International Journal of Agricultural Management and Development (IJAMAD)
Available online on: www.ijamad.com
ISSN: 2159-5852 (Print)
ISSN:2159-5860 (Online)
DOI: 10.5455/ijamd.165294

A Comparative Study of Energy Use and Greenhouse Gas Emissions of Canola Production

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Received: 25 July 2014,
Accepted: 07 September 2014

Abstract

In this research, the energy flow and production energy indices of canola cultivation in Trakya province of Turkey, Golestan and Mazandaran provinces of Iran were compared. Diesel fuel and chemical fertilizer inputs were the highest consumer of energy in the production of canola in these three regions. The results indicated that despite the higher energy use of machinery in Trakya province of Turkey, the energy use of diesel fuel in this province is less than the energy consumed in the two northern provinces of Iran, which could be due to available old machines for the production of canola in Mazandaran and Golestan provinces. Total greenhouse gas emissions of canola production for these regions were computed 562.85, 652.86 and 887.30 $kgCO_2eq\ ha^{-1}$, respectively. The inputs of chemical fertilizer and diesel fuel in canola production produced the highest percentage of gas emissions in these three areas. Energy consumption for potential feedstock production for one kg production of biodiesel fuel in these provinces was calculated as 14.76, 20.66 and 37.77 MJ, respectively. The amounts of greenhouse gas emissions for potential feedstock production for one kg production of biodiesel were obtained 0.45, 0.76 and 1.17 $kgCO_2eq$ for Trakya, Golestan and Mazandaran provinces, respectively.

Keywords:
Carbon dioxide emission, Energy indices, Feedstock for biodiesel, Iran, Turkey

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INTRODUCTION

Canola is an important industrial oilseed crop (Rempel *et al*., 2014). It is now cultivated in many agricultural regions worldwide (Kant *et al*., 2014). The canola growing area increased from 119,000 ha in 2004 to 170,000 ha in 2012 in Iran (Food and Agriculture Organization, 2012). The highest share of canola growing area in Iran belongs to Golestan (27.4%) followed by Mazandaran province (17.3%) (Ministry of Jihad-e-Agriculture of Iran, 2012). Moreover, the Turkish canola growing area increased from 1,700 ha in 2004 to 10,000 ha in 2007 and to 30,000 ha in 2012 (FAO, 2012). Canola is a potential feedstock for biodiesel fuel production (Ahmad *et al*., 2011; Ghobadian, 2012). Sims and Sayigh (2003) reported that the all forms of bioenergy such as biodiesel when substituted for fossil fuels, will directly reduce carbon dioxide emissions. From an economic point of view for producing energy from edible oil seeds, there are five major items that should be considered: increasing crop yield per unit area, assessment of environmental benefits, reduce the consumption of inputs, increasing energy efficiency and reduce the lost opportunity cost of crop land (Nikkhah *et al*., 2015; Safieddin-Ardebili *et al*., 2011; Sims and Sayigh, 2003).

Due to the nature of the energy outputs of various crops, the comparison of energy efficiency, energy productivity, specific energy and net energy cannot give us complete information. Asgharipour *et al*. (2012) performed a research on the energy of sugar beet production in Iran. For sugar beet, energy efficiency, productivity energy, specific energy and net energy were 13.4, 0.8 kgMJ^{-1}, 1.3 MJkg^{-1}, 521,413.7 MJha^{-1}, respectively. In another study that carried out by Salehi *et al*. (2014), these indices for button mushroom production were reported 0.028, 0.017 kgMJ^{-1}, 59.5 MJkg^{-1}, -875 MJha^{-1} respectively. As a consequence, best results are obtained when the comparison of production of one crop in various regions performed.

