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Energy Consumption Pattern of Organic and Conventional Lentil in Iran A Case Study: Kuhdasht County

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Abstract: The aims of this study were to evaluate the energy use in organic and conventional farming of lentil in Kuhdasht county of Iran to investigate the efficiency of energy consumption. Data were collected from 47 organic lentil farms and 39 nonorganic farms by using a face-to-face questionnaire method. The results revealed that total energy consumption and output energy in organic lentil production was less than nonorganic production but energy ratio was higher in organic lentil production with 2.12. Total input energy was 5062 and 6196.5 MJ/ha in organic and nonorganic lentil, respectively. Diesel fuel and seed are the major energy inputs in but farms that diesel fuel mostly consumed in tillage operation. Net energy gain in the nonorganic farms was 6498.1 MJ/ha that was more than organic farms. Renewable energy in the organic farms with 1115.6 MJ/ha (22%) was more than nonorganic farms with 1099.2 MJ/ha (17.7%).

Key words: Energy ratio, energy productivity, Iran, organic lentil

INTRODUCTION

As a food group, legumes make a major contribution to the human diet as good sources of protein, carbohydrates, several water-soluble vitamins, and minerals (Rodrıguez *et al.*, 2008). They contain factors that affect their nutritional value of proteins (such as enzyme inhibitors, phytohemagglutinins) and mineral bioavailability (e.g., oxalates, phytates, and polyphenols) (Viadel *et al.*, 2006) and Dietary importance of their seeds is expected to increase in the future with increasing protein requirement due to population growth and reduction in consumption of animal protein, especially in the developed countries (Makri *et al.*, 2005; Lazou and Krokida, 2010). Also, legumes have demonstrated many health benefits: lowering glycemic index for people with diabetes; in cancer prevention and in protection against cardiovascular diseases due to its dietary fiber content (Wang *et al.*, 2009).

Of the Leguminoceae family, lentils are nowadays considered among the most important legumes for human nutrition (Roy *et al.*, 2010; Wang *et al.*, 2009). It has been recognized as one of the most complete and cheapest sources of vegetable protein for humans (Stanford *et al.*, 1999) and also, it provides a good source of minerals (Fiocchetti *et al.*, 2009). This crop is rich sources of complex carbohydrates, protein, dietary fiber, vitamins, minerals, high energetic value (Costa *et al.*, 2006) and oleic, linoleic and palmitic acid (Roy *et al.*, 2010). Lentil seed is low in crude fibre (range 1.4 .9%) (Stanford *et al.*, 1999) and rich source of protein (up to 28%) for human consumption (Sarker *et al.*, 2003) and has 56% carbohydrate and 1% fat (Stanford *et al.*, 1999). lentil straw is a valued animal feed (Sarker *et al.*, 2003).

Lentil traditionally produced and consumed in certain areas of Asia (Tang and Sokhansanj, 1993). Archaeological evidences revealed that lentil, being one of the oldest crop species in the world, was originated from Near East (Cubero, 1981; Ozberk *et al.*, 2006; Jin *et al.*, 2008) and domesticated with wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.) at same time (Jin et al., 2008). It has produced in the Near East more than 8500 years ago and has spread to the Mediterranean, parts of Asia and was subsequently introduced into North America by the early 1900s (Roy *et al.*, 2010). Nowadays this crop is produced on many continents worldwide. North America, specifically Canada, and areas within Asia and the Middle East are responsible for the majority of lentil production and exportation (Roy *et al.*, 2010). This crop is an important crop in many developing countries and has been the basis of diet for many people living in the Middle East and Asia (Lee *et al.*, 2007) and in 1999; it accounted 5% of world legume production (Rodrıguez *et al.*, 2008). This crop is adapted to less favorable environments, where it is predominantly grown in winter in regions where the annual average rainfall ranges between 300 and 400 mm (Sarker *et al.*, 2003). Lentil is able to tolerate frost after emergence and resistant to high temperatures and drought (Stanford *et al.*, 1999). It is grown annually on a variety of soil types ranging from sand to clay loam soils in semi-arid regions of the world (Roy *et al.*, 2010).

