Erdemir Gundogmus[1]

MODELING AND SENSITIVITY ANALYSIS OF ENERGY INPUTS FOR WALNUT PRODUCTION

This study was conducted to determine the energy balance between energy inputs and yield for walnut production in Turkey. For this purpose the data were collected from 51 walnut orchards. The following results were obtained from this study: Total energy input of 42,092.86 MJ ha-1 was required for walnut production. The share of chemical fertilizers by 46.70% of the total energy inputs was the highest energy input. This was followed by diesel-fuel (19.97%) and pesticides (15.83%), respectively. The energy efficiency, energy productivity, specific energy, and net energy were found as 1.74, 0.11 kg MJ $^{-1}$, 9.25 MJ kg^{-1} and 31,069.04 MJ ha^{-1}, respectively. The results of econometric model estimation revealed that the impacts of human labor, pesticides, chemical fertilizers, diesel-fuel and water for irrigation energy inputs were significantly positive on yield. The results of sensitivity analysis of the energy inputs showed that the MPP value of human labor was the highest, followed by water for irrigation and diesel-fuel energy inputs, respectively.

Keywords: *energy input; energy output; econometric model; sensitivity analysis; energy efficiency; walnut orchards.*

Ердемір Гундогмус

МОДЕЛЮВАННЯ І АНАЛІЗ ЧУТЛИВОСТІ ДО ВИТРАТ ЕНЕРГІЇ У ВИРОБНИЦТВІ ВОЛОСЬКИХ ГОРІХІВ

У статті описано дослідження, проведене для визначення енергетичного балансу між витратами енергії і врожайністю волоських горіхів в Туреччині. Для цих цілей були зібрані дані 51 горіхового саду. У дослідженні було отримано такі результати: для виробництва волоських горіхів були потрібні витрати енергії в 42092,86 МДж/га. Частка хімічних добрив – 46,7% від загальних енерговитрат – склала найбільші витрати енергії. За цим ідуть дизельне паливо (19,97%) і пестициди (15,83%). ККД, енергоефективність, питомий вжиток енергії і корисна енергія склали 1,74, 0,11 кг/МДж, 9,25 МДж/кг і 31 069,04 МДж/га відповідно. Оцінки економетричної моделі показали, що енергетичні витрати людської праці, пестицидів, хімічних добрив, дизпалива і води для поливу значно позитивно вплинули на врожай. Результати аналізу чутливості до витрат енергії показали, що гранична ціннісна значущість людської праці була найвищою, за ним за значущістю йдуть витрати енергії на воду для поливу і дизпаливо.

Ключові слова: *витрати енергії; вихід енергії; економетрична модель; аналіз чутливості; ККД; горіхові сади.*

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Эрдемир Гундогмус

МОДЕЛИРОВАНИЕ И АНАЛИЗ ЧУВСТВИТЕЛЬНОСТИ К ЗАТРАТАМ ЭНЕРГИИ В ПРОИЗВОДСТВЕ ГРЕЦКИХ ОРЕХОВ

В статье описывается исследование, проведенное для определения энергетического баланса между затратами энергии и урожайностью грецких орехов в Турции. Для этих целей были собраны данные 51 орехового сада. В исследовании были получены такие результаты: для производства грецких орехов потребовались затраты энергии в 42092,86 МДж/га. Доля химических удобрений – 46,7% от общих энергозатрат – составила наибольшие затраты энергии. За этим следуют дизельное топливо (19,97%) и пестициды (15,83%). КПД, энергоэффективность, удельное потребление энергии и полезная энергия

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составили 1,74, 0,11 кг/МДж, 9,25 МДж/кг и 31069,04 МДж/га соответственно. Оценки эконометрической модели показали, что энергетические затраты человеческого труда, пестицидов, химических удобрений, дизтоплива и воды для полива значительно положительно повлияли на урожай. Результаты анализа чувствительности к затратам энергии показали, что граничная ценностная значимость человеческого труда была наивысшей, за ним по значимости следуют затраты энергии на воду для полива и дизтопливо.

