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Investigation of the Energy Flow and its Effects on Global Warming Potential (GWP) of Rainfed Wheat Farms in the Golestan Province (Aqal City)

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Abstract- Recently evaluation of input, output and global warming potential (GWP) have been an extension in sciences of agricultural. For this study, 95 farmers were selected for rained Wheat in the semi-salty farm in the north of Golestan Province (Aqal City).The data including (machines, seeds, fertilizers, fuel, and pesticides) were collected by questioner. Then fuel, input and output energy, energy evaluation indexes and global warming potential (kg CO_2/ha^{-1}) were calculated. Results showed that the most direct input energy from fuel in rained Wheat was 38.8 percent. Also, the highest indirect input energy in rainfed Wheat was 31.3 that related to fertilizers. The ratio of output to input energy in rainfed Wheat was calculate 5.01. The amount of GWP was 943.5 (kg CO_2/ha^{-1}) in rainfed Wheat. The highest GWP was related to nitrogen fertilizer and fuel consumption. For Wheat, the consumption of fuel and fertilizer constitute the high percent of energy consumption and greenhouse gas emissions. So that, the use of devices that reduce fuel consumption is recommended, also need for research and investigation on crop rotation and nitrogen fixation plants were revealed.

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Abstract- Recently evaluation of input, output and global warming potential (GWP) have been an extension in sciences of agricultural. For this study, 95 farmers were selected for rained Wheat in the semi-salty farm in the north of Golestan Province (Aqal City).The data including (machines, seeds, fertilizers, fuel, and pesticides) were collected by questioner. Then fuel, input and output energy, energy evaluation indexes and global warming potential (kg CO_2/ha^{-1}) were calculated. Results showed that the most direct input energy from fuel in rained Wheat was 38.8 percent. Also, the highest indirect input energy in rainfed Wheat was 31.3 that related to fertilizers. The ratio of output to input energy in rainfed Wheat was calculate 5.01. The amount of GWP was 943.5 (kg CO_2/ha^{-1}) in rainfed Wheat. The highest GWP was related to nitrogen fertilizer and fuel consumption. For Wheat, the consumption of fuel and fertilizer constitute the high percent of energy consumption and greenhouse gas emissions. So that, the use of devices that reduce fuel consumption is recommended, also need for research and investigation on crop rotation and nitrogen fixation plants were revealed.

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I. Introduction

Because of the many factors, Wheat is grown all around the world. The main Factor is varieties available, which can under many climatic and soil conditions. According to Ministry of Jihad e Agriculture in 2016, Wheat is the most important crop in Iran and its 63.1 percent shares of the total Cultivating area. Also according to the latest statistics, 209 thousand hectares were sown rainfed Wheat in the Golestan province (Ministry of Jihad e Agriculture, 2016). Energy productivity is one of the most factors for sustainable agriculture. The use of fossil fuels and chemical fertilizers were threatening the environment (Kocheki, 1994). Comparison of energy consumption of crops is one way of selecting different in each region. (Feyzbakhsh and Soltani, 2015). Recently evaluation of input, output and global warming potential (GWP) have been an extension in sciences of agricultural. There are many studies on energy usage pattern for crops (Feyzbakhsh and Soltani, 2015; Strapatsa et al., 2006; Darlington,1997; Nasirian et al., 2006; Shahin et al., 2008; Ghorbani et al., 2011).

The crucial role of energy in the development of economic sectors such as industry, transport, and agriculture has led researchers to study management in energy consumption (Strapatsa et al., 2006).

Most of the energy used to produce agricultural products is due to the use of inputs such as machinery, fossil fuels, fertilizers, and pesticides, which inappropriate use of these while lowering energy efficiency in production, also cause health and human health problems. At the moment, due to the energy crisis in the world, it is necessary to study more about energy consumption and find solutions for its optimal use (Darlington,1997).

Energy has defined the ability to do the work. Given the growing need for in today's world, high prices and limited energy resources, as well as the effects of unusual and excessive use of in greenhouse gas emissions, as well as accelerating the global warming process, today the energy category in all economic infrastructures, including the industry, Services and agriculture have become one of the most topics for researchers and scientists (Abdollahpour et al., 2009). Human has turned to using available and affordable fossil fuels to meet his energy needs. This kind of resource accounts for 95% of the world's energy consumption. The rise in fossil fuel consumption contributes to air pollution and global changes in the climate of the planet. Based on the global agricultural scale, it consumes about 5 percent of the total energy of fossil fuels. Industrial crop energy is divided in direct and indirect (Nasirian et al., 2006).

