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FULL LENGTH ARTICLE

A comparison of energy use and productivity of wheat and barley (case study)

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Abstract Comparison of energy productivity of different crops can be used as an effective tool to prioritize crops planting in each area. This study was conducted in order to compare wheat and barley farms of Sistan and Baluchestan province in Iran in relation to various aspects of energy consumption at 2009. 100 wheat and 100 barley fields were selected randomly from main 11 cities in the studied region. Input data and yield of wheat and barley fields were collected in the form of questionnaires in a face-to-face interview. Results showed that total energy inputs of wheat and barley fields were 32492.97 and 25655.81 MJ ha^{-1}, respectively. Total energy outputs for wheat and barley fields were 48517.24 and 49800.87 MJ ha^{-1}, respectively. Based on these results the amount of energy use efficiency for wheat and barley fields were 1.49 and 1.94, respectively, and the amount of energy productivity for mentioned fields were 0.056 and 0.066. The share of renewable energy as one of the sustainability indexes of agricultural systems was 19.60 for wheat and 14.60 for barley fields. Therefore, it seems that barley production is more efficient from various aspects of energy consumption rather than wheat in the studied region.

1. Introduction

After the green revolution and the provision of inputs such as modified seeds, fertilizers and chemical pesticides, their influx into the consumer market, encouraged the farmers into using them, due to the vast support of the inputs, and their short-term profitability, it was not long before the farmers accepted the inputs and many used them. On the other hand tractor and agricultural implements came to help the farmers and these factors along with others have increased the production per unit area (Chaharsooghi et al., 2008). But the lack of awareness and technical knowledge of the farmers led to an undesirable use of the inputs. The available evidence suggests that the excessive consumption of certain agricultural inputs, not only has inhibited the increase in production, but also reduced it in some cases (Omani and Chizari, 2008). The prevalence of high consumption of non-renewable energies is another major challenge in relation to agriculture. The consumer chemicals, machinery, fossil fuels and electricity are among the most important inputs, consumed in large amounts in the process of the production of different agricultural productions; the

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production, distribution, and the usage of these inputs are mainly relied on large amounts of non-renewable energy. According to various studies done in this field, the process of production between 60% and 90% of consumer energy is non-renewable (Canakci et al., 2005; Ozkan et al., 2004). The result of a long-term study in Iran shows that nearly 80% of the consumer energy in Iran's agriculture is non-renewable (Beheshti Tabar et al., 2010). In the other case studies in Iran, the share of non-renewable energy in the common production of potato, green house cucumber, sugarcane, barley and pea has been, respectively reported as 74.27% (Mohammadi et al., 2008), 78.52% (Hosseinpanahi and Kafi, 2012), 89.07% (Mohammadi and Omid, 2010), 90.08% (Karimi et al., 2008), 65.91% (Mobtaker et al., 2010) and 86.7% (Shahin et al., 2008) which are very high values. This situation occurs while the non-renewable energy sources-often fossil fuels are going to run out in near future and the continuance of this process will face the future generations with many hazards.

Although we cannot simply pass by the agricultural common benefits such as the increase in the production in the face of ever-increasing population over the past years, we should consider this point that the usage of non-renewable energy in agriculture will decrease the productivity of the production systems and their sustainability (Moore, 2010; Pimentel et al., 1983). Many studies have shown the reduction in the productivity and the efficiency of energy consumption in common agriculture in contrast to the agriculture based on natural inputs (Gundogmus, 2006; Guzman and Alonso, 2008; Hoeppner et al., 2005; Pimentel et al., 1983). This matter reveals the necessity of revision in relation to managerial and consumer methods in agricultural systems. In this regard it seems urgent to study the patterns of energy consumption to determine the areas of much consumed energy in agricultural systems and the evaluation of the energy use efficiency, environmental problems, and their relation to the persistence of agriculture. In order to reach this goal it is necessary that agricultural systems are analyzed according to the entering and exiting of energy, so that new solutions are taken into account especially for grains that devote over 70% of Iran's under cultivation agricultural production to themselves annually (Ministry of Agriculture, 2007).

