Erwerbs-Obstbau (2022) 64(Suppl 1) :S113–S118
https://doi.org/10.1007/s10341-022-00707-5

ORIGINAL ARTICLE / ORIGINALBEITRAG

Energy Use Efficiency of Grape Production in Vineyard Areas of Nevşehir Province in Turkey

Evrim Şimşek[1] · Halil İbrahim Oğuz[2] · Osman Gökdoğan[3]

Received: 5 April 2022 / Accepted: 20 June 2022 / Published online: 12 July 2022

Abstract

In this study, the efficiency of energy use in grape production of important viticulture enterprises in Nevşehir province located in the Cappadocia region of Turkey was determined. To do this, viticulture enterprises were examined; face-to-face surveys, observations, and field studies were conducted with 165 producers, which were determined according to the proportional sampling method in Merkez, Gülşehir, and Ürgüp districts of Nevşehir province, where the most grapes are grown. Calculations were made on the basis of the results. Grape yield, energy input, energy output, energy use efficiency, specific energy, energy productivity, and net energy in grape production and were calculated to be, respectively, 10,118.53 kg ha^{-1}; 14,226.97 MJ ha^{-1}; 119,398.64 MJ ha^{-1}; 8.39, 1.41 MJ kg^{-1}; 0.71 kg MJ^{-1}; and 105,171.67 MJ ha^{-1}. Renewable energy input in grape production was calculated as 3810.96 MJ ha^{-1} (26.79%), and nonrenewable energy input was calculated as 10,416 MJ ha^{-1} (73.21%). In terms of energy use efficiency (8.39), grape production is an economical activity.

Keywords Cappadocia · Energy productivity · Specific energy · Renewable energy · Viticulture

Introduction

Turkey is located in the most suitable climate zone for culture vine (*Vitis vinifera* L.) production in the world. Furthermore, it is located in the motherland of viticulture and has a rich source of varieties and types due to the rich gene potential, suitable climate conditions for viticulture, and heterozygous structure of vine. The variety identification studies carried out by the Ministry of Agriculture and Forestry have shown that there are 1200 grape types in Turkey (Anonym 2021a). According to data from the Food and Agriculture Organization of the United Nations for 2019 (FAO 2019), world grape production is 7.7 million ha, and 22.7% of this grape production area is located in Spain, followed by France, China, Italy, and Turkey. World fresh grape production decreased by 3.6% in 2019 compared with the previous year and decreased to 77.1 million tons. In the global fresh grape production ranking, China ranks first, with a production of 14.3 million tons; Italy ranks second, with 7.2 million tons of production; and the United States ranks third, with 6.7 million tons of production (Anonym 2021b). Table grape production in Nevşehir was 28,997 tons, wine grape production was 42,623 tons, and raisin grape production was 29,404 tons in 2020 (Anonym 2020). A vineyard and the most commonly grown grape varieties in the study area are shown in Figs. 1, 2, 3, and 4. In the study, it was determined that 'Emir' is the variety used for the most wine grape production in Nevşehir province, and 'Dimrit' and 'Finger' were the varieties used for the most table grape production.

Energy analyses to be done for agricultural production are important in grouping agricultural systems in terms of energy consumption. It is important to carefully analyse the inputs and outputs used in production in order to increase efficiency and reduce inputs in production (Sabah 2010; Çelen 2016). The benefits of energy consumption studies are many. They include ensuring that energy resources are used more effectively, determining the values and places of wastes and losses in production systems, developing more effective practices for existing production methods, ensuring sustainable development by aiming at sustainable use of

✉ Osman Gökdoğan
osmangokdogan@gmail.com

[1] Department of Biology, Institute of Science, University of Nevşehir Hacı Bektaş Veli, 50300 Nevşehir, Turkey

[2] Department of Horticulture, Faculty of Agriculture, University of Adıyaman, 02400 Kahta, Adıyaman, Turkey

[3] Department of Agricultural Machinery and Technologies Engineering, Faculty of Agriculture, Isparta University of Applied Sciences, 32260 Isparta, Turkey

Fig. 1 Vineyard

Fig. 2 'Dimrit'

Fig. 3 Finger grape

Fig. 4 'Emir' (Anonym 2021c)

energy resources and areas of use of high- and low-quality energy resources, determining priorities in terms of utilization, and determining the areas where improvement can be achieved by making use of effective technologies (Dinçer et al. 2004; Öztürk 2005).

