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Assessment Co_2 emission, energy indices and estimating yield in seed and grain corns production in Pars Abad Moghan city of Iran

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ABSTRACT

The aim of this study was to determine greenhouse gas (GHG) emissions and indicators for energy use and to evaluate energy sensitivity of seed and grain corn production in Pars Abad Moghan, Iran. The data was collected by a face-to-face interview method from 144 corn farms during 2011 year. Most of energy consumption in seed and grain corns was related to diesel fuel and chemical fertilizers. The net energy, energy productivity, energy intensity and GHG emission were -4688.77 MJ ha^{-1}, 0.06 Kg MJ^{-1}, 16.4 MJ Kg^{-1} and 1810.11 kg CO_2eq ha^{-1} for seed corn and 58330.63, 0.18, 5.53 and 1490.13 kg CO_2eq ha^{-1} for grain corn, respectively. The percentage share of renewable, nonrenewable, direct and indirect energies were 3, 97, 46 and 54 for seed corn, and 2, 98, 50 and 50 for grain corn, respectively. The highest value of GHG emission belonged to diesel fuel with share of 64.22% and 66.66 % of total emission for seed and grain corn, respectively. An econometric model was also developed to estimate the impact of energy inputs on yield by using Cobb-Douglas production function. For this purpose, seed and grain corn yields were assumed to be functions of energy inputs.

Introduction

Global mean temperature has increased during the past 100 years and raised concerns over global warming and uncertainty over future impacts on the climate (Pimentel et al., 1996). 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 (Pimentel et al., 1973). Energy use within agriculture is considered to be a key indicator of sustainable development and the use of methods to mitigate its environmental impact is vital. Crop production methods that reduce energy input while maintaining output are important components of a sustainable agricultural system.

Corn (*Zea mays L.*) in terms of production in the world, after wheat and rice, is considered as the third most important cereal (Ashofteh et al., 2011). Corn is a plant that is cultivated in order to produce grain, seed and silage for feeding livestock. The amount of energy consumption in agriculture depends on level of mechanization, the number of active farmers and the size of agricultural land (Singh, 2000). Energy is used in all facets of living and in all countries, and makes possible the existence of ecosystems, human civilizations and life itself (Ramedani et al., 2012). Agriculture is both a producer and consumer of energy. It uses large quantities of locally available non-commercial energies, such as seed, manure and livestock energy, and commercial energies directly and indirectly (Singh et al., 2002). Energy requirements in agriculture are divided into groups being direct, indirect, renewable or non-renewable. Direct energy to do work (operation) varied as land preparation, irrigation, threshing, harvesting, transport of agricultural inputs depend. Therefore, direct energy is used to be directly on farms. A wide variety of energy forms, which can be directly used, include diesel fuel, electricity to pump water for irrigation. Indirect energy is the energy contained in the packaging, transportation, chemical fertilizers, herbicides, and agricultural machines in use (Ozkan et al., 2007). Energy consumption in agriculture is one of the important and effective factors in sustainable agricultural production, because it reduces costs and saves, preserved the fossil resources and reduce the amount of air pollution and greenhouse gas emissions (Ulhin, 1998). Any increase in agricultural production,

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dependent on the amount of energy consumption and farm management that tillage system and management of inputs such as chemical fertilizer are important factors in corn production (Gowdy et al. 1987; Liu and Wiatrak, 2012). Optimization of these factors can improve seed and grain corn production in Pars Abad farms. Effective use of all inputs can be achieved by informed farmers and/or efficient production systems. 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 (Taki et al., 2012). Nassiri and Singh (2010) applied Data Envelopment Analysis method (DEA) for assessing source-wise and operation-wise the Technical Efficiency (TE) and Return-to-Scale (RTS) for paddy production in four zones of the state of Punjab, India. They concluded farmers in zone 2 with a source-wise TE of 0.91, have consumed energy from more efficient sources, followed by zone 4 (0.90) and then zones 3 and 5 (0.85).

