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Research Article

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Determination of the Energy Balance in the Sunflower Production in Thrace Region

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Abstract In this study, it is aimed to determine the energy inputs and outputs and the energy balance in the sunflower production in Thrace Region. The research was carried out in the province of Tekirdağ, which has the most agricultural land in the Thrace region. The data from 351 sunflower production enterprises were collected and evaluated. Total energy input in the sunflower production was found as 8014.61 MJ/ha. The ratios of physical, chemical and biological energy inputs in the total energy input were 45.4%, 52.4% and 2.2%, respectively. The total energy output in sunflower production was calculated as 64761.70 MJ/ha. The energy ratio, the specific energy and the energy productivity were calculated as 8.08, 3.24 MJ/kg and 0.31 kg/MJ, respectively. The net energy gain in sunflower production was 56749.09 MJ/ha.

Keywords Sunflower production, energy input, energy balance, energy ratio

Introduction

Efficiency in agricultural production is made by comparing the energy input required for production and the energy values of the outputs obtained. Agricultural mechanization practices are one of the important production elements that should be considered in terms of the expense burden that will affect the functionality and profitability of the enterprise in plant and animal production [1]. Energy analysis related to agricultural production is an important approach in defining and grouping agricultural systems in terms of energy consumption. In addition, in the evaluation of an agricultural production project in line with the principles of sustainable agriculture in recent years, economy, energy and environment are examined together.

Among the oilseed plants, the share of sunflower production in our country is high. Our country is one of the suitable countries in terms of sunflower production. However, sunflower production in Turkey is insufficient to meet the country's needs. Therefore, it is necessary to carefully analyze the inputs and outputs used in production in order to increase the yield and reduce the inputs in sunflower production.

The mechanization method applied in agricultural production significantly affects the energy inputs. In order to choose the most suitable mechanization method, energy analyzes must be done comprehensively. For this purpose, many researches including energy analysis are carried out in the production of different crops. In a study conducted in 23 countries in Europe, it was stated that the fuel energy input in sunflower production is 5300 MJ/ha, and the fertilizer energy input is 6700 MJ/ha [2]. In a study conducted in the province of Tokat, energy inputs in sunflower production were examined. Fertilizer and fuel energy inputs constituted 51.3% and 28.6% of the total energy input, respectively [3]. Energy input and output amounts were compared in the production of sunflower and canola in Fars, Iran. The necessary data for the calculations at the production stage were obtained from 99 producers by random sampling method. For canola production, the energy ratio was 2.90, the energy productivity was 0.12 kg/MJ and the specific energy value was 8.27 kg/MJ. In sunflower production, the energy rate was determined as 2.17, the energy productivity as 0.079 kg/MJ and the specific energy value as 12.52 kg/MJ [4]. In the winter rapeseed production in Adana, the total energy input was calculated as 7662.4 MJ/ha, and the total energy output was calculated as 68332.1 MJ/ha when only the seed yield was taken into account. Among the energy inputs, the highest input was determined in fertilizer energy with 38.2%, followed by fuel energy with 35.7% [5].

In this study, it was aimed to determine the energy efficiency of production by determining the energy inputs and outputs used in the production of sunflower in Tekirdağ province. As a result of the data obtained, production methods can be evaluated in order to increase energy efficiency.

Material and Method

This research was carried out in different sizes of fields where sunflowers are produced in Tekirdağ province. The data from 351 sunflower production enterprises were collected and evaluated. The annual average temperature of the researched region is 13.8 ºC. The annual average rainfall is 632 mm. With 17mm of precipitation, August is the driest month of the year. With an average of 83 mm of precipitation, the highest precipitation is seen in December.

Based on the information obtained from sunflower producers, the main production method applied for sunflower production was determined. Survey data collected in the process from soil preparation to harvest in sunflower production were entered into the computer environment and classified.

Energy inputs in sunflower production were examined under three groups as physical, chemical and biological energy inputs. Physical energy inputs are examined in two groups as direct (fuel and oil) and indirect (machine building energy, repair maintenance energy, transport and distribution energy) [6].

Calculation of physical energy inputs

The human labor energy input during sunflower production is determined as follows [6];

$$hl_{en} = \frac{n * t * l_{ev}}{A}$$

Where; hl_{en} is the human labor energy (MJ/ha), n is number of workers, t is operation time (h), l_{ev} is the energy equivalent of labor (1.96 MJ/h) and A is the processed area (ha).