Ozkan *et al*. (2004) performed a study on the energy use in the Turkish agricultural sector for the period of 1975–2000; they concluded that total energy input increased from 17.4 GJha^{-1} in 1975 to 47.4 GJha^{-1} in the year 2000. Moreover, total output energy increased from 38.8 to 55.8 GJha^{-1} in the same period. The energy efficiency was found to be 2.23 in 1975 and 1.18 in 2000. In a similar study that carried out by Beheshti-Tabar *et al*. (2010), the energy performance of Iranian agricultural systems during 1990-2006 years was evaluated. They reported that total energy input increased from 32.40 GJ ha^{-1} in 1990 to 37.20 GJ ha^{-1} in 2006. Total output energy increased from 30.85 to 43.68 GJ ha^{-1} at the same period. Irrigation with 40.0% and fertilizer with 28.4% had the highest share in energy use. Several studies have been performed on energy consumption of crop production in Iran and Turkey after 2006 year, showing that diesel fuel and chemical fertilizers have the largest share in energy consumption (AghaAlikhani *et al*., 2013; Banaeian *et al*., 2011; Çetin and Vardar, 2008; Erdal *et al*., 2007; Heidari and Omid 2011; Mohammadi and Omid 2010; Mohammadi *et al*., 2008; Samavatean *et al*., 2011).

Several researches have been conducted on energy and GHG emissions in different agricultural crops production. Yilmaz *et al*. (2005) analyzed the energy consumption of cotton production in Turkey and found the total energy use 49.73 Gjha^{-1} and the diesel fuel input was the highest GHG emissions input and followed by chemical fertilizers GHG emissions. In a similar study, carried out by Pishgar-Komleh *et al*. (2012) energy use and GHG emissions of cotton production was performed and concluded that chemical fertilizers and diesel fuel were the most influential factors in energy consumption. The inputs of machinery and diesel fuel in cotton production produced the highest percentage of carbon dioxide emission in Alborz province of Iran. In a another study conducted by Ramedani *et al*. (2011) total energy consumption of soybean production in Golestan province of Iran was obtained 18026 MJha^{-1} and in between the different energy sources, the highest share of energy consumption belonged to diesel fuel (67%) followed by chemical fertilizers (14%). In a study Liu *et al*. (2013) selected five scenarios related to cassava (based fuel ethanol) planting modes to evaluate the en-

Table 1: Greenhouse gas emission coefficients

Inputs	Unit	GHG emissions coefficients ($kgCO_2eq\ unit^{-1}$)	Reference
Agricultural machinery	MJ	0.071	(Dyer and Desjardins, 2006)
Diesel fuel	lit	2.76	(Dyer and Desjardins, 2003)
Chemical Fertilizer			
N	kg	1.3	(Lal, 2004)
P_2O_5	kg	0.2	(Lal, 2004)
K_2O	kg	0.2	(Lal, 2004)
Biocide			
Fungicides	kg	3.9	(Lal, 2004)
Insecticides	kg	5.1	(Lal, 2004)
Herbicides	kg	6.3	(Lal, 2004)
Electricity	kWh	0.608	(Lal, 2004)

ergy balance and GHG emissions. They showed that, although all the five cassava scenarios have positive net energy values and GHG emissions savings in comparing with the conventional gasoline, the planting modes have significant effect on their energy and carbon dioxide emission. Rajaefar *et al*. (2014) analyzed the energy use and GHG emission of biodiesel production from soybean in Iran. The biodiesel production system consisted of six stages: soybean production, soybean transportation, soybean crushing, biodiesel conversion, and transportation. They reported that agricultural soybean production stage ranked the first in energy consumption among the five main stages where it used 50.56% of total fossil energy consumption in the biodiesel production.

Considering there is no published document in terms of energy use and GHG emission from potential feedstock (canola) production of biodiesel fuel in Iran and Turkey, this study was aimed to compare the energy consumption and GHG emissions of canola production in Trakya province of Turkey, Golestan and Mazandaran provinces of Iran.

MATERIALS AND METHODS

Site description and data collection

This study was conducted in Mazandaran and Golestan provinces of Iran and Trakya province of Turkey. Mazandaran and Golestan provinces are located in north of Iran. The data for energy inputs and output and energy indices were collected from the results of other studies (Mousavi-Avval *et al.*, 2011; Taheri-Garavand *et al.,* 2010; Unakitan *et al.*, 2010).

