The impact of farm size on energy use and profitability of red bean production in Iran: A case study in Kurdistan province

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Abstract: In this paper, the red bean production in Kurdistan, Iran and the energy equivalences of input used in this production are investigated. The data were collected through a survey study by using a face-to-face questionnaire performed in April 2009. The aims of this study were to determine the amount of input–output energy used in red bean production, to investigate the efficiency of energy consumption, and to make an economic analysis of red bean production. We classified the land size into 3 types in this study. Type 1 (T1) is 0.1 ha, type 2 (T2) is 0.2 ha, and type 3 (T3) is 0.5 ha. We determine the energy use, productivity and profitability in the 3 types of land size to find out if they have significant difference or not. The following results were obtained at the end of the study: Irrigation energy engrossed 82.68%, 63%, and 55.41 of total energy in T1, T2, and T3 land types respectively, followed by chemical fertilizer (12.64%, 28.1%, and 35.72% respectively) during production period. The highest energy efficiency pertained T3 and it was 0.44, and its energy productivity was 0.03 in the study area. The economic analysis showed that the best profit-cost ratios of the farms pertained T3 and it was 0.97. Its net returns calculated were -228 \$ ha^{-1} in the farms investigated. [Nature and Science. 2009;7(9):95-104]. (ISSN: 1545-0740).

Key words: Economic analysis, energy efficiency, Iran, Kurdistan, Land size, Red bean

1. Introduction

Red bean is indigenous to China and is traditionally used as soup ingredients for therapeutic purposes such as ameliorating symptoms of dropsy, relieving diarrhea, and as a tonic for viscera (Li, 1973). Recent studies have shown that red bean flour has functional properties comparable to the widely studied and used soybean flour (Chau and Cheung, 1998a). Protein is a major component of red bean constituting to 30.2% (dry weight) of the cotyledon and 25.2% of the whole seeds, and the salt-soluble globulin constitutes almost half of the total proteins extracted by Osborne fractionation. It was also reported that red bean protein had high level of all the essential amino acids comparing with the FAO/WHO requirement (Chau et al., 1998b).

In developing countries like Iran, agricultural growth is essential for fostering the economic development and meeting the ever-higher demands of the growing population. Energy in agriculture is important in terms of crop production and agro processing for value adding (Karimi et al., 2008). The relation between agriculture and energy is very close. Agriculture itself is an energy user and energy supplier in the form of bio-energy. At present, productivity and profitability of agriculture depends on energy consumption (Alam et al., 2005).

Energy use in agriculture has been developed in response to increasing populations, limited supply of arable land and desire for an increasing standard of living. In all societies, these factors have encouraged an increase in energy inputs to maximize yields, minimize labor-intensive practices or both (Esengun et al., 2007).

Energy in one form or another is a crucial input to agricultural production. Continually rising prices, increasing proportion of commercial energy in the total energy input to agriculture and the growing scarcity of commercial energy sources, such as fossil fuels, have necessitated the more efficient use of these sources for different crops (Singh et al., 1999).

Agriculture is both a producer and consumer of energy. It uses large quantities of locally available non-commercial energies, such as seed, manure and animate energy, and commercial energies directly and indirectly in the form of diesel, electricity, fertilizer, plant protection, chemicals, irrigation water, machinery and etc. Efficient use of these energies helps to achieve increased production and productivity and contributes to economy, profitability and competitiveness of agriculture sustainability to rural living (Singh et al., 2002).

The importance of sustaining agricultural production to improve nutritional standards has been recognized by all countries throughout history. However, in the economic literature of the 1950s and 1960s the role of agriculture in development was considered ancillary to that of the modern industrial sector where most of the accumulation and growth was expected to take place. Subsequent theoretical investigation and the very disappointing performance of agriculture in many developing countries have led to the belief that the role of agriculture in development should be re-examined (Cornia, 1985).

Relationship between farm size and productivity in developing countries is one of the oldest issues in the academic arena for analyzing the agrarian structure (Thapa, 2007). The most frequently cited phenomenon is an inverse relation between farm size and yield per acre (Feder, 1985).