According to the latest statistics, the under cultivation area of the total crops in Iran has been estimated as 4.12 million ha, of which approximately 3.8 million ha has been devoted to the cultivation of wheat and barley (Ministry of Agriculture, 2007).

This statistics show the importance of the mentioned plants in Iran's agriculture, but the remarkable point is the lack of sufficient attention to the productivity of these plants. Some information shows that in many areas high potential and in many others low potential exist for the production of these two plants (Ministry of Agriculture, 2007). The basic question here is why there is no base for the production of other plants in areas with low potential, and the cultivation of wheat and barley with very low productivity is still in the program of the farmers. Obviously, the identification of the potentials in various regions of the country and making decisions based on coherent studies help so much to increase the productivity on a national scale. Since energy consumption is one of the necessities and a main challenge in the common agriculture, the study of energy budgets of various crops helps a lot to identify the available potential in the country, and a comparison between the energy productivity of the crops is one of the methods used in prioritization in the cultivation of various crops in any area.

The study of the course of energy has been done in agricultural system in different parts of the world, including the apricots (Esengun et al., 2007), cotton (Tsatsarelis, 1991; Yilmaz et al., 2005), cherry (Demircan et al., 2006) 2007, tomato (Esengun et al., 2007), sugar beet (Erdal et al., 2007), citrus (Ozkan et al., 2004), potato (Hosseinpanahi and Kafi, 2012; Mohammadi et al., 2008), greenhouse cucumber (Mohammadi and Omid, 2010), sugar cane (Karimi et al., 2008), barley (Mobtaker et al., 2010), pea (Salimi and Ahmadi, 2010), and wheat (Hosseinpanahi and Kafi, 2012). Limited studies exist for the comparison of the energy of different crops in Iran, and this study has been done to compare wheat and barley production in the studied region from the perspective of energy consumption and productivity. According to the latest statistics, the under cultivation area of the crops in this province in the year 2009 has been estimated nearly as190,000 ha of which about 105,000 ha has been devoted to the cultivation of the grains. The under cultivation area and the production of wheat have been estimated as 83,000 ha and 176,000 tons, respectively and the under cultivation area and the production of barley have been estimated as 11,000 ha and 20,000 tons, respectively (Organization of Agriculture Sistan, 2011).

2. Materials and methods

2.1. Geographic location of the place under study

This studied area, is situated between 25° and 31° north and 58° and 63° east. The province has an area of 187,502 sq km, and its climate is predominantly desert and semi-desert, the average annual rainfall is between 110 and 120 mm, and the average annual temperature is between 22 and 37 °C.

2.2. Data collection and the calculation method

The information used in this study was collected from the fields of wheat and barley in 11 main cities of studied region. In this regard 100 fields of irrigated wheat and 100 fields of irrigated barely available in these areas were chosen randomly and the information related to the inputs and the yield of wheat and barley related to the year 2009 was extracted in the form of questionnaires from the farmers. The reason for choosing the irrigated fields was the very low level of under cultivation areas in non-irrigated fields, since in this province more than 98% of wheat and barley fields are cultivated in irrigated situations, because of the very low annual rainfall (Organization of Agriculture Sistan, 2011). The information related to the kind of inputs and energy equivalent to each group of inputs has been shown in Table 1.

The amount of energy consumption in each group of inputs was calculated from the multiplication of the amount of the input consumption and its energy equivalent per unit (extracted from scientific sources). Then according to energy input and output, energy use efficiency, energy productivity, specific energy, and net energy were calculated.

(1) Energy use efficiency = energy output (MJ ha^{-1})/energy input (MJ ha^{-1}).

Table 1 Energy equivalent of inputs and outputs in wheat and barley production.

