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ENERGY USE ANALYSIS FOR APPLE PRODUCTION (CASE STUDY: MAZANDARAN PROVINCE IN IRAN)

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ABSTRACT

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. Modern agriculture has become very energy-intensive. This study was carried out in Mazandaran province in Iran and aim of investigation was energy analysis (input-output) of apple production systems in Mazandaran Province of Iran. Data were collected from 55apple farms by using a face to face questionnaire method in 2013. The results revealed that in apple production systems total energy input was 34.640 MJ ha^{-1}. The highest share of energy consumed was recorded for N fertilizer (20.80%) which is a nonrenewable resource. Output energy was 102.973 MJ ha^{-1}.Accordingly, energy use efficiency (output-input ratio) was 2.97, energy productivity calculated as 0.20 kg MJ^{-1} and net energy was observed as 68.333 MJ Kg^{-1}. Also, agrochemical energy ratio was 48.97% which is high ratio of input energy in these agro ecosystems.

Keywords: Energy use efficiency, Energy productivity, Apple, Agrochemical, Renewable energy

INTRODUCTION

Energy has been a key input of agriculture since the age of subsistence agriculture. It is an established fact worldwide that agricultural production is positively correlated with energy input (Loghmanpour zarini*et al*, 2013).

Agriculture is both a producer and consumer of energy. Energy input–output analysis is usually used to evaluate the efficiency and environmental impacts of production systems (Loghmanpour zarini et al., 2010). Apple fruit is the most important tree fruit crop in the world. Apple fruits are produced in warm temperate to tropical areas of the world. According to FAO projections of world production and consumption of Apple in 2010, Iran is one of the major Apple producers (Spreen, 2010).

Energy use in agriculture has been increasing in response to increasing population, limited supply of arable land, and a desire for higher standards of living (Loghmanpour zarini et al., 2013). In modern agriculture system input energy is very much higher than in traditional agriculture system, but energy use efficiency has been reduced in response to no affective use of input energy. Efficient use of energies helps to achieve increased productivity and contributes to the economy, profitability and competitiveness of agriculture sustainability in rural areas (Loghmanpour zarini et al., 2013; Singh, 2002).

The main objective of this study is analysis of energy use and energy indicator of apple production systems in Mazandaran province in Iran.

MATERIALS AND METHODS

Location

The study was carried out in 55apple producers in the Mazandaran Province in 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. Data were collected from the growers by using a face-to-face questionnaire in April to May 2013. The location of Mazandaran Province and study zones in Iran is shown in figure 1 (Anonymous, 2008).

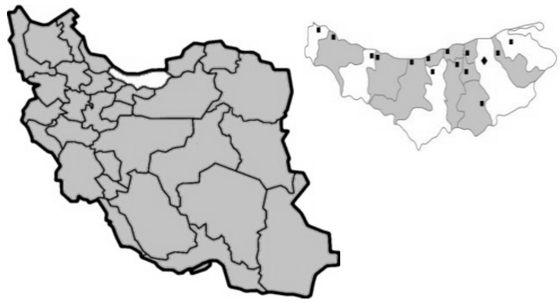

Fig. 1: Location of Mazandaran province and study zones

In this study 5 zones were selected for sample, namely. Ramsar, Chalous, Amol, Sari and Behshahr.

Sampling

Random sampling of farms was done within whole population and the size of each sample was determined using Equation (1) (Stout, 1990).

n = 1 $\left(\sum N_h S_h\right)^2 / \left(N^2 D^2 + \sum N_h D_h^2\right)$ **(1) Where:**

n = required sample size;

N = number of holdings in target population;

N_h= number of the population in the h stratification;

S_h = standard deviation in the h stratification;

S_h^2= variance of h stratification;

d = precision where $\left(\bar{x} - \bar{X}\right)$**; and**

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

Energy indexes and equivalents of used input

The energy ratio (energy use efficiency), energy productivity, specific energy and net energy were calculated as per Equations 2 to 5 (Demircan et al., 2006).

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

$$\textbf{Energy Productivity} = \frac{\text{Maize Output (kg ha}^{-1})}{\text{Energy Input (MJ ha}^{-1})} \qquad (3)$$

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

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

$$\text{Agrochemical Energy Ratio} = \frac{\text{Input Energy of Agrochemicals (MJ ha}^{-1})}{\text{Energy Input (MJ ha}^{-1})} \quad (6)$$

Inputs in apple production in Iran are human labour, machinery, diesel fuel, chemical fertilisers, manure, pesticides, seeds and irrigation water (Rafiee, 2010). Output is only apple. Energy equivalents shown in Table 1 were used for estimation. Basic information on energy inputs and apple yields were analysed using the SPSS Version 19 and Excel 2010.

Based on the energy equivalents of the inputs and outputs, output-input energy ratio, energy productivity, specific energy and net energy gain were calculated (Demircan et al., 2006; Sartori et al., 2005). The input energy is also classified into direct, indirect, renewable and non-renewable forms. The indirect energy consists of pesticide, fertilizer, machine and equipment, manure fertilizer and labour; while the direct energy includes diesel and electricity used in the production process. On the other hand, non-renewable energy includes diesel, electricity, pesticide, fertilisers and machinery; while renewable energy consists of human and manure fertilizer(Demircan et al., 2006).

RESULTS AND DISCUSSION

The farms investigated were mainly devoted to apple production. In the non-mechanized form, tillage was done with human power while in the mechanized form it was done with rotary tiller that gives power from power take off shaft of tractor. Scatter of manure was done before tillage operation. Both of spread and cart of manure was done with human power. Operations of pest control mainly were mechanized and a few of them (e.g. fungicide) were non-mechanized. Pruning operations were done with labour power and handsaw or motor saw. Harvesting was done by labour. Chemical fertilisers were used at about 139 kg ha^{-1}; while manure consumed was about 4,682 kg ha^{-1}.

