Journal of Agricultural Technology 2011 Vol. 7(6): 1509-1521
Available online http://www.ijat-aatsea.com
ISSN 1686-9141

Modeling and sensitivity analysis of energy inputs for greenhouse cucumber production

Pahlavan, R.*, Omid, M and Akram, A.

Department of Agricultural Machinery Engineering, Faculty of Agricultural Engineering and Technology, School of Agriculture and Natural Resources, University of Tehran, Karaj, Iran

Pahlavan, R., Omid, M and Akram, A. (2011) Modeling and sensitivity analysis of energy inputs for greenhouse cucumber production. Journal of Agricultural Technology 7(6): 1509-1521.

This study analyzed the energy use and investigated the influences of energy inputs and forms on output levels for greenhouse cucumber production in Iran. The data were collected from 26 greenhouses in one period of plant cultivation in spring season. The total energy input of 481124 MJ ha^{-1} was required for cucumber production. The share of diesel fuel by 40.07 % of the total energy inputs was the highest energy input. The energy use efficiency, specific energy and net energy were found as 0.27, 2.99 MJ kg^{-1} and -352591 MJ ha^{-1}, respectively. The econometric model estimation revealed that the impact of diesel fuel, human labour and transportation energy inputs that significantly showed a positive on yield. The results of sensitivity analysis of the energy inputs showed that the highest the MPP value of human labour. Econometric analysis indication of the benefit–cost ratio was estimated as 2.7.

Key words: Energy; Greenhouse; Regression; Econometric; Sensitivity analysis

Introduction

Cucumber is one of the major greenhouse vegetables products worldwide. In Iran, cucumber production was 1.46 million tones in 2008. From 2002 to 2008, greenhouse areas of Iran increased from 3380 ha to 7000 ha (FAO, 2008). The shares of greenhouse crops production were as follows: vegetables 59.3%, flowers 39.81%, fruits 0.54% and mushroom 0.35% (Anonymous, 2008). Energy use in agriculture has developed in response to increased population, limited supply of arable land and desire for an increasing standard of living. Many studies have been conducted to determine the energy efficiency of plant production, such as energy use pattern for strawberry (Banaeian *et al.,* 2011) wheat (Houshyar *et al.,* 2010) in Iran, in a typical village in arid zone (Singh *et al.,* 2002, Singh *et al,* 2003), soybean (Singh *et al.,* 2004) and wheat (Mandal *et al.,* 2002) crops in India, sunflower in Greece (Kallivroussis et al., 2002), citrus fruits (Ozkan *et al.,* 2004a), sweet cherry (Demircan *et al.,* 2006) and some

* Corresponding author: Pahlavan, R; e-mail: rezapahlavan@ut.ac.ir

field crops and vegetables (Canakci *et al.,* 2005) in Turkey, maize and sorghum (Franzluebbers and Francis, 1995) in United States.

Greenhouse production is one of the most intensive plant production system and energy-consuming branch in agriculture. In this respect, the energy budget is important. Energy budget is the numerical comparison of the relationship between input and output of a system in terms of energy units (Canakci and Akinci, 2006). Producers are faced with high cost of operations involved in greenhouse production process. So, there is a great importance to define all energy inputs in greenhouse production, in order to find their optimal combination that would make this production more energy efficient. Canakci and Akinci (2006) and Ozkan *et al.*(2004b) investigated that energy use for greenhouse vegetables production of tomato, cucumber, eggplant and pepper production in Turkey, but the authors were not concerned with the functional relationship between energy inputs and yield.

There are no reports about energy sensitivity analysis for greenhouse cucumber production in Iran; so the aim of this study was to investigate the input-output energy balance in greenhouse cucumber production specifying that a relationship between input energies, yield and sensitivity analysis of the energy inputs on greenhouse cucumber yield in Esfahan province of Iran.

