\alpha_i = 1$), it shows that the constant returns to scale [20]. Basic information on energy inputs and orange yields are entered into Excel spreadsheets and SPSS 19 spreadsheets.

Energy and cost indices

Expressions, such as the energy use efficiency, the energy productivity, the specific energy, the net energy gain and the energy intensiveness were given by Mohammadshirazi et al. [23]. Other expressions stated as energy intensity cost, energy intensiveness value and energy ratio cost, were given by Mohammadshirazi et al. [24]:

$$\text{Energy use efficiency} = \frac{\text{Output Energy}(\text{MJ ha}^{-1})}{\text{Input Energy}(\text{MJ ha}^{-1})} \tag{11}$$

$$\text{Energy Productivity} = \frac{\text{Yield}(\text{kg ha}^{-1})}{\text{Input Energy}(\text{MJ ha}^{-1})} \tag{12}$$

$$\text{Net Energy} = \text{Output Energy}(\text{MJ ha}^{-1}) - \text{Input Energy}(\text{MJ ha}^{-1}) \tag{13}$$

$$\text{Energy intensiveness} = \frac{\text{Input Energy}(\text{MJ ha}^{-1})}{\text{Total production cost}(\$\text{ ha}^{-1})} \tag{14}$$

Net profit, gross return, net return, benefit to cost (BC) ratio and productivity were calculated by [23]:

$$\text{Gross production value} = \text{Yield}(\text{kg ha}^{-1}) \times \text{Price of Commodity}(\$\text{ kg}^{-1}) \tag{15}$$

$$\text{Gross return} = \text{Gross production value}(\$\text{ ha}^{-1}) - \text{Variable production cost}(\$\text{ ha}^{-1}) \tag{16}$$

$$\text{Net return} = \text{Gross production value}(\$\text{ ha}^{-1}) - \text{Total production cost}(\$\text{ ha}^{-1}) \tag{17}$$

$$\text{BC} = \frac{\text{Gross Production value}(\$\text{ ha}^{-1})}{\text{Total production cost}(\$\text{ ha}^{-1})} \tag{18}$$

$$\text{Productivity} = \frac{\text{Yeild}(\text{kg ha}^{-1})}{\text{Total production cost}(\$\text{ ha}^{-1})} \tag{19}$$

Energy intensity cost, Energy intensiveness value and Energy ratio cost were calculated by [24]:

$$\text{Energy intensity cost} = \frac{\text{Total energy cost}(\$\ \text{ha}^{-1})}{\text{Yeild}(\text{kg ha}^{-1})} \quad (20)$$

$$\text{Energy intensiveness value} = \frac{\text{Input energy}(\text{MJ ha}^{-1})}{\text{Gross production value}(\$\ \text{ha}^{-1})} \quad (21)$$

$$\text{Energy ratio cost} = \frac{\text{Total energy cost}(\$\ \text{ha}^{-1})}{\text{Total production cost}(\$\ \text{ha}^{-1})} \quad (22)$$

Results and discussion

Data used in this study is collected from 50 orange producers in Mazandaran province in the production period of fall 2011. The farms are privately owned and 100% irrigated with the average farm size of 1 ha ranging from 0.2 to 10 ha.

Analysis of input-output energy use in orange production

Table 2 shows the input energy consumption and output energy in orange production in the study area. The total energy requirement for producing the orange crops is about 48,900 MJ ha^{-1}. Among the different energy sources chemical fertilizers have the highest energy consumption and the maximum use of the chemical fertilizers is 293.4 kg ha^{-1}. Chemicals have the next highest energy consumption of 106.5 kg ha^{-1}. Farmers can use biological and physical methods to decrease energy of chemicals therefore organic methods such as Integrated Nutrient Management, which contains manure, organic fertilizer, biological fertilizer and chemical fertilizers, can be used to reduce energy of chemical fertilizers. From the total energy of chemical fertilizers, the shares of nitrogen, phosphorus and potassium are around 89.1%, 9%, 9.1%, respectively. The inputs energy consumption is least for machinery (768.3 MJ ha^{-1}) which accounts for about 1.6% of the total energy consumption. The average yield of orange is computed as 17,335.8 kg ha^{-1} and the total energy output per hectare is calculated as 32,938 MJ (Table 2).

