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ON THE STUDY OF GHG (GREENHOUSE GAS) EMISSIONS IN RICE PRODUCTION SYSTEMS IN DARGAZ, IRAN

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ABSTRACT
The most important issue which has attracted the attention of many scientists is the climate change and global warming due to greenhouse gas emission which has caused the world faced with a great human and environmental disaster. In this study, the amount of greenhouse gas (GHG) emissions was estimated in the semi-traditional and semi-mechanized rice production systems in Dargaz region, Iran. All the agricultural and consuming inputs procedures responsible for greenhouse gas emissions were collected and recorded in both systems. The amount of GHG emission in semi-traditional and semi-mechanized was 813.17 and 968.31 kg CO_2-eq ha-^{1}, respectively. The fuel consumption with the share of 38.22% in semi-traditional method and 43.32% in semi-mechanized system had the largest share in GHG emission and using Nitrogen fertilizer on farms with the share of 31.97% in semi-traditional method and 26.91% in semi-mechanized system is in the second place of GHG emission. The semi-traditional system had greater GHG emissions in the unit of tone of harvested grain and unit of energy output. The use of alternative methods such as conservation tillage and organic fertilizers can be effective in improving the environmental status of the production area.
KEY WORDS: *Environmental, GHG emissions, Rice, Mechanization*.

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INTRODUCTION

Rice (*Oryza sativa* L.) is one of the food sources which provide more than 70% of human caloric intake in many countries (Pishgar Komleh *et al*, 2011). Rice is one of the important grain crops grown in Iran, accounting for 6.29% of the total cereal production. Iran with amount of 1.7 Mt is the second rice importer country after Philippine (IRRI, 2009).

In recent years there is an increased attention toward environmental issues. The increased awareness of the environmental issues, economic sectors assesses the environmental impact of their activities. Agriculture is an important part of the economy that has significant effects on the environment (Soltani *et al*, 2009).

The most important problem which has attracted the attention of many scientists is the climate change and global warming due to greenhouse gas (GHG) emission which encounters the world with a great human and environmental disaster. The most important greenhouse gases include Carbon Dioxide (CO_2), Nitrogen Oxide (N_2O), Methane (CH_4) (IPCC, 2007).

Agriculture section is one of the most important producers of greenhouse gases. The increasing use of nitrogen fertilizers, frequent land plowing, abundant use of chemical pesticides and fossil fuel consumption in machines are among the most important agricultural activities that lead to greenhouse gas emission and causes problems threatening public health and environment (Darvin *et al*, 1995; Rafiee *et al*, 2010; Faur *et al*, 2012; Gheban *et al*, 2014). Pathak & Vassmann (2007) aiming to reduce GHG emission and global warming potential (GWP) analyzed current rice cultivation methods in Haryana- India and reported that the whole amount of GHG emission in different areas of Haryana was in the range 2766-4054 kg CO2-eq ha^{-1}. The GHG emission in the production of potatoes in Isfahan in central Iran was reported as 992.88 kg CO_2-eq ha^{-1} (Pishgar Komleh *et al.* 2012). In the study conducted by Khoshnevisan *et al*. (2013) in order to improve energy efficiency and reduce GHG emission of the wheat it was observed that the GHG emission of efficient and inefficient producers was 2713.3 and 2740.8 88 kg CO_2-eq ha^{-1}. Yousefi *et al.* (2014) calculated GHG emissions related to the sugar beet agroecosystems in Iran and found the total global warming potential (GWPs) was 9847.77 kg CO_2-eq ha^{-1}.

Energy use in rice crops has been evaluated in Iran (Pishgar Komleh *et al*, 2011; Eskandari Cherati *et al*, 2011; Mansoori *et al*, 2012; AghaAlikhania *et al*, 2013). However, no studies have yet been published on greenhouse gases emissions in rice production in Iran. Therefore, there is an immediate need to undertake such an analysis for future steps to be taken for any improvement in rice production in terms of environmental impact. The objectives of this study were:

(1) estimate the amount of GHG emission in the rice production systems,

(2) compare the production systems based on environmental effect,

(3) identify the most important agricultural activities responsible for the GHG emission,

(4) provide recommendations for reducing greenhouse gas emissions in rice production systems in the region.

MATERIALS AND METHODS

The present study was conducted in the crop year 2013-2014 in Dargaz region. Dargaz is located in Northeast of Iran (37° 43′ to 36° 55′ N, 58° 29′ to 59° 37′ E, 1500 masl). Rice cultivation in this region is mainly done through two production systems: semi-traditional and semi-mechanized. The semi-traditional system includes the fields in which all the agricultural operations from planting to harvesting was done by the human labor and only the bed preparation is done by using the Plough, ridging and a leveler connected to the tractor (Heidarzadeh *et al*, 2006) . The semi-mechanized fields refer to the farms in which a part of the process is done by machine and the other part is done by the human labor (Peyman *et al*, 2005; Heidarzadeh *et al*, 2006). Thus, in these lands the process of bed preparation is done by a Plough, ridging and a leveler connected to the tractor and the transplanting is done by a transplanting machine and the harvesting by combine but irrigation, spraying (backpack sprayer), weeding, spreading fertilizer and harvesting is done with the human labor.