Material and methods

The study was carried out in 26 greenhouse cucumber producers in Esfahan province. The Esfahan province is located within 30-42^0 and 34-30^0 north latitude and 49-36^0 and 55-32^0 east longitude. In the investigated area, 100 % of surveyed greenhouses were the plastic houses. The average size of the studied greenhouses was found to be 0.22 ha. Data were collected from the growers by using a face-to-face questionnaire. The collected data belonged to the production in one period in 2009–2010. The size of each sample was determined using from Neyman technique of Zangeneh *et al.* (2010).

The input energy (MJ ha^{-1}) used from various input sources, human labour, diesel, farm yard manure (FYM), fertilizer, electricity, chemicals, plastic cover and transportation were used as inputs and the cucumber yield (kg ha^{-1}) used as the output. Energy equivalents were used for estimation as shown in Table 1. Based on the energy equivalents of the inputs and output (Table 1), the energy ratio (energy use efficiency), energy productivity, specific energy and net energy were calculated accoeding to Zangeneh *et al.* (2010).

$$\text{Energy use efficiency} = \frac{\text{Energy output (MJ ha}^{-1})}{\text{Energy input (MJ ha}^{-1})} \qquad (1)$$

$$\text{Energy productivity} = \frac{\text{Cucumber output (kg ha}^{-1})}{\text{Energy input (MJ ha}^{-1})} \quad (2)$$

$$\text{Specific energy} = \frac{\text{Energy input (MJ ha}^{-1})}{\text{Cucumber output (kg ha}^{-1})} \quad (3)$$

$$\text{Net energy} = \text{Energy output (MJ ha}^{-1}) - \text{Energy input (MJ ha}^{-1}) \quad (4)$$

For the growth and development, energy demand in agriculture can be divided into direct and indirect energies or renewable and non-renewable energies (Zangeneh *et al.,* 2010). Direct energy (DE) covers human labour, diesel, electricity and transportation, while indirect energy (IDE) includes energy embodied in fertilizers and chemicals used in the cucumber production. Renewable energy (RE) consists of human labour and farm yard manure, whereas non-renewable energy (NRE) includes diesel, electricity, fertilizers and chemicals.

Table 1. Energy coefficients of different inputs and outputs used

Input and output	Units	Energy coefficient, (MJ unit^{-1})	References
A. Input			
1. Human labour	h	1.96	(Mohammadi *et al.,* 2010)
2. Diesel fuel	L	56.31	(Khosruzzaman *et al.,* 2010)
3. Electricity	kW h	11.93	(Esengun *et al.,* 2007)
4. Fertilizers	kg		
(a) Farm yard manure		0.3	(Mohammadi *et al.,* 2010)
(b) Nitrogen		66.14	(Mohammadi *et al.,* 2010)
(c) Phosphate (P_2O_5)		12.44	(Mohammadi *et al.,* 2010)
(d) Potassium (K_2O)		11.15	(Mohammadi *et al.,* 2010)
(e) Sulphur (S)		1.12	(Mohammadi *et al.,* 2010)
(f) Micro		120	(Canakci and Akinci, 2006)
5. Chemicals	kg	120	(Mohammadi *et al.,* 2010)
6. Plastic	kg	90	(Canakci and Akinci, 2006)
7. Machinery	h	62.7	(Cetin and Vardar, 2008)
B. Output			
1. Cucumber	kg	0.8	(Canakci and Akinci, 2006)

In order to specify a relationship between input energies and cucumber yield a mathematical function were identified. For this purpose, Cobb-Douglass production function was chosen as the best function in terms of statistical significance and expected signs of parameters. The Cobb-Douglass function has been used by several authors to investigate the relationship between input energies and production yield (Singh *et al.,* 2004, Mohammadi *et al.,* 2010; Hatirli *et al.,* 2005). The Cobb-Douglass production function is expressed as follows:

$$Y = f(x)\exp(u) \tag{5}$$

This function can be expressed as a linear relationship using the following expression:

$$\ln Y_i = \alpha_0 + \sum_{j=1}^{n} \alpha_j \ln(X_{ij}) + e_i \qquad i = 1,2,...,n \tag{6}$$

Where: Y_i, denotes the yield of the ith greenhouse, X_{ij}, is the vector of inputs used in the production process, α_0, is a constant term, α_j, represent coefficients of inputs which are estimated from the model and e_i, is the error term.

