Chapter 7

A Comparative Study on Energy Use and Cost Analysis of Rice Varieties Under Traditional and Semi-Mechanized Farming Systems in North of Iran

Ebrahim Azarpour and Maral Moraditochaee

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/51165

1. Introduction

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 more than 3 billion people [12]. 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. 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 [13]. Guilan province has allocated more 35 and 42 percent of paddy production and cultivation land area cultivation area of Iran, respectively. In this province more than 181 exploiters on productive and talented areas with more than 230000 hectares, are busy rice farming [26]. 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 in 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.

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 energy of fossil fuel. This change in the pattern of energy consumption has created problems include warming environment results from green house gases and water and soil pollutions and etc. Nowadays, agricultural sector for providing more food needed the population increase like other sectors has depended to energy sources like electricity and fossil fuels [14]. Energy has been a key input of agriculture since the age of subsistence agriculture. It is an established fact worldwide that agricultural production is positively correlated with energy input [28]. Agriculture is both a producer and consumer of energy. It uses large quantities of locally available non-commercial energy, such as seed, manure and animate energy, as well as commercial energies, directly and indirectly, in the form of diesel, electricity, fertilizer, plant protection, chemical, irrigation water, machinery etc. Efficient use of these energies helps to achieve increased production and productivity and contributes to the profitability and competitiveness of agriculture sustainability in rural living [28]. Energy use in agriculture has been increasing in response to increasing population, limited supply of arable land and a desire for higher standards of living [18]. However, more intensive energy use has brought some important human health and environment problems so efficient use of inputs has become important in terms of sustainable agricultural production [31]. Recently, environmental problems resulting from energy production, conversion and utilization increased public awareness in all sectors of the public, industry and government in both developed and developing countries It is predicted that fossil fuels will be the primary source of energy for the next several decades [8, 9]. The level of fossil fuel dependence differs significantly between developed and developing countries. Although total primary fossil energy input into farm production is comparable between developed countries and developing countries, as illustrated in "Figure 1", developed countries use more than four times the energy per capita (8.0 gigajoules/capita/year) than developing countries (1.7 GJ/capita/year). Moreover, Figure 5 further reveals very different distribution of energy use across agricultural inputs. For developing countries, nitrogen fertilizer accounts for more than half the energy inputs, with fuel and irrigation forming the next largest inputs. By contrast, in developed countries, fuel and machinery account for more than half the inputs, with nitrogen accounting for about one quarter. Efficient use of resources is one of the major assets of eco-efficient and sustainable production, in agriculture [10]. Energy use is one of the key indicators for developing more sustainable agricultural practices [29] and efficient use of energy is one of the principal requirements of sustainable agriculture [18]. It is important, therefore, to analyses cropping systems in energy terms and to evaluate alternative solutions, especially for arable crops, which account for more than half of the primary sector energy consumption [27].

Agricultural systems are complex, and understanding this complexity requires systematic research, but resources for agricultural research are limited. The field experiments investigate a number of variables under a few site-specific conditions. Crop simulation models consider the complex interactions of weather, soil properties, and management factors, which influence crop performance. Mechanistic models are very helpful in deciding the best management options for optimizing crop growth and the yield. In the middle of 1990s, Rice Research Institute of Iran (IRRI), Wageningen University, and the Research Centre developed the ORYZA model series to simulate the growth and development of tropical lowland rice. In 2001, a new version of the ORYZA model was released that improved and incorporated all previous versions into one model called ORYZA2000 [7]. The model ORYZA2000, simulates the growth and development of rice under conditions of potential production, water and nitrogen limitations.

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 Guilan province of Iran.

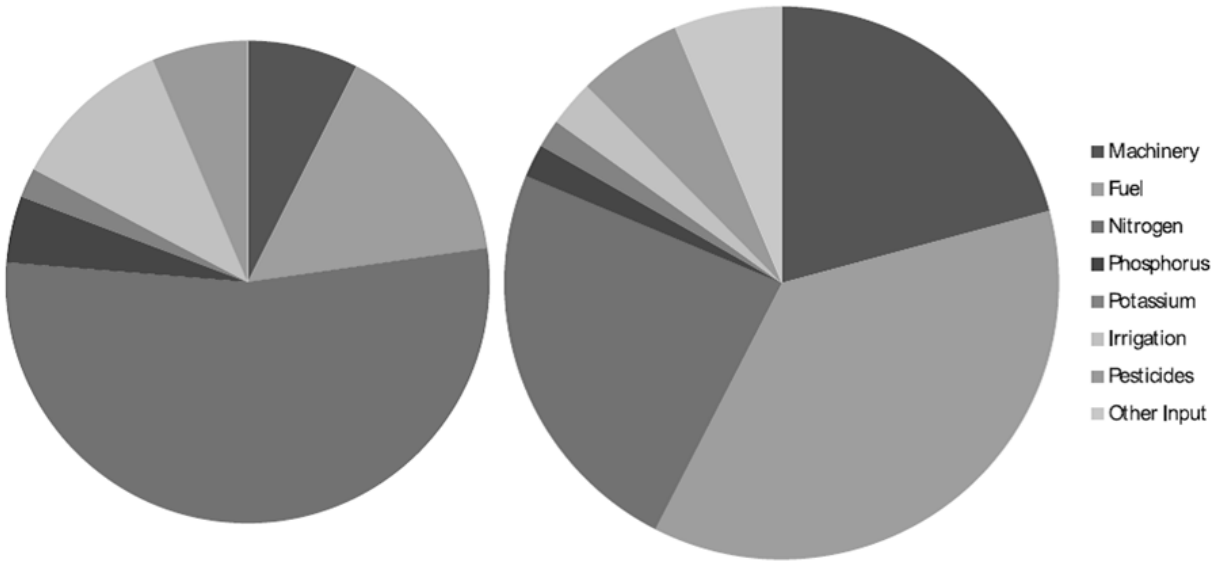

Figure 1. Distribution of farm energy inputs in developing countries (left) and in developed countries (right)

2. Materials and methods

In order to gather the required data in this study, information related to 72 farms in Guilan province during the agricultural year 2010 was studied. The Location of studied region in north of Iran was presented in "Figure 2". The random sampling of production agro ecosystems was done within whole population and the size of each sample was determined by using bottom equation [18].

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

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.

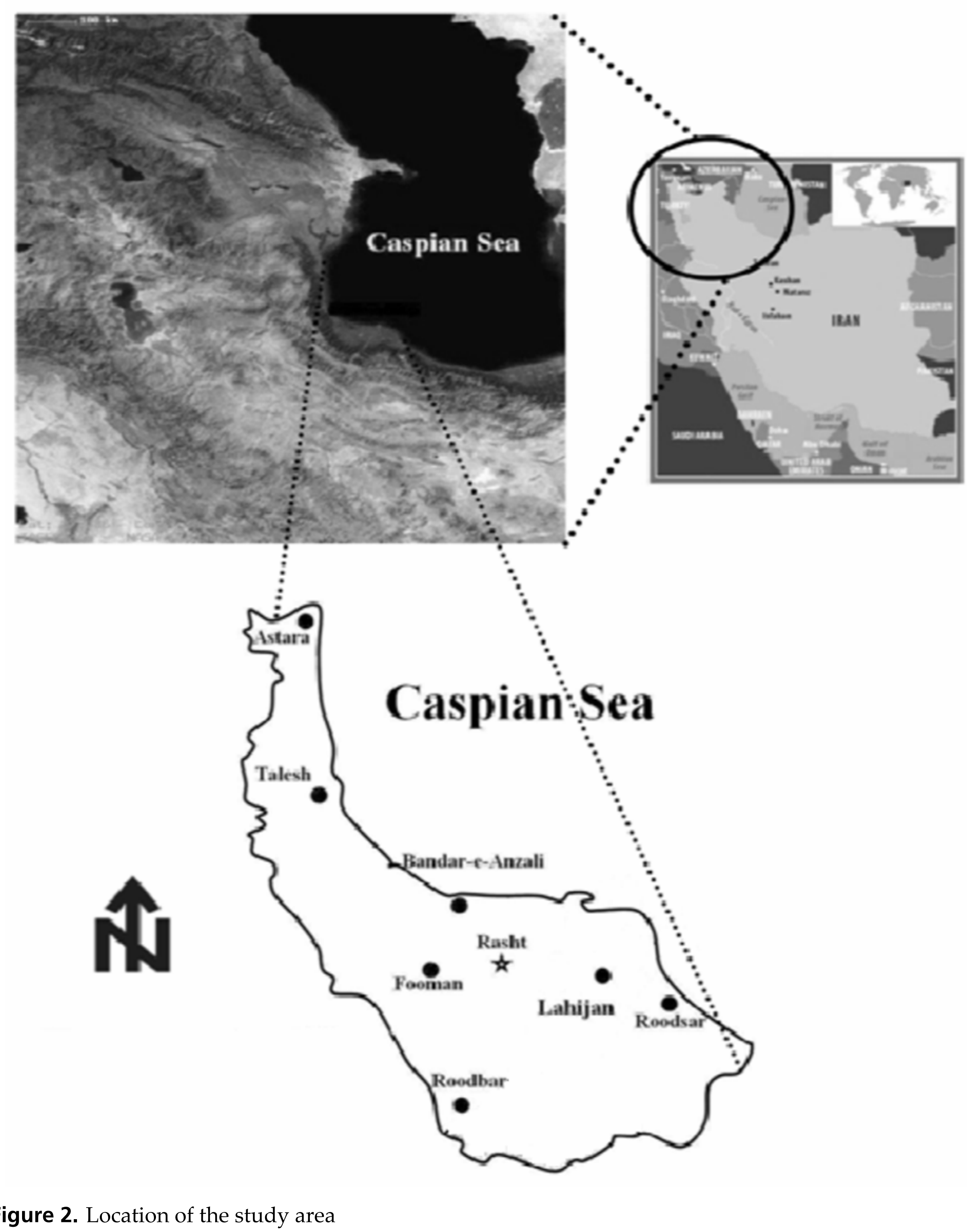

Figure 2. Location of the study area

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, transforming machine and reaping machine are used for plant out and reaping respectively.

Efficient use of the energy resources is vital in terms of increasing production, productivity, competitiveness of agriculture as well as sustainability of rural living. Energy auditing is one of the most common approaches to examining energy efficiency and environmental impact of the production system. It enables researchers to calculate output-input ratio, relevant indicators, and energy use patterns in an agricultural activity. Moreover, the energy audit provides sufficient data to establish functional forms to investigate the relationship between energy inputs and outputs. The amount of inputs used in agricultural production practices (human labor, machinery, diesel fuel, chemical fertilizers, poison fertilizers, water and seeds) were calculated per hectare and then, these data were converted to forms of energy to evaluate the output-input analysis. In order to calculate output and input energy, these input data and amount of output yield were multiplied with the coefficient of energy equivalent. Energy equivalents of inputs and output were converted into energy on area unit. The previous researches "Table 1" were used to determine the energy equivalents' coefficients [15, 19, 20, 21, 22, 23, 24, 25, 30, 31]. Firstly, the amounts of inputs used in the production of rice were specified in order to calculate the energy equivalences in the study. Energy input include human labor, machinery, diesel fuel, chemical fertilizer, chemical poison, water and seed amounts and output yield include paddy of rice.

In this research, energy indices (energy use efficiency, energy ratio, energy productivity, energy intensity, net energy gain and water and energy productivity) based on the energy equivalents of the inputs and output "Table 2" were calculated according to bottom equations [15, 19, 20, 21, 22, 23, 24, 25, 30, 31].

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

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

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

$$\text{Water and energy productivity} = \frac{\text{Yield output (Kg/ha)}}{\text{Water applied (M3/ha)} \times \text{Input energy (Mj/ha)}}$$

$$\text{Net energy gain} = \text{Output energy (Mj/ha)} - \text{Input energy (Mj/ha)}$$

The input energy is also classified into direct and indirect and renewable and non-renewable forms energy equivalents for different inputs and outputs in agricultural production. Indirect energy consists of seeds, chemical fertilizer, chemical poison, and machinery energy while direct energy covered human labor, water and diesel fuel used in the rice production. Non-renewable energy includes diesel fuel, chemical fertilizer, chemical poison and machinery and renewable energy consists of human labor, water and seed [2, 4, 5, 6].

