Cost and energy analysis of sunflower that produced in Turkey: case of Tokat Province

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Gülçin Altıntaş
PhD in Agricultural Economics, Gaziosmanpasa University
İnstitution: Middle Black Sea Transitional Zone Agricultural Research Institute
Address: Middle Black Sea Transitional Zone Agricultural Research Institute Department of Agricultural Economics, P.O.Box:60240, Tokat, Turkey.
E-mail: **altintasgulcin@gmail.com**

Abstract

In this study, energy analysis and economic analysis of sunflower plant are compared according to irrigated circumstances and dry circumstances in Tokat province of Turkey. According to the results of the research, the cost of producing a kilogram of sunflower; it was calculated as 0.33$ in irrigated circumstances and 0.39$ in dry circumstances. The production cost per hectare of sunflower under irrigated circumstances was 1153$, and in dry circumstances it was 774$. In the irrigated circumstances; the share of variable costs in production costs as 67,45 % and the share of fixed costs in production costs was determined as 32,55 %. Maintenance labor cost has constituted a significant part of the variable costs. Share of the maintenance labor cost in the production costs was calculated as 27,75%, share of the labor and machinery cost for soil preparation 9,40 %, then harvest loading-unloading transport cost 9,39 %. In the dry circumstances; he share of variable costs in production costs as 75,03 % and the share of fixed costs in production costs was determined as 24,97%. Share of the maintenance labor cost in the production costs was calculated as 30,85 %, labor and machinery cost 14,02 % harvest loading-unloading transport cost 11,70 %. Total cost per ha in the irrigated circumstances because of the water of irrigation cost and land rent were higher than in the dry circumstances. The energy value of the used inputs for sunflower produced in irrigated circumstances was 16515,05 $MJha^{-1}$ and for in dry circumstances it was 12511,72 $MJha^{-1}$. In irrigated circumstances nitrogen usage was the highest energy consuming input among the all energy consumption (40,05%). The energy consumption for diesel fuel was 32,16% of the total energy input. In dry circumstances nitrogen usage was calculated as 42,29%. The energy consumption for diesel fuel was as calculated 39,90% of the total energy input. As a result, it is more advantageous to production sunflower in the irrigated circumstances as to energy efficiency. Production sunflower in the dry circumstances is more advantageous in terms of production cost.

Keyword: Sunflower. Cost analysis. Energy analysis.

1. Introduction

It is known that great importance of oilseed crops in meeting the oil consumption needs of people depending on rapidly population growth (Gul et al., 2016).

While in the world production of vegetable oils, mainly palm oil, soy, rapeseed and sunflower met, in Turkey are largely met from sunflower (Anonymous, 2020a). The main reasons for this are that sunflower has high adaptability, can be grown in dry and watery conditions, it is suitable for mechanization, and the amount of oil obtained from the unit area is high because its seeds contain a high percentage of oil (40-55%) (Gul et al., 2016).

Oilness sunflower, in addition to vegetable oil, it is also used for pulp and biodiesel production. Approximately 90% of the sunflower produced in the world is processed for oil and the remaining part is consumed as sunflower seeds. Sunflower ranks 3rd in the world oilseed production (Anonymous, 2020b).

According to FAO data, in world are produced sunflower of 56 million tons in 20,8 million hectares of land. In Russia 40,3%, in Ukraine 28,5%, in Argentina 8,9% of the sunflower cultivation lands of the world are located. These three countries account for 61,5% of world sunflower production. In Turkey are produced 2,1 million tons of sunflower in 751 thousand hectare lands. Sunflower produced in Turkey in 2019 composes 3,75 % of world sunflower production. In terms of world production of sunflower Turkey 6th it is located (Anonymous, 2019a).

Most sunflower oil as vegetable oil is preferred in Turkey. For this reason, sunflower ranks first among the grown oilseeds in terms of cultivation area and production amount. Although the sunflower, cultivation area and production amount have increased in recent years, a significant part of the vegetable oil consumption need is met through imports. Closing the vegetable oil gap can be possible by increasing the efficiency of the unit area as well as increasing the existing production areas. However, the desire to obtain more products per unit area causes an increase in main inputs such as fertilizers, seeds, pesticides used in production. Controllability of input use at every stage of agricultural production is extremely important in terms of sustainable agriculture. On the other hand, it is also very important to increase production, increase quality and use energy efficiently.