Greenhouse gas emission

The greenhouse gas emissions were calculated for Trakya province of Turkey, Golestan and Mazandaran provinces. In these regions, the general inputs were seed, human labor, machinery, diesel fuel, chemical fertilizer electricity and biocides and the output was canola yield. The amount of GHG emissions calculated by multiplying the input application rate (seed, human labor, machinery, diesel fuel, chemical fertilizer, electricity and biocide) by its corresponding emission coefficient are shown in Table 1. The energy use of irrigation water was converted to the amount of electricity to gain the total CO_2 emissions in irrigation water input by multiplying the electricity consumption by GHG coefficient (Khoshnevisan *et al*., 2013). GHG emissions of canola production were determined per each hectare of land, each ton of canola grain and per 1000 MJ of total energy output.

Energy and GHG emission from potential

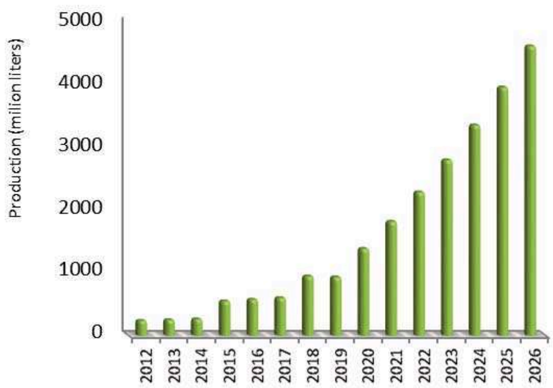

Figure 1: The outlook of biodiesel fuel share in Iran's transportation (Ghobadian, 2012)

feedstock production of biodiesel

The outlook of biodiesel fuel share in Iran's transportation is shown in Figure 1. Biodiesel production in Iran will increase during future years. There is a growing interest for biodiesel production in this region. Moreover, there is a high potential for biodiesel production from edible oil seeds in Iran. Canola is an edible oil seed and potential feedstock for biodiesel fuel production. Also, Turkey plans to widely expand its use of renewable energy, especially use of edible oil for biodiesel production (Acaroğlu and Aydoğan, 2012; Aytav and Kocar, 2013). In this study, canola weight conversion to biodiesel coefficients according to the study by Safieddin-Ardebili *et al*. (2011) was used for estimation. The energy input in cropping systems can be classed into two main categories (Salehi *et al*., 2014): a) direct energy: energy inputs including: human labor, diesel fuel and electricity b) indirect energy: energy inputs including: biocide, chemical fertilizer, seed and agriculture machinery (Kuswardhani *et al*., 2013; Soltani *et al*., 2013).

RESULTS AND DISCUSSION

Energy inputs-output in canola production

The amounts of inputs-output energy for canola production in Trakya province of Turkey, Golestan and Mazandaran provinces of Iran are shown in Table 2. The highest share of energy consumption belongs to chemical fertilizers followed by diesel fuel in the production of canola in these three regions. Human labor used for canola production was as 21.93, 154.79 and 36.14 h ha-1, respectively. The inputs of biocide energy use of canola production in Trakya province is less than the energy consumed in the two northern provinces of Iran. Moreover, the inputs of human labor energy consumption in Trakya province is less than the energy consumed in the two northern provinces of Iran and the energy use of machinery in Trakya province is higher than the energy consumed in the two northern provinces of Iran. It can be concluded that the mechanization degree of canola production in Trakya province of Turkey is high.

As seen in Table 2, despite the higher energy use of machinery in Trakya province, the energy use of diesel fuel in this province is less than the energy consumed in the two northern provinces of Iran, which could be due to available old machines for the production of canola in Mazandaran and Golestan provinces.