Parameter	Hashemi	Alikazemi	Khazar	Hybrid	Gohar	Energy equivalent
Traditional system						
Input						
Human labor (h/ha)	94.3	94.3	94.3	94.3	94.3	1.96
Machinery (h/ha)	37.2	37.2	37.2	37.2	37.2	62.7
Diesel fuel (l/ha)	127.2	127.2	127.2	127.2	127.2	56.31
Nitrogen (kg/ha)	125	125	180	230	230	69.5
Phosphorus(kg/ha)	60	60	80	100	100	12.44
Potassium (kg/ha)	110	110	150	200	200	11.15
Herbicide (l/ha)	3	3	3	3	3	85
Fungicide (l/ha)	2	2	2	2	2	160
Insecticide (l/ha)	2	2	1	1	1	99
Water (m^3/ha)	10000	10000	10000	10000	10000	1.02
Seed (kg/ha)	90	90	70	30	30	17
Output						
Paddy (kg/ha)	3520	4180	4840	6600	8360	14.7
Straw (kg/ha)	4437	5706	6607	9010	11413	12.5
Husk (kg/ha)	813	1045	1210	1650	2090	13.8
Biomass (kg/ha)	8770	10931	12657	17260	21863	13.67
Semi-mechanized system						
Input						
Human labor (h/ha)	73.7	73.7	73.7	73.7	73.7	1.96
Machinery (h/ha)	47.3	47.3	47.3	47.3	47.3	62.7
Diesel fuel (l/ha)	142.1	142.1	142.1	142.1	142.1	56.31
Nitrogen (kg/ha)	125	125	180	230	230	69.5
Phosphorus(kg/ha)	60	60	80	100	100	12.44
Potassium (kg/ha)	110	110	150	200	200	11.15
Herbicide (l/ha)	3	3	3	3	3	85
Fungicide (l/ha)	2	2	2	2	2	160
Insecticide (l/ha)	2	2	1	1	1	99
Water (m^3/ha)	10000	10000	10000	10000	10000	1.02
Seed (kg/ha)	70	70	50	20	20	17
Output						
Paddy (kg/ha)	4000	4750	5500	7500	9500	14.7
Straw (kg/ha)	5461	6485	7508	10239	12969	12.5
Husk (kg/ha)	1000	1188	1375	1875	2375	13.8
Biomass (kg/ha)	10461	12423	14383	19614	24844	13.67

Table 1. Amounts of input-output used and energy equivalent in varieties rice production under traditional system and semi-mechanized system condition

Parameter	Hashemi	Alikazemi	Khazar	Hybrid	Gohar
Traditional system					
Input					
Human labor (h/ha)	184.83	184.83	184.83	184.83	184.83
Machinery (h/ha)	2332.44	2332.44	2332.44	2332.44	2332.44
Diesel fuel (l/ha)	7162.63	7162.63	7162.63	7162.63	7162.63
Nitrogen (kg/ha)	8687.5	8687.5	12510	15985	15985
Phosphorus(kg/ha)	746.4	746.4	995.2	1244	1244
Potassium (kg/ha)	1226.5	1226.5	1672.5	2230	2230
Herbicide (l/ha)	255	255	255	255	255
Fungicide (l/ha)	320	320	320	320	320
Insecticide (l/ha)	198	198	99	99	99
Water (m^3/ha)	10200	10200	10200	10200	10200
Seed (kg/ha)	1530	1530	1190	510	510
Output					
Paddy (kg/ha)	51744	61446	71148	97020	122892
Straw (kg/ha)	55463	71325	82588	112625	142663
Husk (kg/ha)	11219	14421	16698	22770	28842
Biomass (kg/ha)	119857	149390	172979	235887	298794
Semi-mechanized system					
Input					
Human labor (h/ha)	144.45	144.45	144.45	144.45	144.45
Machinery (h/ha)	2965.71	2965.71	2965.71	2965.71	2965.71
Diesel fuel (l/ha)	8001.65	8001.65	8001.65	8001.65	8001.65
Nitrogen (kg/ha)	8687.5	8687.5	12510	15985	15985
Phosphorus(kg/ha)	746.4	746.4	995.2	1244	1244
Potassium (kg/ha)	1226.5	1226.5	1672.5	2230	2230
Herbicide (l/ha)	255	255	255	255	255
Fungicide (l/ha)	320	320	320	320	320
Insecticide (l/ha)	198	198	99	99	99
Water (m^3/ha)	10200	10200	10200	10200	10200
Seed (kg/ha)	1190	1190	850	340	340
Output					
Paddy (kg/ha)	58800	69825	80850	110250	139650
Straw (kg/ha)	68263	81063	93850	127988	162113
Husk (kg/ha)	13800	16394	18975	25875	32775
Biomass (kg/ha)	142967	169781	196568	268058	339535

Table 2. Input-output energy for varieties rice under traditional system and semi-mechanized system condition

In order to calculate energy balance indices, these input data and amount of output yield were multiplied with the coefficient of energy balance equivalent. Energy balance equivalents of inputs and output were converted into energy on area unit. The previous researches "Table 3" were used to determine the energy balance equivalents' coefficients [2, 4, 5, 6] By using of consumed data as inputs and total production as output, and their concern equivalent energy, indicators of energy balance were calculated "Table 4".

Parameter	Hashemi	Alikazemi	Khazar	Hybrid	Gohar	Energy balance equivalent
Traditional system						
Input						
Human labor (h/ha)	848.7	848.7	848.7	848.7	848.7	500
Machinery (h/ha)	37.2	37.2	37.2	37.2	37.2	90000
Diesel fuel (l/ha)	127.2	127.2	127.2	127.2	127.2	9237
Nitrogen (kg/ha)	57.5	57.5	82.8	105.8	105.8	17600
Phosphorus(kg/ha)	12.6	12.6	16.8	21	21	3190
Potassium (kg/ha)	45.1	45.1	61.5	82	82	1600
Chemical Poison (l/ha)	5	5	5	5	5	27170
Water (m^3/ha)	10000	10000	10000	10000	10000	272.2
Seed (kg/ha)	90	90	70	30	30	6513
Depreciation for per diesel fuel (L)	106.85	106.85	106.85	106.85	106.85	9583
Semi-mechanized system						
Input						
Human labor (h/ha)	663.3	663.3	663.3	663.3	663.3	500
Machinery (h/ha)	47.3	47.3	47.3	47.3	47.3	90000
Diesel fuel (l/ha)	142.1	142.1	142.1	142.1	142.1	9237
Nitrogen (kg/ha)	57.5	57.5	82.8	105.8	105.8	17600
Phosphorus(kg/ha)	12.6	12.6	16.8	21	21	3190
Potassium (kg/ha)	45.1	45.1	61.5	82	82	1600
Chemical Poison (l/ha)	5	5	5	5	5	27170
Water (m^3/ha)	10000	10000	10000	10000	10000	272.2
Seed (kg/ha)	70	70	50	20	20	6513
Depreciation for per diesel fuel (L)	119.36	119.36	119.36	119.36	119.36	9583

Table 3. Amounts of input used and energy balance equivalent in varieties rice production under traditional system and semi-mechanized system condition

Parameter	Hashemi	Alikazemi	Khazar	Hybrid	Gohar
Traditional system					
Input					
Parameter	Hashemi	Alikazemi	Khazar	Hybrid	Gohar
Human labor (h/ha)	424350	424350	424350	424350	424350
Machinery (h/ha)	3348000	3348000	3348000	3348000	3348000
Diesel fuel (l/ha)	1174946	1174946	1174946	1174946	1174946
Nitrogen (kg/ha)	1012000	1012000	1457280	1862080	1862080
Phosphorus(kg/ha)	40194	40194	53592	66990	66990
Potassium (kg/ha)	72160	72160	98400	131200	131200
Chemical Poison (l/ha)	135850	135850	135850	135850	135850
Water (m^3/ha)	2722000	2722000	2722000	2722000	2722000
Seed (kg/ha)	586170	586170	455910	195390	195390
Depreciation for per diesel fuel (L)	1023924	1023924	1023924	1023924	1023924
Semi-mechanized system					
Input					
Human labor (h/ha)	331650	331650	331650	331650	331650
Machinery (h/ha)	4257000	4257000	4257000	4257000	4257000
Diesel fuel (l/ha)	1312578	1312578	1312578	1312578	1312578
Nitrogen (kg/ha)	1012000	1012000	1457280	1862080	1862080
Phosphorus(kg/ha)	40194	40194	53592	66990	66990
Potassium (kg/ha)	72160	72160	98400	131200	131200
Chemical Poison (l/ha)	135850	135850	135850	135850	135850
Water (m^3/ha)	2722000	2722000	2722000	2722000	2722000
Seed (kg/ha)	455910	455910	325650	130260	130260
Depreciation for per diesel fuel (L)	1143865	1143865	1143865	1143865	1143865

Table 4. Input energy in varieties rice production under traditional and semi-mechanized system condition from calculated indicators of energy balance energy

Cluster analysis and correlation analysis of energy indices and balance energy indices for rice production were obtained by SPSS software. Yield function of paddy yield, straw yield, husk yield and biomass yield for rice production was obtained by STATISCA software. Simulation growth indices of rice cultivars were obtained by model ORYZA2000 “Figure 3” [7].

In the last part of the study, the economic analysis of varieties rice production under traditional and semi-mechanized system condition was investigated. Net profit, gross profit and benefit to cost ratio was calculated. The gross value of production, net return and benefit to cost ratio were calculated using the following equations (Mohammadi et al., 2008):

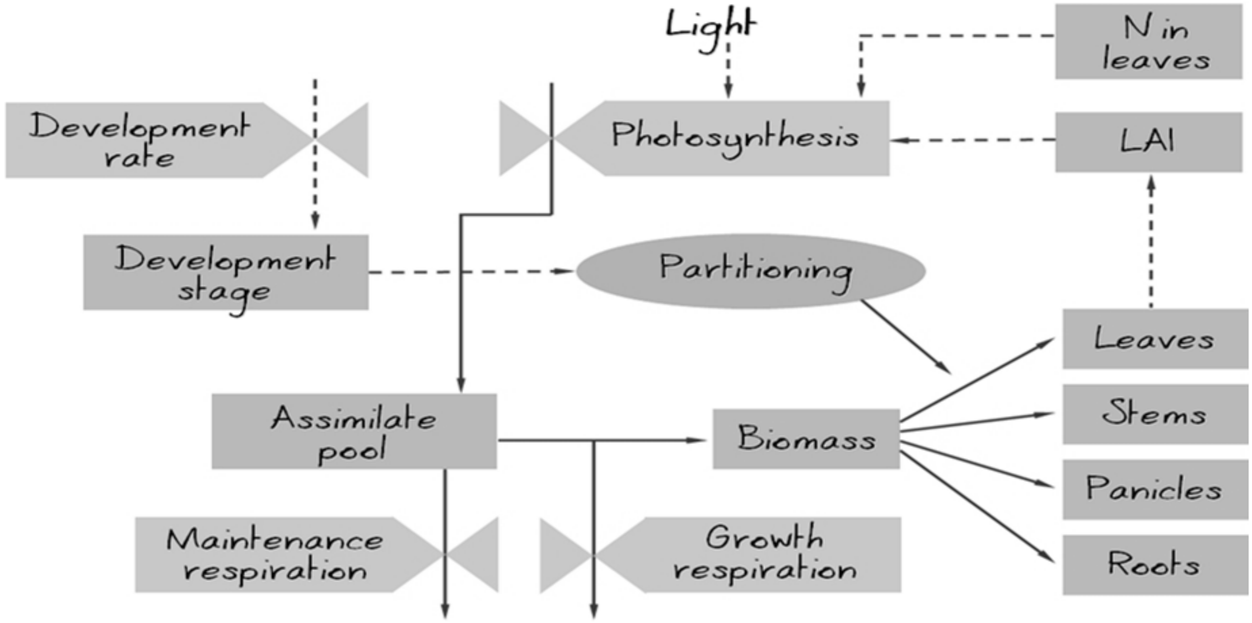

Figure 3. The model ORYZA2000 structure

$$\text{Gross value of production (\$/ha)} = \text{Yield (kg/ha)} \times \text{Sale price (\$/kg)}$$

$$\text{Net return (\$/ha)} = \text{Gross value of production (\$/ha) - Total cost of production (\$/ha)}$$

$$\text{Productivity (kg/\$)} = \frac{\text{Yield (kg/ha)}}{\text{Total cost of production (\$/ha)}}$$

$$\text{Benefit to cost ratio} = \frac{\text{Gross value of production (\$/ha)}}{\text{Total cost of production (\$/ha)}}$$

3. Results and discussions

3.1. Analysis of energy indices in varieties rice production under traditional and semi-mechanized system condition

In “Figure 4” (traditional system) and “Figure 5” (semi-mechanized system), seven groups of reserves of production of studied figures according to percentage of total energy of reserve is observed. Results showed that highest energy consumption in all varieties was related to chemical fertilizer. The amount of further use of fertilizer and also raising of equivalent amounts of energy in this reserve showed this subject. The energy of water reserve, fuel, poison, machines, seed and human labor are in next grades.

