International Journal of Agricultural Technology 2013 Vol. 9(4): 793-800
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Energy consumption and economic analysis of canola production in Iran (case study: Mazandaran Province)

R. Loghmanpour zarini[1*], A. Akram[1], R. Tabatabaee kolour[2]

[1]Department of Agricultural Machinery Engineering, Faculty of Biosystems Engineering, University of Tehran, Karaj, Iran, [2]Department of Agricultural Machinery Engineering, Faculty of Agricultural Engineering, Sari University of Agricultural Science and Natural Resources, Sari, Iran.

R. Loghmanpour zarini, A. Akram, R. Tabatabaeekolour (2013). Energy consumption and economic analysis of canola production in Iran (case study: Mazandaran Province). International Journal of Agricultural Technology 9(4):793-800.

Abstract Energy is a fundamental ingredient in the process of economic development, as it provides essential services that maintain economic activity and the quality of human life. Modern agriculture has become very energy-intensive. Energy in agriculture is important in terms of crop production and agroprocessing for value adding. Canola is one important rapeseed that it is tilled in dry farming systems in north and northeast of Iran. The aims of this study were to determine energy consumption and energy indexes in dry farming canola production, to investigate the efficiency of energy consumption and to make an economic analysis of canola farming in Sari County of Mazandaran Province in Iran. Data were collected from 75 canola farms by using a face to face questionnaire method. The results revealed that canola production consumed a total of 23,505.5 MJ ha^{-1} of which chemical fertilizer and diesel fuel energy consumption were 53.7% and 39.8%, respectively. Also the Output Energy was 43,460 MJ ha^{-1}. Output- input energy ratio, specific energy and energy productivity in this study were about 1.84, 11.7 MJ kg^{-1} and 0.085 respectively. Non-renewable energy was 98.9% total input energy that concluded what canola production needs to improve the efficiency of energy consumption in production and to employ renewable energy. The total cost was 513.3 $ ha^{-1} and Benefit- cost ratio and net income were 0.87 and 447.2 $ ha^{-1} respectively.

Keywords: Canola, Energy ratio, Energy productivity, Economic analysis, Iran.

Introduction

Energy has an influencing role in the development of key sectors of economic importance such as industry, transport and agriculture. This has motivated many researchers to focus their research on energy management. Energy has been a key input of agriculture since the age of subsistence agriculture. It is an established fact worldwide that agricultural production is

[*]**Corresponding author:** R. Loghmanpourzarini; **e-mail:** RLoghmanpour@yahoo.com

positively correlated with energy input (Singh, 1999). Agriculture is both a producer and consumer of energy. It uses large quantities of locally available non-commercial 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, chemicals, irrigation water, machinery, etc. Efficient use of these energies helps to achieve increased productivity and contributes to the profitability and competitiveness of agricultural sustainability in rural living (Singh *et al.*, 2002). Energy use in agriculture has been increasing in response to increasing population, limited supply of arable land, and desire for higher standards of living (Kizilaslan, 2009). However, more intensive energy use has brought some important human health and environment problems so efficient use of inputs has become important in terms of sustainable agricultural production (Yilmaz *et al.*, 2005). Recently, environmental problems resulting from energy production, conversion and utilization have caused increased awareness in all sectors: the public, industry and government, in both developed and developing countries. It is predicted that fossil fuels will be the primary source of energy for the next several decades (Dincer, 2003; Demirbas, 2003). Efficient use of resources is one of the major assets of eco-efficient and sustainable production in agriculture (De Jonge, 2003). Energy use is one of the key indicators for developing more sustainable agricultural practices (Streimikiene *et al.*, 2007) and efficient use of energy is one of the principal requirements of sustainable agriculture (Kizilaslan, 2009). It is important, therefore, to analyze cropping systems in terms of energy and to evaluate alternative solutions, especially for arable crops, which accounts for more than half of the primary sector energy consumption (Sartori *et al.*, 2005).