Table 1: Energy equivalents for different inputs and outputs in apple production in Iran

Input	Unit	Energy equivalent (MJ $unit^{-1}$)	Reference
Labour	h	1.96	(Kitani, 1999)
Machinery	kg	138	(Kitani, 1999)
Diesel	L	47.8	(Kitani, 1999)
Gasoline	L	46.3	(Kitani, 1999)
Manure	ton	303.1	(Esengun, 2007)
NH3	kg	74.2	(Lockeretz, 1980)
P2O5	kg	13.7	(Lockeretz, 1980)
K2O	kg	9.7	(Lockeretz, 1980)
Pesticide	kg	363	(Fluck and Baird, 1982)
Fungicide	kg	99	(Fluck and Baird, 1982)
Herbicide	kg	288	(Kitani, 1999)
Apple	kg	1.96	(Kitani, 1999)

A lot of manure was used because of the availability in the region. Application of chemical fertilisation was manual, while manure application was done by fertilizing equipment and manual. Of all chemical fertilisers, the share of nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) were 46, 29.1 and 24.9%, respectively.

Analysis of energy use

The energy inputs in apple production are showed in Tables 2 and 3. Fertilisers were the most energy consuming, and were the premier of energy inputs required in apple production farms. These results are similar to many studies in orchards (Gezer et al, 2003**;** Canakci, 2010).After fertilisers and pesticides, manure, machinery, fuel, labour and electricity are the most energy consumer inputs, contributing 8.29, 8.18, 7.53, 3.65 and 2.4% total energy use, respectively.

Table 2: Percentage of energy input in apple production in Iran

Inputs	Percentage
Fuel	7.54
Electricity	2.42
Machinery	8.20
Fertilisers	36.30
Pesticides	33.62
Labour	3.65
Manure	8.29
Total	100

Diesel fuel was mainly consumed for landpreparation, pruning practices, orchard spraying with tractor and transportation; and gasoline was mainly consumed for gasoline engine for electricity production for irrigation and power operated sprayer. Electricity was the least demanding energy input in apple production, with 413.1 MJ ha^{-1} (only 2.4% of the total input energy) (Table 3). This was followed by labour with 624.05 MJ ha^{-1} (3.65% of the total input energy). Chemical fertilisers were the highest demanding energy input in apple production with 6212.78 MJ ha^{-1} (36.3% of the total input energy). Results of this study are similar to the result of other studies where chemicalfertilizer consumption was high (Canals, 2006; Strapatsa, 2006; Page, 2009). As in this study, despite the fact that part of fertilisers were replaced by manure, but likewise fertilisers were high. Energy consumption of manure was 1419.38 MJ ha^{-1}. It is a strong point from energy and environment point of view (Table 3). The amount of 88.05% of total energy input resulted from non-renewable and 11.95% from renewable energy; also 9.95% from direct energy and 90.05% indirect energy (Table 4). Direct inputs were mainly fuel and electricity for field operations; and the indirect inputs were included chemical fertilisers, manure, machinery, labour and pesticides. In other words, apple production was highly dependent on indirect inputs. Proper management of chemical fertilisers, pesticides and manure might reduce the indirect energy requirements for fertilisation, pest control.

Efforts to reduce the direct dependent on energy (fuel and electricity); will improve overall energy efficiency of apple production in agricultural production systems. Results indicate that the current energy use pattern among farms is mainly based on non-renewable (Table 4). Average yield of the apple fruit in this study was 15,454 kg ha^{-1}. In energy balances, the output-input energy ratio is often used as a parameter to describe the energy efficiency in agricultural production. The average output-input energy ratio was 1.716. In studies that were done on other fruits production systems, energy ratio was mostly reported between 1 to 2 (Page, 2009; Pimentel, 1983). Energy productivity, specific energy and net gain energy were, respectively, obtained as 0.905, 1.1 and 12,251.4 MJ ha^{-1} in the present study (Table 5).

Table 3: Amount of inputs in apple production in Iran

Inputs	Energy consumption (MJ ha^{-1})
Fuel	1289.01
Electricity	413.1
Machinery	1400.42
Fertilisers	6212.78
Pesticides	5753.43
Labour	624.05
Manure	1419.38
Total	17112.19

Table 4: Total energy input in the form of direct, indirect, renewable and non-renewable energy for apple production in Iran

Form of energy	Quantity (MJ ha^{-1})	Percentage [a]
Direct	2043.43	12
Indirect	15068.76	88
Renewable	1702.12	10
Non-renewable	15410.07	90

Table 5: Energetic parameters in apple production in Iran

Parameter	Unit	Value
Energy input	MJ ha^{-1}	17112.19
Energy output	MJ ha^{-1}	29363.63
Yield	Kg ha^{-1}	15454.54
Energy ratio	…	1.716
Energy production	Kg MJ^{-1}	0.905
Specific energy	MJ kg^{-1}	1.10
Net energy gain	MJ ha^{-1}	12251.40

CONCLUSION

Total input energy in apple production in Mazandaran Province in Iran is 17,112.19 MJ ha^{-1}. Fertilisers and pesticides for fertilisation and pest control are the major energy inputs with 36.3 and 33.62%, respectively. In addition, electricity and labour are lower energy inputs with 2.42 and 3.65%, respectively. About 88% of total energy input in apple production is non-renewable, while about 12% is renewable. Also about 10% of total input energy is direct and while about 90% is indirect. Thus, use of renewable energy in the farms is low. There is need by apple farmers to improve the efficiency of energy consumption in production and to employ renewable energy.

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