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Evaluation green house gases and energy of pumpkin production in north of Iran

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Abstract

Energy has a key role in social-economic development of countries. Efficient use of energy in agriculture is one of the conditions for sustainable production. In this article, evaluation of energy balance and energy indices under dry land farming pumpkin in north of Iran (Guilan province) were investigated. Data were collected from 72 farms by used a face to face questionnaire method during 2011 year in Guilan province. By using of consumed data as inputs and total production as output, and their concern equivalent energy, energy balance and energy indices were calculated. Energy efficiency (energy output to input energy ratio) for seed and fruit in this study were calculated 0.16 and 1.43 respectively; showing the affective use of energy in the agro ecosystems pumpkin production. Energy balance efficiency (production energy to consumption energy ratio) for seed and fruit in this study were calculated 0.09 and 1.54 respectively; showing the affective use of energy in the agro ecosystems pumpkin production.

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Introduction

Pumpkin (*cucurbita maxima)* belongs to the cucurbitacae family, which includes cucumber, melon and squash (Robinson and Decker-Walters, 1997; Teppner, 2000). Within this family is the genus cucurbita which includes all varieties of pumpkin that is consists of 13 species, including *C. pepo* L. and *C. maxima* Duch. Pumpkin seed is characterized by its thin membranous seed coat (skin, peel and testa) rather than the lignified seed coat of conventional pumpkins. Therefore, the entire seed is easily crushed to obtain the edible oil (Percin *et al.,* 2009). Pumpkin seed is very rich in oil and protein and is used as a medicinal plant for products such as such as Pumpkinol, Prostaclenz, and Prostalog that have demonstrated good results for therapies of minor disorders of the prostate gland and the urinary bladder. *Cucurbita pepo* is important in European and American countries, whereas *Cucurbita maxima* is widely cultivated in East-Asian countries, such as China, Japan and Korea. Pumpkin plants are hardy creepers or soil surface runners, but able to climb where there are supports. The fruits vary in shape, colour and sizes. They are monoecious and can be bred from pure lines. The pumpkin orange flesh is eaten for human consumption such as soup, purees, jams, and pies throughout the world (Alfaz, 2004).

Agriculture is considered as an energy conversion process - the conversion of solar energy through the photosynthetic process to produce food and fiber for human and feed for animals. Ancient agriculture included scattering seeds on the land and accepting the meager yields that resulted. Today's agriculture, on the other hand, is the application of energy to get required yield results. Energy used in agriculture mainly depends on fossil fuels which are a scarce commodity and need due consideration for their conservation (Khan *et al.,* 2010). The relation between agriculture and energy is very close. Agriculture itself is an energy user and energy supplier in the form of bio-energy (Alam *et al.,* 2005).

Energy use in agriculture has developed in response to increasing populations, limited supply of arable land and desire for an increasing standard of living. In all societies, these factors have encouraged an increase in energy inputs to maximize yields, inimize labor-intensive practices, or both (Alam *et al.,* 2005). Effective energy use in agriculture is one of the conditions for sustainable agricultural production, since it provides financial savings, fossil resources preservation and air pollution Reduction (Uhlin, 1998). Application of integrated production methods are recently considered as a means to reduce production costs, to efficiently use human labor and other inputs and to protect the environment (often in conjunction with high numbers of tourists present in the area). Energy budgets for agricultural production can be used as building blocks for life-cycle assessments that include agricultural products and canals serve as a first step towards identifying crop production processes that benefit most from increased efficiency (Piringer and Steinberg, 2006). Piringer and Steinberg (2006) showed that, the total energy input into the production of a kilogram of average U.S. wheat grain is estimated to range from 3.1 to 4.9 MJ/kg, with a best estimate at 3.9 MJ/kg. The dominant contribution is energy embodied in nitrogen fertilizer at 47% of the total energy input, followed by diesel fuel (25%), and smaller contributions such as energy embodied in seed grain, gasoline, electricity and phosphorus fertilizer. This distribution is reflected in the energy carrier mix, with natural gas dominating (57%), followed by diesel fuel (30%). High variability in energy coefficients masks potential gains in total energy efficiency as compared to earlier, similar U.S. studies. Estimates from an input-output model for several input processes agree well with process analysis results, but the model's application can be limited by aggregation issues: Total energy inputs for generic food grain production were lower than wheat fertilizer inputs alone, possibly due to aggregation of diverse products into the food grain sector.