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The current situation of worldwide concern over the emission of greenhouse gases and its effect on the climate, demands an evaluation, from the perspective of energy efficiency and more specifically of nonrenewable energy sources, of tendencies for change in the management of agricultural systems which have arisen in recent years (Guzman and Alonso, 2008). The effects of agricultural activities on the environment are of growing concern. Particularly, the consumption of fossil energy, increasing energy prices, and the current debate on human influences on climate change and global warming hold a strong link to agriculture. In fact, today agricultural production relies heavily on using non-renewable fossil fuels (Deike *et al.*, 2008). The increased use of commercial fertilizers (in the developed countries) currently faces environmental and energy constraints. Yet much of these fuels are finite and thus the energy problem must also be approached from the standpoint of energy conservation (Berardi, 1978). Consequently, one main goal for improving the environmental performance of agricultural production has been minimizing energy consumption. Conventional agricultural practices, characterized by industrial methods of production are being challenged by supporters of the organic movement who increasingly draw attention to problems of pollution, land degradation, loss of bio-diversity and environmental amenity, diminishing food quality, health and environmental sustainability. Central to the debate between the efficiencies organic and conventional production systems are issues of energy efficiency (Loake, 2001). Some organic agriculture technologies may offer opportunities to improve resource use and to reduce energy inputs in crop production while maintaining high crop yields (Dazhong, 1984). In general, it is assumed that the risk of harmful environmental effects is lower with organic than with conventional farming methods, though not necessarily so (Deike *et al.*, 2008). The desire for a sustainable agriculture is universal, yet agreement on how to progress towards it remains elusive. Sustainability is considered in relation to organic farming a sector growing rapidly in many countries. The role of regulation and the use of synthetic agrochemicals, the desired degree of self-reliance of agricultural systems, and the scale of production and trade in agricultural goods are all considered in the context of this discussion of sustainability (Rigby and Caceres, 2001). In organic farming, there is an ambition that production should be based on the use of natural, biological and renewable resources. This would include motor fuels for tractors. Mineral oil is a limited resource and the burning of fossil fuel contributes to global warming. The consumption of diesel oil by organic farming is approximately 100 l/ha and year. There is a large amount of literature on the topic energy use in organic agriculture, especially compared to conventional production (Ahlgren *et al.*, 2009).

Organic farming principles give rise to multifunctionality: different activities are combined at farm level to create ecological and economic synergies. As a matter of principle, organic farming strives for a multifunctional farming system (Nauta *et al.*, 2009). From very modest beginnings in the first half of the last century, organic farming has grown dramatically in importance and influence worldwide. A few statistics tell part of the story: from almost negligible levels until the 1980s, the number of organic farms worldwide has grown to an estimated 623 000, with some 31.5 million hectare managed organically. Worldwide sales of organic products reached some US$28 billion in 2004 (Lockeretz, 2007). Organic agriculture is practiced in almost all countries of the world, and its share of agricultural land and farms are growing. The market for organic products is growing, not only in the major markets like Europe, North America, and Japan, but also in many other countries, including developing countries (Shi-mingl and Sauerborn, 2006).

West Asia and North Africa are characterized by high human population growth rate, large and rapidly increasing food deficits, limited arable land and increasingly scarce water resources. As a result, the priority for land use is for the production of crops that are consumed directly the human population. As a result of increased crop production, the production of crop production, the production of residues has increased as well. Lentil straw is a forage source that is seasonally available throughout the Middle East (Haddad and Husein, 2001). In dry years, the income from lentil straw may equal that from seed (Sarker *et al.*, 2003). In Iran, lentil production is about 55.7 thousand metric tonnes and the area planted with lentil is about 15.3 thousand ha in 2007 (Anonymous, 2007a). Lentil is mainly concentrated in the mountain regions of Iran. The objective of the present study was to evaluate the energy use in organic and conventional farming of lentil in Kuhdasht county of Iran.

