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The Evaluation and the Comparison of the Energy and Economic Analysis of Rice Production in Mazandaran Province of Iran

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Abstract: The aim of this study is to consider the energy consuming process and factors influencing two varieties rice production (*Tarom*, *fajr*) under semi-mechanized and traditional systems, to investigate the energy consumption and economic analysis of rice in Mazandaran Province of Iran. Data used in this study were obtained from 76 farmers using a face to face questionnaire method, in farming year of 2011. The results showed that the highest total energy of labor requirements for *Tarom* variety rice production in Traditional and semi-mechanized systems, respectively, 2148.3 and 1547.1 MJ/ha was calculated. The *fajr* variety because of suitable genetic specifications has higher output energy in compared with *Tarom* local variety. Highest output energy with average 237701.70 MJ/ha of semi-mechanized system for *fajr* variety and also 209173.50 MJ/ha for traditional system. The highest energy ratio of rice production was for *fajr* variety in traditional methods and semi-mechanized, respectively 7.03 and 7.95. The highest Energy productivity (EP) of grain for both traditional and semi-mechanized cultivation systems was for *fajr* variety, that respectively, 0.20 and 0.22 kg/MJ. The highest Net energy gain was for *fajr* variety in traditional and semi mechanized systems, respectively, 179.42 and 207.82 GJ/ha that has been calculated. Highest income of rice production with 10834 $/ha (semi-mechanized system) and 9215 $/ha (traditional system) observed in *fajr* variety. Highest profit of rice production with 10039 $/ha (semi-mechanized system) and 8636 $/ha (traditional system) observed in *fajr* variety and so According to the results of this research and studying the energy and economic analysis, that the condition of the management of energy consumption in producing *fajr* varieties are more suitable and according to the need of country about producing rice.

Keywords: Economic analyze, energy, Iran, rice

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food of more than a half of the world population (Sinha and Talati, 2007; Ginigaddara and Ranamukhaarachchi, 2009). The global rice production is 454.6 million ton annually, which has a yield of 4.25 ton/ha. The average yield is about 4.9 ton/ha in Iran, which is the 11th rice producer in the world (IRRI, 2010). However, Iran consumes about 2.05 million ton of its production inside the country. For the last decades, rice consumption has been expanding beyond the traditional rice-growing areas, particularly in western Asia and Europe. In most countries, surveillance measures are taken regarding the presence of different elements in important foodstuff (Samadi-Maybodi and Atashbozorg, 2006).

Energy use is one of the key indicators for developing more sustainable agricultural practices (Streimikiene *et al*., 2007) and efficient use of energy is one of the principal requirements of sustainable agriculture (Kizilaslan 2009).

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).

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

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Table 1: Energy equivalents for different inputs and outputs in rice production

Items	Unit	Energy equivalent (MJ/unit)	Reference
Input			
Fuel	L	56.31	(Cherati *et al*., 2011; Erdal *et al*., 2007)
Agricultural machinery	kg	62.7	(Ozkan *et al*., 2004)
Labor human	hr	2.31	(Yaldiz *et al*., 1993)
Nitrogen fertilizer (N)	kg	60.6	(Esengun *et al*., 2007)
Phosphate fertilizer (P2O5)	kg	11.93	(Esengun *et al*., 2007)
Potassium fertilizer (K2O)	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	(Cherati *et al*., 2011)
Output			
Paddy	kg	14.7	(Moradi and Azarpour, 2011)
Straw	kg	12.5	(Moradi and Azarpour, 2011)
Husk	kg	13.8	(Moradi and Azarpour, 2011)

of high yielding varieties is. Energy ratio in Japanese system was 2.8 and in the American system 2.1.

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.

Cherati *et al*. (2011) compared two rice cultivation systems in Iran. Results showed that the total energy used for semi-mechanized and traditional rice production system was 67217.95 and 67356.28 MJ/ha, respectively.

The aims of the study were to survey input energy in local and breed varieties rice production under two farming systems condition (traditional and semi-mechanized), to investigate the energy consumption and to make an economic analysis of rice in Mazandaran province of Iran.