The energy use efficiency, energy productivity, specific energy, net energy, energy intensiveness, energy intensity cost, energy intensiveness cost and energy ratio cost of orange production, are presented in Table 3.

Energy use efficiency (energy ratio) is calculated as 0.67, showing the inefficiency of input energy in orange production. It is shown that the energy ratio can be increased by decreasing energy use. Similar ratios have been reported for different crops such as:

Table 3
Energy input–output ratio in orange production.

Items	Unit	Orange
Energy input	MJ ha^{-1}	48,900.5
Energy output	MJ ha^{-1}	32,938.0
Yield	kg ha^{-1}	17,335.8
Energy use efficiency	–	0.67
Specific energy	MJ kg^{-1}	2.82
Energy productivity	kg MJ^{-1}	0.35
Net energy	MJ ha^{-1}	–15,962.5
Energy intensiveness	MJ \$$^{-1}$ [a]	5.78
Energy intensity cost	\$ kg^{-1}	0.05
Energy intensiveness value	MJ \$$^{-1}$	4.14
Energy ratio cost	–	0.10

[a] Convert Rial to Dollar [25].

0.15 for strawberry [4]; 0.69 for cucumber [6]; 0.74 for cotton [26]; 0.66 for garlic [27]; 0.61 for eggplant and 0.99 for pepper [28]. The average energy productivity of orange is 0.35 kg MJ^{-1} which means that 0.35 unit output is obtained per unit energy. Calculation of energy productivity rate is well documented in the literature such as; garlic (0.42) [27] and cucumber (0.55) [6]. The specific energy, net energy and energy intensiveness of orange production are 2.82 MJ kg^{-1}, $-$15,962.46 MJ ha^{-1} and 5.78 MJ \$$^{-1}$, respectively. Since the net energy is negative, it is concluded that in orange production, energy is being lost. Similar results obtain 1.24 MJ kg^{-1} for the specific energy of cucumber production [29]. Total energy cost is calculated by converting energy input to other commodities such as: barrel of oil and dollar in indices of energy intensity cost and energy ratio cost for production of orange. Energy intensity cost, energy intensiveness value and energy ratio cost of orange production are 0.05 \$ kg^{-1}, 4.14 MJ \$$^{-1}$ and 0.01, respectively.

Total mean energy input for orange production as direct, indirect, renewable and nonrenewable forms is illustrated in Table 4. The total energy input consumption could be classified as direct energy (35.5%), indirect energy (64.5%), renewable energy (24%) and non-renewable energy (76%). Several researchers show that, for potato in Iran, indirect energy (82.35%) is higher than that of direct energy (17.65%), and nonrenewable energy (74.27%) is greater than that of renewable energy (25.73%) [30], whereas for cotton in Turkey the ratio of indirect energy is higher than that of direct energy, and the rate of non-renewable energy is greater than that of renewable energy consumption [26].

With respect to the obtained results, shown in Fig. 1, shares of energy consumption in orange production consist of 26.9% chemical fertilizers, 26.1% chemicals, 12.8% diesel fuel, 9.9% farmyard manure, 8.6% electricity, 7.9% human labor, 6.2% water for

Table 2
Energy use pattern for orange production.

Inputs/output	Unit	Quantity per unit area (ha)	Total energy equivalent (MJ ha^{-1})	Percentage of the total (%)
A. Inputs				
1. Human labor	(h)	1974.3	3869.7	7.9
2. Machinery	(h)	76.7	768.3	1.6
3. Diesel fuel	(L)	28.8	6280.5	12.8
4. Chemical fertilizers	(kg)	293.4	13,145.5	26.9
(a) Nitrogen (N)		137.8	10,762.2	22.0
(b) Phosphate (P_2O_5)		68.0	1183.2	2.4
(c) Potassium (K_2O)		87.6	1200.1	2.5
5. Farmyard manure	(kg)	16,146.7	4844.0	9.9
6. Chemicals	(kg)	106.5	12,782.5	26.1
7. Water for irrigation	(m3)	1207.8	3013.0	6.2
8. Electricity	(kWh)	1166.0	4197.0	8.6
Total energy input	(MJ)		48,900.5	100.0
B. Output				
1. Orange	(kg)	17,335.8	32,938.0	

Table 4
Total energy input in the form of direct, indirect, renewable and non-renewable for orange production (MJ ha^{-1}).

