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ORIGINAL ARTICLE

Economic and Energy Analysis for Potato Production in North of Khuzestan Province (Case Study: Gotvand City)

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ABSTRACT
In 2012-2013 crop year, the present study conducted in order to determine and assess the efficiency and productivity of energy and also economic analysis of potato crop in north of Khuzestan province (Aghili district and central part of Gotvand). The two-stage stochastic sampling method was applied. Taking into account the participants finally 250 questionnaires were distributed among farmers who cultivate potato in both areas. In addition to questionnaires and in order to complete the needed information, a filed study operation implemented to measure the amount of fuel consumption for different agricultural operations. The results of this study show that the highest amount of energy consumption was related to fertilizer (especially Nitrogen fertilizer). After fertilizer, seed took the next rank of the amount of energy consumption. The lowest amount of energy consumption was related to workers and pesticides. The highest energy efficiency was for potato in acreage higher than 10 hectares with average of 2.24 and lowest energy efficiency was for acreage lower than 1 hectare with average of 1.35. The results show that by increasing cultivated area (acreage) the energy efficiency increased as well. Among different agricultural operations, with average of 48 percent, tillage took the highest amount of energy. The energy for cultivation and harvest operations with average of 500 and 1100 mega joule of total energy consumption respectively are in the next rank of energy consumption. During tillage operation, plowing with moldboard plow had the highest share of energy consumption that 48 percent of this share was related to fuel energy. Meanwhile a meaningful effect on fuel consumption was detected between tractor ownership and type. The effect of factors such as land ownership, experience in cultivation, literacy, farming system and area on the energy efficiency was evaluated as well and a meaningful effect was seen in all factors except area. Moreover, specifying the fixed and variable costs of cultivation, planting, harvest and after harvest of potato in both under study areas was done. Between total cost of machinery operation in both producing systems (mechanized above 10 hectares and traditional under 1 hectare), in 1 percent assured level, a meaningful difference was seen that reached to about 4933553.252 Rilas. Therefore by changing hand (traditional) system to mechanized system, the especial cost of machineries will considerably decrease.
Key words: *potato, energy, amount of efficiency, fuel consumption and economic analysis.*

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INTRODUCTION

With the advent of agriculture and more use of sun energy, necessary food for increasing population was provided and human beings could start operating non-renewable resources of energy. During centuries human beings have used various resources of energy. With progress in agriculture and manufacturing new equipment, energy use has increased in this sector as well in a way that today agriculture is severely dependent on energy, specifically fossil fuels. This issue is more evident in progressed countries due to more use of agricultural machineries and chemical fertilizers. In developed countries use of the abovementioned resources is increasing due to the increase of mechanization. In developing countries due to use of energy, the trend of moving from traditional agriculture toward mechanized and industrialized is increasingly intensified [5].

Energy consumption in agriculture sector depends on the working population in this sector, area of arable lands suitable for cultivation and mechanization level. Based on the fact that whether they are part of consumer or producer network, different agriculture sectors have different energy position and they can be considered as energy consumer or supplier in the form of bio energy [1].In previous years

economic development worldwide depends greatly on fossil fuel resources. These resources have caused environmental damages and energy crisis worldwide that threatened global peace a development [3].
The two accepted methods for evaluating consumed energy in agricultural production includes calculation and economic analysis of energy and analysis of input and output energy. Energy balance in agriculture is obtained via analyzing and comparing input and output energy in an agricultural system. Therefore, it can be concluded that evaluating energy balance, calculating energy efficiency and specifying and recognizing type and amount of energy consumption is the scientific method for proving existence and nonexistence of pollution and measurement degree of constancy and sustainability in production in an farming ecosystem [2].

