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Effects of Increasing Price of Energy Carriers on Energy Consumption in Pistachio Production: Case Study in Rafsanjan, Iran

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ABSTRACT

As one of the most important products of Iran, pistachio has a significant share in non-oil revenues. Its annual foreign exchange earnings are over 800 million dollars. However, production of this nut in the country's major production centers is faced with many problems regarding the efficiency and productivity of the inputs. This study was performed by using two-stage cluster sampling method. The results showed that with the increase in energy carriers' prices, the farmers of the region would tend to use the optimal amounts of inputs in the long term, thus, reducing energy consumption from 46,016.72 to 31,092 MJ ha^{-1}. Also, the present values of energy productivity, its efficiency, and specific energy of, respectively, 0.03, 0.42, and 35.05 MJ kg^{-1} would be optimized to 0.07, 1.10 and 13.47 MJ kg^{-1}. Besides, it was revealed that the net energy, which was negative under the existing condition (-26,532 MJ), would increase to 3,160 MJ following the increase in the price of energy carriers. Above all, the non-renewable energy consumption would be reduced from 39,743 to 26,457 MJ. Of course, to achieve the mentioned results, government support of farmers in the short term is necessary in order to facilitate and expedite the change in technology.

Keywords: Energy carriers, Input-output, Price elasticity, Pistachio production, Profit maximization.

INTRODUCTION

Considering the strategic importance and specific position of pistachio in the non-oil exports of Iran, the increasing expansion of land area devoted to this tree, and the subsidy reforms, the management of energy inputs in producing this product is one of the research priorities of Iran (Amirteimoori and Chizari, 2008). The study of energy input-output relation should be done at regional level because, due to various weather conditions, soil type, and other factors, various regions require different values of inputs to produce agriculture products (Mirzaei Khalil Abadi, 2010; Villano *et al*., 2010). According to the statistics reported by FAO (2011), the annual amount of pistachio production and area harvested in Iran was 472,097 tons and 257,925 ha respectively. Rafsanjan area with more than 110,000 ha of pistachio orchards is a major production center of this nut in the world, with a share in the pistachio cultivation area of the world, Iran, and Kerman of 24, 34, and 60%, respectively (Iranian Pistachio Research Institution, 2010).

In Iran, one of the reasons for excessive consumption of oil and oil-products, which

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has developed in recent years, is their low prices. As economics is the science of optimized assignment of scarce resources and their prices are among the tools to achieve this aim, if the goods and services don't have the real price, their consumption will increase (Karimi *et al*., 2007). Energy consumption is taking an increasing trend in recent years. A major part of oil consumption in agricultural sector is as engine fuel, while a great part of electricity in this sector is consumed in the electric pumps used for lifting water in wells. A few percent of energy consumption is assigned to heat applications and is applied for heating the greenhouse, livestock husbandry, and poultry. Soheily (2007) performed various studies regarding the investigation of the consumption of energy input in various products. Also, in a study performed by Salami *et al*. (2010), it was concluded that the output to input ratio of energy in producing strawberry was 0.48 and the total input energy applied in producing strawberry was 36,822.20 MJ ha^{-1}. The energy productivity was estimated as 0.25 kg MJ^{-1}. On the other hand, 74.50% of the applied energy was renewable energy. Shahan *et al*. (2008) found that total input energy applied in producing wheat was 47.08 GJ ha^{-1} and the energy of producing wheat was 45.71 GJ ha^{-1} that 31.19 and 26.05% of which were obtained of chemical fertilizers and fuel and machinery, respectively. Also, 73.27% of total energy used in the production of wheat was indirect, consisting of the energy obtained of seed, chemical and animal fertilizer, pesticide and machinery. While direct energy, consisting of the energy was achieved of labor force and fuel was 26.73%. The input to output ratio and energy productivity in producing wheat was 1.97 and 0.10 kg MJ^{-1}, respectively (Shahan *et al*., 2008). Asakereh *et al*. (2010) reported that in producing apple, with the increase of mechanization, average energy consumption of inputs increased such that the output –input energy ratio, energy productivity, and specific energy in the group with moderate mechanization were 1.02, 0.42 kg MJ^{-1}, and 2.35 MJ ha^{-1}, respectively, while the corresponding values for the low mechanization group were 1.35, 0.56 kg MJ^{-1} and 1.78 MJ ha^{-1}. In the first and second group, 88.45 and 77.93% of the applied energy in production was non-renewable energy. Taheri and Mousavi (2010) found that energy had significant effect on production of agricultural sector and 10% of increase in energy consumption increased the production by 4.10%. Zoghipour and Torkamani (2007) investigated the input and output energy of agricultural sector and concluded that the total input energy to this sector was increased from 111.50 MJ in 1971 to 378.15 MJ in 2001. Also, total output energy was increased from 122.39 to 3,846 MJ, which showed that the efficiency of energy, input output ratio and energy productivity decreased during the mentioned years (Zoghipour and Torkamani, 2007).

