Available online at www.pelagiaresearchlibrary.com

Pelagia Research Library

European Journal of Experimental Biology, 2014, 4(3):234-239

ISSN: 2248 –9215
CODEN (USA): EJEBAU

Study on energy balance, energy forms and greenhouse gas emission for wheat production in Gorve city, Kordestan province of Iran

Mohamad Reza Moghimi*[1], Mohsen Pooya[2] and Ahmad Mohammadi[3]

[1]*Young Researchers Club, Ghorveh Branch, Islamic Azad University, Ghorveh, Iran*
[2]*Department of Mechanization Engineering, University of Tehran, Science and Research, Khuzestan, Iran*
[3]*Department of Mechanization, Arak Branch, Iran*

ABSTRACT

The main objectives of this research were to investigate the energy use patterns, examine the greenhouse gas emission and analyze the energy input–output in cultivation of wheat in Gorve city, Kordestan province of Iran. For this purpose, the data on 40 wheat production farms in Gorve city were collected and analyzed. The results indicated that total input energy of 42998.44 MJha^{-1} was consumed for wheat production. Electricity and total chemical fertilizers were amongst the highest input energies for wheat production. The lowest share of energy consumption belonged to human labour and biocide. The energy productivity was estimated to be 0.17 kg MJ^{-1}. The ratio of output energy to input energy was approximately 2.27. In this research, the highest value of GHG emission belonged to diesel fuel with (201.34 kg CO_2eq ha^{-1}) of total emission and followed by Chemical fertilizer with (101.3 and 6.99 CO_2eq ha^{-1}for Nitrogen and Phosphate). The least amount of GHG emissions producer input in wheat production was pesticides with amount of 11.47 CO2eqha^{-1} of total GHG emissions. Using chemical fertilizer (especially nitrogen) more than need led to high amount of GHG emission. Moreover, soil and water pollutions are the results of using high amounts of chemical fertilizer which makes agriculture environment unfriendly.

Key words: GHG emission, Wheat production, Energy in agriculture, Energy ratio

INTRODUCTION

In order to maximize the efficiency of modern agricultural technology to farms in a target region, the farming system of the region should be first characterized, especially to identify possible resource constraints and to capture the diversity of farming systems [32]. Currently, agricultural operations have to adapt to a more competitive environment and consequently, use new intelligent technologies [19]. Hydroponics and greenhouse production are the way of obtaining profitable crops [22]. A sustainable crop production system requires keeping a high-quality harvest, while keeping energy and raw material consumption low. The agricultural sector is an important energy consumer. Farmers have an option for reducing energy use by investing in intelligent systems [12]. Wheat is one of the top three most producing cereals in the world, ranks the second place after corn and followed by rice. Winter wheat is one of the most major crops that have been planted in Iran. Planted area was 12.96 million ha in 2005-2006. Cereal planted area was 9.37 (72.28%) million ha, which includes wheat (73.24%), barely (16.73%), paddy (6.73%) and corn (3.12%).Total harvested cereals in 2005-2006 were 22.40 million tons of which wheat recorded of 65.47% followed by barely (13.20%), paddy (11.66%) and corn (9.67%) respectively [3]. At least, 40% of Iran's wheat is dry with an average yield of only 0.8 tons ha^{-1}. Even in irrigated farms the average yield of wheat rarely exceeds three tons ha^{-1}, which is low in comparison to the world standards [2]. Global warming is one of the most important issues in recent century. Global warming is the continuing rise in the average temperature of Earth’s atmosphere and oceans and is caused by increased concentrations of greenhouse gases in the atmosphere, resulting from human activities such as deforestation and burning of fossil fuels. There is scientific agreement that global warming poses one of the major environmental challenges in the future. While the bulk of the so called greenhouse gases (GHG) originate from fossil fuel consumption. Burning fossil fuels results in the emission of carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) that act as barriers to thermal radiation and prevent it from leaving the Earth's atmosphere, the so-called greenhouse effect [10]. As a consequence, the global mean temperature has increased during the past 100 years and raised concerns over global warming and uncertainty over future impacts on the climate [23]. A reduction in greenhouse gas emissions by minimizing the quantity of fossil fuels burnt is therefore essential to arrest global warming. Although the increased use of agricultural inputs in modern farming has resulted in an increase in the energy inputs for fertilizer and crop protection chemicals, higher yields have increased the energy output per unit area and per unit of input [23]. Cetin and vardar [5] studied on differentiation of direct and indirect energy inputs in agro industrial production of tomatoes. Erdal et al [7] have studied on energy consumption and economical analysis of sugar beet production. Damirjan et al [6] studied the energy and economic analysis of sweet cherry production. Alam, et al [1] studied the energy flow in agriculture of Bangladesh for a period of 20 years. Satori et al [26] studied the comparison of energy consumption on two farming system of conservation and organic in Italy. In recent years, Data Envelopment Analysis as a non-parametric method has become a central technique in productivity and efficiency analysis applied in different aspects of economics and management sciences. Although within this context, several researchers have focused on determining efficiency in agricultural units and various products ranging from cultivation and horticulture to aquaculture and animal husbandry for example: surveying the quantity of inefficient resources which are used in cotton production in Panjab in Pakistan [27], reviewing energy performance used in paddy production [21] surveying improving energy efficiency for garlic production [25] evaluation and development of optimum consumption of energy resources in greenhouse cultivation in Tehran province [9] A further comparative review of frontier studies on agricultural products can be found in [20, 28, 29, 30].