Particulars	Unit	Energy equivalent (MJ $unit^{-1}$)	Refs.
A. Inputs			
1. Human labor	H	1.96	Yilmaz et al. (2005), Ozkan et al. (2004), Mohammadi et al. (2008)
2. Machinery	H	62.70	Mohammadi et al. (2008), Erdal et al. (2007), Giampietro et al. (1992)
3. Diesel fuel	L	56.31	Mohammadi et al. (2008), Erdal et al. (2007)
4. Chemical fertilizers	Kg		
(a) Nitrogen (N)	Kg	66.14	Esengun et al. (2007), Yilmaz et al. (2005), Mohammadi and Omid (2010)
(b) Phosphate (P_2O_5)	Kg	12.44	Esengun et al. (2007), Yilmaz et al. (2005), Mohammadi and Omid (2010)
(c) Potassium (K_2O)	Kg	11.15	Esengun et al. (2007), Yilmaz et al. (2005), Mohammadi and Omid (2010)
5. Chemical			
(a) Herbicide	L	238	Gundogmus (2006)
(b) Pesticide	L	199	Gundogmus (2006)
(c) Fungicide	L	92	Gundogmus (2006)
6. Water for irrigation	M^3	1.02	Mohammadi et al. (2008)
7. Seeds (Wheat)	Kg	20.1	Giampietro et al. (1992)
8. Seeds (Barley)	Kg	14.7	Mobtaker et al. (2010)
B. Outputs			
1. Wheat grain yield	Kg	14.48	Giampietro et al. (1992)
2. Barley grain yield	Kg	14.70	Giampietro et al. (1992)
3. Wheat straw yield	Kg	9.25	Mobtaker et al. (2010)
4. Barley straw yield	Kg	11.60	Givens et al. (1988)

Table 2 Energy consumption and energy input–output relationship in wheat production.

Energy	Quantity per unit (ha)	Total energy equivalent (MJ)	Percentage of total energy input (%)
A. Inputs			
Human labor (hr)	220.40	431.98	1.33
Machinery (hr)	40.53	2541.23	7.82
Diesel fuel (l)	167.20	9415.03	28.98
Chemical fertilizers (kg)			
Nitrogen (N) (kg)	115.57	7643.80	23.52
Phosphate (P_2O_5) (kg)	63.54	790.43	2.43
Potassium (K_2O) (kg)	50.56	563.74	1.73
Herbicide (l)	2.08	495.04	1.52
Pesticide (l)	1.50	298.50	0.92
Fungicide (kg)	0.33	30.36	0.09
Water for irrigation (m^3)	4260.10	4345.30	13.37
Seeds (Wheat) (kg)	295.4	5937.54	18.27
Total energy input (MJ)		32492.97	
B. Outputs			
Wheat grain yield (kg)	1825.41	26431.94	54.47
Wheat straw yield (kg)	2387.60	22085.30	45.52
Total energy output (MJ)		48517.24	

(2) Energy productivity = yield of wheat (kg ha^{-1})/energy input (MJ ha^{-1}).
(3) Specific energy = energy input (MJ ha^{-1})/yield of wheat (kg ha^{-1}).
(4) Net energy = energy output (MJ ha^{-1})−energy input (MJ ha^{-1}).

Also the share of direct energies (including man power, fossil fuels, and irrigation water), indirect (including seed, consumer chemicals, and machinery), renewable energies (man power and seed), non-renewable (fossil fuels, fertilizers and chemicals, water and machinery) was calculated (Beheshti Tabar et al., 2010; Ozkan et al., 2004).

3. Results and discussion

3.1. An analysis of energy inputs and outputs in the fields of wheat and barley

The amount of total energy inputs in one hectare wheat was 97.32402 MJ ha^{-1} (Table 2). Machinery and diesel fuel allocated 5.6% of the total consumer energy on the whole (11956.26 MJ ha^{-1}) of which the share of diesel fuel was 28.98% (9415.03 MJ ha^{-1}) and the share of machinery was 7.82% (2541.03 MJ ha^{-1}). Also the total consumer chemicals included 30.21% of the total energy inputs (9821.87 MJ ha^{-1}), and after that seed (5937.54 MJ ha^{-1}), irrigation water

Table 3 Energy consumption and energy input–output relationship in barley production.

