American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-02, Issue-05, pp-173-177
www.ajer.us

Research Paper Open Access

Input-Output Energy and Economic Analysis of Strawberry Production in Iran

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Abstract: The aim of this study was to determine the energy consumption and economic analysis for strawberry production. The data were collected from 80 farmers growing strawberry in the Babolsar zone of Iran by using a face-to-face questionnaire in May-June 2012. The plowing operation at the study area was done by two methods; manually plow and machinery plow. In addition, the irrigation operation was done by two methods; pumping irrigation and non-pumping irrigation. Total energy used in various farm operations during strawberry production was 22275.8 MJ.ha^{-1}. Total energy output was 14820 MJ.ha^{-1}, and the average annual yield of strawberry farms was 7800 kg. ha^{-1}. The energy ratio, productivities, specific and net energy gain were 0.58, 0.3 kg.MJ^{-1}, 3.33 MJ.kg^{-1} and -9355.8 MJ.ha^{-1}, respectively. The profit/cost ratio, productivity, and net profit in the strawberry production are 1.37, 1.1 kg.$^{-1}$ and 2333.4 $.ha^{-1}, respectively. In addition, the net return in the non-pumping and manually plow method is significantly higher than in the other methods.

Keywords: *Economic analysis, energy use, input-output, renewable energy, strawberry*

I. INTRODUCTION

Strawberry is an important small fruit, grown throughout the world. It is deep red in colour with unique shape and flavour. In Iran more than 20,000 tones of strawberries are produced each year. Kurdistan and Mazandaran provinces are two main regions of production with 2,000 and 500 hectares, respectively. Iran with over 3,600 hectares of strawberry cultivation has been ranked twentieth place in the world. Average Strawberry yield per unit area in Iran is 10 tons per hectare [1].

Energy is indeed the live wire of industrial, food and agricultural production, the fuel for transportation as well as for the generation of electricity in conventional thermal power plants [2]. The energy consumption for agricultural production is depended on agro-ecosystems, planting pattern, type of soil and mechanization levels [3]. For strawberry production, total energy consumptions are varied for different type of soils, farm size and level technology of machinery used. There is no reported data on strawberry energy consumption.

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 [4]. Energy use in agriculture has been developed in response to increasing populations, limited supply of arable land and desire for an increasing standard of living. In all societies, these factors have encouraged an increase in energy inputs to maximize yields, minimize labour intensive practices or both [5].

In agriculture, a wide range of modern and traditional energy forms are used directly on the farm, e.g. as tractor or machinery fuel, and in water pumping, irrigation and crop drying, and indirectly for fertilizers and pesticides. Other energy inputs are required for post harvest processing in food production, packaging, storage, transportation and cooking [6].

Energy productivity is an important index for more efficient use of energy although higher energy productivity does not mean in general, more economic feasibility. However, the energy analysis shows the methods to minimize the energy inputs and therefore to increase the energy productivity [7]. Calculating energy inputs of

agricultural production is more difficult than in the industry sector due to the high number of factors affecting the production [8].

In order to maintain economically sustainable level of production of strawberry, it is essential to reduce the cost of production. Therefore, attempts should be made for higher efficiency of energy use.

The aim of this study was (1) to determine the amount of input-output energy used in growing strawberry, (2) to investigate the efficiency of energy consumption and (3) to make an economic analysis of strawberry production.

II. MATERIALS AND METHODS

2.1 Location and Period of the Study

The data were collected from 80 farmers growing strawberry in Babolsar zone of Iran by using a face-to-face questionnaire in May-June 2012. Babolsar zone is located in Mazandaran province of Iran. The province is located in the north of Iran, within 35° 47' and 36° 25' N latitude and 50° 34' and 54° 10' E longitude [9].

2.2 Sample Size

Random sampling of farms was done within whole population and the size of each sample was determined using equation (1) [10].

$$n = 1 \quad \left(\sum N_h S_h\right)^2 \Big/ \left(N^2 D^2 + \sum N_h D_h^2\right) \qquad (1)$$

Where:

n = required sample size;

N = Number of holdings in target population;

Nh= Number of the population in the hr stratification;

Sh = Standard deviation in the h stratification;

S_h^2 = Variance in the h stratification;

d = Precision where $\left(\bar{x} - \overline{X}\right)$(%5); and

z = Reliability coefficient (1.96, which represents the 95% reliability) ($D^2 = {d^2}/{z^2}$)

2.3 Energy and Economic Indexes

The energy ratio (energy use efficiency), energy productivity, specific energy and net energy were calculated as per given below in (Equations 2 to 5) [11].