While calculating the direct energy inputs in sunflower production, the data obtained from the producers and the literature information was used. Fuel and oil energies consumed by agricultural implements/machines during production processes were considered as direct energy inputs.

$$DE_{en} = F_{en} + O_{en}$$

Where; DE_{en} is the direct energy input (MJ/ha), F_{en} is the fuel energy input (MJ/ha) and O_{en} is the oil energy input (MJ/ha).

Fuel and oil energy inputs are calculated with the following equations [7];

$$F_{en} = F_c * F_{ev}$$

Where; F_c is the fuel consumption (l/ha) and F_{ev} is the energy value of fuel (35.7 MJ/l).

$$O_{en} = 0.045 * F_c * O_{ev}$$

Where; O_{ev} is the energy value of oil (6.51 MJ/l).

During the sunflower production processes, the manufacturing energy spent per worked area for the agricultural tools/machines used for each application was determined as follows [8];

$$M_{en} = W_m * U_{ev}$$

Where; M_{en} is the machine energy input (MJ), W_m is the mass of machine (kg), U_{ev} is the specific production energy of the machine (MJ/kg),

With the help of this equation, the manufacturing energy of the tractor, machinery and equipment in the enterprises was calculated separately. Literature and manufacturer information were used in the calculation (ASABE D497.4). The U_{ev} value in the equation is taken as 126 MJ/kg for tractors and combine, 70 MJ/kg for tillage machines and 62 MJ/kg for others [9].

Repair maintenance energy input is a certain ratio of machine building energy;

$$RM_{en} = M_{en} * e_y$$

Where; RM_{en} is the repair maintenance energy input (MJ), e_y is the Repair maintenance rate (~0.1).

Transport and Distribution energy is calculated as follows;

$$TD_{en} = W_m * 8.8$$

Where; TD_{en} is the Transport and Distribution energy input (MJ).

The total indirect energy input was calculated with the help of the following equation;

$$TI_{en} = \frac{M_{en} + RM_{en} + TD_{en}}{El_m * C_{ef}}$$

Where; TI_{en} is the total indirect energy input (MJ/ha), El_m is the economic life of the machine (h) and C_{ef} is the effective field capacity (ha/h).

With the help of these equations above, the total indirect energy input of the tractor, machineries and equipment in the enterprises was calculated separately.

The total physical energy input for each machine is calculated with the following equation;

$$TPh_{en} = hl_{en} + DE_{en} + TI_{en}$$

Where; TPh_{en} is the total physical energy input of each machine (MJ/ha)

Calculation of chemical energy inputs

Chemical fertilizer energy input in sunflower production was calculated by multiplying the amount of chemical fertilizers used in production and the energy equivalents of the fertilizers in the data obtained from the enterprises.

$$Fr_{ei} = A_{fr} * Fr_{ev}$$

Where; Fr_{ei} is the energy input of the fertilizer (MJ/ha), A_{fr} is the amount of fertilizer thrown per unit area (kg/ha) and Fr_{ev} is the amount of energy consumed per unit fertilizer production (MJ/kg).

The amount of energy consumed per unit fertilizer production is 45 MJ/kg for nitrogen, 8 MJ/kg for P_2O_5 and 5 MJ/kg for K_2O [10].

Pesticide energy input was calculated as follows;

$$P_{ei} = A_p * P_{ev}$$

Where; P_{ei} is the energy input of the chemical (MJ/ha), A_p is the amount of pesticide thrown per unit area (kg/ha) and P_{ev} is the amount of energy consumed per unit pesticide production (MJ/kg).

Energy consumption values per active substance in pesticides are 269 MJ/kg for herbicides and 214 MJ/kg for insecticides [11].

Calculation of biological energy input

In order to determine the seed energy in sunflower production, in accordance with the data collected from the enterprises, the sunflower seed planted on 1 ha area was found by multiplying the seed energy equivalent [12];

$$S_{ei} = A_s * S_{ev}$$

Where; S_{ei} is the energy input of the seed (MJ/ha), A_s is the amount of seed thrown per unit area (kg/ha) and S_{ev} is the amount of energy consumed per unit seed production (MJ/kg).

The energy equivalent of sunflower seeds is calculated by taking 52.6 MJ/kg [12].

The total energy input in sunflower production is calculated with the following equation;

$$TP_{en} = \sum TPh_{en} + Fr_{ei} + P_{ei} + S_{ei}$$

Where; TP_{en} is the total energy input of the sunflower production (MJ/ha)

Determination of energy outputs in sunflower production

The energy value of the sunflower obtained from the unit area was calculated as follows [6];

$$TE_{otp} = Y * SF_{ev}$$

Where;TE_{otp} is the total energy output (MJ/ha), Y is the yield of sunflower (kg/ha) and SF_{ev} is the energy value per unit sunflower (MJ/kg). The energy value of sunflower seeds is calculated by taking 26.3 MJ/kg [12]. By-product yield was not evaluated in the study.

