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Investigation life cycle assessment emission of varieties rice under traditional and semi-mechanized farming systems in Iran

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Abstract

Life cycle analysis (LCA) is a tool used to assess the amount of green house gas of a product throughout its whole life cycle. The life cycle of wheat includes production, use of machinery and application of agricultural chemicals such as pesticides and fertilizers. This study was done to evaluate green house gases (GHG) emission of Varieties Rice under Traditional and Semi-mechanized Farming Systems in guilan province (north of Iran). For this purpose data were collected by using a face-to-face questionnaire during 2010 years. The comparison of calculated and measured amounts of green house gases emission were showed that breed varieties higher green house gases emission than local varieties. Also, The comparison of calculated and measured amounts of green house gases emission were showed that semi-mechanized system higher green house gases emission than traditional system.

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Introduction

One of the most important issues in recent century is he global warming and green house gas emission is the main factor of this change in weather conditions. There is scientific consensus that global warming poses one of the major environmental challenges in the future. While the bulk of the so called green house gases (GHG) originate from fossil fuel consumption (Pathak and Wassmann, 2007). Green house gas (GHG) emissions from agriculture account for 10 to 12% of all manmade GHG emissions and are the main source of anthropogenic N2O (60%) and CH (50%) (Browne *et al.,* 2011). Production, formulation, storage, distribution of the inputs and application with machinery lead to combustion of fossil fuel and use of energy from alternate sources, which also emits CO2 and other green house gases in to the atmosphere. Thus, an understanding of the emissions expressed in kilograms of carbon equivalent (kg CE) for different tillage operations, fertilizers and pesticides use, supplemental irrigation practices, harvesting and residue management is essential to identifying C-efficient alternatives such as biofuels and renewable energy sources for seed bed preparation, soil fertility management, pest control and other farm operations (Lal, 2004).

Rice is an important food crop for a large proportion of the world's population. It is staple food in the diet of the population of Asia, Latin America, and Africa. Rice provides 35-60% of the dietary calories consumed by nearly more than 3 billion people (Fageria *et al.,* 2003). Globally, it is also the second most cultivated cereal after wheat. Unlike wheat, 95% of the world's rice is grown in less developed nations, primarily in Asia, Africa, and Latin America. China and India are the largest rice producing and consuming countries in the world. By the year 2025, it is estimated that it will be necessary to produce about 60% more rice than what is currently produced to meet the food needs of a growing world population (Fageria, 2007). In addition, the land available for crop production is decreasing steadily due to urban growth and land degradation. Hence, increases in rice production will have to come from the same or an even less amount of land. This means appropriate rice production practices should be adopted to improve rice yield per unit area (Fageria, 2007). Gilan province has allocated more 35-42 percent of paddy production and under cultivation area of Iran. In this province more than 181 exploiters on productive and talented areas with more than 230000 hectares, are busy rice farming (Peykani *et al.,* 2008). Indeed, rice cultivation is considered the most important agricultural activity in this province and the economy of the province is also based on agriculture, with rice cultivation on top. Most of the under cultivation area of local varieties in Guilan are including Hashemi and Alikazemi. Most of the under cultivation area of breed varieties in Guilan are including Khazar, Hybrid and Gohar (Azarpour and moraditochaee, 2013). The system of agricultural productions in the world has been deeply changed because of using mechanization, chemical fertilizers and poisons and reformed seeds and as a result considerable changes in the direction of consumed energy in agricultural section have been created and caused higher relationship to the green house gases emission. Increased growth in agricultural production has resulted in increased agricultural greenhouse gas emissions. In 2010, global greenhouse gas emissions from the agricultural sector totaled 4.7 billion tons of carbon dioxide (CO_2) equivalent, up 13 percent over 1990. Agriculture is the third largest contributor to global emissions by sector, following the burning of fossil fuels for power and heat, and transportation. In 2010, emissions from electricity and heat production reached 12.5 billion tons, and emissions from transport totaled 6.7 billion tons. Despite their continuing rise, emissions from agriculture are growing at a much slower rate than the sector as a whole, demonstrating the increasing carbon efficiency of agriculture. From 1990 to 2010, the volume of agricultural production overall increased nearly 23 percent, according to data compiled by the United Nations Food and Agriculture Organization (FAO) for its program, FAOSTAT. FAO released a new Greenhouse Gas Emissions database for agriculture, forestry and other land use changes in

December 2012, which can be found here. According to FAO, methane accounts for just under half of total agricultural emissions, nitrous oxide for 36 percent, and carbon dioxide for some 14 percent. The largest source of methane emissions is enteric fermentation, or the digestion of organic materials by livestock, predominantly beef cattle. This is also the largest source of agricultural emissions overall, contributing 37 percent of the total.