Form of energy (MJ ha^{-1})	Orange	%
Direct energy[a]	17,360.20	35.5
Indirect energy[b]	31,540.26	64.5
Renewable energy[c]	11,726.70	24
Non-renewable energy[d]	37,173.76	76

[a] Includes electricity, human labor, diesel fuel.
[b] Includes chemical fertilizer, farmyard manure, chemicals, machinery, water for irrigation.
[c] Includes human labor, farmyard manure, water for irrigation.
[d] Includes diesel fuel, electricity, chemicals, chemical fertilizer, machinery.

irrigation and 1.6% machinery. Therefore the highest portion of energy input incurred by chemical fertilizer is in agreement with the results found by Mousavi-Avval et al. [31] for canola production and Mohammadi et al. [30] for potato production. The results reveal that consumption of chemical fertilizers, chemicals and diesel fuel; are the highest energy input for orange production in the region.

Econometric model estimation of orange production

Relationship between the energy input and yield is estimated using Cobb–Douglas production function for the orange crop on different categories of farms. Orange yield is assumed to be a function of different energies coming from: human labor, machinery, diesel fuel, chemical fertilizers, farmyard manure, chemicals, water for irrigation and electricity energy. For validation of model I (Eq. 6), autocorrelation is performed using Durbin–Watson test [20]. This test revealed that Durbin–Watson value is 2.423 for Model I (Eq. 6). The coefficient of determination (R^2) is 0.81 for this model. The impact of energy input on yield is also investigated by estimating Eq. (6). Regression results for this model are shown in Table 5. It can be seen from Table 5 that the contribution of human labor, machinery and farmyard manure energies; are significant at 1% level. This indicates that an additional use of 1% for each of these inputs would lead to 0.69% increase, 0.44% decrease and 0.425% increase in yield, respectively. Because of using Cobb–Douglas function in the estimation, the coefficient of variables in log form can be regarded as elasticity [15]. The elasticity of diesel fuel is significant at the 5% level. The impact of chemical fertilizers,

Table 5
Econometric estimation results of energy inputs.

Endogenous variable: yield	Coefficient	*t*-Ratio	MPP
Exogenous variables			
1. Human labor	0.689	5.287**	7.117
2. Machinery	−0.438	−3.512**	−6.876
3. Diesel fuel	0.334	2.596*	1.119
4. Chemical fertilizers	0.091	.992	0.213
5. Farmyard manure	0.425	4.206**	2.683
6. Chemicals	0.03	.292	0.072
7. Water for irrigation	0.009	.032	0.150
8. Electricity	−0.256	−.945	−3.913
Durbin–Watson	2.423		
R^2	0.81		
RTS	0.884		

* and ** indicate significance at 5% and 1% levels, respectively.

chemicals, water for irrigation and electricity energies on yield are estimated statistically insignificant. Heidari et al., [6] reported that impact of human labor energy was found to be statistically significant at the 1% level on the stake cucumber yield. Mobtaker et al. [15] estimated an econometric model for barley production in Hamedan province of Iran. They concluded that among the energy inputs, human energy and machinery energy; were found as the most important input that influenced yield.

The results of econometric model development between energy forms and the yield value; are presented in Table 6. It is evident that, the regression coefficients of direct energy and renewable energy forms; are positive and significant ($p < 1\%$). The regression coefficients of indirect energy and non-renewable energy; are negative and significant ($p < 1\%$). The impacts of DE, IDE, RE and NRE; are estimated in the range of: −0.4 to 1.16.

