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Assessment energy, energy balance and economic indices of rain fed farming barley Production in North of Iran

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Key words: Barley, energy indices, energy balance indices, Iran, yield.

Abstract

This study analyzed energy use and investigated influences of energy inputs and energy forms on output levels in barley production under rain fed farming in north of Iran. The data were collected from 70 farmers, by questionnaire method. By using of consumed data as inputs and total production as output, and their concern equivalent energy, energy balance and energy indices were calculated. Energy efficiency (energy output to input energy ratio) for seed and straw in this study were calculated 1.91 and 2.04 respectively, showing the affective use of energy in the agro ecosystems barley production. Energy balance efficiency (production energy to consumption energy ratio) for seed and straw in this study were calculated 1.19 and 0.92 respectively, showing the affective use of energy in the agro ecosystems barley production. Results economic analysis showed the benefit to cost ratio in the studied farms was calculated to be 1.13.

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Introduction

Barley *(Hordeum vulgare L.)* is one of the most important cereal crops of Iran and the world. The yield of Barley has increased twofold because energy consumption in Barley production has increased in recently years. The land area under barley production in Iran is about 1675654 ha which produces 3446228 ton of barley. Energy resources are tightly linked with the development of the agriculture sector, both in terms of input costs and output prices. Energy is a particularly significant input in so-called 'industrial' food and farming systems, with farm systems based on synthetic external inputs and producing for the processing or global markets (i.e. several manufacturing stages and long transport distances). This is usually economically advantageous for such systems in times of cheap energy, as has been the situation for several decades. However, this also makes such systems susceptible to rising to energy prices or unstable energy supplies, a drawback that may become important in the future (Ziesemer, 2007).

Energy use in agricultural production has become more intensive due to the use of fossil fuel chemical fertilizers, pesticides, machinery and electricity to provide sub-stantial increases in food production. The vast majority of energy used in crop production is in the form of fossil fuels. Three main components of an on-farm energy balance are energy use, energy output and energy use efficiency (Hoeppner et al., 2005). Energy consumption should account for all energy inputs, including energy to manufacture farm machinery, fertilizer, pesticides and energy embodied in diesel fuels, electricity and seed. The second component of the energy balance is energy output. By all accounts, food energy output will need to increase in the future in order to satisfy a growing human population (Smil, 2005). The final energy component of interest is energy-use efficiency. Energy use is one of the key indicators for developing more sustainable agricultural practices one of the principal requirements of sustainable agriculture. Energy in agriculture is important in terms of crop production and agro processing for value adding. Human, animal and mechanical energy is extensively used for crop production in agriculture. Energy requirements in agriculture are divided into two groups being direct and indirect. Direct energy is required to perform various tasks related to crop production processes such as land preparation, irrigation, intercultural, threshing, harvesting and transportation of agricultural inputs and farm produce (Singh, 2000). It is seen that direct energy is directly used at farms and on fields. Indirect energy, on the other hand, consists of the energy used in the manufacture, packaging and transport of fertilizers, pesticides and farm machinery. As the name implies, indirect energy is not directly used on the farm. Major items for indirect energy are fertilizers, seeds, machinery production and pesticides. Calculating energy input in agricultural production is more difficult in comparison to the industry sector due to the high number of factors affecting agricultural production (Yaldiz et al., 1993). However, considerable studies have been conducted in different countries on energy use in agriculture (Baruah and Bhattacharya, 1995; Thakur and Mishra, 1993).

The main aim of this study was to determine energy use in barley production, to investigate the efficiency of energy consumption and to make an energy balance and energy indices analysis of barley under rain fed farming in Guilan province of Iran.

Materials and methods

Materials

Data were collected from 72 farms by used a face to face questionnaire method during 2011 year in Guilan province (north of Iran). The Location of studied region in north of Iran was presented in figure 1. The random sampling of production agro ecosystems was done within whole population and the size of each sample was determined by using bottom Equation (Kizilaslan, 2009):

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

In the formula, 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.

