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Estimating the Energy Indices and Profitability of Strawberry Production in Kamyaran Zone of Iran

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Abstract: Problem statement: The aim of this research is to determine the energy indices and to make a cost analysis of strawberry grown in open field in Kamyaran zone of Iran. **Approach:** The data used in the study were obtained from 35 local strawberry growers by using a face-to-face questionnaire in August-September 2009. **Results:** Total energy input for strawberry production was calculated to be 36822.9 MJ.ha^{-1}. The Energy ratio was 0.48 and energy productivity was found to be 0.25 kg.MJ^{-1}. About 74.5% of the total energy inputs used in strawberry production was non-renewable while only about 25.5% was renewable. The share of 56.6% of the total energy input was depended on the indirect form, whereas 43.4% of the total energy input was in the direct form. Specific energy was 3.96 MJ.kg^{-1}. Economic analyses showed that profit/cost ratio and net profit were 1.49 and 4616.9 $.ha^{-1}, respectively. **Conclusion:** The net energy in the study area was negative. This means that the amount of output energy is less than input energy and production in this situation is irrational, thus efficient use of resources and proper land management is needed.

Key words: Economic analysis, energy efficiency, energy productivity, net energy, specific energy

INTRODUCTION

Strawberry is an herbaceous perennial plant having a compressed, shortened stem and produces stolons. The fruit is an Achene attached to a juicy, enlarged receptacle. It is one of the most popular fruits in the world and per capita consumption is increasing annually. Strawberry is the most popular yogurt flavor in many countries. Fruits are eaten raw or used in making juice, desserts, jam, syrup and wine (Biswas *et al*., 2007).

Strawberries are from the Rosaceae family. The name strawberry has a couple of derivations. One was thought to come from the fact that the berries on runners are "strewn" about on the plants and "strewn berry" eventually became "Strawberry". Another was that they were planted in straw mulch to keep them clean and hence straw berries (Kirkpatrick, 2008).

The strawberry is among the first of the fresh fruits and very attractive on the market. A rapid cash return is predicted to strawberry growers. Experience of investigators and local growers is the best guide in selecting profitable culture measures (Kikas and Luik, 2009).

The relation between agriculture and energy is very close. Agriculture itself is an energy user and energy supplier in the form of bio-energy. At present productivity and profitability of agriculture depend on energy consumption. For the growth and development, energy demand in agriculture can be divided into direct and indirect, renewable and non-renewable energy. Energy inputs are sun and support energy. Support direct energy is required for land preparation, irrigation, harvest, post harvest processing, transportation of agricultural inputs and outputs. Support indirect energy is used in the form of fertilizer and pesticides. Energy use depends on mechanization level, the quantity of active agricultural worker and cultivable land (Salami *et al*., 2010).

In developing countries like Iran, agricultural growth is essential for fostering the economic development and meeting the ever-higher demands of the growing population. Energy in agriculture is important in terms of crop production and agro processing for value adding (Salami *et al*., 2009).

Energy productivity is an important index for more efficient use of energy although higher energy productivity does not mean in general, more economic

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feasibility. However, the energy analysis shows the methods to minimize the energy inputs and therefore to increase the energy productivity (Fluck and Baird, 1982).

MATERIALS AND METHODS

The data were collected from 35 farmers growing strawberry in Kamyaran zone by using a face-to-face questionnaire in August-September 2009. This zone is located in Kurdistan province of Iran.

As it is shown in Eq. 1, the sample size was determined by using the simple random sampling method (Salami *et al*., 2009):

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

In which:

n = The required sample size
s = The standard deviation
t = The t value at 95% confidence limit (1.96)
N = The number of holding in target population
d = The acceptable error (permissible error 10%)

The energy efficiency of the agricultural system has been evaluated by the energy ratio between output and input. Human labor, machinery, diesel fuel, fertilizer and Ecesis amounts and output yield values of strawberry crops have been used to estimate the energy ratio. The amounts of input were calculated per hectare and then, these input data were multiplied with the coefficient of energy equivalent. Energy equivalents shown in Table 1 were used for estimation.

