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ORIGINAL ARTICLE

Evaluation of Energy Balance in Organic Olive (*Olea Europaea* L.) Production in Turkey

A Case Study of Aydın-Karpuzlu Region

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Abstract The purpose of this study is to evaluate the energy balance of organic olive production in Aydın-Karpuzlu Region in Turkey in 2015. In order to evaluate the energy input-output of organic olive, data has been provided by Aydın-Karpuzlu Organic Olive Producers Association. The agricultural input energies and output energies used in organic olive production have been calculated to evaluation the energy inputs and energy output. According to the research findings, the energy inputs in organic olive production have been calculated respectively as 19,426.95 MJ ha^{-1} (50.31%) diesel fuel energy, 12,960 MJ ha^{-1} (33.56%) machinery energy, polyethylene trap energy 3520 MJ ha^{-1} (9.12%), 2116.80 MJ ha^{-1} (5.48%) human labour energy, 276.48 MJ ha^{-1} (0.72%) electricity energy, 231.60 MJ ha^{-1} (0.60%) organic chemical energy and 81.87 MJ ha^{-1} (0.21%) transportation energy. Total input energy has been calculated as 38,613.70 MJ ha^{-1}. Total output energy have been calculated as 104,888.78 MJ ha^{-1}. The energy output/input ratio, specific energy, energy productivity and net energy calculations have been calculated respectively as 2.72, 4.34 MJ kg^{-1}, 0.23 kg MJ^{-1} and 66,275.08 MJ ha^{-1} in organic olive production.

Keywords Energy balance · Organic olive · Specific energy · Turkey

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Beurteilung der Energiebilanz bei der ökologischen Erzeugung von Oliven (*Olea Europaea* L.) in der Türkei
Eine Fallstudie aus der Region Aydın-Karpuzlu

Schlüsselwörter Energiebilanz · Ökologisch erzeugte Oliven · Spezifische Energie · Türkei

Introduction

Olive (*Olea europaea* L.) is a member of Oleacea family, Olea cultivar and its homeland is Upper Mesopotamia, covering South-eastern Anatolian Region too and South Asia Minor (Heywood 1978). Olive can be consumed directly or it can be used to produce oil. Olive oil is natural fruit oil produced through physical methods only and contains unique antioxidant matters (phenolic compounds, tocopherol and other aromatic matters), high levels of monounsaturated fatty acid (oleic acid) and high oxidative stability (Öztürk et al. 2009). Olive is a Mediterranean plant and it can be grown regardless of the soil quality, as long as there suitable climate conditions available. In Turkey, 62% of the production is in the Aegean Region, 16% in Marmara Region, 14% in Mediterranean Region, 7.8% in South-eastern Anatolian Region and 0.2% is in Black Sea Region. 49% of the production of olive for oil is in Aegean Region, 26.6% is in Mediterranean Region, 12.3% is in South-eastern Anatolian Region and 12.1% is in Marmara Region (TÜİK 2016).

Organic olive is mostly produced in Mediterranean countries. The significant olive producing countries are Spain, Italy, Greece, Tunisia, Turkey, Morocco and Syria (Özkaya et al. 2015). In all Mediterranean countries, the total area for olive cultivation is 7,379,090 ha and there is organic olive production in 4.91% (362,210 ha) of this area. Among the

Mediterranean countries, the highest organic olive production is in Tunisia by 80,016 ha, followed by Syria, 5000 ha and Turkey by 3776 ha (Santucci 2007; Olgun et al. 2008). Of the organic products produced in Aydın province in the Aegean Region, about 92% consists of fruits, 6% is field plants, 1.5% is vegetables while 0.5% is plants collected from the nature. Among the fruits, olive (168,167 da), fig (96,787 da) and chestnut (12,010 da) have the highest ratios, while cotton (7491 da) is the leading field product. About 25% of Turkey's organic olive production is in Aydın (Anonymous 2014).

An application has been made to Aydın Provincial Directorate of Food Agriculture and Livestock on 22 April 2013, requesting to establish Karpuzlu Organic Olive Producers Association and following an approval of the application on 17 May 2013, the association has been founded. Since then, the association has started to gather the producers registered at Organic Farming under its roof and simplified the membership process. The number of producers has reached 1070 as of 31 December 2012. Producers have been receiving support funding. In 2013, 664 producers received 806,000 TL for 23,280 decare land, In 2014, 821 producers received 2,275,000 TL for 32,500 decare land and in 2015, 1053 producers received 2,940,000 TL for 42,000 decare land. Not satisfied by merely certifying the products, the association has launched plans to make use of the products of the producers, aiming to establish olive press, processing and packaging integrated facilities (Anonymous 2016a).