Total energy inputs for canola production in Trakya province of Turkey, Golestan and Mazandaran provinces were obtained 18297.61, 17786.36 and 28705.31 kg CO_2eq ha^{-1}, respec-

Table 2: Energy inputs and output for canola production in Iran and turkey

	Trakya province (Turkey)		Golestan province (Iran)		Mazandaran province (Iran)	
	Energy ($MJha^{-1}$)	Percentage	Energy ($MJha^{-1}$)	Percentage	Energy ($MJha^{-1}$)	Percentage
Seed	129.06	0.71	29.61	0.17	155.37	0.54
Human Labor	42.99	0.23	154.79	0.87	70.84	0.25
Agricultural machinery	1071.03	5.85	958.27	5.54	930.55	3.24
Diesel fuel	4473.83	24.45	4850.65	27.27	8604.17	29.97
Chemical Fertilizer	11823.37	64.62	8648.36	48.62	18809.84	65.53
N	11489.76	62.79	8368.88		17572.50	61.22
P_2O_5	333.61	1.82	630.07		1237.34	4.31
K_2O	-	-	149.35		-	-
Biocide	757.32	4.14	537.56	3.02	134.54	0.47
Fungicides	216.00	1.18	190.41			
Herbicides	491.28	2.68	303.55			
Insecticides	50.04	0.27	43.59			-
Farmyard manure	-	-	487.16			-
Electricity	-	-	2326.57	13.08	-	
Water for irrigation	-	-	253.56	1.43	-	
Total energy input	18297.61		18786.63		28705.31	
Total energy output	85556.96		53798.46		41230	

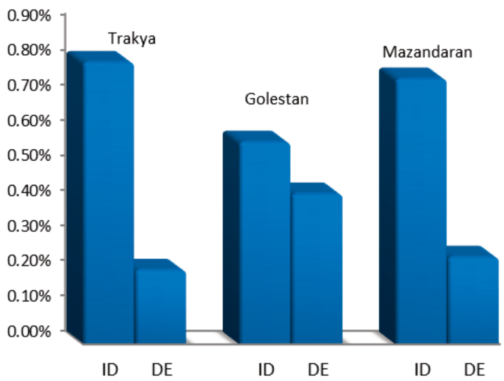

Figure 2: The percentage of direct energy and indirect energy for canola production in Iran and Turkey [1]

tively. Despite the use of electricity in Trakya province, the total energy inputs of canola production in Trakya region is less than the energy consumption in the Mazandaran and Golestan provinces. In addition, the energy output for canola production in Trakya region was higher than the energy output in the Mazandaran and Golestan provinces.

Table 3 presents the energy indices for canola production in these three regions. Average energy efficiency in Trakya province of Turkey, Golestan and Mazandaran provinces were 4.68, 3.02 and 1.44 respectively. The amount of energy efficiency of canola production was more than this index of energy for the production of canola in Mazandaran and Golestan provinces. The highest amount of canola yield belongs to canola production in Trakya province followed by canola production in Golestan province of Iran. The amounts of energy efficiency of canola production in Trakya province of Turkey, Golestan and Mazandaran provinces of Iran were 0.17, 0.12 and 0.066 kgMJ^{-1}, respectively. The share of direct and indirect energy of canola production is shown in Figure 2. The average direct and indirect forms of energy for canola production in Mazandaran province were 20% and 80%, respectively. The share of direct energy for canola production in Mazandaran province of Iran was less than that of canola production in Golestan province of Iran and Trakya province of Turkey.

GHG emissions of canola production

The GHG emissions of machinery input for canola production in Trakya province was more than that of producing canola in Mazandaran and Golestan provinces. In addition, GHG emissions from the diesel fuel for the same crop production in Trakya province was less than this volume in producing canola in the two northern provinces of Iran. The GHG emissions of chemical fertilizer from canola production in Golestan province was less than that of producing canola in Mazandaran and Trakya provinces.

