Research Journal of Applied Sciences, Engineering and Technology 4(15): 2548-2554, 2012
ISSN: 2040-7467

Submitted: March 31, 2012 Accepted: April 17, 2012 Published: August 01, 2012

Optimization of Energy Consumption Pattern in the Maize Production System in Kermanshah Province of Iran

[1]Reza Abdi, [2]Amir Hematian, [3]Ebrahim Zarei Shahamat and [1]Amir Abbas Bakhtiari
1Department of Agricultural Machinery Engineering, University of Tabriz, Tabriz, Iran
[2]Young Researchers Club, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran
[3]Department of Mechanization and Agricultural Machinery Engineering, Ramin Agricultural and Natural Resources University, Ahvaz, Iran

Abstract: The aim of this study was conducted to essay energy use efficiency in the maize production systems in Kermanshah province of Iran in summer 2010. For this study data was collected using questionnaires and face to face interview with 72 farmers. Results showed that the average application of N and P were 300 and 250 Kg/ha, respectively. Total inputs energy in maize production systems was 26917.47 MJ/ha. Energy efficiency (output-input ratio), energy productivity, net energy, water productivity and water-energy productivity together was 3.5 and 0.2 Kg/Mj, 67582.53 Mj/ha, 1.2 Kg/m^3 and 0.047 g (m^{-3}/Mj), respectively. Total energy input reduces 6331.66 Mj/ha by optimization of energy consumption pattern. It was concluded that extension activities are needed to improve the efficiency of energy consumption in maize production.

Keywords: Energy efficiency, inputs, maize, productivity

INTRODUCTION

The high rate of population growth and reducing the extent of fertile land due to the increasing development of urban and industrial areas induce more efficient use of existing facilities. The effective and efficient use of limited resources like water, soil and human power that are of particular importance to provide food requirements for people in developing countries, including Iran (Monjezi *et al.*, 2011). In the developed countries, an increase in the crop yield was mainly due to an increase in the commercial energy inputs in addition to improved crop varieties (Faidley, 1992). Generally, land productivity is measured as the total measure of crop productivity. The yield that is the amount of crop produced per unit area (Kg/ha), has been considered as the total measure of productivity (Singh *et al.*, 2003).

Agriculture is both a producer and consumer of energy. It uses large quantities of locally available non-commercial energies, such as seed, manure and animate energy and commercial energies directly and indirectly in the form of diesel, electricity, fertilizer, plant protection, chemicals, irrigation water and machinery (Kizilaslan, 2009). Similarly, the energy use efficiency (output energy to input energy ratio) and specific energy, i.e., input energy to yield ratio (MJ/Kg) of farmers in crop production systems are indices, which can define the efficiency and performance of farms (Acaroglu, 1998; Omid *et al.*, 2010). Many experimental studies have been conducted on energy use in agriculture (Canakci and Akinci, 2006). Cetin and Vardar (2008) studied on differentiation of direct and indirect energy inputs in agro-industrial production of tomatoes. Erdal *et al.* (2007) have studied on energy consumption and economical analysis of sugar beet production. Demirjan *et al.* (2006) studied the energy and economic analysis of sweet cherry production. Alam *et al*. (2005) studied the energy flow in agriculture of Bangladesh for a period of 20 years.

Maize is one of the most important crops that have consequential effects on animal feeding. LP models are often built for use in one location and are not usually transferable to other agricultural environments (Kline *et al.*, 1988). Maize is the major crop in Iran. The land area under Maize production in Iran is about 239505 ha which produces 2140958 tonnes of Maize in 2010 (Anonymous, 2010).

The relation between agriculture and energy is very close. Agriculture itself is an energy user and energy supplier in the form of bioenergy (Ozkan *et al.*, 2004). Efficient use of energy is an important indicator of agricultural sustainability. Energy use in agricultural production becomes more intensive. Practices such as irrigation, chemical fertilizer application, heavy machinery use and heated greenhouses consume large amounts of energy (Pimentel, 2006).