Rice plants require fertilizer during vegetative stage to promote growth and tillering, which in turn, determines potential number of panicles. Fertilizer contributes to spikelet production during early panicle formation stage, and contributes to sink size during the late panicle formation stage. Fertilizer also plays a role in grain filling, improving the photosynthetic capacity, and promoting carbohydrate accumulation in culms and leaf sheaths [1].

Results of "Tables 5 and 6" showed that breed varieties (Khazar, Hybrid and Gohar) because of suitable genetic specifications have higher operation in compared with local varieties (Hashemi and Alikazemi), highest paddy yield (9500 kg/ha), straw yield (12969 kg/ha), husk yield (2375 kg/ha) and biomass yield (24844 kg/ha) of semi-mechanized system and paddy yield (8360 Kg/ha), straw yield (11413 kg/ha), husk yield (2090 kg/ha) and biomass yield (21863 kg/ha) of traditional system observed in Gohar rice.

Breed varieties because of accepting higher fertilizer have further input energy than local varieties under two farming systems condition "Tables 5 and 6". Traditional system because of consumption higher fertilizer and seed has further input energy than semi-mechanized system "Tables 3 and 4".

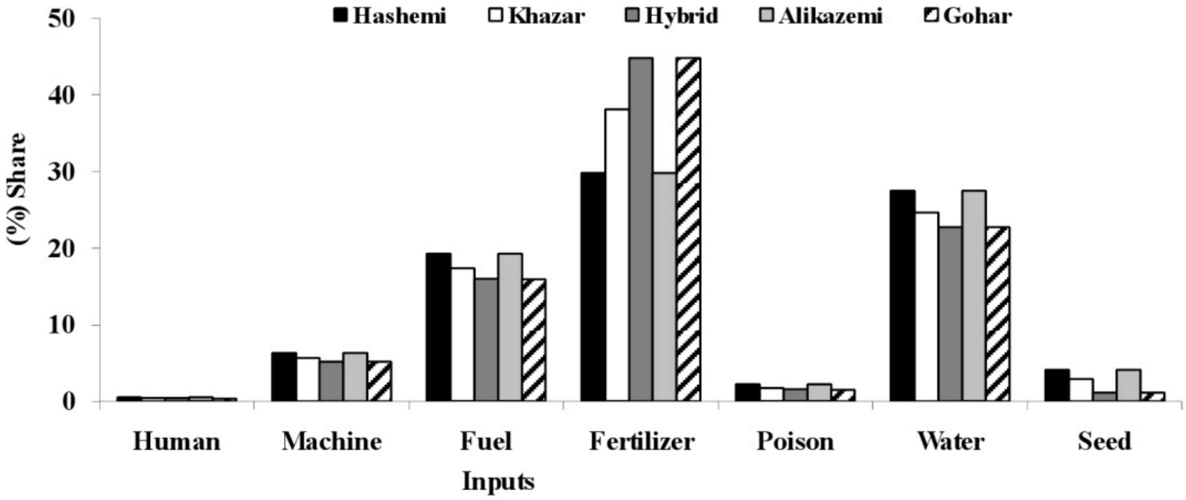

Figure 4. The share (%) production inputs for varieties rice under traditional system condition

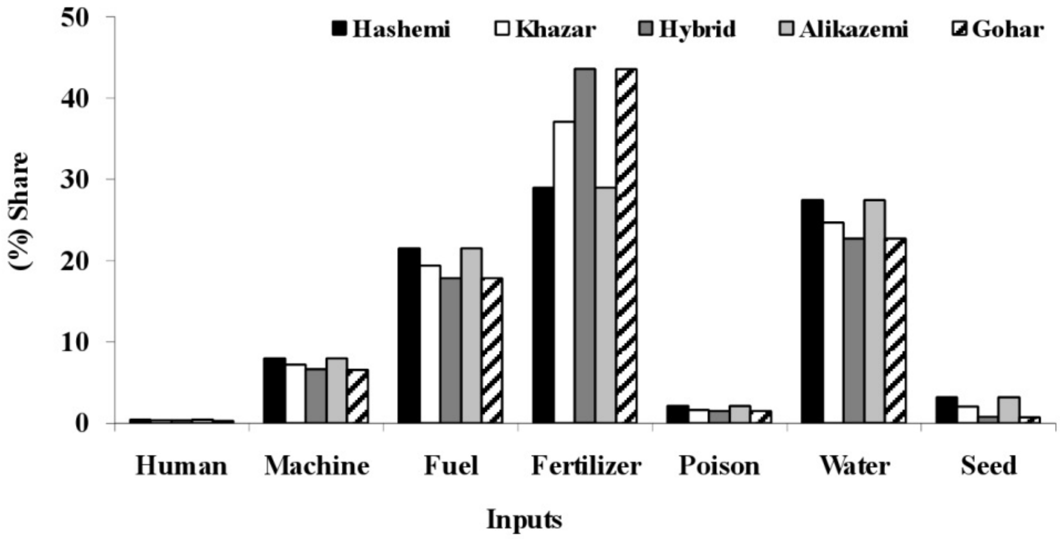

Figure 5. The share (%) production inputs for varieties rice under semi-mechanized system condition

Semi-mechanized system because of producing higher paddy yield, straw yield, husk yield and biomass yield than traditional system of has higher output energy "Tables 5 and 6". Breed varieties (Khazar, Hybrid and Gohar) because of suitable genetic specifications have

Item	Unit	Hashemi	Alikazemi	Khazar	Hybrid	Gohar
Paddy						
Yield	kg/ha	3520	4180	4840	6600	8360
Input energy	MJ/ha	32843	32843	36922	40523	40523
Output energy	MJ/ha	51744	61446	71148	97020	122892
Energy ratio	-	1.58	1.87	1.93	2.39	3.03
Energy intensity	MJ/kg	9.33	7.86	7.63	6.14	4.85
Energy productivity	kg/MJ	0.11	0.13	0.13	0.16	0.21
Net energy gain	MJ/ha	18901	28603	34226	56497	82369
Water and energy productivity	g/m^3.MJ	0.011	0.012	0.013	0.016	0.020
Straw						
Yield	kg/ha	4437	5706	6607	9010	11413
Input energy	MJ/ha	32843	32843	36922	40523	40523
Output energy	MJ/ha	55463	71325	82588	112625	142663
Energy ratio	-	1.69	2.17	2.24	2.78	3.52
Energy intensity	MJ/kg	7.40	5.76	5.59	4.50	3.55
Energy productivity	kg/MJ	0.14	0.17	0.18	0.22	0.28
Net energy gain	MJ/ha	22620	38482	45666	72102	102140
Water and energy productivity	g/m^3.MJ	0.013	0.017	0.018	0.022	0.028
Husk						
Yield	kg/ha	813	1045	1210	1650	2090
Input energy	MJ/ha	32843	32843	36922	40523	40523
Output energy	MJ/ha	11219	14421	16698	22770	28842
Energy ratio	-	0.34	0.44	0.45	0.56	0.71
Energy intensity	MJ/kg	40.40	31.43	30.51	24.56	19.39
Energy productivity	kg/MJ	0.02	0.03	0.03	0.04	0.05
Net energy gain	MJ/ha	-21624	-18422	-20224	-17753	-11681
Water and energy productivity	g/m^3.MJ	0.002	0.003	0.003	0.004	0.005
Biomass						
Yield	kg/ha	8770	10931	12657	17260	21863
Input energy	MJ/ha	32843	32843	36922	40523	40523
Output energy	MJ/ha	119857	149390	172979	235887	298794
Energy ratio	-	3.65	4.55	4.69	5.82	7.37
Energy intensity	MJ/kg	3.74	3.00	2.92	2.35	1.85
Energy productivity	kg/MJ	0.27	0.33	0.34	0.43	0.54
Net energy gain	MJ/ha	87013	116547	136057	195364	258271
Water and energy productivity	g/m^3.MJ	0.027	0.033	0.034	0.043	0.054

Table 5. Energy indices for varieties rice under traditional system condition

higher output energy in compared with local varieties (Hashemi and Alikazemi). Highest output energy with averages 139650, 162113, 32775 and 339535 MJ/ha of semi-mechanized system and with averages 122892, 142663, 28842 and 298794 MJ/ha of traditional system observed in Gohar rice "Tables 5 and 6".

Energy ratio in two farming systems and five varieties showed that positive output of energy production and being further of energy output of semi-mechanized system than traditional system and breed varieties than local varieties (tables 5 and 6).

Results of energy intensity under two farming systems condition "Tables 5 and 6" showed that local varieties require of further input from production of paddy yield, straw yield, husk yield and biomass yield than breed varieties.

Results of energy productivity under two farming systems condition "Tables 5 and 6" were showed that in breed varieties lieu of imported energy consumption have higher energy productions than local varieties.

Net energy gain in two farming systems and five varieties showed that highest net energy gain of semi-mechanized system than traditional system and breed varieties than local varieties. Highest net energy gain with averages 97865, 120328, -9010 and 297750 MJ/ha of semi-mechanized system and with averages 82369, 102140, -11681 and 258271 MJ/ha of traditional system observed in Gohar rice "Tables 5 and 6"

Direct, indirect energy, renewable, non-renewable, % direct, % indirect energy, % renewable and % non-renewable in two farming systems and five varieties were showed "Tables 7". In two farming systems and five varieties were showed that direct energy and % direct energy as compared with indirect energy and % indirect energy; renewable energy and % renewable energy as compared with nonrenewable energy and % nonrenewable energy have lower amount "Tables 7". The amount of higher consumption of machinery and diesel fuel in semi-mechanized system lead to increasing indirect energy in this system in compared with traditional system. The amount of higher consumption of chemical fertilizer in breed varieties lead to increasing indirect energy in these varieties in compared with local varieties. Results showed that, lower amount of consumption of seed and human labor in semi-mechanized system in compared with traditional system leads to being lower of renewable energy in semi-mechanized system than traditional system "Tables 7". Lower amount of consumption of seed in breed varieties in compared with local varieties leads to being lower of renewable energy in breed varieties than local varieties. The amount of higher consumption of chemical fertilizer in breed varieties in compared with local varieties leads to increasing nonrenewable energy in these breed varieties than local varieties. The share of direct and indirect energy from total reserve of energy and share of renewable and nonrenewable energies from total reserve of energy "Tables 7" in studied farming systems and varieties were that the percentage of direct energy is lowest than percentage of indirect energy and percentage of renewable energy in producing rice is lowest than nonrenewable energies that this required to consider saving in energy consumption.

Item	Unit	Hashemi	Alikazemi	Khazar	Hybrid	Gohar
Paddy						
Yield	kg/ha	4000	4750	5500	7500	9500
Input energy	MJ/ha	33935	33935	38014	41785	41785
Output energy	MJ/ha	58800	69825	80850	110250	139650
Energy ratio	-	1.73	2.06	2.13	2.64	3.34
Energy intensity	MJ/kg	8.48	7.14	6.91	5.57	4.40
Energy productivity	kg/MJ	0.12	0.14	0.14	0.18	0.23
Net energy gain	MJ/ha	24865	35890	42836	68465	97865
Water and energy productivity	$g/m^3.MJ$	0.012	0.014	0.014	0.018	0.022
Straw						
Yield	kg/ha	5461	6485	7508	10239	12969
Input energy	MJ/ha	33935	33935	38014	41785	41785
Output energy	MJ/ha	68263	81063	93850	127988	162113
Energy ratio	-	2.01	2.39	2.47	3.06	3.88
Energy intensity	MJ/kg	6.21	5.23	5.06	4.08	3.22
Energy productivity	kg/MJ	0.16	0.19	0.20	0.25	0.31
Net energy gain	MJ/ha	34327	47127	55836	86203	120328
Water and energy productivity	$g/m^3.MJ$	0.016	0.019	0.019	0.024	0.030
Husk						
Yield	kg/ha	1000	1188	1375	1875	2375
Input energy	MJ/ha	33935	33935	38014	41785	41785
Output energy	MJ/ha	13800	16394	18975	25875	32775
Energy ratio	-	0.41	0.48	0.50	0.62	0.78
Energy intensity	MJ/kg	33.94	28.56	27.65	22.29	17.59
Energy productivity	kg/MJ	0.03	0.04	0.04	0.04	0.06
Net energy gain	MJ/ha	-20135	-17541	-19039	-15910	-9010
Water and energy productivity	$g/m^3.MJ$	0.003	0.003	0.004	0.004	0.006
Biomass						
Yield	kg/ha	10461	12423	14383	19614	24844
Input energy	MJ/ha	33935	33935	38014	41785	41785
Output energy	MJ/ha	142967	169781	196568	268058	339535
Energy ratio	-	4.21	5.00	5.17	6.42	8.13
Energy intensity	MJ/kg	3.24	2.73	2.64	2.13	1.68
Energy productivity	kg/MJ	0.31	0.37	0.38	0.47	0.59
Net energy gain	MJ/ha	109032	135846	158554	226273	297750
Water and energy productivity	$g/m^3.MJ$	0.031	0.037	0.038	0.047	0.059

