International Journal of Animal Breeding and Genetics Vol. 3 (5), pp. 001-006, May, 2014. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Energy survey of mechanized and traditional rice production system in Mazandaran Province of Iran

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Accepted 11 April, 2014

The aim of this study is to consider the energy consuming process and factors influencing rice production in semi-mechanized and traditional systems in Mazandaran Province of Iran. Data used in this study were obtained from farmers using a face to face questionnaire method. Results showed that the total energy used for semi-mechanized and traditional rice production system was 67217.95 and 67356.28 MJ/ha, respectively. Based on the results, irrigation and fertilizer in both systems with 50232 and 7610.32 MJ/ha was the most input energy. Total energy output of the traditional method was 127.5 GJ/ha and that of the semi-mechanized was 132.26 GJ/ha. Parallel to the mechanization level of operations that increased, consumption of fuel and machinery energy increased similarly, but the labor and seed energy consumption dropped. The renewable energy in the traditional and semi-mechanized systems was 3168.3 (4.70% total energy) and 2312.1 MJ/ha (3.44%), respectively. Energy ratio and energy productivity in traditional and semi-mechanized systems was 3 and 3.08, and 0.111 and 0.116 kg/MJ 116.0, respectively. Nonetheless, net energy gain and specific energy showed that energy efficiency of semi-mechanized systems was more than the traditional system.

Key words: Energy ratio, rice, net energy gain, energy productivity, mechanization.

INTRODUCTION

Rice has important role in human nutrition. Improve population nutrition; to develop better varieties of rice and methods developed and used to produce it depends. During the last four decades, the researches and interests in the rice production in many countries have been increased.

Rice is produced under various soil conditions (salt, alkali, peat) and under different water and temperature regimes. Nearly 90% of rice cultivation and production allocated to Asia (IRRI, 2000). According to statistics published in the International Rice Research Center website (IRRI) in 2000, under cultivation, the average rice yield and total production in the Iran, respectively 587.150 ha, four tons and 2,348,241 tons which is almost equivalent to 0.4% of the acreage of rice world.

Agriculture is closely linked with energy and can as a consumer and supplier of energy in the form of biomass energy are (Alam et al., 2005). The energy consumption in the agricultural sector depends to the population employed in the agriculture, the amount of cultivable land and the level of mechanization (Ozkan et al., 2004). In future, agriculture not only growing demand for food supply does not meet demand, but fuel and livestock feed will (Alam et al., 2005). Thus saving, efficient use and development or renewable energy sources available to create sustainable development and food security for future generations are very important (Singh, 2002).

Pathak and Binning (1985) conducted among the families expressed a grain of rice cultivation to spend more energy than wheat does, and because of high energy consumption due to high water in the cultivated product. Yoo and Yeony (1991) compared three rice cultivation systems in South Korea. Fusion system while reducing energy input than the other two systems performance similar to conventional systems, automated systems of the two higher energy efficiency is desired. Kennedy (2001) showed that high performance and mechanization are not always related to each other.

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Table 1. The energy equivalent inputs and output

Items	Unit	Energy equivalent (MJ/unit)	Reference
Diesel fuel	L	56.31	(Asakereh et al., 2010; Erdal et al., 2007)
Gasoline Fuel	L	47.8	(Kitani, 1999)
Labor human	h	2.31	(Yaldiz et al., 1993)
Agricultural Machinery	kg	62.7	(Ozkan et al., 2004)
Nitrogen fertilizer (N)	kg	60.6	(Esengun et al., 2007)
Phosphate fertilizer (P_2O_5)	kg	11.93	(Esengun et al., 2007)
Potassium fertilizer (K_2O)	kg	6.7	(Esengun et al., 2007)
Pesticides	kg	101.2	(Yaldiz et al., 1993)
Herbicide	kg	238	(Pathak and Binning, 1985)
Fungicides	kg	216	(Pathak and Binning, 1985)
Seed	kg	17	(Singh and Mital, 1992)
Irrigation canal	m^3	4.184	

Kennedy (2001) compared rice production in Japan with California in America. In Japan 640 labor-hours and 90 L of fuel per hectare were consumed, but in USA for rice production 24 labor-hours and 310 L of fuel per hectare was consumed. Product performance in both countries has equal and high level. In Japan the high performance is in result of large amounts of fertilizer consumption and in the United States in result of high yielding varieties is. Energy ratio in Japanese system was 2.8 and in the American system 2.1. The purpose of this study was investigation the energy needed in rice cultivation and determination of indicators for rice production desired call number two semi-mechanized and traditional cultivation methods in the Mazandaran Province of Iran.