Several research and reviews have been conducted about energy consumption of corn and other crops. Effect tillage (conventional and no-tillage) and energy efficiency on the performance of seed corn in the west of Turkey were studied and concluded that the highest fuel consumption in conventional tillage and the lowest it has been in No tillage (Yalcin and Cakir, 2006). Chemical fertilizers and diesel fuel acquired as a large consumer of energy resources, in corn silage production (Amanlou et al., 2010). Effect tillage on consumer energy for silage corn production in Turkey (Mediterranean coast) were studied and this were result that highest energy efficiency (8.78) and energy productivity (2.12) in low-tillage while lowest was in No tillage (Bereket et al., 2011). Energy consumption reviewed in the production of corn in 10 provinces, during the period of 7 years, and the energy ratio was estimated as 0.6 (Banaeian and Zangeneh, 2011). Existing guidelines for energy consumption in the production of cotton in Australia studied and the range of energy consumptions were between 3.7-15.2 GJ ha^{-1} which is the equivalent of 80-310 dollars per hectare. The irrigation water was 40 to 60% of total cost of the energy (Chen and Baillie, 2009). Energy consumption efficiency studied in different tillage systems for wheat production in two types of clay and loam soil in Sweden and the range of energy consumption for the production of product was between 5 percent for direct culture on soil silt loam to 25% to plough with moldboard plow in clay soils. Tillage energy compared with harvest energy was lower (Arvidsson, 2010).

The aim of this paper has been to reach the following goals: (1) to determine the energy indices per hectare for the production of seed and grain corns, (2) compare energy indices in different groups or cultivated area levels and (3) develop econometric models to estimate the impact of energy inputs on yield by using Cobb-Douglas production function and (4) determine GHG emission in seed and grain corn production.

Material and methods

Ardabil province of Iran is one of the most important agricultural centers in the country. The province is located in northwest of Iran, within 34^o 04′ and 39^o 42′ north latitude and 47^o 55′ and 48^o 55′ east longitude. Pars Abad city is located at the northern part of the province and is the most important center for seed and grain corn production in the province. Approximately 90% of Iranian seed corns and 100% sorghum is produced in this region. The area devoted to grain and seed corns cultivation in 2011, were 15832.5 and 963.5 ha, respectively. The largest land division level, in this area is 12 hectares. The necessary data to conduct this research were collected through face to face questioners including the hour of machinery usage and labors, diesel fuel, seeds, fertilizers and chemicals consumption per hectare and the yield of seed and grain corns. Data about the production of seed and grain corns was collected for the agricultural year 2010-2011. In this study, seed and grain corn fields, depending on the level of cultivation area, were divided into three groups (up to 3 ha, 3-6 ha, 6-12 ha).

The amount of inputs (chemicals, human labor, machinery, seeds, fertilizers and diesel fuel) and outputs (seed and grain corn yields) were calculated per hectare and then these data were converted to forms of energy to evaluate the input-output energies. In order to estimate output and input energies, these input data and output yields were multiplied with their coefficient of energy equivalents. Energy equivalents of inputs and output were converted into energy on area unit. For estimating the sample size, Cochrane formula and Morgan’s table were used (Banaeian and Zangeneh, 2011):

$$n = \frac{Nt^2 s^2}{Nd^2 + t^2 s^2} \qquad (1)$$

where n is the required sample size; N is the size of the statistical society (The number of corn farmers); t is the reliability coefficient (1.96 which represents the 95% reliability); s is the standard deviation; d is the acceptable error (the permissible error in the sample size was defined for 95% confidence). Based on this formula, number of sampling of 76 farms was obtained. For more accuracy 144 farmers were considered. Machines, human labor, diesel fuel, fertilizers, seeds and chemicals as input and the output value was taken as the generating and the amount of each input for the calculation of energy consumption per hectare.

