CO_2 EMISSION AND GWP OF ENERGY CONSUMPTION IN THE COTTON PRODUCTION IN GOLESTAN PROVINCE OF IRAN

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Abstract. Careful choosing of appropriate methods in farming operations reduces fuel consumption, energy, and Greenhouse Gas (GHG) emissions in agricultural production. The present study was conducted to investigate the input and output energies and GHG emissions in cotton production in Golestan Province of Iran and the cities of Ali Abad Katool and Aqqala. For this purpose, agricultural operations were randomly selected from 100 farms for the years 2014 and 2015 and the related data on all farms were recorded. Various inputs and comprehensive information at every phase from planting to harvesting were collected, recorded, and processed and then extracted from multiple sources for each equivalence operation during different crop operations for cotton production using a conversion ratio of energy and GHG emissions. Afterward, the energy and GHG emissions for each input and operation were calculated. According to the obtained results, the mean power output was 154 GJ per ha, which is approximately six times of the average input energy (26 GJ/ha). The output and input energies for cotton production were 49 to 243 and 15 to 43 GJ/ha, respectively. Moreover, Global Warming Potential (GWP) of various activities in the cotton fields varied between 741 up to 7790 kg CO_2 equivalent per ha. The maximum GHG emissions were related to fertilizers with manure and fuel ranked in the next orders. The comparison between input energy and GWP revealed their direct relation in cotton production farms. Irrigation, feeding, and preparation operations had the highest fuel consumption and led to an increase in GHG release. Based on these results, it can be concluded that energy consumption and GHG emissions can be reduced by lowering fuel consumption and using chemical fertilizers.
Keywords*: cotton, GHG emissions, GWP, input energy, output energy*

Introduction

Many factors, whether natural or human-made affect the climatic changes. The sunlight hitting the earth and the reflection of infrared rays from the earth create a balance in the earth's atmospheric system that varies from place to place due to the environmental factors. One of the factors influencing climate change is the excessive absorption of infrared rays by greenhouse gases. Agriculture has led to the production of greenhouse harmful gases (Johnson et al., 2007). Greenhouse gas (GHG) emission reduction is possible by minimizing fossil fuels burning and applying effective strategies to reduce global warming (Tzilivakis et al., 2005a). The reduction in fuel consumption is also important for the production of sustainable agricultural products, in order to return economic optimization and the preservation of fossil fuel reserves (Pervanchon et al., 2002; Rathke and Diepenbrock, 2006).

Cotton (*Gossypium hirsutum* L.) is one of the most important and valuable agricultural products that are planted in more than 100 countries and plays a crucial role in economies of some countries in Asia and Africa. This product has been found to be

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of great economic importance and a particular agricultural and commercial status in the world, to an extent that it is called as the “white gold” (Marashi and Vaghif, 1981).

Energy as an input is of particular significance in the agricultural sector. According to the latest statistics, nearly 49% of the registered industrial projects are related to energy (renewable and renewable resources) and 24% to waste disposal. Estimates also suggest that agricultural activities contribute to the emission of 15% of global pollutants worldwide (Monthly Clean Development Mechanism, 2009). Today, due to population growth, reduction in arable land and improvement of the living standards, energy consumption has increased in agricultural sectors. Presently, the intensive uses of chemical fertilizers, pesticides, agriculture machinery, electricity, and natural resources are required to supply the food of the growing population (Barut et al., 2011). After transportation, the agricultural sector is the largest consumer of gasoline in Iran (Hydrocarbon balance sheet, 2011).

Rajabi et al. (2013) investigated GHG emissions and Global Warming Potential (GWP) in six wheat fields in Gorgan and reported that the average GWP production was 662 kg equivalent to CO_2 per ha in total farms. Furthermore, the highest and lowest amounts of GWP production were reported 923 and 268 kg, respectively, equivalent to 0.9 and 0.3 tons CO_2 per ha. These values showed that there is a direct relationship between GWP values and consumption of the crops inputs (input energy). In this regard, chemical fertilizers (especially nitrogen) and fossil fuels with 45.8% and 22.5%, respectively, have the highest share in energy consumption. Moreover, the largest share of the GHG emissions and GWP were 56.8% and 36.8% for the chemical fertilizers and fossil fuels, respectively. In addition, it was found that the maximum and minimum GWPs in terms of weight were 44.6 and 34.8 kg equivalent to CO_2 in GJ and in the output energy unit, respectively, as 11.7 and 4.5 kg equivalent to CO_2 in GJ. Soltani et al. (2013) showed that the highest value of energy is used to prepare a planting bed with 53%, irrigation with 15%, and harvest with 19% of total energy. Also, in the entire scenarios, more than 99% of GHG emissions was related to CO_2 and less than 1% was related to CH4 and N2O (Soltani et al., 2013). Ahmadi and Aghaalikhani (2013) investigated energy consumption in cotton cultivation in Golestan province of Iran and concluded that the share of energy consumed in cotton cultivation in Golestan province, the share of energy consumed in the fuel inputs of the tractor and engine fuel were 24% and 30%. In general, 54% of the energy consumed was related to diesel fuel, followed by fertilizers with 24% and chemicals with 13%. Furthermore, the total input energy for cotton production in the Alborz province was 31 GJ/ha. Dastan et al. (2014) examined the energy consumption of rice planting systems and CO_2 emissions and stated that the largest share of input energy in production systems was related to electric power for irrigation water pumps that had highest CO_2 emissions and global heating potential. After electric power, the nitrogen fertilizer and fuel had the second and third rank in CO_2 emission, respectively. Nikkhah et al. (2014) examined the GHG emissions in tea production in Golestan province and reported that chemical fertilizer inputs provide the largest share of GHG emissions. CO_2 as the most important GHG plays a significant role in absorbing infrared radiation produced in the atmosphere over the past decades. Feyzbakhsh and Soltani (2014) studied the energy flow and GWP in corn fields in Gorgan and reported that the lowest GWP was obtained from spring cultivation of 2349 kg equivalent to CO_2 per ha. Pathak and Wassmann (2007) considered GHG emissions and the GWP resulting from the conventional rice cultivation system in India and came to the conclusion that agronomic and non-agronomic operations (fertilizer and pesticide