Sen explained the inverse relationship with labor dualism, where given the same technology, small-scale farmers have lower opportunity costs of their labor than operators of large farms (Sen, 1962). Deininger and Feder applied agency theory analysis on this subject. When a farm is small and labor markets are not functioning, small-scale farms use only family labor (Deininger and Feder, 2001). Hence, in the terminology of principal-agent theory, the principal and his family members supply all of the labor for the farm. These family members have a strong incentive to work because they share the farm output directly and in the long run can expect to inherit the farm. Here monitoring and incentive problems are minimal and excess family labor would push the value of the marginal product below the off-farm wage thus may result the inverse relationship (Taylor and Adelman, 2003). Bhalla and Roy and Benjamin suggested that unobserved land quality is positively related to farm productivity but inversely related to farm size, which might explain the inverse relationship between farm size and productivity as well (Bhalla and Roy, 1988; Benjamin et al., 2001).

Heltberg claimed that Bhalla and Roy's conclusions are undermined by their use of district aggregate data (Heltberg, 1998). However, using farm level data obtained in Haryana, India, Carter found a significant within-village inverse relationship between farm size and productivity (Carter, 1984).

The majority of studies of agricultural productivity in developing countries support the view that there is an inverse relationship between productivity and farm size (Berry and Cline, 1979; Barrett, 1996). If correct, land reform could contribute to improving both equity and efficiency in agriculture. Most of these studies, however, are based on partial measures of productivity such as yield which are biased in favor of small producers.

2. Materials and methods

The data were collected from 36 farmers growing red bean in Kurdistan province, Iran by using a face-to-face questionnaire in April 2009. The province is located in the west of Iran, within 34° 44´–36° 30´ north latitude and 45° 31´–48° 16´ east longitude. The total area of the Kurdistan province is 2,820,300 ha. The average rainfall of the province is 450 millimeters (Najafi, 1996). The location of Kurdistan province is shown in figure 1.

The total land area cultivated for legumes and red bean crop is 81499 and 430 ha, respectively in Kurdistan; also the total production of this crop is 11545 and 566 ton, respectively in Kurdistan. Thus about 0.05% of total legumes production in Kurdistan is obtained from red bean production (Ministry of Jihad-e-Agriculture of Iran, 2008).

We chose this area for the investigation, because according to the low yield in this province, it seems that the farmers don't use the resources in an efficient situation. Red bean is a sample for the low efficiency and there are some other crops in a same situation. If the results corroborate this hypothesis, so it would be a big alarm for the farmers and governments to use the resources in an efficient situation.

The sample size was determined using the simple random sampling method (Kizilaslan, 2009):

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

In which 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 (permissible error 5%).

For the growth and development, energy demand in agriculture can be divided into direct and indirect, renewable and non-renewable energies (Alam et al., 2005). The energy efficiency of the agricultural system has been evaluated by the energy ratio between output and input. Human labor, machinery, diesel oil, fertilizer, pesticides, herbicides, fungicides, and seed amounts and output yield values of red bean crops have been used to estimate the energy ratio. The amounts of input were calculated per hectare and then, these input data were multiplied with the coefficient of energy equivalent. Energy equivalents shown in Table 1 were used for estimation.

Figure 1. The location of Kurdistan province in Iran

Table 1. Energy equivalent of inputs and outputs in agricultural production

Particulars	Unit	Energy equivalent (MJ unit^{-1})	Ref.
A. Inputs			
1. Human labor	h	1.96	(Singh and Mittal, 1992; Erdal et al., 2007)
2. Machinery	kg		
Tractor	kg	138	(Kitani, 1999)
Plow	kg	180	(Kitani, 1999)
Disk	kg	149	(Kitani, 1999)
Harrow			
3. Diesel fuel	L	56.31	(Singh and Mittal, 1992; Erdal et al., 2007)
4.Fertilizers(N)	kg	78.1	(Kitani, 1999)
5. Seeds	kg	14.7	(Kitani, 1999)
B.Outputs (Yield)	kg	14.7	(Kitani, 1999)