Table 1- Energy equivalent of inputs and output in corn production

Input	Unit	Energy equivalent (MJ unit^{-1})	Refs.
A. Input			
1.Human labor	H	1.96	Kitani (1999)
2. Machinery	kg	62.7	Banaeian and Zangeneh (2011)
3.Diesel fuel	L	47.8	Kitani (1999)
4.Fertilizers			
Nitrogen(N)	kg	66.14	Erdal et al. (2007)
Phosphate(P_2O_5)	kg	12.44	Erdal et al. (2007)
Liquid	L	85	Esengun et al. (2007)
5. Chemicals			
Atrazine	kg	190	Kitani (1999)
24D	L	85	Kitani (1999)
Other	L	101.2	Banaeian and Zangeneh (2011)
6.Seed (corn)	kg	14.7	Houshyar et al. (2012)
B. Output			
Corn	Kg	14.7	Houshyar et al. (2012)

In this study, farms were divided at two regional and three cultivation areas. Various measuring input energy forms such as direct, indirect, and renewable, non-renewable were introduced. Direct energy includes diesel fuel and human labor while indirect energy consists of machines, chemicals, fertilizers and the amount of seed consumed (Banaeian and Zangeneh, 2011).

Energy input and energy output are presented in Table1. Energy ratio (energy efficiency), productive energy, intensity energy and net energy was calculated with use the following equations (Mandal et al., 2002):

$$\text{Energy Ratio} = (\text{Energy output}(\text{MJ ha}^{-1})) / (\text{Energy Input}(\text{MJ ha}^{-1})) \qquad (2)$$

$$\text{Energy Productivity} = (\text{Corn output}(\text{kg ha}^{-1})) / (\text{Energy Input}(\text{MJ ha}^{-1})) \qquad (3)$$

$$\text{Intensity energy} = (\text{Energy Input}(\text{MJ ha}^{-1})) / (\text{Corn output}(\text{kg ha}^{-1})) \qquad (4)$$

$$\text{Net energy} = (\text{Energy output}(\text{MJ ha}^{-1})) - (\text{Energy Input}(\text{MJ ha}^{-1})) \qquad (5)$$

These energy indices were calculated for the production of seed and grain corns for small (up to 3 ha), medium (3 - 6 ha) and large (more of 6 ha) groups, respectively.

In order to investigate the relationship between input energies and seed and grain corn yields a mathematical function can be used. For this purpose, Cobb-Douglass production function was chosen:

$$Y = f(x)\, exp(u) \qquad (6)$$

Equation (6) can be expressed in the following form

$$lnY_i = a + \sum_{j=1}^{n} a_j\, ln(X_{ij}) + e_i \qquad i = 1,2,\dots,n \qquad (7)$$

where Y_i denotes the yield of the ith farmer, X_{ij} the vector of inputs used in the production process, a the constant term, a_j represent coefficients of inputs which are estimated from the model and e_i is the error term. With the assumption that when the energy input is zero, the crop production is also zero, Eq. (7) is changed to Eq. (8);

$$lnY_i = \sum_{j=1}^{n} a_j\, ln(X_{ij}) + e_i \qquad i = 1,2,\dots,n \qquad (8)$$

Finally, Eq. (8) can be expanded to:

$$lnY_i = a_1\, ln(X_1) + a_2\, ln(X_2) + a_3\, ln(X_3) + a_4\, ln(X_4) + a_5\, ln(X_5) + a_6\, ln(X_6) + e_i \qquad (9)$$

where X_1 is human labor, X_2 diesel fuel, X_3 chemicals energy, X_4 chemical fertilizer, X_5 machinery, X_6 corn is energy inputs. With respect to this pattern, by using Eq. (9), the impact of the energy of each input on the output energy was studied. Because of low seed energy consumption and not significant in two seed and grain productions, its energy was ignored in Eq.(9). Finally, Eq. (9) was estimated using ordinary least square technique.

All calculations were carried out using the SPSS 20 and Excel software programs. All the data collected of seed and grain corn fields were imported into Excel 2010 worksheets and the energy values were calculated and analyzed. In order to measure the strength of a linear relationship between variables the coefficient of determination (R^2) was estimated for models and analyzed.