The main aim of this study was to determine energy use in pumpkin production, to investigate the efficiency of energy consumption and to make an energy balance and energy indices analysis and green house gases emissions of pumpkin in Guilan province of Iran.

Materials and methods

Materials

In order to gather the required data in this study, information related to 72 farms in Guilan province during the agricultural year 2011 was studied. The location of studied region in north of Iran was presented in figure 1. The random sampling of production agro ecosystems was done within whole population and the size of each sample was determined by using bottom Equation (Kizilaslan, 2009):

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

In the formula, n is the required sample size, s is the standard deviation, t is the t value at 95% confidence limit (1.96), N is the number of holding in target population and d is the acceptable error.

Method to calculate the energy

In order to calculate input-output ratios and other energy indicators, the data were converted into output and input energy levels using equivalent energy values for each commodity and input. Energy equivalents shown in table 1 were used for estimation (Azarpour, 2012; Azarpour *et al.,* 2012, Namdari, 2011; Namdari *et al.,* 2011; Hosini *et al.,* 2009). Firstly, the amounts of inputs used in the production of pumpkin were specified in order to calculate the energy equivalences in the study. Energy input include human labor, machinery, diesel fuel, chemical fertilizers, poison fertilizers, farmyard manure, electricity and seed; and output yield include seed yield and fruit yield of pumpkin. The energy use efficiency, energy specific, energy productivity and net energy gain were calculated according to bottom equations (Azarpour, 2012; Azarpour *et al.,* 2012, Namdari, 2011; Namdari *et al.,* 2011; Hosini *et al.,* 2009).

$$\text{Energy ratio} = \frac{\text{Output energy (Mj/ha)}}{\text{Input energy (Mj/ha)}}$$

$$\text{Energy production} = \frac{\text{Fruit yield (Kg/ha)}}{\text{Input energy (Mj/ha)}}$$

$$\text{Energy intensity} = \frac{\text{Input energy (Mj/ha)}}{\text{Fruit yield (Kg/ha)}}$$

Net energy gain = Input energy (Mj/ha) Out put energy (Mj/ha)

The input energy was divided into direct, indirect, renewable and non-renewable energies (Namdari, 2011; Yilmaz, 2005). Direct energy covered electricity, human labor and diesel fuel, used in the pumpkin production while indirect energy consists of seed, chemical fertilizers, farmyard manure, poison fertilizers, and machinery energy. Renewable energy consists of human labor, farmyard manure and seed; and nonrenewable energy includes electricity, chemical fertilizers, poison fertilizers and machinery energy.

In order to indicators of energy balance, Basic information on energy inputs were entered into excel spreadsheets and then energy equivalent were calculated according table 2 (Azarpour, 2012; Azarpour *et al.,* 2012, Namdari *et al.,* 2011; Hosini *et al.,* 2009). By using of consumed data as inputs and total production as output, and their concern equivalent energy, indicators of energy balance were calculated. Energy input include human labor, machinery, diesel fuel, chemical fertilizers, poison fertilizers, machinery depreciation for per diesel fuel, farmyard manure, electricity and seed; and output yield include seed yield and fruit yield of pumpkin.

Method to calculate the green house gases:

To find the amount of GHG emission of inputs in wheat production per unit area (hectare), CO_2 emission coefficient was applied (Table 3). For every GHG producers (diesel fuel, poison, chemical fertilizer and water) the amount of produced CO_2 was calculated by multiplying the input application rate by emission coefficient that is shown in table 4 (Ghahderijani *et al.,* 2013).

Results and discussion

Analysis of input–output energy use in pumpkin production

The inputs used in pumpkin production and their energy equivalents and output energy equivalent are illustrated in table 1. About 5 kg seed, 400 h human labor, 12 h machinery power, 27 Kwh electricity, 3 L chemical poison and 110 L diesel fuel for total operations were used in agro ecosystems pumpkin production on a hectare basis. The use of nitrogen fertilizer, phosphorus fertilizer, potassium fertilizer and farmyard manure were 69, 21, 13 and 1200 kg per one hectare respectively. The total energy equivalent of inputs was calculated as 13978 MJ/ha. The highest shares of this amount were reported for diesel fuel (44.31%) and chemical fertilizer (37.17%).