Sample farms were randomly selected from the villages in the study area by using a stratified random sampling method. The sample size was calculated using Eq. (1) (Pishgar Komleh *et al*, 2012):

$$n = \frac{\sum N_h S_h}{N^2 D^2 + \sum N_h S^2_h} \qquad (1)$$

where 'n' is the 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, 'z' the reliability coefficient (1.96 which represents 95% confidence) and $D^2 = d^2/z^2$ is the permissible error in the sample population was defined to be 5% within 95% confidence interval. Based on the calculation, the size of 25 and 30 were considered as the sampling size for the semi -traditional and semi-mechanized production systems, respectively. The area of the semi-traditional farms is 0.5-1 hectare and the area of the semi-mechanized farms is 1-6 hectares.

The seeding step of rice cultivation occurs in the second month of spring (April-May) and continues with transplanting in the third month of spring (May-June). All the required information related to crop management including bed preparation, planting, irrigation, plant nutrition, plant protection, machinery use, labor and harvest were collected. This information was distributed in the form of questionnaires among the farmers and filled during the growth season.

TABLE 1. Greenhouse gas (GHG) emission coefficients of agricultural inputs.

Input	unit	GHG Coefficient (kg CO_{2eq}.unit^{-1})	Ref.
Fuel	Liter	2.76	[3]
Machinery	MJ	0.071	[4]
Nitrogen (N)	Kg	1.3	[10]
P (P_2O_5)	Kg	0.2	[10]
K (K_2O)	Kg	0.2	[10]
Herbicides	Kg	6.3	[10]
Insecticides	Kg	5.1	[10]
Fungicides	Kg	3.9	[10]

In order to calculate the GWP resulted from GHG emission due to input consumptions and agricultural operations the relevant coefficients were used (Table 1).

The total emitted Greenhouse Gases was calculated based on kg CO_2-eq ha^{-1} which indicates GWP. In the present research inputs and actions that have the potential global warming included: production of nitrogen fertilizers, phosphorus and potassium, production of herbicides, fungicides and insecticides, using fossil fuels and the production and maintenance of farm machinery. GHG emissions can be calculated and represented per unit of the land used in crop production, per unit weight of the produced grain and per unit of the energy input or output (Soltani *et al*, 2013).

RESULTS AND DISCUSSIONS

The values of consumed agricultural inputs in the semi-traditional and semi-mechanized are represented in Table 2. It is observed that the major difference between the two systems is due to the fuel. Fuel consumption in semi-mechanized system is 26% higher than the semi-traditional method. The main reason for this difference is the greater use of mechanization in stages of harvesting and transplanting in semi-mechanized system.

Average GHG emissions for the semi- mechanized and semi- traditional system is 554 and 704 kg CO_2-eq ha^{-1} (table 3). It seems that higher use of machineries and fuel consumption makes the difference. Figure 1 shows the share of different inputs in the GHG emission. In both systems fuel has the major role in global warming potential. Accordingly, the share of fuel in the global warming potential of the semi-traditional and semi-mechanized was 56 and 60%, respectively. The use of nitrogen fertilizers with a share of 21.6% and 17% in semi-traditional and semi-mechanized was in the second place after the use of fuel (figure 1). Pishgar Komleh *et al.* (2012) in a study calculated the GHG emissions for the potato production. In their study fuel and nitrogen fertilizer with 32.79% and 31.83% had the highest share among the inputs. The study of GHG emission in producing cucumber in Yazd province of Iran showed that the fuel with 61% of the whole emission has the highest share in GHG emissions (Pishgar Komleh *et al*, 2013). Yousefi *et al*. (2014) reported the highest share of GHG emission of inputs was related to electricity power (with a share of 73%) and N fertilizers (with a share of 15%) in sugar beet production.

TABLE 2. Inputs used for each rice production system

Agricultural inputs	Unit	Semi-traditional	Semi-mechanized
Fuel	l ha^{-1}	112.6	152
N fertilizer	Kg N ha^{-1}	92	92.48
P fertilizer	Kg P_2O_5 ha^{-1}	12	12.48
K fertilizer	Kg K_2O ha^{-1}	0	26.44
Insecticide	Kg ha^{-1}	3.35	3.35
Herbicide	Kg ha^{-1}	3.70	3.70
Fungicide	Kg ha^{-1}	0.32	0.32

