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EVOLUTION ENERGY INDICES OF SOYBEAN PRODUCTION IN NORTH OF IRAN

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ABSTRACT

Soybean is the main source of supplying protein and oil in the world. Energy in agriculture is important in terms of crop production and agro processing for value adding. 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 indices under rain fed farming soybean 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, and energy indices were calculated. The average yield of soybean was found to be 2377 kg/ha and its energy equivalent was calculated to be 56573 MJ/ha. Energy efficiency (energy output to input energy ratio) for seed in this study was calculated to be 4.32, showing the affective use of energy in the agro ecosystems soybean production. Nonrenewable energy was 82.41% total input energy that concluded that soybean production needs to improve the efficiency of energy consumption in production and to employ renewable energy.

Keywords: soybean, energy indices, Iran, yield.

INTRODUCTION

Soybean (Glycine max) is one of the most important oil seed crop in the world. It contains 18 to 22% oil, highly desirable in diet and has 40 to 42% of good quality protein. Therefore it is the best source of protein and oil and truly claims the title of the meat/oil on plants. Generally, it is used in the food industry for flour, oil, cookies, candy, milk, vegetable cheese, lecithin and many other products (Asadi and Faraji, 2009; Fatima *et al*., 2006).

Agriculture has become an increasingly energy-intensive sector in the last half-century with much of it attributable to the needed inputs. For example, chemical fertilizers and pesticides require much greater energy to manufacture than to apply on-farm (Dyer and Desjardins, 2006). Agriculture is both a producer and a consumer of energy. Through photosynthesis, crops convert solar energy to biomass, thus providing food, feed and fiber (Stanhill, 1984). Energy parameters are meaningful indicators for assessing or comparing the environmental impacts from agricultural practices (Kelm, 2004). Energy parameters can be used to assess the efficiency of production systems and to make comparisons among systems (Haciseferogullari *et al*., 2003). To evaluate the sustainability of agriculture, the energy efficiency of the system must be considered (Pervanchon *et al*., 2002).

Energy is an integral part of a society and plays a pivotal role in its economic growth and social development by raising the standard of living and the quality of life (Singh and Bajpai, 2010). Scientific forecasts and analysis of energy consumption will be of great importance for the planning of energy strategies and policies (Liang *et al*., 2007). The relation between agriculture and energy is very close. Agriculture itself is an energy user and energy supplier in the form of bio-energy (Mohammadi *et al*., 2008). Energy consumption in developing countries has been increasing rapidly due to recent economic growth and development (Iwaro and Mwasha, 2010); however, increased input use in agricultural production may not bring maximum profits due to increasing production costs (Eradal *et al*., 2007). Furthermore, intensive use of energy causes problems threatening public health and the environment. Efficient use of energy is one of the principal requirements for sustainable agricultural productions (Schroll, 1994). It will minimize environmental problems and improve sustainable agriculture as an economical production system (Rafiee *et al*., 2010). The development of agricultural systems with low input of energy compared to the output of food would result in improvement of energy use efficiency and reduction of the environmental impacts (Dalgaard *et al*., 2001). Improving the energy efficiency not only helps in improving competitiveness through cost reduction but also results in minimized energy-related environmental pollution, thus positively contributing towards sustainable development (Nagesha, 2008). The energy input-output analysis is usually made to evaluate the efficiency and environmental impacts of production systems. This analysis will determine how efficient the energy is used. In recent years, many researchers have investigated the energy use for agricultural productions.

The main aim of this study was to determine energy use in soybean production, to investigate the efficiency of energy consumption and energy indices analysis of soybean 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 (Ozkan *et al*., 2004; Moradi and azarpour, 2011; Rathke *et al*., 2007). Firstly, the amounts of inputs used in the production of soybean were specified in order to calculate the energy equivalences in the study. Energy input includes human labor, machinery, diesel fuel, chemical fertilizers, poison fertilizers and seed and output include yield of soybean. The energy use efficiency, energy specific, energy productivity and net energy gain were calculated according to bottom equations (Moradi and azarpour, 2011; Ozkan *et al*., 2004; Rathke *et al*., 2007).

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

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

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

Net energy gain =

Output energy (Mj/ha) - Input 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 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, and machinery energy.