Several local and international studies have been conducted in relation to energy use efficiency. These include energy use in agriculture (Öztürk and Barut 2005), grape (Ozkan et al. 2007; Koctürk and Engindeniz 2009; Rasouli et al. 2014; Baran et al. 2017), apricot (Gezer et al. 2003), apple (Ekinci et al. 2005), sweet sorghum (Eren 2011), strawberry (Banaeian et al. 2011), pear (Aydın et al. 2017), chickpea (Baran et al. 2019), pumpkin seed (Baran and Gökdoğan 2020), olive (Gökdoğan and Erdoğan 2021), and others. In recent years, there has been a significant increase in vineyard input costs in Nevşehir province. Therefore, the calculation of energy inputs is extremely important to ensure profitable grape production. In this study, energy use efficiency calculations of grape production in the vineyard areas of Nevşehir province were done, and evaluations were made. A detailed study should be conducted on the efficiency of energy use, determination of renewable or nonrenewable energy use, and efficiency in vineyard areas in Nevşehir province. Such a study will contribute to the literature.

Materials and Method

Located in the central Kızılırmak section of the central Anatolian region of Turkey, Nevşehir's coordinates are 38° 12′ and 39° 20′ north latitudes and 34° 11′ and 35° 06′ east longitudes (Anonym 2021d). The material of the study consisted of information obtained from the Nevşehir Provincial Directorate of Agriculture and Forestry (Anonym 2018) and from 165 producers and businesses in Nevşehir province, where the most grape production is carried out and where face-to-face surveys were conducted. In the study, all data were calculated in Microsoft Office Excel 2007 (Microsoft Corporation, Redmond, WA, USA) and then evaluated. The number of enterprises examined in the study was determined according to the proportional sampling method. For

Table 1 Energy equivalents of inputs and outputs used in agricultural production

	Unit	Energy equivalent (MJ unit^{-1})	References
Input			
Human labour	h	1.96	Mani et al. (2007); Karaağaç et al. (2011)
Machinery	h	64.80	Singh (2002); Kizilaslan (2009)
Chemicals			
Fungicide	Kg	99	Ekinci et al. (2005); Fluck (1992)
Insecticide	Kg	363.60	Ekinci et al. (2005); Pimentel (1980)
Farm manure	Kg	0.30	Singh (2002); Demircan et al. (2006)
Chemical fertilisers			
Nitrogen	Kg	60.60	Singh (2002); Demircan et al. (2006)
Phosphorus	Kg	11.10	Singh (2002); Demircan et al. (2006)
Potassium	Kg	6.70	Singh (2002); Demircan et al. (2006)
Sulphur	Kg	1.12	Nagy (1999); Mohammadi et al. (2010)
Micro elements	Kg	120	Mandal et al. (2002); Singh (2002); Canakci and Akinci (2006); Banaeian et al. (2011)
Irrigation water	m^3	0.63	Yaldiz et al. (1993); Demircan et al. (2006)
Diesel fuel	l	56.31	Singh (2002); Demircan et al. (2006)
Lime	Kg	1.32	Pimentel (1980); Ekinci et al. (2005)
Output			
Grape fruit	Kg	11.80	Singh (2002); Ozkan et al. (2007)

Table 2 Energy balance in grape production

	Unit	Energy equivalent (MJ unit^{-1})	Input used per hectare (unit ha^{-1})	Energy value (MJ ha^{-1})	Ratio (%)
Input					
Human labour	h	1.96	104.94	205.69	1.45
Machinery	h	64.80	32.49	2105.38	14.80
Chemicals	–	–	0.47	79.65	0.56
Fungicide	Kg	99	0.34	33.68	0.24
Insecticide	Kg	363.60	0.13	45.97	0.32
Farm manure	Kg	0.30	6710.35	2013.11	14.15
Chemical fertilisers	–	–	126.97	3927.24	27.60
Nitrogen	Kg	60.60	41.73	2528.54	17.77
Phosphorus	Kg	11.10	30.38	337.24	2.37
Potassium	Kg	6.70	10.29	68.92	0.48
Sulphur	Kg	1.12	36.64	41.04	0.29
Micro elements	Kg	120	7.93	951.50	6.69
Irrigation water	m^3	0.63	2527.25	1592.17	11.19
Diesel fuel	l	56.31	75.90	4273.88	30.04
Lime	Kg	1.32	22.62	29.86	0.21
Total inputs	–	–	–	14,226.97	100.00
Output					
Grape fruit yield	Kg	11.80	10,118.53	119,398.64	100.00
Total output	–	–	–	119,398.64	100.00