MATERIALS AND METHODS

This study was conducted in the Kuhdasht County of Iran in November 2009-February 2010. This Country is located in the West of Iran, within 47 39' North latitude and 33 31' East longitude. It is a semiarid region in west of Lorestan province and its high from sea level is 1198 meters. The average of annual rainfall of it is 405 mm, the minimum and maximum temperature is -20.6 and 43ºC respectively (Anonymous, 2009a). Its population is 1.7 million and about 41% of them are lived in rural area (Anonymous, 2007b). This county is one of the important lentil production areas in Iran that about 99% it cultivated in dray farming form. The total farming area of the Kuhdasht County is 192 thousand ha (Anonymous, 2007a).

Data were collected from 47 and 39 farms that use of organic (first group farms) and conventional (second group farms) method, respectively in the Kuhdasht county of Iran by using a face-to-face questionnaire. The simple random sampling method was used to determine survey volume (Kizilaslan, 2009).

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

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%).

In order to calculate input utput 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 lentil were specified in order to calculate the energy equivalences in the study. Energy input in organic farming includes human labor, machinery, diesel fuel and seed wile in non organic is human labor, machinery, diesel fuel, seed, chemical fertilizer fungicide and output yield include grain and straw of lentil in to method. Basic information on energy inputs and lentil yields were entered into SPSS 15 spreadsheets. Based on the energy equivalents of the inputs and output (Table 1), output- input energy ratio energy productivity, net energy gain and Specific energy were calculated (Hatirli *et al*., 2008; Mohammadi *et al*., 2008).

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

$$\text{Energy productivity} = \frac{\text{lentil output (Kg/ha)}}{\text{Input energy (MJ/ha)}} \qquad (3)$$

$$\text{Net energy gain} = \text{Energy output (MJ/ha)} - \text{Energy Input (MJ/ha)} \qquad (5)$$

$$\text{Specific energy} = \frac{\text{Input energy (MJ/ha)}}{\text{lentil output (Kg/ha)}} \qquad (6)$$

The input energy is also classified into direct and indirect and renewable and non-renewable forms Energy equivalents for different inputs and outputs in agricultural production (Mandal *et al*., 2002; Hatirli *et al*., 2008).

Table 1: Energy equivalent of inputs and outputs in lentil production

Item	Unit	Energy equivalent (MJ/unit)	Reference
input			
Labour	MJ/h	2.2	(Pimentel and Pimentel, 1979)
Diesel fuel	MJ/L	56.31	(Singh, 2002)
Machinery			
Tractor	MJ/kg	138	(Kitani, 1999)
Plow	MJ/kg	180	(Kitani, 1999)
Disc harrow	MJ/kg	149	(Kitani, 1999)
Trailer	MJ/kg	138	(Kitani, 1999)
Thresher	MJ/kg	148	(Kitani, 1999)
Fertilizer	MJ/kg	129	(Kitani, 1999)
Fungicide (Captan)	MJ/kg	115	(Kitani, 1999)
Fertilizer (P_2O_5)	MJ/kg	17.4	(Kitani, 1999)
seed	MJ/kg	14.7	(Singh and Mital, 1992)
Output			
Grain of lentil	MJ/kg	14.7	(Singh and Mital, 1992)
Straw of lentil	MJ/kg	12.5	(Singh and Mital, 1992)

Table 2: Management practices for lentil and types of input energy

Operation	Period	Type of input energy
Tillage	September twenty- January twenty	Machinery+ diesel fuel + human labor
Fertilizing operation	March twenty - April ten	Machinery+ diesel fuel + human+ fertilizer
Pest control	January	Human labour + fungicide
Planting	January	Seed + human labor
Thinning	April	Human labor
Harvesting	May twenty- Jun twenty	Machinery+ diesel fuel + human

Indirect energy consists of seeds, fertilizer, fungicide and machinery energy while direct energy covered human labor and diesel fuel used in the lentil production. Non-renewable energy includes diesel fuel, fertilizer, fungicide and machinery, and renewable energy consists of human labor and seeds.

