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INVESTIGATION ENERGY INDICES OF CORN PRODUCTION IN NORTH OF IRAN

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ABSTRACT

Optimum use of energy is very vital for agricultural productions section. 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 corn 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 corn was found to be 2375 kg/ha and its energy equivalent was calculated to be 37050 MJ/ha. Energy efficiency (energy output to input energy ratio) for seed in this study was calculated 2.25, showing the affective use of energy in the agro ecosystems corn production. Nonrenewable energy was 94.88% total input energy that concluded that corn production needs to improve the efficiency of energy consumption in production and to employ renewable energy.

Keywords: corn production, energy indices, yield, Iran.

INTRODUCTION

Corn (*Zea mays* L.) is one of the important cereal crops in the world as well as in Iran after wheat and rice (Alvi *et al*., 2003; Gerpacio and Pingali, 2007).

Humans have found ways to secure their food from the Earth's land, beginning more than a million years ago with the hunter-gatherers. One of the major factors that caused humans to move from hunting and gathering to slash-and-burn agricultural production was the continual expansion of their population. From about 10000 years ago human began the agricultural activity when total population on the earth was 1 million people. About 200 years ago when fossil energy supplies became available, intensive agricultural production developed (Pimental and Pimental, 2005). The crop yield is a function of energy input. Depending on the environmental conditions, crops convert only 0.5-5% of the photosynthetic active radiation (PAR) into biomass (Hulsbergen *et al*., 2001). Sources of energy other than solar radiation, wind, etc. were summarized as support energy (Alam *et al*., 2005). Input of support energy into agricultural systems increase the proportion of solar energy that is captured by the plants. Support direct energy is required to perform various tasks related to crop production processes such as for land preparation, irrigation, harvest, post harvest processing, transportation of agricultural inputs and outputs. In other word, direct energy includes fuel and electricity which are directly used at farm (Hulsbergen *et al*., 2001). Indirect energy is not directly consumed at the farm. The major items for support indirect energy are the energy used in the manufacture, packaging and transport of fertilizers, seeds, machinery production and pesticides (Ozkan *et al*., 2004). Nowadays, energy has an influencing role in the development of key sectors of economic importance such as industry, transport and agriculture (Baruah and Bora, 2008). Agriculture requires energy as an important input to production. Agriculture uses energy directly as fuel or electricity on the farm, and indirectly in the fertilizers and chemicals produced off the farm. An increase in the worldwide average air and ocean temperatures, prevalent snow and ice melting and rising levels of sea waters have been attributable to anthropogenic greenhouse gas emissions, where the agriculture is playing a significant role (Nielsen *et al*., 2007). Efficient use of energy resources is one of the major assets of eco-efficient and sustainable production, in agriculture (Taheri-Garavand *et al*., 2010). Shakibai and Koochekzadeh (2009) show that energy consumption in Iran agricultural section will have an increasing trend as shown before and it warns the authorities that in a case where the price of energy increases in Iran, the prices will have a huge increase in the agricultural section and this has a negative effect on State competitive power.

The main aim of this study was to determine energy use in corn production, to investigate the efficiency of energy consumption and energy indices analysis of corn 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 equation, 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 corn 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 corn. 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).

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

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

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

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

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 corn production

The inputs used in corn production and their energy equivalents and output energy equivalent are illustrated in Table-1. About 20 kg seed, 270 h human labor, 1 L poison chemical, 12 h machinery power and 110 L diesel fuel for total operations were used in agro ecosystems corn production on a hectare basis. The use of nitrogen fertilizer, phosphorus and potassium were 115, 21 and 25 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 chemical fertilizer (51.90%), diesel fuel (37.68%) respectively. The energy inputs of poison (0.73 %), machinery (4.58%), human labor (3.22%) and seed (1.90%) were found to be quite low compared to the other inputs used in production (Figure-1).

The average seed yield of corn was found to be 2375 kg/ha and its energy equivalent was calculated to be 37050 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	270	1.96	529.20
Machinery	h/ha	12	62.7	752.40
Diesel fuel	L/ha	110	56.31	6194.10
Nitrogen	Kg/ha	115	69.5	7992.50
Phosphorus	Kg/ha	21	12.44	261.24
Potassium	Kg/ha	25	11.15	278.75
Poison	L/ha	1	120	120
Seed	Kg/ha	20	15.6	312
Output				
Yield	Kg/ha	2375	15.6	37050

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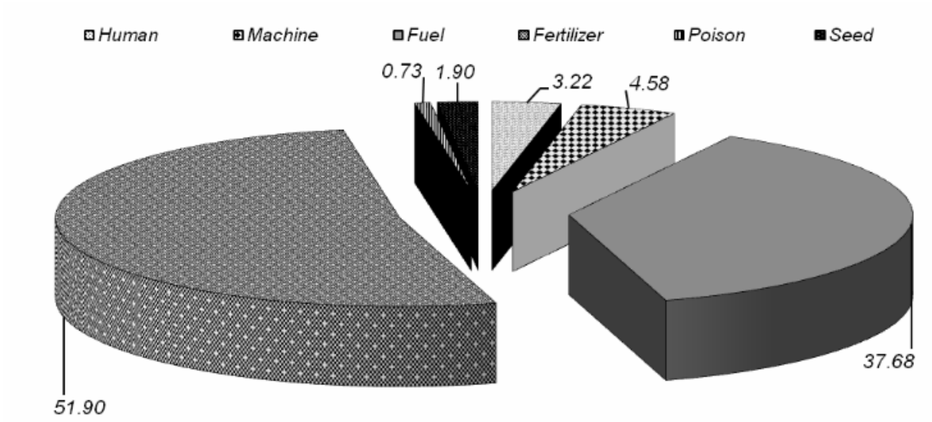

Figure-1. The share (%) production inputs in corn.

Evaluation indicators of energy in corn production

The energy use efficiency, energy production, energy specific, energy productivity, net energy gain, and intensiveness of corn seed production were shown in Table-2. Energy efficiency (energy output-input ratio) in this study was calculated 2.25, showing the affective use of energy in the agro ecosystems corn production. Energy specific was 6.92 MJ/kg this means that 6.92 MJ is needed to obtain 1 kg of corn seed. Energy productivity calculated as 0.14 Kg/MJ in the study area. This means that 0.14 kg of output obtained per unit energy. Net energy gain was 20610 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 corn production are also investigated in Table-2. The results show that the share of direct input energy was 40.90% (6723 MJ/ha) in the total energy input compared to 59.10% (9717 MJ/ha) for the indirect energy. On the other hand, nonrenewable and renewable energy contributed to 94.88% (15599 MJ/ha) and 5.12% (841 MJ/ha) of the total energy input, respectively.

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

Item	**Unit**	**Corn**
Yield	Kg/ha	2375
Input energy	Mj/ha	16440
Output energy	Mj/ha	37050
Energy use efficiency	-	2.25
Energy specific	Mj/Kg	6.92
Energy productivity	Kg/Mj	0.14
Net energy gain	Mj/ha	20610
Direct energy	Mj/ha	6723 (40.90%)
Indirect energy	Mj/ha	9717 (59.10%)
Renewable energy	Kg/Mj	841 (5.12%)
Nonrenewable energy	Mj/ha	15599 (94.88%)

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

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