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Full Length Research Paper

Evaluation energy balance and energy indices of peanut production in north of Iran

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One way to evaluation of sustainable developing in agriculture is using of energy flow method. This method in an agricultural product system is the energy consuming in product operations and energy saving in produced crops. In this article, evaluation of energy balance and energy indices under rain fed farming peanut in north of Iran (Guilan province) was investigated. Data were collected from 72 farms by using a face to face questionnaire method during 2011 year in Guilan province. By using of consumed data as inputs and total production as output, and their concern equivalent energy, energy balance and energy indices were calculated. Energy efficiency (energy output to input energy ratio) in this study was calculated as 3.50, showing the affective use of energy in the agro ecosystems peanut production. Energy balance efficiency (production energy to consumption energy ratio) in this study was calculated as 2.73, showing the affective use of energy in the agro ecosystems peanut production.

Key words: Iran, energy indices, energy balance indices, peanut.

INTRODUCTION

Peanut is one of the most important and economical oilseeds in tropical and subtropical regions which is mostly grown due to its oil, protein and carbohydrates (Panhwar, 2005). It is an annual shrub of leguminous family and Arachis genus which has a main straight root. This crop is used for its oil and also as a dry nut by human. China, India, the United States, Nigeria, Indonesia, Burma and Senegal are the major peanut producing countries. Guilan province is one of the major peanut producing provinces in Iran was provided from this province. In Guilan, it is mostly planted in Astaneh Ashrafiyeh and also along Sepidroud river margin. In the modern world, energy is an essential input to every production, transport, and communication process and is thus a driver for economic as well as social development (Kofoworola and Gheewala, 2008). 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 (Singh, 1999). Agriculture has become an increasingly energy-intensive sector in the last half-century with much of it attributable to the needed inputs (Dyer and Desjardins, 2006). It is a producer and on the other hand a consumer of energy. Agriculture uses large quantities of locally available noncommercial energy such as seed, manure and animate energy as well as commercial energies, directly and indirectly, in the form of diesel, electricity, fertilizer, plant protection, chemical, irrigation water, machinery etc (Dyer and Desjardins, 2006; Singh et al., 2002).

Nowadays, energy usage in agricultural activities has been intensified in response to continued growth of human populations and tendency for an overall improved standard of living within a limited supply of arable land (Rafiee et al., 2010). Rational and effective use of energy resources in agriculture is one of the principal requirements for sustainable development; it will minimize environmental problems, prevent destruction of natural resources and promote sustainable agriculture as an economical production system (Rafiee et al., 2010). Calculating energy inputs of agricultural production is more difficult than in the industry sector due to the high number of factors affecting agricultural production (Yaldiz et al., 1993). The analysis of energy usage is important to ascertain more efficient and environment friendly production systems (Schroll, 1994). Considerable studies

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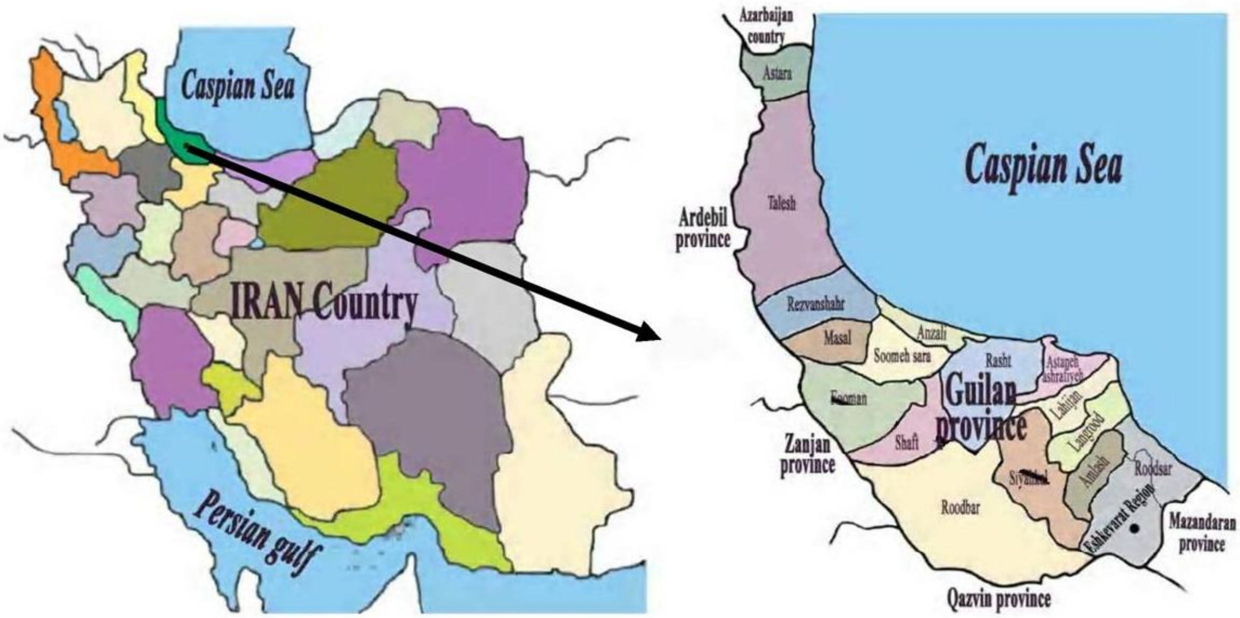

Figure 1. Location of the study area.