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

$$\text{Energy Productivity} = \frac{\text{Citrus Output (kg ha}^{-1})}{\text{Energy Inpu t (MJ ha}^{-1})} \qquad (3)$$

$$\text{Specific Energy} = \frac{\text{Energy Input (MJ ha}^{-1})}{\text{Citrus Output (kg ha}^{-1})} \qquad (4)$$

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

The gross production value and productivity for economic analysis were calculated as per given below in (Equations 6 and 7).

$$\text{Gross production value (\$ ha}^{-1}) = \text{Strawberry yield (kg ha-1) * price (\$ kg}^{-1}) \qquad (6)$$

$$\text{Productivity (kg \$}^{-1}) = \frac{\text{Strawberry yield (kg ha}^{-1})}{\text{Total production costs (\$ ha}^{-1})} \qquad (7)$$

Basic information on energy inputs and strawberry yields were entered into Excel and SPSS 19 spreadsheets. The plowing operation at the study area was done by two methods. At the first method, the workers did it manually, while at the second method it was done by agricultural machinery. In addition, the irrigation operation was done by two methods. In some places, the farmers used a river or spring water without using any energy for pumping the water. This was non-pumping irrigation method. In other fields there was not such a source and the farmers pumped the water from a well or a river in a lower altitude. This was pumping irrigation method.

The energy efficiency of the agricultural system has been evaluated by the energy ratio between output and input. Human labor, machinery, diesel oil, 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 given in table 1.

Table 1. Energy equivalents for different inputs and outputs in strawberry production in Iran.

Input	Unit	Energy Equivalent (MJ unit^{-1})	Reference
Labor	h	1.96	[12]
Tractor-Machinery	kg	138	[12]
Diesel fuel	L	47.8	[12]
Manure	ton	303.1	[5]
NH3	kg	74.2	[13]
P2O5	kg	13.7	[13]
Disk harrow	kg	149	[12]
Ecesis	kg	0.8	[14]
Strawberry	kg	1.96	[14]

III. RESULTS AND DISCUSSION

3.1 Analysis of Input-Output Energy Use

Used inputs in the strawberry production, energy equivalences, and ratio of inputs and output are illustrated in table 2. Total energy used in various farm operations during strawberry production was 22275.8 MJ.ha^{-1}. 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 evaluation of data in table 2 and figure 1, the average human labor required in the study area was 1204.08 h.ha^{-1}, and machine power was just 2.39 h.ha^{-1}. Total energy consumed in various farm operations during strawberry production was 22275.8 MJ.ha^{-1}. Irrigation energy consumed 30.12% of total energy followed by manure (23.11%) during production period. Machinery was the least demanding energy input for strawberry production with 330.5 MJ ha^{-1} (only 1.48% of the total energy input), followed by ecesis with 1080 MJ. ha^{-1} (4.84%). Total energy output was 12920 MJ.ha^{-1}, and the average annual yield of strawberry farms was 6800 kg ha^{-1}.

Table 2. Amounts of inputs and output energy in strawberry production

Inputs	Energy consumption(MJ ha^{-1})
Fuel	1850
Ecesis	1080
Machinery	330.5
Fertilizers	4795.3
Labor	2360
Manure	5150
Irrigation	6710
Total input energy	22275.8
Yield	12920

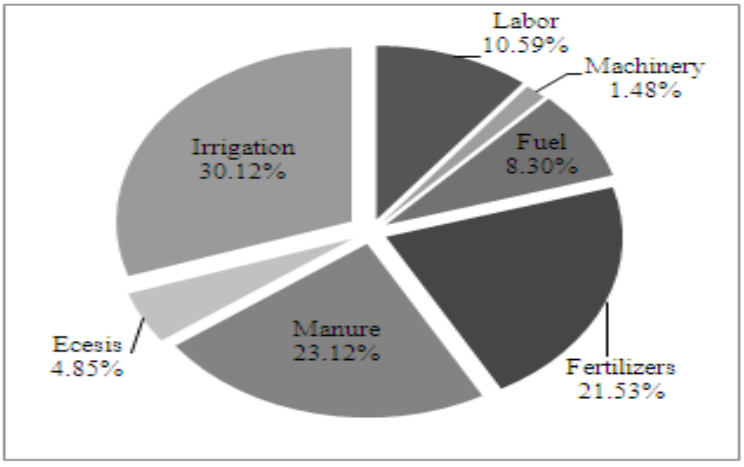

Fig. 1. Distribution of energy input ratios in the strawberry production.

Energy output-input ratio (energy efficiency) in this study was 0.58, and energy productivity calculated as 0.3 kg MJ^{-1} (Table 3). This means that 0.3 kg of strawberry was obtained per unit of energy. This result is more than similar study in Sanandaj zone of Iran by Salami et al. in 2010 [14]. In that study, energy ratio and productivity reported 0.32 and 0.17 kg MJ^{-1}, respectively.