Total GHG emissions of canola production were calculated as 562.85, 652.86 and 887.30 kgCO$_2$eq ha^{-1}, respectively (Table 4). The GHG emissions from canola production in Mazandaran province were high. The highest share of GHG emissions belongs to diesel fuel followed by chemical fertilizer in these three areas. Diesel fuel was accounted for 56% of total GHG emissions. The amounts of GHG emissions from canola production in Trakya province of Turkey, Golestan and Mazandaran provinces of Iran for 1000 MJ generation of energy were calculated as 6.58, 10.46 and 21.52 kgCO$_2$eq respectively. Moreover, the amounts of GHG emissions from canola production in these three regions were

Table 3: Energy indicators and forms for canola production in Iran and turkey

	Unit	Trakya province (Turkey)	Golestan province (Iran)	Mazandaran province (Iran)
Energy efficiency	-	4.68	3.02	1.44
Energy productivity	kg MJ^{-1}	0.17	0.12	0.066
Specific energy	MJ kg^{-1}	5.90	8.27	15.1
Net energy	MJ ha^{-1}	67259.36	36012.09	12524.69
Direct energy	MJ ha^{-1}	4516.82	7585.56	8674.74
Indirect energy	MJ ha^{-1}	13780.78	10200.80	20030.57
Renewable energy	MJ ha^{-1}	172.06	952.12	28478.54
Non-renewable energy	MJ ha^{-1}	18125.55	16861.24	226.77

[1] *DE: direct energy and ID: indirect energy*

Table 4: Greenhouse gas emissions of canola production in Iran (Golestan and Mazandaran provinces) and Turkey (Trakya province) ($kgCO_2eq\ ha^{-1}$)

	Trakya		Golestan		Mazandaran	
		Percentage		Percentage		Percentage
Agricultural machinery	76.04	13.51	69.95	10.71	66.07	7.45
Diesel fuel	219.28	38.96	280.08	42.90	496.81	56
Chemical Fertilizer						
N	246.48	43.79	144.83	22.18	307.87	34.70
P_2O_5	5.98	1.06	10.13	1.55	14.22	1.60
K_2O	-	-	2.68	0.41	-	
Biocide	15.06	2.67	13.69	2.10	2.33	0.26
Electricity	-	-	118.57	18.16	-	
Water for irrigation	-	-	12.92	1.98	-	
Total GHG emissions	562.85		652.86		887.30	

Table 5: GHG emission of canola production in Iran and Turkey ($kgCO_2eq$ per $unit^{-1}$)

	1000 kg	1000 MJ
Trakya province of Turkey	181.57	6.58
Golestan province of Iran	303.38	10.46
Mazandaran province of Iran	467	21.52

calculated as 181.75, 303.38 and 467 $kgCO_2eq$ $Tone^{-1}$, respectively (Table 5).

Analysis of energy and GHG emissions from potential feedstock production of biodiesel

Energy consumption for potential feedstock production for one kg production of biodiesel fuel in these provinces was calculated as 14.76, 20.66 and 37.77 MJ, respectively. The amounts of greenhouse gas emissions for potential feedstock production as one kg production of biodiesel were obtained 0.45, 0.76 and 1.17 $kgCO_2eq$ for Trakya, Golestan and Mazandaran provinces, respectively. According to the study was done by Dyer and Desjardins (2003), the GHG emissions for the combustion of each liter of diesel fuel are 2.76 $kgCO_2eq$. If we are going to use the canola to produce biodiesel, we should consider the inputs of canola cultivation systems in terms of environmental management.

CONCLUSIONS

Based on the present study the following conclusions are drawn:

• Diesel fuel and chemical fertilizers had the largest share in energy use and greenhouse gas emissions from canola production in Trakya province of Turkey, Golestan and Mazandaran provinces of Iran.

• Despite the higher energy use of machinery in Trakya province of Turkey, the energy use of diesel fuel in this province is less than the energy consumed in the two northern provinces of Iran.

• The energy consumption and GHG emissions from canola production in Trakya province were less than that of producing canola in Mazandaran and Golestan provinces.

• The amounts of greenhouse gas emissions for potential feedstock production for one kg production of biodiesel were obtained 0.45, 0.76 and 1.17 $kgCO_2eq$ for Trakya, Golestan and Mazandaran provinces, respectively.