Corresponding Author: Amir Hematian, Young Researchers Club, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran, Tel.: +98-918-330-6978

Bender *et al.* (1984) generalized linear programming model is presented which can be used to optimize agricultural production systems by evaluating the time-varying competition between crops for land, labor and machinery. Audsley (1981) developed a linear programming model for the use of researchers or engineers developing new machines and techniques. The model assesses, within a range of farm conditions, the economic and technical bounds within which a machine must operate, if it is to be commercially viable. The model is also useful for looking at different management strategies for individual farms. In Sartori *et al.* (2001) the use of linear programming was proposed in formulating mathematical models for optimizing the quantity of residue at harvest and of the production of energy present in the residues. Results showed that the models have strength as a tool to choose the sugar cane varieties.

Mixed-integer linear programming models were constructed from farm management data, therefore, to examine the viability of biofuel production systems on four typical U.K. farm types (Jones, 1986). Suparaporn (1991) developed a model of linear programming to determine the yield needs in crops on some farms in India. This model was compared with the real production plan. The linear programming in addition to its application in quantifying the needs of the crops, resulted in an increase of 318, 37% in the net income. Whitson *et al.* (1981) utilized a linear programming approach for the selection of machinery to evaluate crop alternatives of grain sorghum, cotton, soya bean and maize in Texas under weather risk.

In 1993 a model of linear programming was developed for maximizing the net income of the agricultural sector for sugar-alcohol industries. The model was able to describe and simulate the agricultural system of any sugar and/or alcohol mill, thus providing an instrument for optimization of management decision making, useful for operational planning, selection of machinery and varieties and in other management processes in agriculture (Soffner *et al.*, 1993). Although good results were obtained with this model, it did not take into consideration the facet of residue reduction, which is the present concern preoccupation. Ismintarti and Susmiadi (1996) developed a model of linear programming with the purpose of optimizing the utilization of available resources at the mill. Form the results obtained, the mill functioned below its maximum capacity, resulting in high losses in its net income.

Several researchers have worked with linear programming with a single objective (Joshi *et al.*, 1991) and in the majority of cases that objective has been minimization of total cost. Others such as Ramanathan (1995) had handled the optimization problem with an additional objective function such as maximization of revenue return or maximization of overall efficiency. Jana and Chattopadhyay (2005) offers a model which attempts to optimize the direct energy use for different operations in the agricultural sector, taking into consideration certain objective functions against a set of constraints. The exercise is essentially the application of multi-objective fuzzy linear programming techniques in which efforts are made to arrive at a compromise solution among the objectives in a fuzzy environment. This model is capable of accommodating the needs at local level to provide solutions which are sectorally, spatially and sectionally realistic.

The objective of the present study was to analyse energy flow and examine energy use efficiency in maize production system. This can exert positive effects on managing agro-ecosystems in a way to realize sustainability in agriculture.

MATERIALS AND METHODS

Kermanshah province has 1.54% of total area of the country and is located in the west of Iran, within 34º 41′ latitude and 46º 75′ longitude. The total area of this province is 2499800 ha and the farming area is 880095 ha. Maize is the important agricultural commodity in Kermanshah province. In 2010, the maize was planted in 19141 ha of this province under irrigated conditions and produced about 215445 tonnes with a share of 7.99% of the Iran total production (Anonymous, 2010).

In this study, maize growers were surveyed in Kermanshah province. Maize growers were surveyed in 14 Villages from Kermanshah province. The size of each sample was determined using Eq. (1) derived from Neyman technique (Yamane, 1967):

$$n = \frac{\left(\sum N_h S_h\right)}{N^2 D^2 + \sum N_h S_h^2} \qquad (1)$$

where, n is the required sample size; N is the number of holdings in target population; N_h is the number of the population in the h stratification; S_h is the standard deviation in the h stratification, S_h^2 is the variance of h stratification; d is the precision where $\left(\bar{y} - \bar{y}\right)$ is the reliability coefficient (1.96 which represents the 95% reliability); $D_2 = d^2/z^2$. For calculation of sample size, criteria of 5% deviation from population mean and 95% confidence level were used. Thus, the number of 72 was considered as sampling size and these 72 farms were selected randomly. In maize production agro-ecosystems of this region input energy sources included human labor, machinery, diesel fuel, fertilizers (N, P), chemicals, irrigation water and seeds; while output energy sources was maize grain yield. In this study energy use efficiency, energy productivity, net energy, water productivity and water-energy productivity together were determined applying standard Eq. 2 of 6 (Singh *et al.*, 1997; Burnett, 1982; Maddal *et al.*, 2002; Khan *et al.*, 2008).