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production) contribute to the GHG emissions as 80 to 98 and 16 to 91 kg equivalent to CO_2 per ha. The totals GWP of rice production was reported to be between 2766 and 4054 kg equivalent to CO_2 per ha. Meisterling et al. (2008) conducted a study on energy assessment and reduction of greenhouse gases in wheat production with two conventional and organic systems and estimated different effects in different stages of the growing season of the seed till transportation to the factory in two methods. They concluded that the GWP produced for the production of 1 kg of organic wheat bread is about 30 grams equivalent to CO_2 per ha.

Due to the increasing trend of energy consumption in Iranian agricultural sector, it is necessary to consider the current state of energy consumption in this sector. Although Golestan province (Iran) has been previously known as the cotton capital of Iran in the world, its planting rate has decreased notably due to the increased production costs. This study aims to evaluate GHG emissions and estimate GWP and to investigate the correlation between energy consumption and GHG emissions.

Materials and methods

Study area

This study was carried out in Golestan province, which is located in northern Iran between 36°30′ to 38° 80′ northern latitude and 53°51′ to 56°220′ eastern longitude (*Fig. 1*).

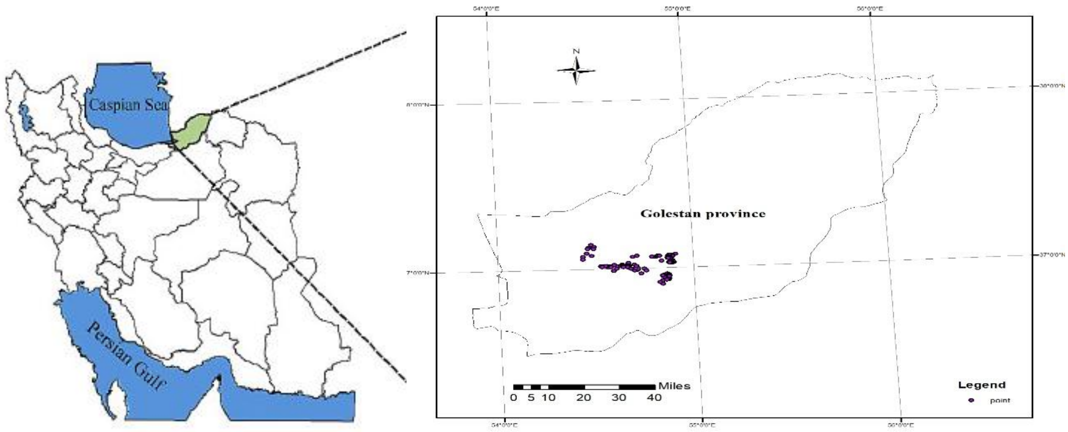

***Figure 1.** Location of the study region Golestan province within Iran (left) and the geographical distribution of the 100 Agricultural fields within Golestan province (right).*

The area of Golestan province is 20,438 km2, which accounts for 1.3% of Iran's total area (Bureau of Statistics and Information Technology, 2015). The province is bordered by Turkmenistan in the north, Mazandaran province and the Caspian Sea in the west, Semnan province in the south, and north Khorasan province in the east. Golestan is geographically characterized by the Alburz mountain range in the south and southeast and flat plain regions in the north and northwest. Accordingly, the climatic conditions range from humid temperate to semi-arid temperate climate. In average the study region's mean annual temperature is 18.1°C, the mean solar radiation is 14.2 MJ m^{-2} d^{-1}, and the total annual precipitation is 565 mm.

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The statistical population of this study consisted of the cotton farmers who provided the seeds from the service centers. Since data were collected during the crop year, farmers who were more likely to cooperate were introduced by the service centers (130 farmers). Accordingly, the number of fields was calculated using Cochran's formula as 96. In order to increase the accuracy, 100 farmers were randomly selected (*Eq. 1*).

$$n = \frac{\frac{Z^2 pq}{d^2}}{1+\frac{1}{N}\left(\frac{Z^2 pq}{d^2}-1\right)} \quad \text{(Eq. 1)}$$

where p and q = 0.5; z = 1.96; d = 0.05; N is the volume of statistical population, and n is the sample size.

A total of 100 samples were selected from Aliabad and Aq Qala cities in Golestan province of Iran during two crop years, 2014 and 2015. These farms were selected to include a range of farmers. All operations and events during the growing season were observed in these fields. Also, full details of the typical methods of production and agronomic operations in recent years (e.g., the use of machinery, fuel, fertilizer, and pesticides) were collected. For this purpose, all agricultural practices were first separated into 8 types including land preparation, planting, fertilization, plant protection, weed control, irrigation, harvesting, and transportation to the factory for delivery of the product. Next, different inputs values and more comprehensive information were collected and recorded at each stage from planting to harvest and their initial processing was conducted using Excel software. After that, data analysis was performed in three sectors including (consumed) input energy, (produced) output energy, and the GWP resulting from GHG emissions. The results of energy analysis are presented in *Table 1*. The main focus of the present study is on the GHG emissions and resulting climate change.