Table 1. Amounts of inputs and output and their equivalent energy from calculated indicators of energy.

Parameter	Unit	Quantity per hectare	Energy equivalents	Total energy equivalents	Percent (%)
Inputs					
Human labor	h/ha	585	1.96	1146.6	4.87
Machinery	h/ha	14	62.7	877.8	3.73
Diesel fuel	L/ha	110	56.31	6194.1	26.33
Nitrogen	kg/ha	92	69.5	6394	27.18
Phosphorus	kg/ha	21	12.44	261.24	1.11
Potassium	kg/ha	25	11.15	278.75	0.97
Poison	L/ha	3	120	360	1.53
Electricity	kWh	550	11.93	6561.5	27.89
Seed	kg/ha	60	25	1500	6.38
Output					
Grain yield	kg/ha	3300	25	82500	100

have been conducted on energy use in agriculture (Kuesters and Lammel, 1999; Sartori et al., 2005; Jianbo, 2006; Strapatsa et al., 2006; Uzunoz et al., 2008; Kizilaslan, 2009; Moradi and Azarpour, 2011).

The main aim of this study was to determine energy use in peanut production, to investigate the efficiency of energy consumption and to make an energy balance and energy indices analysis of peanut in Guilan province of Iran.

MATERIALS AND METHODS

Data were collected from 72 peanut farms all through Guilan province (north of Iran) by using a face to face questionnaire in summer season of 2011 (Figure 1). The random sampling of production agro ecosystems was done within whole population and the size of each sample was determined by using the following equation (Kizilaslan, 2009):

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

In the formula, n is the required sample size, s is the standard deviation, t is the t value at 95% confidence limit (1.96), N is the number of holding in target population and d is the acceptable error.

For calculating input-output ratios and other energy indicators, the data were converted into output and input energy levels using equivalent energy values for each commodity and input (Taheri et al., 2010a). Energy equivalents shown in Table 1 was used for estimation (Hulsbergen et al., 2002; Ma et al., 2008; Mandel et al.,

Table 2. Amounts of inputs and their equivalent energy from calculated indicators of energy balance.

Parameter	Unit	Quantity per hectare	Energy equivalents	Total energy equivalents	Percent (%)
Inputs					
Human labor	h/ha	585	500	292500	4.04
Machinery	h/ha	14	90000	1260000	17.41
Diesel fuel	L/ha	110	9237	1016070	14.04
Nitrogen	kg/ha	92	17600	1619200	22.38
Phosphorus	kg/ha	21	3190	66990	0.93
Potassium	kg/ha	25	1600	40000	0.55
Poison	L/ha	3	27170	81510	1.13
Electricity	kWh	550	2863	1574650	21.76
Seed	kg/ha	60	6660	399600	5.52
Depreciation for per diesel fuel	L	92.4	9583	885469	12.24

2002; Mohammadi and Omid, 2010; Mohammadi et al., 2008; Moradi and Azarpour, 2011; Ozkan et al., 2003, 2004; Taheri et al., 2010b; Yilmaz et al., 2005). At the beginning, the values of inputs used in the production of peanut crop were determined for calculating the energy equivalences in this research. Energy input include human labour, machinery, diesel fuel, chemical fertilizers, poison fertilizers, electricity and seed and output yield include grain yield of peanut.

The energy use efficiency, energy specific, energy productivity and net energy gain were calculated according to the following equations (Hulsbergen et al., 2002; Ma et al., 2008; Mandel et al., 2002; Mohammadi and Omid, 2010; Mohammadi et al., 2008; Moradi and Azarpour, 2011; Ozkan et al., 2003, 2004; Taheri et al., 2010a; Yilmaz et al., 2005):

$$\text{Energy use efficiency} = \frac{\text{output energy (Mj/ha)}}{\text{input energy (Mj/ha)}}$$

$$\text{Energy production} = \frac{\text{Grain yield (Kg/ha)}}{\text{input energy (Mj/ha)}}$$

$$\text{Energy specific} = \frac{\text{input energy (Mj/ha)}}{\text{Grain yield (Kg/ha)}}$$

$$\text{Net energy gain} = \text{Input energy (Mj/ha)} - \text{output energy (Mj/ha)}$$