Table 1: Energy equivalents of input and output in maize production systems

Equipment /inputs	Unit	Energy equivalents	References
A. Inputs			
Human labor	H	1.96	(Bojaca and Schrevens, 2010)
Machinery	H	62.70	(Erdal *et al*., 2007; Esengun *et al*., 2007)
Diesel fuel	L	47.80	(Kitani, 1999)
Chemical fertilizer	Kg		
Nitrogen	64.40		(Pimentel, 2006; Mobtaker *et al*., 2010; Yilmaz, *et al*., 2005; Mohammadi *et al*., 2010)
Phosphate (P_2O_5)		11.60	(Ozkan *et al*., 2004)
Chemical	Kg	114.00	(Ozkan *et al*., 2004)
Water for irrigation	M^3	0.63	(Esengun *et al*., 2007; Hatirli *et al*., 2006)
Seed	Kg	17.50	(Singh, 2000)
Output			
Maize	Kg	17.50	(Singh, 2000)

$$\text{Energy use efficiency} = [\text{Output Energy (Mj/ha)}]/[\text{Input Energy (Mj/ha)}] \quad (2)$$

$$\text{Energy Productivity} = [\text{Grain yield (Kg/ha)}]/[\text{Input Energy (Mj/ha)}] \quad (3)$$

$$\text{Net Energy} = \text{Ouput Energy (Mj/ha)} - \text{Input Energy (Mj/ha)} \quad (4)$$

$$\text{Water Productivity} = [\text{Grain Yield(Kg/ha)}]/[\text{Water used}(m^3/\text{ha})] \quad (5)$$

$$\text{Water-Energy Productivity} = [\text{Grain Yield(Kg/ha)}]/[\text{Water used}(m^3/\text{ha}) \times \text{input Energy(Mg/ha)}] \quad (6)$$

The input and output were calculated per hectare and then, these input and output data were multiplied by the coefficient of energy equivalent. The data was transformed to energy term by appropriate energy equivalent factors given in Table 1.

In order to optimization of energy productivity linear programming was used. Linear programming is the most powerful technique that can resolve various issues with regard to the conditions apply. A linear programming model has objective function and constrains. Objective function is a mathematical function that consists of decision variables and shown with (Z). It is indicator of model Objective. This function represents maximize utility or minimize the cost as following (Sidho *et al.*, 2004):

$$\text{Max } Z = f(x_j) \qquad j = (1, ..., n) \quad (7)$$

OR

$$\text{Min } Z = f(x_j) \qquad j = (1, ..., n) \quad (8)$$

$$Z = C_1X_1 + C_2X_2 + ... + C_nX_n \quad (9)$$

Constrains consisting of an equation or no equation from decision variables that express the limitations of the model or decision in order to research the model objectives and shown with (C).

Status of decision variables is similar to one of two following case:

$$x_j \geq 0 \qquad j = (1, ..., n) \quad (10)$$

Or free mark decision variable (x_j) that can be in the case of positive values, negative or zero.

Constrain include all limitation can be met on each inputs consumption or yield production. Constrains are as follows;

$$x_j \geq 0 \qquad j = (1, ..., n) \quad (11)$$

$$a_{m1}X_1 + a_{m2}X_2 + ... + a_{mn}X_1 + (\leq \text{OR} \geq \text{OR} =) b_m$$

$$X_1, X_2 ..., X_n + \geq 0 \text{ OR (freemark decision variables)}$$

In this study with linear programming and considering all the conditions and limitations the optimal pattern were determining. Solving of problem was done by the WINQSB software.

Objective function and constrains: Generally, inputs used in maize production in this region was divided into 8 groups including that: labor (x_1), machinery (x_2), diesel fuel (x_3), N fertilizer (x_4), P fertilizer (x_5), chemical (x_6), seed (x_7) and water for irrigation (x_8). In this study objective function is maximizing energy productivity. One of the ways for the maximizing energy productivity is minimizing amount of energy input. Objective function is equal to;

$$Z = \text{Maximize } E_p = \text{Maximize } \frac{y}{\sum x_i e_i} \quad i = (1, 2, ..., 8) \quad (12)$$

$$Z = \text{Minimize } E_{in} = \text{Minimize } \sum x_i e_i \quad i = (1, 2, ..., 8) \quad (13)$$