Ключевые слова: *затраты энергии; выход энергии; эконометрическая модель; анализ чувствительности; КПД; ореховые сады.*

Introduction. Turkey is ranked third in the world after China and the USA in walnut production (FAO, 2011). The production of walnut was about 177,000 tons per year in Turkey and the harvested land area was 86,000 ha in 2009. Walnuts do not only provide healthy fatty acids and high calorie, they are also rich in vitamins and minerals which help us to stay healthy. It includes potassium, magnesium, phosphorus, iron, calcium, zinc, copper, vitamin B9, B6, E, A etc. (Koyuncu et al., 2004).

Today's agricultural production relies heavily on the consumption of non-renewable fossil fuels. Consumption of fossil energy results in direct negative environmental effects through release of CO2 and other combustion gases. Indirectly, there have been positive effects: increased yields and reduced risk. Yet large amounts of cheap fossil energy have indirect negative impacts on the environment like less diversified nature through the intensification of agricultural practices. Thus, looking for agricultural production methods with higher energy productivity is as topical today as it was some 20 years ago (Refsgaard et al., 1998). Calculating energy inputs of agricultural production is more difficult than the industry sector due to the high number of factors affecting agricultural production (Yaldiz et al., 1993).

The main objective in agricultural production is to increase yield and decrease costs. In this respect, energy budget is important. Energy budget is the numerical comparison of the relationship between input and output of a system in terms of energy units (Gezer et al., 2003). In general, increases in agricultural production on a sustainable basis and at a competitive cost are vital to improve farmer's economic condition (De et al., 2001). Although many experimental works have been conducted on energy use in agriculture, but there is only one study on the energy and economic analysis of walnut production (Banaeian and Zangeneh, 2011).

Table 1. **Nomenclature**

n – required sample size;
N – number of holdings in target population;
s – standard deviation;
D – acceptable error (permissible error was chosen as 5%);
T – confidence limit (1.96 in the case of 95% reliability);
Y_i – yield level of the i^{th} farmer;
X_1 – human labour energy;
X_2 – machinery energy;
X_3 – pesticides energy;
X_4 – chemical fertilizers energy;
X_5 – diesel-fuel energy;
X_6 – water for irrigation energy;
X_7 – electricity energy;
ε_i – error term;
α_i – coefficients of the variables;
β_i – coefficients of the variables;
γ_i – coefficients of the variables;
DE – direct energy;
IDE – indirect energy;
RE – renewable energy;
NRE – non-renewable energy;
MPP_{xj} – marginal physical productivity of j^{th} input;
α_j – regression coefficient of j^{th} input;
GM(Y) – geometric mean of yield;
GM(Xj) – geometric mean of j^{th} input energy.

The aims of this research were to determine the energy use efficiency per hectare for walnut production, carry out a sensitivity analysis on energy inputs for walnut yield and compare input energy use with input costs. This study reveals the relationship between energy inputs and yield by developing mathematical models based on walnut orchards in South Marmara Region of Turkey.

Material and methods. ***Selection of case study farms and data collection.*** In this study the data were obtained from 51 walnut orchards in Bursa and Bilecik Provinces in South Marmara Region. A face-to-face questionnaire was conducted in the production year 2008/2009. For sampling, stratified random sampling method was used. The sample size was calculated using the Neyman method (Yamane, 1967):

$$n = \frac{N \times \sum N_h \times S^2{}_h}{N^2 D^2 + \sum N_h \times S^2{}_h}, \qquad (1)$$

where N_h is the number of producers in the h^{th} stratum; $S^2{}_h$ is the variance of h^{th} stratum; D^2 is the value of $(d/t)^2$; d is the quantity of error permitted from the population mean and $t = 1.96$ in response to 95% confidence limit. Thus, the sample size was calculated to be equal 51, then selection of 51 walnut producers from the population were randomly carried out.

In this region the input energy sources for walnut production were human labor, electricity, diesel fuel, machinery, chemicals and irrigation water; while output energy sources were walnut kernel and wooden shell. The energy equivalent of inputs and output, shown in Table 2, were used to estimates the energy values.