Table 1. *Input and output of energy used in the production of cotton*

Type of input and output	Unit (in ha)	Energy equivalent	Reference
Input			
Human labor	h	2.96	Ozkan et al, 2005
Cotton grains	kg	34	Ozkan et al, 2005
Machinery	kg	143.7	Kaltsas et al, 2008
Chemical fertilizer	kg	61.6	
(a) Nitrogen	kg	61.6	Akcaoz et al, 2010
(b) Phosphate	kg	7.7	Akcaoz et al, 2010
(c) Potassium	kg	12.1	Akcaoz et al, 2010
Animal manure	kg	1.3	Ozkan et al, 2005
Gasoline	L	39	Balance sheet hydrocarbon Iran, 2009
Electriciy	kwh	4.6	Pimental & Pimental, 2009
Herbicides	Kgai	279	Tzilivakis et al, 2006
Pesticides	Kgai	238	Tzilivakis et al, 2006
Fungicides	Kgai	100	Strapatsa et al, 2007
Output			
lint	kg	55.5	Ozkan et al, 2005

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(Consumed) input energy: At this stage, all direct (fuel, electricity, and human force) and indirect (seeds, chemical materials, chemical fertilizers, and machinery) inputs during various cropping operations for cotton production were extracted from multiple sources for each operation using energy conversion coefficients, and then, the energy input was calculated for each input and operation.

(Produced) output energy: At this stage, the amount of energy output from cottonseed was equated using the energy conversion coefficients extracted from cottonseed, followed by calculating the total amount of output energy. The energy conversion coefficient for cottonseed was estimated to be 54.5 (Ozkan et al., 2004).

Global Warming Potential (GWP): GWP is the sum of GHG emissions that are expressed as equivalent to CO_2 (IPCC, 1996; IPCC, 2007). To calculate GWP, the production of CO_2, N2O, and CH4 from energy consumption was considered in the production of various inputs and operations. These inputs and operations included the production of nitrogen, phosphorus, and potassium fertilizers, the production of chemical toxins of herbicide, fungicide, and insecticides, consumption of fossil fuels for agronomic operations, irrigation, transportation, production, and maintenance of agricultural machinery and equipment.

The GWP was calculated as follows

The equivalent of coefficients of production and GHG emissions was calculated in *Table 2* for each of the stages including the amount of energy of agricultural machinery, fuel (L), chemical fertilizers (kg), chemicals (kg), and manure (kg). Followed by calculating the total GWP, GWP values were calculate in terms of area (kg equivalent to CO_2 per ha), weight (kg equivalent to CO_2 per tons of wheat), input energy (kg equivalent to CO_2 per GJ), and output energy (Kg equivalent to CO_2 in GJ) (Rajabi et al., 2013).

Initial calculations and plotting some graphs were performed in Excel while plotting cumulative graphs and regression correlation was conducted by SPSS software.

Table 2. *GWP emission factors (kg co2eq unit-1)*

Input	Unit	GWP emission factors	Reference
Machinery	KJ	1.017	Dayer & Desjardins, 2007
Diesel fuel	L	3.76	Dayer & Desjardins, 2007
Nitrogen fertilizer	kg	2.3	Lal, 2005
Phosphate fertilizer	kg	1.2	Lal, 2005
Potassium fertilizer (K2O)	kg	1.2	Lal, 2005
Fungicides	kg	4.9	Lal, 2005
Pesticides	kg	6.1	Lal, 2005
Herbicides	kg	7.3	Lal, 2005
Animal manure	kg	1.126	Pishgar-Komleh et al, 2013; Xiamei & Koltelko, 2004

Results and discussion

Incoming and outgoing energy

According to the results, the average output energy was equal to 154 GJ/ha, which is about 6 times the average input energy with 26 GJ/ha (*Table 3*). The output energy

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range for producing cotton is between 49 GJ/ha to 243 GJ/ha and for input energy varied from 15 to 43 GJ/ha (*Fig. 2*). This amount was reported in another study conducted in this area as 31 GJ/ha (Ahmadi and Aghaalikhani, 2013). Total input energy for cotton production in the Alborz province was reported as 31 GJ/ha (Pishgar-Komleh et al., 2012, 2013) and in the provinces of Antalya and Hataa, Turkey, it was reported as 49 and 19 GJ, respectively (Dagistan et al., 2009; Yilmaz et al., 2005). Mousavi-Avval et al. (2011) reported the amount of input energy for soybean production in Golestan province 35 GJ/ha on average. Rajabi et al. (2013) studied the energy use for wheat production in Gorgan and reported that the average input energy in the understudy fields as 15577 MJ/ha.

Table 3. *The amounts of incoming and outgoing energy in MJ ha for cotton production in Golestan province*

Kind of energy	Average	Minimum	Maximum
Input Energy	26326.60499	15614.81698	43321.65855
Output Energy	154371.25	49050	234350

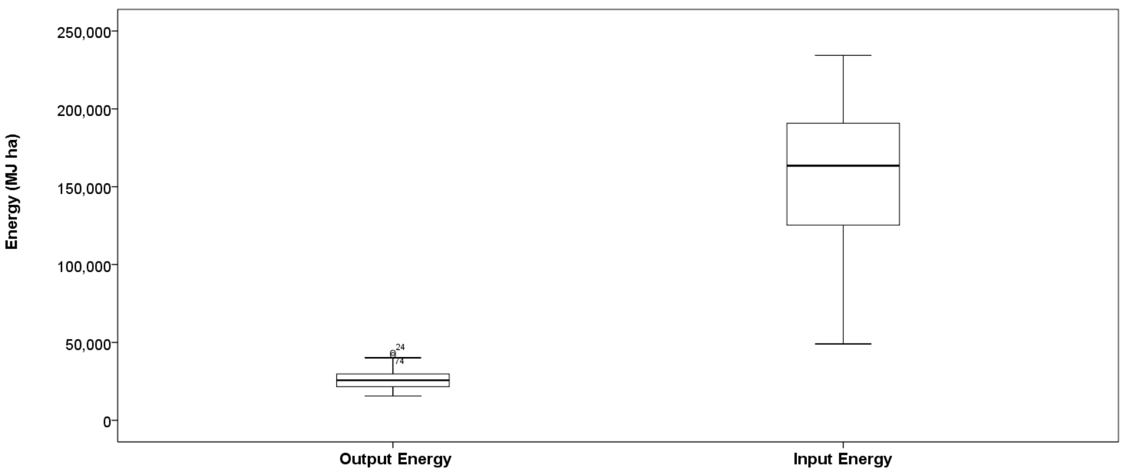

Figure 2. *Box plot of input and output energy for cotton production in Golestan province*