$$x_i e_i \geq e_i \quad (14)$$

$$x_i \geq A_i \quad (15)$$

$$e_i \geq 0 \quad (16)$$

$$Z = \text{Minimize}(1.96x_i + 62.7x_2 + 47.8x_3 + 64.4x_4 + 11.6x_5 \; 114x_6 + 17.5x_7 + 0.63x_8) \quad (17)$$

where, E_P is energy productivity, E_{in} is total energy input, x_i is amount of used input, A_i is the minimum amount recommended, e_i is energy equivalent of x_i and x_1, x_2, x_3, x_4, x_5, x_6, x_7 and x_8 is quantity of labor, machinery, diesel fuel, N fertilizer, P fertilizer, chemical, seed and water for irrigation, respectively.

Constrains result from regional conditions, expert analysises and production system by interview with growers and including:

$$C_1: 58.7 \le x_1 \le 109.2 \quad (18)$$

$$C_2: 10.7 \le x_2 \le 25.6 \quad (19)$$

$$C_3: 88.3 \le x_3 \le 169 \quad (20)$$

$$C_4: 102 \le x_4 \le 221 \quad (21)$$

$$C_5: 46 \le x_5 \le 92 \quad (22)$$

$$C_6: 2.5 \le x_6 \le 7 \quad (23)$$

$$C_7: 14 \le x_7 \le 30 \quad (24)$$

$$C_8: 38.20 \le x_8 \le 5500 \quad (25)$$

$$C_9: x_1 + x_2 \ge 115 \quad (26)$$

$$C_{10}: x_4 + x_5 + x_6 \ge 270 \quad (27)$$

$$C_{11}: x_6 + x_7 \ge 27 \quad (28)$$

RESULTS AND DISCUSSION

Analysis of input-output energy use: The number of 72 farms was considered as sampling farms and the inputs used and output in maize production systems in the studied area and their energy equivalents with output energy rates are shown in the Table 2.

Total energy requirement for producing the maize crops was 26917.47 MJ/ha. Among the different energy sources N fertilizer was the highest energy consumer. The average use of the N fertilizer was 300 Kg/ha in the maize production it is a common belief that increased use of fertilizer will increase the yield. Because of the high N fertilizer used in the production systems had the big values of 13717.20 MJ/ha. The other inputs applied in the growing process in the surveyed area and percentage of each input of the total energy inputs are shown in Table 2. The share of important energy inputs of total inputs energy are shown approximately in Fig. 1.

The energy input (Table 3) of chemical fertilizer (N and P) had the biggest share (56% approximately) of total energy inputs. After that diesel fuel, water for irrigation, machinery, pesticide, seed and human labor were 26, 10, 2, 4, 1 and 1% approximately, respectively. Table 4 shows the energy indicators of maize production agro-ecosystems. The energy use efficiency, energy productivity, water productivity, water-energy productivity and net energy together were 3.5, 0.2 Kg/ha, 1.28 Kg/m^3, 0.04 g (m^{-3}/MJ) and 67582.5 MJ/ha, respectively. Energy use efficiency in Turkey for maize production recorded 3.66% (Kitani, 1999). Energy productivity was 0.2 Kg/MJ. This means that produced maize grain yield per input energy unit was 0.2 Kg. Also, Net energy per hectare, in this study for maize production agro-ecosystems was 67582.53 MJ per ha. Water productivity was 1.28 Kg/M^3. This means that produced maize grain yield per 1 m^3 of water was 0.2 Kg. Water-energy productivity together was 0.047 g/M^3/MJ. This

Table 2: Energy equivalents of input and output in maize production systems in Kermanshah

Input/output	Quantity per unit area (ha)	Total energy equivalents (MJ/ha)	Percentage of total energy (%)
A. Inputs			
Human labor (h)	81.50	159.74	0.59
Machinery (h)	17.73	1111.67	4.13
Diesel fuel (L)	147.00	7026.60	26.10
Chemical fertilizer (Kg)			
Nitrogen	213.00	13717.20	50.96
Phosphate (P_2O_5)	115.00	1334.00	4.96
Pesticides (Kg)	4.80	547.20	2.04
Seed (Kg)	21.00	367.50	1.37
Water for irrigation	4212.00	2653.56	9.86
Total energy input (MJ)		26917.47	100.00
Output			
Maize	5400	54639.90	100.00
Total energy output (MJ)		54639.90	100.00