The amounts of GHG emission from inputs in seed and grain corn production 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

Input	Unit	GHG coefficient (kg CO_2 eq unit^{-1})	Reference
Machinery	MJ	0.071	(Lal, 2004)
Diesel fuel	L	2.76	Lal, 2004)
Chemical fertilizer		1.3	Lal, 2004)
Nitrogen (N)	Kg	0.2	Lal, 2004)
Phosphorus (P2O5)	Kg	0.2	Lal, 2004)
Liquid	Kg	0.2	Lal, 2004)
Chemicals	Kg	5.1	Lal, 2004)

Results and discussion

Statistical analysis and energy indices in corn production

Tables 3 and 4 show average of consumed energies for the three group of farm sizes. The results showed that, in the production of seed and grain corns, chemical fertilizers and diesel fuel have the biggest shares and the human labor and seeds have the lowest share in energy consumption. Tables 5 and 6 show seed and grain corn energy indicators at different levels of cultivation. The average value of energy use efficiency (energy ratio) was calculated as 0.89 and 2.65 for seed and grain corns. It was almost higher and lower than Banaeian and Zangeneh (2011) and Bereket et al. (2011) research results on grain corn production where energy ratio calculated as 0.61 and 8.78, respectively. Net energy seed corn (Table 4) is negative (less than zero). Therefore, it can be concluded that in seed corn production energy is being lost. Pahlavan et al. (2012) studied relationship between energy inputs and crop yield in greenhouse basil production in Esfahan province and obtained energy ratio, productivity and net energy 0.25, 0.11 kg MJ^{-1} and -177377MJ ha^{-1}, respectively.

Table 3- Energy input and output seed corn production (MJ ha^{-1})

Inputs	Farm size groups				Percentage(%)
	Small(≤3 ha)	Medium(3-6ha)	Large(>6)	Average(MJ ha^{-1})	
A. input					
Machinery	2333.46	1805.37	2120.5	2086.44	4.62
Labor	740.47	772.29	826.75	779.84	1.73
Diesel fuel	23555.84	16635	20203.87	20131.57	44.57
Chemical fertilizers	20621.97	17567.01	20238.41	19475.79	43.12
Nitrogen(N)	19395.56	16733.42	19205.4	18444.79	40.84
Phosphate(P_2O_5)	679.22	615.78	671.76	655.58	1.45
Liquid	547.19	217.81	361.25	375.42	0.83
Chemicals	2564.4	2037.87	2334.38	2311.21	5.12
Seed	374.85	376.69	382.2	377.91	0.84
Total energy input	50190.98	39191.22	46106.11	45162.77	100
B. Output					
Seed corn	41031.38	38128.13	42262.5	40474	

Table 4. Energy input and output grain corn production (MJ. ha^{-1})

Inputs	Farm size groups				Percentage(%)
	Small(≤3 ha)	Medium(3-6 ha)	Large(>6 ha)	Average(MJ ha^{-1})	
A. input					
Machinery	1823.86	1679.77	1678.95	1729.68	4.91
Labor	298.09	256.1	248.98	267.73	0.76
Diesel fuel	18672.47	16810.84	16130.23	17204.51	48.88
Chemical fertilizers	13827.71	12923.4	13758.65	13503.25	38.36
Nitrogen(N)	12930.37	12169.76	12930.37	12676.83	36.01
Phosphate(P_2O_5)	615.78	541.14	615.78	590.91	1.68
Liquid	281.56	212.5	212.5	235.52	0.67
Chemicals	2019.33	2152.63	2160.25	2110.73	6
Grain	298.09	385.87	382.2	382.2	1.09
Total energy input	37019.99	34208.61	34359.26	35198.11	100
B. Output					
Grain corn	89302.5	92977.5	113006.3	93528.75	

Table 5- Energy indices in seed corn production.