RESULTS AND DISCUSSIONS

Analysis of input-output energy use in soybean production

The inputs used in soybean production and their energy equivalents and output energy equivalent are illustrated in Table-1. About 70 kg seed, 324 h human labor, 1 L poison chemical, 12 h machinery power and 110 L diesel fuel for total operations were used in agro ecosystems soybean production on a hectare basis. The use of nitrogen fertilizer, phosphorus and potassium were 46, 31 and 12 kg per one hectare, respectively. The total energy equivalent of inputs was calculated as 13084 MJ/ha.

The highest shares of this amount were reported for diesel fuel (47.29%), chemical fertilizer (28.40 %) and seed (12.83%), respectively. The energy inputs of poison (0.92%), machinery (5.74%) and human labor (4.85%) were found to be quite low compared to the other inputs used in production (Figure-1).

The average seed yield of soybean was found to be 2377 kg/ha and its energy equivalent was calculated to be 56573 MJ/ha (Table-1).

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
Inputs				
Human labor	h/ha	324	1.96	635.04
Machinery	h/ha	12	62.7	752.40
Diesel fuel	L/ha	110	56.31	6194.10
Nitrogen	Kg/ha	46	69.5	3197
Phosphorus	Kg/ha	31	12.44	385.64
Potassium	Kg/ha	12	11.15	133.80
Poison	L/ha	1	120	120
Seed	Kg/ha	70	23.8	1666
Output				
yield	Kg/ha	2377	23.8	56573

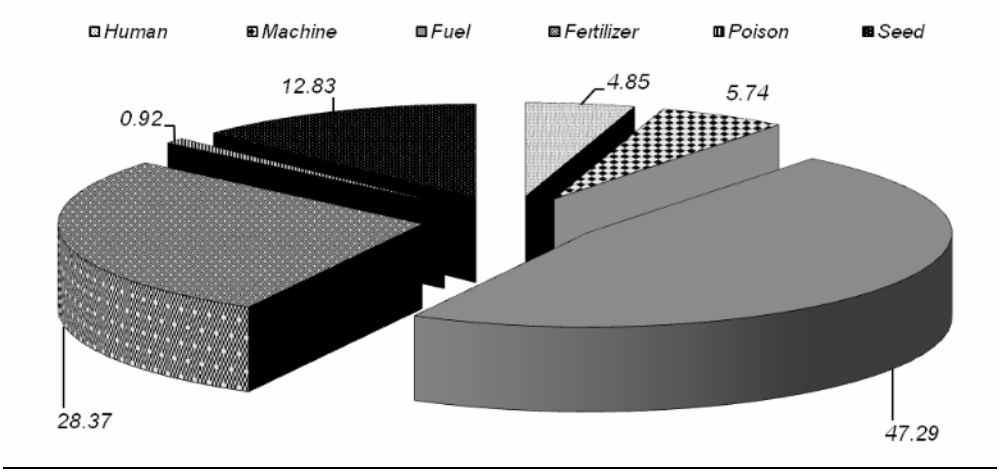

Figure-1. The share (%) production inputs in soybean.

Evaluation indicators of energy in soybean production

The energy use efficiency, energy production, energy specific, energy productivity, net energy gain, and intensiveness of soybean seed production were shown in Table-2. Energy efficiency (energy output-input ratio) in this study was calculated 4.32, showing the affective use of energy in the agro ecosystems soybean production. Energy specific was 5.50 MJ/kg this means that 5.50 MJ is needed to obtain 1 kg of soybean seed. Energy productivity calculated as 0.18 Kg/MJ in the study area. This means that 0.18 kg of output obtained per unit energy. Net energy gain was 43489 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 soybean production are also investigated in Table-2. The results show that the share of direct input energy was 52.19% (6829 MJ/ha) in the total energy input compared to 47.81% (6255 MJ/ha) for the indirect energy. On the other hand, nonrenewable and renewable energy contributed to 82.41% (10783 MJ/ha) and 17.59% (2301 MJ/ha) of the total energy input, respectively.

Table-2. Analysis of energy indices in soybean production.

Item	Unit	Soybean
Yield	Kg/ha	2377
Input energy	Mj/ha	13084
Output energy	Mj/ha	56573
Energy use efficiency	-	4.32
Energy specific	Mj/Kg	5.50
Energy productivity	Kg/Mj	0.18
Net energy gain	Mj/ha	43489
Direct energy	Mj/ha	6829 (52.19%)
Indirect energy	Mj/ha	6255 (47.81%)
Renewable energy	Kg/Mj	2301 (17.59%)
Nonrenewable energy	Mj/ha	10783 (82.41%)

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

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