REFERENCES

1- Acaroğlu, M., & Aydoğan, H. (2012). Biofuels energy sources and future of biofuels energy in Turkey. *Biomass and Bioenergy,* 36, 69-76.

2- Aghaalikhani, M., Kazemi-Poshtmasari, H., & Habibzadeh, F. (2013). Energy use pattern in rice production: A case study from Mazandaran province, Iran. *Energy Conversion and Management*, 69, 157-162.

3- Ahmad, AL., Yasin, N.H.M., Derek, C.J.C., & Lim, J.K. (2011). Microalgae as a sustainable energy source for biodiesel production: A review. *Renewable and Sustainable Energy Reviews*, 15,584-593.

4- Asgharipour, M.R., Mondani, F., & Riahinia, S. (2012). Energy use efficiency and economic analysis of sugar beet production system in Iran: A case study in Khorasan Razavi province. *Energy*, 44,

1078-1084.
5- Aytav, E., & Kocar, G. (2013). Biodiesel from the perspective of Turkey: Past, present and future. *Renewable and Sustainable Energy Reviews*, 25, 335-350.
6- Banaeian, N., Omid, M., & Ahmadi, H., (2011). Energy and economic analysis of greenhouse strawberry production in Tehran province of Iran. *Energy Conversion and Management*, 52, 1020-1025.
7- Beheshti-Tabar, I., Keyhani, A., & Rafiee, S. (2010). Energy balance in Iran's agronomy (1990–2006). *Renewable and Sustainable Energy Reviews*, 14, 849-855.
8- Çetin, B., & Vardar, A. (2008). An economic analysis of energy requirements and input costs for tomato production in Turkey. *Renewable Energy*, 33, 428-433.
9- Dyer, J.A., & Desjardins, R.L. (2003). Simulated farm fieldwork, energy consumption and related greenhouse gas emissions in Canada. *Biosystems Engineering,* 85, 503-513.
10- Dyer, J.A., & Desjardins, R.L. (2006). Carbon Dioxide Emissions associated with the manufacturing of tractors and farm machinery in Canada. *Biosystems Engineering,* 93, 107-118.
11- Erdal, G., Esengün, K., Erdal, H., & Gündüz, O. (2007). Energy use and economical analysis of sugar beet production in Tokat province of Turkey. *Energy*, 32, 35-41.
12- Food and Agriculture Organization (FAO). (2012). FAOSTAT, Available on: www.fao.org
13- Ghobadian, B. (2012). Liquid biofuels potential and outlook in Iran. *Renewable and Sustainable Energy Reviews*, 16, 4379-4384.
14- Heidari, M.D., & Omid, M. (2011). Energy use patterns and econometric models of major greenhouse vegetable productions in Iran. *Energy*, 36, 220-225.
15- Kant, S., Burch, D., Ehrenberger, W., Bitter, R., Rüger, S., Mason, J., Zimmermann, U., & Spangenberg, G. (2014). A novel crop water analysis system: identification of water stress tolerant genotypes of canola (*Brassica napus* L.) using non-invasive magnetic turgor pressure probes. *Plant Breeding*: doi:10.1111/pbr.12187.
16- Khoshnevisan, B., Rafiee, S., Omid, M., Yousefi, M., & Movahedi, M. (2013). Modeling of energy consumption and GHG (greenhouse gas) emissions in wheat production in Esfahan province of Iran using artificial neural networks. *Energy*, 52, 333-338.
17- Kuswardhani, N., Soni, P., & Shivakoti, G. P. (2013). Comparative energy input–output and financial analyses of greenhouse and open field vegetables production in West Java, Indonesia. *Energy*, 53, 83-92.
18- Lal, R. (2004). Carbon emission from farm operations. *Environment International,* 30, 981-990.
19- Liu, B., Wang, F., Zhang, B., & Bi, J. (2013). Energy balance and GHG emissions of cassava-based fuel ethanol using different planting modes in China. *Energy Policy,* 56, 210-220.
20- Ministry of Jihad-e-Agriculture of Iran (MAJ). (2012). Annual Agricultural Statistics. Retrieved from http://www.maj.ir (In Persian).
21- Mohammadi, A., & Omid, M. (2010). Economical analysis and relation between energy inputs and yield of greenhouse cucumber production in Iran. *Applied Energy*, 87, 191-196.
22- Mohammadi, A., Tabatabaeefar, A., Shahin, S., Rafiee, S., & Keyhani, A. (2008). Energy use and economical analysis of potato production in Iran a case study: Ardabil province. *Energy Conversion and Management,* 49, 3566-3570.
23- Mousavi-Avval, S.H., Rafiee, S., Jafari, A., & Mohammadi, A. (2011). Energy flow modeling and sensitivity analysis of inputs for canola production in Iran. *Journal of Cleaner Production*, 19, 1464-1470.
24- Nikkhah, A., Khojastehpour, M., Emadi, B., Taheri-Rad, A., & Khorramdel, S. (2015). Environmental impacts of peanut production system using life cycle assessment methodology. *Journal of Cleaner Production*, doi:10.1016/j.jclepro.2014.12.048
25- Ozkan, B., Akcaoz, H., & Fert, C. (2004). Energy input–output analysis in Turkish agriculture. *Renewable Energy*, 29, 39-51.
26- Pishgar-Komleh, S.H., Sefeedpari, P., & Ghahderijani, M. (2012). Exploring energy consumption and CO [sub 2] emission of cotton production in Iran. *Journal of Renewable and Sustainable Energy*, doi: 10.1063/1.4727906
27- Rajaeifar, M.A., Ghobadian, B., Safa, M., & Heidari, M.D. (2014). Energy life-cycle assessment and CO_2 emissions analysis of soybean-based biodiesel: a case study. *Journal of Cleaner Production*, 66, 233-241.
28- Ramedani, Z., Rafiee, S., & Heidari, M.D. (2011). An investigation on energy consumption and sensitivity analysis of soybean production farms. *Energy*, 36, 6340-6344.
29- Rempel, C.B., Hutton, S.N., & Jurke, C.J. (2014). Clubroot and the importance of canola in Canada. *Canadian Journal of Plant Pathology*, 36, 19-26.
30- Safieddin-Ardebili, M., Ghobadian, B., Najafi, G., & Chegeni, A. (2011). Biodiesel production potential from edible oil seeds in Iran. *Renewable and Sustainable Energy Reviews*, 15, 3041-3044.