Item*	Unit	Farm size groups				Percentage
		Small (≤3ha)	Medium(3-6ha)	Large (>6ha)	Average	
Energy ratio	-	0.81	0.97	0.91	0.89	-
Energy productivity	Kg MJ^{-1}	0.05	0.06	0.04	0.06	-
Specific energy	MJ ha^{-1}	17.98	16.32	22.52	16.4	-
Net energy	MJ ha^{-1}	-9159.61	-1063.1	-3843.61	-4688.77	-
DE	MJ ha^{-1}	24296.31	17407.29	21030.62	20911.4	46.3
IDE	MJ ha^{-1}	25894.68	21783.93	25075.49	24251.37	53.7
RE	MJ ha^{-1}	1115.32	1148.98	1208.95	1157.75	2.56
NRE	MJ ha^{-1}	49075.67	38042.24	44897.15	44005.02	97.44
Total energy	MJ ha^{-1}	50190.98	39191.22	46106.11	45162.77	100

***DE, IDE, RE and NRE refer to direct, indirect, renewable and nonrenewable forms of energy, respectively**

Table 6- Energy indices in grain corn production

Item*	Unit	Farm size groups				Percentage
		Small (≤3ha)	Medium(3-6ha)	Large(> 6ha)	Average	
Energy ratio	-	2.41	2.71	2.86	2.65	-
Energy productivity	kg MJ^{-1}	0.11	0.19	0.19	0.18	-
Specific energy	MJ ha^{-1}	8.57	5.03	5.13	5.53	-
Net energy	MJ ha^{-1}	52282.5	58768.88	63946.98	58330.63	-
DE	MJ ha^{-1}	18970.56	17066.94	16379.21	17472.24	49.64
IDE	MJ ha^{-1}	18049.42	17141.67	17980.04	17725.87	50.36
RE	MJ ha^{-1}	676.61	641.98	631.18	649.93	1.85
NRE	MJ ha^{-1}	36343.37	33566.63	33728.07	34584.18	98.15
Total energy	MJ ha^{-1}	37019.99	34280.61	34359.26	35198.11	100

***DE, IDE, RE and NRE refer to direct, indirect, renewable and nonrenewable forms of energy, respectively**

Fig. 1 shows the average percentage share of energy consumption in the production of the two products by inputs. Fig. 2 shows a variety of energy forms used in the production of two products. The portion of direct and indirect input energies were 43, 57%, and 46, 54%, in total energy input for seed and grain corns, respectively. According to Fig. 2, the maximum amount of energy consumption in both products related to non-renewable energy that a large part of it was related to diesel fuel and fertilizer inputs. This indicates that corn production depends mainly on non-renewable energy (chemicals, machinery, seed and fertilizers) in the studied area.