Shahin et al. (2008) in their research in Ardabil provinces indicated that Wheat production consumed a total of 38.36 GJ ha^{-1} of which fertilizer energy consumption was 38.45% followed by diesel and machinery energy. And Output–input energy ratio and energy productivity were found to be 3.13 and 0.16 kg of Wheat MJ^{-1}, respectively. Also, large farms were more successful in energy use and energy ratio.

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Esengun et al. (2007) reported that energy use in agriculture had been developer in response to increasing populations, a limited supply of arable land and desire for an increasing standard of living. In all societies, these factors have encouraged an increase in energy inputs to maximize yields, minimize labor-intensive practices, or both.

Tipi et al. (2009) reported that Wheat production consumed a total of 20,653.54 MJ ha-1 energy depending mainly on fossil fuels. Also, they showed that the energy input of diesel (45.15%) has share in the total energy consumption followed by fertilizers (34.21%), mainly nitrogen (31.77%).

Valadiani et al. (2005) evaluated energy consumption in rainfed Wheat of East Azarbaijan and showed that the highest energy consumption in these fields was related to nitrogen fertilizer, machinery ,and diesel fuel respectively. They that the lowest energy consumption belongs to human labor and herbicide.

There are much research regarding energy (input and output rates) in different crops. Low input systems compared to high input systems have greater energy use efficiency and lower emissions of greenhouse gasses (Dalgaard et al., 2001).

Beheshti Tabar et al. (2010) reported that with higher yields and improved agricultural practices in the Wheat irrigated systems, the unit of land used per unit of output, reduced by 32% in 2006 compared to 1990.

Ghorbani et al. (2011) reported that total energy input used in irrigated Wheat production was about 45367.63 MJ ha^{-1}, which is five times more than that of dryland fields (9354.2 MJ ha^{-1}) in North Khorasan, Iran. They stated that the factor resulting in excessive energy use in irrigated production was application chemical fertilizers. Also, they reported that the amount of energy used in different agricultural practices such as machinery, irrigation, electricity, and diesel in irrigated production system was higher than those of dryland systems.

This study was conducted to determine the GWP and its energy evolution and global warming potential (GWP) in Wheat production in northern lands of Gorgan to identify suitable strategies for avoiding energy losses and reducing environmental impacts of resources.

II. Materials and Methods

This research was did in the semi-salty farm in the north of Gorgan- Golestan province (Aqal City). This is locating in the North of Iran near the Caspian Sea. Overall, Golestan has a moderate and humid climate known as "the moderate Caspian climate." The factors lead to such are the Alborz mountain range, the direction of the mountains, vicinity to the Caspian sea, especial vegetation surface, local winds, and altitude and weather fronts. As a result of the above factors, three different climates exist in the region: plain moderate, mountainous, and semi-arid. The weather in this area is moderately cool in the spring and warm and humid in the summer (Mokhtarpour 2011). This province extends from 36°44' N to 38°05' N, and from 51°53' E to 56°14' E. The Golestan province area covers approximately 2115 Km2 (Kazemi Poshtmasari et al. 2012). The data for this study were collecting from 93 Wheat farms by using a face-to face questionnaire in the production year 2015/2016. Farms were randomly choose from the villages in the area. The data including (machines, seeds, fertilizers, fuel, and pesticides) were collected by questioner.

After this stage, data were calculated by Excel software in three parts: Fuel consumption, Energy consumption and Global Warming Potential (kg CO_2/ha^{-1}).

Based on the energy equivalents of the inputs and output (Tables 2.3.4 and 5), the energy ratio (energy use efficiency), energy productivity specific energy and the Net energy were calculated (Feyzbakhsh and Soltani, 2015).

$$\text{Energy use efficiency} = \text{Energy Output (MJ ha}^{-1}) / \text{Energy Input (MJ ha}^{-1}) \quad (1)$$

$$\text{Energy productivity} = \text{Grain output (kg ha}^{-1}) / \text{Energy Input (MJ ha}^{-1}) \quad (2)$$

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

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

The global warming potential was calculate as follows:

1. Estimated energy consumption of each input and crop operation.
2. Calculate the energy consumption for each and operation from various sources such as electricity, gas oil, natural gas, and oil about each of these energies.
3. Calculation of the amount of three greenhouse gas CO_2, N_2O, and CH_4 produced by using the product of the amount of energy consumed and the coefficients of production of each gas. Given the different power of N_2O and CH_4 in global warming potential, the total greenhouse gas emissions were calculation as equivalent to Co_2.

