World Applied Sciences Journal 13 (6): 1375-1379, 2011
ISSN 1818-4952

Diesel Fuel Consumption and Energy Use Efficiency of Rainfed Barley Production Systems in Iran

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Abstract: The aim of this study was conducted to essay effects of diesel fuel application on energy use efficiency in the Barley production agroecosystems in Kangavar county, western Iran in autumn 2010. Data was collected by using questionnaires and face to face interview with 50 farmers. The results showed that total energy input and output in these production systems were 12400 and 43600 MJ/ha, 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 rainfed barley production agroecosystems 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 agroecosystems can be reduced the energy use efficiency by increasing input energy.

Key words: Diesel fuel • Barley • Biologic energy • Energy use efficiency

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 production of Barley is about 3446227.3 tons/year in Iran [1]. Kangavar County is an important agricultural rejoin in Iran, this county has a high cereal growing potential. Barley, chickpea, wheat, corn and alfalfa are dominant products grown in this county. Energy use in agriculture has been increasing in response to increasing population, limited supply of arable land and a desire for higher standards of living [2]. The global economy has depended largely upon such fossil energies as coal, petroleum and natural gas. These energy sources have been consumed throughout the world, seriously degrading the Earth's environment [3, 4]. Fuel consumption is one of the important inputs energy [5] in agriculture systems, which must be put under close managerial supervision in order to optimize the amount of energy consumed.

In order to sustain agricultural production, effective energy use in agriculture is required, since it provides financial savings, preservation of fossil resources [6]. Also efficient use of energy consumed is an important indicator of agricultural sustainability [7]. Recently, environmental problems resulting from energy production, conversion and utilization have caused increased public awareness in all sectors of 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 [8].However, excessive application of diesel fuel would result in increasing energy consumption in production systems. This leads to the reduction of energy use efficiency and causes environmental challenges, [9] including, CO_2 Emissions, air pollution and global warming thereby affecting human health. Meany researchers have studied energy use for agriculture production in different rejoins [10-12]. Nevertheless, no one has worked on the role of diesel fuel input in agricultural production.

The objectives of the present study was to analyze energy flow, examine energy use efficiency and estimated shear of diesel fuel energy input in the total process production in rainfed barley agroecosystems. This can exert positive effects on managing agroecosystems in a way to realize sustainability in agriculture.

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MATERIAL AND METHODS

Site of Study: In this study, wheat growers were surveyed in Kangavar, Iran. The Kangavar region is located in the western of Iran, within 33° 4' and 35° 17' north latitude and 45°25' and 48° 6' east longitudes. The climate of this rejoin [in 1989-2009 period) was characterized by an annual average rainfall of 403 mm, distributed 44.3% in winter and 55.7% spring and fall. The annual average temperature is 14.2° C, with a monthly maximum of 27° C in July and a minimum of-1 °C in January.

Data Gendering: Data was collected employing questionnaire via face to face interviews with 50 farmers in summer 2009 in Kangavar County. The Farmers were selected randomly among the farmers of this rejoin. Some other information was collected from regional agricultural departments.

Data Analysis: The data included hours or amount of inputs used from effective energy sources: human for different operations (land preparing, irrigation, harvest and post harvest), fertilizers (nitrogen, phosphate and potassium), transportation and yield as output by question gendering. The data was transformed to energy term by appropriate energy equivalent factors (Table 1). In this studied rejoin Massey Ferguson 285 tractor, a tractor with 75 hp was used in most operations. Accordingly, for estimated consumed diesel fuel in tractor and other agricultural machinery were calculated using of equation (1 and 2) [5];

$$Q_{avg} = 0.06 \times 0.73 \times P_{pto} \quad (1)$$

Where Q_{avg} is the average gasoline consumption of the machine L/h, MJ ha^{-1}; and P_{pto} is the maximum PTO power of machine, KW.

$$\text{Fuel Energy (MJ/ha)} = Q_{avg}\ \text{(L/h)} \times \text{Fuel energy equivalent (MJ/L)} \quad (2)$$

Energy use efficiency, energy productivity, Net energy and diesel fuel energy ratio were determined applying standard equations 3-6 [17, 19 and 20];

$$\text{Energy use efficiency} = (\text{output energy [MJha}^{-1}]) / (\text{input energy [MJha}^{-1}]) \quad (3)$$

$$\text{Energy productivity} = (\text{Grain yield[Kgha}^{-1}])/(\text{input energy [Mjha}^{-1}]) \quad (4)$$

$$\text{Net energy} = \text{output energy (MJha}^{-1})\text{-input energy (MJha}^{-1}) \quad (5)$$

$$\text{Diesel fuel energy ratio (\%)} = (\text{input energy from diesel fuel [MJha}^{-1}]) / (\text{Total input energy [MJha}^{-1}]) \quad (6)$$

The input energy was divided into biologic and industrial energies [21]: biologic energy consists of human labor and seeds and industrial energy includes diesel fuel, pesticide, fertilizers and machinery.

RESULTS AND DISCUSSION

Source Wise Energy Consumption for Irrigated and Rain-fed Canola Production: The amount of energy input and output in barley production under rainfed production systems is presented in Table 2. In these agroecosystems, about 18.02h human labuor and 7.5h machinery power and 115.86L diesel fuel for total operations were used of barley production on a hectare basis. The use of nitrogen fertilizer and phosphorus were 30.56 and 25.3 kg per one hectare respectively. Also in these systems 200 Kg seed was used. The total energy equivalent of all inputs was calculated as 12416.62 MJha^{-1}. The highest share, of this amount was reported for diesel fuel (52.4%), seed (23.6%) and nitrogen fertilizer (16.2%) respectively. Similar results have been reported in literature according to which the energy input of diesel fuel has the biggest share of the total energy input in barley production such as greenhouse vegetable [18], cucumber [22] and apple [17] rainfed wheat [12].