Beheshti-Tabar et al. (2010) examined the energy consumption in the agricultural sector from 1990 to 2006. Their results showed that the amount of input energy in 1990 increased from 32.4 GJ/ha to 37.2 GJ in 2007. The amount of output energy also increased from 30.85 GJ/ha to 43.68 GJ/ha. The increase in the use of chemical fertilizers, the field mechanization index and the consumption of agricultural toxins, which resulted in an increase in fertilizer use and high yielding cultivars, were considered as the reasons for increased use of input and output energies from 1990 to 2006. Haidari and Omid (2011) investigated energy consumption pattern for greenhouse cucumber and tomato production in Iran. The input energies for cucumbers and tomatoes were 141 and 131 GJ/ha, respectively. However, this amount was reported as 14 GJ/ha for input energy of the rapeseed in northern Iran (Azarpour, 2012). The main reasons for this difference might be the energy consumption of different products due to different conditions in cultivation, climate, and crop management in the production of each product.

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Greenhouse gas emissions

As presented in *Table 4*, the total GWP of different activities per cotton farm varied from 741 to 7790 kg equivalent to CO_2 per ha. In the next order, the highest GHG emissions were related to the chemical fertilizers and the amount of GHG emission in the inputs of manure and fuel (*Fig. 3*). Taheri-Rad et al. (2014) reported that GHG emissions from diesel fuel was 646.23 kg of CO_2 per ha that had 45% of GHG emissions of cotton production in Golestan province, followed by manure with 23% of GHG emissions. In this regard, Tzilivakis et al. (2005a) estimated the total GWP values per area for potato products, wheat, oilseed rape, barley, and chickpea as 3, 1.7, 1.2, 0.7, and 0.7 tons equivalent to CO_2 per ha.

Table 4. *The amounts of greenhouse gases in kilograms of carbon dioxide per hectare for cotton production inputs*

The type of operation	Average	Minimum	Maximum
Diesel fuel	983.00	586.22	1364.54
Fungicides	0.87	0.53	1.14
Chemical fertilizer	1019.15	9.20	6406.90
Machinery	144.59	58.22	300.08
Pesticides	23.20	0.00	58.65
Animal manure	946.26	0.00	6300.00
Herbicides	7.84	0.00	25.20
Total	2178.65	741.65	7790.81

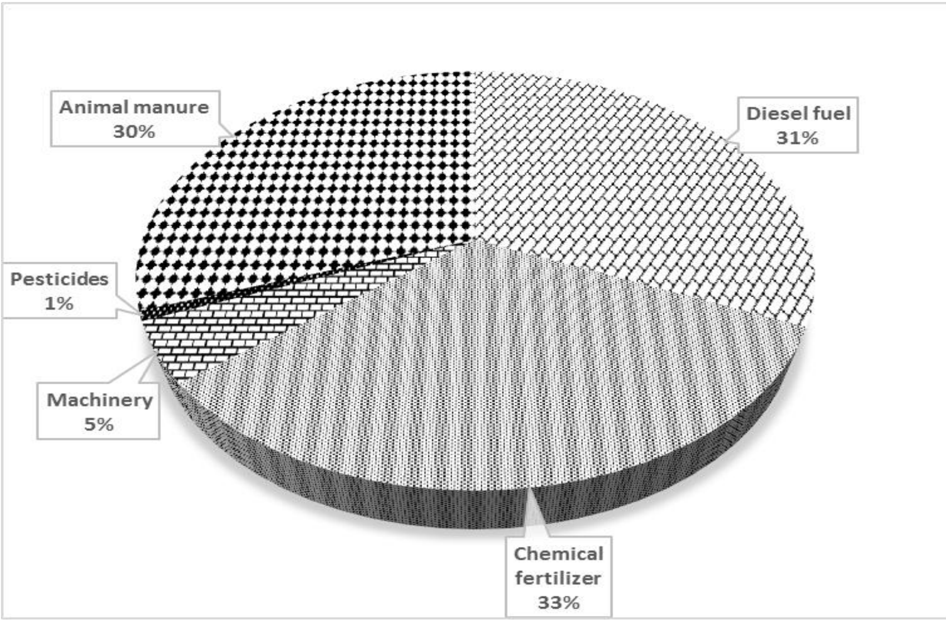

Figure 3. *The share of each crop inputs in terms of percent of total GWP*

The results of the present research showed that manure was not used in 60% of farms; hence, GHG emissions in these fields was zero (*Fig. 4*). The minimum amount of GHG emission with the least dispersion is related to the input of herbicides and insecticides (*Fig. 5*). Moreover, the comparison between the output energy and the GWP of the manure input showed that there was a direct and very significant relationship between the output energy in the cotton production and the GWP (*Table 5*).