Esengun *et al*. (2007) divided the farmers into two groups with farm size of less than 3 hectares and more than 3 hectares and found that energy consumption values by the first and second group were 28,647.03 and 17,884.72 MJ ha^{-1}, respectively. Energy input-output ratio and energy productivity in the first group were 1.24 and 0.24 kg MJ^{-1}, respectively, and in the second group 1.31 and 0.25 kg MJ^{-1}. Also, three quarters of the cost of the applied energy in both energy groups were related to non-renewable energy and only one quarter was from renewable energy. In another study performed regarding cotton production, the researchers found that energy consumption to produce cotton was 49.72 GJ ha^{-1}, such that 31.10% of it was related to diesel consumption and the remaining were associated with fertilizer and machinery (Yilmaz *et al*., 2005). Ahmadi and Mirzaei (2012) used input-output table to investigate the effect of increasing prices of energy carriers on pistachio production. They found that although the increase in energy carriers prices resulted in lower production in the short term, but it caused technological change in the long term. Sağlam *et al*.

(2012) found that renewable and non-renewable energies were, respectively, 3.80 and 96.20% of the supplied energy in pistachio production in Turkey.

We mentioned there have been various studies about the energy input consumption in other products but there was no study about the energy input consumption in pistachio production. In the present research, we focused on the investigation of the effect of releasing energy price in production of pistachio. In other words, the objective of the current study was investigation of using energy based on sustainable development of the region. Therefore, in this study, the effects of increasing the price of energy carriers on energy consumption in pistachio production was investigated based on the main issue of energy in the subsidy reform plan.

MATERIALS AND METHODS

The information required for this study was collected by field and library methods. The general information was collected from FAO (2011) and Iranian Pistachio Research Institution reports (2010). The data related to amount of production input and products were provided by field survey and interview with farmers. The sampling approach of this paper was two-stage cluster sampling, with the main clusters being the wells and farmers as units of each sample. From 1,400 wells under management of almost 40,000 farmers, we stochastically chose 33 well as the main clusters. Data for outputs and inputs were obtained in the crop year 2010 by filling questionnaires and interviewing 228 farmers. To estimate the size of the required sample, Equation (1) was used:

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

Where, *s* is standard deviation, *t* is *t*-value, *d* represents allowable error and *N* is the total number of farmers.

Then, the square production function is estimated by the data of the questionnaires and Eviews software. Since the market for agricultural inputs and products largely follows the complete competition market, the first and second marginal laws should be established for profit maximization (Hojabr Kiani, 1999). In other words, to maximize the utility that comes from x input consumption, producers are forced to continue consumption of input x until:

$$VMP_x = P_x \qquad (2)$$

Where, *VMPx* is the value of final production of input x and *Px* is the input price *x*. Also, with regard to the role of the price elasticity of demand on producer behaviours in short and long term, the price elasticity of energy carriers was estimated as Equations (3) and (4).

$$LPE = f\left(LRPE, LPOPE, LY\right) \qquad (3)$$

$$LGOIL = f\left(LRPGOIL, LPOP, LY\right) \qquad (4)$$

Where, *LPE* and *LGOIL* denote logarithm of demand for electricity and gasoline, and *LRPE* and *LRPGOIL* denote logarithm of real price for these energy carriers in agriculture sector, respectively. *LPOPE* and *LPOP* is logarithm of the numbers of electricity and gasoline consumers, while *LY* denotes logarithm of real added value in agriculture sector.