Basic information on energy inputs and red bean yields were entered into Excel and SPSS 17 spreadsheets. Based on the energy equivalents of the inputs and output (Table 1), the energy ratio (energy use efficiency) and energy productivity were calculated (Mandal et al., 2002; Singh et al., 1997).

$$\text{Output - input ratio} = \frac{\text{Energy output (MJ ha}^{-1}\text{)}}{\text{Energy input (MJ ha}^{-1}\text{)}} \quad (2)$$

$$\text{Energy productivity} = \frac{\text{Red bean output (kg ha}^{-1}\text{)}}{\text{Energy input (MJ ha}^{-1}\text{)}} \quad (3)$$

Indirect energy included energy embodied in seeds, fertilizers, manure, chemicals, machinery while direct energy covered human labor and diesel used in the red bean production. Non-renewable energy includes diesel, chemical, fertilizers and machinery, and renewable energy consists of human labor, seeds, and manure. In the last part of the research, economic analysis of red bean production was investigated, and net profit and benefit–cost ratio was calculated. The net return was calculated by subtracting the total cost of production from the gross value of production per hectare. The benefit–cost ratio was calculated by dividing the gross value of production by the total cost of production per hectare (Demircan et al., 2006; Ozkan et al., 2004).

We have 3 types of land size in this study. Type 1 (T1) is 0.1 ha, type 2 (T2) is 0.2 ha, and type 3 (T3) is

0.5 ha. We determine the energy use, productivity and profitability in the 3 types of land size to find out if they have significant difference or not. Differences between mean values for the various treatments were tested by Duncan method ($P < 0.05$).

3. Results and discussion

3.1 Analysis of input–output energy use in red bean production

Amounts of inputs used and output in red bean production for each item are illustrated in Table 2. Inputs used in red bean production, energy equivalences and ratios of inputs and output are illustrated in Table 3, Table 4, and Table 5. Total energy used in various farm operations during red bean production was 105540.2 MJ ha^{-1}, 47571 MJ ha^{-1}, and 43725.4 MJ ha^{-1} in T1, T2, and T3 land types respectively. Total energy used in the first type of land size (T1) was significantly higher than the other land types at the 5% level.

Table 2. Amounts of inputs and output in red bean production

	T1 land type	T2 land type	T3 land type
Inputs	**Quantity per unit area (ha)**	**Quantity per unit area (ha)**	**Quantity per unit area (ha)**
Labor (h ha^{-1})	803.77	451.72	369.66
Land preparation	5.3	5.16	4.29
Planting	79.76	21.73	40.67
Irrigation	226.67	103.27	67.14
Fertilizer application	3.54	2.24	3.71
Harvesting	299.76	163.07	141.71
Threshing	173.21	145.96	108
Transporting	15.53	10.29	4.14
Machinery (h ha^{-1})	6.26	6.37	5.15
Land preparation	5.3	5.16	4.29
Transporting	0.96	1.21	0.86
Diesel (L ha^{-1})	37.81	37.42	30.55
Land preparation	33.87	32.82	27.2
Transporting	3.94	4.6	3.35
Fertilizers (kg ha^{-1})	170.83	171.15	200
Nitrogen (N)	170.83	171.15	200
Seeds	60.08	61.92	80.71
Output			
Red bean yield (kg ha^{-1})	1275	1344.23	1307.14

According to the evaluation of data in Table 2, the average human labor required in the study area was 803.77 h ha^{-1}, 451.72 h ha^{-1}, and 369.66 h ha^{-1} in T1, T2, and T3 land types respectively, and machine power was 6.26 h ha^{-1}, 6.37 h ha^{-1}, and 5.15 h ha^{-1} respectively. Almost 37%, 36%, and 38% of total human labor, in the land types respectively, was required for harvesting, because in the study area the harvesting operation was done only by human labor without using machinery. About 85%, 81%, and 83% of machine power, in the land types respectively, was consumed for land preparation, and 15%, 19%, and 17%, in the land types respectively, was for transporting the harvested red bean. The distribution of the energy input ratios in the red bean production are given in figure 2.