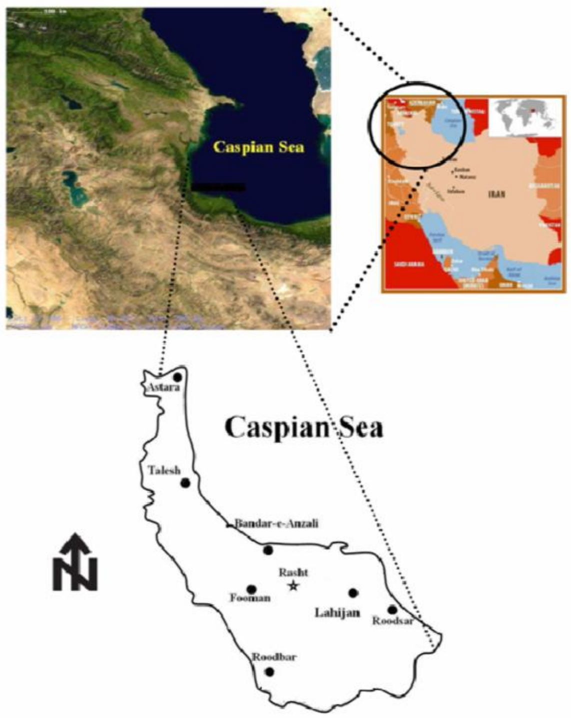

Fig. 1. Location of the study area.

Method to calculate the energy

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 was used for estimation (Hulsbergen et al., 2005; Ma et al., 2008; Mandel et al., 2002; Mohammadi and Omid, 2010; Mohammadi et al., 2008, Moradi and azarpour, 2011; Ozkan et al, 2003; Ozkan et al, 2003; Taheri et al., 2010; Yilrmnaz et al., 2005). Firstly, the amounts of inputs used in the production of barley were specified in order to calculate the energy equivalences in the study. Energy input include human labor, machinery, diesel fuel, chemical fertilizers, poison fertilizers and seed and output yield include grain yield of barley. The energy use efficiency, energy specific, energy productivity and net energy gain were calculated according to bottom equations (Hulsbergen et al., 2005; Ma et al., 2008; Mandel et al., 2002; Mohammadi and Omid, 2010; Mohammadi et al., 2008, Moradi and azarpour, 2011; Ozkan et al, 2003; Ozkan et al, 2003; Taheri et al., 2010; Yilrmnaz et al., 2005).

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

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

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

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

The input energy was divided into direct, indirect, renewable and non-renewable energies (Kizilaslan, 2009; Samavatean et al., 2011). Direct energy covered human labor and diesel fuel, used in the barley production while indirect energy consists of seed, chemical fertilizers, poison fertilizers, and machinery energy. Renewable energy consists of human labor and seed and nonrenewable energy includes chemical fertilizers, poison fertilizers and machinery energy.

In order to indicators of energy balance, Basic information on energy inputs were entered into Excel spreadsheets and then energy equivalent were calculated according table 2 (Abdollahpour and Zaree, 2010; Taghavi et al., 2007). By using of consumed data as inputs and total production as output, and their concern equivalent energy, indicators of energy balance were calculated. Energy input include human labor, machinery, diesel fuel, chemical fertilizers, poison fertilizers, machinery depreciation for per diesel fuel and seed and output yield include grain yield and straw yield of barley.

Method to calculate the economic analysis

In the last part of the study, the economic analysis of barley production was investigated. Net profit, gross profit and benefit to cost ratio was calculated. The gross value of production, net return and benefit to cost ratio were calculated using the following equations (*Mohammadi et al., 2008)*:

$$\text{Gross value of production } (\$\ ha^{-1}) = \text{Yield } (kg\ ha^{-1}) \times \text{Sale price } (\$\ kg^{-1})$$

$$\text{Net return } (\$\ ha^{-1}) = \text{Gross value of production } (\$\ ha^{-1}) - \text{Total cost of production } (\$\ ha^{-1})$$

$$\text{Productivity } (kg/\$) = \frac{\text{Yield } (kg/ha)}{\text{Total cost of production } (\$/ha)}$$

$$\text{Benefit to cost ratio} = \frac{\text{Gross value of production } (\$\ ha^{-1})}{\text{Total cost of production } (\$\ ha^{-1})}$$