NECESSITY OF RESEARCH

Lack of production resources such as energy has led to increasing development of rare resources optimal allocation methods amongst different activities. By taking into account the vital role of agriculture in national economy, creating job opportunity and food supply, it is necessary to use production resources and tools in this sector to the best way possible. Managing energy consumption as one of the main inputs of production is the only closest way for more operation of existing fuels and energy resources [6].
The main question of the present study is that whether the energy consumption in potato production is optimal? And if it is not optimally consumed, what are the reasons and what strategies for optimum consumption should be suggested? Assessing the consumed energy of potato in each section including agriculture machineries, fuel, human resources, fertilizers, irrigation etc. will lead us to introduce useful strategies. Due to the fact that yield potential is more than this amount, it is necessary to conduct widespread studies for optimizing consumed energy in this section in order to obtain an optimum energy consumption pattern for cultivating potato in the area with regard to energy indexes. In fact calculation and comparison of energy indexes such as energy ratio, energy productivity and net energy gained that are not measured accurately yet, can lead us achieve to an optimum pattern. Now considering the mentioned points and importance of potato crop in Iran , Khuzestan and Gotvand city and existence of energy crisis that nowadays world is facing, it is vital to present a suitable strategy for optimizing energy consumption in potato production of the area. Therefore as far as cost of potato production in the area is high cultivated area (acreage) has no noticeable growth and is low that caused severe fluctuation in cultivated area. On the other hand any type of energy consumption mechanism is under effect of economic issues of this crop. That's why the present study attempts to consider both energy and economy issues of this crop together [3].

METHODOLOGY

In terms of goal the present study is practical because its results are useful for planners and those involved in agriculture development policies. The dependent variables of the study are energy efficiency (ratio), energy productivity, fuel energies, irrigation, fertilizer, pesticides, worker and machineries. The independent variables are acreage, records, literacy, land ownership, tractor and machineries ownership, education level, city and different farming systems. Based on the existing statistics in Khuzestan Jihad and Agriculture Organization and Gotvand Jihad and Agriculture Organization and also filling the preliminary questionnaires at last 4 levels (acreage) are considered for potato crop. Most of the operations are in less than 1 hectare acreage and done by hand (traditional method). In 1 to 3 hectare acreage most operations are performed in half-mechanized methods. In higher acreage approximately most operations are done in half-mechanized or mechanized methods. Different acreages for potato are 1. Under 1 hectare, 2. 1 to 3 hectare, 3. Between 3 to 10 hectare, 4. More than 10 to 50 hectare. Tables 1 and 2 show the frequency and average acreages in the area.

Table 1. Frequency (number and percentage) of acreages for potato

Acreage	Gotvand	Percent	Aghili	Percent	Sum
Under 1 ha.	85	76	60	32	145
1 to 3 ha.	26	15	85	48	111
3 to 10 ha.	2	8	20	15	22
10 to 50 ha.	0	0	1	5	1
Sum	113	100	166	100	279

It was seen that the number of questionnaires distributed among farmers in Gotvand City (central part) are less than Aghili district due to lower number of participants. Also for potato cultivation due to lack of higher than 50 hectare lands it was not categorized separately. As it can be seen 85 percent of potato

farmers of central part of Gotvand own lands less than 1 hectare and only 26 percent of them have lands over 1 hectare. However most of the Aghili district potato farmers (60 percent) have lands over 1 hectare. In this study different acreage of land is considered as the main criterion for comparing efficiency and productivity. By taking into account the fact that farmers in the area are different with each other in terms of background in potato cultivation, after filling the preliminary questionnaires they were classified in different levels. Based on the background farmers were classified in 4 classifications as follow: 1. Under 5 years, 2. 5 to 10 years, 3. 10 to 15 years, 4. Over 15 years. Farmers of the area were different in terms of literacy level as well; therefore in this regard they were classified as follow: 1. Illiterate, 2. Primary School (5 grades), 3. Junior High School and High School (from grade 5 to Diploma), 4. Diploma, 5. Over diploma. Land ownership is classified into 2 levels of own and hired.

Finally city factor was classified into 2 levels: 1. Central part of Gotvand, 2. Aghili district. Different methods of potato cultivation in the area are mechanized and traditional (by hand). In the area under study irrigation measure was leak irrigation (furrow irrigation).

Participants

The geographical area of the study were Gotvand city central part and Aghili district and the time span of gathering information was beginning of December to the end of June of 2012 (end of December to end of June of 2012). The participants of the study include potato farmers of both mentioned areas and 1200 farmers in Gotvand and 1750 farmers in Aghili plant potato.

Sample volume and sampling method

In this study the simple two-stage stochastic sampling method was applied. Stochastic sampling that is in sampling method and its results are reliable and generalizable to the whole society by observing sampling principles. Another reason for selecting this method is its coordination and compatibility with the method taken by Iran Statistics Center and Management and Planning Organization in the country. In this sampling method, selection possibility in each stage is equal for all units of society [8]. Based on this point, in the first stage totally 27 villages, 9 villages of Gotvand (central part) and 18 villages of Aghili district, were selected and list of their farmers were gathered. After that by using stochastic sampling and appropriate selection, questionnaires were distributed among them. Cochran formula was used to find sample volume.