In sunflower production to increase efficiency and reduce inputs, used inputs and outputs should be analyzed carefully (Sabah et al., 2016) besides calculated the sunflower production cost.

The decrease in water potential as a result of climate change necessitates the efficient use of water resources. Since approximately 70% of the world's water resources are used in agriculture, water saving in agricultural irrigation becomes a priority, especially (Anonymous, 2020c). It is of great importance to determine the input and energy consumption of products and production cost that can be grown in dry conditions and to investigate yield-increasing methods.

2. Literature Review

Das and Roud, (2018) determined in their study the economic analysis of sunflower crop. The overall cost of production was found Rs. 44346.05. The gross income per hectare in cultivation of sunflower was found Rs. 90282.00. The net income was found workout Rs. 37682.65. The timely not availability of labor, irrigation supply, electricity, lack of storage facility at farm level, weeding problem, unawareness of the seed rate were the major constraints identified in production of oilseed crops.

Karaagaç et al. (2018) calculated energy balance and economy analysis in sunflower in Adana. According to study results The energy output/input rate, specific energy value, energy productivity, net energy production, were found as 8.00, 3.29 MJ/kg, 0.30 kg/MJ and 77322.41 MJ/ha respectively. In sunflower production, it was found that the highest usage ratio in total energy input belongs to fertilizer energy by 50.93 %. This ratio was followed by 32.84 % fuel-oil energy and 10.73 % machine energy. In economy analysis of sunflower production was obtained total input amount 345.47 TL/da, output amount 504.00 TL/da, net gain amount 158.53 TL/da.

Unakitan and Aydin (2018) determined the production costs, gross returns, net returns and benefit/cost ratios of wheat and sunflower production. The variable costs of wheat and sunflower production were determined to be 692.68 USD and 483.75USD, respectively. The total cost and gross value of sunflower production were 755.63 and 1,323.3$/ha, respectively, with an approximate 48% variable costs, and 52% fixed costs. Gross values of sunflower were calculated to be 1132 USD.

Aghili Nategh et al. (2020) determined the total cost and gross value of sunflower production were 755.63 and 1,323.3$/ha, respectively, with an approximate 48% variable costs, and 52% fixed costs.

So as to determine production costs and the energy efficiency in plant production in the world, separate studies have been conducted. However, there is no study comparing the production cost and energy consumption of sunflower grown in both irrigated and dry circumstances. As it is known, sunflower is grown in both dry and irrigated conditions in the world.

In this study the costs of production and economic analysis of sunflower plant are compared according to irrigated and dry circumstances. Moreover in this study, energy consumptions and input-output relations, energy forms and economic analysis were calculated separately for sunflower that produced in the circumstances irrigated and dry.

3. Materials and Methods

In this study data used in the research came from the annual cost study which was done Republic of Turkey Ministry of Agriculture and Forestry Tokat Directorate of Provincial Agriculture and Forestry and from the cost study which was done in 2014 by Altintas (Anonymous, 2019b; Altintas, 2014).

Tokat province, located in the Central Black Sea Region, it is one of Turkey's most important agricultural production areas. Different geographical and climatic characteristics increase the variety of crop patterns in the province (Uzunoz et al., 2008). The major field crops grown in Tokat are wheat, sugar beet, sunflower, chickpea, barley, tomato, etc. The arable land is 311 196 ha in Tokat and the irrigable arable area is approximately 35% (110 795 ha). 14.65% of the total arable lands in Tokat are used for sunflower production and approximately 57% of this sunflower cultivation area is grown in irrigated conditions and 43% in dry conditions (Anonymous, 2019c). According to the Meteorological Service of the Republic of Turkey (2019) meteorology data the average rainfall of Tokat is 436 mm per year (Anonymous, 2019d).

The cost and profitability were separately detected for sunflower that produced in the circumstances irrigated and dry. In this context, single product budget analysis was used while making calculations (Kiral et al., 1999).

The costs of production were calculated as fixed and variable costs. As variable costs; labor and machinery cost for soil preparation, maintenance labor cost, harvest loading-unloading- transport cost, seeds, fertilizers, herbicides, insecticide, fungicide, water of irrigation, revolving capital interest cost have been taken.

In the calculation of family labor fee, the daily wages given to the workers in the region were taken basis. In the calculation of capital interest, half of the interest rate applied by T.C. Ziraat Bank on crop production credits (5%) was taken into consideration (Kiral et al., 1999).