Energy	Quantity per unit (ha)	Total energy equivalent (MJ)	Percentage of total energy input (%)
A. Inputs			
Human labor (hr)	145.60	285.37	1.11
Machinery (hr)	34.25	2147.47	8.37
Diesel fuel (l)	134.2	7556.80	29.45
Chemical fertilizers (kg)			
Nitrogen (N) (kg)	116.31	7692.74	29.98
Phosphate (P_2O_5) (kg)	47.83	595.01	2.31
Potassium (K_2O) (kg)	–	–	–
Herbicide (l)	–	–	–
Pesticide (l)	–	–	–
Fungicide (kg)	–	–	–
Water for irrigation (m^3)	3841.2	3918.02	15.27
Seeds (Wheat) (kg)	235.4	3460.38	13.48
Total energy input (MJ)		25655.81	
B. Outputs			
Wheat grain yield (kg)	1694.53	24909.59	50.01
Wheat straw yield (kg)	2145.80	24891.28	49.98
Total energy output (MJ)		49800.87	

(4345.3 MJ ha^{-1}) and man power (431.98 MJ ha^{-1}) were, respectively on the next places with 18.27%, 13.37%, and 1.33%. Among the consumer chemicals nitrogen fertilizer, devoted the highest energy consumption (23.52% of the total energy input) and among all inputs was on the second place after the diesel fuel (7643.8 MJ ha^{-1}). The average yield and the total energy output in wheat fields obtained were 1825.41 kg $ha^{-1}$and 48517.24 MJ ha^{-1}, respectively.

The total energy inputs in one hectare barley were estimated equivalent to 25655.81 MJ ha^{-1} (Table 3); this amount was about 21% lesser than energy inputs in wheat fields. Like wheat fields total energy consumed by machinery and diesel fuel (9704.27 MJ ha^{-1}) allocated 37.82% of the total energy, and after it the total consumer chemicals were on the next place with 32.29% of the total energy (8287.75 MJ ha^{-1}). The share of irrigation water (3918.02 MJ ha^{-1}), seed (3460.38 MJ ha^{-1}), and man power (285.37 MJ ha^{-1}) were, respectively 15.27%, 13.48%, 1.11% of the total energy input. Like wheat fields, nitrogen fertilizer was the largest energy consumer among the consumer chemicals, so that 92% of the total energy consumed by chemicals, and 29.98% of the total energy input were related to this input. Average yield and the total energy output of barley fields obtained were 1694.53 kg ha^{-1} and 49800.87 MJ ha^{-1}. Previous studies showed that the amount of energy inputs in the production of one hectare of irrigated wheat obtained was 45367.63 MJ ha^{-1} in semi-desert weather conditions (Giampietro et al., 1992) and 49956.08 MJ ha^{-1} in mountain weather conditions (Hosseinpanahi and Kafi, 2012) which are, respectively 29% and 35% more than the energy input calculated in this study. The reason for the differences is the difference in managerial practices and the amount of input consumption. Nevertheless difference in the amount of energy input will be less important than the difference in energy productivity and efficiency studied in the next chapter. But to determinate the energy inputs and their share in production is very remarkable. For example, unlike the results of this experiment, the consumer chemicals in the semi-desert and mountain weather conditions devoted the largest amount of energy consumption to themselves, and machinery and diesel fuel were on the next place. Moreover in both mentioned studies, the amount of consumer energy in both groups of mentioned inputs by MJ $ha^{-1}$was more than the results of this study. Meanwhile the share of man power in the production of wheat in studied region (220 h.ha^{-1}) was estimated more than the one in the weather conditions of semi-disert (108 h.ha^{-1}) and mountain (176 h.ha^{-1}). These differences clearly indicate the kind of agricultural management in different areas. Although in the studied region machinery and chemicals are used, the total form of agriculture is much like subsistence agriculture, hence the amount of labor involved in production is higher than in the studied semi-desert and mountain weather conditions. Nevertheless this matter is seen quite positive from the perspective of ecology, because of increasing use of chemicals and machinery and as a result increasing share of non-renewable energies can reduce the sustainability of agricultural systems (Moore, 2010; Pimentel et al., 1983). Moreover wherever labor share in production has decreased, the social problems caused by rural migration to cities have been rising.