The objectives of this study was to evaluated life cycle assessment emission of Varieties Rice under Traditional and Semi-mechanized Farming Systems in north of Iran.

Materials and methods

Materials

In this study, data were collected from 72 farmers growing wheat by using aface to face questionnaire. The location of studied region in north of Iran was presented in fig 1. The stratified random sampling technique was used to select farms randomly in the study region the sample size was calculated using the Neyman method as (Yamane, 1967).

$$n = \frac{N \times s^2 \times t^2}{(N-1)d^2 + s^2 \times t^2}$$

where ' n' is t he required sample size; 'N' is the number of farmers in the target population; 'N_h' the number of the farmers in the 'h' stratification; 'S^2_h' the variance of the 'h' stratification; 'd' permitted error ratio deviated from average of population ($\bar{x}$-$\bar{X}$), 'z' the reliability coefficient (1.96 which represents 95% confidence) and D2 = d^2/z^2 is the permissible error in the sample population was defined to be 5% within 95% confidence interval.

Fig. 1. Location of the study area.

Cultivated varieties in these farms include local varieties (Hashemi and Alikazemi) and breed varieties (khazar, Hybrid (GRH1) and Gohar (SA13)). Farming methods in these farms include traditional system and semi-mechanized system. In semi-mechanized system in addition to tiller and thrasher, transfarming machine and reaping machine are used for plant out and reaping respectively.

Method to calculate green house gases emission

To find the amount of green house gases emission of inputs in potato production per unit area (hectare), CO2 emission coefficient was applied (Tables 1 and 2). For every green house gases producers (diesel fuel, poison, chemical fertilizer and water) the amount of produced CO2 was calculated by multiplying the input application rate by emission coefficient that is shown in tables 1 and 2. Cluster analysis and correlation analysis were obtained by SPSS software.

Results and discussion

Green house gases emission

The inputs used in varieties rice production under two farming system and their GHG equivalents were illustrated in tables 1 and 2. About 37.2 h machinery power, 10000 m3 water, 6-7 L chemical poison and 127.2 L diesel fuel for total operations were used in varieties rice production under traditional system on a hectare basis. The highest use of nitrogen fertilizer (105.8 kg/ha), phosphorus (21 kg/ha) and potassium (82 kg/ha) were observed in Gohar rice. The lowest use seed in varieties rice production under traditional was observed in Gohar rice (30 kg/ha). About 47.3 h machinery power, 10000 m3 water, 6-7 L chemical poison and 142.1 L diesel fuel for total operations were used in varieties rice production under semi-mechanized system on a hectare basis. The highest use of nitrogen fertilizer (105.8 kg/ha), phosphorus (21 kg/ha) and potassium (82 kg/ha) were observed in Gohar rice.

In figure 2 (traditional system and semi-mechanized system), nine groups of reserves of production of studied figure according to percentage of total GHG emissions were observed. Results show that highest shares of this amount were reported for diesel fuel and water in all varieties rice production respectively. Chemical fertilizer, chemical poison and machinery were found to be quite low compared to the other inputs used in all varieties rice production respectively. Between chemical fertilizers, nitrogen had the first rank in Green house gases emission and next ranks belonged to phosphorus and potassium. Between chemical poisons, herbicide had the first rank in Green house gases emission and next ranks belonged to fungicide and insecticide.

Table 1. Amounts of inputs and their equivalent green house gases (GHG) emission in varieties rice production under traditional system condition.

	Amounts in surface unit					
	Input					
Parameter	Hashemi	Alikazemi	Khazar	Hybrid	Gohar	GHG coefficient ($kgCO_{2eq}ha^{-1}$)
Machinery (H/ha)	37.2	37.2	37.2	37.2	37.2	0.071
Diesel fuel (L/ha)	127.2	127.2	127.2	127.2	127.2	2.76
Nitrogen (Kg/ha)	57.5	57.5	82.8	105.8	105.8	1.3
Phosphorus(Kg/ha)	12.6	12.6	16.8	21	21	0.2
Potassium (Kg/ha)	45.1	45.1	61.5	82	82	0.2
Water (M^3/ha)	10000	10000	10000	10000	10000	0.057
Herbicide (L/ha)	3	3	3	3	3	6.3
Fungicide (L/ha)	2	2	2	2	2	3.9
Insecticide (L/ha)	2	2	1	1	1	5.1

Table 2. Amounts of inputs and their equivalent green house gases (GHG) emission in varieties rice production under semi-mechanized system condition.