The main objectives of this research were to investigate the energy use patterns, examine the greenhouse gas emission and analyze the energy input–output in cultivation of wheat in Gorve city, Kordestan province of Iran.

MATERIALS AND METHODS

The research was done in Gorve city, Kordestan province of Iran which is located in the west of Iran. The data used in this study, has been collected form 40 wheat farms in Gorve city. A simple random sampling method was used to determine survey volume and the farms were chosen randomly from study region. The data included amount of inputs used in wheat production such as human labor, machinery, diesel fuel, fertilizers, biocide, electricity (for irrigation) and seeds, and the yield as an output. The inputs and output were transformed to energy term by multiply their Quantity per unit area by the coefficient of energy equivalent. For this propose the energy coefficient of previous study was used (Table 1). The inputs energy equivalents used in wheat production with output energy rates are shown in the Table 2.

Table 1 Energy equivalent of inputs and output in agricultural production

Inputs	Unit	Energy equivalents	Reference
A. Inputs			
1. Human Labor	h	1.96	(Mobtaker et al., 2010)
2. Machinery	h	64.80	(Kizilaslan, 2009)
3. Diesel fuel	l	56.31	(Heidari and Omid, 2011)
4. Total fertilizer	kg		
(a) Nitrogen	kg	66.14	(Rafiee et al., 2010)
(b) Phosphate (P_2O_5)	kg	12.44	(Mobtaker et al., 2010)
(c) Calcium	kg	8.8	(Pimentel, 1980)
(d) Farmyard manure	kg	0.3	(Heidari et al., 2011)
5. Biocides	kg	120	(Mobtaker et al., 2010)
6. Electricity	kWh	11.93	(Mobtaker et al., 2010)
7. Seed	kg	14.7	(Ozkan et al., 2007)
B. Output			
1. Grain wheat	kg	14.7	(Ozkan et al., 2007)
2. Straw	kg	9.25	(Tabatabaeefar et al. 2009)

Based on the energy equivalents of the inputs and output (Table 1), the energy ratio (energy use efficiency), energy productivity, specific energy and net energy gain were calculated [18]:

$$\text{Energy use efficiency} = \frac{\text{Energy output (MJ ha}^{-1})}{\text{Energy input (MJ ha}^{-1})} \quad (1)$$

$$\text{Energy productivity} = \frac{\text{Total output (kg ha}^{-1})}{\text{Energy input (MJ ha}^{-1})} \quad (2)$$

$$\text{Specific energy} = \frac{\text{Energy input (MJ ha}^{-1})}{\text{Total output (kg ha}^{-1})} \quad (3)$$

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

The energy use efficiency is one of the indices that show the energy efficiency of agriculture. In particular, this ratio, which is calculated by the ratio of input fossil fuel energy and output food energy, has been used to express the ineffectiveness of crop production in developed countries [31]. An increase in the ratio indicates improvement in energy efficiency, and vice versa. Changes in efficiency can be both short and long term, and will often reflect changes in technology, government policies, weather patterns, or farm management practices. By carefully evaluating the ratios, it is possible to determine trends in the energy efficiency of agricultural production, and to explain these trends by attributing each change to various occurrences within the industry [31].

The amounts of GHG emission from inputs per hectare were calculated by using CO_2 emission coefficient of agricultural inputs (Table 2). The amount of produced CO_2 was calculated by multiplying the input application rate (diesel fuel, chemical fertilizer, chemicals and Machinery) by its corresponding emission coefficient that is given in Table 2.