Like the results of this study, the studies of Hosseinpanahi and Kafi (2012) and Giampietro et al. (1992) have also demonstrated that nitrogen fertilizer allocated the largest part of energy consumption among chemicals. Although nitrogen fertilizer has an effective role in the growth and yield of agricultural plants, it has been always raised as a serious challenge in relation to energy consumption in agriculture. The amount of energy needed to produce each kilogram nitrogen has been estimated about 66.14 MJ ha^{-1} (Esengun et al., 2007) which compared with other fertilizers, and especially animal manures is a very high figure. According to the reports of Singh et al. (1998) the amount of consumer energy in the production of chemical fertilizers-in which nitrogen is located above them-includes about 40% of the total energy inputs in agricultural production. Also previous studies on the energy consumption in the fields of corn and soybean have shown that nitrogen fertilizer has been the main difference in energy consumption and efficiency of conventional system versus the sustainable systems in the production of these plants (Pimentel et al., 2005).

So considering that the energy consumed in the Haber Bush process to produce Nitrogen, is largely provided with non-renewable resources and considering the completion of these resources in the future, a proper solution should be pondered upon for the replacement or lesser use of nitrogen fertilizers. Obviously animal manures have more effective nutritional effects than chemical fertilizers and also their production requires far less energy consumption, so that the consumption of one ton animal manure has been equal to only 300 MJ ha^{-1} (Ozkan et al., 2004) which is equivalent to only 5 kg nitrogen fertilizer. So the consumption of fertilizers with natural origin helps so much to reduce energy consumption in production system and increase its productivity.

The importance of the use of animal manures with the comparison of barley results in this study is more defined in the study of Mobtaker et al. (2010). The amount of energy input in their study was estimated as 25027.47 MJ ha^{-1} that is 2.5% lesser than the amount of energy input in the studied region. According to the results of Mobtaker et al. (2010), 1490.97 kg ha^{-1} fertilizer has been used on an average, including 84.43 kg nitrogen fertilizer, 76.54 kg phosphate fertilizer and 1330 kg manure fertilizer. The total consumer energy by fertilizers has been estimated equivalent to 6935.36 MJ ha^{-1}. While based on the results of this study in the studied region per each hectare of barley, 164.14 kg fertilizer is used on an average, including 116.31 kg nitrogen and 47.83 kg phosphate, equivalent to 8287.75 MJ energy. The amount of energy inputs for the production of different agricultural crops in Iran has been reported as 81624.96 and 93330.67 MJ ha^{-1} for potato (Hosseinpanahi and Kafi, 2012; Mohammadi et al., 2008), 148836.76 MJ ha^{-1} for greenhouse cucumber (Mohammadi and Omid, 2010), 148020 MJ ha^{-1} for sugarcane (Karimi et al., 2008) and 30285.62 MJ ha^{-1} for kiwi (Mohammadi et al., 2010).