	Amounts in surface unit					
	Input					
Parameter	Hashemi	Alikazemi	Khazar	Hybrid	Gohar	GHG coefficient ($kgCO_{2eq}ha^{-1}$)
Machinery (H/ha)	47.3	47.3	47.3	47.3	47.3	0.071
Diesel fuel (L/ha)	142.1	142.1	142.1	142.1	142.1	2.76
Nitrogen (Kg/ha)	57.5	57.5	82.8	105.8	105.8	1.3
Phosphorus(Kg/ha)	12.6	12.6	16.8	21	21	0.2
Potassium (Kg/ha)	45.1	45.1	61.5	82	82	0.2
Water (M^3/ha)	10000	10000	10000	10000	10000	0.057
Herbicide (L/ha)	3	3	3	3	3	6.3
Fungicide (L/ha)	2	2	2	2	2	3.9
Insecticide (L/ha)	2	2	1	1	1	5.1

Green house gases emissions in varieties rice production under traditional and semi-mechanized system condition were showed tables 3 and 4. In traditional system, breed varieties (Khazar: 1079 kgCO2eqha-1, Hybrid: 1114 kgCO2eqha-1and Gohar: 1114 kgCO2eqha-1) because of characterized accepting higher fertilizer have higher GHG emissions in compared with local varieties (Hashemi: 1047 kgCO2eqha-1 and Alikazemi: 1047 kgCO2eqha-1). In semi-mechanized system, breed varieties (Khazar: 1121 kgCO2eqha-1, Hybrid: 1155 kgCO2eqha-1and Gohar: 1155 kgCO2eqha-1) because of characterized accepting higher fertilizer have higher GHG emissions in compared with local varieties (Hashemi: 1089 kgCO2eqha-1 and Alikazemi: 1089 kgCO2eqha-1). Semi-mechanized system because of consumption higher machinery (47.3 h) further input GHG emissions than Traditional system.

Table 3. green house gases (GHG) emission in varieties rice production under traditional system condition.

Parameter	Hashemi	Alikazemi	Khazar	Hybrid	Gohar
Machinery (H/ha)	2.64	2.64	2.64	2.64	2.64
Diesel fuel (L/ha)	351.07	351.07	351.07	351.07	351.07
Nitrogen (Kg/ha)	74.75	74.75	107.64	137.54	137.54
Phosphorus(Kg/ha)	2.52	2.52	3.36	4.20	4.20
Potassium (Kg/ha)	9.02	9.02	12.30	16.40	16.40
Water (M^3/ha)	570.00	570.00	570.00	570.00	570.00
Herbicide (L/ha)	18.90	18.90	18.90	18.90	18.90
Fungicide (L/ha)	7.80	7.80	7.80	7.80	7.80
Insecticide (L/ha)	10.20	10.20	5.10	5.10	5.10
Total	1047	1047	1079	1114	1114

Table 4. green house gases (GHG) emission in varieties rice production under semi-mechanized system condition.

Parameter	Hashemi	Alikazemi	Khazar	Hybrid	Gohar
Machinery (H/ha)	3.36	3.36	3.36	3.36	3.36
Diesel fuel (L/ha)	392.20	392.20	392.20	392.20	392.20
Nitrogen (Kg/ha)	74.75	74.75	107.64	137.54	137.54
Phosphorus(Kg/ha)	2.52	2.52	3.36	4.20	4.20
Potassium (Kg/ha)	9.02	9.02	12.30	16.40	16.40
Water (M^3/ha)	570.00	570.00	570.00	570.00	570.00
Herbicide (L/ha)	18.90	18.90	18.90	18.90	18.90
Fungicide (L/ha)	7.80	7.80	7.80	7.80	7.80
Insecticide (L/ha)	10.20	10.20	5.10	5.10	5.10
Total	1089	1089	1121	1155	1155