Table 3. Amounts of inputs and output in red bean production in type T1 land size

Inputs & output	Quantity per unit area (ha)	Total energy equivalent (MJ ha^{-1})	Percentage
A. Inputs			

1. Human labor (h)	803.77	1575.4	1.49
2. Machinery (h)	6.26	354.7	0.34
3. Diesel fuel (L)	37.81	2129.1	2.02
4. Chemical fertilizers (kg)			
Nitrogen (N)	170.83	13341.8	12.64
5. Seeds (red bean) (kg)	60.08	883.2	0.84
6. Irrigation (m^3)	14388	87256	82.68
Total energy input (MJ)		105540.2	100
B. Output			
1. Red bean (kg)	1275	18742.5	
Total energy output (MJ)		18742.5	
Output-input ratio		0.18	
Energy productivity (kg MJ^{-1})		0.01	

Table 4. Amounts of inputs and output in red bean production in type T2 land size

Inputs & output	**Quantity per unit area (ha)**	**Total energy equivalent (MJ ha^{-1})**	**Percentage**
A. Inputs			
1. Human labor (h)	451.72	885.4	1.86
2. Machinery (h)	6.37	333.8	0.7
3. Diesel fuel (L)	37.42	2107.1	4.43
4. Chemical fertilizers (kg)			
Nitrogen (N)	171.15	13366.8	28.1
5. Seeds (red bean) (kg)	61.92	910.2	1.91
6. Irrigation (m^3)	4528	29967.7	63
Total energy input (MJ)		47571	100
B. Output			
1. Red bean (kg)	1344.2	19759.7	
Total energy output (MJ)		19759.7	
Output-input ratio		0.42	
Energy productivity (kg MJ^{-1})		0.03	

Table 5. Amounts of inputs and output in red bean production in type T3 land size

Inputs & output	**Quantity per unit area (ha)**	**Total energy equivalent (MJ ha^{-1})**	**Percentage**
A. Inputs			
1. Human labor (h)	369.66	724.5	1.66
2. Machinery (h)	5.15	244.7	0.56
3. Diesel fuel (L)	30.55	1720.3	3.93
4. Chemical fertilizers (kg)			
Nitrogen (N)	200	15620	35.72
5. Seeds (red bean) (kg)	80.71	1186.4	2.71
6. Irrigation (m^3)	3186	24229.5	55.41
Total energy input (MJ)		43725.4	100
B. Output			

1. Red bean (kg)	1307.1	19214.4
Total energy output (MJ)		19214.4
Output-input ratio		0.44
Energy productivity (kg MJ^{-1})		0.03

Total energy consumed in various farm operations during red bean production in the first type of land size (T1) was 105540.2 MJ ha^{-1}. Irrigation energy consumed 82.68% of total energy followed by chemical fertilizer 12.64% during production period. Diesel energy mainly consumed for land preparation, and transportation. Total energy output was 18742.5 MJ ha^{-1}, and average annual yield of farms investigated was 1275 kg ha^{-1}. It is shown in Table 3 that machinery was the least demanding energy input for red bean production with 354.7 MJ ha^{-1} (only 0.34% of the total energy input), followed by seeds by 883.2 MJ ha^{-1} (0.84%).

Energy output-input ratio (energy use efficiency) was 0.18, and energy productivity was calculated as 0.01 in the study area. This means that 0.01 of output was obtained per unit energy.

Total energy consumed in various farm operations during red bean production in the second type of land size (T2) was 47571 MJ ha^{-1}. Irrigation energy consumed 63% of total energy followed by chemical fertilizer 28.1% during production period. Diesel energy mainly consumed for land preparation, and transportation. Total energy output was 19759.7 MJ ha^{-1}, and average annual yield of farms investigated was 1344.2 kg ha^{-1}. It is shown in Table 4 that machinery was the least demanding energy input for red bean production with 333.8 MJ ha^{-1} (only 0.7% of the total energy input), followed by human labor by 885.4 MJ ha^{-1} (1.86%).