MATERIALS AND METHODS

The study was conducted on 63 rice farms in the Mazandaran Province of Iran. Data were collected from the farms using a face to-face questionnaire technique on August- August 2011. 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 Eq. (1) derived from Neyman method (Yamane, 1967):

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

where, n: sample size required, N: number of the beneficiary population of N_h: the number of people in the class h, S^2_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 labor, 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 and SPSS 15 spreadsheets 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):

Energy ratio = Output energy (Mj/ha)/Input energy (Mj/ha) (2)

Energy ratio = Grain yield (Kg/ha)/Input energy (Mj/ha) (3)

Energy ratio = Input energy (Mj/ha)/Grain yielt (Kg/ha) (4)

Net energy gain = Output energy yield-Intput energy (Mj/ha) (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

Table 2: Direct and indirect energy in rice production systems

Input energy		Energy consumption: Traditional methods: Tarom (MJ/ha)	%	Traditional methods: Fair (MJ/ha)	%	Semi-mechanized methods: Tarom (MJ/ha)	%	Semi-mechanized methods: Tarom (MJ/ha)	%
Direct energy									
Fuel	Land preparation	3378.60	45.89	3378.60	46.73	3378.60	45.45	3378.60	45.45
	Transplantation	0.00	0.00	0.00	0.00	183.80	2.47	183.80	2.47
	Sprayer	136.57	1.85	136.57	1.89	136.75	1.84	136.57	1.84
	Self-reaper	0.00	0.00	0.00	0.00	487.75	6.56	487.75	6.56
	Thrasher	1698.90	23.08	1698.90	23.50	1698.90	22.86	1698.90	22.86
	Total	5214.07	70.82	5214.07	72.11	5885.80	79.19	5885.62	79.19
Labor	Land preparation	346.50	4.71	346.50	4.79	346.50	4.66	346.50	4.66
	Planting	693.00	9.41	561.33	7.76	376.00	5.06	376.00	5.06
	(weeding, thinning fertilizer, spraying)	485.10	6.59	485.10	6.71	485.10	6.53	485.10	6.53
	Harvesting	415.80	5.65	415.80	5.75	131.60	1.77	131.60	1.77
	Threshing	207.90	2.82	207.90	2.88	207.90	2.80	207.90	2.80
	Total	2148.30	29.18	2016.63	27.89	1547.10	20.81	1547.10	20.81
Total direct energy		7362.37	100.00	7230.70	100.00	7432.90	100.00	7432.90	100.00
Indirect energy									
	Seed	1020.00	5.02	867.00	3.85	765.00	3.79	703.80	3.13
	Nitrogen fertilizer	6969.00	34.29	8711.25	38.68	6969.00	34.57	8711.25	38.80
	Phosphorus fertilizer	286.32	1.41	357.90	1.59	286.32	1.42	357.90	1.59
	Potassium fertilizer	355.00	1.75	443.75	1.97	355.00	1.76	443.75	1.98
	Herbicide	595.00	2.93	595.00	2.64	595.00	2.95	595.00	2.65
	Pesticides	151.80	0.75	151.80	0.67	151.80	0.75	151.80	0.68
	Fungicides	324.00	1.59	324.00	1.44	324.00	1.61	324.00	1.44
	Irrigation	10500.00	51.67	10950.00	48.62	10500.00	52.08	10950.00	48.77
	Trailer	29.47	0.15	29.47	0.13	29.47	0.15	29.47	0.13
	Transplanter	0.00	0.00	0.00	0.00	36.99	0.18	36.99	0.16
	Sprayer	2.61	0.01	2.61	0.01	2.61	0.01	2.61	0.01
	Reaper	0.00	0.00	0.00	0.00	9.51	0.05	9.51	0.04
	Thresher	28.71	0.14	28.71	0.13	28.71	0.14	28.71	0.13
Total machines		60.79	0.30	60.79	0.27	106.93	0.53	106.93	0.48
Total indirect energy		20322.70	100.00	22522.28	100.00	20160.34	100.00	22451.72	100.00
Total input energy		27685.07	-	29752.98	-	27593.24	-	29884.62	-
Output energy									
Energy production									
Paddy		49156.80	43.69	87318.00	41.74	55860.00	41.74	99225.00	41.74
Straw		52689.85	46.83	101362.50	48.46	64849.85	48.46	115189.20	48.46
Husk		10658.05	9.47	20493.00	9.80	13110.00	9.80	23287.50	9.80
Total output energy		112504.7	100.00	209173.50	100.00	133819.85	100.0	237701.70	100.00

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 rice 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 systems in semi-mechanized and traditional. In both systems production for all of two varieties the most fuel energy related to land operations that in the traditional and semi-mechanized systems was 5214.07 MJ/ha (64.73% total fuel consumption) 5885.6 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,