Original varieties of rapeseed had high levels of erucic acid and glucosinolates, making them unsuitable for human consumption. Breeding experiments led to the development of rapeseed varieties that contained lower amounts of these undesirable compounds. The improved varieties called canola became commercially important in the 1960's (Edwards, 2005). Canola was bred (using conventional breeding techniques) to have by definition less than 2 percent erucic acid in the oil and less than 30 micromoles per gram of glucosinolates in the oil-free meal. Canola oil is recognized as a high quality and healthy edible oil, or as a potential source for manufacturing a wide variety of environmental-friendly products such as biodiesel and bioplastics; the residual canola meal after oil extraction usually contains 35-40% protein content and is mostly utilized as an animal feed or fertilizer. It has previously been reported that rapeseed proteins contain essential amino acids (Ohlson and Anjou, 1979; Wu *et al.*, 2008). These differences allow canola oil to be used for human consumption and the meal for livestock feed protein supplement.

The aims of this study were to determine energy consumption and in Canola production, to investigate the efficiency of energy consumption and to make an economic analysis of canola in Sari County of Mazandaran Province in Iran.

Materials and methods

Data were collected from 75 canola farms in the Sari County of Mazandaran province in Iran by using a face to face questionnaire in September-December 2011. The simple random sampling method was used to determine survey volume (Kizilaslan, 2009).

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

In the formula, the below signs and letters represent: 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 (permissible error 5%).

Sari County is located in the north of Iran, within 36 ° 25' north latitude and 50 ° 34' east longitude. It is a semi wet region in west of Mazandaran province and the average annual rainfall is 580 mm, (Anon, 2009). In this region canola is tilled in dry farming method. 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. Energy equivalents shown in Table 1 were used for estimation.

Firstly, the amounts of inputs used in the production of canola were specified in order to calculate the energy equivalences in the study. Energy input includes human labor, machinery, diesel fuel, chemical fertilizers, pesticides and seed amounts and the output yield include grain of Canola. Basic information on energy inputs and canola yields were entered into SPSS 16 spreadsheets. Based on the energy equivalents of the inputs and output (Table 1), output-input energy ratio, energy productivity, specific and energy net energy gain were calculated (Singh, 2002; Mohammadi *et al.*, 2008; Sartori *et al.*, 2005; Demircan *et al.*, 2006).

$$\text{Output- input ratio} = \frac{\text{Output energy (MJ/ha)}}{\text{Input energy (MJ/ha)}} \quad (2)$$

$$\text{Energy productivity} = \frac{\text{Canola output (kg/ha)}}{\text{Input energy (MJ/ha)}} \quad (3)$$

$$\text{Net energy gain} = \text{Energy output (MJ ha}^{-1}) - \text{Energy Input (MJ ha}^{-1}) \quad (4)$$

$$\text{Specific energy} = \frac{\text{Input energy (MJ/ha)}}{\text{Canola output (kg/ha)}} \quad (5)$$

Table 1. Energy equivalent of inputs and outputs in canola production

Item	Unit	Energy equivalent (MJ $unit^{-1}$)	Reference
Inputs			
Labour	h	1.96	(Yilmaz *et al*., 2005)
Diesel fuel	L	47.8	(Kitani, 1999)
Machinery	kg	138	(Kitani, 1999)
Tractor	kg	180	(Kitani, 1999)
Plow	kg	129	(Kitani, 1999)
Sprayer	kg	129	(Kitani, 1999)
Equipment of fertilizing	kg	138	(Kitani, 1999)
Trails	kg	148	(Kitani, 1999)
Thresher	kg	17.4	(Kitani, 1999)
Chemical fertilizer	kg	74.2	(Kitani, 1999)
Phosphorus (P2O5)	kg	295	(Kitani, 1999)
Nitrogen fertilizer (N)	kg	21.7	(Lockeretz, 1980)
Pesticide	kg	21.7	(Kitani, 1999)
Seed	kg		(Kitani, 1999)
Output			
Canola	kg		(Shaw *et al*., 1990)

The input energy was also classified into direct, indirect, renewable and non-renewable forms which were equivalents to different inputs and outputs in agricultural production (Mandal *et al.*, 2002; Hatirli *et al.*, 2008). Indirect energy consists of seeds, fertilizers, pesticides and machinery energy while direct energy covered human labor and diesel fuel used in the canola production. Non-renewable energy includes diesel, pesticide, fertilizers and machinery, and renewable energy consists of human labor and seeds. In the last part of the research, economic analysis of canola production was investigated. Net income and benefit-cost ratio as economic indicators was calculated based on the existing price of the inputs and outputs. The net income was calculated by subtracting the total cost of production from the gross income of production per hectare. The benefit-cost ratio was calculated by dividing the net income of production by the total cost of production per hectare.