The energy inputs of human labor (5.61%), machinery (5.38%), farmyard manure (2.58%), chemical poison (2.58 %), electricity (2.30%) and seed (0.07%) were found to be quite low compared to the other inputs used in pumpkin production (Figure 2). The average seed yield of pumpkin was found to be 1200 kg/ha and its energy equivalent was calculated to be 2280 MJ/ha (Table 1). The average fruit yield of pumpkin was found to be 25000 kg/ha and its energy equivalent was calculated to be 2000 MJ/ha **(Table 1).**

Evaluation indicators of energy in pumpkin production:

The energy use efficiency, energy production, energy specific, energy productivity, net energy gain, and intensiveness of seed pumpkin production were shown in table 4. Energy efficiency (energy output-input ratio) in this study was calculated 0.16; showing the affective use of energy in the agro ecosystems pumpkin production. Energy specific was 11.65 MJ/kg this means that 11.65 MJ is needed to obtain 1 kg of seed pumpkin. Energy productivity calculated as 0.09 Kg/MJ in the study area, this means that 0.09 kg of output obtained per unit energy. Net energy gain was -11698 MJ/ha of seed pumpkin production.

The energy use efficiency, energy production, energy specific, energy productivity, net energy gain, and intensiveness of fruit pumpkin production were shown in table 3. Energy efficiency (energy output-input ratio) in this study was calculated 1.43; showing the affective use of energy in the agro ecosystems pumpkin production. Energy specific was 0.56 MJ/kg this means that 0.56 MJ is needed to obtain 1 kg of fruit pumpkin. Energy productivity calculated as 1.79 Kg/MJ in the study area, this means that 1.79 kg of output obtained per unit energy. Net energy gain was 6022 MJ/ha of fruit pumpkin production.

This means that the amount of output energy is more than input energy and production in this situation is logical. Direct, indirect, renewable and non-renewable energy forms used in pumpkin production are also investigated in table 4. The results show that the share of direct input energy was 52.23% (7300 MJ/ha) in the total energy input compared to 47.77% (6678 MJ/ha) for the indirect energy. On the other hand, nonrenewable and renewable energy contributed to 94.32% (12825 MJ/ha) and 1154% (5.68 MJ/ha) of the total energy input, respectively.

Analysis of energy balance in pumpkin production:

The inputs used in pumpkin production and their energy equivalents and output energy equivalent are illustrated in table 2. About 5 kg seed, 400 h human labor, 12 h machinery power, 27 Kwh electricity, 3 L chemical poison and 110 L diesel fuel for total operations were used in agro ecosystems pumpkin production on a hectare basis. The use of nitrogen fertilizer, phosphorus fertilizer, potassium fertilizer and farmyard manure were 69, 21, 13 and 1200 kg per one hectare respectively. Also 92.4 L depreciation power in this system was used.

The total energy equivalent of inputs was calculated as 5035460 MJ/ha. The highest shares of this amount were reported for chemical fertilizer (25.84%), machinery (21.45%), diesel fuel (20.18%), and depreciation for per diesel fuel (17.58%).

The energy inputs of farmyard manure (7.22%), human labor (3.97%), chemical poison (1.62%), electricity (1.54%) and seed (0.60%) were found to be quite low compared to the other inputs used in pumpkin production (Figure 3).

The highest percent of compositions (6.3%), Amounts (76 kg/ha), production energy (302400 kcal/ha) and production energy to consumption energy ratio (0.06) in pumpkin seed were obtained from starch as compared with protein and fat, The lowest consumption energy to production energy ratio (16.65) in pumpkin seed was obtained from starch as compared with protein and fat (Table 5).

The highest percent of compositions (4.5%), Amounts (1125 kg/ha), production energy (4500000 kcal/ha) and production energy to consumption energy ratio (0.89) in pumpkin fruit were obtained from starch as compared with protein and fat, The lowest consumption energy to production energy ratio (1.12) in pumpkin fruit was obtained from starch as compared with protein and fat (Table 5).

Evaluation indicators of energy balance in pumpkin production:

The consumption energy (5035460 kcal/ha), production energy (463200 kcal/ha), energy per unit (386 kcal), production energy to consumption energy ratio (0.09) and consumption energy to production energy ratio (158.64) of pumpkin seed production were shown in table 5. Energy balance efficiency (production energy to consumption energy ratio) in this study was calculated 0.09; showing the affective use of energy in the agro ecosystems pumpkin seed production.