MATERIALS AND METHODS

The study was conducted on 500 rice farms in the Mazandaran Province of Iran. Data were collected from the farms using a face-to-face questionnaire technique on August- August 2010. The Province is located between 35° 47' and 36°35' north latitude and 50° 34' east longitude. Data were collected from the farms using a face-to-face questionnaire technique. The size of each sample was determined using Equation 1 derived from Neyman method (Yamane, 1967):

$$n = \left(\sum N_h S_h\right) / \left(N^2 D^2 + \sum N_h S_h^2\right) \quad (1)$$

Where: n: sample size required, N: number of the beneficiary population of N_h: the number of people in the class h, S_h: class standard deviation h, S_h^2:class variance, d: making accuracy $(X - \overline{X})$, Z: reliability (95%), D^2 is: $D^2 = d^2 / z^2$

Rice usually all around the world in two ways: indirect and direct culture (Awan et al., 2007). Indirect culture consists of rice cultivation in nursery and then transplant to the land transfer if the original is in direct seeding cultivation technique directly on the main land is cultivated. The original ground indirect method has been previously prepared. The transplanting with labore, reduce the density of rice in the farm high costs led to delay in transplant business and culture of older transplant (Santhi et al., 1998) and thus performance is reduced (Awan et al., 2007). To calculate energy input and energy output and other indicators of energy equivalent inputs you use. Equivalent energy input in the Table 1 is shown. First inputs for rice production in the two systems are calculated. Inputs including labor input, diesel fuel, gasoline, pesticides, chemical fertilizers, irrigation, agriculture and seed are cars. Initial data were entered in the software based on Axel equivalent amount of energy towards energy efficiency, energy intensity and the net output was calculated using the following relationships (Singh, 2002; Sartori et al., 2005):

$$\text{Output- input energy ratio} = \frac{\text{Output energy (MJ/ha)}}{\text{Input energy (MJ/ha)}} \quad (2)$$

$$\text{Energy productivity} = \frac{\text{Apple output (kg/ha)}}{\text{Input energy (MJ/ha)}} \quad (3)$$

$$\text{Net energy gain} = \text{output energy (MJ/ha)} - \text{input energy (MJ/ha)} \quad (4)$$

$$\text{Specific energy} = \frac{\text{Input energy (MJ/ha)}}{\text{Apple output (kg/ha)}} \quad (5)$$

Two categories of energy consumption energy consumption is divided into direct and indirect: direct consumption of energy inputs in rice production, including fuel, manpower, water and energy, inputs consumed indirectly are seed, fertilizer, machinery and chemical pesticides. Also, two categories of energy and nonrenewable energy include diesel, chemicals, chemical fertilizers, machinery and equipment. Renewable energy consists of human and manure fertilizer in apple production (Mandal et al., 2002; Hatirli et al., 2006).

RESULTS AND DISCUSSION

Direct and indirect energy

Table 2 shows the direct and indirect energy consumption per unit of operation per hectare rice production

Table 2. Direct and indirect Energy in rice production systems.

Input energy		Energy consumption			
		Traditional methods		Semi-mechanized methods	
		MJ/ha	%	MJ/ha	%
Direct energy					
Fuel	Land preparation	3378.6	45.89	3378.6	45.45
	Transplantation	0	0.00	183.8	2.47
	Sprayer	136.57	1.85	136.75	1.84
	Self-reaper	0	0.00	487.75	6.56
	Thrasher	1698.9	23.08	1698.9	22.86
	Total	5214.07	70.82	5885.8	79.19
Labor	Land preparation	346.5	4.71	346.5	4.66
	Planting	693	9.41	376	5.06
	(weeding, thinning fertilizer, spraying)	485.1	6.59	485.1	6.53
	Harvesting	415.8	5.65	131.6	1.77
	Threshing	207.9	2.82	207.9	2.80
	Total	2148.3	29.18	1547.1	20.81
Total direct energy		7362.37	100	7432.9	100
Indirect energy					
Seed		1020	1.70	765	1.28
Nitrogen fertilizer		6969	11.62	6969	11.66
Phosphorus fertilizer		286.32	0.48	286.32	0.48
Potassium fertilizer		355	0.59	355	0.59
Herbicide		595	0.99	595	1.00
Pesticides		151.8	0.25	151.8	0.25
Fungicides		324	0.54	324	0.54
Irrigation		50232	83.73	50232	84.02
Trailer		29.47	0.05	29.47	0.05
Transplanter		0	0.00	36.99	0.06
Sprayer		2.61	0.00	2.61	0.00
Reaper		0	0.00	9.51	0.02
Thresher		28.71	0.05	28.71	0.05
Total machines		60.79	0.10	106.93	0.18
Total indirect energy		59993.91	100	59785.05	100
Total input energy		67356.28		67217.95	