RESULTS AND DISCUSSION

Socio-economic structure of lentil farms that use of organic method: The average of land size of organic lentil in area is 0.57 ha but the average of each plot size of under cultivation is about 0.53 ha for reason of not being integration of farms wile in nonorganic is 0.8 and 0.7 ha, respectively. Tractor and equipment in this crop production in region were about 87 and 13% in form of rental and private, respectively and in organic 78% of farms are private and the rest are in form of rental but in nonorganic were 89 and 11%. Lentil production in region is highly dependent on labor power. Most labor is domestic. A Massey Ferguson 285 tractor, 75 hp, was used in operations of tillage, transporting and threshing. Average Farmers' experience in lentil copping was 12 years while in organic was 8. About 60% of farmers that plant organic lentil just pay to farming and the rest, in addition to farming pay to animal husbandry or horticulture too, while in other group farms, 69% pay to farming. Total of farmland wasn't irrigated. In both farms,

Table 3: Inputs and outputs for lentil production

	First group			Second group		
		Energy			Energy	
Item	Quantity per hectare	MJ/ha	%	Quantity per hectare	MJ/ha	%
Input						
Labour	100.4 h	221.8	4.4	109.4 h	240.7	3.9
Diesel fuel	64.1 L	3609.5	71.3	69.6	4031.8	65.1
Machinery	-		6.7	-		6.4
Tractor	1.43 kg	183.2	3.6	1.56	215.3	3.5
Plow	0.33 kg	59.4	1.2	0.33 kg	59.4	1.0
Disc harrow	0.152 kg	22.6	0.4	0.152 kg	22.6	0.4
Trailer	0.14 kg	28.3	0.6	0.14 kg	28.3	0.5
Thresher	0.293 kg	43.4	0.9	0.293 kg	43.4	0.7
Fertilizing equipments	-	-	-	0.16	20.6	0.3
Fungicide	-	-	-	0.43 kg	49.5	0.8
Chemical fertilizer (P_2O_5)	-	-	-	36 kg	626.4	10.1
Seed	60.8 kg	893.8	17.7	58.4 kg	858.5	13.9
Total input		5062	100		6196.5	100
Output						
Lentil grain	432.6 kg	6359.2	59.2	543 kg	7982.1	62.9
Lentil straw	350.4 kg	4380	40.8	377 kg	4712.5	37.1
Total output		10739.2	100		12694.6	100

Planting, Thinning and harvesting (cutting) operations are done by human labor. Proportions of males and females within the population were 63 and 37% in organic farming while in second group were 67 and 33%, respectively.

Agronomic practices period during the process of lentil production and type of input energy are showed in Table 2. Tillage operations performed during September twenty to January twenty while harvesting are done in May twenty to Jun twenty. Input energy types of tillage and harvesting operations are Machinery, diesel fuel and human labor. The Planting and thinning period are January and April, respectively and Types of input energy of planting are Seed and human labor wile thinning is human labor. Inputs energy in fertilizing operation are human labour, machinery, fuel and chemical fertilizer that do in 20 of March to 10 of April.

Analysis of input-output energy: The input and output energy values used in lentil production are illustrated in Table 3. Total input energy in first conventional farms was bigger than organic farms and was 6196.5.1 and 5062 MJ/ha, respectively. Of all the inputs in the first and second groups, the diesel fuel has the biggest share of the total energy with a 71.6% (3609.5 MJ/ha) and 65.1% (4031.8 MJ/ha), respectively. The diesel fuel energy was mainly used for operating tractor. Tillage operation consumes 61.7 and 55.2% diesel fuel energy in organic and conventional farms, respectively. Operations of tillage were the most energy consuming operations with 2408.5 MJ/ha in both group farms (Table 4). In each type of farms, diesel energy is followed by the seed energy, which was 17.7 and 13.9% total input energy in first and second farms, respectively. Consumption of fertilizer and fungicide energy in second group farms