Extraction method and data analysis

After interviewing the farmers and completing the questionnaires, by Excel and SPSS 16 soft wares data extracted from the questionnaires were processed. Variance analysis test, comparing means (T-Student and Duncan), was used for data analysis.

The effect of land area and location on energy efficiency for potato crop

Two factors of land area with 4 levels (under 1 hectare, 1 to 3 hectare, 3 to 10 hectare, and over 10 hectare) and location with 2 levels (Gotvand central and Aghili district) were considered. The effect of these two factors and their mutual effect on energy indexes were assessed. For this, variance analysis by factorial experiment in the format of complete stochastic blocks plan was used. As it can be seen in table 1-4 about 8 percent of potato farmers of Gotvand central part own lands over 3 hectares though however farmers of Aghili district own 15 percent of this level of land. Therefore most of the farmers in Aghili district use mechanized methods for cultivating potato and by noticing the fact that 76 percent of farmers in Gotvand central part own land under 1 hectare they use traditional methods more.

Table 2. Variance analysis of energy efficiency in 4 levels of area and 2 levels of location for potato crop.

Variation source	Freedom degree	Sum of Squares	Mean of Squares	F
Land area	**3**	**26.16**	**12.8**	**83.480****
Location	**1**	**0.027**	**0.025**	**0.94^{ns}**
Iteration	**69**	**1.82**	**0.014**	**0.46^{ns}**
Land area × Location	**3**	**0.133**	**0.062**	**2.29^{ns}**
Error	**203**	**5.77**	**0.039**	
Total sum	**279**	**33.90**		

^{ns}: not significant *: 5 percent meaningful level, **: 1 percent meaningful level.

According to table 2-4. Comparison of means show that the effect of land area on energy efficiency was meaningful in 1 percent level. Most of the agricultural operations are mechanized in high levels and for cultivation and harvest different machineries were used.

Table 3. Comparison of energy efficiency mean in different land areas using Duncan test (0.05) for potato

Land area	Frequency	Under 1 ha.	1 to 3 ha.	3 to 10 ha.	Over 10 ha.
Under 1 ha.	45	1.35			
1 to 3 ha.	111		1.66		
3 to 10 ha.	22			2.17	
Over 10 ha.	1				2.24

The average energy efficiency in levels less than 1 hectare is equal to 1.35. The energy productivity for potato crop is estimated equal to 2.5 Mega Joule on Kilogram in these levels. The average input energy for potato for levels less than 1 hectare is equal to 48.12 Giga Joule in each hectare that show in order to plant potato more energy is required. On the other hand the amount of output energy from potato is calculated 65.14 Giga Joule in each hectare. The researchers showed that by increasing acreage (cultivated area) the amount of input energy decreased and the amount of output energy (yield) increased. The amount of productivity decreased as a result of increase in acreage as well. In levels over 3 hectares it can be seen that the energy efficiency is more than 2 (2.18). As it can be seen in variance analysis table the effect of location on energy efficiency is not meaningful in any level. Also the mutual effect of location and land area did not have a meaningful effect on energy efficiency. In table 4 different indexes of energy in the under study area (in different levels of cultivating) are presented.

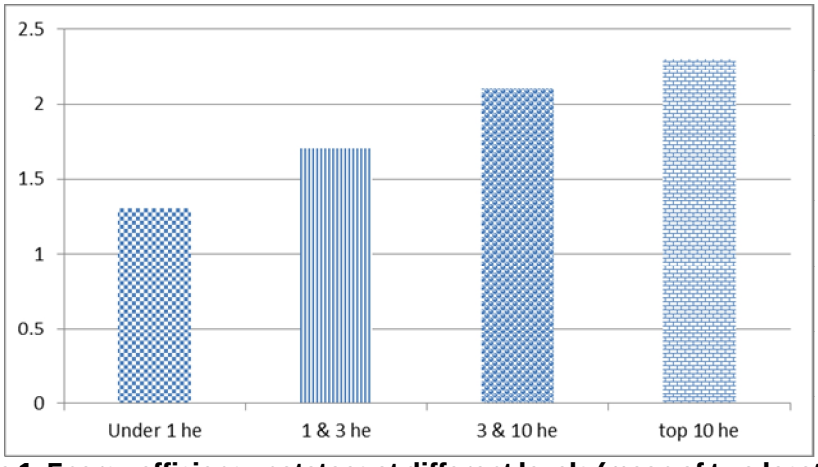

Figure 1: Energy efficiency potatoes at different levels (mean of two locations)

Table 3. Different indexes of energy for potato in Gotvand central part and Aghili district.