a finite population, the sample volume is given in the following formula (Eq. 1) according to the known or estimated proportion of those with a certain characteristic. In order to reach the maximum sample volume and in cases where p is not known, $p = 0.5$ should be taken, as working with the maximum sample volume will reduce the possible error (Miran 2003; Aksoy and Yavuz 2012). The number of viticulture enterprises to be studied was calculated using a 95% confidence interval and 5% deviation.

$$n = \frac{(N \cdot p \cdot (1 - p))}{(N - 1) \cdot \alpha 2p + p \cdot (1 - p)} \quad (1)$$

Table 3 Calculations of energy use efficiency in grape production

Calculation	Unit	Value
Grape fruit	Kg ha^{-1}	10,118.53
Energy input	MJ ha^{-1}	14,226.97
Energy output	MJ ha^{-1}	119,398.64
Energy use efficiency	–	8.39
Specific energy	MJ kg^{-1}	1.41
Energy productivity	Kg MJ^{-1}	0.71
Net energy	MJ ha^{-1}	105,171.67

Table 4 Calculations of energy input types in grape production

Energy group	Energy input (MJ ha^{-1})	Ratio (%)
Direct energy[a]	6071.74	42.68
Indirect energy[b]	8155.23	57.32
Total	14,226.97	100.00
Renewable energy[c]	3810.96	26.79
Nonrenewable energy[d]	10,416	73.21
Total	14,226.97	100.00

[a]Includes human labour, diesel fuel, and irrigation water
[b]Includes chemical fertilisers, chemicals, machinery, farm manure, and lime
[c]Includes human labour, irrigation water, and farm manure
[d]Includes diesel fuel, machinery, chemical fertilisers, chemicals, and lime

In the formula, n: sample size, N: number of enterprises in the population, $\alpha^2 p$: variance of ratio (0.0346), and p: ratio of grape growers among the population. Face-to-face surveys, observations, and field studies were conducted with 59 enterprises related to viticulture in Nevşehir Province Centre district, 42 enterprises in Gülşehir district, and 64 enterprises in Ürgüp district. For the calculations of energy input and output, it is necessary to know the energy equivalents of the inputs and outputs. Previous studies were used to determine the energy equivalent coefficients. The energy equivalents of the inputs and outputs used in agricultural production are given in Table 1. Energy output/input ratio (energy use efficiency), energy productivity, specific energy, and net energy were calculated using the following formulas (Eq. 2–5) (Mandal et al. 2002; Mohammadi et al. 2008, 2010).

$$Energy\,use\,efficiency = \frac{Energy\,output\,\left(MJ\,ha^{-1}\right)}{Energy\,input\,\left(MJ\,ha^{-1}\right)} \quad (2)$$

$$Energy\,productivity = \frac{Yield\,output\,\left(kg\,ha^{-1}\right)}{Energy\,input\,\left(MJ\,ha^{-1}\right)} \quad (3)$$

$$Specific\,energy = \frac{Energy\,input\,\left(MJ\,ha^{-1}\right)}{Yield\,output\,\left(kg\,ha^{-1}\right)} \quad (4)$$

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

The input energy is classified as direct or indirect and as nonrenewable or renewable. Indirect energy consists of pesticides and fertilisers, while direct energy includes human and animal power, diesel, and electricity. Nonrenewable energy consists of oil, diesel, electricity, chemicals, fertilisers, and machinery. Renewable energy consists of human and animal power (Mandal et al. 2002; Singh et al. 2003; Koctürk and Engindeniz 2009). The energy balance, energy use efficiency calculations, and classification of energy input types in grape production as direct or indirect and renewable or nonrenewable are given in Tables 2–4.