Results and discussions

In Sari county cultivation of canola is in form of dry farming. The average land size of canola in area is 1.45 hectares but the average of each plot size for cultivation is about 0.55 hectares for reason of not being integration of farms. Tractor and equipment in canola production in the region are about 73%, 10.2% and 6.5% in forms of rented, private and partnership, respectively. About 96% of canola farms are private and the rest are rented. Canola production in the region is mechanized and highly dependent on commercial input.

Analysis of input-output energy use in canola production

The input and output energy values used in canola production are shown in Table 2. Total input energy in production was 23,505.5 MJ ha^{-1}. Of all the inputs, the fertilizer (mostly N fertilizer) has the biggest share in the total energy with a 53.7% (12,622.45 MJ ha^{-1}) which shows that the canola production is severely dependent on fertilizer. Fertilizer energy is followed by diesel fuel energy which was 39.8% (9,355.19 MJ ha^{-1}). Diesel fuel was mainly used for operating tractor and combine harvester. Because of mechanized operation in canola production, use of human labor was low that was 0.37% of total input energy but it was very important input in increasing productivity. Energy of machinery and seed was 4.85% and 0.72% of total input energy, respectively. Average output energy of canola was found to be 43,460 MJ ha^{-1}. Direct energy was 40.17% (labour and diesel fuel) while indirect energy was 59.83% of total input energy.

The percentage renewable and nonrenewable energy as well as output-input energy ratio, net energy and energy productivity of canola production in the Sari County are presented in Table 3. The output- input energy ratio and energy productivity were calculated as 1.84 and 0.085 kg MJ^{-1}, respectively. Net energy gain and specific energy were 19954.5 MJ ha^{-1} and 11.7 MJ kg^{-1}, respectively.

As it can be seen from Table 3 that 98.9% of the total energy input resulted from non-renewable and 1.1% from renewable energy. The results indicate that the current energy use pattern among the investigated farms is based on non-renewable energy in the canola production. Therefore this method of production caused environment problem.

Table 2. Inputs and outputs for canola production

Item	**Energy**	
	MJ ha^{-1}	**%**
Inputs		
Labour	86.97	0.37
Diesel fuel	9355.19	39.8
Machinery	1140.01	4.85
Fertilizer	12622.45	53.7
Nitrogen (N)	11541.2	49.1
Phosphorus (P_2O_5)	1081.25	4.6
Pesticide	133.47	0.56
Seed	169.55	0.72
Total input	23505.5	100
Output		
Total output (Canola)	43460	100

Table 3. Energetic parameters in canola production

Renewable Energy (%)	Nonrenewable Energy (%)	Output-Input Energy ratio	Energy Productivity (MJ kg^{-1})	Specific Energy (kg MJ^{-1})	Net Energy Gain (MJ)
1.1	98.9	1.84	0.085	11.7	19954.5

Analysis of finance performance in canola production

The total cost of production, gross income, net income and benefit-cost ratio (B:C ratio) were calculated and is shown in Table 4. Opportunity cost of land with 352.5 \$ ha^{-1} has the most cost in canola production and followed by machinery with 74.1 \$ ha^{-1}. The total cost for the production was 513.3 \$ ha^{-1} while the gross income was found to be 960.5 \$ ha^{-1}. The net income and benefit-cost ratio was calculated to be 447.2 \$ ha^{-1} and 0.87. Since the government of Iran gives subsidy to chemical fertilizers and pesticides the cost of these was low.

Table 4. Economic analysis of canola production

Cost and return components	Value
Labour cost (\$ ha^{-1})	31.3
Opportunity cost of land (\$ ha^{-1})	352.5
Machinery cost (\$ ha^{-1})	74.1
Seed cost (\$ ha^{-1})	18.4
Pesticide cost (\$ ha^{-1})	12.2
Fertilizer cost (\$ ha^{-1})	24.8
Total cost (\$ ha^{-1})	513.3
Gross income (\$ ha^{-1})	960.5
Net income (\$ ha^{-1})	447.2
Benefit-Cost ratio	0.87

Conclusion

In this study, energy consumption for input and output energies in canola production was investigated in Sari county of Mazandaran Province in Iran. Data were collected from 75 farms which were selected based on random sampling method. Total energy consumption in canola production was 23505.5 MJ ha^{-1}. Chemical fertilizer and diesel fuel were the major energy inputs with 53.7% and 39.8% total input energy, respectively, in the production. Input-output energy ratio and energy productivity were calculated and was found to be 1.84 and 0.085 kg MJ^{-1}, respectively. Non-renewable energy was 98.9% of the total input energy which mean that canola production needs to improve the efficiency of energy consumption in production and to employ renewable energy. The total cost was 513.3 \$ ha^{-1}, the opportunity cost of land was 352.5 \$ ha^{-1} followed by machinery costs. Benefit- cost ratio and net income were 0.87 and 447.2 \$ ha^{-1} respectively.