Organic farming both utilizes and maintains ecosystem services. Ecosystem services, such as biological control, pollination, soil formation, nutrient cycling in agriculture are staminal for the sustainable supply of food. It is therefore more sustainable than is conventional agriculture which degrades some ecosystem services (Sandhu et al. 2010; Bilalis et al. 2013). Organic farming, through its ecological approach, upgrades biodiversity and maintains the integrity of the ecosystem. Research into organic farming practices has shown that organic systems can support biodiversity conservation through increasing the number and variety of wild species found on farms and supporting high levels of agrobiodiversity (Grandi 2008; Bilalis et al. 2013). The current situation of worldwide concern over the emission of greenhouse gases and its effect on the climate, demands an evaluation, from the perspective of energy usage efficiency and more specifically of non-renewable energy sources, of tendencies for change in the management of agricultural systems which have arisen in recent years (Guzman and Alonso, 2008; Mirzaee et al. 2011).

Efficient usage of energy is one of the primary requirements of sustainable agriculture. Energy usage in agriculture has been increasing in response to increasing population, restricted supply of arable land and a desire for higher standards of living. Continuous demand in increasing food production resulted in intensive usage of chemical fertilizers, pesticides, agricultural machinery and other natural resources. Intensive usage of energy causes problems threatening public health and environment. Efficient usage of energy in agriculture will minimize environmental problems, prevent destruction of natural resources, and promote sustainable agriculture as an economical production system. The development of energy usage efficiency agricultural systems with a low input of energy compared to the output of products should therefore help to decline the emissions of greenhouse gasses in agricultural production (Dalgaard et al. 2001; Kızılaslan 2009).

Several researches have been performed on energy input-output analysis of agricultural products. For example, researches have been done on energy input-output analyses of organic olive (Guzman and Alonso 2008), organic and conventionel black carrot (Çelik et al. 2010), organic apricot (Gündoğmuş 2006), organic grape (Baran et al. 2017a), organic mulberry (Gokdogan et al. 2017), walnut (Baran et al. 2017b) cherry (Kizilaslan 2009), sweet cherry (Demircan et al. 2006), apple (Asakereh et al. 2010), citrus (Özkan et al. 2004a), pomegranate (Çanakçı 2010), grape (Koçtürk and Engindeniz 2009), peach (Göktolga et al. 2006), kiwifruit (Mohammadi et al. 2010), apricot (Gezer et al. 2003), lemon (Bilgili 2012), organic maize and organic potato (Pimentel 1993), organic lentil (Mirzaee et al. 2011), sugar beet (Baran and Gökdoğan 2016), wheat (Marakoğlu and Çarman 2010), corn (Öztürk et al. 2006), corn silage (Barut et al. 2011), garlic (Samavatean et al. 2011), soybean (Mandal et al. 2002), stake-tomato (Esengün et al. 2007), cotton (Baran 2016), beef cattle (Demircan and Köknaroğlu 2007), broiler (Atılgan and Köknaroğlu 2006), lamb (Köknaroglu et al. 2007) etc. Although many experimental works have been done on energy input-output analysis in agriculture, there is no study on the energy input-output analysis of organic olive production in Turkey. In this study, it is aimed to evaluate the energy input-output analysis of organic olive production.

Materials and Method

The surface features of Aydın-Karpuzlu Region are being shaped by the Karpuzlu Stream from Beşparmak Mountains and Gökbel mountain, Karpuzlu Plain fed by this stream and many creeks joining this stream and the mountains surrounding this plain (Uyguç 1998). Karpuzlu Region is 55 km away from Central Aydın. The region is surrounded by mountains all sides (Anoymous 2016b). In order to evaluate the energy input-output of organic olive (2015 production season) data has been provided by Aydın-Karpuzlu Organic Olive Producers Association. Total energy input in unit area (ha) constitutes each total of input energy. Human