One of the suitable tools to investigate the conditions of inputs is input-output (IO) method. The calculations and the mentioned method findings provide that a quantity and real perception of input performance in production is achieved to act better in the planning.

$$Energy\cos umtionefficiency = \frac{Outputenergy(MJha^{-1})}{Inputenergy(MJha^{-1})} \qquad (4)$$

Energy consumption efficiency, energy productivity, specific energy, and net energy were calculated as Equations (5), (6), (7) and (8) (Salami and Hojat Ahmadi, 2010; Zoghipour and Torkamani, 2007):

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$$Energy productivity = \frac{Output product (kg ha^{-1})}{Input energy (MJ ha^{-1})} \quad (5)$$

The above index shows how much energy is obtained for each MJ ha[-1] of applied energy in production of a product.

In Equation (6), energy productivity shows how much product is obtained in kg for each MJ input energy in the farm,.

$$Specific energy = \frac{Input energy (MJ ha^{-1})}{Output product (kg ha^{-1})} \quad (6)$$

Where, specific energy shows how much energy in MJ is used for each kg of product.

$$Net energy = Output energy (MJ ha^{-1}) - Input energy (MJ ha^{-1}) \quad (7)$$

The negative net energy shows that the input energy used in the farm is greater than the output energy.

Usually, in research, the applied energy in the system is grouped into direct and indirect energy. Indirect energy includes the energy stored in seed, chemical fertilizers and animal manure, pesticides, and machinery, while the direct energy is the energy of labor and fuel. Another classification that is used for the applied energy of the system is renewable and non-renewable energy. Therefore, firstly price elasticity of energy in pistachio production was calculated then the effect of increasing price on farmers' behavior was investigated. Finally, we used input-output method to determine the effect of Farmer behavior pattern on energy consumption in pistachio production including the consumed energy per hectare, energy input-output ratio, energy productivity and renewability and non-renewability of the energy resources applied in production of pistachio that farmers by knowing this issue, avoid the loss of this valuable input.

Non-renewable energy is the energy contained in fuel, pesticides, and machinery that is not renewable after application; while the energy in labor, animal manure, and seed are renewable energy (Salami and Hojat Ahmadi, 2010; Shahan *et al*., 2008). Summary of the data analysis of the 228 questionnaires used in this survey are shown in Table 1.

RESULTS AND DISCUSSION

Fuel is an intermediate input in production of agricultural products and profit maximization is the purpose of major agricultural production; therefore, increase in fuel price plays an important role in its use and consumption. Price elasticity of energy carriers is necessary to estimate their final demand; therefore, demand function was estimated for gasoline and electricity by using ARDEL method (Table 2). Also, the number of optimal orders in each of the used variables and short and long term relation of energy carriers demand were identified by using Schwartz-Bayesian Criterion (Noferesti, 1999). Although the results of some research showed that the increase in energy carriers prices resulted in short term

Table 1. The maximum, minimum, and average inputs and yield in pistachio production.

Input	Yield (t ha^{-1})	Machinery (h ha^{-1})	Labor (h)	Pesticides (L ha^{-1})	Chemical fertilizer (kg ha^{-1})	Animal manure (t ha^{-1})	Water (m^3 ha^{-1})
Min	496	8	190	4	100	0	4200
Max	1325	137	1390	26	975	40	15820
Average value	1131	30	650	11	338	17	9105
SD	14.14	5.28	5.52	2.40	15.44	3.06	52.05
Average price (Rials)	47200	78504	8693	56205	549	179567	265

Table 2. Price elasticity of demand of energy carriers in regional agriculture.

Description	Gasoline	Electricity
Short-term price elasticity	-0.14	-0.11
Long-term price elasticity	-0.31	-0.21
Speed of price adjustment	-0.61	-0.52

decrease in production, farmers of the region would tend to change the composition of inputs with increase in relative prices of inputs based on Equation (2) and elasticity of the inputs prices in the long term (Ahmadi and Mirzaei, 2012).