3.2. A comparison of energy efficiency and productivity in the fields of wheat and barley

In Tables 2 and 3, data show that in the studied region, the amount of consumer energy in each hectare of barley was less than each hectare of wheat while the amount of energy output is higher than wheat. This matter indicates that the efficiency of energy consumption in barley fields (1.94) is higher than wheat fields (1.49) in this region (Table 4). The amount of energy efficiency in irrigated fields of wheat in semi-desert and mountain weather conditions has been reported as 1.44 (Giampietro et al., 1992) and 2.40 (Hosseinpanahi and Kafi, 2012), respectively, 2.8 (Canakci et al., 2005) and 3.13 (Shahin et al., 2008) in other parts of the world and between 4.24 and 8.5 in Indian heights (Mani et al., 2007). The energy use efficiency of Iran's products has been reported as 1.25 (Mohammadi et al., 2008), 1.37 for potato (Hosseinpanahi and Kafi, 2012), 0.64 for greenhouse cucumber (Mohammadi et al., 2008), 1.04 for pea (Salimi and Ahmadi, 2010) and in other parts of the world, 4.8 for cotton, 3.8 for corn, 1.5 for sesame (Canakci et al., 2005), 0.8 for tomato (Esengun et al., 2007), 25.75 for sugar beet (Erdal et al., 2007), 1.22 for cherry (Demircan et al., 2006), and 0.74 for cotton (Yilmaz et al., 2005). These observations suggest that different crops have different efficiencies depending on yield degree per kilogram and cultivation area. As it was shown the amount of energy use efficiency of wheat in the studied region is slightly more than other areas in the literature.

Table 4 Energy input–output ratio in wheat and barley production.

Items	Unit	Wheat	Barley
Energy input	MJ ha^{-1}	32492.97	25655.81
Energy output	MJ ha^{-1}	48517.24	49800.87
Energy use efficiency	–	1.49	1.94
Specific energy	MJ.kg^{-1}	17.80	15.14
Energy productivity	kg MJ^{-1}	0.056	0.066
Net energy	MJ ha^{-1}	16024.27	24145.07

Naturally the more suitable climatic condition for crop production in the west of country in comparison to the studied region is the cause of such differences. This matter is also clear in the difference of wheat yield between the studied region and mountain climate (Hosseinpanahi and Kafi, 2012) (4936.29 vs. 1825.41 kg ha^{-1}). In this region, drought, high temperatures, strong winds and soil salinity are the most important factors which reduce the production yield of different crops especially wheat and barley.

The amount of energy efficiency of barley fields was obtained higher than wheat fields respectively 0.066 and 0.056 (Table 4). This means that per each unit of energy consumption in the fields of wheat and barley, 0.056 and 0.066 yield units is , respectively achieved. The amount of energy productivity for different crops has been reported as 0.06 for resources (Giampietro et al., 1992), 0.010 for wheat (Hosseinpanahi and Kafi, 2012), 0.19 for barley (Mobtaker et al., 2010), 1 for tomato (Esengun et al., 2007), 0.06 for cotton (Yilmaz et al., 2005) and 1.53 for sugar beet (Erdal et al., 2007). Energy productivity is an almost better parameter in comparison to energy efficiency to compare two different regions from the point of the production of a plant. Because difference in energy efficiency can be due to difference in energy input and yield, it will make it a bit difficult to judge. But energy productivity index calculates the ratio of production yield per kg into consumer energy, and better shows the difference between the two regions.

The amount of specific energy and net energy in wheat production obtained was 17.80 MJ/kg and 16024.27 MJ ha^{-1}, respectively: in barley 15.14 MJ/kg and 24145.07 MJ ha^{-1}, respectively (Table 4). Kankani et al. have reported the amount of specific energy for wheat 5.24, cotton 11.24, corn 3.88, sesame 16.21, tomato 1.14, melon 0.98, and watermelon 0.07. Specific energy is the reversal of energy productivity hence its lower amounts show that lesser energy is used for the production of each yield unit. So barley production in the studied region is superior to wheat production due to both specific energy and net energy.