Table 1 Energy equivalents in agriculture production

Inputs and outputs	*Unit*	*Energy equivalent (MJ/unit)*	*References*
Human labour	h	1.96	Mani et al. 2007; Karaağaç et al. 2011
Machinery	h	64.80	Singh 2002; Kızılaslan 2009
Diesel fuel	l	56.31	Singh 2002; Demircan et al. 2006
Electricity	kWh	3.60	Özkan et al. 2004b
Organic chemical	kg	77.20	Guzman and Alonso 2008; Bilalis et al. 2013
Polyethylene trap	Unit	4.40	Green 1987; Pimentel 1992; Guzman and Alonso 2008
Transportation	MJ (ton km)$^{-1}$	9.22	Acaroğlu 2004
Outputs	*Unit*	*Values (MJ/unit)*	*References*
Yield	kg	11.80	Özkan et al. 2004c

labour energy, machinery energy, diesel fuel energy, electricty energy, organic chemical energy, polyethylene trap energy and transportation energy have been calculated as inputs. Organic olive has been calculated as output. In Table 1, the agricultural production inputs, energy equivalents of input and output have been taken as energy values. Energy usage efficiency calculations have been made to determine the productivity levels of organic olive production.

The units shown in Table 1 have been used to find out the input values in organic olive production. Input amounts have been calculated and then these input data have been multiplied by the energy equivalent coefficient. When determining the energy equivalent coefficients, previous energy analysis sources have been used. By adding energy equivalents of all inputs in MJ unit, the total energy equivalent has been evaluationed. In order to evaluation the energy input-output in organic olive production, "Energy usage efficiency, energy productivity, specific energy and net energy have been calculated by using the following formulates (Mandal et al. 2002; Mohammadi et al. 2008, 2010)".

$$\text{Energy efficiency} = \text{Energy output}\,(\text{MJ ha}^{-1}) / \text{Energy input}\,(\text{MJ ha}^{-1}) \quad (1)$$

$$\text{Energy productivity} = \text{Yield output}\,(\text{kg ha}^{-1}) / \text{Energy input}\,(\text{MJ ha}^{-1}) \quad (2)$$

$$\text{Specific energy} = \text{Energy input}\,(\text{MJ ha}^{-1}) / \text{Yield output}\,(\text{kg ha}^{-1}) \quad (3)$$

$$\text{Net energy} = \text{Energy output}\,(\text{MJ ha}^{-1}) - \text{Energy input}\,(\text{MJ ha}^{-1}) \quad (4)$$

Results and Discussion

The amount of organic olive produced per hectare during the 2015 production season has been calculated as an average of 8888.88 kg. For the 2015 organic olive production season, the energy balance of organic olive production related to this study has been given in Table 2. It can be seen from these tables that the first, second and third highest energy inputs in organic olive production have diesel fuel energy by 50.31%, machinery energy by 33.56% and polyethylene trap energy by 9.12%, respectively. If the average values are investigated by referring to Table 2, it can be seen that the highest energy inputs in organic olive production are diesel fuel energy by 19,426.95 MJ ha^{-1} (50.31%), machinery energy by 12,960 MJ ha^{-1} (33.56%), polyethylene trap energy by 3520 MJ ha^{-1} (9.12%), human labour energy by 2116.80 MJ ha^{-1} (5.48%), electricity energy by 276.48 MJ ha^{-1} (0.72%), organic chemical energy by 231.60 MJ ha^{-1} (0.60%) and transportation energy by 81.87 MJ ha^{-1} (0.21%), respectively.

Human labour time input has been calculated 1080 h ha^{-1}. Machinery time input has been calculated 200 h ha^{-1} and diesel fuel amount has been calculated 345 l ha^{-1}. Human labour energy and diesel fuel energy have been used for tractor and farm operations. The amount of electricity used for organic olive yield harvesting has 76.80 kWh ha^{-1}. Accumulator machine powered by electricity has been used for harvesting in organic olive yield. Polyethylene trap has been used for olive fly for (one unit for one tree). Organic chemical has been used 3 kg ha^{-1} in organic olive production. Organic olive yield has been produced as 8888.88 kg ha^{-1}.

In this study, diesel fuel energy has the biggest share by 19,426.95 MJ ha^{-1} (50.31%). Similarly, in previous studies, Gündoğmuş (2006) has found in organic apricot study that the diesel fuel energy has the biggest share by 6199.73 MJ ha^{-1} (44.99%), Azizi and Heidari (2013) have found in wheat study that the diesel fuel energy has the biggest share by 3399.32 MJ ha^{-1} (43.21%), Çelik et al. (2010) have found in organic black carrot study that the diesel fuel energy has the biggest share by 13,311.68 MJ ha^{-1} (35.26%), Moham-