systems in semi-mechanized and traditional. In both systems production the most fuel energy related to land operations that in the traditional and semi-mechanized systems was 5214.07 MJ/ha (64.8% total fuel consumption) 5885.8 MJ/ha (57.4% total fuel consumption), respectively; shows the importance of plowing operations and increase the efficiency of this operation a suitable model system for preparation of the land can be somewhat of a waste of energy in this section would avoid. After the land preparation, threshing operation in both systems has the highest fuel consumption. Lowest fuel consumption in both systems is related to the spraying operation. In semi mechanized system due to the use of transplanting and harvesting machinery fuel consumption than traditional systems. Energy fuel in the semi-mechanized and traditional systems, respectively 5885.8 and 5214.07 MJ/ha was calculated.

Energy of labor required in the semi-mechanized method 601.2 MJ/ha is less than traditional methods and semi-mechanized method of reducing the labor energy in the planting and harvesting process than traditional methods, respectively 4.33 and 1.61%. The most energy consumption of labor in the traditional system related to the planting operation with 693 MJ/ha (9.41% of direct energy) and in the semi-mechanized system was an operations relating to the weeding, thinning fertilizer, spraying with 485.1 MJ/ha (6.53% of direct energy). Total energy of labor requirements for rice production in

Table 3. Energy inputs used in rice production systems in both traditional and semi-mechanized.

Item	Traditional methods		Semi-mechanized methods	
	MJ/ha	%	MJ/ha	%
Fuel consumption	5214.07	7.74	5885.8	8.76
Labor	2148.3	3.19	1547.1	2.30
Direct energy	7362.37	10.93	7432.9	11.06
Seed	1020	1.51	765	1.14
Chemical fertilizers	7610.32	11.30	7610.32	11.32
Toxins	1070.8	1.59	1070.8	1.59
Irrigation	50232	74.58	50232	74.73
Machine	60.79	0.09	106.93	0.16
Indirect energy	59993.91	89.07	59785.05	88.94
Renewable energy	3168.3	4.70	2312.1	3.44
Nonrenewable energy	64187.98	95.30	64905.67	96.56
Total energy consumption	67356.28	100	67217.95	100

traditional and semi-mechanized systems, respectively, 2148.3 and 1547.1 MJ/ha was calculated. The total direct energy in the semi-mechanized and traditional systems is 7362.37 and 7432.9 MJ/ha, respectively.

Seed energy in the semi mechanized was 255 MJ/ha less than the traditional, which decreased 25% energy consumption of seed. The difference in the use of machinery in both systems related to use transplanting and harvesting machinery, which is caused that energy consumption of machinery in the semi-mechanized more than the traditional. Among the indirect energy inputs, irrigation in both systems was the most input energy that irrigation energy in the semi-mechanized and traditional systems, respectively, was 83.73 and 84.02% of total indirect energy. Nitrogen with 6969 MJ/ha in both system, top energy consumer inputs after irrigation in the production of rice was obtained. Machinery in the semi-mechanized and traditional systems, respectively with 60.79 and 106.93 MJ/ha values was calculated the lowest indirect energy. Transplanting in semi-mechanized and traditional system with 36.99 and 29.47 MJ/ha, respectively, the highest energy machines were having. Total indirect energy used in traditional and mechanized systems respectively 59993.91 and 59785.05 MJ/ha was calculated to be more indirect energy consumed in the traditional system.

As seen from Table 3 indirect energy in traditional system with 67356.28 MJ/ha was more than semi-mechanized systems with 67217.77 MJ/ha, indicating that despite the mechanization of some operations out of machinery and more fuel being used but the total energy consumption in the semi-mechanized system due to reduced labor and seed input due to the use of machines instead of humans, has been reduced. Irrigation with 83.73 and 74.73%, respectively, in the semi-mechanized and traditional systems was the most indirect energy consumption that shows management methods that reduce water use are very important. The second indirect input energy in rice production systems was Nitrogen fertilizer in both systems with about 11.6% of indirect energy. The third energy inputs in the both rice production system was fuel. The less input energy related to machinery that in traditional and semi mechanized system was 0.10 and 0.18% total indirect input energy, respectively. Direct energy in the semi-mechanized and traditional systems, respectively, was 10.93 and 11.06% of total energy consumption, while indirect energy was 89.07 and 88.94% of total energy consumption. Renewable energy systems in the rice production were very low and showed that rice production was based on nonrenewable resources that these sources cause the environmental pollution. The Renewable energy system over the traditional semi-mechanized and the amount of 3168.3 MJ/ha (7.4% of total energy) while the semi-mechanized systems is 2312.1 MJ/ha (44.3% total energy).