III. Results and Disruptions

Variable inputs for Wheat are give in Table (3). Fuel consumption as one of the energy inputs for land preparation, cultivation and transportation is use. The results of this study showed that fuel consumption is high in Wheat cropping. The reason for the high fuel consumption in these fields can be due to the use of non-efficient machines and equipment. In general, the amount and percentage of energy consumed in different operations in agriculture and crops and different countries are different. Unclear antecedent is due to the different climatic, ecological and agricultural conditions of these countries. The use of fossil fuels in agriculture has begun since about 70 years ago and continues. There is a need to find other fossil fuels other than fossil fuels, even for exporting countries (Kocheki et al., 1999). One of the ways to reduce fuel consumption is using new and suitable agro-industry such as a multi-purpose machine (Combined). This fuel consumption (Rajabi et al., 2010). Adhering to sustainable agricultural systems and adhering to low farming practices such as reduced plowing can be a means of reducing the high fuel consumption in agriculture. It is reported that tillage can reduce up to 55% of fuel consumption without lowering yield (Bonari et al., 1995).

Table (4) shows the input energy of the rainfed Wheat regarding megajoules per hectare. Among different inputs, seed with the average input energy of 3140 MJ/ha^{-1} (24.23%), had the highest share. The amount used depends on the type and manner of use of planting machines. Factors such as tillage and proper land preparation for cultivation and the use of efficient planting machines can in seedling consumption. Also, the herbicide with 7.3% had the lowest input of energy.

In Table 5, energy consumption is divide into two direct and indirect energy consumption. The highest direct input energy is related to fuel. The high share of fuel in the input energy of these fields can be due to the use of low-productivity machinery. Also, the most indirect input energy is related to nitrogen fertilizer with values of 31.3%.

Table 6 shows that the output to input ratio in rainfed Wheat fields is 1.05, which energy efficiency in low, which can be due to increasing energy input in the form of fuel and chemical fertilizers. Input-to-output ratio in Wheat cultivation in Turkey, 2.8 (Canakci et al., 2005), in Ardabil Wheat fields 1.92 (Shahan et al., 2008), the Wheat fields in the Rey, 2.63 (Alipour et al., 2014), and in the Saveh, 0.1-0.6 (Tabatabayefar, 2002) had been reported. It seems that one of the reasons for the relative efficiency of energy use in Wheat fields of Gorgan is to regard crop rotation and use its benefits in the cultivation of this product. Constant cultivation of a plant in one land, in addition to reducing plant yield due to nutrient evacuate, causes weed infestation, pests, and diseases that the invading of these factors inevitably leads to more use of inputs, which, in addition to reducing energy efficiency, causes Increases environmental pollution. In general, using high yielding cultivars, compact farming systems, increasing the use of fertilizers and chemical pesticides, and high levels of agricultural mechanization has led to an increase in energy consumption in modern agriculture (Singh et al., 2004).

In this study net, energy efficiency was estimated at Wheat fields 58701, and the specific energy content was 6.3. Konkhani et al. (2005) reported energy were 5.24 and 3.88 for Wheat and Corn respectively.

Table 7 shows the GWP per kilogram CO_2 per hectare. The greatest GWP is in rainfed Wheat fields, related to fuel with a share of 42.7 percent. The highest amount of greenhouse gas emissions from nitrogen fertilizers was obtain, and the least amount of greenhouse gas emissions was due to potassium fertilizer. This indicates that the sectors with the highest fuel consumption had the highest greenhouse gas emissions and hence the GWP. Also, the GWP was obtained Per unit area, Per unit weight, Per unit energy input and Per unit energy output (kg eq-CO_2 GJ^{-1}) with 943.5, 410.2, 64.6 and 12.8 respectively in rainfed Wheat in the Aqal City. Feyzbakhsh and Soltani (2013) their study on maize in Golestan province reported that the least GWP was obtain from spring planting with 2349 kg eq-CO_2 GJ^{-1}.

IV. Conclusions

In rainfed Wheat, the consumption of fuel and fertilizer constitute the highest percent of energy consumption and greenhouse gas emissions. So that, the use of devices that reduce fuel consumption is recommend, also need for research and investigation on crop rotation and nitrogen fixation plants were reveal. With attention on the results we suggested that with improved management practices, efficient use of fertilizers, efficient use of fertilizers, increased yield and with increasing the yield, improved energy efficiency.