Table 2 Greenhouse gas (GHG) emission coefficients of agricultural inputs

Inputs	Unit	GHG Coefficient (kg CO_{2eq} unit^{-1})	Reference
Machinery	MJ	0.071	Taki et al, 2012b
Diesel fuel	L	2.76	Taki et al, 2012b
Chemical fertilizers	kg		
(a) Nitrogen	kg	1.3	Zhang et al, 2009
(b) Phosphate	kg	0.2	Zhang et al, 2009
(c) Potassium	kg	0.2	Zhang et al, 2009
Pesticides	kg		
(a) Herbicide	kg	6.3	Zhang et al, 2009
(b) Insecticide	kg	5.1	Zhang et al, 2009
(c) Fungicide	kg	3.9	Zhang et al, 2009

RESULTS AND DISCUSSION

As it can be seen in the Table 2, 77.97 kg nitrogen, 34.98 kg Phosphate, 9.99 kg Calcium, 4587.50 kg of farm fertilizer, 72.95 l diesel fuel, 2.25 kg Biocides, 260.75 kg seed, 98.47 h human labor, 21.64 h machinery, 2190.77 Kwh electrical energy per hectare are used for the production of wheat in Gorve city in Iran. The average wheat output were found to be 7325 kg ha^{-1} in the enterprises that were analyzed. The energy equivalent of this is calculated as 97935.63MJha^{-1}. The highest energy input is provided by electrical. Some results have been reported in the literature that the energy input of chemical fertilizers has the biggest share of the total energy input in agricultural production [17, 21, 28, and 20]. The share of each input can be seen in Fig. 1.

Table 3 Amounts of inputs, outputs and energy inputs and output in wheat production

Inputs (unit)	Quantity per unit area (ha)	Total energy equivalent (MJ ha^{-1})
A. Inputs		
1. Human labor (h)	98.47	193.00
2. Machinery (h)	21.64	1402.42
3. Diesel fuel (l)	72.95	4107.81
4. Total fertilizers (kg)	4710.44	7056.26
(a) Nitrogen (kg)	77.97	5156.94
(b) Phosphate (P_2O_5) (kg)	34.98	435.13
(c) Calcium (kg)	9.99	87.95
(d) Farmyard manure (kg)	4587.50	1376.25
5. Biocides (kg)	2.25	270.00
6. Electricity (m^3)	2190.77	26135.93
7. Seed (kg)	260.75	3833.03
The total energy input (MJ)		42998.44
B. Output		
1. Grain wheat	5537.50	81401.25
2. straw	1787.50	16534.38
Total energy output (MJ)		97935.63

It can be seen in table 3 that the ratio of direct and indirect energy and also the ratios of renewable and non–renewable energy are fairly different from each other in wheat production. Erdal et al [7] investigated the relationship between fruit yield and energy inputs used in stake tomato production under field conditions in Tokat province of Turkey. They reported that among the total energy used, 57.12% was in the form of direct energy and 77.54% was in the form of non-renewable energy.

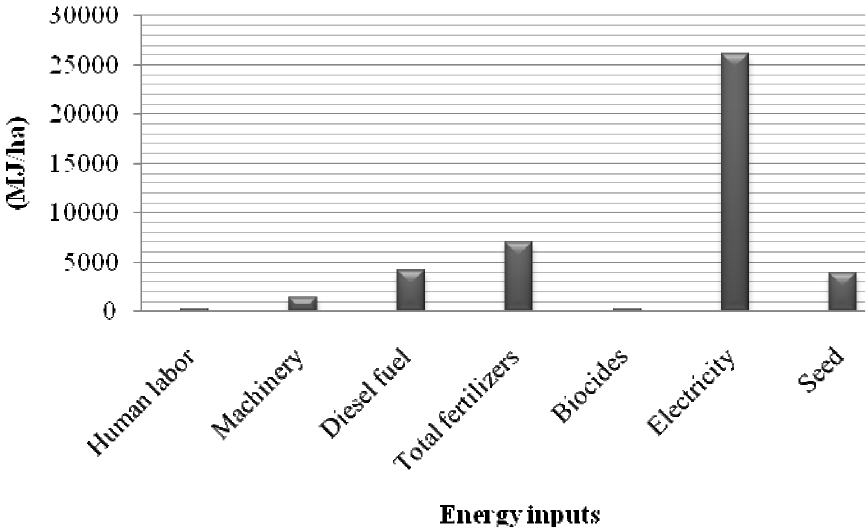

Fig1. The anthropogenic energy input ratios in the production of wheat

Table 4 Energy input–output ratio and forms in wheat production

Items	Unit	Quantity
Direct energy [a]	MJ m^{-2}	30436.74
Indirect energy [b]	MJ m^{-2}	12561.70
Renewable energy [c]	MJ m^{-2}	5402.27
Non–renewable energy [d]	MJ m^{-2}	37596.17