Result and Discussion

Analysis of input–output energy use in barley production

The inputs used in barley production and their energy equivalents and output energy equivalent are illustrated in table 1. About 138 kg seed, 360 h human labor, 12 h machinery power and 110 L diesel fuel for total operations were used in agro ecosystems barley production on a hectare basis. The use of nitrogen fertilizer, phosphorus and potassium were 38, 11 and 6 kg per one hectare respectively. The total energy equivalent of inputs was calculated as 13050 MJ/ha. The highest shares of this amount were reported for diesel fuel (47.47%), nitrogen fertilizer (20.44%) and seed (16.57%) respectively. The energy inputs of potassium chemicals (0.51%), Phosphorus chemicals (1.08%), and poison (2.76%) were found to be quite low compared to the other inputs used in production (Table 1). The average seed yield of barley was found to be 1693 kg/ha and its energy equivalent was calculated to be 24880 MJ/ha (Table 1). The average straw yield of barley was found to be 2133 kg/ha and its energy equivalent was calculated to be 26663 MJ/ha (Table 1).

Azarpour (2012) of barley production under watered farming in north of iron showed that the rates of other inputs in the total amount of energy such as diesel fuel, nitrogen fertilizer, seed, water, potassium chemicals, phosphorus chemicals, and chemical poison were 37.36%, 26.51%, 13.62%, 9.84%, 0.67%, 1.02%, and 2.17%, respectively. Total energy input and total energy output in this research were calculated 16579 MJ/ha and 44762 MJ/ha respectively.

Evaluation indicators of energy in barley production

The energy use efficiency, energy production, energy specific, energy productivity, net energy gain, and intensiveness of barley seed production were shown in table 3. Energy efficiency (energy output-input ratio) in this study was calculated 1.91, showing the affective use of energy in the agro ecosystems barley production. Energy specific was 7.71 MJ/kg this means that 7.71 MJ is needed to obtain 1 kg of barley seed. Energy productivity calculated as 0.13 Kg/MJ in the study area. This means that 0.13 kg of output obtained per unit energy. Net energy gain was 11831 MJ/ha.

The energy use efficiency, energy production, energy specific, energy productivity, net energy gain, and intensiveness of barley straw production were shown in table 3. Energy efficiency (energy output-input ratio) in this study was calculated 2.04 showing the affective use of energy in the agro ecosystems barley production. Energy specific was 6.12 MJ/kg this means that 6.12 MJ is needed to obtain 1 kg of barley straw. Energy productivity calculated as 0.16 Kg/MJ in the study area. This means that 0.16 kg of output obtained per unit energy. Net energy gain was 13613 MJ/ha.

Yousefi and Gazvineh (2011) analyzed the energy indices of barley production in Kangavar, Iran, and found that the results showed that total energy input and output in these production systems were 12400 and 43600 MJIha, respectively. The highest share of input energy was recorded for diesel fuel (53%) which is a nonrenewable resource. Energy use efficiency and energy productivity of rained barley production agro ecosystems were 3.52 and 0.11 kg/MJ respectively. Total mean energy input as biologic and industrial forms were 24 and 76%, respectively. Thus, application high consumption of diesel fuel in agro ecosystems can be reduced the energy use efficiency by increasing input energy.

This means that the amount of output energy is more than input energy and production in this situation is logical. Direct, indirect, renewable and non-renewable energy forms used in barley production are also investigated in table 3. The results show that the share of direct input energy was 52.87% (6900 MJ/ha) in the total energy input compared to 47.13% (6150 MJ/ha) for the indirect energy. On the other hand, nonrenewable and renewable energy contributed to 78.02% (10182 MJ/ha) and 21.98% (2868 MJ/ha) of the total energy input, respectively. Azarpour[2] of barley production under watered farming in north of iron showed that share of direct input energy was 51.46% (8532 MJ/ha) in the total energy input compared to 48.54% (8047 MJ/ha) for the indirect energy. Also, share of renewable input energy was 27.72% (4596 MJ/ha) in the total energy input compared to 72.28% (11982 MJ/ha) for the non-renewable energy. In this research that Energy use efficiency, energy productivity, specific energy and net energy gain were 2.70, 0.18 kg/MJ, 5.44 MJ/kg, 28183 MJ/ha respectively.

Table 1. Amounts of inputs and output and their equivalent energy from calculated indicators of energy.