Sensitivity analysis of energy inputs and energy forms

MPP results

The sensitivity of energy inputs on production is analyzed by using MPP technique based on response coefficient of inputs; results are shown in Table 5. Human labor (energy) has the major MPP value of 7.12. This indicates that the additional utilization of 1 MJ for each of the human labor energy would result in an increase in yield by 7.12 kg. These inputs (exogenous parameters) have a strong impact on the yield (endogenous variable) with large

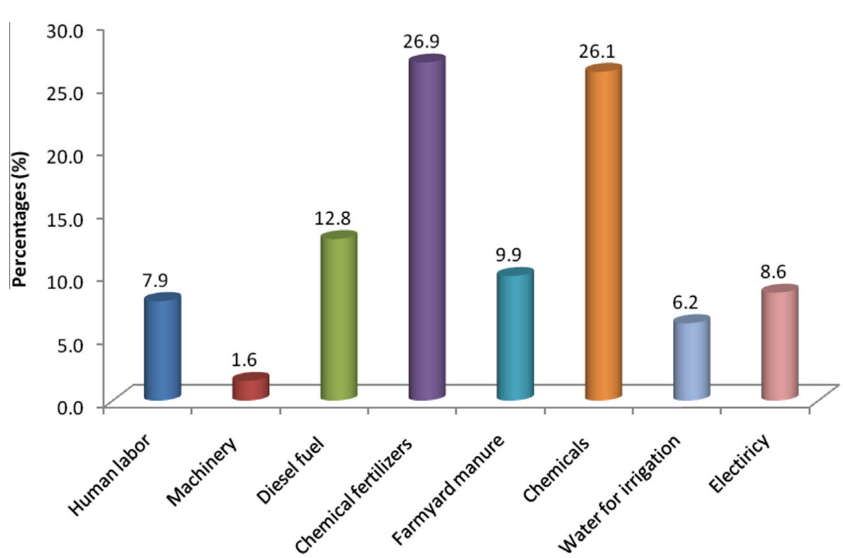

Fig. 1. Distribution of energy use from different inputs in orange production.

Table 6
Econometric estimation of direct and indirect and renewable and nonrenewable energies.

Exogenous variables	Coefficient	*t*-Ratio	MPP
DE (b1)	1.163	8.294**	4.921
IDE (b2)	−0.397	−2.832**	−0.325
Durbin-Watson	2.385		
R^2	0.824		
RTS	0.766		
RE (g1)	0.938	11.628**	3.463
NRE (g2)	−0.309	−3.834**	−0.273
Durbin–Watson	1.85		
R^2	0.85		
RTS	0.629		

** Indicates significance at 1% level.

sensitivity coefficients. Human labors are mainly employed for spraying and harvesting operations, in the surveyed region. Mobtaker et al. [15] analyzed the sensitivity of energy inputs on barley production. They reported that the major MPP was due to human labor (energy) (7.37), followed by machinery energy (1.66).

The values of MPP for DE, IDE, RE and NRE are in the range of: −0.27 to 4.92 (Table 6). This indicates that an additional use of 1 MJ of each of these energy forms; will lead to an additional increase in yield by: −0.27 to 4.92 kg.

Returns to Scale results

The Returns to Scale (RTS) values for the econometric models; are calculated by gathering the regression coefficients shown in Tables 5, 6 and 8. RTS values of Model I, II, III, IV, for orange yield; are 0.88, 0.77, 0.63 and 0.86, respectively; which are a decreasing return to scale (DRS) of orange for estimated models. The higher values of RTS than unity indicates increasing return to scale (IRS), whereas the lower value than unity reveals a DRS. This reveals that by 1% increase in total energy inputs utilized; would lead to 0.88% increase in the orange yield, for model I. In the study of Heidari and Omid [6] for tomato production the sum of regression coefficients (i.e., values for RTS in Table 5) of energy inputs; is calculated to be less than unity.

Table 7
Economic analysis of orange production.

Cost and return components	Unit	Value
Yield	kg ha^{-1}	17,772.61
Sale price	$ kg^{-1}	0.66
Gross value of production	$ ha^{-1}	11,802.25
Variable cost of production	$ ha^{-1}	5862.53
Fixed cost of production	$ ha^{-1}	2595.83
Total cost of production	$ ha^{-1}	8458.36
Total cost of production	$ kg^{-1}	0.48
Gross return	$ ha^{-1}	5939.73
Net return	$ ha^{-1}	3343.90
Benefit to cost ratio		1.40
Productivity	kg $\$^{-1}$	2.10

Table 8
Econometric estimation results of input costs.