[a] *Includes human labor, diesel fuel and electricity.*
[b] *Includes machinery, fertilizers, biocides and seed.*
[c] *Includes human labor, farmyard manure and seed.*
[d] *Includes machinery, diesel fuel, chemical fertilizers, biocides and electricity.*

The energy use efficiency, energy productivity, specific energy and net energy gain of wheat production in Gorve city are listed in Table 4. The energy use efficiency in this production was found to be 2.27. The energy ratio is often used as an index to examine the energy efficiency in crop production [14].

The energy ratio for some crops are reported as 2.8 for wheat, 4.8 for cotton, 3.8 for maize and 1.5 for sesame [4] and 1.25 for potato [19]. The energy productivity and specific energy of wheat production was calculated as 0.17 kg $MJ^{-1}$and 5.87 MJ kg^{-1} respectively. The net energy of wheat production was found to be 54937.19MJ ha^{-1}. It indicates that in this crop production energy is gained (net energy is greater than zero). In literature, similar results have been reported [8, 16].

Table 5 Energy input–output ratio for wheat production in Gorve city

Items	Unit	Quantity
Energy use efficiency	–	2.27
Energy productivity	kg MJ^{-1}	0.17
Specific energy	MJ kg^{-1}	5.87
Net energy gain	MJ ha^{-1}	54937.19

The results of greenhouse gas emission wheat production are shown in Table 5. The highest value of GHG emission belonged to diesel fuel with (201.34 kg CO_2eq ha^{-1}) of total emission and followed by Chemical fertilizer with (101.3 and 6.99 CO_2eq $ha^{-1}$for Nitrogen and Phosphate). Using chemical fertilizer (especially nitrogen) more than need led to high amount of GHG emission. Moreover, soil and water pollutions are the results of using high amounts of chemical fertilizer which makes agriculture environment unfriendly. The least amount of GHG emissions producer input in wheat production was Pesticides with amount of 11.47 CO2eqha^{-1} of total GHG emissions (Table 5).

Some of the investigations that have been done in greenhouse gas(GHG) emissions on wheat and other crops as follows: Khakbazan et al [11] calculated the greenhouse gas emissions from wheat production and found that it can be ranged from 410 kg CO_2eq ha^{-1} to 1130 kg CO_2eq ha^{-1} depending on fertilizer rate, location and seeding system. Kramer et al [13] calculated the total greenhouse gas emissions related to the Dutch crop production system (potato, grain, vegetable and.) and found that the agricultural products produce 1100 k ton CO_2, 3 k ton N_2O and 0.7 k ton CH_4. The results indicated the production of 0.147 kg CO_2eq per kg of potato production.

Table 6 GHG emission of inputs in wheat production

Input	Unit	GHG coefficient (kg CO_2eq ha^{-1})	(kg CO_{2eq} ha^{-1})
Machinery	MJ	0.071	99.57
Diesel fuel	L	2.76	201.34
Chemical fertilizer	kg	1.3 for Nitrogen 0.2 for Phosphate	101.3 6.99
Pesticides	kg	6.3 for Herbicide 5.1 for Insecticide 3.9 for Fungicide	11.47
Total	-	1490.136	420.67

CONCLUSION

The main objectives of this research were to investigate the energy use patterns, examine the greenhouse gas emission and analyze the energy input–output in cultivation and vegetables in Gorve city, Kordestan province of Iran. Based on the present study the following conclusions are drawn:

1. The total energy consumption for wheat production was 42998.44 $MJha^{-1}$. Highest energy consumption related to electricity and chemical fertilizers. The lowest share of energy consumption belonged to human labour and biocide.
2. The energy use efficiency, energy productivity, specific energy and net energy for wheat production were 2.27, 0.17 kg MJ^{-1}, 5.87 MJ kg^{-1} and 54937.19 MJ ha^{-1}, respectively.
3. In this research, the highest value of GHG emission belonged to diesel fuel with (201.34 kg CO_2eq ha^{-1}) of total emission and followed by Chemical fertilizer with (101.3 and 6.99 CO_2eq $ha^{-1}$for Nitrogen and Phosphate). The least amount of GHG emissions producer input in wheat production was Pesticides with amount of 11.47 $CO2eqha^{-1}$ of total GHG emissions.