Assuming that yield is a function of input energies, for investigating the impact of each input energy on cucumber yield, the Eq. (6) can be expanded in the following form;

$$\begin{aligned}\ln \mathrm{Y_i} = {} & \alpha_1 \ln \mathrm{X_1} + \alpha_2 \ln \mathrm{X_2} + \alpha_3 \ln \mathrm{X_3} + \alpha_4 \ln \mathrm{X_4} + \alpha_5 \ln \mathrm{X_5} + \alpha_6 \ln \mathrm{X_6} \\ & + \alpha_7 \ln \mathrm{X_7} + \alpha_8 \ln \mathrm{X_8} + \mathrm{e_i}\end{aligned} \tag{7}$$

Where: X_i (i = 1,2,8) represents input energies from chemicals (X_1), farmyard manure (X_2), chemical fertilizer (X_3), human labour (X_4), diesel fuel (X_5), transportation (X_6), electricity (X_7), and plastic (X_8). The constant coefficient (α_0) in Eq. (6) is zero, because when the energy input is zero, the crop production is also zero.

In addition the impacts of DE and IDE energies and RE and NRE energies on the yield were investigated. For this purpose the Cobb-Douglass function was selected and investigated as the following forms:

$$\ln Y = \beta_1 \ln DE + \beta_2 \ln IDE + e_i \tag{8}$$

$$\ln Y = \gamma_1 \ln RE + \gamma_2 \ln NRE + e_i \tag{9}$$

Where Y_i is the greenhouse's yield, β_i and γ_i are coefficient of exogenous variables. DE and IDE are direct and indirect energies, respectively, RE is renewable energy and NRE is non-renewable energy.

In this study, the return to scale (RTS) index was determined in order to analyze the proportional changes in output due to a proportional change in all the inputs (where all inputs increase by a constant factor). So, the RTS values for the Eqs. (7)-(9) were determined by gathering the elasticities, derived in the form of regression coefficients in the Cobb-Douglas production function. If the sum is more than, equal to, or less than unity, implying that there are increasing returns to scale (IRS), constant returns to scale (CRS), or decreasing returns to scale (DRS), respectively (Singh *et al.,* 2004). An increasing, constant and decreasing RTS indicate that when the energy inputs are increased by X value, then the yield of cucumber production increases by more, exactly and less than X value, respectively.

The sensitivity of energy inputs on cucumber yield was also determined. For this purpose, the marginal physical productivity (MPP), based on the response coefficients of the inputs was utilized. The MPP of the various inputs was calculated using the α_j of the various energy inputs as follows (Singh *et al.,* 2004; Ghasemi *et al.,* 2010):

$$MPP_{xj} = \frac{GM(Y)}{GM(X_j)} \times \alpha_j \tag{10}$$

Where MPP_{xj} is marginal physical productivity of jth input, α_j, regression coefficient of jth input, GM(Y), geometric mean of yield, and GM (X_j), geometric mean of jth input energy on per hectare basis. The MPP of a factor implies the change in the total output with a unit change in the factor input, assuming all other factors are fixed at their geometric mean level. A positive value of MPP of any input variable identifies that the total output is increasing with an increase in input; so, one should not stop increasing the use of variable inputs so long as the fixed resource is not fully utilized. A negative value of MPP of any variable input indicates that every additional unit of input starts to diminish the total output of previous units; therefore, it is better to keep the variable resource in surplus rather than utilizing it as a fixed resource.

Basic information on energy inputs of cucumber production were entered into Excel 2007 spreadsheets and SPSS 17.0 software program.