Based on the price elasticity of energy input (electricity of gasoline) and the facilities, the farmers are inclined to maximize the profit or minimize the costs in the long term. In other words, if the farmer has adequate input, profit is maximized. If he is faced with the limitation of production factors, the costs are minimized. In this study, the two mentioned fields are considered. Based on two hypotheses in this study, by the data of the questionnaires and Eviews software, the square production function is estimated. This function is selected as the best function based on estimation of some various functions (Cobb–Douglas, Trans dental, multi-nominal, etc.) and econometric criteria. Then, to remove the problem of linearity, the square functions were estimated for each input by Divisia index. To determine the optimized value of the inputs in profit maximization method, the principle of equality of the marginal value product with input price was used [Equation (1)]. Thus, the optimized value of inputs found by using profit maximization for animal manure, chemical fertilizer, labor,

Table 3. Input-output energy values in pistachio production in the existing conditions (Salami and Hojat Ahmadi 2010; Yilmaz *et al*., 2005; Anonymous, 2000).

Inputs and outputs	Amount ha^{-1}	Energy based on MJ per unit	Total energy (MJ ha^{-1})	%
Labor (h)	650	1.96	1274	2.77
Chemical fertilizer (kg)	338	56	18,928	41.13
Machinery (h)	30	56.90	1707	3.71
Irrigation water (m^3)	9105	0.63	5736.15	12.47
Animal manure (ton)	17	300	5100	11.08
Pesticides (L)	11	454	4994	10.85
Fuel (Gasoline) (L)	147	56.31	8277.57	17.99
Sum of inputs			46016.72	100
Output [Pistachio (kg)]	1313	14084	19484.92	

Table 4. Input-output energy values in pistachio production in the cost minimizing scenario.

Inputs and outputs	Amount ha^{-1}	Energy based on MJ per unit	Total energy (MJ ha^{-1})	%
Labor (h)	375	1.96	735	2.51
Chemical fertilizer (kg)	173.80	56	9732.80	33.25
Machinery (h)	13.90	56.90	790.91	2.70
Irrigation water (m^3)	7294	0.63	4595.20	15.70
Animal fertilizer (ton)	11	300	3300	11.27
Pesticides (L)	11	454	4994	17.06
Fuel (Gasoline) (L)	91	56.31	5124.20	17.51
Sum of inputs			29272	100
Output [Pistachio (kg)]	1313	14.84	19484.92	

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Table 5. Input-output energy values in pistachio production in the profit maximization scenario.

Inputs and outputs	Amount ha^{-1}	Energy based on MJ per unit	Total energy (MJ ha^{-1})	%
Labor (h)	375	1.96	735	2.36
Chemical fertilizer (kg)	178.52	56	9996	32.15
Machinery (h)	14.34	56.92	813.67	2.62
Irrigation water (m^3)	7793.10	0.63	4909.71	15.79
Animal fertilizer (ton)	13	300	3,900	12. 54
Pesticides (L)	11	454	4994	16.06
Fuel (Gasoline) (L)	102	56.31	5743.62	18.47
Sum of inputs			31092	100
Output [Pistachio (kg)]	2308.12	14.84	34252	

Table 6. Investigation of energy indices (in pistachio production) in the existing costs minimization and profit maximization conditions.

Indices	Value (In the existing conditions)	Value (In the costs minimization conditions)	Value (In the profit maximization conditions)
Input energy (MJ)	29272	46016.72	31092
Output energy (MJ)	19484.92	19484.92	34252
Energy productivity (kg MJ^{-1})	0.04	0.03	0.07
Energy efficiency	0.67	0.42	1.10
Specific energy (MJ kg^{-1})	22.29	35.05	13.47
Net energy (MJ ha^{-1})	-9787	-26532	3160
Direct energy (MJ)	5859.20	9551.57	6478.60
Indirect energy (MJ)	23412.80	36465	24613.40
Renewable energy (MJ)	4035	6274	4635
Non-renewable energy (MJ)	25237	39743	26457

pesticides, water, and machinery was 13 tons ha^{-1}, 178.52 kg ha^{-1}, 375 h ha^{-1}, 11 L ha^{-1}, 7,793.10 m^3 ha^{-1}, and 14.34 h ha^{-1}, respectively (Table 5). If the farmers cannot achieve the maximum profit due to the limitation of production factors, the best decision is minimizing the costs. To minimize the price, based on production function constraint, Lagrange function was used. By minimizing the costs of inputs, the optimized amount of water, animal manure, chemical fertilizer, labor, pesticides, and machinery was obtained as 7,294 m^3 ha^{-1}, 11 tons ha^{-1}, 173.80 kg ha^{-1}, 375 h ha^{-1}, 11 L ha^{-1} and 13.90 h ha^{-1}, respectively (Table 4). It should be noted that the reason for difference between the optimized values of inputs in the two scenarios lies in the fact that, in the second scenario, the farmers aim to produce the present product with the minimum cost.