Acknowledgments

We thank the Department of Agricultural Machinery Engineering, Faculty of Agricultural Engineering and Technology, University of Tehran, Karaj, Iran.

Reference

Anonymous. (2009). Iran meteorological organization, Mazandaran meteorological organization. www.mazandaranmet.ir.

De Jonge, A.M. (2003). Eco-efficiency improvement of a crop protection product: the perspective of the crop protection industry. Crop Protect. 23(12):1177-1186.

Demirbas, A. (2003). Energy and environmental issues relating to greenhouse gas emissions in Turkey. Energy Conversion and Management. 44:203-213.

Demircan, V, Ekinci, K., Keener, H.M., Akbolat, D. and Ekinci, C. (2006). Energy and economic analysis of sweet cherry production in Turkey: a case study from Isparta province. Energy Convers Manage. 47:1761-1769.

Dincer, I. (2003). Environmental issues: I-energy utilization. Energy Source 23: 69-81.

Edwards, M. (2005).Detecting foreign bodies in food. Cambridge Publishing, England.

Hatirli, S.A., Ozkan, B. and Fert, C. (2008). Energy inputs and crop yield relationship in greenhouse tomato production. Renewable Energy 31:427-438.

Kitani, O. (1999). CIGR Handbook of Agricultural Engineering.Vol, V, Energy and Biomass Engineering.ASAE publication, ST Joseph, MI.

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

Lockeretz. W. (1980). Energy inputs for nitrogen, phosphorus and potash fertilizers. In: Pimentel, D. (Ed.). Handbook of Energy Utilization in Agriculture. CRC Press, Boca Raton, FL. pp.15-21.

Mandal, K.G., Saha, K.P., Ghosh, P.K., Hati, K.M. and Bandyopadhyay, K.K. (2002). Bioenergy and economic analysis of soybean-based crop production systems in central India.Biomass Bioenergy 23:337- 45.

Mohammadi, A., Tabatabaeefar, A., Shahin, S., Rafiee, S. and Keyhani, A. (2008). Energy use and economical analysis of potato production in Iran a case study: Ardabil province. Energy Conversion and Management. 49:3566-3570.

Ohlson, R. and Anjou, K. (1979).Rapeseed protein products.Journal of the American Oil Chemists' Society. 56:431-437.

Sartori, L., Basso, B., Bertocco, M. and Oliviero, G. (2005). Energy use and economic evaluation of a three year crop rotation for conservation and organic farming in NE Italy. Biosystems Engineering. 9(2):245-250.

Shaw, J., Baidoo, S.K. and Aherne, F.X. (1990).Ileal and Faecal Energy Digestibility Coefficients of Full-fat Canola Seed for Swine.Animal Feed Science and Technology. 28: 71-77.

Singh, G. (1999). Relationship between mechanization and productivity in various parts of India. A paper presented during the XXXIV Annual Convention. Indian Society of Agricultural Engineers, CCSHAU, Hisar, 16-18 December, 1999.

Singh, H., Mishra, D. and Nahar, N.M. (2002). Energy use pattern in production agriculture of typical village in arid zone. India--part-I.Energ.Convers. Manage. 43:2275-86.

Streimikiene, D., Klevas, V. and Bubeliene, J. (2007).Use of EU structural funds for sustainable energy development in new EU member states. Renew Sustain Energy Rev. 116:1167-87.
Wu, J., Aluko, R.E. and Muir, A.D. (2008).Purification of angiotensin I-converting enzyme- inhibitory peptides from the enzymatic hydrolysate of defatted canola meal.Food Chemistry. 111:942-950.
Yilmaz, I., Akcaoz, H. and Ozkan, B. (2005).An analysis of energy use and input costs for cotton production in Turkey. Renew. Ene. 30:145-155.

(Received 31 March 2013; accepted 30 June 2013)