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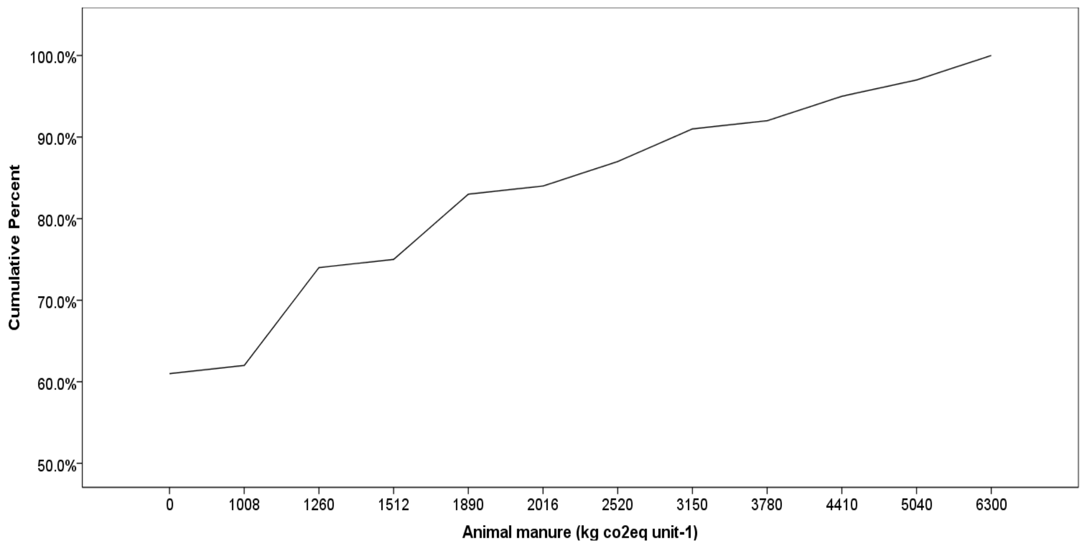

Figure 4. *Cumulative frequency graph of CO_2 produced from manure input on one ha of cotton fields*

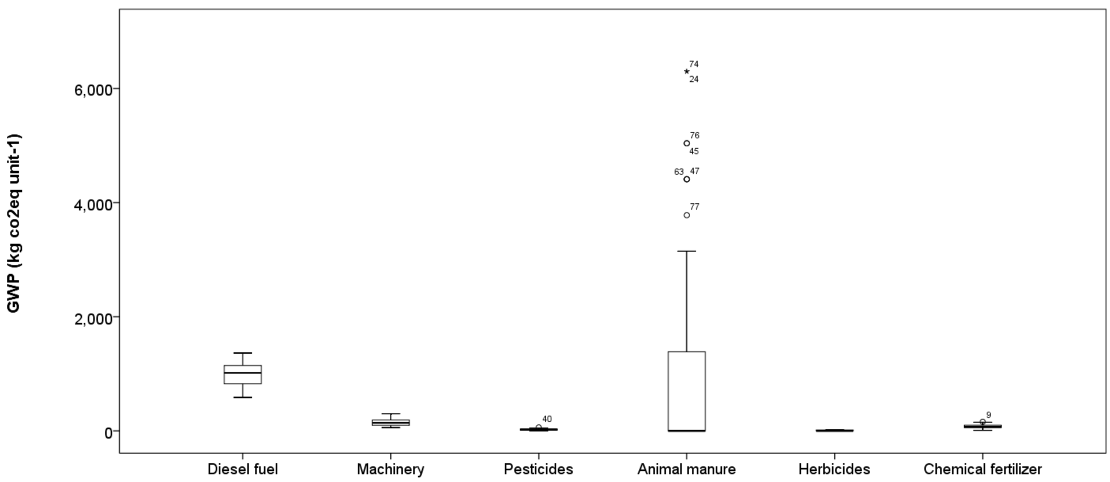

Figure 5. *Box plot of the GHG emissions resulting from the use of machinery, fuels, pesticides, manure, and herbicides in cotton production fields*

Table 5. *Pearson correlation coefficients between the emissions between field operations for cotton production*

The type of operation	Diesel fuel (kg co2eq unit-1)	Machinery (kg co2eq unit-1)	Pesticides (kg co2eq unit-1)	Animal manure (kg co2eq unit-1)	Herbicides (kg co2eq unit-1)	Chemical fertilizer (kg co2eq unit-1)	Energy input (MJ ha)	Yield	Total greenhouse gas emissions
Diesel fuel (kg co2eq unit-1)	1								
Machinery (kg co2eq unit-1)	.452**	1							
Pesticides (kg co2eq unit-1)	.367**	0.176	1						
Animal manure (kg co2eq unit-1)	1.050	.701**	-0.055	1					
Herbicides (kg co2eq unit-1)	-0.054	-0.095	-0.070	-0.064	1				
Chemical fertilizer (kg co2eq unit-1)	-0.142	-0.104	-0.082	-0.008	-0.163	1			
Energy input (MJ ha)	.560**	.827**	1.169	.798**	-0.108	0.177	1		
Yield	.384**	.531**	.238*	.408**	0.045	0.022	.593**	1	
Total greenhouse gas emissions	1.179	.762**	1.002	.990**	-0.078	-0.006	.868**	.457**	1

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

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The results showed that the highest rate of the greenhouse gases emissions was related to the chemical fertilizer input with an average of 1019 kg CO_2 per ha of global warming (*Fig. 4* and *Table 5*). The rate of GHG emission released from the chemical fertilizer in 20% of the farms under investigation was more than 1 ton per ha (*Fig. 6*). In addition, similar research results on other crops showed that the use of chemical fertilizers (especially nitrogen fertilizer) and fossil fuels have the highest impact on GHG emissions and GWP (Tzilivakis et al., 2005a, 2005b; Kaltsas et al., 2007; Lal, 2004). Rajabi et al. (2013) reported the amount of GHG emissions from nitrogen, phosphorus, and potassium fertilizers to produce wheat in Gorgan as 97, 67, and 64 kg, respectively, equivalent to CO_2-carbon per ha. Safa et al. (2011a) reported that GHG emissions from chemical fertilizers in wheat production in New Zealand were 52% and equal to 539 kg equivalent to CO_2 per ha, of which 48% was related to the nitrogen fertilizers.