Table 4: Energy inputs in each operation

	Energy			
	First group		Second group	
Operation	MJ/ha	(%)	MJ/ha	(%)
Tillage	2408.5	47.6	2408.5	38.9
Planting	907.2	17.9	907.2	14.6
Fungi control	-	-	53.2	0.9
Fertilizing	-	-	1081.3	17.5
Thinning	45.2	0.94	5.2	0.7
Harvesting	1701.1	33.6	1701.1	27.5
Total	5062	100	6196.5	100

were 626.4 (10.1% total input energy) and 49.5 (0.85% total input energy), respectively while in organic farms did consume. Tractor with 4.4 and 3.5% total input energy in organic and non-organic lentil, respectively, was the most energy use of whole machinery that mainly used for tillage. Human energy was the least input energy in lentil production in both farms. Input energy of harvesting, planting and thinning operation wear 1701.1, 907.2 and 45.2 MJ, respectively in both type farms. Harvesting operations include of cutting, transporting and threshing the lentil crop. Average yield of grain in nonorganic farms was more than organic farms. Average yield of grain and straw of lentil were found 543 and 377 kg in second group farms wile in first group were 432.6 and 350.4 kg, respectively. Total output energy in nonorganic farms was more than organic farms. Total output energy in first group farms was 10739.2 MJ/ha, where 59.2 and 40.8% of it included grain and straw, while in second group was 12694.6 MJ/ha, where 62.9 and 37.1% of it included grain and straw, respectively.

Table 5 shows the percentage of renewable and nonrenewable, direct and indirect energy and output-input energy ratio, energy productivity, net energy and specific energy of lentil production in the Kuhdasht

Table 5: Energetic parameters in lentil production

	First group		Second group	
Item	Value	%	Value	%
Renewable energy	1115.6 (MJ/ha)	22.04	1099.2 (MJ/ha)	17.74
Nonrenewable energy	3946.4 (MJ/ha)	77.96	5097.3 (MJ/ha)	82.26
Direct energy	3831.3 (MJ/ha)	75.7	4272.5 (MJ/ha)	68.95
Indirect energy	1230.7 (MJ/ha)	24.3	1924 (MJ/ha)	31.05
Output-input energy ratio	2.12	-	2.05	-
Energy productivity (grain)	0.085 (Kg/MJ)	-	0.088 (Kg/MJ)	-
Total net energy gain	5677.2 (MJ/ha)	-	6498.1 (MJ/ha)	-
Specific energy (grain)	11.70 (MJ/kg)	-	11.41 (MJ/kg)	-

County. Renewable energy in the organic farms with 1115.6 MJ/ha (22%) was more than nonorganic farms with 1099.2 MJ/ha (17.7%). Direct input energy was 3831.3 MJ/ha (75.7% of total input energy) and 4272.5 (69%) in first and second group farms, respectively while indirect input energy was 1230.7 MJ/ha (24.3% of total input energy) and 1924 (31%), respectively. total net energy gain and energy productivity of grain in second farms was bigger but Output-input energy ratio was lower. Energy productivity and specific energy of grain, net energy gain and energy ratio in first group farms 0.085, 11.7, 5677.2 and 2.12 MJ/ha, respectively while in second group farms were 0.088, 11.4, 6498.1 and 2.05 MJ/ha.

CONCLUSION

In this study, energy consumption for input and output energies in organic and nonorganic lentil production was investigated in Kuhdasht county of Iran. Data were collected from 47 organic farms and 39 nonorganic farms, which were selected based on random sampling method. Total energy consumption and output energy in organic lentil production was less than nonorganic production but energy ratio was higher in organic lentil production with 2.12. Total input energy was 5062 and 6196.5 MJ.ha^{-1} in organic and nonorganic lentil, respectively. Diesel fuel and seed are the major energy inputs in but farms that diesel fuel mostly consumed in tillage operation. Net energy gain in the nonorganic farms was 6498.1 MJ/ha that was more than organic farms. Renewable energy in the organic farms with 1115.6 MJ/ha (22%) was more than nonorganic farms with 1099.2 MJ/ha (17.7%). Direct input energy was 3831.3 MJ/ha and 4272.5 in first and second group farms, respectively.

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