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EVALUATION ENERGY BALANCE AND ENERGY INDICES OF ALFALFA PRODUCTION UNDER RAIN FED FARMING IN NORTH OF IRAN

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ABSTRACT

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 alfalfa 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) for alfalfa forage in this study were calculated to be 4.51 and 1.51 respectively, showing the affective use of energy in the agro ecosystems alfalfa production.

Keywords: alfalfa production, energy indices, energy balance, Iran.

INTRODUCTION

Alfalfa (*Medicago sativa* L.) has considerable potential as a feedstock for production of fuels, feed, and industrial materials. However, unlike other major field crops such as corn and soybeans, which are commonly rened for production of fuel and industrial materials, rening of alfalfa remains undeveloped. Instead, alfalfa is primarily processed and used on-farm in the form of dried hay, silage, and fresh forage known as greenchop, or is grazed by animals in pastures. In many countries, including the United States, alfalfa is used as a basic component in feeding programs for dairy cattle and is an important feed for beef cattle, horses, sheep, and other livestock. Known as the Queen of the Forages, alfalfa provides highly nutritious forage in terms of protein, fiber, vitamins, and minerals for ruminant animals. If alfalfa is developed to its full potential as a feedstock for biorening, a major shift may occur in the manner in which alfalfa is produced and used for feeding farm animals. Energy use is one of the key indicators for developing more sustainable agricultural practices. Wider use of renewable energy sources increases the energy supply and efficient use can make a valuable contribution to meeting sustainable energy development targets (Streimikiene *et al*., 2007). Energy use in agriculture has been intensified 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 (Esengun *et al*., 2007). Efficient use of energy is one of the principal requirements of sustainable agriculture. 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. Continuous demand in increasing food production resulted in intensive use of chemical fertilizers, pesticides, agricultural machinery, and other natural resources. However, intensive use of energy causes problems threatening public health and environment. Efficient use of energy in agriculture will minimize environmental problems, prevent destruction of natural resources, and promote sustainable agriculture as an economical production system (Erdal *et al*., 2007). Efficient energy use in agriculture sector is one of the conditions of sustainable agriculture, because it allows financial savings, fossil resources preservation and decreasing air pollution (Pervanchon *et al*., 2002). Using energy in agricultural production has been studied for different crops. The main aim of this study was to determine energy use in alfalfa production, to investigate the efficiency of energy consumption and to make an energy balance and energy indices analysis of alfalfa under rain fed farming in Guilan province of Iran.

MATERIALS AND METHODS

Data were collected from 72 farms by using a face to face questionnaire method during 2011 year in Guilan province (north of Iran). The random sampling of production agro ecosystems was done within whole population and the size of each sample was determined by using bottom equation (Kizilaslan, 2009):

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

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.

In order to calculate 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. An energy equivalent shown in Table-1 was used for estimation (Ghasemi Mobtaker, 2011; Moradi and azarpour, 2011; Yousefi and Mohammadi, 2011). Firstly, the amounts of inputs used in the production of alfalfa were specified in order to

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calculate the energy equivalences in the study. Energy input include human labour, machinery, diesel fuel, chemical fertilizers, poison fertilizers, electricity and seed and output yield include grain yield of alfalfa. The energy use efficiency, energy specific, energy productivity and net energy gain were calculated according to bottom equations (Ghasemi Mobtaker, 2011; Moradi and azarpour, 2011; Yousefi and Mohammadi, 2011).

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

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

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

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

The input energy was divided into direct, indirect, renewable and non-renewable energies (Kizilaslan, 2009; *Ozkan et al*., 2004). Direct energy covered human labor and diesel fuel, used in the alfalfa 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 seed, chemical fertilizers, poison fertilizers and machinery energy.

In order to illustrate the indicators of energy balance, basic information on energy inputs was entered into Excel spreadsheets and then energy equivalent were calculated according to Table-2. (Abdollahpour and Zaree, 2010; Taghavi *et al*., 2007). 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, machinery depreciation for per diesel fuel and seed and output yield include grain yield and straw yield of alfalfa.