Results and Discussion

A total of 165 viticulture enterprises were examined in the study, 62 of them (37.57%) with a size between 5 decares and 20 decares. The average grape yield per hectare of the 165 enterprises was calculated as 10,118.53 kg ha^{-1}. It was determined that only three of the enterprises are irrigated, and the other enterprises are not irrigated. The energy balance in grape production is given in Table 2. As shown in Table 2, the inputs in grape production are diesel fuel energy at 4273.88 MJ ha^{-1} (30.04%), chemical fertiliser energy at 3927.24 MJ ha^{-1} (27.60%), machinery energy at 2105.38 MJ ha^{-1} (14.80%), farm manure energy at 2013.11 MJ ha^{-1} (14.15%), irrigation water energy at 1592.17 MJ ha^{-1} (11.19%), human labour energy at 205.69 MJ ha^{-1} (1.45%), chemical energy at 79.65 MJ ha^{-1} (0.56%), and lime energy at 29.86 MJ ha^{-1} (0.21%).

In other studies conducted on grape production, Ozkan et al. (2007) calculated energy input as 23,640.9 MJ ha^{-1} and energy output as 120,596 MJ ha^{-1}; Koctürk and Engindeniz (2009) calculated energy input as 37,488 MJ ha^{-1} and energy output as 323,910 MJ ha^{-1}; and Baran et al. (2017) calculated energy input as 24,875.06 MJ ha^{-1} and energy output as 163,430 MJ ha^{-1}. Energy use efficiency calculations in grape production are given in Table 3. The grape yield, energy input, energy output, energy use efficiency, specific energy, energy productivity, and net energy were respectively calculated as 10,118.53 kg ha^{-1}, 14,226.97 MJ ha^{-1}, 119,398.64 MJ ha^{-1}, 8.39, 1.41 MJ kg^{-1}, 0.71 kg MJ^{-1}, and 105,171.67 MJ ha^{-1}.

In other studies conducted on grape production, Ozkan et al. (2007) calculated energy use efficiency as 5.10, Koctürk and Engindeniz (2009) calculated it as 8.64, and Baran et al. (2017) calculated it as 6.57. Energy input type calculations in grape production are given in Table 4. Direct energy input was calculated as 6071.74 MJ ha^{-1} (42.68%), indirect energy input as 8155.23 MJ ha^{-1} (57.32%), renewable energy input as 3810.96 MJ ha^{-1} (26.79%), and nonrenewable energy input as 10,416 MJ ha^{-1} (73.21%).

Direct energy input was calculated as 6071.74 MJ ha^{-1} (42.68%), indirect energy input as 8155.23 MJ ha^{-1} (57.32%), renewable energy input as 3810.96 MJ ha^{-1} (26.79%), and nonrenewable energy input as 10,416 MJ ha^{-1} (73.21%). In previous studies, Ozkan et al. (2007) and Koctürk and Engindeniz (2009) have similarly concluded a higher ratio of nonrenewable energy than renewable energy in energy inputs.

Conclusion

The outcomes of this study can be summarised as follows:

The first three energy inputs in grape production were respectively determined to be diesel fuel energy at 4273.88 MJ ha^{-1} (30.04%), chemical fertiliser energy at 3927.24 MJ ha^{-1} (27.60%), and machinery energy at 2105.38 MJ ha^{-1} (14.80%).

Grape yield, energy input, energy output, energy use efficiency, specific energy, energy productivity, and net energy were respectively calculated to be 10,118.53 kg ha^{-1}, 14,226.97 MJ ha^{-1}, 119,398.64 MJ ha^{-1}, 8.39, 1.41 MJ kg^{-1}, 0.71 kg MJ^{-1}, and 105,171.67 MJ ha^{-1}. In terms of energy use efficiency (8.39), grape production can be considered to be economical.

Direct energy input was calculated as 6071.74 MJ ha^{-1} (42.68%), indirect energy input as 8155.23 MJ ha^{-1} (57.32%), renewable energy input as 3810.96 MJ ha^{-1} (26.79%), and nonrenewable energy input as 10,416 MJ ha^{-1} (73.21%).

To reduce energy inputs in viticulture, it is necessary to increase the rate of renewable energy among energy inputs. In addition, it is important to increase the use of farm manure or organic fertilisers and to encourage organic viticulture in order to reduce the rate of chemical fertiliser use.

Acknowledgements This study was summarised from Evrim Şimşek's master's thesis.

Conflict of interest E. Şimşek, H.İ. Oğuz, and O. Gökdoğan declare that they have no competing interests.