3.3. The contribution of different forms of energy in the production of wheat and barley

The percent of direct, indirect, renewable and non-renewable energies in wheat fields obtained were 43.67, 56.32, 19.60 and 80.39, respectively, and these values in the fields of barley were, respectively 45.83, 54.16, 14.60, and 85.39 (Table 5). These results show that the share of renewable energies in the production of wheat and barley is very low in the studied region. This issue is of considerable importance from the ecological

Table 5 Total energy input in the form of direct, indirect, renewable energy for wheat and barley.

Types of energy	Wheat		Barley	
	(MJ ha^{-1})	%[a]	(MJ ha^{-1})	%
Direct energy[b]	14192.32	43.67	11760.20	45.83
Indirect energy[c]	18300.65	56.32	13895.60	54.16
Renewable energy[d]	6369.52	19.60	3745.75	14.60
Non-renewable energy[e]	26123.45	80.39	21910.05	85.39
Total energy input	32492.97		25655.80	

[a] Percentage of total energy input.
[b] Human labor, diesel, electricity and water.
[c] Seeds, chemical fertilizers (NPK), herbicide, pesticide, fungicide and machinery.
[d] Human labor, seeds and water.
[e] Diesel, electricity, chemical fertilizers (NPK), herbicide, pesticide, fungicide and machinery.

perspective, since the source of non-renewable energies which is often fossil fuel is going to run out in near future and relying on these sources is along with large stakes in the future. Certainly this problem is not only dedicated to the studied region and the results of long-term studies in Iran show that agriculture in Iran is very much dependent on non-renewable energies (about 87%) (Beheshti Tabar et al., 2010).

According to the results of other studies in Iran, the share of non-renewable energies in the common production of potato, greenhouse cucumber, sugar cane, barley, and pea has been reported as 24.72 (Mohammadi et al., 2008) and 78.52 (Hosseinpanahi and Kafi, 2012), 89.07 (Mohammadi and Omid, 2010), 90.08 (Karimi et al., 2008), 65.61 (Mobtaker et al., 2010), and 86.7% (Salimi and Ahmadi, 2010), respectively, which are high values. High consumption of non-renewable energies will reduce the energy use efficiency in production systems, because production of chemicals and using of machinery as the main index of common systems require large amounts of energy consumption (Pimentel et al., 1983). According to the report of Moore (2010) to achieve a sustainable system of food production, the amount of energy efficiency and the share of renewable energies should be increased in agricultural systems. Undoubtedly in present time to feed a growing world population is almost difficult and perhaps impossible without the use of non-renewable energies. But considering the environmental impacts of the use of chemicals and fossil fuels, agricultural experts will have no choice but to increase the sustainability in agriculture and the share of renewable energies in the production system. Resorting to decreased plow, using combined devices to reduce car traffic machinery, using natural fertilizers instead of chemical ones, returning remains and resorting to precise agriculture which is based on the exact consumption of inputs, are the ways that the authorities should consider in order to increase the agricultural sustainability.

4. Conclusion

Totally the results of this study showed that barley production in the studied region is superior to wheat production in terms of consumer energy, energy efficiency, energy productivity, specific energy and net energy. But wheat yield (kg ha^{-1}) was estimated as 130 kg more than barley. So it seems that regional weather condition is more suitable for the cultivation of barley. The existence of growing season drought, soil salinity and high temperatures has been the most important climatic characteristic of the studied region, and due to the higher resistance of barley against salinity and drought, energy efficiency of barley looks very natural. Although factors such as agricultural sector's overall policies, appropriate market for buying and selling and region's social-economic characteristics have huge impact on farmer's planting program, based on the results of such studies, we cannot make a final decision in relation to the cultivation of different crops. Wheat has been accounted as the staple diet of Iran and as a strategic product which devotes the highest level of annual cultivation. In addition the current policies of Ministry of Agriculture focus on continuation of wheat production. The last point is that in this study the information related to specific inputs and common operations was examined. Processes such as transport during growing season and other factors exist which were not evaluated due to the lack of appropriate data by the farmers. As a result values of energy use efficiency and productivity in this study have been estimated somewhat beyond the actual amounts.

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