Table 2. **Energy equivalents of inputs and output in walnut production**

Equipment/input	Unit	Energy coefficients (MJ/unit)	Reference
A. INPUTS			
1. Human labor	h	1.96	(Singh and Singh, 1992)
2. Machinery (h)	h	62.70	(Singh and Singh, 1992)
3. Chemical fertilizers	kg		(Singh and Singh, 1992)
a) Nitrogen		60.60	(Singh and Singh, 1992)
b) Phosphorus		11.10	(Singh and Singh, 1992)
c) Potassium		6.70	(Singh and Singh, 1992)
4. Pesticides	kg		
a) Insecticides		199	(Hessel, 1992)
b) Fungicides		92	(Hessel, 1992)
5. Diesel-fuel	L	56.31	(Singh and Singh, 1992)
6. Water for irrigation	m^3	0.63	(Yaldiz et al., 1993)
7. Electricity	kWh	11.93	(Singh and Singh, 1992)
B. OUTPUT			
1. Walnut	kg	26.15	(Banaeian and Zangeneh, 2011)
2. Wooden shell	kg	10.00	(Banaeian and Zangeneh, 2011)

The input energy in agricultural systems can be divided into direct and indirect or renewable and non-renewable forms. The sources of direct energy include human labor, diesel fuel, electricity and water for irrigation while indirect energy sources include chemical fertilizer, pesticides and machinery.

Renewable energy consists of human labour; and non-renewable energy sources consist of electricity, machinery, diesel-fuel, pesticides, water for irrigation and chemical fertilizers. The energy input-output ratio (energy use efficiency), energy productivity, specific energy and net energy were calculated by using the total energy equivalent of inputs and outputs per unit (MJ ha^{-1}) and fruit yield (kg ha^{-1}), using the following equations (Rafiee et al., 2010):

$$Energy\ use\ efficiency = \frac{Energy\ output(MJ\ ha^{-1})}{Energy\ input(MJ\ ha^{-1})}; \tag{2}$$

$$Energy\ productivity = \frac{Walnut\ \ output(kg\ ha^{-1})}{Energy\ input(MJ\ ha^{-1})}; \tag{3}$$

$$Specific\ energy = \frac{Energy\ input(MJ\ ha^{-1})}{Walnut\ \ output(MJ\ ha^{-1})}; \tag{4}$$

$$Net\ energy = Energy\ output\ (MJ\ ha^{-1})\ -\ Energy\ input\ (MJ\ ha^{-1}). \tag{5}$$

In order to specify the relationship between input energies and yield a mathematical function needs to be identified. For this purpose Cobb-Douglas production function was chosen as the best function in terms of statistical significance and expected signs of parameters. The Cobb-Douglas function has been used by several authors to investigate the relationship between input energies and production yield (Banaeian and Zangeneh, 2011; Heidari and Omid, 2011). The Cobb-Douglas production function is expressed as follows:

$$Y = f(x)\exp(u). \tag{6}$$

This function can be expressed as a linear relationship using the following expression:

$$\ln Y_i = a + \sum_{j=1}^{n} \alpha_j \ln(X_{ij}) + e_i, \quad i = 1,2,.....,n, \tag{7}$$

where Y_i denotes the yield of the i^{th} farmer; X_{ij} is the vector of inputs used in the production process; a is a constant term; α_j represent coefficients of inputs which are estimated from the model; e_i is the error term. Assuming that yield is a function of input energies, for investigating the impact of each input energy on walnut yield, (7) can be expanded in the following form:

$$\begin{aligned} \ln Y_i = \alpha_0 + \alpha_1 \ln X_1 + \alpha_2 \ln X_2 + \alpha_3 \ln X_3 + \alpha_4 \ln X_4 + \\ + \alpha_5 \ln X_5 + \alpha_6 \ln X_6 + \alpha_7 \ln X_7 + e_i, \end{aligned} \tag{8}$$

where X_i (i = 1, 2, ..., 7) represents input energies from human labour (X_1), machinery (X_2), pesticides (X_3), chemical fertilizer (X_4), diesel fuel (X_5), water for irrigation (X_6), and electricity (X_7). In addition, the impacts of DE and IDE energies and RE and NRE energies on the yield were investigated. For this purpose the Cobb-Douglas function was selected and investigated as the following forms:

$$\ln Y_i = \beta_0 + \beta_1 \ln DE + \beta_2 \ln IDE + e_i, \tag{9}$$

$$\ln Y_i = \gamma_0 + \gamma_1 \ln RE + \gamma_2 \ln NRE + e_i, \tag{10}$$

where Y_i is the i^{th} farmer's yield; β_i and γ_i are coefficient of the exogenous variables; DE and IDE are direct and indirect energies, respectively, RE is renewable energy and NRE is non-renewable energy.