References

Aksoy A, Yavuz F (2012) Analysis on the reasons for quitting sheep and goat rearing of farmers: A case of East Anatolia Region. Anadolu J Agr Sci 27(2):76–79 (in Turkish)

Anonym (2018) Republic of Türkiye, Ministry of Agriculture and Forestry. Nevşehir Directorate of Provincial Agriculture and Forestry

Anonym (2020) Turkish Statistical Institute. 2020 Grape production statistics. http://www.tuik.gov.tr. Accessed 10 Dec 2021

Anonym (2021a) Türkiye and world viticulture (Dr. Selçuk Karabat). https://arastirma.tarimorman.gov.tr/manisabagcilik/Belgeler/genelbagcilik/DUNYA%20VE%20TURKIYE%20BAGCILIGI%20SELCUK%20KARABAT.pdf. Accessed 10 Dec 2021

Anonym (2021b) Republic of Türkiye, Ministry of Agriculture and Forestry. Agricultural products markets, grape, Jan 2021. Institute of Agricultural Economics and Policy Development (Zeliha Yasan Ataseven). https://arastirma.tarimorman.gov.tr/tepge/Belgeler/PDF%20Tar%C4%B1m%20%C3%9Cr%C3%BCnleri%20Piyasalar%C4%B1/2021-Ocak%20Tar%C4%B1m%20%C3%9Cr%C3%BCnleri%20Raporu/%C3%9Cz%C3%BCm,%20Ocak-2021,%20Tar%C4%B1m%20%C3%9Cr%C3%BCnleri%20Piyasala%20Raporu.pdf. Accessed 10 Dec 2021

Anonym (2021c) Table and wine grape varieties. https://isparta.tarimorman.gov.tr/Belgeler/Faydal%C4%B1%20Bilgiler/%E2%80%8BBitkisel%20Yeti%C5%9Ftiricilik/Ba%C4%9F%20Yeti%C5%9Ftiricili%C4%9Fi/Sofral%C4%B1k%20ve%20%C5%9Earapl%C4%B1k%20%C3%9Cz%C3%BCm%20%C3%87e%C5%9Fitleri.pdf. Accessed 1 Dec 2021

Anonym (2021d) Nevşehir Hacı Bektaş Veli University Information Package. Nevşehir (Kapadokya). https://ects.nevsehir.edu.tr/ects/index/dil/tr/sayfa/76. Accessed 10 Dec 2021

Aydın B, Aktürk D, Özkan E, Hurma H, Kiracı MA (2017) Comparatively energy use efficiency and economic analysis in pear farming: Case of Thrace Region. Turkish J Agric Sci Technol 5(9):1072–1079 (in Turkish)

Banaeian N, Omid M, Ahmadi H (2011) Energy and economic analysis of greenhouse strawberry production in Tehran province of İran. Energy Convers Manag 52:1020–1025

Baran MF, Gökdoğan O (2020) Determination of energy balance in pumpkin seed (Cucurbita pepo L.) production. Eur J Sci Technol 19:43–47

Baran MF, Lüle F, Gökdoğan O (2017) Energy input-output analysis of organic grape production: a case study from Adiyaman Province. Erwerbs-Obstbau 59(4):275–279

Baran MF, Karaağaç HA, Mart D, Bolat A, Eren Ö (2019) Determination of energy usage efficiency and greenhouse gas (GHG) emissions in chickpea production (The case of Adana province). Eur J Sci Technol 16:41–50 (in Turkish)

Canakci M, Akinci I (2006) Energy use pattern analyses of greenhouse vegetable production. Energy 31:1243–1256

Çelen İH (2016) An evaluation energy use in agricultural practices. Electron J Vocat Coll 6(3):18–29 (in Turkish)

Demircan V, Ekinci K, Keener HM, Akbolat D, Ekinci C (2006) Energy and economic analysis of sweet cherry production in Turkey: a case study from Isparta province. Energy Convers Manag 47:1761–1769

Dinçer İ, Hussain MM, Al-Zaharnah I (2004) Energy and exergy use in agricultural sector of Saudi Arabia. In Press, Corrected Proof, Energy Policy.