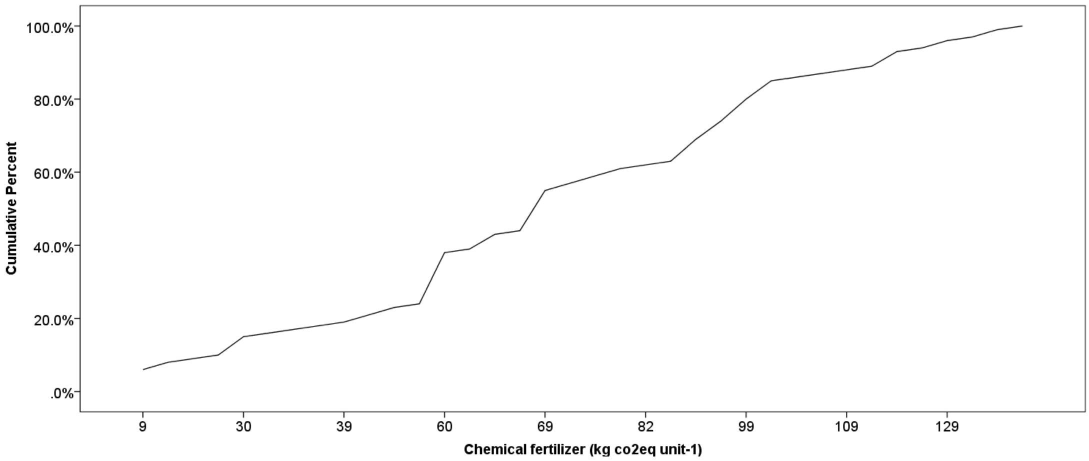

Figure 6. *The cumulative frequency graph of fertilizer (kg of CO_2 equivalent per ha) fields in cotton production*

In all fields studied in this work, the average GHG emissions from the consumption of fuel were 983 kg CO_2 per ha of global warming, of which 678 kg/ha was related to the irrigation, while tillage and spraying operations standing in the next ranks (*Fig. 7*).

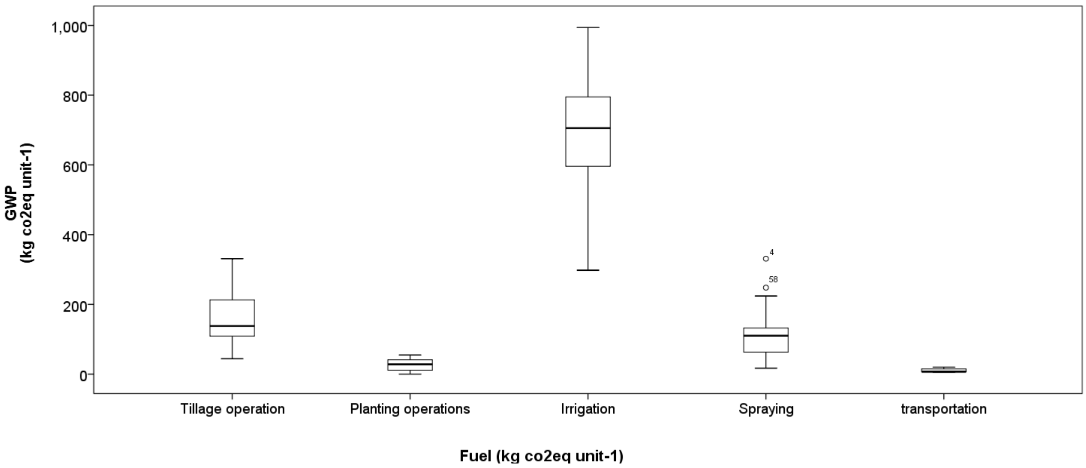

Figure 7. *Box plot of GHG emissions and fuel consumption of inputs in the production of cotton in the various crop operations*

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When using different irrigation methods, GHG emissions for the fuel use for this operation also changes in the farms.

In all fields studied in this work, GHG emissions in the use of machinery for irrigation operation had the highest rank as 49 kg of CO_2 dioxide per ha of global warming, while tillage, nutrition, and control of weeds and pests standing in the next ranks (*Fig. 8*).

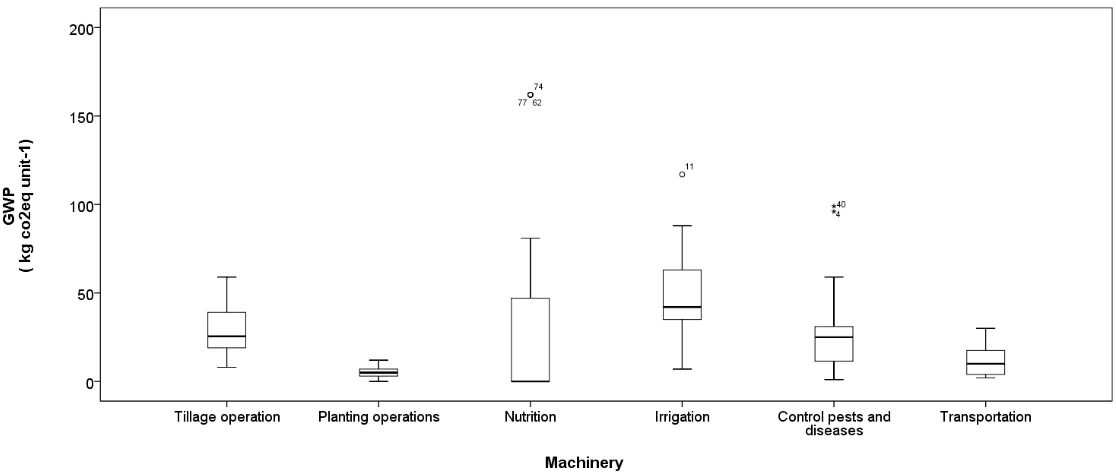

Figure 8. *Box plot of the production of GHG emissions from the use of machinery in the cotton fields*

Studying the CO_2 released by the pesticide input showed that the highest GHG emission is related to the Kauqueron and Lavrin pesticides (*Fig. 9*).