RESULTS AND DISCUSSIONS

Analysis of input-output energy use in alfalfa production

The inputs used in alfalfa production and their energy equivalents and output energy equivalent are illustrated in Table-1. About 40 kg seed, 500 h human labor, 12 h machinery power and 110 L diesel fuel for total operations were used in agro ecosystems alfalfa production on a hectare basis. The use of nitrogen fertilizer, phosphorus and potassium were 92, 32 and 25 kg per one hectare respectively. The total energy equivalent of inputs was calculated as 15706 MJ/ha. The highest shares of this amount were reported for nitrogen fertilizer (40.71%) and diesel fuel (39.44%), respectively. The energy inputs of seed (1.76%) potassium chemicals (1.77%), Phosphorus chemicals (2.50.08%), and poison (2.29%) were found to be quite low compared to the other inputs used in production (Table-1). The average alfalfa forage was found to be 3983 kg/ha and its energy equivalent was calculated to be 15706 MJ/ha (Table-1).

Evaluation indicators of energy in alfalfa production

The energy use efficiency, energy production, energy specific, energy productivity, net energy gain, and intensiveness of alfalfa forage production were shown in Table-3. Energy efficiency (energy output-input ratio) in this study was calculated 4.51, showing the affective use of energy in the agro ecosystems alfalfa production. Energy specific was 3.94 MJ/kg this means that 3.94 MJ is needed to obtain 1 kg of alfalfa forage. Energy productivity was calculated as 0.25 Kg/MJ in the study area. This means that 0.25 kg of output obtained per unit energy. Net energy gain was 55072 MJ/ha.

Yousefi and Mohammadi (2011) analyzed the energy indices of alfalfa production in Kermanshah, Iran, and found that at total energy input and output in alfalfa agro ecosystems were 49689.59 and 240072.7 MJ/ha, respectively. The highest share of input energy was recorded for diesel fuels (43.1%), electricity (24.36%) and N fertilizer (12.2%). The results also showed that energy use efficiency, specific energy, energy productivity and net energy were 4.83, 3.68, 0.27 and 190383.11 MJ/ha, respectively. Total mean energy input as renewable and nonrenewable forms were calculated to be 10.24 and 89.76%, respectively.

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 alfalfa production are also investigated in Table-3. The results showed that the share of direct input energy was 46.18% (7253 MJ/ha) in the total energy input compared to 53.82% (8453 MJ/ha) for the indirect energy. On the other hand, nonrenewable and renewable energy contributed to 91.5% (14371 MJ/ha) and 8.50% (1334 MJ/ha) of the total energy input, respectively.

Analysis of energy balance in alfalfa production

The inputs used in alfalfa production and their energy equivalents and output energy equivalent are illustrated in Table-2. About 40 kg seed, 500 h human labor, 12 h machinery power and 110 L diesel fuel for total operations were used in agro ecosystems alfalfa production on a hectare basis. The use of nitrogen fertilizer, phosphorus and potassium were 92, 32 and 25 kg per one hectare, respectively. Also 92.4 L depreciation power in this system was used. The total energy equivalent of inputs was calculated as 5300734 MJ/ha.

The highest shares of this amount were reported for nitrogen fertilizer (30.55%), machinery (20.37%) and diesel fuel (19.17%), respectively. The energy inputs of

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potassium chemicals (0.75%) poison (1.54%) and Phosphorus chemicals (1.90%) were found to be quite low compared to the other inputs used in production (Table-2).

The highest percent of compositions (24%), amounts (955.92 kg/ha), production energy (3823680 kcal/ha) and production energy to consumption energy ratio (0.72) in alfalfa forage were obtained from starch as compared with protein and fat. The lowest consumption energy to production energy ratio (1.39) in alfalfa forage was obtained from starch as compared with protein and fat (Table-4).

Evaluation indicators of energy balance in alfalfa production

The consumption energy (5300734 kcal/ha), production energy (8029728 kcal/ha), energy per unit (2016 kcal), production energy to consumption energy ratio (1.51) and consumption energy to production energy ratio (9.13) of alfalfa forage production were shown in Table-4. Energy balance efficiency (production energy to consumption energy ratio) in this study was calculated 1.51, showing the affective use of energy in the agro ecosystems alfalfa forage production.