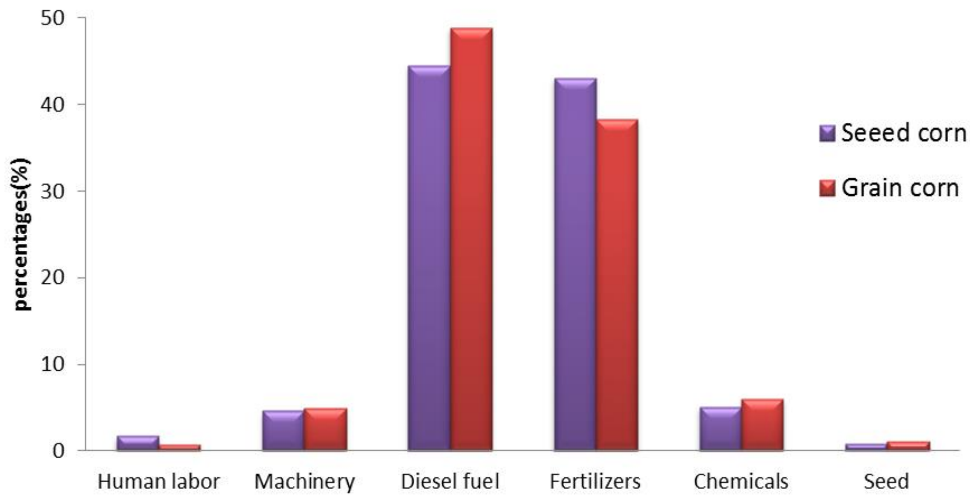

Figure 1 The share of total mean energy input in corn production

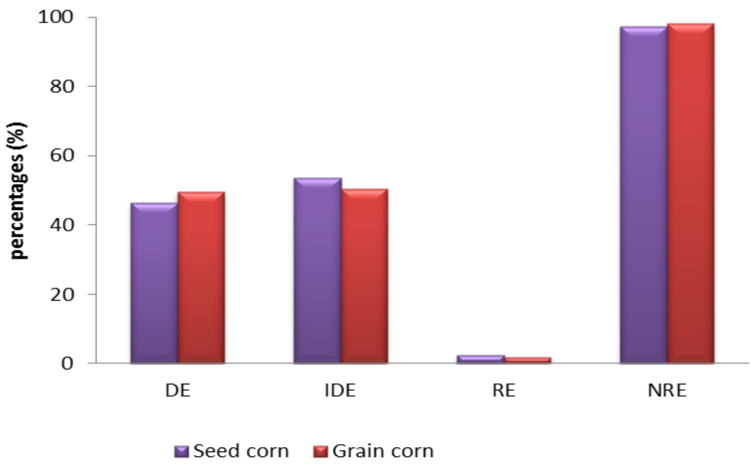

Figure 2 Total mean energy input as direct, indirect, renewable and nonrenewable forms

Main causes of the high consumption of fertilizer chemicals in the studied area were low level of awareness of farmers in agricultural practices and failure to perform testing of soils. Also, the high contribution of fertilizer energy showed that, farmers were not fully aware of proper time and quantity of fertilizers usage. The causes of high consumption of diesel fuel in operation of corn production were; (1) not setting fuel pumps and injector of tractors properly, and (2) lack of appropriate equipment with the type of tractor being used.

Econometric model for estimating corn production

The average yield of seed corn was 2753.33 kg ha^{-1} and that of grain corn was 6362.5 kg ha^{-1}. One of the most basic aspects of farm management in corn cultivation, like any other product, is determining of seed planting date, as it can have a major impact on the growth of the plant. Corn is a plant that is very sensitive to planting date and for every day of delay in the planting, the performance of the product slow down. One of the main cause of low performance in the studied year (2011) was being late planting date due to bad weather conditions. In seed and grain corns, the best performance was related to the level cultivation of the third group with 2875 kg ha^{-1} and 6687.8 kg ha^{-1}, respectively. Also the lowest yield in seed corn was in the second group, while the lowest yield in grain corn was in the first group.

To determine the most effective inputs, regression method was used. An econometric model was developed to estimate the impact of energy inputs on yield by using Cobb-Douglas function. For this purpose, seed and grain corn yields as endogenous variables were assumed to be function of energy inputs. These results indicated (Table 7) that in seed corn with an additional use of machinery and chemicals energy by 1%, yield will increase by 2.71% and 0.218%, respectively. However, in the case of seed corn, a 1% additional use of diesel fuel and human labor would lead to a decrease by 0.203% and 0.651 % in yield, respectively.

Table 7-The model offered to produces seed and grain corn by using energy consumption

Independent variable a_i	Coefficient		t- ratio	
	Seed	Grain	Seed	Grain
Model: $\ln Y_1=a_1\ln(x_1)+ a_2 \ln(x_2)+ a_3 \ln(x_3)+ a_4 \ln(x_4)+ a_5 \ln(x_5)+e_i$				
Human labor	-0.651	-0.185	-1.88***	-.105
Diesel fuel	-0.203	-0.483	-7.176*	-3.566*
Fertilizer	0.051	0.015	3.96*	0.294
Chemical	0.218	0.667	1.37	2.071**
Machinery	2.714	7.547	8.405*	4.049*
Durbin- Watson	1.66	1.98		
R^2	0.987	0.982		
Return to scale($\sum_{j=1}^{n} a_j$)	2.129	7.561		

*Significance at 1% level.