Table 6. Energy indices for varieties rice under semi-mechanized system condition

Item	Hashemi	Alikazemi	Khazar	Hybrid	Gohar
Traditional system					
Direct energy (MJ/ha)	17547	17547	17547	17547	17547
Direct energy (%)	53.43	53.43	47.53	43.30	43.30
Indirect energy (MJ/ha)	15296	15296	19375	22976	22976
Indirect energy (%)	46.57	46.57	52.47	56.70	56.70
Renewable energy (MJ/ha)	11915	11915	11575	10895	10895
Renewable energy (%)	36.28	36.28	31.35	26.89	26.89
Nonrenewable energy (MJ/ha)	20928	20928	25347	29628	29628
Nonrenewable energy (%)	63.72	63.72	68.65	73.11	73.11
Semi-mechanized system					
Direct energy (MJ/ha)	18346	18346	18346	18346	18346
Direct energy (%)	54.06	54.06	48.26	43.91	43.91
Indirect energy (MJ/ha)	15589	15589	19667	23439	23439
Indirect energy (%)	45.94	45.94	51.74	56.09	56.09
Renewable energy (MJ/ha)	11534	11534	11194	10684	10684
Renewable energy (%)	33.99	33.99	29.45	25.57	25.57
Nonrenewable energy (MJ/ha)	22401	22401	26819	31100	31100
Nonrenewable energy (%)	66.01	66.01	70.55	74.43	74.43

Table 7. Division of the energy for varieties rice under traditional and semi-mechanized system condition

Moradi and Azarpour [23] with study of energy indices for native and breed rice varieties production in Iran were recorded the highest grain yield, input energy, output energy, energy ratio, energy productivity and Net energy gain obtained from breed varieties as compared with local varieties. Eskandari Cherati et al. [11] with study energy survey of mechanized and traditional rice production system in Mazandaran province of Iran 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 human 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. Khan et al. [16] with energy requirement and economic analysis of rice production in western part of Pakistan Energy requirement and economic analysis of rice production in western part of Pakistan revealed that energy consumption and rice yield were 5,756 kWh and 3.23 tons per hectare on Bullock Operated Farms (BOF) and 11,162 kWh and 4.12 tons per hectare on Tractor Operated Farms (TOF). Consumption of animate energy on BOF was more than TOF due to heavy use of animate energy in land preparation operation. Result also showed that energy efficiency i.e. output-input ratio on BOF (6.32) was higher than TOF (4.16). Cost of production remained lower on BOF than TOF, however, the yield and consequently crop values and net return were higher on TOF than BOF.

Khan et al. [17] with study energy requirements and economic analysis of wheat, rice and barley production in Australia revealed that chemical fertilizer consumed 47, 43 and 29 % of the total energy inputs on wheat, rice and barley growing farms, respectively. Wheat consumed 3028, rice 6699 and barley consumed 2175 $kWhha^{-1}$. Similarly, wheat utilized 2852, rice 17754 and barley 856 m^3ha^{-1}. Average energy output of wheat was 27874, rice 44885, and barley obtained 17865 $kWhha^{-1}$. Wheat was most energy efficient crop compared to rice and barley, whereas barley achieved the highest water productivity.

3.2. Analysis of energy indices and balance energy indices in varieties rice production under traditional and semi-mechanized system condition

The inputs used in varieties rice production under two farming system and their energy equivalents and output energy equivalent were illustrated in "Tables 3 and 4". About 848.7 h human labor, 37.2 h machinery power, 1000 m3 water, 5 L chemical poison and 127.2 L diesel fuel for total operations were used in varieties rice production under traditional on a hectare basis; Also 106.85 L depreciation power in this system was used. 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 663.3 h human labor, 47.3 h machinery power, 1000 m3 water, 5 L chemical poison and 142.1 L diesel fuel for total operations were used in varieties rice production under traditional on a hectare basis; Also 119.36 L depreciation power in this system was used. 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 (20 kg/ha).

In "Figure 6" (traditional system) and "Figure 7" (semi-mechanized system), eight groups of reserves of production of studied figures according to percentage of total energy of reserve were observed. Results showed that highest shares of this amount were reported for machinery, water, diesel fuel, chemical fertilizer and depreciation for per diesel fuel in all varieties rice production respectively. The energy inputs of seed, human labor and chemical poison were found to be quite low compared to the other inputs used in all varieties rice production respectively.

The highest percent of compositions, amounts, production energy, and production energy to consumption energy ratio in rice paddy were obtained from starch as compared with protein and fat; the lowest consumption energy to production energy ratio in rice paddy was obtained from starch as compared with protein and fat "Table 8". Results of "Table 8" showed that breed varieties (Khazar, Hybrid and Gohar) because of suitable genetic specifications have higher operation in compared with local varieties (Hashemi and Alikazemi); the highest amounts (protein: 551.76, fat: 183.92 and starch: 6688), production energy (protein: 2207040 kg/ha, fat: 1655280 kg/ha and starch: 26752000 kg/ha), and production energy to consumption energy ratio (protein: 0.20, fat: 0.15 and starch: 2.41) in rice paddy of traditional system and highest amounts (protein: 627, fat: 209 and starch: 7600), production energy (protein: 2508000 kg/ha, fat: 1881000 kg/ha and starch: 30400000 kg/ha), and production energy to consumption energy ratio (protein: 0.21, fat: 0.16 and starch: 2.51) in rice paddy of semi-mechanized observed in Gohar rice.

The highest percent of compositions, amounts, production energy, and production energy to consumption energy ratio in rice husk were obtained from starch as compared with fat and protein; the lowest consumption energy to production energy ratio in rice husk was obtained from starch as compared with fat and protein "Table 9". Results of "Table 9" showed that breed varieties (Khazar, Hybrid and Gohar) because of suitable genetic specifications have higher operation in compared with local varieties (Hashemi and Alikazemi); the highest amounts (protein: 107.22, fat: 107.64 and starch:1045), production energy (protein: 428868 kg/ha, fat: 968715 kg/ha and starch: 4180000 kg/ha), and production energy to consumption energy ratio (protein: 0.04, fat: 0.09 and starch: 0.38) in rice husk of traditional system and highest amounts (protein: 121.84, fat: 122.31 and starch: 1187.50), production energy (protein: 487350 kg/ha, fat: 1100813 kg/ha and starch: 4750000 kg/ha), and production energy to consumption energy ratio (protein: 0.04, fat: 0.09 and starch: 0.39) in rice husk of semi-mechanized observed in Gohar rice.

The highest percent of compositions, amounts, production energy, and production energy to consumption energy ratio in rice straw were obtained from starch as compared with protein and fat; the lowest consumption energy to production energy ratio in rice straw was obtained from starch as compared with protein and fat "Table 10". Results of "Table 10" showed that breed varieties (Khazar, Hybrid and Gohar) because of suitable genetic specifications have higher operation in compared with local varieties (Hashemi and Alikazemi); the highest amounts (protein: 490.76, fat: 148.37 and starch:4941.83), production energy (protein: 1963036 kg/ha, fat: 1335321 kg/ha and starch: 19767316 kg/ha), and production energy to consumption energy ratio (protein: 0.18, fat: 0.12 and starch: 1.87) in rice straw of traditional system and highest amounts (protein:557.67, fat: 168.60 and starch: 6515.68), production energy (protein: 2230668 kg/ha, fat: 1517373 kg/ha and starch: 22462308 kg/ha), and production energy to consumption energy ratio (protein: 0.18, fat: 0.13 and starch: 1.86) in rice straw of semi-mechanized observed in Gohar rice.

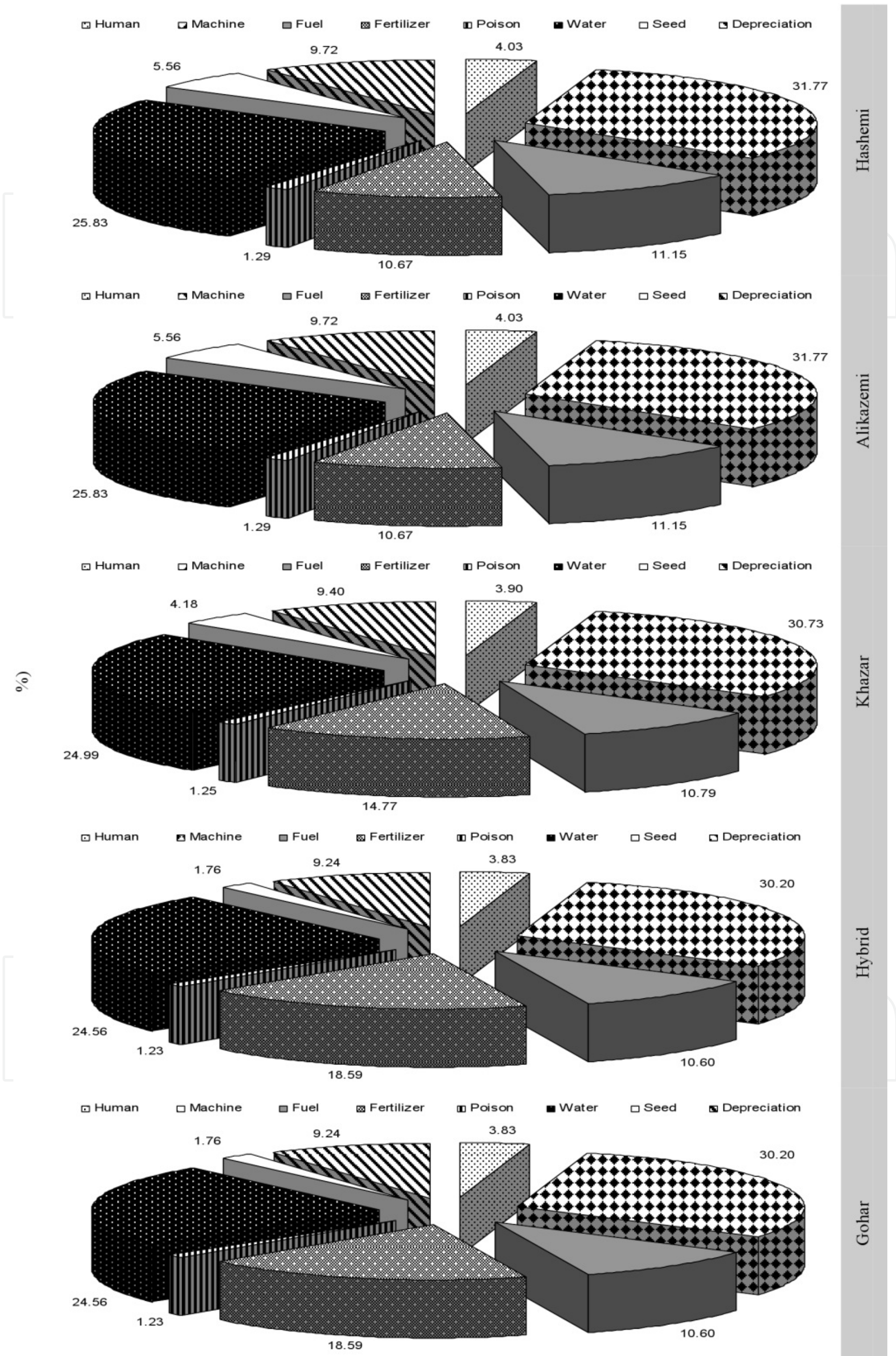

Figure 6. The share (%) production inputs for varieties rice under traditional system condition