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	540	1.96	1058.40	6.74
Machinery	h/ha	12	62.7	752.40	4.79
Diesel fuel	L/ha	110	56.31	6194.10	39.44
Nitrogen	Kg/ha	92	69.5	6394.00	40.71
Phosphorus	Kg/ha	32	12.44	391.86	2.50
Potassium	Kg/ha	25	11.15	278.75	1.77
Poison	L/ha	3	120	360.00	2.29
Seed	Kg/ha	40	6.9	276	1.76
Output					
Forage yield	Kg/ha	3983	17.77	70778	100

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	540	500	270000	5.09
Machinery	h/ha	12	90000	1080000	20.37
Diesel fuel	L/ha	110	9237	1016070	19.17
Nitrogen	kg/ha	92	17600	1619200	30.55
Phosphorus	kg/ha	32	3190	100485	1.90
Potassium	kg/ha	25	1600	40000	0.75
Poison	L/ha	3	27170	81510	1.54
Seed	kg/ha	40	5200	208000	3.92
Depreciation for per diesel fuel	L	92.4	9583	885469	16.7

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Table-3. Analysis of energy indices in wheat production.

Item	Unit	Wheat
Forage yield	Kg/ha	3983
Input energy	Mj/ha	15706
Output energy	Mj/ha	70778
Energy use efficiency	-	4.51
Energy specific	Mj/Kg	3.94
Energy productivity	Kg/Mj	0.25
Net energy gain	Mj/ha	55072
Direct energy	Mj/ha	7253 (46.18%)
Indirect energy	Mj/ha	8453 (53.82%)
Renewable energy	Kg/Mj	1334 (8.50%)
Nonrenewable energy	Mj/ha	14371 (91.5%)

Table-4. Analysis of energy balance indices in wheat 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	21	4	836.43	3345720	0.63	1.58
Fat	2.4	9	95.59	860328	0.16	6.16
Starch	24	4	955.92	3823680	0.72	1.39
Item	**Forage yield** (kg/ha)	**Consumption energy** (kcal/ha)	**Production energy** (kcal/ha)	**Energy per unit** (kcal)	**Production energy/ consumption energy**	**Consumption energy/ production energy**
	3983	5300734	8029728	2016	1.51	9.13

CONCLUSIONS

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 alfalfa production should be considered an important field in terms of efficient, sustainable and economical use of energy. Use of combination machines, doing timely required repairs and services for tractors and representing a fit crop rotation are suggested to decrease energy consuming for dry farming alfalfa in Guilan province.

REFERENCES

Abdollahpour Sh and Zaree S. 2009. Evaluation of Wheat Energy Balance under Rain fed Farming in Kermanshah. Sustainable Agriculture Science. 20(2): 97-106.

Erdal G, Esengun K, Erdal H and Gunduz O. 2007. Energy use and economical analysis of sugar beet production in Tokat province of Turkey. Energy. 32: 35-41.

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. Renew. Energy. 32: 1873-1881.

Ghasemi Mobtaker H, Akram A, Keyhani A and Mohammadi A. 2011. Energy consumption in alfalfa production: A comparison between two irrigation systems in Iran. African Journal of Plant Science. 5(1): 47-51.

Kizilaslan H. 2009. Input-output energy analysis of cherries production in Tokat Province of Turkey. Applied Energy. 86: 1354-1358.

Moradi M Azarpour. 2011. Study of energy Indices for native and breed rice varieties production in Iran. World Applied Sciences Journal. 13(1): 137-141.

Ozkan B, Akcaoz H and Fert C. 2004. Energy input output analysis in Turkish agriculture. Renewable Energy. 29: 39-51.

©2006-2012 Asian Research Publishing Network (ARPN). All rights reserved.

Pervanchon F, Bockstaller C and Girardin P. 2002. Assessment of energy use in arable farming systems by means of an agro ecological indicator: the energy indicator. Agric. Syst. 72: 149-172.

Streimikiene D, Klevas V and Bubeliene J. 2007. Use of EU structural funds for sustainable energy development in new EU member states. Renew. Sust. Energ. Rev. 11: 1167-1187.

Taghavi D, Ajli J, Valdiani A and Fatahi E. 2007. Evaluation energy balance of *Hordeum vulgar* L. production under rain fed farming in Azarbijan north of Iran. Modern science of sustainable agriculture. pp. 41-48.

Yousefi M and Mohammadi A. 2011. Economical analysis and energy use efficiency in alfalfa production systems in Iran. Scientific Research and Essays. 6(11): 2332-2336.