Energy Efficiency Analysis

The energy ratio is a measure used in energy efficiency assessments. It was calculated using the following equation [1];

$$E_r = \frac{TE_{otp}}{TP_{en}}$$

Where; E_r is the energy ratio (-), TE_{otp} is the total energy output (MJ/ha) and TP_{en} is the total energy input (MJ/ha).

The specific energy was calculated with the following equation [1];

$$E_s = \frac{TE_{otp}}{Y}$$

Where; E_s is the specific energy of sunflower production (MJ/kg).

The energy productivity value was calculated as follows [10];

$$E_p = \frac{Y}{TE_{otp}}$$

Where; E_p is the energy productivity of sunflower production (kg/MJ).

The net energy gain is expressed as the difference between the energy equivalent of the product obtained as a result of production and the total amount of energy spent for the same production. The following equation was used while calculating the net energy efficiency value [1; 10];

$$E_{ng} = TE_{otp} - TP_{en}$$

Where; E_{ng} is net energy gain of sunflower production (MJ/ha).

Result and Discussion

The physical energy input in sunflower production was given Table 1. Total physical energy input was calculated as 3640.01 MJ/ha. Combine and plow have the highest physical energy input with values of 977.22 MJ/ha and 767.76 MJ/ha, respectively. The lowest physical energy input was 56.35 MJ/ha in sprayer. The highest direct energy input (fuel and oil) was 685.33 MJ/ha in plow. Combine follows this value with 582.27 MJ/ha. The highest indirect energy input was 393.94 MJ/ha in combine.

Table 1: The physical energy input of the sunflower production (MJ/ha)

Machine	hl_{en}	DE_{en}	TI_{en}		TPh_{en}
			Machine	Tractor	
Plow	1.37	685.33	11.22	69.85	767.76
Chisel	1.65	446.42	14.00	83.82	545.88
Cultivator 1	0.44	281.79	4.18	23.22	309.63
Cultivator 2	0.44	261.82	4.18	23.22	289.67
Harrow	0.49	130.57	5.56	24.74	161.35
Precision seeder	1.08	174.48	37.84	27.40	240.80
Centrifugal fertilizer	0.18	60.70	2.79	9.28	72.95
Hoeing machine	0.47	187.62	6.45	23.85	218.39
Sprayer	0.25	40.94	2.31	12.84	56.35
Combine	1.00	582.27	368.50	25.44	977.22
Total	**7.37**	**2851.95**	**457.02**	**323.67**	**3640.01**

Total energy input in sunflower production has been given in Table 2. Chemical energy input was highest with value of 4196.3 MJ/ha. This value constitutes 52.4% of the total energy input. Physical energy input follows this value with 45.4%. The lowest value has been in biological energy input with 178.30 MJ/ha (2.2%).

Table 2: The total energy input of the sunflower production (MJ/ha)

	Energy Input	Rate (%)
Physical	3640.01	45.4
Chemical (fertilizer)	3596.90	44.9
Chemical (pesticide)	599.40	7.5
Biological (seed)	178.30	2.2
Total	**8014.61**	**100.0**

Average sunflower yield was 2470 kg/ha. The total energy output was calculated as 64761.70 MJ/ha.

The energy ratio of sunflower production was found as 8.08 (Table 3). The specific energy and energy productivity were 3.24 MJ/kg and 0.31 kg/MJ, respectively. For canola production, the specific energy and energy productivity were determined as 3.20 and 0.31 kg/MJ, respectively [13]. Energy efficiency indicators of sunflower and canola production have been seen to be close each other. Net energy gain in sunflower production was 56747.09 MJ/ha.

Table 3: Energy efficiency indicator values

Energy ratio	8.08
Specific energy	3.24 MJ/kg
Energy productivity	0.31 kg/MJ
Net energy gain	56747.09 MJ/ha

Conclusion

In this research, the energy input and output in sunflower production have been evaluated in Thrace region, Turkey. According to the results of the survey conducted with the sunflower producers in the region, it is possible to make some suggestions for increasing the energy efficiency in sunflower production. A tool/machine with a suitable capacity for the power source (tractor) should be used. Thus, both fuel consumption and tool/machine energy input will decrease. Soil analysis should be done before fertilizing. According to the analysis results, the type and amount of fertilizer should be determined. The producer should choose the sunflower seeds to be purchased according to the land structure and adjust the sowing norm. Seeds of good quality, resistant to diseases and pests should be selected.

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