Basic information on energy inputs and strawberry yields were entered into Excel and SPSS 17 spreadsheets. 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, as they are shown in Eq. 2-5 (Mandal *et al*., 2002; Mohammadi and Omid, 2010; Singh *et al*., 1997):

$$\text{Energy ratio} = \frac{\text{Energy output (MJ.ha}^{-1})}{\text{Energy input (MJ.ha}^{-1})} \quad (2)$$

$$\text{Energy productivity} = \frac{\text{Strawberry output (kg.ha}^{-1})}{\text{Energy input (MJ.ha}^{-1})} \quad (3)$$

$$\text{Specific energy} = \frac{\text{Energy input (MJ.ha}^{-1})}{\text{Strawberry output (kg.ha}^{-1})} \quad (4)$$

$$\text{Net energy} = \text{Energy output (MJ.ha}^{-1}) - \text{Energy input (MJ.ha}^{-1}) \quad (5)$$

Table 1: Energy equivalent of inputs and output in strawberry production

Particulars	Unit	Energy equivalent (MJ.unit^{-1})	Reference
A. Inputs			
1. Human labor	h	1.96	(Erdal *et al*., 2007; Singh and Mittal, 1992)
2. Machinery	kg		
Tractor	kg	138.00	(Kitani, 1999)
Plow	kg	180.00	(Kitani, 1999)
Disk harrow	kg	149.00	(Kitani, 1999)
3. Diesel fuel	L	56.31	(Erdal *et al*., 2007; Singh and Mittal, 1992)
4. Fertilizers			
(N)	kg	78.10	(Kitani, 1999)
(P)	kg	3.50	(Salami *et al*., 2010)
5. Manure	kg	0.30	(Singh and Mittal, 1992)
6. Ecesis	kg	0.80	(Singh and Mittal, 1992)
B. Outputs (Yield)	kg	1.90	(Singh and Mittal, 1992)

Indirect energy included energy embodied in ecesis, fertilizers, manure and machinery while direct energy covered human labor and diesel used in the strawberry production. Non-renewable energy includes diesel, fertilizers and machinery and renewable energy consists of human labor, ecesis and manure. In the last part of the study, economic analysis of strawberry production was investigated and net profit and benefit-cost ratio was calculated. The net return was calculated by subtracting the total cost of production from the gross value of production per hectare. The benefit-cost ratio was calculated by dividing the gross value of production by the total cost of production per hectare (Demircan *et al*., 2006; Ozkan *et al*., 2004).

RESULTS AND DISCUSSION

Analysis of input-output energy use in strawberry production: Table 2 shows the amounts of used inputs in the strawberry production, energy equivalences, ratio of inputs and output, energy productivity, specific energy and net energy. The last column in Table 2 gives the percentage of each input of the total energy input.

The most of the agricultural operations was done manually in the study area, while using the agricultural machinery was limited to some areas and only for land preparation. According to the estimation of data in Table 2, the average human labor required in the study area was 1231.4 h.ha^{-1}and machine power was just 2.2 h.ha^{-1}.

Total energy consumed in various farm operations during strawberry production was 36822.9 MJ.ha^{-1}. Irrigation energy consumed 34.3% of total energy followed by nitrogen fertilizer 31.6% during production period. Total energy output was 17680.3 MJ.ha^{-1}and the average annual yield of strawberry farms was 9305.4 kg.ha^{-1}. It is shown in Table 2 that machinery was the least demanding energy input for strawberry production with 130.5 MJ.ha^{-1} (only 0.4% of the total energy input), followed by diesel fuel (for land preparation) with 957.3 MJ.ha^{-1} (2.6%).