Ekinci K, Akbolat D, Demircan V, Ekinci Ç (2005) Determination of energy use efficiency apple production in Isparta province, Turkey. In: 3. Renewable Energy Sources Symposium, Mersin, pp 19–21 (in Turkish)

Eren Ö (2011). Life cycle energy and environmental effect assessment at the sweet sorghum (Sorghum bicolor (L.) Moench) production in the Çukurova region. PhD Thesis. Çukurova University, Institute of Natural and Applied Sciences, Department of Agricultural Machinery, Adana (in Turkish)

FAO (2019) Food and Agriculture Organization of the United Nations. https://www.fao.org Accessed 10 Dec 2021

Fluck RC (1992) Energy in farm production. Energy in World Agriculture, vol 6. Elsevier, New York

Gezer I, Acaroglu M, Haciseferogullari H (2003) Use of energy and labour in apricot agriculture in Turkey. Biomass Bioenergy 24(3):215–222

Gökdoğan O, Erdoğan O (2021) Determining the Energy use efficiency and greenhouse gas emissions (GHG) in olive farming. Eur J Sci Technol 23:717–724

Karaağaç HA, Aykanat S, Çakır B, Eren Ö, Turgut MM, Barut ZB, Öztürk HH (2011) Energy balance of wheat and maize crops production in Hacıali undertaking. In: 11th International Congress on Mechanization and Energy in Agriculture Congress, Istanbul, Turkey, 21–23 September, pp 388–391

Kizilaslan H (2009) Input-output energy analysis of cherries production in Tokat province of Turkey. Appl Energy 86(2009):1354–1358

Koctürk OM, Engindeniz S (2009) Energy and cost analysis of sultana grape growing: a case study of Manisa, west Turkey. Afr J Agric Res 4(10):938–943

Mandal KG, Saha KP, Ghosh PK, Hati KM, Bandyopadhyay KK (2002) Bioenergy and economic analysis of soybean-based crop production systems in central India. Biomass Bioenergy 23:337–345

Mani I, Kumar P, Panwar JS, Kant K (2007) Variation in energy consumption in production of wheat-maize with varying altitudes in hill regions of Himachal Prades. India Energy 32:2336–2339

Miran B (2003) Temel İstatistik. Ege Üniversitesi Basımevi, Bornova, İzmir (in Turkish)

Mohammadi A, Tabatabaeefar A, Shahin S, Rafiee S, Keyhani A (2008) Energy use and economical analysis of potato production in Iran a case study: Ardabil province. Energy Convers Manag 49:3566–3570

Mohammadi A, Rafiee S, Mohtasebi SS, Rafiee H (2010) Energy inputs-yield relationship and cost analysis of kiwifruit production in Iran. Renew Energy 35:1071–1075

Nagy CN (1999) Energy coefficients for agriculture inputs in western Canada. http://www.csale.usask.ca/PDFDocuments/energyCoefficientsAg.pdf. Accessed 31 May 1999

Ozkan B, Fert C, Karadeniz F (2007) Energy and cost analysis for greenhouse and open-field grape production. Energy 32: 1500–1504

Öztürk HH (2005) Energy and exercy efficiency in agricultural sector of Turkey. J Agric Mach Sci 1(3):221–228 (in Turkish)

Öztürk HH, Barut ZB (2005) Energy use in agriculture in Turkey. In: Turkey Agricultural Engineering Technical Congress, Ankara, pp 1253–1264 (in Turkish)

Pimentel D (1980) Handbook of energy utilization in agriculture. CRC Press, Boca Raton

Rasouli M, Namdari M, Avval SM (2014) Modeling and analysis of energy efficiency in grape production of Iran. Int J Agric Technol 10(3):517–532

Sabah M (2010) Söke ovasında ikinci ürün yağlık ayçiçeği üretiminde enerji kullanımı. Yüksek Lisans Tezi. Çukurova Üniversitesi Fen Bilimleri Enstitüsü Tarım Makinaları Anabilim Dalı, Adana (in Turkish)

Singh H, Mishra D, Nahar NM, Ranjan M (2003) Energy use pattern in production agriculture f a typical village in arid zone India: part II. Energy Convers Manag 44:1053–1067

Singh JM (2002) On farm energy use pattern in different cropping systems in Haryana, India. Master of Science. International Institute of Management University of Flensburg, Flensburg

Yaldiz O, Ozturk HH, Zeren Y, Bascetincelik A (1993) Energy usage in production of field crops in Turkey. In: 5th International Congress on Mechanization and Energy in Agriculture, İzmir, 11–14 October, pp 527–536 (in Turkish)