Results and discussion

Analysis of input–output energy use in cucumber production

The energy use pattern and the yield for the 26 farmers was seen in Table 2. The energy use pattern indicated that diesel, electricity, plastic and chemical fertilizers are the major sources of energy for greenhouse cucumber production in the region. The average of human, diesel, electricity, transportation, FYM, chemical fertilizers, chemicals and plastic energy were 9935, 192798, 121856, 31942, 28412, 41023, 10860 and 44299, respectively. The majority of human labour in the greenhouses was used in the harvest operations.

The energy consumption of diesel and electricity due to their low cost was very high in the studied area. In order to improve the greenhouse environment as well as reduction of diesel fuel consumption, it is strongly suggested that the heating system efficiency is raised or replaced with alternative sources of energy such as natural gas, solar energy, etc.

Table 2. Amounts of inputs, output and energy inputs and output in cucumber production

Particular	Human	Diesel	Electricity	Transportation	FYM	chemical Fertilizers	Chemicals	Plastic	Yield
Max	17640	337985	299702	91222	78000	136351	22350	60286	333333
Min	7317	45116	45432	2703	0	10719	3172	22401	55556
Average	9935	192798	121856	31942	28412	41023	10860	44299	160666
Percentage	2.06	40.07	25.33	6.64	5.91	8.53	2.26	9.21	

The last row gives the percentage of each input of the total energy input. Total mean energy used in various greenhouse stages during cucumber production was 481124 MJ ha^{-1}. In another study (Ozkan *et al.,* 2004b), total energy inputs for greenhouse tomato, cucumber, eggplant and pepper production were reported to be 127324.9, 134771.3, 98682.5 and 80253.4 MJ ha^{-1}, respectively. Pashaee *et al.* (2008) calculated the energy inputs for greenhouse tomato production in Kermanshah province of Iran at 123130 MJ ha^{-1}.

The results showed that the most energy consuming input for cucumber production in the different greenhouses investigation was diesel fuel (40.07%). Similar results were found in the literature that the highest energy item was diesel fuel in agricultural crop production (Cetin and Vardar, 2008; Esengun *et al.,* 2007; Yilmaz *et al.,* 2005; Ozkan *et al.,* 2007). High percentage of fuel consumption in the greenhouses of the studied region could be attributed to use of heaters with low efficiency and also low price of diesel fuel in Iran (about 0.02 \$ L^{-1}). The total energy equivalent of electricity consumption placed second among the energy inputs and constituted 25.33% of the total energy input, followed by plastic (9.21%), chemical fertilizer (8.53%). Nitrogen 62.21% was in the first place, and followed by microelements 23.55%, potassium 8.86%, phosphate 4.76% and Sulphur 0.62%. Average annual yield of greenhouses investigated in one period was 160666 kg ha^{-1}, and calculated total energy output was 128533 MJ ha^{-1}. It is shown that chemicals and human labour were the least demanding energy input for cucumber production with 10860 and 9935 MJ ha^{-1}, respectively (Table 2).

The energy use efficiency, energy productivity, specific energy and net energy of cucumber production were shown in Table 3. Energy use efficiency or energy ratio was calculated as 0.27, showing the inefficiency use of energy in the greenhouse cucumber production. It is concluded that the energy ratio can be increased by raising the yield and/or by decreasing energy inputs consumption. Other results in different crops such as cotton of 0.74 for cotton reported by Yilmaz *et al.* (2005), 0.76 for cucumber, 0.61 for eggplant, 0.99 for pepper (Ozkan *et al.,* 2004b) and 0.99 for tomato (Pashaee *et al.,* 2008).

The average energy productivity of greenhouses was 0.33 kg MJ^{-1}. This means that 0.33 units output was obtained per unit energy. Calculation of energy productivity rate is well documented in soybean of 0.18 units (DE *et al.,* 2001) and cherries of 0.51 units (Kizilaslan, 2009). The specific energy and net energy of cucumber production were 2.99 MJ kg^{-1} and -352591 MJ ha^{-1}, respectively. Net energy is negative (less than zero). Therefore, it can be concluded that in cucumber production, energy is being lost.