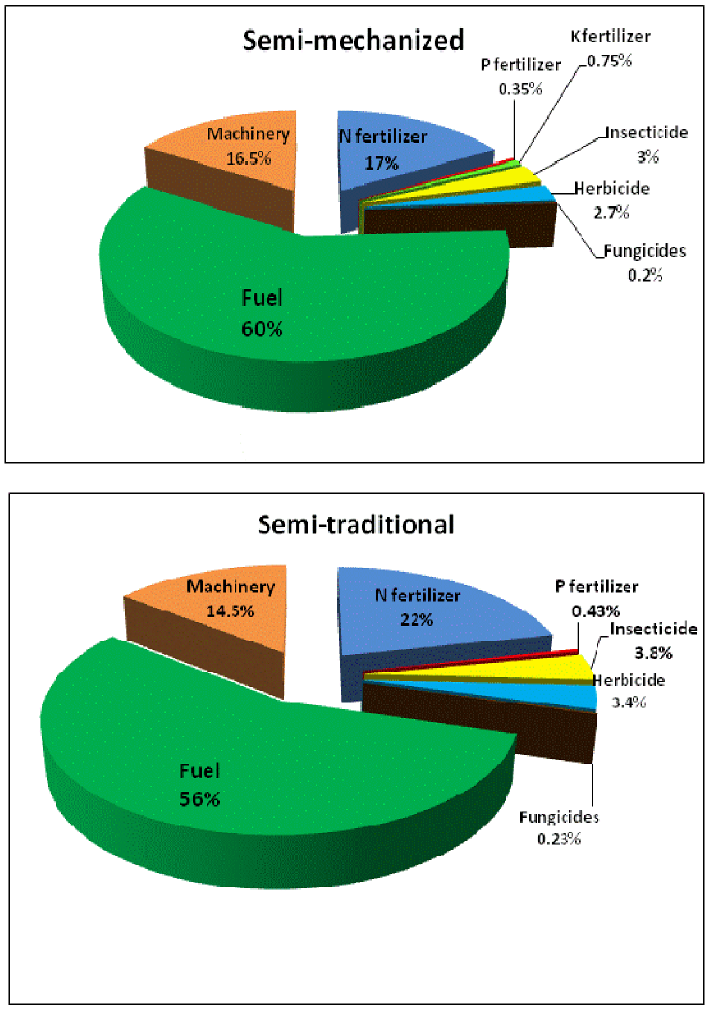

FIG 1. The share of inputs in the GHG emissions in the semi-traditional and semi-mechanized rice production systems

TABLE 3. GHG emissions (kg CO2-eq ha^{-1}) for each rice production system

Inputs	semi-traditional	semi-mechanized
N fertilizer	119.6	120.22
P fertilizer	2.4	2.5
K fertilizer	0	5.29
Insecticide	21.10	21.10
Herbicide	18.87	18.87
Fungicides	1.27	1.27
Fuel	310.78	419.52
Machinery	80.28	115.67
Total	554.3	704.44

Table (4) represents global warming potential values for other scales, including the weight of harvested grain, input energy and the output energy for semi-mechanized and semi-traditional systems. The semi-traditional system had greater GHG emissions per tone of grain and unit of energy output. Pishgar Komleh *et al*, (2013) reported a GHG emission in cucumber production as 0.53 kg CO_2-eq kg $^{-1}$ of the produced crop and 0.66 53 kg CO_2-eq MJ^{-1} of the output energy. Soltani *et al*, (2013) reported a GHG emission in Gorgan wheat production equivalent to 291.3 kg CO_2-eq t^{-1} per ton of grain, 71.5 kg CO_2-eq GJ^{-1} per unit of energy input and 12.2 kg CO_2-eq GJ^{-1} per unit output energy. In the other study in Iran, the results indicated that each kilogram production of sugar beet in research area would lead to GWP generation of 0.15 kg per kg, 0.98 kg m^{-2}, 0.20 kg CO_2eq MJ^{-1} of input energy and 0.009 kg CO_2eq MJ^{-1} of output energy (Yousefi *et al*, 2014).

TABLE 4. GHG emissions in different bases for each rice production system

GHG emissions	Semi-traditional	Semi-mechanized
Per unit area (kg CO2-eq ha^{-1})	554.3	704.44
Per unit weight (kg CO2-eq t^{-1})	83.48	82.10
Per unit input energy (kg CO2-eq GJ^{-1})	17.84	18.35
Per unit output energy (kg CO2-eq GJ^{-1})	8.08	7.95

The results of GHG emissions for different scales showed that when the GHG emissions scale was changed from the unit area (kg CO_2-eq ha^{-1}) into unit weight (kg CO_2-eq t $^{-1}$) and the unit energy output (kg CO_2-eq GJ^{-1}), the semi-traditional system had higher GHG emissions than that of semi-mechanized. This indicates that in the global warming potential assessment the selection of scale may lead to different result so that it may make the systems under study seem similar or different in assessing GWP. Therefore it is necessary to assess the environmental impact of farming system based on different scales to get a proper result.

CONCLUSIONS

This study was carried out in Dargaz region in Iran. The present study showed that the semi-mechanized rice production is associated with increased GHG emissions per unit area. In both systems fuel and nitrogen fertilizer had the largest share of the global warming potential. So it seems that the replacement of conventional methods with conservation tillage methods which is associated with reduced fuel consumption and the use of organic fertilizers (animal, green manure, compost) instead of nitrogen fertilizer can be effective in improving the environmental situation of rice production systems in the area.

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