Parameter	Unit	Quantity per Hectare	Energy equivalents	Total energy equivalents	Percent
		Inputs			
Human labor	h/ha	360	1.96	705.60	5.41
Machinery	h/ha	12	62.7	752.40	5.77
Diesel fuel	L/ha	110	56.31	6194.10	47.47
Nitrogen	Kg/ha	38	69.5	2667.90	20.44
Phosphorus	Kg/ha	11	12.44	140.34	1.08
Potassium	Kg/ha	6	11.15	66.90	0.51
Poison	L/ha	3	120	360	2.76
Seed	Kg/ha	138	14.7	2162.36	16.57
		Output			
Grain yield	Kg/ha	1693	14.7	24880	100
Straw yield	kg/ha	2133	12.5	26663	100

Table 2. Amounts of inputs and their equivalent energy from calculated indicators of energy balance.

Parameter	Unit	Quantity per Hectare	Energy equivalents	Total energy equivalents	Percent
		Inputs			
Human labor	h/ha	360	500	180000	3.96
Machinery	h/ha	12	90000	1080000	23.77
Diesel fuel	L/ha	110	9237	1016070	22.37
Nitrogen	kg/ha	38	17600	675611.20	14.87
Phosphorus	kg/ha	11	3190	35987.03	0.79
Potassium	kg/ha	6	1600	9600	0.21
Poison	L/ha	3	27170	81510	1.79
Seed	kg/ha	138	4200	578466	12.73
Depreciation for per diesel fuel	L	92.4	9583	885469.20	19.49

Table 3. Analysis of energy indices in barley production.

Item	Unit	Barley
	Seed	
Yield	Kg/ha	1693
Input energy	Mj/ha	13050
Output energy	Mj/ha	24880
Energy use efficiency	-	1.91
Energy specific	Mj/Kg	7.71
Energy productivity	Kg/Mj	0.13
Net energy gain	Mj/ha	11831
Direct energy	Mj/ha	6900 (52.87%)
Indirect energy	Mj/ha	6150 (47.13%)
Renewable energy	Kg/Mj	2868 (21.98%)
Nonrenewable energy	Mj/ha	10182 (78.02%)
	Straw	
Yield	Kg/ha	2133
Input energy	Mj/ha	13050
Output energy	Mj/ha	26663
Energy use efficiency	-	2.04
Energy specific	Mj/Kg	6.12
Energy productivity	Kg/Mj	0.16
Net energy gain	Mj/ha	13613
Direct energy	Mj/ha	6900 (52.87%)
Indirect energy	Mj/ha	6150 (47.13%)
Renewable energy	Kg/Mj	2868 (21.98%)
Nonrenewable energy	Mj/ha	10182 (78.02%)

Analysis of energy balance in barley production

The inputs used in barley production and their energy equivalents and output energy equivalent are illustrated in table 2. About 138 kg seed, 360 h human labor, 12 h machinery power and 110 L diesel fuel for total operations were used in agro ecosystems barley production on a hectare basis. The use of nitrogen fertilizer, phosphorus and potassium were 38, 11 and 6 kg per one hectare respectively. Also 92.4 L depreciation power in this system was used. The total energy equivalent of inputs was calculated as 4542713 MJ/ha. The highest shares of this amount were reported for machinery (23.77%), diesel fuel (22.37%) and depreciation for per diesel fuel (19.49%) respectively. The energy inputs of potassium chemicals (0.21%), Phosphorus chemicals (0.79%), and poison (1.79%) were found to be quite low compared to the other inputs used in production (Table 2).

The highest percent of compositions (65%), Amounts (1100.15 kg/ha), production energy (4400604 kcal/ha) and production energy to consumption energy ratio (0.97) in barley seed were obtained from starch as compared with protein and fat, The lowest consumption energy to production energy ratio (0.15) in barley seed was obtained from starch as compared with Protein and fat (Table 4).

Table 4. Analysis of energy balance indices in barley production.

			Seed			
Item	Percent of compositions	Energy per gram (kcal)	Amounts (kg/ha)	Production energy (kcal/ha)	Production energy/ consumption energy	Consumption energy/ production energy
Protein	10	4	169.25	677016.00	0.15	6.71
Fat	2.3	9	38.93	350355.78	0.08	12.97
Starch	65	4	1100.15	4400604.00	0.97	1.03
Item	Yield (kg/ha)	Consumption energy (kcal/ha)	Production energy (kcal/ha)	Energy per unit (kcal)	Production energy/ consumption energy	Consumption energy/ production energy
	1693	4542713	5427976	3207	1.19	20.71
			Straw			
Item	Percent of compositions	Energy per gram (kcal)	Amounts (kg/ha)	Production energy (kcal/ha)	production energy/ consumption energy	Consumption energy/ production energy
Protein	1.9	4	40.53	162108	0.04	28.02
Fat	1.7	9	36.26	326349	0.07	13.92
Starch	43.3	4	923.59	3694356	0.81	1.23
Item	Yield (kg/ha)	Consumption energy (kcal/ha)	Production energy (kcal/ha)	Energy per unit (kcal)	Production energy/ consumption energy	Consumption energy/ production energy
	2133	452713	4182813	1961	0.92	43.17

Table 5. Economic analysis of barley production.