Total mean energy input as direct, indirect, renewable and nonrenewable forms is given in Table 3. The total energy input consumed could be classified as direct energy (74.10%), indirect energy (25.90%), renewable energy (7.97%) and non-renewable energy (92.03%). Several researchers found that the ratio of direct energy is higher than indirect energy, and the rate of non-renewable energy was greater than renewable energy consumption in cropping systems as reported by Esengun *et al.* (2007), Kizilaslan (2009) and Ozkan *et al.* (2007).

Table 3. Energy output–input ratio and forms in cucumber production

Items	Unit	Quantity	%
Energy use efficiency	-	0.27	
Energy productivity	kg MJ^{-1}	0.33	
Specific energy	MJ kg^{-1}	2.99	
Net energy	MJ ha^{-1}	-352591	
Direct energy[a]	MJ ha^{-1}	356531	74.10
Indirect energy[b]	MJ ha^{-1}	124593	25.90
Renewable energy[c]	MJ ha^{-1}	38346	7.97
Non-renewable energy[d]	MJ ha^{-1}	442777	92.03
Total energy input	MJ ha^{-1}	481124	100.00
Total energy output	MJ ha^{-1}	128533	

[a] Includes human labour, diesel, electricity and transportation
[b] Includes fertilizers, plastic and chemicals
[c] Includes human labour and Farm yard manure
[d] Includes diesel,plastic, transportation, chemical fertilizers, chemicals and electricity

Econometric model estimation of cucumber production

Relationship between the energy inputs and yield was estimated using Cobb–Douglas production function for the cucumber on different categories of greenhouse. Cucumber yield as endogenous variable was assumed to be a function of human labour, diesel fuel, FYM, chemical fertilizers, chemicals, electricity, plastic cover energy and transportation as exogenous variables. In validating of the Models I, II and III (Eqs. (7)–(9), respectively, autocorrelation was performed using Durbin–Watson test (Hatirli *et al.,* 2005). This test revealed that Durbin–Watson value was as 2.08 for Model I (Eq. (7)), i.e. there was no autocorrelation at the 5% significance level in the estimated model. The coefficient of determination (R^2) was 0.98 for this model. The impact of energy inputs on yield was also investigated by estimating Eq. (7). Regression result for this model is shown in Table 4.

The contribution of diesel fuel energy is significant at the 1% level. This indicates that with an additional use of 1% for diesel fuel energy would lead, to 0.45% increase in yield. The human labour and transportation energy contributed significantly to the yield at 5% level (Table4). Hatirli (2006) estimated an econometric model for greenhouse tomato production in Antalya province of Turkey. He concluded that among the energy inputs, human energy was found as the most important input that influences yield. Singh *et al.* (2004) concluded that in zone 2 of Punjab, the impact of human and electrical energies were significant showed the productivity at 1% level. The MPP value of model variables is shown in the last column of Table 4. The MPP of human labour and chemicals inputs were found to be 11.07 and -2.77, respectively. This indicated that an increase of 1 MJ in each input of human labour and chemicals energy, would lead to a change in yield by 10.73, -3.89 kg ha^{-1}, respectively. The value of return to scale (RTS) for the Model I was calculated by gathering the regression coefficients as 1.15. The higher value of RTS than unity implies IRS.

The regression coefficients of direct and indirect energies (Model II) as well as renewable and non-renewable energies (Model III) on yield were also investigated through Eqs. (8) and (9), respectively.