Endogenous variable: yield	Coefficient	*t*-Ratio	MPP
Exogenous variables			
1. Labor expense	0.203	2.263*	1.296
2. Machinery expense	0.455	4.425**	13.266
3. Diesel fuel expense	−0.23	−1.978*	−13.674
4. Chemical fertilizers expense	−0.021	−0.240	−0.469
5. Farmyard manure expense	0.121	1.508	8.437
6. Electricity expense	0.04	0.364	3.842
7. Poison expense	−0.03	−0.366	−0.544
8. Packaging expense	0.325	3.050**	8.813
9. Rant land expense	−0.001	−0.245	−0.005
Durbin–Watson	2.171		
R^2	0.834		
RTS	0.862		

* and ** indicate significance at 5% and 1% levels, respectively.

Economic analysis of orange production

The total cost and the gross value of orange production is calculated as shown in Table 7. The fixed and variable expenditure included in the cost of production is calculated separately. The total expenditure for the orange production of this research is 8458.4 $ ha^{-1} while the gross production value found to be 11,802.3 $ ha^{-1}, and the share of variable costs in total is 69%. With respect to results of Table 7, the benefit cost ratio from orange productions; is calculated to be 1.4. Other researchers reported similar results, such as; 1.83 for greenhouse grape [32], 1.68 for greenhouse cucumber, 3.28 for greenhouse tomato [6], 0.86 for cotton [26], 1.74 for strawberry [4], 2.09 for canola [33], 2.37 for orange, 1.89 for lemon, 1.88 for mandarin [34], and 0.8 for greenhouse winter crop tomato production [35].

The results of econometric model development between costs of inputs and the yield are presented in Table 8. Regression results for this equation show that among the variables included in the model, machine and packing expenses; are found to be as the most important variables that influenced income. Elasticity for machine and packing expenses; are 0.455 and 0.325, implying that a given 1% change in machine and packing expenses will result in 0.455% and 0.325% increase in income, respectively. The third important input is found as diesel fuel with −0.23 elasticity. Other important variables that influence orange income; are human labor and farmyard manure with elasticity of 0.203 and 0.121, respectively.

Conclusions

Based on the presented paper, the following conclusions are drawn:

1. The total energy consumption in orange production is 48,900.5 MJ ha^{-1}. Chemical fertilizer (26.9% of total energy) is found to be the most energy consuming commodity among all energy sources. Organic methods such as Integrated Nutrient Management, which contains manure, organic fertilizer, biological fertilizer and chemical fertilizer, can be used to reduce energy of chemical fertilizers. The energy input of chemicals and diesel fuel have the secondary and tertiary shares within the total energy inputs. Energy output is calculated as 32,938 MJ ha^{-1}; Indirect (31,540.26 MJ ha^{-1}) and non-renewable (37,173.76 MJ ha^{-1}) energies are rather high, accordingly.
2. The share of non-renewable energy is 76%. The use of renewable resources of energy like green manure instead of chemical fertilizers could be practiced to improve the situation.
3. Energy use efficiency, energy productivity, specific energy, net energy and energy intensiveness of orange production are 0.67, 0.35 kg MJ^{-1}, 2.82 MJ kg^{-1}, −15,962.5 MJ ha^{-1}, and 5.78 MJ $\$^{-1}$; respectively.
4. The elasticity estimate of human labor was found as 0.689 which has major impact on orange production. Use of mechanization can reduce the human hand work. Also the contribution of human labor, machinery and farmyard manure energies; are significant at 1% level. MPP of machinery energy was found negative, indicating that machinery energy consumption is high in orange production.

5. Orange production in the region showed a high sensitivity on nonrenewable energies which may result in both the environmental deterioration and rapid rate of depletion of these energetic resources. Therefore, policies should emphasize development of new technologies to substitute fossil fuels with renewable energy sources aiming efficient use of energy and lowering the environmental footprints.
6. According to the result of economical analysis of orange production, the benefit cost ratio is found to be 1.4. The net return and productivity from orange production is obtained as $3343.9\ \$\ \mathrm{ha}^{-1}$ and $2.1\ \mathrm{kg}\ \$^{-1}$, respectively.
7. From the econometric estimation results of cost inputs, the elasticity estimate of machinery cost is found to be as 0.45, which has the major impact on orange production, followed by packaging (0.32), diesel fuel (0.23) and labor (0.20).

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