As by the increase in the price of energy carriers the farmers of the region try to use the optimized inputs, in this study, energy input-output data and the related indices were investigated in three cases: existing

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condition, minimizing the costs, and maximizing the profit. The results showed that, in the existing condition, the energy consumption was 46,016.72 MJ, while the output was 19,484.92 MJ. In other words, energy productivity, its efficiency, and specific energy were 0.03 kg MJ^{-1}, 0.42, and 35.05 MJ kg^{-1}). The net energy was negative (-26,532) indicating that output energy of the farm was less than input energy (Table 6). Above all, non-renewable energy consumption was 39,743 MJ indicating the unsuitable use of the inputs. With the increase in the price of energy, the farmers were inclined to minimize the cost or maximize the profit, and the indices were improved. In the profit maximizing case, the profit of energy efficiency was bigger than one and the net energy was positive. Non-renewable energy was reduced when the inputs were used properly.

Thus, the followings are recommended: (1) educating and encouraging the farmers to make optimized use of the inputs, (2) considering the key role of agriculture sector in producing food and to avoid reduction of agricultural products, the government should adopt suitable policies and mechanisms such as guaranteed purchasing prices, avoiding unduly import of agriculture products, and provision of different facilities for this sector to change the current production technology to reduce energy consumption.

Finally, based on the results of this research, it was concluded that in response to the increase in the price of energy, the farmers were inclined to adopting optimal use of inputs; and, especially, energy output indices, energy productivity, specific energy, and non-renewable energy consumption were improved. To achieve the mentioned results, government support of farmers in the short term is necessary in order to facilitate and expedite the change in technology.

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آثار افزایش قیمت حامل های انرژی بر مصرف ان در تولید پسته (مطالعه موردی شهرستان رفسنجان)

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چکیده

یکی از محصولات مهم صادراتی کشور پسته می باشد که نقش زیادی در صادرات غیر نفتی داشته است . سالانه بیش از ۸۰۰ میلیون دلار ارزآوری دارد. اما تولید این محصول در مراکز عمده تولید آن با مشکلات زیادی بخصوص در زمینه کارائی و بهروری مصرف انرزی روبرو است. جمع اوری داده ها در این تحقیق به روش نمونه گیری خوشه ا ی دومرحله ای انجام شد. نتایج نشان داد با افزایش قیمت حامل های انرژی، در بلندمدت کشاورزان منطقه به استفاده بهینه از نهاده ها انرژی روی خواهند آورد به طوریکه مقدار انرژی مصرف شده در هکتار از ۴۶۰۱۶.۷۲ به ۳۱۰۹۲ مگاژول کاهش می یابد. همچنین ارزش حال بهره وری انرژی،کارائی و انرژی ویژه که به ترتیب۰.۰۲۹ کیلوگرم بر مگاژول، ۰.۴۲۳ و ۳۵.۰۵ مگاژول بر کیلو گرم می باشد، بترتیب به ۰.۰۷۴کیلوگرم بر مگاژول، ۱.۱۰۲ و۱۳.۴۷ مگاژول بر کیلو گرم بهبود می یابند. از طرف دیگر انرژی خالص که در وضعیت موجود منفی بوده(۲۶۵۳۲-) به ۳۱۶۰ مگاژول با افزایش قیمت انرژی افزایش می یابد. از همه مهم تر اینکه مصرف انرژی غیر قابل تجدید شونده که در حال حاضر ۳۹۷۴۳ مگاژول می باشد به ۲۶۴۵۷ مگاژول کاهش می یابد.البته لازمه تحقق همه این موارد، حمایت دولت از کشاورزان در کوتاه مدت به منظور تغییر تکنولوژی است.

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