The regression coefficients of direct and non-renewable energies were all statistically significant at 1% level, whereas the regression coefficient of indirect and renewable energies were found insignificant (Table 5). The impacts of direct, indirect, renewable and non-renewable energies were estimated as 0.78, 0.17, 0.04 and 0.89, respectively. Similar result was reported by Hatirli *et al.* (2005) that stated the impact of non-renewable energy was more than renewable energy. Durbin–Watson values were calculated as 1.99 and 2.03 for Eqs. (8) and (9); indicating that there is no autocorrelation at the

1% significance level in the estimated models. The R^2 value was 0.96 for both these estimated models (Model II and Model III). The RTS values for the Models II and III were 0.95 and 0.93, respectively, implied DRS. The MPP values of indirect and renewable energies were 0.13 and 0.12, respectively (Table 5). It indicated that an additional use of 1 MJ in each of the indirect and renewable energies, would lead to an additional increase in yield by 0.13 and 0.12 kg ha^{-1}, respectively.

Table 4. Econometric estimation results of inputs

Endogenous variable: yield Exogenous variables	Coefficient	t-ratio	MPP
Model I: $\ln Y_i = a_1 \ln X_1 + a_2 \ln X_2 + a_3 \ln X_3 + a_4 \ln X_4 + a_5 \ln X_5 + a_6 \ln X_6 + a_7 \ln X_7 + a_8 \ln X_8 + e_i$			
1.Chemicals	-0.24	-1.70	-3.89
2.FYM	0.16	1.79	1.54
3.Chemical fertilizer	-0.04	-0.39	-0.16
4.Human labour	0.69	2.25**	10.73
5.Diesel	0.45	3.21*	0.39
6.Transportation	0.16	2.39**	1.04
7.Electricity	-0.15	-1.07	-0.21
8.Plastic	0.11	0.70	0.39
Durbin-Watson	2.08		
R^2	0.98		
Return to scale	1.15		

* Significance at 1% level.
** Significance at 5% level.

Table 5. Econometric estimation results of direct, indirect, renewable and non-renewable energies

Endogenous variable: yield Exogenous variables	Coefficient	t-ratio	MPP
Model II: $\ln Y_i = \beta_1 \ln DE + \beta_2 \ln IDE + e_i$			
Direct energy	0.78	4.43*	0.46
Indirect energy	0.17	0.86	0.13
Durbin-Watson	1.99		
R^2	0.96		
Return to scale	0.95		
Model III: $\ln Y_i = \gamma_1 \ln RE + \gamma_2 \ln NRE + e_i$			
Renewable energy	0.04	0.31	0.12
Non-renewable energy	0.89	8.42*	0.34
Durbin-Watson	2.03		
R^2	0.96		
Return to scale	0.93		

*Significance at 1% level.

Economic analysis of cucumber production

The costs of each input used and calculated gross production values for cucumber production are given in Table 6. Fixed and variable costs within total production costs were calculated independently. The gross value of production (112466 \$ ha^{-1}) was found by multiplying the cucumber yield (160666 kg ha^{-1}) by cucumber price (0.7 \$ kg^{-1}). The total cost of production was 41654 \$ ha^{-1}. About 84% of the total cost was variable costs, whereas 16% was fixed expenditures. Several studies were reported that the ratio of variable cost was higher than fixed cost in cropping systems (Cetin and Vardar, 2008; Esengun *et al.,* 2007). Based on these results, the benefit–cost ratio from cucumber production in the surveyed greenhouses was calculated as 2.7. These results are consistent with the findings reported by other authors, such as 2.37 in orange, 1.89 in lemon and 1.88 in mandarin (Ozkan *et al.,* 2004), 1.83 and 2.21 in greenhouse and open-field grape (Ozkan *et al.,* 2007) and 1.10 in soybean, 2.03 in wheat, 1.98 in mustard and 2.30 in chickpea (Mandal *et al.,* 2002). The gross return of 77362 \$ ha^{-1} was calculated by subtracting the variable cost of production per hectare (35104 \$ ha^{-1}) from the gross value of production. The productivity (3.86 kg \$$^{-1}$) was obtained by dividing cucumber yield (160666 kg ha^{-1}) by total production costs (41654 \$ ha^{-1}).