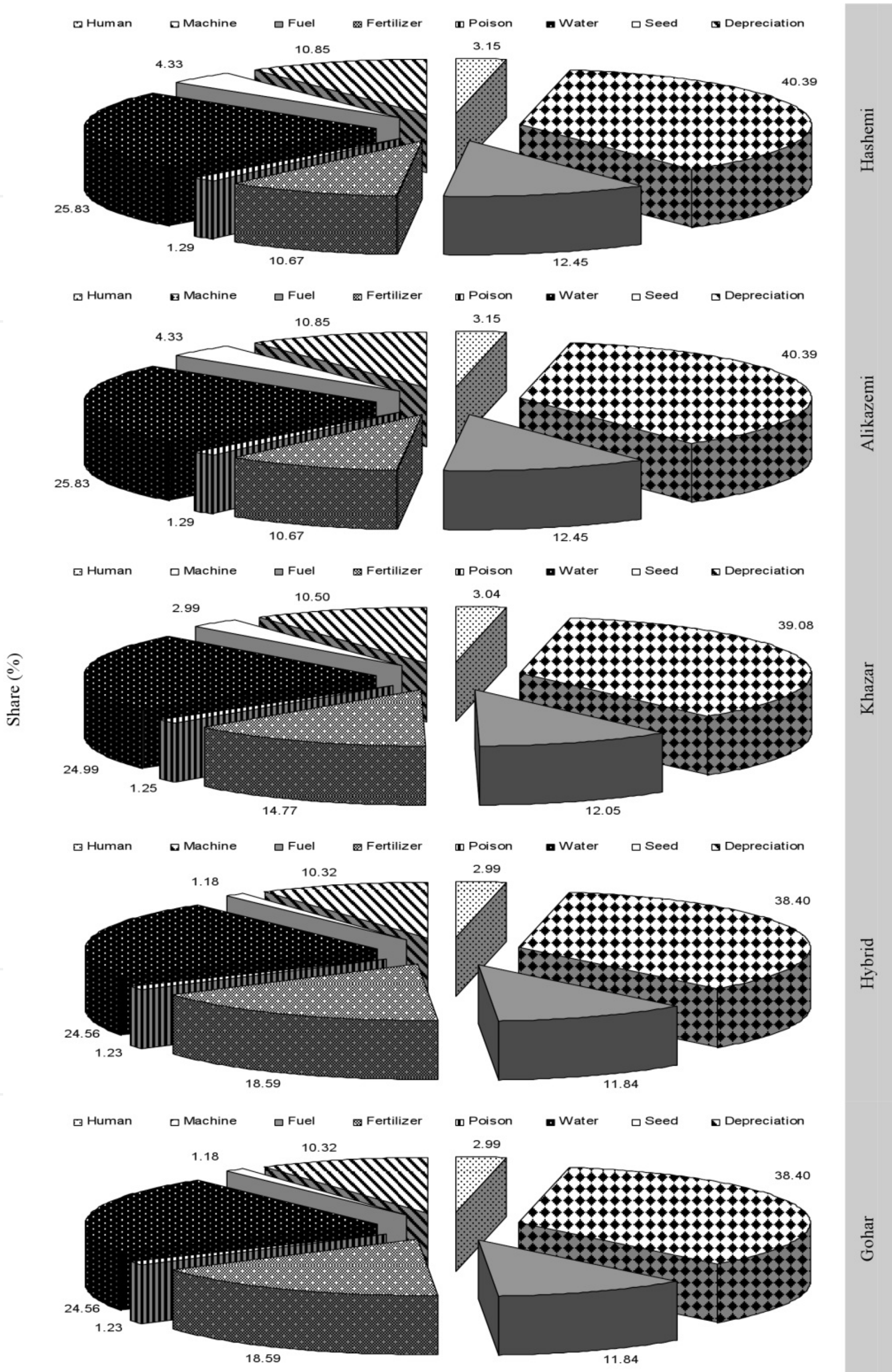

Figure 7. The share (%) production inputs for varieties rice under semi-mechanized system condition

Varieties rice	Item	Percent of compositions	Energy per gram (kcal)	Amounts (kg/ha)	Production energy (kcal/ha)	Production energy / Consumption energy	Consumption energy / Production energy
Traditional system							
Hashemi	Protein	6.6	4	232.32	929280	0.09	11.34
	Fat	2.2	9	77.44	696960	0.07	15.12
	Starch	80	4	2816	11264000	1.07	0.94
Alikazemi	Protein	6.6	4	275.88	1103520	0.10	9.55
	Fat	2.2	9	91.96	827640	0.08	12.73
	Starch	80	4	3344	13376000	1.27	0.79
Khazar	Protein	6.6	4	319.44	1277760	0.12	8.53
	Fat	2.2	9	106.48	958320	0.09	11.37
	Starch	80	4	3872	15488000	1.42	0.70
Hybrid	Protein	6.6	4	435.6	1742400	0.16	6.36
	Fat	2.2	9	145.2	1306800	0.12	8.48
	Starch	80	4	5280	21120000	1.91	0.52
Gohar	Protein	6.6	4	551.76	2207040	0.20	5.02
	Fat	2.2	9	183.92	1655280	0.15	6.70
	Starch	80	4	6688	26752000	2.41	0.41
Semi-mechanized system							
Hashemi	Protein	6.6	4	264	1056000	0.09	10.87
	Fat	2.2	9	88	792000	0.07	14.50
	Starch	80	4	3200	12800000	1.11	0.90
Alikazemi	Protein	6.6	4	313.5	1254000	0.11	9.16
	Fat	2.2	9	104.5	940500	0.08	12.21
	Starch	80	4	3800	15200000	1.32	0.76
Khazar	Protein	6.6	4	363	1452000	0.12	8.15
	Fat	2.2	9	121	1089000	0.09	10.87
	Starch	80	4	4400	17600000	1.49	0.67
Hybrid	Protein	6.6	4	495	1980000	0.16	6.11
	Fat	2.2	9	165	1485000	0.12	8.14
	Starch	80	4	6000	24000000	1.98	0.50
Gohar	Protein	6.6	4	627	2508000	0.21	4.82
	Fat	2.2	9	209	1881000	0.16	6.43
	Starch	80	4	7600	30400000	2.51	0.40

Table 8. Items of energy balance indices in rice paddy production under traditional and semi-mechanized system condition

The highest percent of compositions, amounts, production energy, and production energy to consumption energy ratio in rice biomass were obtained from starch as compared with protein and fat; the lowest consumption energy to production energy ratio in rice biomass was obtained from starch as compared with protein and fat "Table 11". Results of "Table 11" showed that breed varieties (Khazar, Hybrid and Gohar) because of suitable genetic specifications have higher operation in compared with local varieties (Hashemi and Alikazemi); the highest amounts (protein: 1087.52, fat: 355.91 and starch:12259.26), production energy (protein: 4350060 kg/ha, fat: 32032260 kg/ha and starch: 49037040 kg/ha), and production energy to consumption energy ratio (protein: 0.41, fat: 0.30 and starch: 4.65) in rice biomass of traditional system and highest amounts (protein:1235.80, fat: 404.44 and starch: 13930.87), production energy (protein: 4943180 kg/ha, fat: 3639978 kg/ha and starch: 55723120 kg/ha), and production energy to consumption energy ratio (protein: 0.47, fat: 0.35 and starch: 5.29) in rice biomass of semi-mechanized observed in Gohar rice.

Varieties rice	Item	Percent of compositions	Energy per gram (kcal)	Amounts (kg/ha)	Production energy (kcal/ha)	$\frac{\text{Production energy}}{\text{Consumption energy}}$	$\frac{\text{Consumption energy}}{\text{Production energy}}$
Traditional system							
Hashemi	Protein	5.13	4	41.71	166828	0.02	63.18
	Fat	5.15	9	41.87	376826	0.04	27.97
	Starch	50	4	406.50	1626000	0.15	6.48
Alikazemi	Protein	5.13	4	53.61	214434	0.02	49.15
	Fat	5.15	9	53.82	484358	0.05	21.76
	Starch	50	4	522.50	2090000	0.20	5.04
Khazar	Protein	5.13	4	62.07	248292	0.02	43.88
	Fat	5.15	9	62.32	560835	0.05	19.43
	Starch	50	4	605.00	2420000	0.22	4.50
Hybrid	Protein	5.13	4	84.65	338580	0.03	32.74
	Fat	5.15	9	84.98	764775	0.07	14.49
	Starch	50	4	825.00	3300000	0.30	3.36
Gohar	Protein	5.13	4	107.22	428868	0.04	25.85
	Fat	5.15	9	107.64	968715	0.09	11.44
	Starch	50	4	1045.00	4180000	0.38	2.65
Semi-mechanized system							
Hashemi	Protein	5.13	4	51.30	205200	0.02	55.96
	Fat	5.15	9	51.50	463500	0.04	24.77
	Starch	50	4	500.00	2000000	0.17	5.74
Alikazemi	Protein	5.13	4	60.94	243778	0.02	47.11
	Fat	5.15	9	61.18	550638	0.05	20.85
	Starch	50	4	594.00	2376000	0.21	4.83
Khazar	Protein	5.13	4	70.54	282150	0.02	41.96
	Fat	5.15	9	70.81	637313	0.05	18.57
	Starch	50	4	687.50	2750000	0.23	4.30
Hybrid	Protein	5.13	4	96.19	384750	0.03	31.43
	Fat	5.15	9	96.56	869063	0.07	13.92
	Starch	50	4	937.50	3750000	0.31	3.22
Gohar	Protein	5.13	4	121.84	487350	0.04	24.81
	Fat	5.15	9	122.31	1100813	0.09	10.99
	Starch	50	4	1187.50	4750000	0.39	2.55

Table 9. Items of energy balance indices in rice husk production under traditional and semi-mechanized system condition

Varieties rice	Item	Percent of compositions	Energy per gram (kcal)	Amounts (kg/ha)	Production energy (kcal/ha)	$\frac{\text{Production energy}}{\text{Consumption energy}}$	$\frac{\text{Consumption energy}}{\text{Production energy}}$
Traditional system							
Hashemi	Protein	4.3	4	190.79	763164	0.07	13.81
	Fat	1.3	9	57.68	519129	0.05	20.30
	Starch	43	4	1921.22	7684884	0.73	1.37
Alikazemi	Protein	4.3	4	245.36	981432	0.09	10.74
	Fat	1.3	9	74.18	667602	0.06	15.79
	Starch	43	4	2470.70	9882792	0.94	1.07
Khazar	Protein	4.3	4	284.10	1136404	0.10	9.59
	Fat	1.3	9	85.89	773019	0.07	14.09
	Starch	43	4	2860.83	11443324	1.05	0.95
Hybrid	Protein	4.3	4	387.43	1549720	0.14	7.15
	Fat	1.3	9	117.13	1054170	0.10	10.52
	Starch	43	4	3901.33	15605320	1.41	0.71
Gohar	Protein	4.3	4	490.76	1963036	0.18	5.65
	Fat	1.3	9	148.37	1335321	0.12	8.30
	Starch	43	4	4941.83	19767316	1.78	0.56
Semi-mechanized system							
Hashemi	Protein	4.3	4	234.82	939292	0.08	12.23
	Fat	1.3	9	70.99	638937	0.06	17.97
	Starch	43	4	2364.61	9458452	0.82	1.21
Alikazemi	Protein	4.3	4	278.86	1115420	0.10	10.29
	Fat	1.3	9	84.31	758745	0.07	15.13
	Starch	43	4	2808.01	11232020	0.98	1.02
Khazar	Protein	4.3	4	322.84	1291376	0.11	9.17
	Fat	1.3	9	97.60	878436	0.07	13.48
	Starch	43	4	3250.96	13003856	1.10	0.91
Hybrid	Protein	4.3	4	440.28	1761108	0.15	6.87
	Fat	1.3	9	133.11	1197963	0.10	10.10
	Starch	43	4	4433.49	17733948	1.47	0.68
Gohar	Protein	4.3	4	557.67	2230668	0.18	5.42
	Fat	1.3	9	168.60	1517373	0.13	7.97
	Starch	43	4	5615.58	22462308	1.86	0.54

Table 10. Items of energy balance indices in rice straw production under traditional and semi-mechanized system condition

Results of "Table 12" showed that breed varieties (Khazar, Hybrid and Gohar) because of suitable genetic specifications have higher operation in compared with local varieties (Hashemi and Alikazemi); the highest paddy yield (8360 kg/ha), consumption energy (11084731 kcal/ha), production energy (30614320 kcal/ha) and production energy to consumption energy ratio (2.76) in rice paddy of traditional system and highest paddy yield (9500 kg/ha), consumption energy (12093473 kcal/ha), production energy (34789000 kcal/ha) and production energy to consumption energy ratio (2.88) in rice paddy of semi-mechanized observed in Gohar rice. Energy per unit for rice varieties under to farming system was equaled. Highest Consumption energy to production energy ratio for rice varieties under to farming system was observed in Hashemi rice. Energy balance efficiency (production energy to consumption energy ratio) in this study was calculated 2.76 and 2.88; showing the affective use of energy in the agro ecosystems rice paddy production.