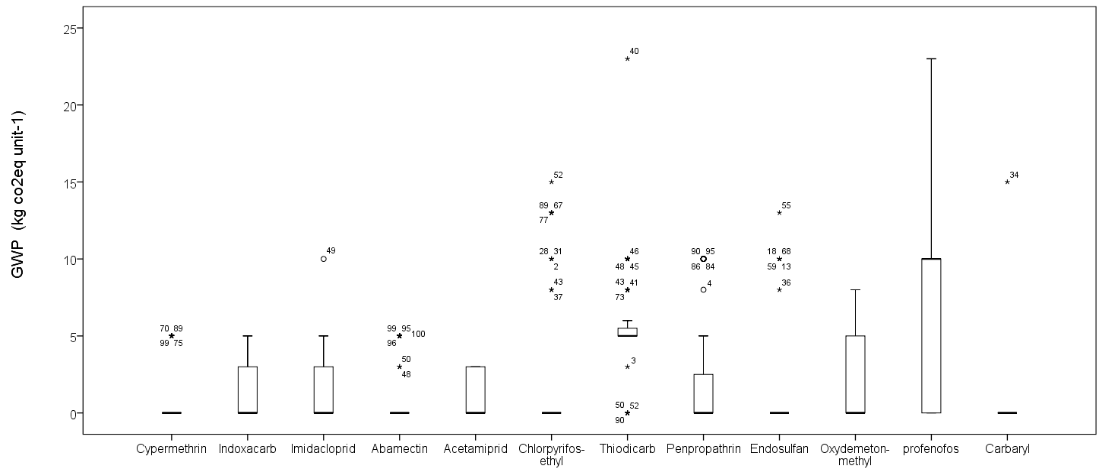

Figure 9. *Box plot of GHG emissions from inputs of pesticides in the cotton field*

The total average of the released gas was 23 kg CO_2 of the global warming. Safa et al. (2011a) estimated GHG emission as 55 kg, equivalent to CO_2 per ha. Some researchers reported that the use of natural methods of controlling pests and plant diseases could greatly reduce the use of agricultural pesticides, including. Among these natural methods are: increasing the resistance genes of the crops against the pests, diseases, and

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weeds, strengthening their natural enemies, using the correct crop rotation, combing the conservation tillage, and cultivating some forage plants and trees in the fields (Pimentel and Pimentel, 2008; Safa et al., 2011b; Kitani, 1999). The largest herbicide followed by the highest release of the gases released by Trafuralin herbicides is equivalent to 26.6 kg of CO_2 per ha of global warming (*Fig. 10*).

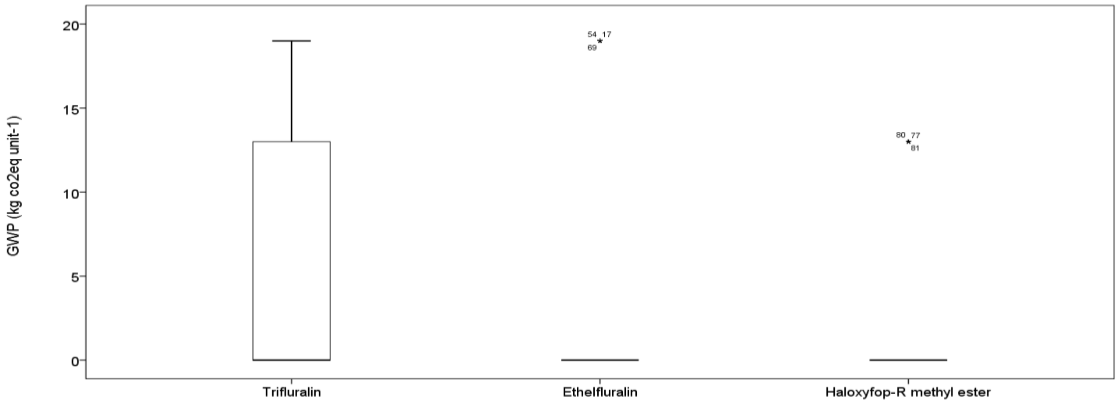

Figure 10. *Box plot of GHG emissions resulting from herbicide input in cotton fields*

The relationship between GWP and the amount of input energy production

The results of the comparison between the input energy and the GWP (*Fig. 11*) show that there is a direct and significant relationship between input energy in the cotton fields and the GWP; in other words, increasing energy consumption in the production of cotton will increase the emissions of greenhouse gases.

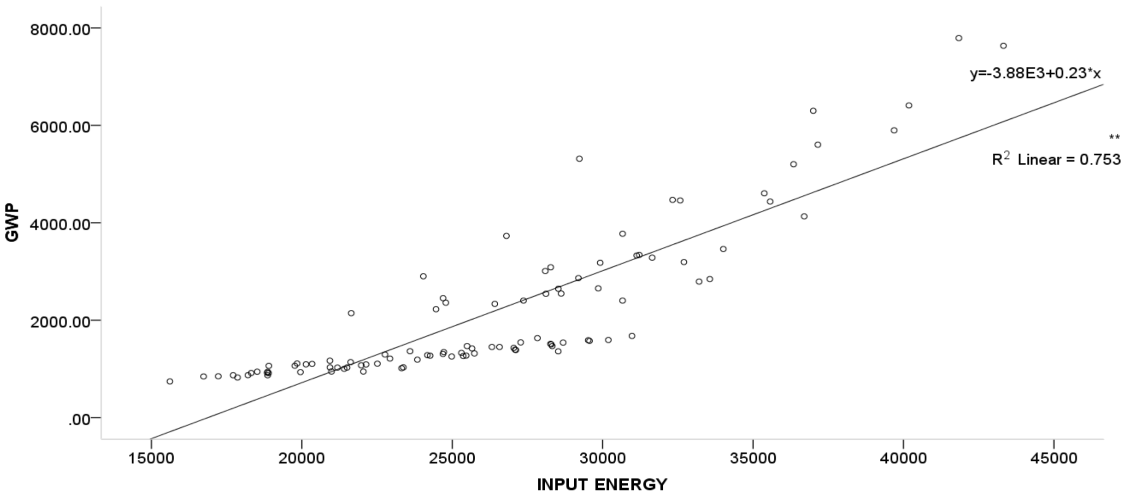

Figure 11. *The relationship between GWP and the amount of input energy production in cotton fields*