Table 3: Optimized amount of energy inputs and energy saved

Input	Optimize quantity	Total energy equivalent	Percentage of total energy (%)
Human labor (h)	104.3	204.43	0.99
Machinery (h)	10.7	670.89	3.26
Diesel fuel (Lit)	88.3	4220.74	20.50
Nitrogen fertilizer (Kg)	175.51	1302.20	54.90
Phosphor fertilizer (Kg)	92.0	1067.20	5.18
Pesticide (Kg)	2.5	285.00	1.38
Seed (Kg)	24.5	428.75	2.08
Water for irrigation (m^3)	3820.0	2406.60	11.69
Total energy input		20585.81	100

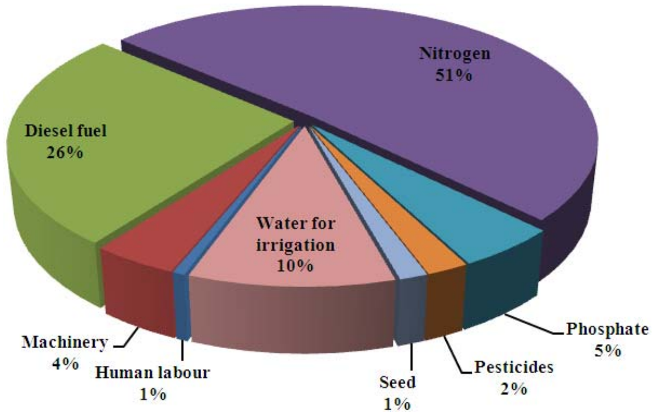

Fig. 1: Share of important energy inputs of total input energy

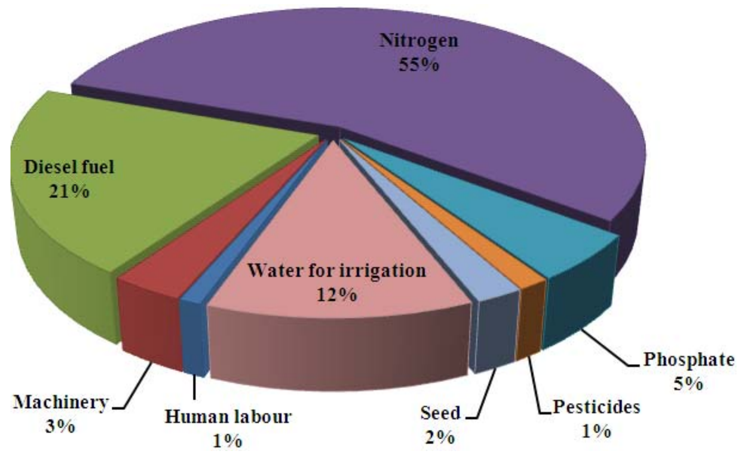

Fig. 2: Share of important energy inputs of total input energy

Table 4: Indicators of energy use in maize production systems

Indicators	Quantity	Unit
Inputs energy	26917.470	MJ/ha
Output energy	94500.000	MJ/ha
Grain yield	5400.000	Kg/ha
Energy use efficiency	3.500	%
Energy productivity	0.200	Kg/MJ
Water productivity	1.280	Kg/M^3
Water-energy productivity	0.047	g (m^{-3}/Mj)
Net energy	67582.530	MJ/ha

Table 5: Indicators of energy use in maize production systems

Indicators	Quantity	Unit
Inputs energy	20585.800	MJ/ha
Output energy	94500.000	MJ/ha
Grain yield	5400.000	Kg/ha
Energy use efficiency	4.590	%
Energy productivity	0.260	Kg/MJ
Water productivity	1.410	Kg/M^3
Water-energy productivity	0.068	g (M^{-3}/Mj)
Net energy	73914.190	MJ/ha

means that produced maize grain yield per unit of water and unit of energy was 0.047 g.

Optimization energy consumption pattern: For optimizing of energy consumption pattern WINQSB Software was used. To solving the problem an objective function with constraints was designed. Solving of problem was done by Simplex method. Results of optimization energy consumption pattern were shown in Table 3. The share of important energy inputs of total inputs energy are shown approximately in Fig. 2.