Table 2 Energy balance in organic olive production

Inputs	*Unit*	*Energy equivalent (MJ unit^{-1})*	*Input used per hectare (unit ha^{-1})*	*Energy value (MJ ha^{-1})*	*Ratio (%)*
Human labour	h	1.96	1080	2116.80	5.48
Machinery	h	64.80	200	12,960	33.56
Diesel fuel	l	56.31	345	19,426.95	50.31
Electricity	kWh	3.60	76.80	276.48	0.72
Organic chemical	kg	77.20	3	231.60	0.60
Polyethylene trap	Number	4.40	800	3520	9.12
Transportation	MJ (ton km)$^{-1}$	9.22	8.88	81.87	0.21
Total inputs	–	–	–	38,613.70	100.00
Outputs	*Unit*	*Energy equivalent (MJ unit^{-1})*	*Output per hectare (unit ha^{-1})*	*Energy value (MJ ha^{-1})*	*Ratio (%)*
Yield	kg	11.80	8888.88	104,888.78	100.00
Total outputs	–	–	–	104,888.78	100.00

Table 3 Energy usage efficiency calculations in organic olive production

Calculations	Unit	Values
Yield	kg ha^{-1}	8888.88
Energy input	MJ ha^{-1}	38,613.70
Energy output	MJ ha^{-1}	104,888.78
Energy use efficiency	–	2.72
Specific energy	MJ kg^{-1}	4.34
Energy productivity	kg MJ^{-1}	0.23
Net energy	MJ ha^{-1}	66,275.08

madi and Omid (2010) have found in cucumber study that the diesel fuel energy has the biggest share by 62,426.96 MJ ha^{-1} (41.94%), Özkan et al. (2007) have found in open-field grape study that the diesel fuel energy has the biggest share by 7545.50 MJ ha^{-1} (31.92%), Pishgar-Komleh et al. (2011) have found in rice study that the diesel fuel energy has the biggest share by 18,072.93 MJ ha^{-1} (45.95%), Esengün et al. (2007) have found in stake-tomato study that the diesel fuel energy has the biggest share by 40,757.18 MJ ha^{-1} (42.04%) etc.

Energy usage efficiency calculations in organic olive production have been given in Table 3. According to Table 3, organic olive yield, energy input, energy output, energy usage efficiency, specific energy, energy productivity and net energy in organic olive production have been calculated as 8888.88 kg ha^{-1}, 38,613.70 MJ ha^{-1}, 104,888.78 MJ ha^{-1}, 2.72, 4.34 MJ kg^{-1}, 0.23 kg MJ^{-1} and 66,275.08 MJ ha^{-1}, respectively. In previous studies, in the studies conducted to determine energy usage efficiency in organic maize, organic potato, organic apricot, organic black carrot, organic lentil, organic soybean, organic spring barley, organic pea, banana, apple production, the energy usage efficiency value has been determined as; 5.90, 1.08 (Pimentel 1993), 2.22 (Gündoğmuş 2006), 1.90 (Çelik et al. 2010), 2.12 (Mirzaee et al. 2011), 3.80 (Pimentel et al. 2005; Arthurson and Jäderlund 2011), 10.9, 12.8 (Klimekova and Lehocka 2007; Arthurson and Jäderlund 2011), 1.90 (Akçaöz 2011), 2.26 (Yılmaz et al. 2010), respectively.

In this study, energy balance of organic olive production has been determined. Organic olive production is a profitable production in terms of energy usage efficiency (2.72). In this study, diesel fuel energy has the highest input. Guzman and Alonso (2008) have reported that, "The usage of biofuel could increase the energy usage efficiency of agricultural systems in general, although it would involve more extensive land use, which would need to be taken into consideration (Fredriksson et al. 2006)". Some of the benefits desired to be obtained through energy input/output analysis are summarized as: being able to evaluation whether energy has been used effectively or not. Once this is determined, then energy wastage will be avoided, as use of excessive energy will be avoided, which in turn, will lower the negative effects caused by environmental exposure of excessive energy, fuel, etc. (Göktolga et al. 2006). Demircan et al. (2006) reported that, "proper tractor selection and management of machinery to decrease direct use of diesel fuel (Işık and Sabancı 1991) have needed to save non-renewable energy sources without impairing the yield or profitability, in order to improve the energy usage efficiency of sweet cherry production". For decrease of inputs (machinery and diesel fuel) of organic olive production, these notices may apply for organic olive production.

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Conflict of interest O. Gökdoğan and O. Erdoğan declare that they have no competing interests.

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