Variable	Under 1 ha.	1 to 3 ha.	3 to 10 ha.	Over 10 ha.	Mean of the area
Input energy GJ/ha	48.12	42.14	41.10	40.13	42.87
Output energy GJ/ha	65.14	70.29	89.50	90.12	78.76
Energy efficiency	1.353	1.668	2.17	2.24	1.85
Energy productivity MJ/Kg	2.5	1.98	1.65	1.64	1.94
Net energy added GJ/ha	15.00	32.22	45.66	43.17	34.01

In Gotvand central part and Aghili district sometimes it is seen that farmers spent 350 kg Azote fertilizer in each hectare and this factor is estimated as one of the main reasons of energy consumption increase in p cultivating lanting potato. In a research that is the same as that of Pimentel et al., energy efficiency in

potato production in the United States and England was estimated 1.2 and 1.6 respectively. They considered too much use of chemical fertilizers among reasons of high amount of input energy [6].

The effect of land area and farming system on energy efficiency for potato crop

Most of the potato farmers in the area embark on cultivating grains as well (usually along with potato they plant crops such as wheat, corn, colza and alfalfa). Also it was seen that significant number of them plant cucurbits as well as potato and grains. Factorial experiment was used in complete stochastic block plan format to analyze the variance. As the variance analysis table shows, in addition to different levels, kind of farming system such as cultivating grains had a meaningful effect on energy efficiency in 1 percent level. Because farmers who just embark on cultivating grains spend most of their potential and power in this area and are able to manage their farm better. Finally in order to determine the reason a comparison done using Duncan test among different levels energy efficiency mean (kind of farming system).

Table 4. Energy efficiency variance analysis in 4 levels of area and 4 levels of farming system for potato crop

Variation source	Freedom degree	Sum of squares	Mean of squares	F
Land area	3	1.24	0.673	26.24**
Farming system	3	0.329	0.113	5.55**
Land area× Farming system	9	0.178	0.038	1.65
Iteration	69	2.37	0.023	0.962
Error	201	4.86	0.025	
Total sum	279	970.90		

ns: not significant *: 5 percent meaningful level, **: 1 percent meaningful level.

As the table shows, the energy efficiency means are different with each other in different levels of farming system and each of them are placed in a separate group. It can be seen that potato farmers embark on farming cucurbits and husbandry as well that have lower energy efficiency (1.35) with respect to other levels.

Table 5. Comparison of energy efficiency mean in different levels of farming system using Dankan test (5 %) for potato crop.

Kind of farming system	Frequency	Under 1 ha.	1 to 3 ha.	3 to 10 ha.	Over 10 ha.
Farming grains, husbandry & cucurbits	51	1.30			
Farming grains & husbandry	65		1.47		
Farming grains & cucurbits	85			1.69	
Farming grains	140				0.03

It can be seen that potato farmers who plant cucurbits in addition to farming grains have more energy efficiency than those farmers who embark on husbandry besides farming grains (1.69 to 1.47). One of the reasons for such conclusion can be the correspondence between farming grain and cucurbits activities in supplying inputs (fertilizers, pesticides and water etc.).

The effect land area and land ownership on energy efficiency for potato crop

In Gotvand and Aghili districts some of the farmers usually hire land for cultivating wheat and corn due to the fact that price of these crops is annually guaranteed by Jihad and Agriculture Ministry and farmers have more confidence for cultivating them. However cultivating potato in the area encountered high risk especially in recent years. Farmers, therefore, tend less to hire land for cultivating potato. In crop year 2011, among farmers who plant potato in the area only 5 percent embarked on hiring land for cultivating potato. As it can be seen in the following table the effect of energy efficiency and land ownership is not meaningful in any of the levels. The cause of this fact is the low number of farmers who hired land. The low number of farmers embarked on cultivating in different levels of land.

Table 6- Energy efficiency variance analysis in 4 levels of land area and 2 levels of land ownership for potato crop.

Variation source	Freedom degree	Sum of squares	Mean of squares	F
Land size	3	3.14	2.07	52.47**
Land ownership	1	0.006	0.006	0.172 ns
Land size× land ownership	2	0.118	0.069	2.04 ns
Iteration	109	3.85	0.027	0.978 ns
Error	205	6.841	0.029	
Total sum	320	970.90		

ns: meaningless *: 5 percent meaningful level, **: 1 percent meaningful level.