As fixed costs; land rent and management cost were taken. The land rent in the fixed cost group was evaluated over the current rental rates in the village. Management cost; have been calculated by taking 3% the sum of the variable cost and land rent.

The gross value of production, net returns, total cost of production, benefit to cost ratio and productivity indices (Mohammadi et al., 2008; Mrini et al., 2001) were calculated by using equation (1; 2; 3; 4; 5).

$$Gross\ production\ value\ =\ Product\ yield\ (kg\ \ ha^{-1})\ \times\ Product\ price\ (\$\ \ kg^{-1}) \quad (1)$$

$$Cost\ of\ production\ (\$\ kg^{-1})\ =\ Cost\ of\ production\ (\$\ \ ha^{-1})/Product\ yield\ (kg\ ha^{-1}) \quad (2)$$

$$Net\ return\ \ ==\ Gross\ production\ value\ (\$\ ha^{-1})\ -\ Cost\ of\ production\ (\$\ \ ha^{-1}) \quad (3)$$

$$Benefit\ to\ cost\ ratio\ \ =\ Gross\ production\ value\ (\$\ ha^{-1})/Cost\ of\ production\ (\$\ ha^{-1}) \quad (4)$$

$$Productivity\ \ =\ Product\ yield\ \ (\ kg\ \ ha^{-1})/Cost\ of\ production\ (\$\ ha^{-1}) \quad (5)$$

In this study, their amounts and the inputs which are used in sunflower production pertains production period in 2019. Energy equivalents of input output for sunflower production are given in Table 1. The data in Table 1 were gathered from various sources.

Table 1: Energy equivalents of inputs and output in agricultural production

Particulars	Unit Energy	Equivalent (MJ unit^{-1})	References
Human Labor	hour	1,96	[De et al., 2001;Singh, 2002;Mohammadi and Omid, 2010]
Machinery	hour	62,7	[Singh et al., 2002; Alam et al., 2005; Canakci et al., 2005; Esengun et al., 2007]
Nitrogen (N)	kg	66,14	[Singh, 2002; Esengun et al., 2007;Mousavi-Avval et al., 2011a; Shrestha, 1998]
Phosphate (P_2O_5)	kg	12,44	[Esengun et al., 2007; Shrestha, 1998]
Herbicides	kg	288	[Green, 1987; Hulsbergen et al., 2001]
Insecticides	kg	237	[Green, 1987; Hulsbergen et al., 2001]
Fungicides	kg	196	[Green, 1987; Hulsbergen et al., 2001]
Seeds	kg	25	[Hamzei and Seyyedi, 2016; Sinha et al. 2017]
Diesel-oil	liter	56,31	[Singh, 2002; Esengun et al., 2007; Barber, 2003]
Water irrigation	m^3	1,02	[Hamedani et al., 2011;Rafiee et al., 2010; Mohammadi and Omid 2010; Mohammadi et al., 2008]
Output (Sunflower)	kg	25	[Uzunoz et al., 2008; Hamzei and Seyydi, 2016;Hatirli et al., 2005]

The input and output for sunflower were calculated per hectare. These input and output data were multiplied by the coefficient of energy equivalents. The energy equivalences of unit inputs are given in mega joule (MJ). Then the energy use efficiency, energy productivity and specific energy were determined. The energy ratio (energy use efficiency), energy productivity, specific energy (Mohammadi and Omid, 2010), net energy, energy intensiveness (Ghorbani et al., 2011) were calculated by using equation (6; 7; 8; 9; 10).

$$Energy\ use\ efficiency = \frac{Energy\ output\ (MJ\ ha^{-1})}{Energy\ input\ (MJ\ ha^{-1})} \quad (6)$$

$$Energy\ productivty = \frac{Product\ output\ (kgha^{-1})}{Energy\ input\ (MJ\ ha^{-1})} \quad (7)$$

$$Specific\ energy = \frac{Energy\ input\ (MJ\ ha^{-1})}{Product\ output\ (kgha^{-1})} \quad (8)$$

$$Net\ energy = Energy\ output\ (MJ\ ha^{-1}) - Energy\ input\ (MJ\ ha^{-1}) \quad (9)$$

$$Energy\ intensiveness = \frac{Energy\ input\ (MJha^{-1})}{Cost\ of\ cultivations\ (\$\ ha^{-1})} \quad (10)$$

In this study, the input energy was examined in direct, indirect, renewable and non-renewable forms. The direct energy covers human labor, diesel and water for irrigation. The indirect energy covers the seeds, fertilizers, chemicals and machinery.