By optimization of energy input reduced 440.78, 2805.86, 2415, 266.8, 262.2 and 246.96 MJ/ha in machinery energy, diesel fuel, nitrogen fertilizer, phosphor fertilizer, pesticide and water for irrigation respectively and increasing 44.69 and 61.25 MJ/ha in human labor and seed respectively.

In this status (Table 5) total energy input reduce 6331.66 MJ/ha and energy efficiency, energy productivity, net energy, water productivity and water-energy productivity were 4.59 and 0.26 Kg/MJ, 73914.19 MJ/ha, 1.41 Kg/M^3, 0.068 g/m^3/MJ, respectively.

CONCLUSION

In this study, the energy flow of maize production systems in Kermanshah province, western part of Iran has been investigated. Total energy consumption in maize production was 29307.74 MJ/ha. The energy input of chemical fertilizer had the biggest share (56%) of total energy inputs. Results shows that reduce in chemicals fertilizer consumptions are important for energy saving and decreasing the environmental risk problem in the area. By optimization of energy input total energy reduces to 6331.66 MJ/ha. The results of this study indicate that in order to optimize energy pattern machinery energy, diesel fuel, nitrogen fertilizer, phosphor fertilizer; pesticide and water for irrigation must be reduce while human labor and seed energy must be increase.

REFERENCES

Acaroglu, M., 1998. Energy from Biomass and Applications. University of Selcuk, Graduate School of Natural and Applied Sciences, Turkish.

Alam, M.S., M.R. Alam and K.K. Islam, 2005. Energy flow in Bangladesh agriculture. Am. J. Env. Sci., 1: 213-220.

Anonymous, 2010. Annual Agricultural Statistics. Ministry of Jihad-e-Agriculture of Iran. Retrieved from: <http://www.maj.ir>.

Audsley, E., 1981. An arable farm model to evaluate the commercial viability of new machines or techniques. J. Agric. Eng. Res., 26: 135-149.

Bender, D.A., R.M. Peart, D.H. Doster, J.R. Barrett and M.O. Bagby, 1984. Energy crop evaluation by linear programming. Energ. Agric., 3: 199-210.

Bojaca, C.R. and E. Schrevens, 2010. Energy assessment of peri-urban horticulture and its uncertainty: Case study for Bogota, Colombia. Energy, 35(5): 2109-2118.

Burnett, M., 1982. Energy analysis of three agro-eco systems. Hill SB, editor, Paper presented at second International Conference on Basic Techniques in Ecological Farming held during 1-5 October at IFO, Montreal, Basel: Birkhauser, pp: 183-95.

Canakci, M. and I. Akinci, 2006. Energy use pattern analyses of greenhouse vegetable production. Energy, 31: 1243-1256.

Cetin, B. and A. Vardar, 2008.An economic analysis of energy requirements and input cost for tomato production in Turkey. Renew. Energ., 33: 428-433.

Demirjan, V., K.K. Ekinci, D.H.M. Akbolat and C. Ekinci, 2006. Energy and economic analysis of sweet cherry production in Turkey: A case study from Isparta province. Energ. Conver. Manage., 47: 1761-1769.

Erdal, G., K. Esengun and O. Guduz, 2007. Energy use and economic analysis of sugar beet production in Tokat province of Turkey. Energy, 32: 34-35.

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

Esengun, K., O. Gunduz and G. Erdal, 2007. Input-output energy analysis in dry apricot production of Turkey. Energ. Conver. Manage., 48: 592-598.

Faidley, L.W. 1992. Energy and Agriculture. In: Fluck, R.C., (Ed). Energy in Farm Production. Elsevier, Amsterdam, pp: 1-12.

Hatirli, S.A., B. Ozkan and C. Fert, 2006. Energy inputs and crop yield relationship in greenhouse tomato production. Renew. Energ., 31: 427-38.

Ismintarti, A.S. and A. Susmiadi, 1996. Optimization of raw material supply, milling days and milling schedule: Application of optimization model for Trangkil Sugar Mill. Majalah-Penelitian-Gula Indonesia, 32(1-2): 47-59.

Jana, C. and R.N. Chattopadhyay, 2005. Direct energy optimization for sustainable agricultural operation-a fuzzy linear programming approach. Energ. Sus. Dev., 9(3): 5-12.

Jones, M.R., 1986. Evaluation of the potential of biofuel production systems on U.K. farms using mixed-integer programming models. Energ. Agric., 5: 21-36.