The consumption energy (5035460 kcal/ha), production energy (7750000 kcal/ha), energy per unit (310 kcal), production energy to consumption energy ratio (1.54) and consumption energy to production energy ratio (8.39) of pumpkin fruit production were shown in table 5. Energy balance efficiency (production energy to consumption energy ratio) in this study was calculated 1.54; showing the affective use of energy in the agro ecosystems pumpkin fruit production.

Hosini *et al* (2009) analyzed the energy balance indices of pumpkin production in Khoy, Iran; and found that Energy value of used inputs of this type cultivation was 5981297 kcal/ha and output (production) energy of value of pumpkin yield was 6910800, respectively. Also, energy efficiency value was 1.15.

Green house gases emissions

It is revealed that diesel fuel was the major source contributing 23.18% of total Green house gases emission and followed by chemical fertilizer, machinery and poison contributing 23.18%, 0.20% and 3.68% of global warming potential, respectively (Figure 4). Between chemical fertilizers, nitrogen had the first rank in Green house gases emission emission and next ranks belonged to phosphorus and potassium with portion of 21.55%, 1.01 and 0.62%, respectively (Figure 4). Green house gases emissions for pumpkin production were showed table 6 (416.15 kgCO2 eqha-1).

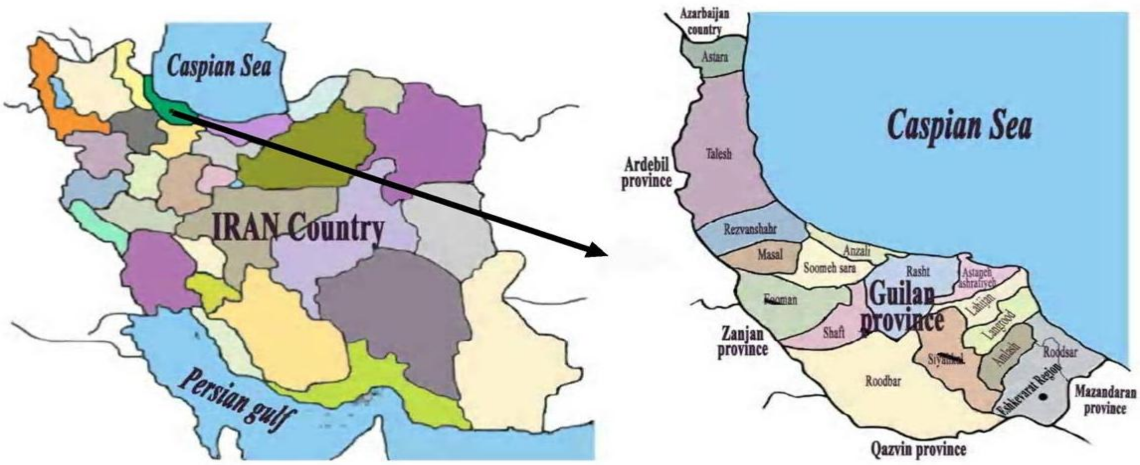

Fig. 1. Location of the study area.