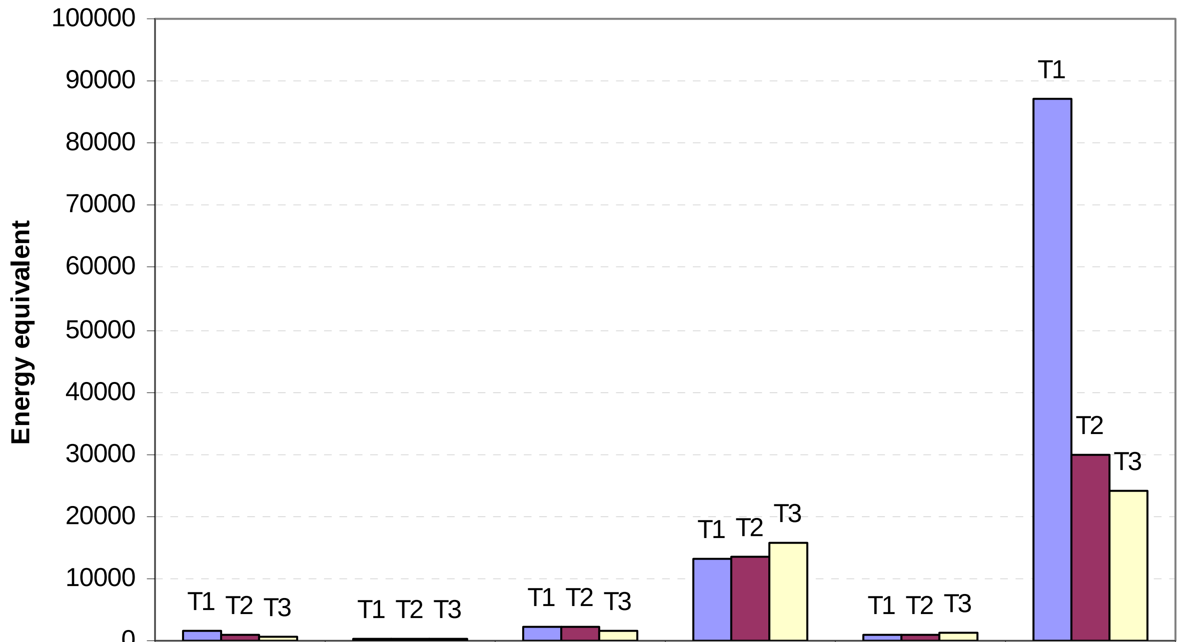
Energy output-input ratio (energy use efficiency) was 0.42, and energy productivity was calculated as 0.03 in the study area. This means that 0.03 of output was obtained per unit energy.

Total energy consumed in various farm operations during red bean production in the third type of land size (T3) was 43725.4 MJ ha^{-1}. Irrigation energy consumed 55.41% of total energy followed by chemical fertilizer 35.72% during production period. Diesel energy mainly consumed for land preparation, and transportation. Total energy output was 19214.4 MJ ha^{-1}, and average annual yield of farms investigated was 1307.1 kg ha^{-1}. It is shown in Table 5 that machinery was the least demanding energy input for red bean production with 244.7 MJ ha^{-1} (only 0.56% of the total energy input), followed by human labor by 724.5 MJ ha^{-1} (1.66%).

Energy output-input ratio (energy use efficiency) was 0.44, and energy productivity was calculated as 0.03 in the study area. This means that 0.03 of output was obtained per unit energy.

The irrigation energy used in the first type of land size (T1) was significantly higher than the other land types at the 5% level and was significantly higher than the third type of land size (T3) at the 1% level. No significant differences in yield at the 5% level by different land types were found for the red bean crops. The farmers didn't use any fungicides, pesticides, or herbicides. Overall they didn't care about crop protection and the yield is much lower than the average of the Iran.

The distribution of total energy input is shown in Table 6 as direct, indirect, renewable and non-renewable forms. As it is shown, the total energy input consumed could be classified as direct energy (3.51%, 6.3%, and 5.6% in T1, T2, and T3 land types respectively) and indirect energy (96.49%, 93.7%, and 94.4 respectively), and also renewable energy (2.33%, 3.77, and 4.4 respectively) and non-renewable energy (97.67%, 96.23%, and 95.6 respectively).