The concentration of the points around the line indicates that there is a complete and important relationship between input energy and GHG emissions. As shown in *Table 5*, the input energy with fuel gases emitted by fuel inputs, machinery, and manure is significant at 0.01%. Tzilivakis et al. (2005 b) also investigated GWP in beet production in England and stated that there is a direct relationship between the GWP values and

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amount of input energy in beet production. The findings of other studies were consistent with those of the present work in terms of assessing the input energy and the GWP obtained from it in various products (Kaltsas et al., 2007; Lal, 2004; Pathak and Wassmann, 2007). In this work, a direct relationship was found between the output energy and the input energy; in other words, the increase of input energy will increase the yield of the product and consequently the output energy and GHG emissions (*Table 5*). *Figure 12* shows a direct and significant relationship between the performance and the GHG emissions from cotton production. As the performance increases, the dispersion rate of the points in the line also increases. The high scattering of the points shown in *Figure 12* suggests that there is a high variation in energy consumption in high performances.

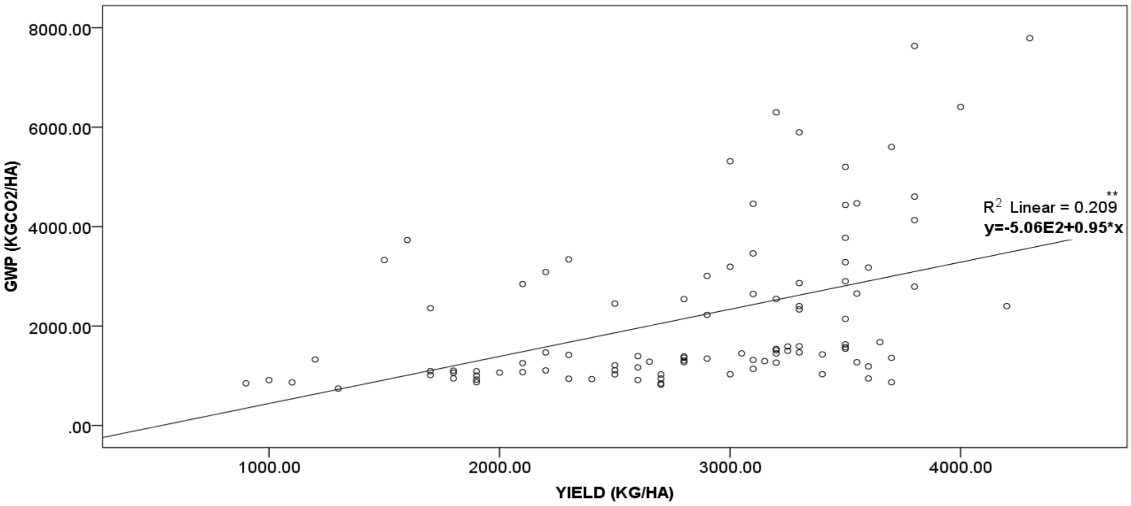

Figure 12. *The relationship between performance and GHG emissions in cotton production*

Global warming potential values for kg of CO_2 per unit area, weight, energy input and energy output

Table 6 presents the total GWP values in terms of area, weight, input energy, and output energy. GWP per weight represents CO_2 emissions per tons of product. Our results show that for 1 ton of cotton, 2178 kg of CO_2 per ton of cotton is produced. Gas emissions in terms of area, input energy, and output energy were estimated as 768 kg CO_2 per ha, 76 kg equivalent to CO_2 in GJ, and 14 kg equivalent to CO_2 in GJ, respectively.

Table 6. *Global warming potential values for kg of CO_2 per unit area, weight, energy input and energy output*

G W P	Unit (in ha)	Average	Minimum	Maximum
Global warming per unit weight	Kg CO2 equivalent per ton of cotton	2178.65	741.65	7790.81
Global warming per unit area	Kg CO2 equivalent per hectare	768.05	234.91	2331.44
Global Warming per unit energy input	Kg of CO2 equivalent in GJ	76.38	42.85	186.21
Global Warming energy per unit of output	Kg of CO2 equivalent in GJ	14.09	4.31	42.78

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Conclusion

In this research, we estimated the input and output energies of GHG emissions and the GWP due to agronomic activities in cotton fields in Golestan province. The results revealed that the average input and output energies are 26 and 154 GJ/ha, respectively, with an output energy being six times larger than the input energy. The average GHG emission for cotton production was estimated at 2181 kilograms of CO_2 per ha, with the highest value as 33% of the total GHG emissions for chemical fertilizer input, with fuel inputs and manure standing at the next ranks. Irrigation, nutrition, and preparation had the highest fuel consumption and resulted in the increased GHG emissions. Hence, it can be concluded that reducing fuel consumption and the use of chemical fertilizers reduced energy consumption and GHG emissions. Among the management methods to reduce fossil fuel consumption and chemical fertilizers that release greenhouse gases in agriculture we can name: protective tillage that reduces traffic in the field, which results in the lowered fuel consumption; using legumes in agriculture, which leads to the reduced nitrogen consumption; using the new irrigation methods and increasing water efficiency; using agronomic rotation and biological methods to control pests and weeds; using the nitrogen fertilizers based on soil test; adapting the time of fertilization with the needs of the plant; improving the fertilization methods such as placement in soil instead of manual propulsion and centrifugation; using the nitrification inhibitor compounds or coated fertilizers; and finally, using the green fertilizers. Further research are required with respect to above mentioned measures to decline GHG emissions.

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