Table 6. Economic analysis of cucumber production

Cost and return components	Unit	Value
Yield	kg ha^{-1}	160666
Sale price	\$ kg^{-1}	0.70
Gross value of production	\$ ha^{-1}	112466
Variable cost of production	\$ ha^{-1}	35104
Fixed cost of production	\$ ha^{-1}	6550
Total cost of production	\$ ha^{-1}	41654
Total cost of production	\$ kg^{-1}	0.26
Gross return	\$ ha^{-1}	77362
Net return	\$ ha^{-1}	70812
Benefit to cost ratio	-	2.70
Productivity	kg \$$^{-1}$	3.86

Optimization is an important tool to maximize the amount of productivity which can significantly impact the energy consumption and production costs. Optimization of energy usage in agricultural systems is reflected in two ways:- an increase in productivity with the existing level of energy inputs or conserving energy without affecting the productivity. In practice, a farmer has limited resources for the total cost of different inputs (chemicals, diesel, etc.)

Since each unit of cucumber production makes the same amount of profit, then the farmer would reasonably locate available resources to maximize the number of products it produces. This problem can be expressed in mathematical form as a linear programming. So, this study can be extended to identify efficient farmers from inefficient ones, determined wasteful uses of energy inputs by inefficient farmers and suggested necessary quantities of various inputs to be utilized by each inefficient farmer from every energy source.

Conclusions

In this study, the energy balance between the input and output for cucumber production was investigated. The total energy consumption in cucumber production was 481124 MJ ha^{-1}. The energy input of diesel fuel gave the biggest share within the total energy inputs followed by electricity plastic cover and chemical fertilizer, respectively. High percentage of diesel fuel and electricity consumption in the greenhouse of the studied region are due to use of heaters with low efficiency and also low price of diesel fuel and electricity in Iran (about 0.02 \$ L^{-1} for diesel and 0.002 \$ kWh^{-1} for electricity in agricultural section). On average, 74.10% of total energy input used in cucumber production was direct afftected, while the contribution of indirect energy was 25.90%. Also the shares of renewable and non-renewable energy inputs were 7.97% and 92.03%, respectively. The impact of diesel, human labour and transportation energy inputs was significantly positive on yield. The MPP value of human labour was the highest. Energy management becomes more important when the required energy should be economical, sustainable and productive. It is concluded that reduce in diesel fuel, electricity and fertilizer consumptions are important for energy saving and decreasing the environmental risk problem in the area. Since electric pumps are old, high level of electricity energy is used and chemicals and fertilizer energies are applied due to the lack of soil analysis leading to unconscious usage of total fertilizer. Reducing diesel fuel consumption and fertilizer usage, mainly nitrogen, are important for energy management. A saving in diesel fuel by improving heating performance may be possible introduced. Using direct and local marketing improves profitability for growers while reducing the amount of energy used to transport products. The benefit cost ratio was found to be 2.7, in the result of economical analysis of cucumber production. The mean net return from cucumber production was obtained 70812 \$ ha^{-1}.

Acknowledgement

The financial support provided by the University of Tehran, Iran, is duly acknowledged.

References

Anonymous (2008). Iran annual agricultural statistics. Ministry of Jihad-e-Agriculture of Iran;. <www.maj.ir>.

Banaeian, N., Omid, M and Ahmadi, H. (2011). Energy and economic analysis of greenhouse strawberry production in Tehran province of Iran. Energy Conversion and Management 52: 1020-1025.

Canakci, M and Akinci, I. (2006). Energy use pattern analyses of greenhouse vegetable production. Energy 31: 1243–56.

Canakci, M., Topakci, M., Akinci, I. and Ozmerzi, A. (2005). Energy use pattern of some field crops and vegetable production: case study for Antalya region, Turkey. Energy Conversion and Management 46: 655–666.

Cetin, B and Vardar, A. (2008). An economic analysis of energy requirements and input costs for tomato production in Turkey. Renewable Energy 33: 428–433.

De, D., Singh, R.S and Chandra, H. (2001). Technological impact on energy consumption in rainfed soybean cultivation in Madhya Pradesh. Applied Energy 70: 193–213.