Table 3. Energetic parameters in strawberry production in Iran

Parameter	Unit	Value
Energy Input	MJ ha^{-1}	22275.8
Energy Output	MJ ha^{-1}	14820
Yield	Kg ha^{-1}	7800
Energy Ratio	...	0.58
Energy Production	Kg MJ^{-1}	0.3
Specific Energy	MJ kg^{-1}	3.33
Net Energy Gain	MJ ha^{-1}	-9355.8

The amount of 68.6% (15300 $MJ.ha^{-1}$) of total energy input resulted from renewable and 31.4% (6975.8 $MJ.ha^{-1}$) from non-renewable energy; also 8.3% (1850 MJ ha^{-1}) from direct energy and 91.7% (20425.8 $MJ.ha^{-1}$) indirect energy (Figure 2). Direct inputs were mainly fuel for field operations; and chemical fertilizers, manure, machinery, labor and ecesis dominated the indirect inputs. In other words, strawberry production was highly dependent on the production of indirect inputs.

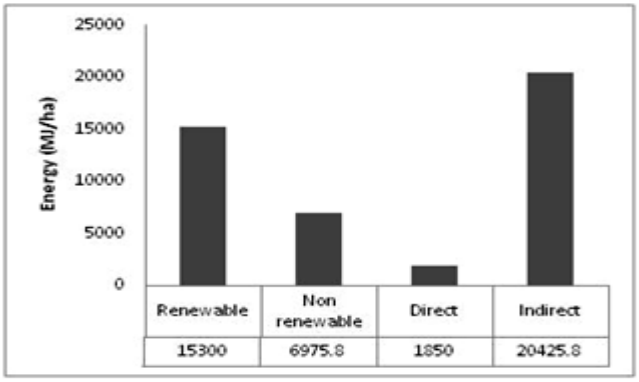

Fig. 2. Total energy input in the form of Direct, Indirect, Renewable and Non-renewable energy for strawberry production (MJ ha^{-1}).

Table 4 shows the values of total input energy for manually plow-pumping, manually plow-non-pumping, machinery plow-pumping and machinery plow-non-pumping. The least of total input energy was 11768 $MJ.ha^{-1}$ for manually plow-non pumping and the highest total input energy was 36755 $MJ.ha^{-1}$ for machinery plow-pumping.

Table 4. The values of total input energy (MJ ha^{-1}) for manually plow-pumping, manually plow-non-pumping, machinery plow-pumping and machinery plow-non-pumping.

Plow type	Irrigation type	
	Pumping	Non-Pumping
Manually plow	27223	11768
Machinery plow	36755	20235

3.2 Economic Analysis of Strawberry Production

The economic analysis is presented in table 5. The profit/cost ratio, productivity, and net profit in the strawberry production were 1.37, 1.1 kg $\$^{-1}$, and 3333.4 \$ ha^{-1}, respectively. Results show the net return in this study is higher than similar study in Sanandaj zone of Iran by Salami et al. in 2010 [14]. They reported the net return about 1825 \$ ha^{-1}, while in this study it was 2333.4 \$ ha^{-1}.

The net return in the non-pumping irrigation is significantly higher than in the other irrigation type (Pumping irrigation) (Table 6). This result is acceptable, because there was not any cost for production in the non-pumping

method for irrigation operation, while acquiring water in the pumping irrigation method required some cost (Electricity or Diesel cost).

Table 5. Economic analysis of strawberry production

Cost and return items	Value
Total production cost ($ ha^{-1})	6166.6
Gross production value ($ ha^{-1})	8500
Benefit/Cost ratio	1.37
Productivity (kg $^{-1}$)	1.1
Net return ($ ha^{-1})	2333.4

Table 6. The mean values of net return ($ ha^{-1}) for manually plow-Pumping, machinery plow-pumping, manually plow–non pumping and machinery plow – non pumping

Plow type	Irrigation type	
	Pumping	Non-Pumping
Manually plow	1.733	7.858
Machinery plow	4.881	2.33

IV. CONCLUSION

In this study, the total energy used in various farm operations during strawberry production was 22275.8 MJ.ha-1. The average annual yield of strawberry farms was 6800 kg.ha-1, and total energy output was 12920 MJ ha-1. Energy productivity calculated as 0.305 kg MJ-1, and energy efficiency was 0.58. The net energy gain was 9355.8 MJ.ha-1. It shows loss of energy in strawberry farms. The benefit-cost ratio, productivity, and net profit in the strawberry production were 1.37, 1.1, and 2333.4 $ ha-1, respectively. The net return in the non-pumping and manually plow method was significantly higher than in the other methods and energy consumption in the pumping and machinery plow method was significantly higher than in the other methods.

V. ACKNOWLEDGEMENTS

The authors would like to thanks all the farmers who are participated in this research specially the strawberry growers in Babolsar zone of Mazandaran province.

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