Table 1: Energy equivalents of input and output in agricultural systems

Equipment /inputs	Unit	Energy equivalents	Reference
A. Inputs			
1.Human Labuor	H	1.96	[11,13]
2.Machinery	h	62.7	[6,14]
3.Diesel fuel	L	51.33	[11,15]
4. Chemical Fertilize			
(a) Nitrogen	Kg	66.14	[16,17]
(b) Phosphate(P2O5)	Kg	12.44	[16,17]
5. Chemical	kg	120	[6,11]
6.Seed	Kg	14.7	[14,18]
B. Output			
1. grain yield	Kg	14.7	[14,18]
2.straw	Kg	12.5	[14,18]

Table 2: Inputs and outputs Energy in rainfed barely production systems

Equipment /inputs(unit)	Quantity per unit area (ha)	Total energy equivalents	% Of Total
A. Inputs			
1.Human Labuor (h)	18.02	35.32	0.28
2.Machinery(h)	7.5	470.25	3.77
3.Diesel fuel(L)	115.86	6524.08	52.4
4. Chemical Fertilizer(kg)			
(a) Nitrogen	30.56	2021.24	16.2
(b) Phosphate(P2O5)	25.3	314.73	2.53
5. Chemical (kg)	1.3	156	1.25
6.Seed(kg)	200	2940	23.6
Total energy input		12416.62	100
B. Output			
1. grain yield(kg)	1335	19624.5	44.95
2.straw(kg)	3256.1	24031.75	55.05
Total energy output		43656.25	100

Table 3: Different form and indicators of energy use in barley production systems

Indicators	Unit	Quantity for rainfed wheat
Inputs energy	$MJha^{-1}$	12416.62
Output energy	$MJha^{-1}$	43656.25
Grain yield	$Kgha^{-1}$	1335
Straw yield	$Kgha^{-1}$	3256.1
Energy use efficiency		3.51
Energy productivity	$KgMJ^{-1}$	0.11
Net energy	$MJha^{-1}$	31239.63
Diesel fuel energy ratio a	%	52.5
Biological energy b	$MJha^{-1}$	2975.32(23.96%)
Industrial energy c	$MJha^{-1}$	9486.3(76.04%)

[a] Diesel fuel energy ratio = input energy of diesel fuel consumed/ total energy input

[b] Includes human labuor, seeds. [c] Includes diesel, pesticides, fertilizers, machinery.

In rainfed barley agroecosystems investigated, the average grain yield and straw were 1335 and 3256.1 kg ha^{-1} and calculated total energy output were 19624.5 and 24031.75 MJ ha^{-1}. In total amount of output energy in rainfed barley agroecosystems in Kangavar region was 43656.25 MJ ha^{-1}. This amount for wheat, rice and barely were 100346.4, 161586and 64314$MJha^{-1}$ [20] respectively; and for rainfed and irrigated wheat production systems were 35427 and 50127 $MJha^{-1}$[23].

Different Form and Indicators of Energy Use in Producing Barley: Table 3 present the different form and indicators of energy use in Barley production systems. In this study energy use efficiency, energy productivity, net energy and diesel fuel energy ratio were evaluated. Energy use efficiency (output energy/ input energy) was determined as 3.51. Several authors have reported the energy use efficiency for different crops such as 2.86 for barley production in Iran [14], 1.54 for kiwifruit in Iran [11], 2.80 for maize production in Turkey [24], 0.32, 0.19, 0.31 and 0.23, for tomato, pepper, cucumber and eggplant greenhouse vegetables, respectively, in Turkey [25]. The energy productivity and net energy were found to be 0.11$kgMJ^{-1}$and31239.63 $MJha^{-1}$, respectively. Ghasemi Mobtaker *et al. et al.* [14] reported the energy productivity and net energy as 0.19 kg MJ^{-1} and 4649790$MJha^{-1}$, respectively, for barley production in Iran

Diesel fuel energy ratio of barley production systems was calculated as 52.5% which illustrate more input energy per diesel fuel by agricultural machines. Higher ratio of Diesel fuel energy ratio may imply higher Diesel fuel footprint [20]. Also, this research indicates that the total energy input used was mainly dependent on industrial energy form (Table 3). As shown in the table, the industrial form of energy input in barley agroecosystems was 76.04% while the biological form of energy input in the agroecosystems studied was 23.96%.

Several researches have shown that the share of Industrial energy input is more than biological energy input in production of different agricultural products [13, 17 and 22]. The high rate of Industrial energy input indicates an intensive use of diesel fuel consumption in these agroecosystems as far as the total operation by agricultural machines is concerned.

CONCLUSION

In this study, energy consumption for input and output energies in Barley production was investigated in Kangavar County of western Iran. Data were collected from 50 farms which were selected based on random sampling method. Total energy input and output in barely production were 12416.62 and 43656.25 MJ/ha. Diesel fuel was major energy inputs with 52.4% of total input energy, in barley agroecosystems. Energy use efficiency and energy productivity were calculated, 3.51 and 0/11 kg/MJ, respectively. Also amount of diesel fuel energy ratio in this study was 52.5%. Industrial energy was76% total input energy that concluded barely production needs to improve the efficiency of energy consumption in production and to applying of biological energy resource. Therefore Better use of diesel fuel especially gasoil in Barley agroecosystems can be saved diesel fuel, reduced air pollution and improved energy use efficiency by replaced old machines/equipment with new ones to avoid energy wastage from leakages and stabilize energy supply.

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