Varieties rice	Item	Percent of compositions	Energy per gram (kcal)	Amounts (kg/ha)	Production energy (kcal/ha)	$\frac{\text{Production energy}}{\text{Consumption energy}}$	$\frac{\text{Consumption energy}}{\text{Production energy}}$
Traditional system							
Hashemi	Protein	5.5	4	437.64	1750540	0.17	6.02
	Fat	1.8	9	143.23	1289034	0.12	8.18
	Starch	62	4	4933.34	19733360	1.87	0.53
Alikazemi	Protein	5.5	4	543.73	2174920	0.21	4.85
	Fat	1.8	9	177.95	1601532	0.15	6.58
	Starch	62	4	6129.32	24517280	2.33	0.43
Khazar	Protein	5.5	4	629.59	2518340	0.24	4.33
	Fat	1.8	9	206.05	1854414	0.18	5.87
	Starch	62	4	7097.14	28388560	2.69	0.38
Hybrid	Protein	5.5	4	858.55	3434200	0.33	3.23
	Fat	1.8	9	280.98	2528820	0.24	4.38
	Starch	62	4	9678.20	38712800	3.67	0.29
Gohar	Protein	5.5	4	1087.52	4350060	0.41	2.55
	Fat	1.8	9	355.91	3203226	0.30	3.46
	Starch	62	4	12259.26	49037040	4.65	0.23
Semi-mechanized system							
Hashemi	Protein	5.5	4	520.36	2081420	0.20	5.52
	Fat	1.8	9	170.30	1532682	0.15	7.49
	Starch	62	4	5865.82	23463280	2.23	0.49
Alikazemi	Protein	5.5	4	617.93	2471700	0.23	4.65
	Fat	1.8	9	202.23	1820070	0.17	6.31
	Starch	62	4	6965.70	27862800	2.64	0.41
Khazar	Protein	5.5	4	715.44	2861760	0.27	4.14
	Fat	1.8	9	234.14	2107296	0.20	5.62
	Starch	62	4	8064.96	32259840	3.06	0.37
Hybrid	Protein	5.5	4	975.65	3902580	0.37	3.10
	Fat	1.8	9	319.30	2873718	0.27	4.21
	Starch	62	4	10998.18	43992720	4.17	0.27
Gohar	Protein	5.5	4	1235.80	4943180	0.47	2.45
	Fat	1.8	9	404.44	3639978	0.35	3.32
	Starch	62	4	13930.78	55723120	5.29	0.22

Table 11. Items of energy balance indices in rice biomass production under traditional and semi-mechanized system condition

Energy balance indices	Hashemi	Alikazemi	Khazar	Hybrid	Gohar
Traditional system					
Grain yield (kg/ha)	3520	4180	4840	6600	8360
Consumption energy (kcal/ha)	10539595	10539595	10894253	11084731	11084731
Production energy (kcal/ha)	12890240	15307160	17724080	24169200	30614320
Energy per unit (kcal)	3662	3662	3662	3662	3662
Production energy/ Consumption energy	1.22	1.45	1.63	2.18	2.76
Consumption energy/ Production energy	27.40	23.07	20.60	15.37	12.13
Semi-mechanized system					
Grain yield (kg/ha)	4000	4750	5500	7500	9500
Consumption energy (kcal/ha)	11483207	11483207	11837865	12093473	12093473
Production energy (kcal/ha)	14648000	17394500	20141000	27465000	34789000
Energy per unit (kcal)	3662	3662	3662	3662	3662
Production energy/ Consumption energy	1.28	1.51	1.70	2.27	2.88
Consumption energy/ Production energy	26.27	22.12	19.70	14.76	11.65

Table 12. Analysis of energy balance indices in rice paddy production under traditional and semi-mechanized system condition

Results of "Table 13" showed that breed varieties (Khazar, Hybrid and Gohar) because of suitable genetic specifications have higher operation in compared with local varieties (Hashemi and Alikazemi); the highest husk yield (2090 kg/ha), consumption energy (11084731 kcal/ha), production energy (5577583 kcal/ha) and production energy to consumption energy ratio (0.50) in rice husk of traditional system and highest husk yield (2357 kg/ha), consumption energy (12093473 kcal/ha), production energy (6338163 kcal/ha) and production energy to consumption energy ratio (0.52) in rice husk of semi-mechanized observed in Gohar rice. Energy per unit for rice varieties under to farming system was equaled. Highest Consumption energy to production energy ratio for rice varieties under to farming system was observed in Hashemi rice. Energy balance efficiency (production energy to consumption energy ratio) in this study was calculated 0.50 and 0.52; showing the affective use of energy in the agro ecosystems rice husk production.

Results of "Table 14" showed that breed varieties (Khazar, Hybrid and Gohar) because of suitable genetic specifications have higher operation in compared with local varieties (Hashemi and Alikazemi); the highest straw yield (11413 kg/ha), consumption energy (11084731 kcal/ha), production energy (23065673 kcal/ha) and production energy to consumption energy ratio (2.08) in rice husk of traditional system and highest paddy yield (12969 kg/ha), consumption energy (12093473 kcal/ha), production energy (26210349 kcal/ha) and production energy to consumption energy ratio (2.17) in rice husk of semi-mechanized observed in Gohar rice. Energy per unit for rice varieties under to farming system was equaled. Highest Consumption energy to production energy ratio for rice varieties under to farming system was observed in Hashemi rice. Energy balance efficiency (production energy to consumption energy ratio) in this study was calculated 2.08 and 2.17; showing the affective use of energy in the agro ecosystems rice straw production.

Energy balance indices	Hashemi	Alikazemi	Khazar	Hybrid	Gohar
Traditional system					
Grain yield (kg/ha)	813	1045	1210	1650	2090
Consumption energy (kcal/ha)	10539595	10539595	10894253	11084731	11084731
Production energy (kcal/ha)	2169653.1	2788792	3229127	4403355	5577583
Energy per unit (kcal)	2669	2669	2669	2669	2669
Production energy/ Consumption energy	0.21	0.26	0.30	0.40	0.50
Consumption energy/ Production energy	97.63	75.95	67.80	50.59	39.94
Semi-mechanized system					
Grain yield (kg/ha)	1000	1188	1375	1875	2375
Consumption energy (kcal/ha)	11483207	11483207	11837865	12093473	12093473
Production energy (kcal/ha)	2668700	3170416	3669463	5003813	6338163
Energy per unit (kcal)	2669	2669	2669	2669	2669
Production energy/ Consumption energy	0.23	0.28	0.31	0.41	0.52
Consumption energy/ Production energy	86.48	72.79	64.84	48.57	38.35

Table 13. Analysis of energy balance indices in rice husk production under traditional and semi-mechanized system condition

Energy balance indices	Hashemi	Alikazemi	Khazar	Hybrid	Gohar
Traditional system					
Grain yield (kg/ha)	4437	5706	6607	9010	11413
Consumption energy (kcal/ha)	10539595	10539595	10894253	11084731	11084731
Production energy (kcal/ha)	8967177	11531826	13352747	18209210	23065673
Energy per unit (kcal)	2021	2021	2021	2021	2021
Production energy/ Consumption energy	0.85	1.09	1.23	1.64	2.08
Consumption energy/ Production energy	35.48	27.59	24.63	18.38	14.51
Semi-mechanized system					
Grain yield (kg/ha)	5461	6485	7508	10239	12969
Consumption energy (kcal/ha)	11483207	11483207	11837865	12093473	12093473
Production energy (kcal/ha)	11036681	13106185	15173668	20693019	26210349
Energy per unit (kcal)	2021	2021	2021	2021	2021
Production energy/ Consumption energy	0.96	1.14	1.28	1.71	2.17
Consumption energy/ Production energy	31.41	26.45	23.55	17.64	13.93

Table 14. Analysis of energy balance indices in rice straw production under traditional and semi-mechanized system condition

Results of "Table 15" showed that breed varieties (Khazar, Hybrid and Gohar) because of suitable genetic specifications have higher operation in compared with local varieties (Hashemi and Alikazemi); the highest biomass yield (19773 kg/ha), consumption energy (11084731 kcal/ha), production energy (56590326 kcal/ha) and production energy to consumption energy ratio (5.37) in rice biomass of traditional system and highest biomass yield (22469 kg/ha), consumption energy (12093473 kcal/ha), production energy (6430278 kcal/ha) and production energy to consumption energy ratio (6.10) in rice biomass of semi-mechanized observed in Gohar rice. Energy per unit for rice varieties under to farming system was equaled. Highest consumption energy to production energy ratio for rice varieties under to farming system was observed in Hashemi rice. Energy balance efficiency (production energy to consumption energy ratio) in this study was calculated 5.37 and 6.10; showing the affective use of energy in the agro ecosystems rice biomass production.

Energy balance indices	Hashemi	Alikazemi	Khazar	Hybrid	Gohar
Traditional system					
Grain yield (kg/ha)	7957	9886	11447	15610	19773
Consumption energy (kcal/ha)	10539595	10539595	10894253	11084731	11084731
Production energy (kcal/ha)	22772934	28293732	32761314	44675820	56590326
Energy per unit (kcal)	2862	2862	2862	2862	2862
Production energy/ Consumption energy	2.16	2.68	3.11	4.24	5.37
Consumption energy/ Production energy	14.73	11.86	10.58	7.90	6.23
Semi-mechanized system					
Grain yield (kg/ha)	9461	11235	13008	17739	22469
Consumption energy (kcal/ha)	11483207	11483207	11837865	12093473	12093473
Production energy (kcal/ha)	27077382	32154570	37228896	50769018	64306278
Energy per unit (kcal)	2862	2862	2862	2862	2862
Production energy/ Consumption energy	2.57	3.05	3.53	4.82	6.10
Consumption energy/ Production energy	13.50	11.37	10.12	7.58	5.99

Table 15. Analysis of energy balance indices in rice biomass production under traditional and semi-mechanized system condition

3.3. Correlation analysis of energy indices and balance energy indices for rice production

Result of "Table 16" (balance energy indices) showed that between paddy yield, straw yield, husk yield and biomass yield with production energy and production energy to consumption energy ratio have a positive and very significant correlation, also between paddy yield, straw yield, husk yield and biomass yield with consumption energy to production energy ratio energy intensity a negative and significant correlation in probability level of 1% were recorded.

Item	Yield	Consumption Energy	Production energy	Production energy / Consumption energy	Consumption energy / Production energy
Paddy yield	1				
Consumption energy	0.58	1			
Production energy	0.99**	0.58	1		
Production energy/ Consumption energy	0.99**	0.48	0.99**	1	
Consumption energy/ Production energy	-0.96**	-0.50**	-0.96**	-0.97**	1
Straw yield	1				
Consumption energy	0.59	1			
Production energy	0.99**	0.59	1		
Production energy/ Consumption energy	0.99**	0.49	0.99**	1	
Consumption energy/ Production energy	-0.96**	-0.52**	-0.96**	-0.96**	1
Husk yield	1				
Consumption energy	0.59	1			
Production energy	0.99**	0.59	1		
Production energy/ Consumption energy	0.99**	0.48	0.99**	1	
Consumption energy/ Production energy	-0.96**	-0.52**	-0.96**	-0.96**	1
Biomass yield	1				
Consumption energy	0.59	1			
Production energy	0.99**	0.59	1		
Production energy/ Consumption energy	0.99**	0.59	0.99**	1	
Consumption energy/ Production energy	-0.96**	-0.51**	-0.96**	-0.96**	1

**and*respectively significant in 1% and 5% area

Table 16. Correlation of energy balance indices for rice production

Result of "Table 17" (energy indices) showed that between paddy yield, straw yield, husk yield and biomass yield with input energy, output energy, energy ratio, energy productivity, net energy gain and water and energy productivity have a positive and very significant correlation, also between paddy yield, straw yield, husk yield and biomass yield with energy intensity a negative and significant correlation in probability level of 1% were recorded.

3.4. Growth analysis of rice varieties

Most climate change studies benefit from crop models. Crop simulation models could provide an alternative, less time-consuming and inexpensive means of determining the optimum crop N requirements under management nitrogen conditions. The model ORYZA2000, which simulates the growth and development of rice under conditions of potential production, water and nitrogen limitations, Results of growth indices analysis of rice varieties "Figure 8" showed that breed varieties (Khazar, Hybrid and Gohar) higher growth indices rather than Hashemi local varieties (Hashemi and Alikazemi). Azarpour et al. [3] with study Evaluation of the ORYZA2000 model of rice cultivars in Guilan climate condition showed that the model ORYZA2000 can satisfactorily in Simulates processes of growth and development and grain yield of rice cultivars under weather conditions of Guilan. Therefore validated ORYZA2000 model can apply to research purposes for rice cultivars under weather conditions of Guilan.