The non-renewable energy sources include diesel, fertilizers, chemicals and machinery, whereas the renewable energy sources include human labor, seeds and irrigation water (Samavatean et al., 2011).

4. Results and Discussion

4.1. Economic analysis of sunflower in irrigated and dry circumstances

Cost analysis in sunflower is given in Table 2. The total cost of production in irrigated circumstances were found to be $ 1153,34. The share of variable costs in production costs as 67,45 % and the share of fixed costs in production costs was determined as 32,55 %. Maintenance labor cost has constituted a significant part of the variable costs. Share of the maintenance labor cost in the production costs was calculated as 27,75 %, share of the labor and machinery cost for soil preparation 9,40 %, then harvest loading-unloading transport cost 9,39 %.

The total cost of production in dry circumstances were found to be $ 774,88. The share of variable costs in production costs as 75,03 % and the share of fixed costs in production costs was determined as 24,97 %. Share of the maintenance labor cost in the production costs was calculated as 30,85 %, labor and machinery cost 14,02 % harvest loading-unloading transport cost 11,70 %. Total cost per ha in the irrigated circumstances because of the water of irrigation cost and land rent were higher than in the dry circumstances.

Turkey Blacksea Region (Uzunoz et al., 2008) the share of variable cost in production costs sunflower 69.26%, the proportion of the fixed cost is calculated as 30.74%. In Iran (Nageth-Aghili et al., 2020) the share of variable cost in production costs sunflower 48%, the proportion of the fixed cost is calculated as 52%.

Table 2: Costs analysis in sunflower production

Cost Elements	Irrigated Circumstances		Dry Circumstances	
	Cost of production ($)/ha	%	Cost of production ($)/ha	%
Labor and machinery cost for soil preparation (a)	108,45	9,40	108,63	14,02
Maintenance labor cost (b)	320,07	27,75	239,08	30,85
Harvest loading-unloading transport cost (c)	108,28	9,39	90,67	11,70
Input costs				
Seeds	31,69	2,75	31,69	4,09
Fertilizers (N)	38,73	3,36	30,99	4,00
Fertilizers (P2O5)	38,73	3,36	19,37	2,50
Herbicides	11,45	0,99	11,44	1,48
Insecticides	7,04	0,61	7,04	0,91
Fungicides	14,79	1,28	14,79	1,91
Water of irrigation cost	61,62	5,34	0,00	0,00
Total input costs (d)	204,05	17,69	115,32	14,88
Total (e) (e=a+b+c+d)	740,85	64,23	553,70	71,46
Revolving capital interest (f=e*0,05)	37,04	3,21	27,68	3,57
Variable Cost (g) (g=e+f)	**777,89**	**67,45**	**581,38**	**75,03**
Management cost (h) (h= (g*0,03)	23,34	2,02	17,44	2,25
Land rent (i)	352,11	30,53	176,06	22,72
Fixed cost (j) (j= h+i)	**375,45**	**32,55**	**193,50**	**24,97**
Cost of Production (g+j)	**1153,34**	**100,00**	**774,88**	**100,00**

1US$ = TL 5,68 in average monthly 2019

Table 3 presents the economic comparison for sunflower in irrigated circumstances and dry circumstances. In the irrigated circumstances the cost of raising one kg of sunflower was calculated as 0,33 $ and the average yield was found as 3500 kg. Gross production value is 1470 $\$ha^{-1}$, net income is 316,66 $. The benefit-cost ratio was found to be 1,27 in the irrigated circumstances.

In the dry circumstances the cost of raising one kg of sunflower was calculated as 0,39 $ and the average yield was found as 2000 kg. Gross production value is 840 $\$ha^{-1}$, net income is 65,12 $. The benefit-cost ratio was found to be 1,08 in the dry circumstances.

In Turkey Blacksea Region (Uzunoz et al., 2008) the net income was calculated as negative, in Adana-Turkey (Karaagac et al., 2018) , in Punjub-Indian (Sinha et al., 2017), and in Iran –Kermanshah (Nageth-Aghili et al., 2020) were calculated the net income as positive.