In this study the return to scale index was determined in order to analyze the proportional changes in output due to a proportional change in all the inputs (where all inputs increase by a constant factor). So, return to scale values for (8)—(10) were determined by gathering the elasticities, derived in the form of regression coefficients in the Cobb-Douglas production function. If the sum is more than, equal to, or less than unity, implying that there are increasing, constant, or decreasing returns to scale, respectively (Rafiee et al., 2010), an increasing, constant and decreasing return to scale indicate that when the energy inputs are increased by X value, then the yield of walnut production increases by more than, exactly and less than X value, respectively.

In the last part of the research, the marginal physical productivity (MPP) method, based on the response coefficients of the inputs was utilized to analyze the sensitivity of energy inputs on walnut yield. The MPP of a factor implies the change in the total output with a unit change in the factor input, assuming all other factors are fixed at their geometric mean level. A positive value of MPP of any input variable identifies that the total output is increasing with an increase in input; so, one should not stop increasing the use of variable inputs as long as the fixed resource is not fully utilized. A negative value of MPP of any variable input indicates that every additional unit of input starts diminishing the total output of previous units; therefore, it is better to keep the variable resource in surplus rather than utilizing it as a fixed resource.

The MPP of the various inputs was calculated using the α_j of the various energy inputs as follow (Rafiee et al., 2010):

$$MPP_{xj} = \frac{GM(Y)}{GM(X_j)} \times \alpha_j, \tag{11}$$

where MPP_{xj} is marginal physical productivity of j^{th} input; α_j is regression coefficient of j^{th} input; $GM(Y)$ is geometric mean of yield; $GM(X_j)$ is geometric mean of j^{th} input energy on per hectare basis. (8)—(11) were estimated using ordinary least square (OLS) technique.

Results and discussion:

1. Analysis of input-output energy used in walnut production. Table 3 represents the quantity of inputs and output used in walnut production and their energy equivalents. The results reveal that the quantity of labour and machinery power required in the walnut production were 1,305.19 and 37.26 ha^{-1}, respectively. The highest use of human labour was in harvesting operations (46%) and irrigation (15%). Also, the majority of machinery power was used in cultivating (47%). Additionally, according to the results, 149.31 L of diesel fuel, 276.60 kg of nitrogen, 215.34 kg of phosphate, 75.37 kg of potassium, 26.87 kg of insecticides, 14.31 kg of fungicides, 147.01 m^3 of water, 199.20 kW/h of electricity are used per hectare for walnut production. Average walnut yield was about 4,551.00 kg ha^{-1} in the studied region including 40% of kernel. The total energy equivalents of the inputs and outputs were calculated by multiplying the quantity per unit area by their equivalent energy. The total energy input and energy output were calculated as 42,092.86 and 73,161.88 MJ ha^{-1}, respectively.

Banaeian and Zangeneh (2011) found the total energy input and output for walnut production in Iran were 15,196.10 and 44,454.60 MJ ha^{-1} respectively. According to physical input use level in Iran, the total energy input and output was very low.