Demircan, V., Ekinci, K., Keener, H.M., Akbolat, D and Ekinci, C. (2006). Energy and economic analysis of sweet cherry production in Turkey: a case study from Isparta province. Energy Conversion and Management 47: 1761-1769.

Esengun, K., Erdal, G., Gunduz, O and Erdal, H. (2007). An economic analysis and energy use in stake-tomato production in Tokat province of Turkey. Renewable Energy 32: 1873–1881.

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

Food and Agriculture Organization (FAO); 2008. <www.fao.org>.

Franzluebbers, A.J and Francis, C.A. (1995). Energy output–input ratio of maize and sorghum management systems in Eastern Nebraska. Agric Ecosyst Environ 53(3): 271-278.

Ghasemi Mobtaker, H., Keyhani, A., Mohammadi, A., Rafiee, S.H and Akram, A. (2010). Sensitivity analysis of energy inputs for barley production in Hamedan Province of Iran. Agriculture Ecosystems and Environment 137: 367-372.

Hatirli, S.A., Ozkan, B and Fert, C. (2005). An econometric analysis of energy input-output in Turkish agriculture. Renewable Sustain Energy Rev 9: 608-623.

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

Houshyar, E., Sheikh, Davoodi. M.J and Nassiri, S.M. (2010). Energy efficiency for wheat production using data envelopment analysis (DEA) technique. Journal of Agricultural Technology 6(4): 663-672.

Kallivroussis, L., Natsis, A and Papadakis, G. (2002). The energy balance of sunflower production for biodiesel in Greece. Biosyst Eng 81(3): 347-354.

Khosruzzaman, S., Asgar, M.A., Karim, N and Akbar, S. (2010). Energy intensity and productivity in relation to agriculture-Bangladesh perspective Journal of Agricultural Technology 6(4): 615-630.

Kizilaslan, H. (2009). Input-output energy analysis of cherries production in Tokat province of Turkey. Applied Energy 86(7–8): 1354–1358.

Mandal, K.G., Saha, K.P., Ghosh, P.K., Hati, K.M and Bandyopadhyay, K.K. (2002). Bioenergy and economic analysis of soybean-based crop production systems in central India. Biomass Bioenergy 23(5): 337-345.

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

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

Ozkan, B., Kurklu, A and Akcaoz, H. (2004a). An input–output energy analysis in greenhouse vegetable production: a case study for Antalya region of Turkey. Biomass Bioenergy 26: 189-195.

Ozkan, B., Akcaoz, H and Karadeniz, F. (2004b). Energy requirement and economic analysis of citrus production in Turkey. Energy Conversion and Management 45: 1821–1830.

Pashaee, F., Rahmati, M.H and Pashaee, P. (2008). Study and determination of energy consumption to produce tomato in the greenhouse. In: The 5th national conference on agricultural machinery engineering and mechanization; 27-28 August, 2008, Mashhad, Iran.

Singh, G. Singh, S and Singh, J. (2004). Optimization of energy inputs for wheat crop in Punjab. Energy Conversion and Management 45: 453-465.

Singh, H., Mishra, D and Nahar, N.M. (2002). Energy use pattern in production agriculture of a typical village in arid zone India part I. Energy Conversion and Management 43(16): 2275-2286.

Singh, H., Mishra, D., Nahar, N.M. and Ranjan, M. (2003). Energy use pattern in production agriculture of a typical village in arid zone India part II. Energy Conversion and Management 44(7): 1053–1067.

Yilmaz, I., Akcaoz, H and Ozkan, B. (2005). An analysis of energy use and input costs for cotton production in Turkey. Renewable Energy 30: 145–155.

Zangeneh, M., Omid, M and Akram, A. (2010). A comparative study on energy use and cost analysis of potato production under different farming technologies in Hamadan province of Iran. Energy 1-7.

(Received 18 April 2011; accepted 1 October 2011)