Table 1: Agricultural operations times for rainfed Wheat in Aqal City

Field operations	Time
Tillage (30 cm)	November
Disk (1)	Erlay December
Disk (2)	Erlay December
Mixing fertilizer with soil	Erlay December
Basal dressing	Erlay December
Planting seeds	Erlay December
Weed control	March
Top dressing	Erlay March
Fungi Disease Control	April
Harvest	Late June

Table 2: Energy equivalent of inputs and outputs in rainfed Wheat in Aqal City

Iinputs / outputs	Unit	Energy equivalent (MJ/unit)	Reference
Wheat Seed	kg	15.7	(Canakci*et al*., 2005; Rathkee*t al*., 2007)
Human labor	Hour	1.96	(Akcaoz *et al*., 2009)
N fertilizers	kg	60.6	(Ozkan *et al*., 2004; Akcaoz *et al*., 2009)
P fertilizers	kg	11.1	(Ozkan *et al*., 2004; Akcaoz *et al*., 2009)
K fertilizers	kg	6.7	(Ozkan *et al*., 2004; Akcaoz *et al*., 2009)
Gasoline	L	38	(Hydrocarbon balance sheet of Country, 2008)
Herbicide	kg a.i.b	287	(Tzilivakis *et al*., 2005; Rathke *et al*., 2007)
Insecticide	kg a.i.b	237	(Tzilivakis *et al*., 2005; Rathke *et al*., 2007)
Wheat grain	kg	15.7	(Canakci *et al*., 2005)
Stems and leaves of Wheat	kg	9.25	(Rajabi et al.,2012)
Fungicide	kg a.i.b	99	(Strapasta et al.,2006)

Table 3: Inputs used for Rainfed Wheat in Aqal City

Input	Unit	Rainfed Wheat
Fuel	$l\ ha^{-1}$	136
Seed	$kg\ ha^{-1}$	200
Fertilizer		
Nitrogen	$kg\ ha^{-1}$	150
Phosphorus	$kg\ ha^{-1}$	70
Potassium	$kg\ ha^{-1}$	50
Herbicide	kg a.i.b	257
Human labor	Hour	18
Agricultural operations		
Plow	Time	1
Fertilizer Distribution	Time	2
Planting with row planter	Time	1
Spraying (pesticides, fungicides)	Time	3
Harvest	Time	1

Table 4: Energy inputs (MJ^{-1} ha^{-1}) dividing farming group in rainfed Wheat

Field operations	Average	Percent of total
Plow	1379.4	10.3
Disk	1909.4	14.2
Basal dressing	1004.5	7.5
Seed	3140	23.4
Row planter	1083.2	8.1
Herbicides	510.9	3.7
Fungiicides	506.3	3.8
Top dressing	3084.1	23
Harvest	748.2	5.6
Total	13366.5	100

Table 5: Direct and indirect energy inputs for rainfed Wheat in Aqal City

Energy inputs Direct	Average	Percent of total
Fuel for field operations	5168	38.7
Human labor	27.4	0.2
Indirect		
N fertilizers	4178.6	31.3
P fertilizers	322	2.4
K fertilizers	160.8	1.2
Seed	3140	23.5
Herbicide	133	1
Fungiicides	128.3	0.9
Machinery	661.2	5
transportation	696.4	5.2
Total	14615.7	100

Table 6: Different energy indices for rainfed Wheat in Aqal City

Indices energy	Rainfed Wheat
Inputs	
Direct input energy (GJ ha^{-1})	5.1
Indirect input energy (GJ ha^{-1})	22.6
outputs	
Stem+leaf output energy (GJ ha^{-1})	39.5
Grain output energy (GJ ha^{-1})	33.8
Ouput/input ratio	5.01
Specific energy (GJ ton^{-1})	6.3
Energy productivity (ton GJ^{-1})	0.157
Net energy (GJ ha^{-1})	58701

Table 7: GHG emissions (kg e-CO_2 ha^{-1}) for rainfed for rainfed Wheat Aqal City

Operations	Average	Percent of total
Production and transportation		
Nitrogen	304.2	32. 24
Phosphorus	26.4	2.79
Potassium	13.1	1.38
Pesticides	26.9	2.85
Fuel	403.1	42.72
Production, transportation and maintenance equipment and machinery	138.6	14.68
Total GWP	943.5	100

Table 8: GHG emissions in per unit area, per unit weight, per unit energy input and per unit energy output in rainfed Wheat in Aqal City

Per unit area (kg eq-CO_2 ha^{-1})	943.5
Per unit weight (kg eq-CO_2 t^{-1})	410.2
Per unit energy input (kg eq-CO_2 GJ^{-1})	64.6
Per unit energy output (kg eq-CO_2 GJ^{-1})	12.8

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