Ho (2011) calculated the amount of GHG emissions in wheat production and found 2,963 MgCO2 ha where; fertilizer production was responsible 89% of GHG emissions in this crop production. Biswas *et al.* (2008) presented a greenhouse gas (GHG) life cycle assessment of 1 tons of wheat transported to portin south-western Australia, including emissions from prefarm, on-farm and post-farm stages. The results indicated that fertilizer production in the pre-farm stage contributed significantly (35%) to GHG, followed by on-farm CO2 emissions (27%) and emissions from transportation of inputs and wheat (12%). DeFigueiredo *et al.* (2010) studied the association of green house gas emission with sugar production in southern Brazil. According to their calculations, 241 kg of carbon dioxide equivalent were released to the atmosphere per a ton of sugar produced (2,406 kg of carbon dioxide equivalent per a hectare of the cropped area). The major part of the total emission (44%) resulted from residues burning; about 20% resulted from the use of fertilizers, and about 18% from fossil fuel combustion.

Table 5. Results of stepwise regression.

Step	Model
Constant number	671.271
Diesel fuel	0.749
Potassium	11.708
Insecticide	1.255
R^2	0.97

The regression coefficient between the variables in stepwise regression with single GHG emissions is shown in table 5 (GHG emissions= 671.271 + 0.749 (Diesel fuel) + 11.708 (Potassium) + 1.255 (Insecticide); R^2: 0.97).

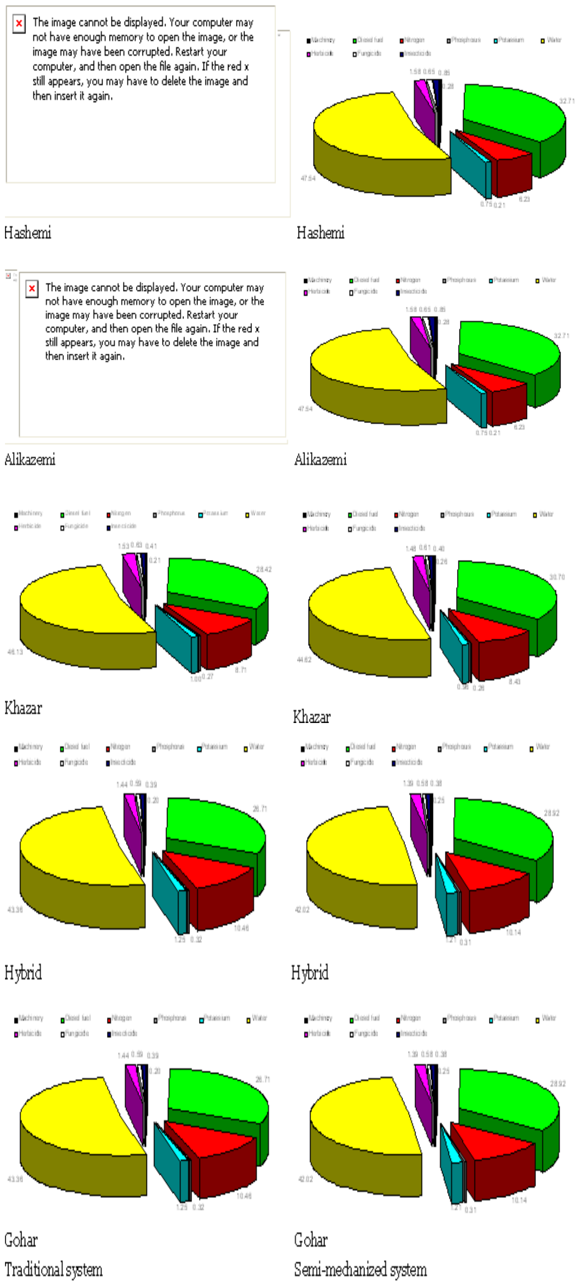

Fig. 2. share (%) data inputs for varieties rice under traditional system and semi-mechanized system.

In cluster analysis genotypes were classified into four groups based on Ward's method. Cluster analysis showed that Hybrid and Gohar varieties and Alikazemi, Khazar and Hashemi varieties in group similarities (Figure 3).

```
Rescaled Distance Cluster Combine

   C A S E      0         5        10        15        20        25
  Label     Num  +---------+---------+---------+---------+---------+

  Hybrid      4   -+-------------------------------------------------+
  Gohar       5   -+                                                 |
  Hashemi     1   -+-----+                                           |
  Alikazemi   2   -+     +-------------------------------------------+
  Khazar      3   -------+
```

Fig. 3. Dendrogram of rice genotypes based on different ward method.

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