Gross production value and net return in the irrigated circumstances was higher than in the dry circumstances. Because in the irrigated circumstances are high sunflower yield. Benefit to cost ratio in the irrigated circumstances (1,27) was higher than in the dry circumstances (1,08). In this study productivity for in the irrigated circumstances and in the dry circumstances was 3,03 and 2,58 kg$^{-1}, respectively.

In Turkey Blacksea Region (Uzunoz et al., 2008) the benefit-cost ratio was calculated as 0,51. However, on the other studies , in Adana-Turkey (Karaagac et al., 2018) , in Punjub-Indian (Sinha et al., 2017), and in Iran –Kermanshah (Nageth-Aghili et al., 2020) were found higher than one.

Table 3: Economic analysis (sunflower)

Elements of analysis	Unit	Irrigated Circumstances	Dry Circumstances
Yield	kg ha^{-1}	3500,00	2000,00
Cost of production	$ ha^{-1}	1153,34	774,88
Cost of production	$ kg^{-1}	0,33	0,39
Sales price	$ kg^{-1}	0,42	0,42
Gross production value	$ ha^{-1}	1470,00	840,00
Net return	**$**	**316,66**	**65,12**
Benefit-cost ratio		1,27	1,08
Productivity	**kg$-^{1}**	3,03	2,58

4.2. Energy consumption analysis

In this study, the energy usage levels of output and the inputs used in the production for the sunflower grown with irrigated circumstances and dry circumstances were determined. Then the energy equivalents of the inputs and outputs used in sunflower were calculated. Energy consumption and input-output relationship in the Table 4 are given.

When the use of inputs in the sunflower production is examined, it is determined that per hectare 147,80 hours of labor is used in the sunflower grown with irrigated circumstances and 139,20 hours of labor in the sunflower grown with dry circumstances (Table 4). The labor force used per hectare for sunflower production it was seen that 131,7 hours in Golestan-Iran (Mousavi-Avval et al., 2011b), 167,20 hours in Fars-Iran (Davoodi and Houshyar, 2009), 179,20 hours in Blacksea Region -Turkey (Uzunoz et al. 2008).

In the sunflower grown with irrigated circumstances, it is seen that per hectare 147,80 hours of labor, 11 hours machine power, 100 kg nitrogen, 100 kg phosphate, 1 kg herbicides, 0,50 kg insecticides, 0,70kg fungicides, 94,32 liters diesel oil, 1640 m^3 water are used. In the sunflower grown with dry circumstances, it is seen that 139,20 hours of labor, 10,20 hours machine power, 80 kg nitrogen, 50 kg phosphate, 1 kg herbicides, 0,50 kg insecticides, 0,70 kg fungicides, 88,66 liters diesel oil are used (Table 4). It was determined that the use of input was lower in the sunflower grown with dry circumstances. When the output amounts are examined, it is seen that in the sunflower yield grown with irrigated circumstances is high.

The energy equivalents of the inputs and output used in sunflower production was compared in the both of cultivation systems. The total input energy in sunflower production was found to be 16515,05 MJ in irrigated circumstances and 12511,72 MJ in dry circumstances (Table 4). The total energy input in irrigated circumstances was higher than in dry circumstances. In the studies conducted in Turkey, the total input energy in sunflower production was determined as 15565,10 MJ in Thrace Region (Baran and Karaagac, 2014), 11045,59 MJ in Adana (Karaagac et al., 2018), as 18931,09 MJ in Blacksea (Uzunoz et al., 2008). In the other countries, the total input energy values were determined as 22945,3 in Fars-Iran (Davoodi and Houshyar, 2009), as 29647 MJ – 34744 MJ in different tillage treatments in Hamedan- Iran (Hamzei and Seyyedi, 2016), as 10430 MJ in Evros-Greece (Kallivroussis et al., 2002). The total energy input in our study is similar to studies conducted in Turkey, from the studies conducted in Iran is low, it is higher than study conducted in Greece.

Among the all energy sources used in irrigated circumstances, the highest share is nitrogen usage with 40,05 %. The share of the diesel-oil in the total energy input was calculated as 32,16 %. The share of in the total energy input of the water for irrigation was determined as 10,13 % (Table 4). In Turkey; was reported that 28% of total input energy is chemical fertilizer, 24% of it is diesel energy and 30% water for irrigation in Thrace Region (Baran and Karaagac, 2014). In Blacksea Region was stated that chemical fertilizers (51%), diesel fuel (28%) and machinery energy (%8), were the foremost contributors to the total input energy followed by water for irrigation (5%) (Uzunoz et al., 2008). In Kermanshah- Iran was reported that 40% of total input energy is fertilizer, 25% of it is diesel energy and 1% water for irrigation (Nageth-Aghili et al., 2020). In Fars-Iran was reported that 26% of total input energy is fertilizer, 27% of it is diesel energy and 6% water for irrigation (Davoodi and Houshyar, 2009).