**Significance at 5% level.

***Significance at 10% level.

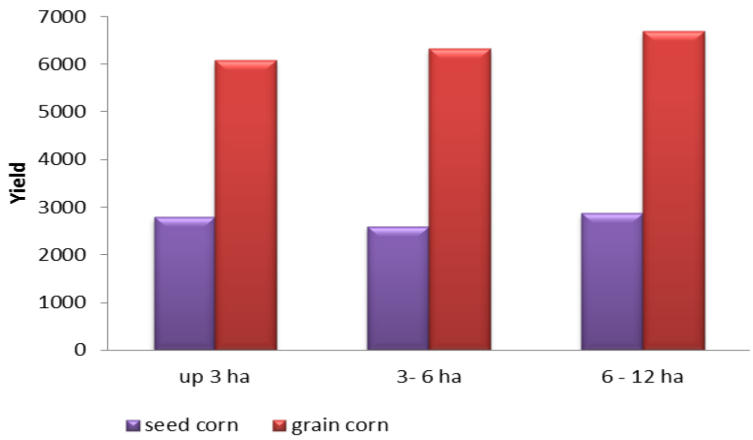

Figure 3- Seed and grain corn yields for different levels of cultivation

GHG emission of corn production

The results of greenhouse gas emission of seed and grain corn production are shown in Table 8. The highest value of GHG emission belonged to diesel fuel with share of 64.22% and 66.66 % of total emission and followed by Chemical fertilizer with proportion of 20.65% (373.96 kg CO_2eq ha^{-1}) and 17.4% (259.21 kg CO_2eq ha^{-1}) for seed and grain corn, respectively. Nitrogen in chemical fertilizer had the first rank in GHG emission (20.03% and 16.72 of total GHG emission). Using chemical fertilizer (especially nitrogen) more than seed and grain corn 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 seed and grain corn production was Liquid and Phosphorus (P_2O_5) with amount of 0.883,0.55 kg CO2eq ha^{-1}(0.04%, 0.4%) and 10.54, 9.5kg CO2eq ha^{-1}(0.58%, 0.64 %) of total GHG emissions (Table 8).

Table 8- GHG emission of inputs in seed and grain corn production

Input	GHG coefficient (kg CO_2eq ha^{-1})		Percentage(%)	
	Seed	Grain	Seed	Grain
Machinery	148.13	122.81	8.18	8.24
Diesel fuel	1162.4	993.4	64.22	66.66
Chemical fertilizer	373.963	259.216	20.65	17.4
Nitrogen (N)	362.54	249.166	20.03	16.72
Phosphorus (P_2O_5)	10.54	9.5	0.58	0.64
Liquid	0.883	0.55	0.04	0.04
Biocide	125.61	114.71	6.94	7.7
Total	1810.11	1490.136	100	100

With lack of similar research in corn production, some of the investigations that have been done in greenhouse gas(GHG) emissions on other crops as follows: Khakbazan et al. (2009) 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. (1999) 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. Ho (2011) calculated the amount of GHG emissions in wheat production and found 2963 MgCO_2 ha^{-1} where, fertilizer production had the highest GHG emissions (with share of 89%).

Conclusion

This study analyzed the input and output energy of seed and grain corns production based on three groups of farms (small (≤ 3ha), medium(3- 6 ha) and large (> 6 ha)). Based on the present study the following conclusions are drawn:

The total energy consumptions for seed and grain corns were 45162.77 and 35198.11, respectively. Highest energy consumption related to diesel fuel and chemical fertilizers**.** The lowest share of energy consumption belonged to seeds and human labor. The results showed in seed corn fields, energy consumption in large farms was more than the second group and less than the first group.

The energy ratios for the seed and grain corns were 0.89 and 2.65, respectively. The net energy, energy productivity, energy intensity and GHG emission were -4688.77 MJ ha^{-1}, 0.06 Kg MJ^{-1}, 16.4 MJ Kg^{-1} and 1810.11 kg CO2eq ha^{-1} for seed corn and 58330.63, 0.18, 5.53 and 1490.13 kg CO2eq ha^{-1} for grain corn, respectively. Analysis of different groups indicated that the best results for the energy indicators belong to the third group (greater than 6 ha).

The ratio of direct to indirect energy for seed corn (0.86) was less than that of grain (0.98). The main cause of it was usage of more manure (N) in the seed corn production.

The results of regression analysis indicated that machinery energy input had major impact (2.714) on seed corn yield while the coefficient value of human labor and diesel fuel calculated as -0.651 and **-**0.203, respectively.

A high proportion of indirect energy in corn production can be supplied through animal manure. Recently farmers in this region, try replacing it with the part of chemical fertilizers.

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