	Labor	Machinery	Diesel fuel	Nitrogen (N)	Seeds	Irrigation
T1	1575.4	354.7	2129.1	13341.8	883.2	87256
T2	885.4	333.8	2107.1	13366.8	910.2	29967.7
T3	724.5	244.7	1720.3	15620	1186.4	24229.5

Figure 2. The distribution of energy input (MJ ha^{-1}) ratios in the red bean production.

Table 6. Total energy input in the form of direct, indirect, renewable and non-renewable for red bean production (MJ ha^{-1})

	T1 land type		**T2 land type**		**T3 land type**	
Form of energy	**Quantity (MJ ha^{-1})**	**Percentage** [a]	**Quantity (MJ ha^{-1})**	**Percentage** [a]	**Quantity (MJ ha^{-1})**	**Percentage** [a]
Direct energy [b]	3704.5	3.51	2292.5	6.3	2444.8	5.6
Indirect energy [c]	101835.7	96.49	44578.5	93.7	41280.6	94.4
Renewable energy [d]	2458.6	2.33	1795.6	3.77	1910.9	4.4
Non-renewable energy [e]	103081.6	97.67	45775.4	96.23	41814.5	95.6
Total energy input	105540.2	100	47571	100	43725.4	100

[a] Indicates percentage of energy input.

[b] Includes human labor and diesel.

[c] Includes seeds, fertilizers, manure, chemicals, and machinery.

[d] Includes human labor, seeds, and manure.

[e] Includes diesel, chemical, fertilizers, and machinery.

3.2 Economic analysis of red bean production

Data obtained from economic analysis are presented in Table 7. The profit/cost ratio was found to be 0.59, 0.82, and 0.83 in T1, T2, and T3 land types respectively. The productivity in red bean production was attained as 0.53, 0.89, and 0.97 respectively. Net profit was -982.6 \$ ha^{-1}, -267.6\$ ha^{-1}, -228\$ ha^{-1}. Net profit in the first type of land size (T1) was significantly lower than the other land types at the 5% level.

Table 7. Economic analysis of red bean production

	T1 land type	T2 land type	T3 land type
Cost and return items	Value	Value	Value
Total production costs (\$ ha^{-1})	2408.4	1502.8	1342.3
Gross production value [a] (\$ ha^{-1})	1425.8	1235.2	1114.3
Benefit/Cost ratio	0.59	0.82	0.83
Productivity (kg $\$^{-1}$) [b]	0.53	0.89	0.97
Net return (\$ ha^{-1})	-982.6	-267.6	-228

[a] Gross production value=Red bean yield (kg ha^{-1})*Price (\$ kg^{-1})

[b] Productivity (kg\$-1)= Red bean yield (kg ha^{-1})/Total production costs (\$ ha^{-1})

As shown in Table 7, the net return in red bean production in the studied area is negative. The reason can be due to the fact that the human labor in the region is provided by the farmer and his family and no payment is considered for the job done. In the economic analysis in this study, the human labor wage was considered as the conventional rate paid in regular agricultural operations. Therefore, in appearance, the farmer gets a false feeling of a profitable task while in reality the case is different. The outcome will influence the standard of living of the rural families involved in producing this type of crop. The economic analysis without estimating the human labor wage has shown in table 8. as it has shown, the false feeling of the farmer is obvious. Even without estimating the human labor wage, the net return in the first type of land size (T1) is negative and notwithstanding the net return in other land types is not negative, the production of this crop in the study area is not profitable.