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

Item	Traditional methods				Semi-mechanized methods			
	Tarom (MJ/ha)	%	Fair (MJ/ha)	%	Tarom (MJ/ha)	%	Fair (MJ/ha)	%
Fuel consumption	5214.07	18.83	5214.07	17.52	5885.80	21.33	5885.62	19.69
Labor	2148.30	7.76	2016.63	6.78	1547.10	5.61	1547.10	5.18
Direct energy	7362.37	26.59	7230.70	24.30	7432.90	26.94	7432.90	24.87
Seed	1020.00	3.68	867.00	2.91	765.00	2.77	703.80	2.36
Chemical fertilizers	7610.32	27.49	9512.90	31.97	7610.32	27.58	9512.90	31.83
Toxins	1070.80	3.87	1070.80	3.60	1070.80	3.88	1070.80	3.58
Irrigation	10500.00	37.93	10950.00	36.80	10500.00	38.05	10950.00	36.64
Machinery	60.79	0.22	60.79	0.20	106.93	0.39	106.93	0.36
Indirect energy	20322.70	73.41	22522.28	75.70	20160.34	73.06	22451.72	75.13
Renewable energy	3168.30	11.44	2883.63	9.69	2312.10	8.38	2250.90	7.53
Nonrenewable energy	24516.77	88.56	26869.35	90.31	25281.14	91.62	27633.72	92.47
Total energy consumption	27685.07	100.00	29752.98	100.0	27593.24	100.00	29884.62	100.00
Total energy Production	112504.70	-	209173.50	-	133819.85	-	237701.70	-

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 of labor required in the semi-mechanized method for *Tarom* variety is (1547.10 MJ/ha) that 601.2 MJ/ha less than traditional methods (2148.30 MJ/ha 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 traditionalsystem is for *Tarom* variety that 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).the highest total energy of labor requirements for *Tarom* variety rice production in Traditional and semi-mechanized systems, respectively, 2148.3 and 1547.1 MJ/ha was calculated.

The highest total direct energy is for *Tarom* variety in the semi-mechanized and traditional systems to 7362.37 and 7432.9 MJ/ha, respectively. Seed energy in the semi mechanized for *fajr* variety was 316.2 MJ/ha less than the traditional for *Tarom* variety, which decreased 31% 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 for *fajr* variety was the most input energy that irrigation energy in the semi-mechanized and traditional systems. Nitrogen with 8711.25 MJ/ha in both system for *fajr* variety, top energy consumer inputs after irrigation in the production of rice was obtained. Machinery in the semi-mechanized and traditional systems, respectively with 106.93 and 60.79 MJ/ha values was calculated the lowest indirect energy for two varieties.

As seen from Table 3 indirect that The highest total indirect energy used in traditional and mechanized systems for *fajr* variety, respectively 22522.28 and 22451.72 MJ/ha was calculated to be more indirect energy consumed in the traditional system, 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 highest input energy, in the semi-mechanized and traditional systems for two varsities was the most indirect energy consumption that shows management methods that reduce water use are very important. The highest second indirect input energy in two varieties of rice production systems was Nitrogen fertilizer in both systems for *fajr* variety with about 31.97 % 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 about (0.20 and 0.22%) and (0.39 and 0.36%) total indirect input energy for (*Tarom, fajr*) variety, respectively.

The highest direct energy in the semi-mechanized and traditional systems, respectively, was for *Tarom*