The input energy was divided into direct, indirect, renewable and non-renewable energies (Kizilaslan, 2009; Samavatean et al., 2010). Direct energy covered human labor, diesel fuel and electricity used in the peanut production while indirect energy consists of seed, chemical fertilizers, poison fertilizers and machinery energy. Renewable energy consists of human labor and seed and nonrenewable energy includes , chemical fertilizers, poison fertilizers, electricity and machinery energy. In order of indicators of energy balance, basic information on energy inputs were entered into Excel spreadsheets and then energy equivalent were calculated according to Table 2 (Abdollahpour and Zaree, 2009). By using of consumed data as inputs and total production as output, and their concern equivalent energy, indicators of energy balance were calculated. Energy input include human labor, machinery, diesel fuel, chemical fertilizers, poison fertilizers, electricity, machinery depreciation for per diesel fuel and seed and output yield include grain yield of peanut.

RESULTS AND DISCUSSION

The interaction of these techniques and the estimates of profits optioned in terms of yields (agronomy trails) are given in Figure 2.

Analysis of input–output energy use in peanut production

The inputs used in peanut production and their energy equivalents and output energy equivalent are illustrated in Table 1. About 65 kg seed, 585 h human labor, 14 h machinery power and 110 L diesel fuel for total operations were used in agro ecosystems peanut production on a hectare basis. The use of nitrogen fertilizer, phosphorus and potassium were 92, 21 and 25 kg per 1 ha respectively. Also, 550 kWh electricity power in this systems was used. The total energy equivalent of inputs was calculated as 23574 MJ/ha. The highest shares of this amount were reported for electricity (27.89%), nitrogen fertilizer (27.18%) and diesel fuel (26.33%) respectively. The energy inputs of potassium chemicals (0.97%), phosphorus chemicals (1.11%) and poison (1.53%) were found to be quite low compared to the other inputs used in production (Table 1). The average yield of peanut was found to be 3300 kg/ha and its energy equivalent was calculated to be 82500 MJ/ha (Table 1).

Evaluation indicators of energy in peanut production

The energy use efficiency, energy production, energy specific, energy productivity, net energy gain and intensiveness of peanut production were shown in Table 3. Energy efficiency (energy output-input ratio) in this study was calculated as 3.50, showing the affective use of energy in the agro ecosystems peanut production.