Among the all energy sources used in dry circumstances, the highest share is nitrogen usage with 42,29 %. The share of the diesel-oil in the total energy input was calculated as 39,90 %. The share of in the total energy input of the machine power was determined as 5,11 % (Table 4). In Adana-Turkey was reported that 51% of total input energy is fertilizer and 33% of it is diesel energy (Karaagac et al., 2018). In Aydın-Turkey was reported that 55% of total input energy is fertilizer and 23% of it is diesel energy (Ozturk and Kucukerdem, 2016).

In Greece-Evros was reported that 42% of total input energy is fertilizer and 34% of it is diesel energy (Kallivroussis et al., 2002).

In this study energy use efficiency were determined as 5,30 in the irrigated circumstances and as 4 in the dry circumstances (Table 4). Energy use efficiency in the studies conducted to determine energy use for sunflower in Turkey were determined as 8 in Adana-East Mediterranean Region (Karaagac et al., 2018), as 3,21 in Thrace Region (Baran and Karaagac, 2014), as 6,63 in Aydın-Aegean Region (Ozturk and Kucukerdem, 2016), as 2,95 Tokat-Blacksea Region (Uzunoz et. al, 2008). Energy use efficiency in sunflower production in the other countries were determined as 8,97-7,17 under different irrigation and fertigation programs in Punjab-Indian (Sinha et al., 2017). In Iran were determined as 2,17 in Fars (Davoodi and Housyhar, 2009), as 6,35-6,07 at different tillage treatments in Hamedan (Hamzei and Seyyedi, 2016). In Greece were determined as 4,5 (Kallivroussis et al., 2002), as 2,88 in Thessaly (Gemtos et al., 2013). In our study, the energy ratios calculated are compatible with the energy ratios in previous studies.

Table 4: Energy consumption and input-output relationship for sunflower production

Practices	Unit	Quantity per unit area (ha)		Energy equivalent (MJ/unit)	Total energy equivalent (MJ)		Percentage (%)	
		Irrigated circumstances	Dry circumstances		Irrigated circumstances	Dry circumstances	Irrigated circumstances	Dry circumstances
Human Labor	hour	147,80	139,20	1,96	289,69	272,83	1,75	2,18
Land preparation		8,80	9,80	1,96	17,25	19,21	0,10	0,15
Cultural practices		135,30	125,80	1,96	265,19	246,57	1,61	1,97
Harvesting		3,70	3,60	1,96	7,25	7,06	0,04	0,06
Machinery	hour	11,00	10,20	62,7	689,70	639,54	4,18	5,11
Land preparation		7,20	8,10	62,7	451,44	507,87	2,73	4,06
Cultural practices		1,60	0,00	62,7	100,32	0,00	0,61	0,00
Transportation		2,20	2,10	62,7	137,94	131,67	0,84	1,05
Fertilizers								
Nitrogen (N)	kg	100,00	80,00	66,14	6614,00	5291,20	40,05	42,29
Phosphate (P_2O_5)	kg	100,00	50,00	12,44	1244,00	622,00	7,53	4,97
Chemicals								
Herbicides	kg	1,00	1,00	288	288,00	288,00	1,74	2,30
İnsecticides		0,50	0,50	237	118,50	118,50	0,72	0,95
Fungicides		0,70	0,70	196	137,20	137,20	0,83	1,10
Seeds	kg	6,00	6,00	25	150,00	150,00	0,91	1,20
Diesel-oil	lt	94,32	88,66	56,31	5311,16	4992,44	32,16	39,90
Water for irrigation	(m^3)	1640,00	0,00	1,02	1672,80	0,00	10,13	0,00
Yield (Output)		3500,00	2000,00	25	87500,00	50000,00		

Total input energy	**MJ**	**16515,05**	**12511,72**	**100,00**	**100,00**
Energy Ratio (Energy use efficiency)		**5,30**	**4,00**		

There are several parametric and non-parametric approaches to measure the efficiency in agricultural productions; based on the literature, the indices of energy use efficiency (output energy to input energy ratio) and specific energy (i.e., input energy to yield ratio) have been used extensively to measure the energy efficiency of agricultural production systems (Mousavi-Avval et al., 2011a).