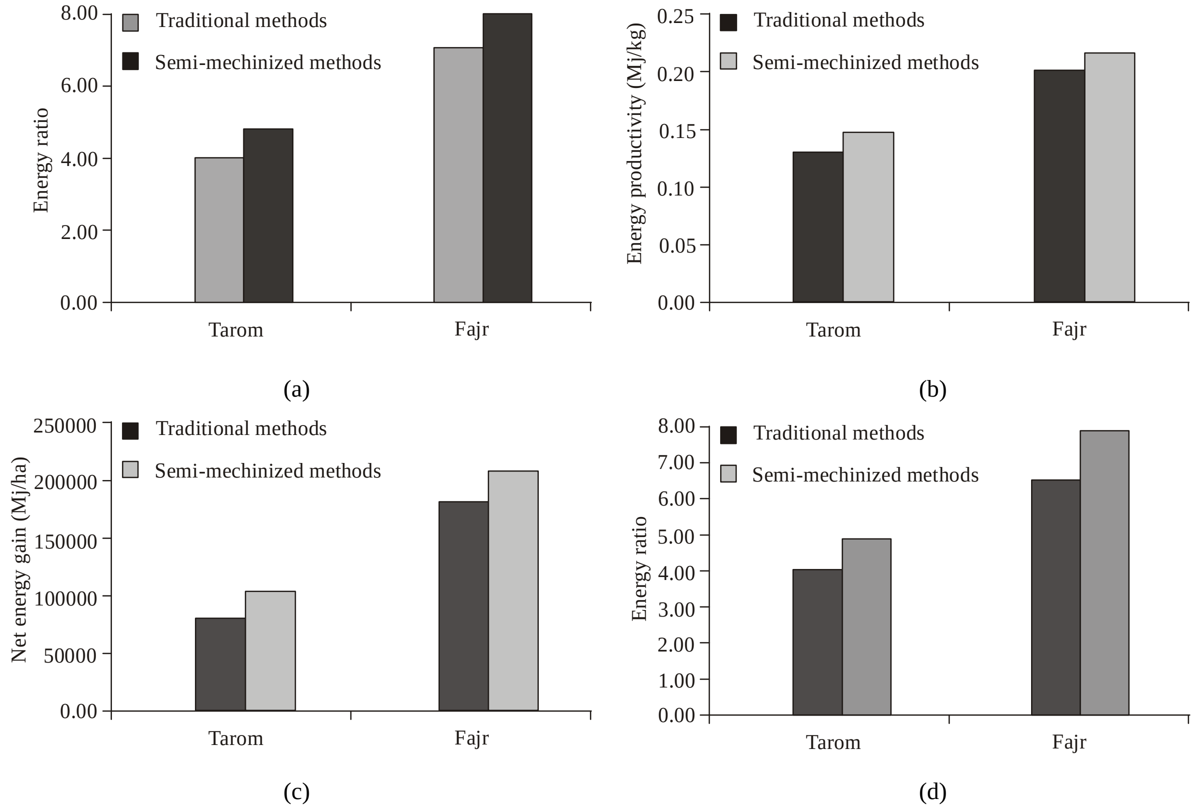

Fig. 1: Energy indicator

variety with 26.94 and 26.59% of total energy consumption, while indirect energy in the semi-mechanized and traditional systems was for *fajr* variety with 75.13 and 75.70% 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.
Semi-mechanized system because of producing higher paddy yield, straw yield and husk yield than traditional system of has higher output energy. The *fajr* variety because of suitable genetic specifications has higher output energy in compared with *Tarom* local variety. Highest output energy with averages 183991.5 and 237701.70 MJ/ha of semi-mechanized system for *fajr* variety and also 161912.30 and 209173.50 MJ/ha for traditional system.

Energy indicators: Figure. 1 shows ratio, productivity, energy intensity and energy output of the net for two varieties in the semi-mechanized production systems and traditional. According to rice, energy output and energy expenditure, the highest energy ratio of rice production is for *fajr* variety in traditional methods and semi-mechanized, respectively 7.03 and 7.95 was obtained. This ratio shows a better use of input energy in semi-mechanized and was more efficient.

The amount of higher consumption of human, fertilizer, poison and seed in traditional system lead to increasing charge of rice production in this system in compared with semi-mechanized system.

The highest Energy Productivity (EP) of grain for both traditional and semi-mechanized cultivation systems was for *fajr* variety, that respectively, 0.20 and 0.22 kg/MJ obtained that indicate per MJ of energy consumption in both traditional and semi-automated system 0.20 and 0.22 kg of rice was produced and shows that the semi-mechanized systems more product levels. Energy intensity shows that the highest energy consumption was for *Tarom* variety for each kg of rice production in the traditional and mechanization production system was 7.87 and 6.90 MJ, respectively. The highest Net energy gain was for *fajr* variety in traditional and semi mechanized systems, respectively, 179.42 and 207.82 GJ/ha that has been calculated.

Analysis of finance performance in rice production: Income of rice production in two farming systems and two varieties were showed that highest income of semi-mechanized system than traditional system. Highest income of rice production with 10834 $/ha (semi-mechanized system) and 9215 $/ha (traditional system) observed in *fajr* variety.

Profit of rice production in two farming systems and two varieties were showed that highest profit of semi-mechanized system than traditional system. Highest profit of rice production with 10039 $/ha (semi-mechanized system) and 8636 $/ha (traditional system) observed in *fajr* variety.

CONCLUSION

Most input energy in rice production was irrigation that for two varieties in traditional and semi-mechanized method was highest amount of total input energy that shows the importance of irrigation management. 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. Second on the energy inputs to fertilizer in the traditional method of approximately (27.49% for *Tarom* variety, 31.97% *fajr* variety) and (27.58 % for *Tarom* variety, 31.83% *fajr* variety) of the semi-mechanized energy input includes an 82.91% is related to nitrogen.

According to the results of this research and studying the energy and economic analysis, that the condition of the management of energy consumption in producing *fajr* varieties are more suitable and according to the need of country about producing rice and limitation of energy sources which are mainly nonrenewable energy, producing *fajr* varieties is a step towards sustainable agriculture.

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