Field studies showed that the amount of straw produced in the two methods is not much different rice production rate at 3.8 tons per hectare is the product rate to call in case of traditional rice, 7.5 and 7.5 tons in the state semi-mechanized respectively. According to the obtained grain and energy per kg of rice equivalent energy output for traditional and semi-mechanized farm respectively 127.5 and 132.26 GJ/ha calculated.

Energy indicators

Figure 1 shows ratio, productivity, energy intensity and energy output of the net in the semi-mechanized production systems and traditional. According to rice, energy output and energy expenditure, energy ratio of rice in traditional methods and semi-mechanized, respectively 3 and 3.08 was obtained. This ratio shows a better use of input energy in semi-mechanized and was more efficient. Energy productivity (EP) of grain for both

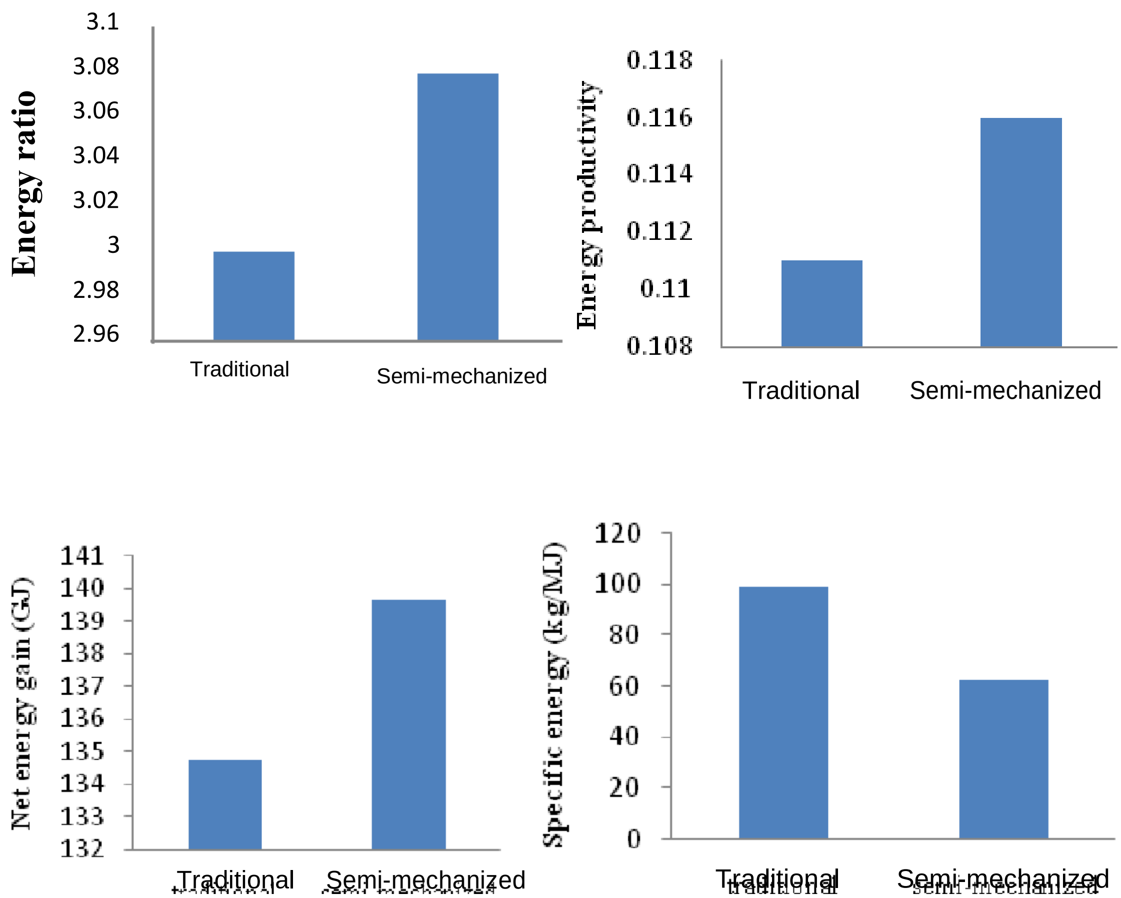

Figure 1. Energy Indicators.