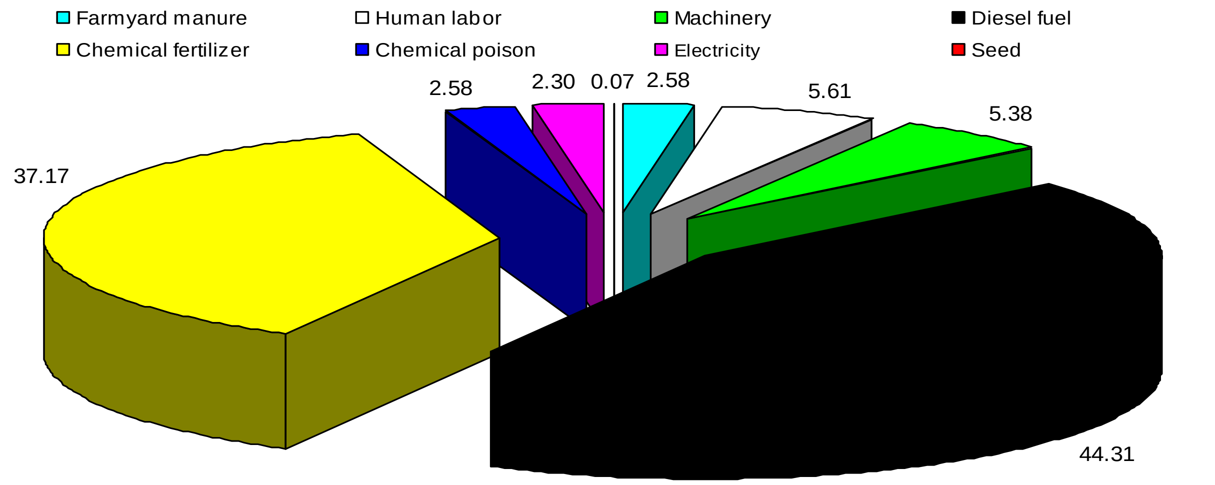

Fig. 2. The share (%) production inputs in pumpkin (energy).

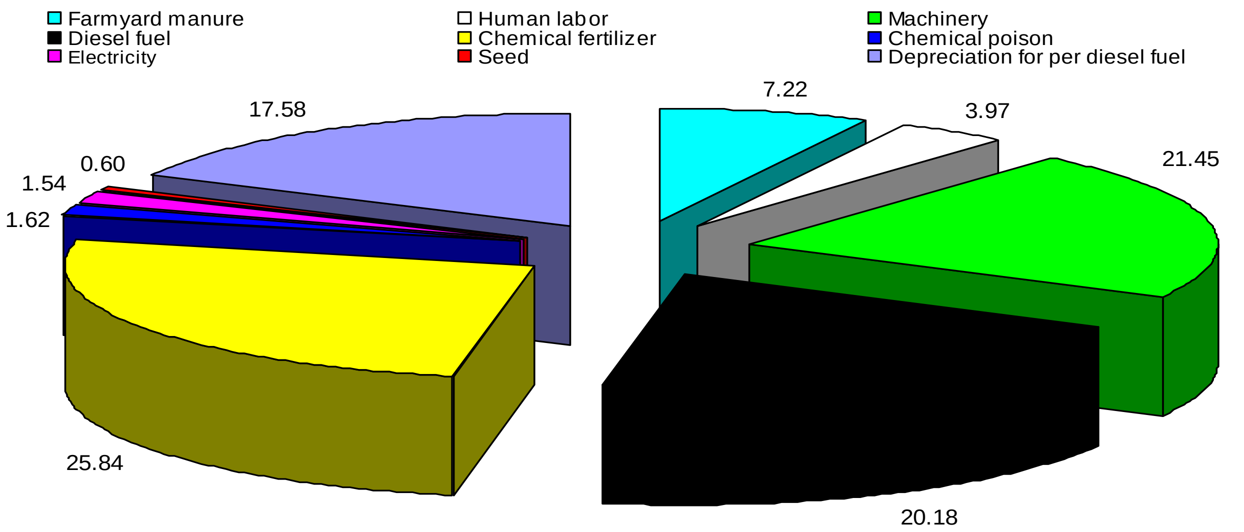

Fig. 3. The share (%) production inputs in pumpkin (energy balance).

Table 1. Amounts of inputs and output and their equivalent energy from calculated indicators of energy

Parameter	Unit	Quantity per Hectare	Energy equivalents	Total energy equivalents	Percent
			Inputs		
Farmyard manure	Kg/ha	1200	0.3	360	2.58
Human labor	h/ha	400	1.96	784	5.61
Machinery	h/ha	12	62.7	752.40	5.38
Diesel fuel	L/ha	110	56.31	6194.10	44.31
Nitrogen	Kg/ha	69	69.5	4795.50	34.31
Phosphorus	Kg/ha	21	12.44	261.24	1.87
Potassium	Kg/ha	13	11.15	139.38	1
Poison	L/ha	3	120	360	2.58
Electricity	Kwh	27	11.93	322.11	2.30
Seed	Kg/ha	5	1.9	9.50	0.07
			Output		
Seed yield	Kg/ha	1200	1.9	2280	100
Fruit yield	Kg/ha	25000	0.8	20000	100

Table 2. Amounts of inputs and their equivalent energy from calculated indicators of energy balance