Table 3. **Amount of inputs, outputs and their energy equivalences in walnut production**

Input	Quantity per unit area (ha)	Total energy equivalent (MJ ha $^{-1}$)	% of total energy input
A. Inputs			
1. Human labour (h)	1,305.19	2,558.18	6.08
2. Machinery (h)	37.26	2,336.23	5.55
3. Pesticides (kg)			
a) Insecticides	26.87	5,347.60	12.70
b) Fungicides	14.31	1,316.58	3.13
4. Chemical fertilizers (kg)			
a) Nitrogen	276.60	16,761.96	39.82
b) Phosphorus	215.34	2,390.31	5.68
c) Potassium	75.37	504.98	1.20
5. Diesel-fuel (l)	149.31	8,407.89	19.97
6. Water for irrigation (m^3)	147.01	92.62	0.22
7. Electricity (kWh)	199.20	2,376.51	5.65
Total energy input (MJ)		**42,092.86**	**100.00**
B. Output			
1. Walnut kernel (kg)	1,820.40	45,855.88	
2. Wooden shell (kg)	2,730.60	27,306.00	
Total energy output (MJ)		**73,161.88**	

With respect to the obtained results, shown in Table 3, the shares of energy consumption in walnut production consist of 46.70% chemical fertilizer, 19.97% diesel fuel, 15.83% pesticides, 6.08% human labour, 5.65% electricity, 5.55% machinery and 0.22% water for irrigation. The highest portion of energy input incurred by chemical fertilizers. This is in agreement with the results found by Goktolga et al. (2006), Demircan et al. (2006), Gundogmus (2006), for peach, cherry and apricot productions, respectively. The results revealed that consumption of chemical fertilizers, diesel fuel, pesticides and electricity energy inputs is high for walnut production in the region.

The energy efficiency, energy productivity, specific energy and net energy of walnut production are listed in Table 4. The energy use efficiency (energy ratio) was determined as 1.74, indicating that energy consumption in walnut production in the surveyed region is efficient, i.e. energy production was greater than energy utilization.

Table 4. **Energy input-output ratio in walnut production**

Items	Unit	Quantity[e]
Energy use efficiency	-	1.74
Energy productivity	Kg MJ^{-1}	0.11
Specific energy	MJ kg^{-1}	9.25
Net energy	MJ ha^{-1}	31,069.04
Direct energy[a]	MJ ha^{-1}	13,435.20 (31.92%)
Indirect energy[b]	MJ ha^{-1}	28,657.66 (68.08%)
Renewable energy[c]	MJ ha^{-1}	2,558.18 (6.08%)
Non-renewable energy[d]	MJ ha^{-1}	39,534.68 (93.92%)
Total energy input	MJ ha^{-1}	42,092.86

[a] Includes human, diesel fuel, electricity and water for irrigation.
[b] Includes fertilizers, pesticides and machinery energy sources.
[c] Includes human labour.
[d] Includes diesel fuel, electricity, pesticides, fertilizers, machinery and water for irrigation.
[e] Figures in parentheses indicate percentage of total energy input.

Several authors have reported the energy ratio for different fruits such as 0.96 for cherries production (Demircan et al., 2006) and 0.93 for peach production (Goktolga et al., 2006) in Turkey, 1.54 for kiwi in Iran (Mohammadi et al., 2010), 1.25 for orange, 1.06 for lemon and 1.17 for mandarin in Turkey (Ozkan et al., 2004). Banaeian and Zangeneh (2011) found the energy ratio for walnut production as 2.90 in Iran. They considered the green shell while calculating the energy output differently.

The energy productivity, specific energy and net energy were found to be 0.11 kg MJ^{-1}, 9.25 MJ kg^{-1}, and 31,069.04 MJ ha^{-1}, respectively. Banaeian and Zangeneh (2011) reported the energy productivity and specific energy as 0.30 kg MJ^{-1} and 3.40 MJ kg^{-1} respectively, for walnut production in Iran.

The distribution of input energy in walnut production according to direct, indirect, renewable and non-renewable energy forms is listed in Table 4. As can be seen the direct and indirect energy forms consist of 31.92% and 68.08% of total energy input, respectively. The chemical fertilizer input energy has the highest share (68.59%) in indirect energy, followed by pesticides (23.25%). The shares of renewable and non-renewable energy are 6.08% and 93.92% of total energy input. Several researches have shown that the contribution of indirect energy is higher than that of direct energy, and the share of nonrenewable energy is more than that of renewable energy in production of different agricultural products (Banaeian and Zangeneh, 2011; Goktolga et al., 2006; Demircan et al., 2006; Akcaoz et al., 2009).