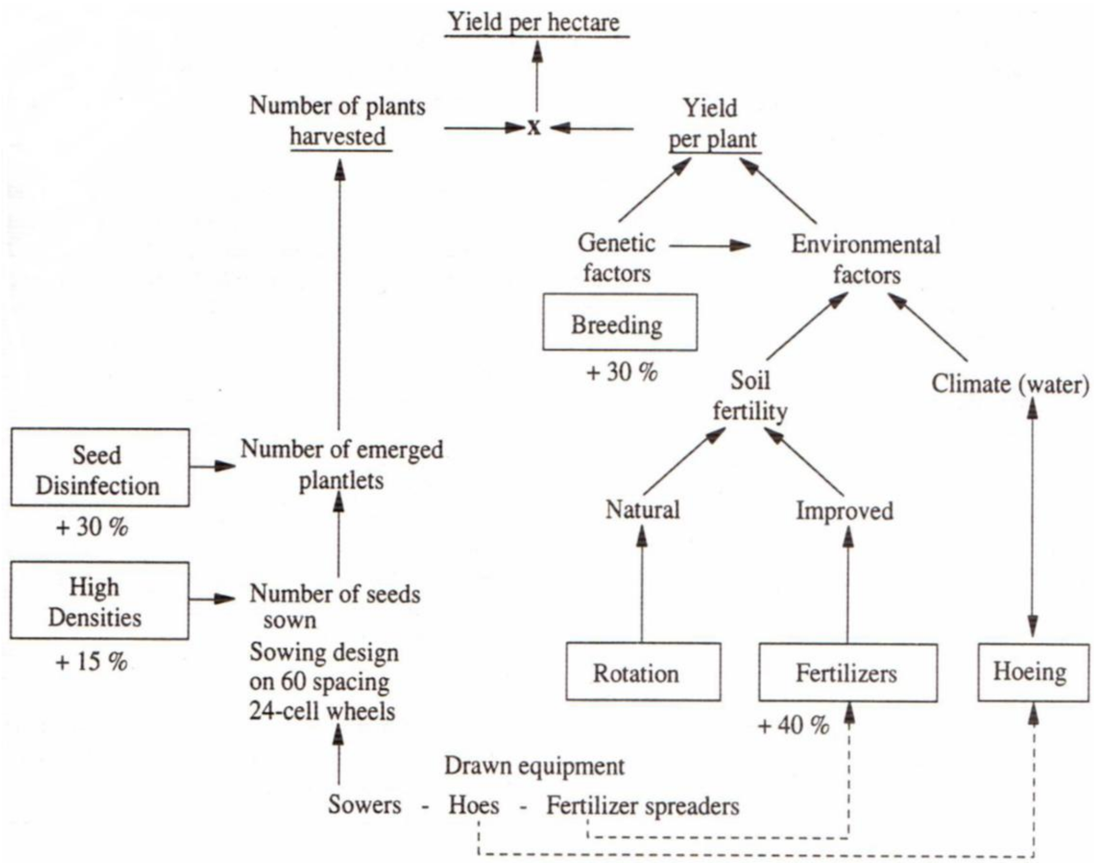

Figure 2. Principal peanut yield factors.

Table 3. Analysis of energy indices in peanut production.

Item	Unit	Peanut
Grain yield	Kg/ha	3300
Input energy	Mj/ha	23574
Output energy	Mj/ha	82500
Energy use efficiency	-	3.50
Energy specific	Mj/Kg	7.14
Energy productivity	Kg/Mj	0.14
Net energy gain	Mj/ha	58926
Direct energy	Mj/ha	13902 (59.10%)
Indirect energy	Mj/ha	9672 (40.90%)
Renewable energy	Kg/Mj	2647 (11.25%)
Nonrenewable energy	Mj/ha	20927 (88.75%)

Energy specific was 7.14 MJ/kg; this means that 7.14 MJ is needed to obtain 1 kg of peanut. Energy productivity was calculated as 0.14 Kg/MJ in the study area. This means that 0.14 kg of output was obtained per unit energy. Net energy gain was 58926 MJ/ha. This means that the amount of output energy is more than input energy and production in this situation is logical. Direct, indirect, renewable and non-renewable energy forms used in peanut production are also investigated in Table 3. The results show that the share of direct input energy was 59.10% (13902 MJ/ha) in the total energy input compared to 40.90% (9672 MJ/ha) for the indirect energy. On the other hand, nonrenewable and renewable energy contributed to 88.75% (20927 MJ/ha) and 11.25% (2647

Table 4. Analysis of energy balance indices in peanut production.

Item	Percent of compositions	Energy per gram (kcal)	Amounts (kg/ha)	Production energy (kcal/ha)	Production energy/consumption energy	Consumption energy/production energy
Protein	30.4	4	1003	4012800	0.56	1.80
Fat	47.7	9	1574	14166900	1.96	0.51
Starch	12	4	396	1584000	0.22	4.56

Item	Grain yield (kg/ha)	Consumption energy (kcal/ha)	Production energy (kcal/ha)	Energy per unit (kcal)	Production energy/consumption energy	Consumption energy/production energy
	3300	7235989	19763700	5989	2.73	6.88

MJ/ha) of the total energy input, respectively.

Analysis of energy balance in peanut production

The inputs used in peanut production and their energy equivalents and output energy equivalent are illustrated in Table 2. About 65 kg seed, 585 h human labor, 14 h machinery power and 110 L diesel fuel for total operations were used in agro ecosystems peanut production on a hectare basis. The use of nitrogen fertilizer, phosphorus and potassium were 92, 21 and 25 kg per 1 ha respectively. Also, 550 kWh electricity and 92.4 L depreciation power in this system were used. The total energy equivalent of inputs was calculated as 7235989 kcal/ha. The highest shares of this amount were reported for nitrogen fertilizer (22.38%), electricity (21.76%) and machinery (17.41%) respectively. The energy inputs of potassium chemicals (0.55%), phosphorus chemicals (0.93%) and poison (1.13%) were found to be quite low compared to the other inputs used in production (Table 2). The highest percent of compositions (47.7%), energy per gram (9 kcal), amounts (1574 kg/ha), production energy (14166900 kcal/ha) and production energy to consumption energy ratio (1.96) in peanut seeds were obtained from fat as compared with protein and starch.

The lowest consumption energy to production energy ratio (0.51) in peanut seeds was obtained from fat as compared with protein and starch (Table 4).

Evaluation indicators of energy balance in peanut production

The consumption energy (7235989 kcal/ha), production energy (19763700 kcal/ha), energy per unit (5989 kcal), production energy to consumption energy ratio (2.73) and consumption energy to production energy ratio (6.88) of peanut production were shown in Table 4. Energy balance efficiency (production energy to consumption energy ratio) in this study was calculated as 2.73, showing the affective use of energy in the agro ecosystems peanut production.

Conclusion

Finally, energy use is one of the key indicators for developing more sustainable agricultural practices, one of the principal requirements of sustainable agriculture; therefore, energy management in systems peanut production should be considered an important field in terms of efficient, sustainable and economical use of energy.

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