traditional and semi-mechanized cultivation systems, respectively, 0.111 and 0.116 kg/MJ obtained that indicate per MJ of energy consumption in both traditional and semi-automated system 0.111 and 0.116 kg of rice was produced and shows that the semi-mechanized systems more product levels. Specific energy shows that the energy consumption for each kg of rice production in the traditional and mechanization production system was 98.8 and 62.8 MJ, respectively. Net energy gain in traditional and semi-mechanized systems, respectively, 134.77 and 139.67 GJ/ha has been calculated.

Conclusion

Most input energy in rice production was irrigation that in traditional and semi-mechanized method was 74.58 and 73.74% of total input energy that shows the importance of irrigation management. Second on the energy inputs to fertilizer in the traditional method of approximately 30.11 and 34.11% of the semi-mechanized energy input includes an 82.91% is related to nitrogen. Total energy intake worker in the semi-mechanized method of 9.27% less than traditional methods is that workers with high wages for semi-mechanized method of paddy land to save money in production costs will be. The most important effect of semi-mechanized method for the production of lower energy consumption but instead more and more energy the amount of product is suitable for the justification of this method is used. Energy than traditional systems, respectively, three mechanized and is 08.3. In both methods, rice production is based on nonrenewable resources that cause environmental pollution is the importance of alternative and renewable sources shows.

REFERENCES

Alam MS, Alam MR, Islam KK (2005). Energy flow in agriculture: Bangladesh. Am. J. Environ. Sci., 1(3): 213-220.

Asakereh A, Shiekhdavoodi MJ, Almassi M, sami M (2010). Effects of mechanization on energy requirements for apple production in Esfahan province, Iran. Afr. J. Agric. Res., 5(12): 1424-1429.

Awan IU, Shahid M, Nadeem MA (2007). Comparative study of variable seeding rates and herbicides application for weed control in direct wet seeded rice. Pak. J. Biol. Sci., 3: 1824-1826.

Erdal G, Esengun K, Erdal H, Gunduz O (2007). Energy use and economical analysis of sugar beet production in Tokat province of Turkey. Energy, 32: 35-41.

Hatirli SA, Ozkan B, Fertr C (2006). Energy input and crop yield relationship in agreegouse tomato production. Renew. Energy, 31: 127-438.

IRRI (2000). International Rice Research Institute. A handbook of weed control in rice, p. 113.

Kennedy S (2001). Energy Use in American agriculture. Sustainable Energy term.pp:2001.www.web.mit.edu/energy lab/proceeding.

Kitani O (1999). CIGR Handbook of Agricultural Engineering. Vol, V, Energy and Biomass Engineering. ASAE publication, ST Joseph, MI.

Mandal KG, Saha KP, Ghosh PK. Hati KM, Bandyopalbyay KK (2002). Bioenergy and economic analysis of soybean- based crop production systems in central India. Biomass and Bioenergy, 23: 337-345.

Ozkan B, Akcaoz H, Karadeniz F (2004). Energy requirement and economic analysis of citrus production in Turkey. Energy Convers. Manage., 45:1821-1830.

Pathak B, Binning A (1985). Energy use pattern and potential for energy saving in rice-wheat cultivation. Agric energy, 4: 271-280.

Santhi P, Ponnuswamy K, Kempuchktty N (1998). A labour saving technique in direct-sown and transplanted rice. Int. Rice. Res. Notes, 23(2): 35.

Sartori L, Basso B, Bertocco M, Oliviero G (2005). Energy use and economic evaluation of a three year crop rotation for conservation and organic farming in NE Italy. Biosyst. Eng., 9 (2): 245-250.

Singh JM (2002). On farm energy use pattern in different cropping systems in Haryana, India. Master of Science thesis. Management University of Flensburg, Germany.

Singh S, Mital JP (1992). Energy in Production Agriculture. Mittal Pub, New Delhi.

Yaldiz O, Ozturk HH, Zeren Y, Bascetincelik, A (1993). Energy usage in production of field crops in Turkey. In: Vth international congress on mechanization and energy in agriculture. Izmir-Turkey, pp. 527-536 [in Turkish].

Yamane T (1967). Elementary sampling theory. Engle wood Cliffs, NJ, USA: Prentice- Hall Inc.

Yoo SH, Yeony SJ (1991). Soil management for sustainable Agriculture in korea. Seoul National University, Suwon, Korea.