The effect of cultivation background and literacy on energy efficiency for potato crop

As it is shown in table 4-7, the effect of two factors namely literacy (with 5 levels) and background (with 4 levels) is analyzed with factorial experiment and in complete stochastic blocks plan format. As it can be seen in the following table the effect of energy efficiency with literacy level is meaningful in 5 levels.

Table 7- Energy efficiency variance analysis in 4 levels of background and 5 levels of literacy for potato crop.

Variation source	Freedom degree	Sum of squares	Mean of squares	F
Background	3	1.931	0.504	3.225*
Literacy	4	2.014	0.483	3.313*
Background × Literacy	11	1.221	0.122	0.753 ns
Iteration	109	7.055	0.065	0.422
Error	192	28.065	0.146	
Total sum	320	970.907		

ns: meaningless *: 5 percent meaningful level, **: 1 percent meaningful level.

Also in table 7 It can be seen that level 1 (illiteracy) has the lowest efficiency comparing to other levels in a way that it is classified in a separate group. People who have diploma or higher degrees although have more efficiency than those illiterates but have less efficiency than those with primary school level. The reason for this is more in using lower levels by farmers who are literate. Also among the main reasons of low energy efficiency of literate farmers are lack of enough working experiment among young and educated farmers, working in other jobs and having education degree not related to agriculture.

Table 8. Comparison of energy efficiency mean in levels of literacy using Duncan test (5%) for potato crop

Education level	Frequency	1	2	3
Illiterate	57	1.51		
Above Diploma University degree	41	1.55	1.55	
Diploma	53	1.56	1.56	
Primary school (up to grade 5)	82		1.66	1.66
From grade 5 to Diploma	37			1.705

Assessing the effect of tractor ownership and tractor type (model) on fuel energy for cultivating potato (amount of fuel consumed in hectare)

Fuel is one of the important consuming inputs by tractor and other machineries (potato harvester) in the amount of energy input for cultivating potato. Therefore in this part the effect of tractor ownership and type on fuel energy will be assessed. For cultivating potato fuel energy is consumed from tillage operation to transport from farm, tractor also is used in harvest operation which is done in a half-mechanized method. In cultivating potato weeding operation (cultivar) and soil maintenance are performed in addition to production operation of certain row crops such as corn. Therefore fuel consumption in cultivating potato is more than other cultivations in the area. As it is shown in table 8 the effect of fuel energy with tractor ownership and type in 1 percent level is meaningful. The mutual effect of tractor ownership and type had no meaningful effect on fuel energy.

CONCLUSION

After assessing the effect of all factors on energy indexes, factors of each result were separately discussed. In this section the obtained results of the study will be pointed out briefly.

Assessing the obtained results show that the highest amount of energy consumption was related to chemical fertilizers (especially Nitrogen fertilizer). After that the next rank is seed. The lowest amount of energy consumption was related to worker energy and the highest amount to potato harvest operation.

The effect of different levels of cultivation on energy efficiency in 1 percent levels was meaningful, in a way that by increasing cultivated area from 1 hectare to above 10 hectares energy efficiency mean increased as well. The reason for this can be found in increase of output energy (yield amount), optimum use of inputs (fertilizer amount, water, etc.) and increase in using machine in different operations. The amount of input energy for cultivation was estimated from 48 Gj in hectare for under 1 hectare levels and 65 Gj for above 10 hectares levels. As it is specified, the amount of energy needed for cultivating potato is 56 Gj. Energy efficiency is calculated for potato crop in levels under 1 hectare, it showed that in traditional (using hand) cultivation efficiency is higher. The effect of farming system type on energy efficiency in 1 percent level was meaningful. The energy efficiency for farmers who, in addition to farming grains, cultivate cucurbits and embark on husbandry is lower than those who only embark on farming grains. Lack of concentration in work and farmers' correct management in using inputs is one of the reasons for low energy efficiency for farmers of this type (who embark on husbandry and farming cucurbits in addition to farming grains). The effect of land ownership on energy efficiency of potato did not have meaningful difference and the reason for this was the fact that farmers own the lands themselves. Most of the potato cultivated lands had personal ownership (approximately 97%). The effect of background and literacy was meaningful in 5 percent level. Meanwhile illiterate farmers, most of them had low literacy and high working background, had lowest energy efficiency. Also farmers with cultivation background of 15 to 25 years had highest efficiency. Farmers with more background did not have high efficiency due to using old and outdated methods.

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