Item	Yield	Input energy	Output energy	Energy Ratio	Energy intensity	Energy productivity	Net energy gain	Water and energy productivity
Paddy yield	1							
Input energy	0.91**	1						
Output energy	0.99**	0.91**	1					
Energy ratio	0.99**	0.86**	0.99**	1				
Energy intensity	-0.97**	-0.90**	-0.97**	-0.97**	1			
Energy productivity	0.98**	0.84**	0.98**	0.99**	-0.96**	1		
Net energy gain	0.99**	0.89**	0.99**	0.99**	-0.97**	0.99**	1	
Water and energy productivity	0.99**	0.87**	0.99**	0.99**	-0.97**	0.99**	0.99**	1
Straw yield	1							
Input energy	0.92**	1						
Output energy	0.99**	0.92**	1					
Energy ratio	0.99**	0.87**	0.99**	1				
Energy intensity	-0.96**	-0.83**	-0.96**	-0.96**	1			
Energy productivity	0.99**	0.88**	0.99**	0.99**	-0.96**	1		
Net energy gain	0.99**	0.90**	0.99**	0.99**	-0.96**	0.99**	1	
Water and energy productivity	0.99**	0.87**	0.99**	0.99**	-0.97**	0.99**	0.99**	1
Husk yield	1							
Input energy	0.92**	1						
Output energy	0.99**	0.92**	1					
Energy ratio	0.99**	0.87**	0.99**	1				
Energy intensity	-0.96**	-0.88**	-0.96**	-0.96**	1			
Energy productivity	0.92**	0.77**	0.92**	0.95**	-0.94**	1		
Net energy gain	0.93**	0.71**	0.93**	0.96**	-0.89**	0.93**	1	
Water and energy productivity	0.95**	0.84**	0.95**	0.96**	-0.93**	0.96**	0.92**	1
Biomass yield	1							
Input energy	0.92**	1						
Output energy	0.99**	0.92**	1					
Energy ratio	0.99**	0.87**	0.99**	1				
Energy intensity	-0.96**	-0.89**	-0.96**	-0.97**	1			
Energy productivity	0.99**	0.97**	0.99**	0.99**	-0.97**	1		
Net energy gain	0.99**	0.91**	0.99**	0.99**	-0.96**	0.99**	1	
Water and energy productivity	0.99**	0.87**	0.99**	0.99**	-0.97**	0.99**	0.99**	1

**and*respectively significant in 1% and 5% area

Table 17. Correlation of energy indices for rice production

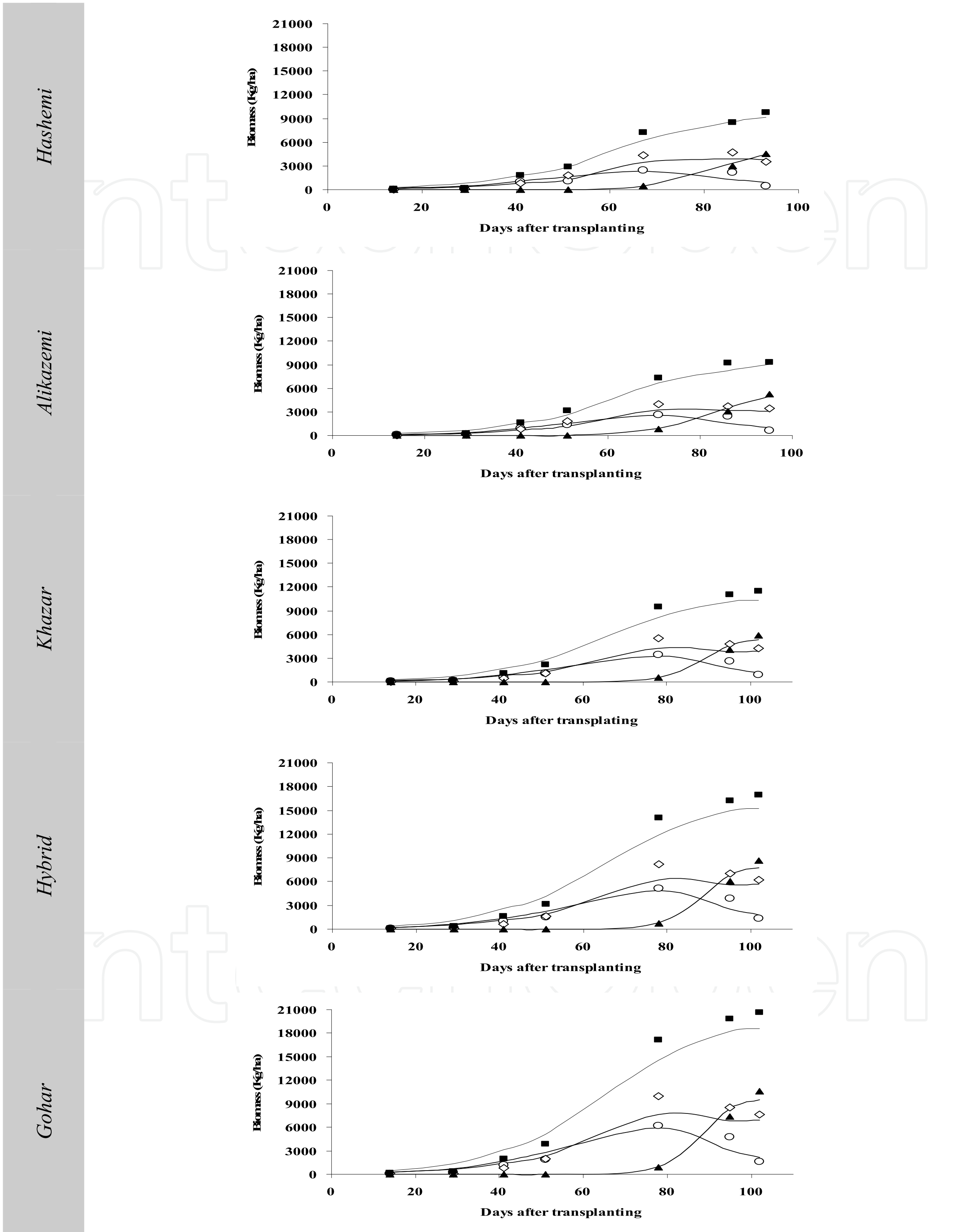

Figure 8. Simulation and measured of biomass of leaves (○), stem (◊), panicles (▲), and total aboveground biomass (■)

3.5. Cluster analysis of energy indices and balance energy indices for rice production

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 9".

```
          Rescaled Distance Cluster Combine

  C A S E   0     5    10    15    20    25

 Label   Num +---------+---------+---------+---------+---------+

 Alikazemi  2  -+-+

 Khazar    3  -+ +-----------------------------------------------+

 Hashemi   1  ---+                                               |

 Hybrid    4  -----------+-------------------------------------+

 Gohar    5  ------------+
```

Figure 9. Dendrogram of rice genotypes based on different ward method

3.6. Yield function

Relation between amounts of energy efficiency (energy output to input energy ratio) and energy balance efficiency (production energy to consumption energy ratio) and their effect on paddy yield, straw yield, husk yield and biomass yield were showed in figure 10. Paddy yield, straw yield, husk yield and biomass yield were increased with of use energy efficiency and energy balance efficiency "Figure 10". Yield function of paddy yield, straw yield, husk yield and biomass yield obtained by following relationship "Figure 10".

3.7. Economic analysis of varieties rice production under traditional and semi-mechanized system condition

Crop profitability is the indicator for a farmer to decide what to grow and what and how much should be the energy inputs for growing that specific crop. Total cost of production in two farming systems and five varieties were showed that highest total cost of production in traditional system than semi-mechanized system and local varieties than breed varieties "Figure 11". The amount of higher consumption of human labor, chemical fertilizer, chemical poison and seed in traditional system lead to increasing total cost of production in this system in compared with semi-mechanized system. Also, because of suitable genetic specifications have higher operation in compared with local varieties. The suitable genetic specifications in breed varieties lead to reducing total cost of production in these varieties in compared with local varieties.

Gross value of production in two farming systems and five varieties were showed that highest gross value of production of semi-mechanized system than traditional system and breed varieties than local varieties "Figure 12". Highest gross value of production with average of 11717 $/ha (semi-mechanized system) and 10311 $/ha (traditional system) observed in Gohar rice.

Net return in two farming systems and five varieties were showed that highest net return of semi-mechanized system than traditional system and breed varieties than local varieties "Figure 13". Highest net return with average of 9391 $/ha (semi-mechanized system) and 11239 $/ha (traditional system) observed in Gohar rice.

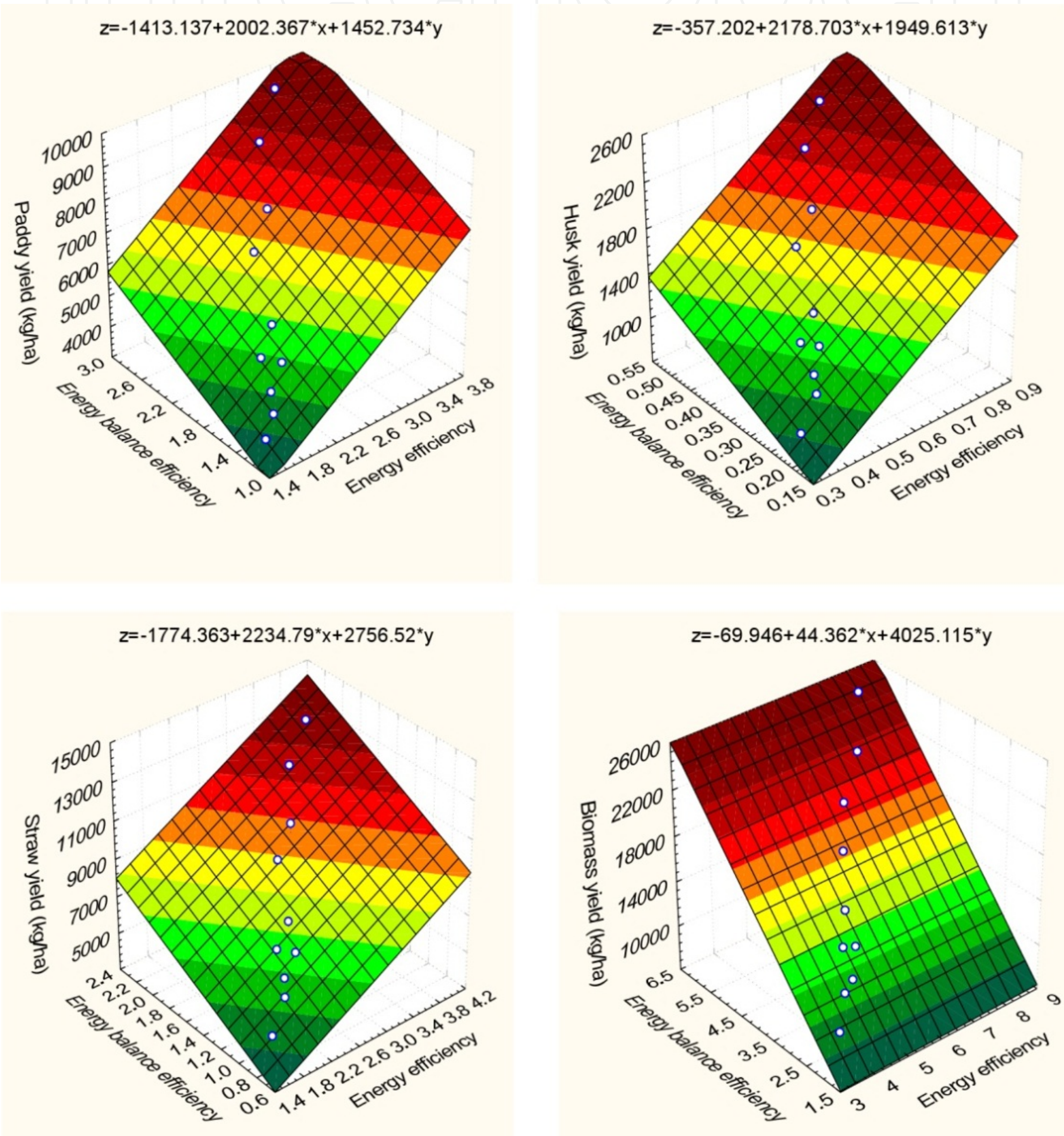

Figure 10. The effect of energy efficiency and energy balance on paddy yield, straw yield, husk yield and biomass yield