Table 8. Economic analysis of red bean production without estimating the human labor wage

	T1 land type	T2 land type	T3 land type
Cost and return items	Value	Value	Value
Total production costs (\$ ha^{-1})	1462.6	969.1	918
Gross production value [a] (\$ ha^{-1})	1425.8	1235.2	1114.3
Benefit/Cost ratio	0.97	1.27	1.21
Productivity (kg $\$^{-1}$) [b]	0.87	1.39	1.42
Net return (\$ ha^{-1})	-36.8	266.1	196.3

[a] Gross production value=Red bean yield (kg ha^{-1})*Price (\$ kg^{-1})

[b] Productivity (kg $\$^{-1}$)= Red bean yield (kg ha^{-1})/Total production costs (\$ ha^{-1})

4. Conclusions

In this study, the red bean production in Kurdistan, Iran and the energy equivalents of inputs used in this production were investigated. Irrigation energy monopolized 82.68%, 63%, and 55.41 of total energy in T1, T2, and T3 land types respectively, followed by chemical fertilizer as (12.64%, 28.1%, and 35.72% respectively). Total energy consumption in various farm operations during red bean production was found to be 105540.2 MJ ha^{-1}, 47571 MJ ha^{-1}, and 43725.4 MJ ha^{-1} in T1, T2, and T3 land types respectively. Total energy used in the first type of land size (T1) was significantly higher than the other land types at the 5% level. No significant differences in yield at the 5% level by different land types were found in the red bean production. Total energy output attained as 18742.5 MJ ha^{-1}, 19759.7 MJ ha^{-1}, and 19214.4 MJ ha^{-1} respectively, and average annual yield was 1275 kg ha^{-1}, 1344.2 kg ha^{-1}, and 1307.1 kg ha^{-1} respectively. The highest energy use efficiency hinged T3 and was calculated as 0.44, and its energy productivity was 0.03. The machinery was the least demanding energy input in T1 for red bean production with 354.7 MJ ha^{-1} (only 0.34% of the total energy input), followed by seeds as 883.2 MJ ha^{-1} (0.84%). The total energy input consumption could be classified as direct energy (3.51%, 6.3%, and 5.6% in T1, T2, and T3 land types respectively) and indirect energy (96.49%, 93.7%, and 94.4 respectively), and also renewable energy (2.33%, 3.77, and 4.4 respectively) and non-renewable energy (97.67%, 96.23%, and 95.6 respectively). The economic analysis showed that the best profit-cost ratios of the farms hinged T3 and it was 0.97. Its net returns calculated were -228 $ ha^{-1} in the farms investigated. Net profit in the first type of land size (T1) was significantly lower than the other land types at the 5% level. The net return in red bean production in the studied area was negative due to not considering any labor costs for family works. Without estimating the human labor wage, the highest net returns hinged T2 and calculated as 266.1 $ ha^{-1}.

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References

[1] Alam, M.S., Alam, M.R., and Islam, K.K. Energy flow in agriculture: Bangladesh. American Journal of Environmental Sciences 2005; 1(3): 213–220.
[2] Barrett, C.B., 1996. On price risk and the inverse farm size–productivity relationship. J. Dev. Econ. 51 (2), 193–216.
[3] Benjamin, D., Brandt, L. and Giles, J. Income Persistence and the Evolution of Inequality in Rural China. Paper prepared for the NEUDC Meetings, Riga 2002. Available online at: http://www.cepr.org/meets/wkcn/7/753/papers/giles.pdf.
[4] Berry, R.A., and Cline,W. Agrarian Structure and Productivity in Developing Countries. Johns Hopkins University Press, Baltimore, 1979: 248.
[5] Bhalla,S.S., and Roy, P. Mis-Specification in Farm Productivity Analysis - the Role of Land Quality. Oxford Economic Papers-New Series March 1988; 40: 55-73.
[6] Carter, M.R. Identification of the Inverse Relationship Between Farm Size and Productivity: An Empirical Analysis of Peasant Agricultural Production. Oxford Economic Papers 1984; 36: 131-45.
[7] Chau, C. F., and Cheung, C. P. K. Functional properties of flours prepared from three Chinese indigenous legume seeds. Food Chemistry 1998a; 61(5): 429-433.
[8] Chau, C. F., Cheung, C. P. K., and Wong, Y. S. Chemical composition of three underutilized legume seeds grown in China. Food Chemistry 1998b; 61(4): 505-509.
[9] Cornia, G. A. Farm Size, Land Yields and the Agricultural Production Function: An Analysis for Fifteen Developing Countries. World Development 1985; 13(4): 513-534.
[10] Deininger,K. W. and Feder, G. Chapter 6 Land Institutions and land markets. Handbook of Agricultural Economics, Elsevier Science 2001; 1(1) 288-331. Available online at: http://www.sciencedirect.com/science/article/B7P5B-4FPWV0B-1B/2/3250f8b99d71baacc9c75a6984849d10.
[11] Demircan, V., Ekinci, K., Keener, H.M., Akbolat, D., and Ekinci, C. Energy and economic analysis of sweet cherry production in Turkey: A case study from Isparta province. Energy Conversion and Management 2006; 47: 1761–9.
[12] Erdal, G., Esengün, K., Erdal, H., and Gündüz, O. Energy use and economical analysis of sugar beet production in Tokat province of Turkey. Energy 2007; 32: 35–41.
[13] Esengun, K., Gündüz, O., and Erdal, G. Input–output energy analysis in dry apricot production of Turkey. Energy Conversion and Management 2007; 48: 592–598.
[14] Feder, G. The relation between farm size and farm productivity. Journal of Development Economics 1985; 18: 297-313.
[15] Heltberg,R. Rural market imperfections and the farm size-productivity relationship: Evidence from Pakistan. World Development 1998; 26: 1807-26.
[16] Karimi, M., Beheshti Tabar, I., and Khubbakht, G.M. Energy production in Iran’s agronomy. American-Eurasian J. Agric. & Environ. Sci. 2008; 4(2): 172-177.