Cost and return components	
Yield (kg/ha)	1693
Sale price ($/kg)	0.25
Gross value of production ($/ha)	423.25
Total cost of production ($/ha)	375
Net return ($/ha)	48.25
Productivity (kg/$)	4.51
Benefit to cost ratio	1.13

The highest percent of compositions (43.3%), Amounts (923.59 kg/ha), production energy (3694356 kcal/ha) and production energy to consumption energy ratio (0.81) in barley straw were obtained from starch as compared with protein and fat, The lowest consumption energy to production energy ratio (0.04) in barley straw was obtained from starch as compared with Protein and fat (Table 4).

Azarpour (2012) of barley production under watered farming in north of iron showed that the rates of other inputs in the total amount of energy such as Depreciation for per diesel fuel, diesel fuel, nitrogen fertilizer, seed, water, potassium chemicals, phosphorus chemicals, and chemical poison were 16.23%, 18.63%, 20.40%, 11.08%, 7.98%, 0.29 %, 0.80%, and 1.49%, respectively. Azarpour[2] of barley production under watered farming in north of iron showed that The highest percent of compositions (65%), amounts (1979.25 kg/ha), production energy (7917000 kcal/ha) and production energy to consumption energy ratio (1.45) in barley seed were obtained from starch as compared with protein and fat, The lowest consumption energy to production energy ratio (0.69) in barley seed was obtained from starch as compared with Protein and fat

Evaluation indicators of energy balance in barley production

The consumption energy (4542713 kcal/ha), production energy (5427976 kcal/ha), energy per unit (3207 kcal), production energy to consumption energy ratio (1.19) and consumption energy to production energy ratio (20.71) of barley seed production were shown in table 4. Energy balance efficiency (production energy to consumption energy ratio) in this study was calculated 1.19, showing the affective use of energy in the agro ecosystems barley seed production.

The consumption energy (4542713 kcal/ha), production energy (4182813 kcal/ha), energy per unit (1961 kcal), production energy to consumption energy ratio (0.92) and consumption energy to production energy ratio (43.17) of barley straw production were shown in table 4. Energy balance efficiency (production energy to consumption energy ratio) in this study was calculated 0.92, showing the affective use of energy in the agro ecosystems barley seed production.

Taghavi et al. (2007) analyzed the energy balance indices of barley production in Iran (Azarbijan province), and found that energy value of used inputs of this type cultivation was 5923739.4 kcal/ha and output (production) energy of value of barley grain yield and straw were 4096000 kcal/ha and 3548160 kcal/ha, respectively. Also, energy efficiency value was 1.222 and that of grain and straw separately was 0.69 and 0.53, respectively. Results showed that the highest input energy was due to machinery using, nitrogen fertilizer and fuel; and lowest ones were related to human muscle power and herbicide.

Economic analysis of barley production

The cost of the inputs used in the production of barley and the gross value of production were calculated and shown in table 5. In the research area, the barley sale price (0.25 $/kg), gross value of production (423.25 $/ha), total cost of production (375 $/ha), Productivity (4.51 kg/$) and net return (48.25 $/ha) were calculated. Results showed the benefit to cost ratio in the studied farms was calculated to be 1.13. Therefore barley production was a cost effective business based on the data of the 2010 season of barley production under rain fed farming in north of Iran. This means economic success increased by using high level of farming technology.

Conclusion

Finally Energy use is one of the key indicators for developing more sustainable agricultural practices one of the principal requirements of sustainable agriculture, Therefore energy management in systems barley production should be considered an important field in terms of efficient, sustainable and economical use of energy. Using of combination machines, doing timely required repairs and services for tractors and representing a fit crop rotation are suggested to decrease energy consuming for dry farming barley in Guilan province.

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