The energy use efficiency, energy intensiveness, specific energy, energy productivity and net energy of sunflower production were given in Table 5.

Specific energy is the amount of energy consumed to produce a unit of product. To be low specific energy value means to be high of energy efficiency in production. The specific energy was determined as 4,72 MJ kg^{-1} in the sunflower grown with irrigated circumstances and 6,26 MJ kg^{-1} for dry circumstances (Table 5). In this case, the energy required to produce one kg of sunflower was used more effectively on the irrigated circumstances. Specific energy on irrigated circumstances in Turkey were determined as 8,19 in Thrace Region (Baran and Karaagac, 2014), as 8,4 Tokat-Blacksea Region (Uunoz et al., 2008). Specific energy on dry circumstances in Turkey were determined as 3,29 in Adana-East Mediterranean Region (Karaagac et al., 2018), as 3,69 in Aydın-Aegean Region (Ozturk and Kucukerdem, 2016). Specific energy in the other countries were determined as 12,52 in Fars-Iran(Davoodi and Houshyar, 2009), as 2,43 in Kermanshah- Iran (Nageth-Aghili et al., 2020), as 2,88 in Thessaly- Greece (Gemtos et al., 2013).

The energy productivity in sunflower production was found to be 0,21 $kgMJ^{-1}$ in the irrigated circumstances and 0,16 $kgMJ^{-1}$ in the dry circumstances. This means that 0,21 and 0,16 outputs were obtained per unit energy consumed according to production condition (Table 5). This coefficient, which refers to the amount of product received per energy use, is more advantageous for sunflower produced with irrigated circumstances. The energy productivity on irrigated circumstances in Turkey were determined as 0,12 in Thrace Region (Baran and Karaagac, 2014), as 0,12 in Tokat-Blacksea Region (Uzunoz et al., 2008). The energy productivity on dry circumstances in Turkey were determined as 0,30 in Adana-East Mediterranean Region (Karaagac et al., 2018), as 0,25 in Aydın-Aegean Region (Ozturk and Kucukerdem, 2016). The energy productivity in the other countries were determined as 0,079 in Fars-Iran (Davoodi and Houshyar, 2009), as 0,41 in Kermanshah- Iran (Nageth-Aghili et al., 2020), as 0,13 in Thessaly- Greece (Gemtos et al., 2013).

The net energy is calculated as the difference between energy output and energy input. Net energy was found to be 70984,95 MJha^{-1} in the irrigated circumstance and 37488,28 MJha^{-1} in dry circumstances (Table 5). In this case, sunflower cultivation is seen to be more advantageous in the irrigated circumstances. The net energy in Turkey were determined as 34 404,90 MJha^{-1} in Thrace Region (Baran and Karaagac, 2014), as 36 819 MJha^{-1} in Tokat-Blacksea Region (Uzunoz et al., 2008). The net energy in the other countries were determined as 26 912,93 MJha^{-1} in Fars-Iran (Davoodi and Houshyar, 2009), as 39 803,10 MJha^{-1} in Kermanshah- Iran (Nageth-Aghili et al., 2020), as 51 002 MJha^{-1} in Thessaly- Greece (Gemtos et al., 2013).

The energy intensiveness was calculated as 14,32 MJ^{-1} in irrigated circumstances and 16,15 MJ \$$^{-1}$ in dry circumstances.

Table 5: Energy input-output ratio in sunflower production

Items	Unit	Irrigated circumstances	Dry circumstances
Energy input	MJ ha^{-1}	16515,05	12511,72
Energy output	MJ ha^{-1}	87500,00	50000,00
Sunflower output (yield)	kg ha^{-1}	3500,00	2000,00
Energy use efficiency	-	5,30	4,00
Specific energy	MJ kg^{-1}	4,72	6,26
Energy productivity	kg MJ^{-1}	0,21	0,16
Net energy	MJ ha^{-1}	70984,95	37488,28
Energy intensiveness	MJ \$$^{-1}$	14,32	16,15

Table 6 shows the distribution of total energy input as direct, indirect, renewable and nonrenewable forms for sunflower production. As it can be seen from the Table 6 in the irrigated circumstances 44,04% of total energy input are composed from direct and 55,96% from indirect energy and 12,79% from renewable and 87,21% from non-renewable energy. In the dry circumstances are composed 42,08% of total energy input resulted from direct and 57,92% from indirect energy and 3,38% from renewable and 96,62% from non-renewable energy. The results are similar in both production methods.