Joshi, B., T.S. Bhatia, N.K. Bansal and P.D. Grover, 1991. Decentralised energy planning model for optimum resources allocation with a case study of the domestic sector of rurals in Nepal. Int. J. Energ. Res., 15: 71-78.

Khan, M.A., J. Zafar and A. Bakhash, 2008. Energy requirement and economic analysis of sugarcane production in Dera Islamic Khan district of Pakistan. Gomal U. J. Res., 24: 72-82.

Kitani, O., 1999. Energy and biomass engineering. Cigr. Handbook Agric. Eng., 5(ASAE): 330.

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

Kline, D.E., D.A. Bender, B.A. McCarl and C.E. Van Donge, 1988. Machinery selection using expert systems and linear programming. Comput. Electr. Agric., 3: 45-61.

Maddal, K.G., K.P. Saha, P.K. Ghosh and K.M. Hati, 2002. Bioenergy and economic analysis of soybean-based crop production systems in central India. Bio. Bioenerg., 23: 337-45.

Mobtaker, H.G., A. Keyhani, A. Mohammadi, S. Rafiee and A. Akram, 2010. Sensitivity analysis of energy inputs for barley production in Hamedan Province of Iran. Agric. Ecosyst. Env., 137: 367-72.

Mohammadi , A., S. Rafiee, S.S. Mohtasebi and H. Rafiee, 2010. Energy inputs-yield relationship and cost analysis of kiwifruit production in Iran. Renew. Energ., 35: 1071-1075.

Monjezi, N., M.J. Sheikhdavoodi and M. Taki, 2011. Energy use pattern and optimization of energy consumption for greenhouse cucumber production in Iran using Data Envelopment Analysis (DEA). Mod. Appl. Sci., 5(6): 139-151.

Omid, M., F. Ghojabeige, M. Delshad and H. Ahmadi, 2010. Energy use pattern and benchmarking of selected greenhouses in Iran using data envelopment analysis. Energ. Conver. Manage., 52: 153-162.

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

Pimentel, D., 2006. Impacts of Organic Farming on the Efficiency of Energy Use in Agriculture. An Organic Center State of Science Review: Retrieved from: www.organic-center.org/reportfi les/ENERGY_ SSR.pdf.

Ramanathan, R., 1995. Rural energy planning incorporating energy and agricultural interactions. RERIC Int. Energ. J., 17(1): 73-81.

Sartori, M.M.P., H. de Oliveira Florentino, C. Basta and A. Lopes Lea˜o, 2001. Determination of the optimal quantity of crop residues for energy in sugarcane crop management using linear programming in variety selection and planting strategy. Energy, 26: 1031-1040.

Sidho, H.S., S. Singh and S. Ahuja, 2004. Optmizaton of energy usage in different crop production systems. LE(1). J. Agric., 85: 50-55.

Singh, H., D. Mishra, N.M. Nahar and R. Mohnot, 2003. Energy use pattern in production agriculture of a typical village in arid zone India part II. Energ. Conver. Manage., 44: 1053-1067.

Singh, J.M., 2000. On farm energy use pattern in different cropping system in Haryana, India. MA. Thesis, International Institute of Management, University of Flensburg, Germany.

Singh, M.K., S.K. Pal, R. Thakur and U.N. Verma, 1997. Energy input-output relationship of cropping systems. Ind. J. Agric. Sci., 67(6): 262-266.

Soffner, R.K., M. Milan and T.C.C. Ripoli, 1993. Global management system farmer: Glue units sugarcane through liner programming. Stab-Ac¸u´car, a´lcool e subprodutos, 11(5): 16-19.

Suparaporn, S., 1991. Crop Production Planning for Increasing Farmers' Income. In: ChangwatSukhothai. Bangkok, Thailand.

Whitson, R.E., R.D. Kay, W.A. Lepori and E.M. Rister, 1981. Machinery and crop selection with weather risk. Trans. ASAE, 24(2): 288-295.

Yamane, T., 1967. Elementary sampling theory. Prentice Hall Englewood Cliffs, N.J., USA.

Yilmaz, I., H. Akcaoz and B. Ozkan, 2005. An analysis of energy use and input costs for cotton production in Turkey. Renew. Energ., 30: 145-155.