[17] Kitani, O. 1999. CIGR Handbook of Agricultural Engineering. Vol. V. Energy and Biomass Engineering. ASAE Publication, St. Joseph, MI.
[18] Kizilaslan, H. Input–output energy analysis of cherries production in Tokat Province of Turkey. Applied Energy 2009; 86: 1354–1358.
[19] Li, S. C. Chinese medical herbs. San Francisco. Georgetown Press 1973. pp. 155 and 316.
[20] Mandal, K.G., Saha, K.P., Ghosh, P.K., Hati, K.M., and Bandyopadhyay, K.K. Bioenergy and economic analysis of soybean-based crop production systems in Central India. Biomass and Bioenergy 2002; 23(5): 337–345.
[21] Ministry of Jihad-e-Agriculture of Iran, Statistics 2008. Available online at: Http://www.maj.ir.
[22] Najafi, Y. Kurdistan Geography. Iran 1996. (In Persian)
[23] Ozkan, B., Akcaoz, H., and Karadeniz, F. Energy requirement and economic analysis of citrus production in Turkey. Energy Conversion and Management 2004; 45: 1821–30.
[24] Sen, A.K. An Aspect of Indian Agriculture. Economic Weekly 1962; 14: 4-6.
[25] Singh, H., Mishra, D., and Nahar, N.M. Energy use pattern in production agriculture of a typical village in arid zone, India-part I. Energy Conversion and Management 2002; 43: 2275–2286.
[26] Singh, M.K., Pal, S.K., Thakur, R., and Verma, U.N. Energy input–output relationship of cropping systems. Indian J. Agric Sci. 1997; 67(6): 262–266.
[27] Singh, S., and Mittal, J.P. Energy in Production Agriculture. Mittal Pub. New Delhi 1992.
[28] Singh, Sa., Singh, Su., Pannu, C.J.S., and Singh, J. Energy input and yield relations for wheat in different agro-climatic zones of the Punjab. Applied Energy 1999; 63: 287-298.
[29] Taylor, J. E. and Adelman, I. Agricultural Household Models: Genesis, Evolution, and Extensions, Review of Economics of the Household 2003; 1(1): 33-59. Available online at: http://www.reap.ucdavis.edu/research/Agricultural.pdf.
[30] Thapa, S. The relationship between farm size and productivity: empirical evidence from the Nepalese mid-hills. CIFREM, Faculty of Economics, University of Trento, Trento (Italy) 2007; MPRA Paper No. 7638.

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