In Thrace Region of Turkey (Baran and Karaagac, 2014) were found indirect energy (75,26%) was higher than direct energy (24,74%). In Adana-Turkey (Karaagac et al., 2018) were found indirect energy (68%) was higher than direct energy (32%). In Blacksea Region of Turkey (Uzunoz et al., 2008) were found indirect energy (64,13%) was higher than direct energy (30,41%). In the studies done in Iran calculated the indirect energy as 58,52%,direct energy as 41,47% (Nageth-Aghili et al., 2020) . However, in their study of Davoodi and Houshyar 2009 found direct energy (57,94%) was higher than indirect energy (42,06%).

The amount of non-renewable energy in both production circumstances is high. This is due to the high consumption of fertilizer and diesel oil. The share of diesel fuel and fertilizer (mainly nitrogen) can play a major role in improving of energy use efficiency. Similar results were found in other studies.

For example in the Blacksea Region of Turkey (Uzunoz et al., 2008) was calculated the nonrenewable energy as 92,46% the renewable energy as 2,08%. In the Iran was calculated the nonrenewable energy as 76,97%, the renewable energy as 23,03% (Nageth-Aghili et al. 2020).

Table 6: Total energy input in the form of direct, indirect, renewable, nonrenewable for sunflower production (MJha-1)

Type of Energy	Irrigated circumstances		Dry circumstances	
	Sunflower	%[e]	Sunflower	%[e]
Direct energy[a]	7273,65	44,04	5265,28	42,08
Indirect energy[b]	9241,40	55,96	7246,44	57,92
Renewable energy[c]	2112,49	12,79	422,83	3,38
Nonrenewable energy[d]	14402,56	87,21	12088,88	96,62
Total energy input[e]	16515,05	100,00	12511,72	100,00

[a] Includes human labor, diesel, water for irrigation
[b] Includes machinery, fertilizers, chemicals, seeds
[c] Includes human labor, seeds, water for irrigation
[d] Includes machinery, fertilizers, chemicals, diesel,
[e] Indicate percentage of total energy input.

5. Conclusions

In this study gross production value, net return, benefit-cost ratio and productivity for sunflower production in the irrigated circumstances are higher than in the dry circumstances. This is due to the fact that in dry circumstances their sunflower yield in lower amount.

Moreover the energy analysis and cost analysis of sunflower plant are compared according to irrigated circumstances and dry circumstances. The energy use efficiency and energy productivity of the sunflower in irrigated circumstances in the research region are higher than in dry circumstances.

In research are obtained important findings in terms of calculating business energy inputs, making energy planning and establishing an energy management system. According to the results obtained, the energy value of the total inputs for sunflower production in the irrigated circumstances is 16515,05 MJha^{-1} and for in the dry circumstances it is 12511,72 MJha^{-1}.

Because of the usage levels of inputs are dense in irrigated circumstances, the total energy requirement is determined to be higher than in dry circumstances. More energy input is consumed for sunflower production under irrigated conditions. However, it is observed that higher efficiency is obtained.

Intensive mechanization and chemical inputs are used in sunflower production in Turkey. According to the results, it has been determined that diesel oil and chemical fertilizers (nitrogen) had a large share in total production of energy in sunflower production in both production systems.

It has been determined that the inputs should be reduced in order to increase the efficiency and profitability of energy use in sunflower production. It can be said that energy use efficiency and profitability can be increased with the conscious application of inputs. In addition to reducing the use of fertilizers in sunflower production, it is also very important to reduce the use of machinery and fuel consumption. For this reason, farmer training should be given on the use of chemical fertilizers. Farmers should be made conscious by providing trainings on correct machine use.

In the world, sunflower is grown under either irrigated or dry circumstances. It presents positive energy balance both in the irrigated circumstances and in the dry circumstances. But in irrigated circumstances sunflower the input energy needed it needs is high.

When we evaluate it in terms of energy management, it seems more advantageous to grow sunflower in dry conditions as it needs lower energy input. However when we evaluate from in terms of the energy use efficiency, energy productivity, gross production value, net return, benefit-cost ratio and productivity it is considered more appropriate to grow sunflower in irrigated circumstances.

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