2. Econometric model estimation of energy inputs for walnut production. For investigating the relationship between energy inputs and yield of walnut production, the Cobb-Douglas production function was specified and estimated using ordinary least squares (OLS) estimation technique. Therefore, assumed that the walnut yield (endogenous variable) to be a function of human labour, machinery, pesticides, chemical fertilizers, diesel fuel, water for irrigation and electricity (exogenous variables). For the data used in this study presence of autocorrelation in the residuals from the regression analysis was tested using the Durbin-Watson statistic test (Hatirli et al., 2005). This test revealed that Durbin-Watson value was as 1.85 for (8), indicating no autocorrelation at the 5% significance level in the estimated model. The R^2 (coefficient of determination) was as 0.98 for this linear regression model. The regression results of (8) (Table 5) revealed that the contribution of water for irrigation is significant at the 1% level. Also the impact of human labour, machinery and chemical fertilizer are significant at the 5% level. The estimated coefficients indicate that the impact of energy inputs could be assessed as positive on walnut yield except machinery and electricity. These results show that machinery and electricity inputs were used excessively in walnut production.

Water for irrigation had the highest impact (0.37) between the inputs in walnut production indicating that by increase in the energy obtained from water for irrigation input, the amount of yield improves in present condition. With respect to the assessed results, increasing 100% in the energy of water for irrigation led to 37% increase in walnut output. The second important input was human labour with the elasticity of 0.43. Mohammadi et al. (2010) estimated an econometric model for kiwi production in Iran. They reported that the parameters of human labour, machinery, total fertilizers and water for irrigation had significant impacts in improving the yield of kiwi. For the same production, Banaeian and Zangeneh, (2011) found that the parameters of human labour, transportation, farmyard manure, chemical fertilizer, electricity and water for irrigation had significant impacts on walnut yield.

Table 5. **Econometric estimation results of inputs**

Exogenous variables	Coefficient	t-ratio	MPP
Model 1: $lnY_i = \alpha_0 + \alpha_1 lnX_1 + \alpha_2 lnX_2 + \alpha_3 lnX_3 + \alpha_4 lnX_4 + \alpha_5 lnX_5 + \alpha_6 lnX_6 + \alpha_7 lnX_7 + \varepsilon_i$			
Constant	0.44	1.98 [a]	
Human labour	0.43	2.33 [a]	0.50
Machinery	-0.15	-2.01 [a]	-0.31
Pesticides	0.06	0.78	0.11
Chemical fertilizers	0.15	1.81 [a]	0.18
Diesel-fuel	0.15	0.98	0.23
Water for irrigation	0.37	2.69 [b]	0.36
Electricity	-0.03	-0.28	-0.04
Durbin-Watson	1.85		
R^2	0.98		
Return to scale	1.42		

[a] Indicates significance at the 5% level.
[b] Indicates significance at the 1% level.

The MPP value of model variables is shown in the last column of Table 5. As can be seen the MPP of human labour, water for irrigation, and diesel-fuel were found to be 0.50, 0.36 and 0.23, respectively. This indicates that an increase of 1 MJ in each input of human labour, water for irrigation, and diesel-fuel energy, would lead to an additional increase in yield by 0.50, 0.1.32 and 0.71 kg ha^{-1}, respectively. The value of return to scale for the Model 1 was calculated by gathering the regression coefficients as 1.42.

The higher value of return to scale than unity implies increasing return to scale. For investigating the regression coefficients of direct, indirect, renewable and non-renewable forms of energy input with yield of walnut production the Models 2 and 3 were estimated using (9) and (10), respectively. The results are presented in Table 6. As can be seen, all the regression coefficients of direct, indirect, renewable and non-renewable energy forms were positive and significant at the 1% level.