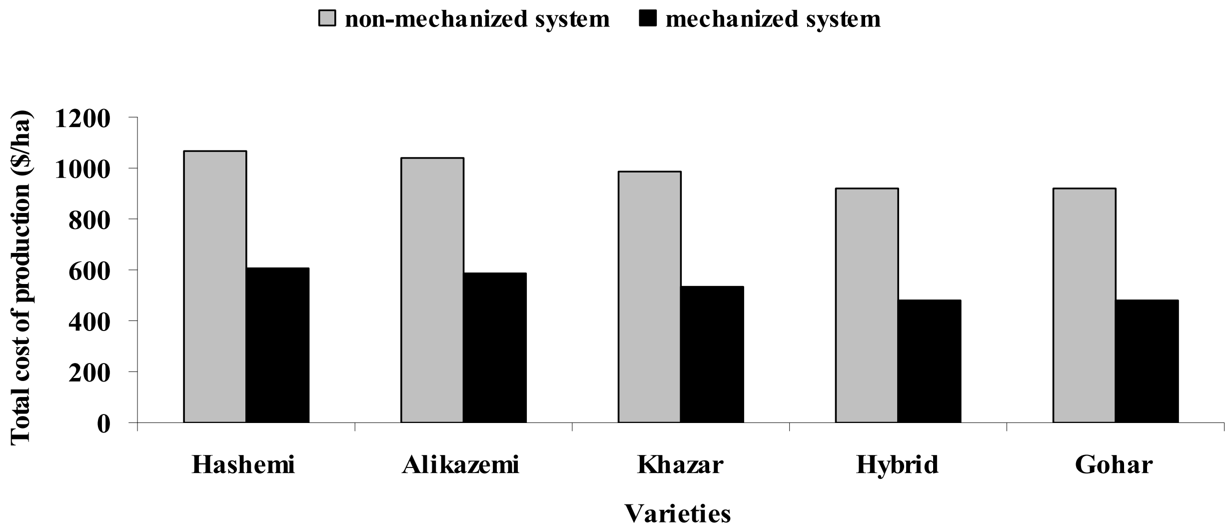

Figure 11. Total cost of production in varieties rice production under traditional and semi-mechanized system condition

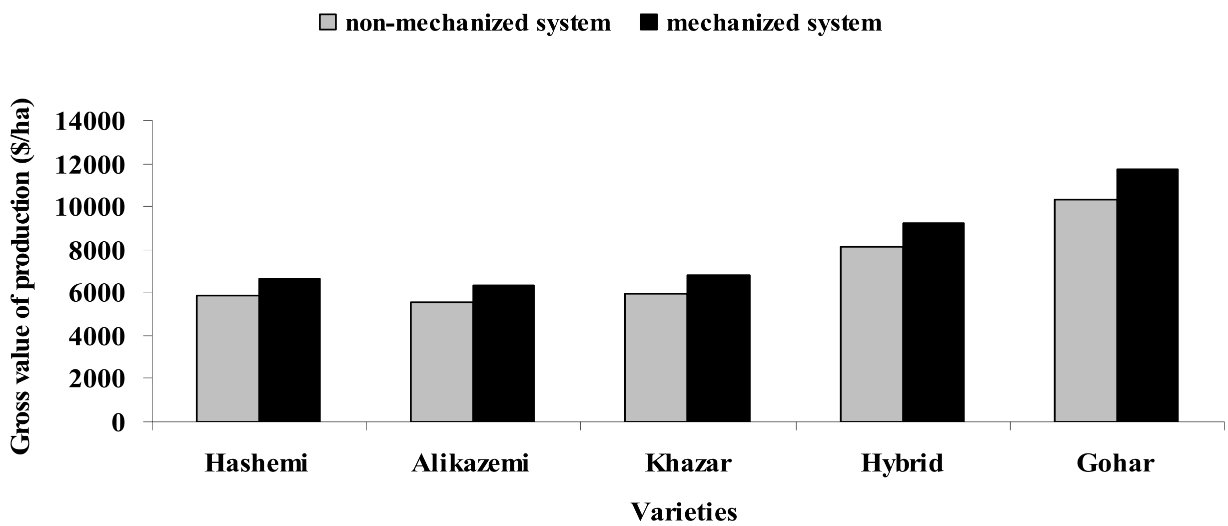

Figure 12. Gross value of production in varieties rice production under traditional and semi-mechanized system condition

Productivity in two farming systems and five varieties were showed that highest productivity of semi-mechanized system than traditional system and breed varieties than local varieties “Figure 14”. Highest productivity with average of 19.87 kg/$ (semi-mechanized system) and 9.09 kg/$ (traditional system) observed in Gohar rice.

Benefit to cost ratio in two farming systems and five varieties were showed that highest benefit to cost ratio of semi-mechanized system than traditional system and breed varieties than local varieties “Figure 15”. Highest benefit to cost ratio with average of 11.21 (semi-mechanized system) and 24.51 (traditional system) observed in Gohar rice.

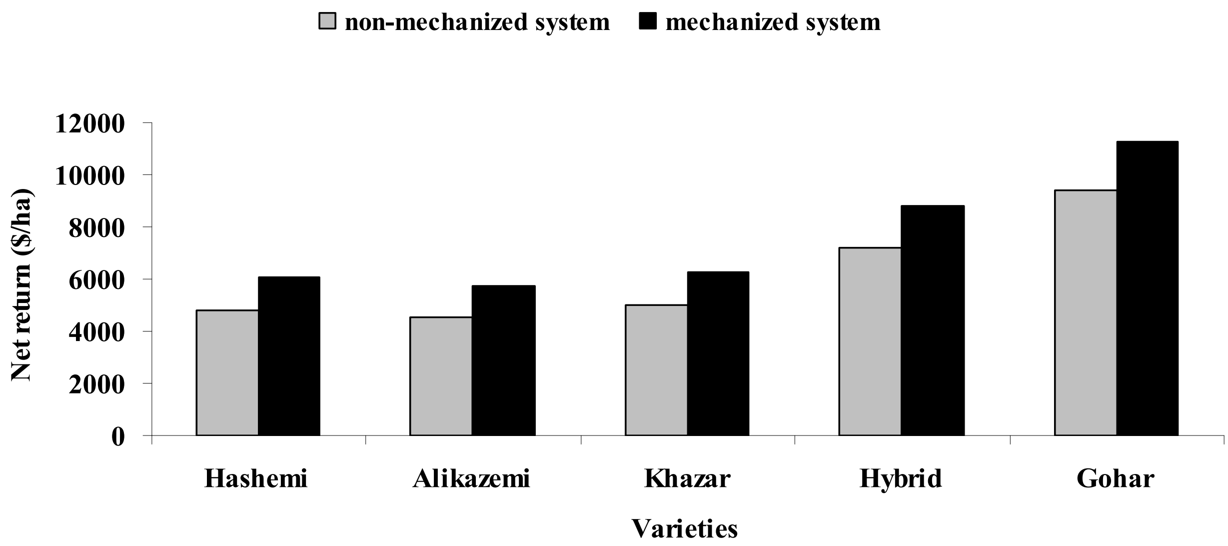

Figure 13. Net return in varieties rice production under traditional and semi-mechanized system condition

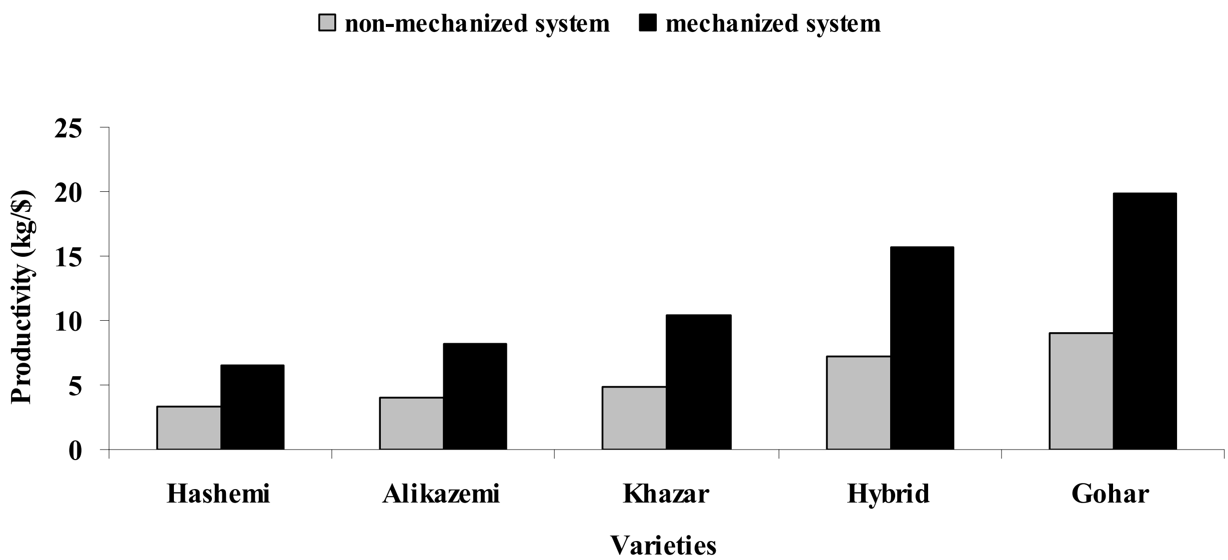

Figure 14. Productivity in varieties rice production under traditional and semi-mechanized system condition

Khan et al. [17] with study energy requirements and economic analysis of wheat, rice and barley production in Australia showed that Cost of production on wheat crop was 323, rice 896 and barley was A$ 246 ha^{-1}. Rice grower obtained the highest return of A$ 2088, as compared to wheat and barley growers, who obtained A$ 589 and 370 ha^{-1}. Therefore, the benefit-cost ratio was the highest on rice farms (3.33) as compared to wheat (2.82) and Barley (2.50). It was concluded that increase in energy consumption at farm level increased yield of rice, hence the farmers with higher cost of production could get better return of their crop [16].

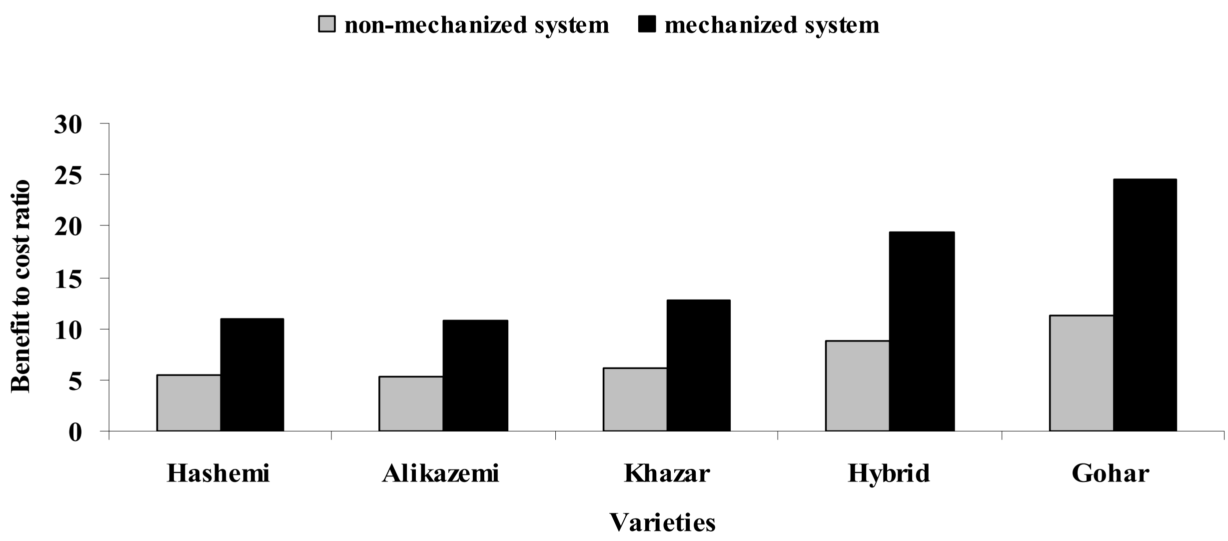

Figure 15. Benefit to cost ratio in varieties rice production under traditional and semi-mechanized system condition

4. Conclusion

Consider that breed varieties rice and semi-mechanized farming system are suitable case for increasing production of rice according to the limitation of rice fields of Guilan province (Iran). Identifying the way of developing and exploitation, energy indicators in agricultural section of Iran either in the light of having weak economical fundamentals or in the light of strict competition in global scene for obtaining better economical condition, helps that we lead our resources and facilities of our production in a direction that can obtain our suitable place in international occasions faster. According to the results of this research and studying the energy and economic analysis, we can say that the condition of the management of energy consumption in producing breed varieties (Khazar, Hybrid (GRH1) and Gohar (SA13)) are more suitable and according to the need of country about producing rice and limitation of energy sources which are mainly nonrenewable energy, producing breed varieties is a step towards sustainable agriculture.

Author details

Ebrahim Azarpour* and Maral Moraditochaee
Young Researchers and Elite Club, Lahijan Branch, Islamic Azad University, Lahijan, Iran

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