31- Salehi, M., Ebrahimi, R., Maleki, A., & Ghasemi Mobtaker, H. (2014). An assessment of energy modeling and input costs for greenhouse button mushroom production in Iran. *Journal of Cleaner Production*, 64, 377-383.
32- Samavatean, N., Rafiee, S., Mobli, H., & Mohammadi, A. (2011). An analysis of energy use and relation between energy inputs and yield, costs and income of garlic production in Iran. *Renewable Energy,* 36, 1808-1813.
33- Sims, R.E.H., & Sayigh, A. (2003). Bioenergy options for a cleaner environment: in developed and developing countries. Elsevier Science.
34- Soltani, A., Rajabi, M.H., Zeinali, E., & Soltani, E. (2013). Energy inputs and greenhouse gases emissions in wheat production in Gorgan, Iran. *Energy*, 50, 54-61.
35- Taheri-Garavand, A., Asakereh, A., & Haghani, K. (2010). Energy elevation and economic analysis of canola production in Iran a case study: Mazandaran province. *International Journal of Environmental Sciences*, 1, 236-242.
36- Unakitan, G., Hurma, H., & Yilmaz, F. (2010). An analysis of energy use efficiency of canola production in Turkey. *Energy*, 35, 3623-3627.
37- Yilmaz, I., Akcaoz, H., & Ozkan, B. (2005). An analysis of energy use and input costs for cotton production in Turkey. *Renewable Energy*, 30,145-155.