Parameter	Unit	Quantity per Hectare	Energy equivalents	Total energy equivalents	Percent
			Inputs		
Farmyard manure	Kg/ha	1200	303.1	363720	7.22
Human labor	h/ha	400	500	200000	3.97
Machinery	h/ha	12	90000	1080000	21.45
Diesel fuel	L/ha	110	9237	1016070	20.18
Nitrogen	Kg/ha	69	17600	1214400	24.12
Phosphorus	Kg/ha	21	3190	66990	1.33
Potassium	Kg/ha	13	1600	20000	0.40
Poison	L/ha	3	27170	81510	1.62
Electricity	Kwh	27	2863	77301	1.54
Seed	Kg/ha	5	6000	30000	0.60
Depreciation for per diesel fuel	L	92.4	9583	885469.20	17.58

Table 3. Amounts of inputs and their equivalent green house gas (GHG) emission

Parameter	Unit	Quantity per Hectare	GHG coefficient ($kgCO_{2eq}ha^{-1}$)
Machinery	h/ha	12	0.071
Diesel fuel	L/ha	110	2.76
Nitrogen	Kg/ha	69	1.3
Phosphorus	Kg/ha	21	0.2
Potassium	Kg/ha	13	0.2
Poison	L/ha	3	5.1

Table 4. Analysis of energy indices in pumpkin production.

Item	Unit	Pumpkin
	Seed	
Yield	Kg/ha	1200
Input energy	Mj/ha	13978
Output energy	Mj/ha	2280
Energy use efficiency	-	0.16
Energy specific	Mj/Kg	11.65
Energy productivity	Kg/Mj	0.09
Net energy gain	Mj/ha	-11698
Direct energy	Mj/ha	7300 (52.23%)
Indirect energy	Mj/ha	6678 (47.77%)
Renewable energy	Kg/Mj	1154 (5.68%)
Nonrenewable energy	Mj/ha	12825 (94.32%)
	Fruit	
Yield	Kg/ha	25000
Input energy	Mj/ha	13978
Output energy	Mj/ha	20000
Energy use efficiency	-	1.43
Energy specific	Mj/Kg	0.56
Energy productivity	Kg/Mj	1.79
Net energy gain	Mj/ha	6022
Direct energy	Mj/ha	7300 (52.23%)
Indirect energy	Mj/ha	6678 (47.77%)
Renewable energy	Kg/Mj	1154 (5.68%)
Nonrenewable energy	Mj/ha	12825 (94.32%)

Table 5. Analysis of energy balance indices in pumpkin production

Seed						
Item	**Percent of compositions**	**Energy per gram (kcal)**	**Amounts (kg/ha)**	**production energy (kcal/ha)**	**Production energy/ Consumption energy**	**Consumption energy/ Production energy**
Protein	1.1	4	13	52800	0.01	95.37
Fat	1	9	12	108000	0.02	46.62
Starch	6.3	4	76	302400	0.06	16.65
Item	yield (kg/ha)	consumption energy (kcal/ha)	Production energy (kcal/ha)	Energy per unit (kcal)	production energy/ consumption energy	Consumption energy/ production energy
	1200	5035460	463200	386	0.09	158.64
Fruit						
Item	**Percent of compositions**	**Energy per gram (kcal)**	**Amounts (kg/ha)**	**production energy (kcal/ha)**	**Production energy/ Consumption energy**	**Consumption energy/ Production energy**
Protein	1	4	250	1000000	0.20	5.04
Fat	1	9	250	2250000	0.45	2.24
Starch	4.5	4	1125	4500000	0.89	1.12
Item	yield (kg/ha)	consumption energy (kcal/ha)	production energy (kcal/ha)	Energy per unit (kcal)	production energy/ consumption energy	Consumption energy/ production energy
	25000	5035460	7750000	310	1.54	8.39

Table 6. Greenhouse gas emissions of inputs for pumpkin production.

Parameter	**GHG emissions ($kgCO_{2eq}ha^{-1}$)**
Machinery	0.852
Diesel fuel	303.6
Nitrogen	89.7
Phosphorus	4.2
Potassium	2.6
Poison	15.3
Total	416.25

Conclusion

Finally Energy use is one of the key indicators for developing more sustainable agricultural practices one of the principal requirements of sustainable agriculture, Therefore energy management in systems pumpkin production should be considered an important field in terms of efficient, sustainable and economical use of energy. Using of combination machines, doing timely required repairs and services for tractors and representing a fit crop rotation are suggested to decrease energy consuming for pumpkin in north of Guilan province.

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