REFERENCES

[1] Alam MS, Alam MR, Islam KK. *American Journal of Environmental Science*. **2005.** 1: 213-220.
[2] Anonymous (**2007**). www.fao.org
[3] Anonymous (**2009**). Ministry of Agriculture- Jihad of Esfahan Province of Iran.
[4] Canakci, M., Topakci. M., Akinci. I. and Ozmerzi. A. *Energy Convers. Manage*, **2005.** 46: 655–666.
[5] Cetin B, Vardar A. *Renewable Energy*. **2008.** 33: 428-433.
[6] Demirjan V, Ekinci KK, Akbolat DHM, Ekinci C. *Energy Conversion and Management*. **2006.** 47: 1761-1769.
[7] Erdal G, Esengun K, Guduz O. *Energy*. **2007.** 32: 34–41.
[8] Esengun, K., Gunduz. O. and Erdal. G. *Energy Convers. Manage*, **2007.** 48: 592–598.
[9] Gochebeyg F, Omid M, Ahmadi H, Delshad D. **2009**. Agriculture and natural resources faculty, University of Tehran.
[10] Intergovernmental Panel on Climate Change (IPCC). **1997**. IPCC Technical Support Unit, London.
[11] Khakbazan M., R.M. Mohr, D.A., Derksen, M.A., Monreal,C.A., Grant, R.P., Zentner, A.P., Moulin, D.l., McLaren, R.B., Irvine and C.N. Nagy. *Soil and Tillage Research*, **2009.**104: 30-38.
[12] Korner, G. and Straten, V. *Computers Electronics Agric*. **2008.** 60: 18–30.
[13] Kramer K.J., H.C. Moll and S. Nonhebel. *Agriculture Ecosystems and Environment*, **1999.** 72: 9-16.
[14] Kuesters. J. and Lammel. J. *Eur. J. Agron*, **1999.**11; 35–43.
[15] Mahmoud, O. *Int. J.Agric Biol.* **2004.** 6:1084–1088.
[16] Mandal, K.G., Saha. K.P., Gosh. P.L., Hati. K.M. and Bandyopadhyay. K.K. *Biomass. Bioenergy*, **2002.** 23: 337–345.
[17] Mobtaker HG, Akram A, Keyhani A. **2011**. Energy for sustainable development (In press).
[18] Mohammadi, A., Omid. M. *Appl Energy*, **2010.** 87: 191–196.
[19] Mohammadi, A., Tabatabaeefar. A., Shahin. S., Rafiee. S. and Keyhani. A. *Energy Conver. Manage*, **2008.** 49: 3566–3570.
[20] Monjezi N, Sheikhdavoodi MJ, Taki M. *Modern Applied Science*. **2011.** 5(6): 139-151.
[21] Nassiri SM, Singh S. *Applied Energy*. **2009.** 86: 1320–5.
Nelson, P.V. Greenhouse operation and management. 6th edition.pp: **2002.**128–147.

[22] Pimentel, D., L.E. Hurd, A.C., Belloti, A.C., Forster, M.J., Oka, I.N., Scholes, O.D., A.G. Salway. **1996**. ISBN 0-7058-1728-8.
[23] Pimentel, D., L.E., Hurd, A.C., Bellotti, M.J., Forster, I.N., Oka, O.D. Sholes and R.J.Whitman.**1973**. *Science*, 182: 443–449.
[24] Samavatian N, Rafii Sh, Mobli M. **2009**. Agriculture and natural resources faculty, University of Tehran.
[25] Satori L, Basso M, Bertocco B, Oliviero G. *Bio system Engineering*. **2005.** 91(2): 245-246.
[26] Shafiq M, Rehman M. *Agric. Econ*. **2000.** 22: 321-330.
[27] Taki M, Ajabshirchi Y, Mahmoudi A. *Modern Applied Science*. **2012a.** 6(1): 75-87.
[28] Taki, M., Abdi, R., Akbarpour, M., Mobtaker, HG., *CIGR Journal*, **2013.**15, 59–67.
[29] Taki, M., Mahmoudi, A., Mobtaker, HG., Rahbari, H., *CIGR Journal*, **2012b.** 14, 93–101.
[30] Unakitan, G., Hurma. H. and Yilmaz. F. *Energy*, **2010.** 35: 3623–3627.
[31] Zangeneh, M., Omid, M. and Akram, A. *African journal of Agricultural Research*, **2010.** 5(10): 993-998.
[32] Zhang, X., Huang G.H., Lin, Q., Yu, H., *Expert Systems with Applications* **2009.** 36, 5666–5672.