Table 6. **Econometric estimation results of direct, indirect, renewable and non-renewable energies**

Exogenous variables	Coefficient	t-ratio	MPP
Model 2: $lnY_i = \beta_0 + \beta_1 lnDE + \beta_2 lnIDE + \varepsilon_i$			
Constant	0.24	2.11 [a]	
Direct energy	0.74	9.53 [b]	0.71
Indirect energy	0.22	2.78 [b]	0.27
Durbin-Watson	1.63		
R^2	0.96		
Return to scale	1.20		
Model 3: $lnY_i = \gamma_0 + \gamma_1 lnRE + \gamma_2 lnNRE + \varepsilon_i$			
Constant	0.45	4.71 [b]	
Renewable energy	0.61	3.80 [b]	0.70
Non-renewable energy	0.36	3.02 [b]	0.35
Durbin-Watson	1.69		
R^2	0.97		
Return to scale	1.42		

[a] Indicates significance at the 5% level.
[b] Indicates significance at the 1% level.

The impact of direct energy was higher than that of indirect energy (0.74 versus 0.22), implying that 100% increase in direct energy inputs led to 74% increase in yield, while 100% increase in indirect energy led to 22% increase in yield. Also the results show that the impact of renewable energy (0.61) was more than that of non-renewable energy (0.36) in walnut production.

Several authors had reported that the impact of direct energy is higher than that of indirect energy (Banaeian and Zangeneh, 2011) and the impact of renewable energy is higher than that of non-renewable energy (Heidari and Omid, 2011). For the Models 2 and 3 the statistic variables are presented in Table 5. Durbin-Watson statistic test revealed that Durbin-Watson values were 1.63 and 1.69 for (9) and (10), respectively; indicating no autocorrelation at the 1% significance level in the estimated models. The R^2 values were 0.96 and 0.97 for both estimated models.

The return to scale values for Models 2 and 3 were 1.20 and 1.42, respectively, implied increasing return to scale. As can be seen from Table 5, the MPP values of direct, indirect, renewable and non-renewable energies were 0.71, 0.27, 0.70 and 0.35, respectively. It indicates that an additional use of 1 MJ in each of the direct, indirect, renewable and non-renewable energies, would lead to an additional increase in yield by 0.71, 0.27, 0.70 and 0.35 kg ha^{-1}, respectively.

Conclusions. Optimization is an important tool to maximize the amount of productivity which can significantly impact the energy consumption and production costs. Optimization of energy usage in agricultural systems is reflected in two ways: an increase in productivity with the existing level of energy inputs or conserving energy without affecting the productivity. Energy management becomes more important when required energy should be economical, sustainable and productive.

In practice, according to econometric results walnut producers should reduce machinery and electricity inputs in order to obtain optimization. This problem can be expressed in mathematical form as a linear programming. So, the present study can be extended to identify efficient growers from inefficient ones, determine wasteful uses of energy inputs by inefficient growers and suggest necessary quantities of various inputs to be utilized by each inefficient grower from every energy source. More studies in this direction are currently underway.

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КНИЖКОВИЙ СВІТ

СУЧАСНА ЕКОНОМІЧНА ТА ЮРИДИЧНА ОСВІТА
ПРЕСТИЖНИЙ ВИЩИЙ НАВЧАЛЬНИЙ ЗАКЛАД

НАЦІОНАЛЬНА АКАДЕМІЯ УПРАВЛІННЯ

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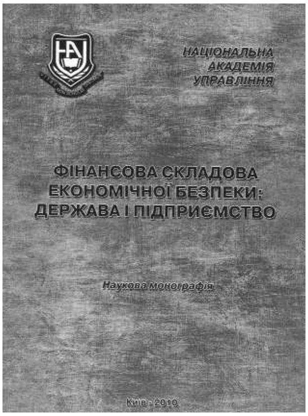

НАЦІОНАЛЬНА АКАДЕМІЯ УПРАВЛІННЯ

ФІНАНСОВА СКЛАДОВА ЕКОНОМІЧНОЇ БЕЗПЕКИ: ДЕРЖАВА І ПІДПРИЄМСТВО

Наукова монографія

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У монографії розкрито місце і засади фінансової безпеки в системі економічної безпеки на двох рівнях управління економікою країни: держави і підприємства. Розкрито роль економічної безпеки в розвитку економіки України, визначено і обґрунтовано шляхи забезпечення фінансової безпеки на рівні держави.

Викладено методологічні основи фінансової безпеки підприємства та управління нею. Визначено форми і методи удосконалення механізму управління фінансовою безпекою на рівні підприємства.