Table 2: Amounts of inputs and output in strawberry production

Inputs and output	Quantity per unit area (ha)	Total energy equivalent (MJ.ha^{-1})	Percent
A. Inputs			
1. Human labor (h)	1231.4	2413.6	6.6
2. Machinery (h)	2.2	130.5	0.4
3. Diesel fuel (L)	17.0	957.3	2.6
4. Chemical fertilizers (kg)			
Nitrogen (N)	324.3	11650.8	31.6
Phosphate (P)	592.7	2074.5	5.6
5. Manure (kg)	19037.6	5711.3	15.5
6. Ecesis (kg)	1582.1	1265.7	3.4
7. Irrigation (m^3)	31428.6	12619.2	34.3
Total energy input (MJ)	-	36822.9	100.0
B. Output			
1. Strawberry (kg)	9305.4	17680.3	-
Total energy output (MJ)	-	17680.3	-
Energy ratio	-	-	0.48
Energy productivity (kg.MJ^{-1})	-	-	0.25
Specific energy (MJ.kg^{-1})	-	-	3.96
Net energy (MJ.ha^{-1})	-	-19142.6	
Direct energy[a] (MJ.ha^{-1})	-	15990.1	43.40
Indirect energy[b] (MJ.ha^{-1})	-	20832.8	56.60
Renewable energy[c] (MJ.h^{-1})	-	9390.6	25.50
Non-renewable energy[d] (MJ.ha^{-1})	-	27432.3	74.50

[a]: Includes human labor, diesel; [b]: Includes ecesis, fertilizers, manure, machinery; [c]: Includes human labor, seeds, manure; [d]: Includes diesel, electricity, fertilizers, machinery

Table 3: Economic analysis of strawberry production

Cost and return items	Value
Total production costs ($.ha^{-1})	9493.30
Gross production value [a]($.ha^{-1})	14110.20
Benefit/cost ratio	1.49
Productivity (kg.$ $^{-1}$)[b]	0.98
Net return ($.ha^{-1})	4616.90

[a]: Gross production value = strawberry yield (kg.ha^{-1})*price ($.kg^{-1}); [b]: Productivity (kg.$ $^{-1}$) = strawberry yield (kg.ha^{-1})/total production costs ($.ha^{-1})

This result is marvelous, because diesel fuel is one of the most energy consumers in the major of the studies, while in this study the case is inversed. That's because of that the major of the agricultural operations was done manually and using the agricultural machinery was limited to some areas and only for land preparation.

Energy efficiency (energy output-input ratio) in this study was 0.48and energy productivity calculated as 0.25 kg.MJ^{-1} in the study area. This means that 0.25 kg of output obtained per unit energy. Specific energy was 3.96 MJ.kg^{-1}. This means that 3.96 MJ is needed to obtain 1 kg of strawberry. Net energy was-19142.6 MJ.ha^{-1}. As it's obvious, the net energy in the study area was negative. This means that the amount of output energy is less than input energy and production in this situation is irrational.

Direct, indirect, renewable and non-renewable forms of input energy are also shown in Table 2. The share of 56.6% of the total energy input was depended on the indirect form, whereas 43.4% of the total energy input was in the direct form. The share of renewable energy was 25.5% in the total energy compared to 74.5% for the non-renewable energy. Therefore, it revealed that the rate of indirect energy was greater than that of direct energy consumption in strawberry production. This result was in agreement with the results of Ozkan *et al*. (2004) for lemon and mandarin and Esengun *et al*. (2007b) for apricot. The rate of non-renewable energy also was higher than that of renewable energy consumption in surveyed farms; similar results have been found by Kizilaslan (2009) and Esengun *et al*. (2007a) for cherries and stake-tomato.

Economic analysis of strawberry production: The data obtained from economic analysis are presented in Table 3. The benefit/cost ratio was 1.49 in the study area. The productivity was 0.98 kg. $ $^{-1}$ for the strawberry production. Net profit was 4616.9 $.ha^{-1}. Apparently this shows that producing strawberry is profitable in the study area, but the real net return could be less than this amount by eliminating the subsidies. In many developing countries like Iran, the governments pay subsidies for energy resources or inputs for the production, thus the appropriate yield, efficiency and profitability could not be attained. By eliminating the subsidies, the resources would be used in an efficient manner.

CONCLUSION

In this study the energy indices and cost analysis of strawberry production in Kamyaran zone of Iran

have been investigated. Total energy used in various farm operations during strawberry production was 36822.9 $MJ.ha^{-1}$. Energy productivity estimated as 0.25 $kg.MJ^{-1}$ and energy efficiency was 0.48. Specific energy calculated as 3.96 $MJ.kg^{-1}$. The profit-cost ratio, productivity and net profit in the strawberry production were 1.49, 0.98 and 4616.9 $\$.ha^{-1}$, respectively.

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