Erwerbs-Obstbau (2017) 59:77–82
DOI 10.1007/s10341-016-0301-y

ORIGINAL ARTICLE

Determining the Energy Usage Efficiency of Walnut (*Juglans Regia* L.) Cultivation in Turkey

Mehmet Fırat Baran[1] · Osman Gökdoğan[2] · Halil İbrahim Oğuz[2]

Received: 27 April 2016 / Accepted: 13 September 2016 / Published online: 4 November 2016

Abstract The aim of this study is to reveal the energy balance of walnut in Central Anatolian Region in Turkey. This study has been conducted at the walnut cultivating facilities during the 2014–2015 production season in Kırşehir, Konya, Nevşehir and Niğde provinces of Central Anatolian Region in Turkey, where walnut cultivation is intense. In the study, a total of 28 walnut cultivation facilities, yielding walnut, have been selected through Neyman method and surveys and observations have been performed in these facilities. The agricultural input energies and output energies used in walnut cultivation have been calculated to define the energy use efficiency. According to the study findings, the energy inputs in walnut cultivation are calculated respectively 17,851.33 MJ ha^{-1} (74.40%) chemical fertilizer energy, 2229.87 MJ ha^{-1} (9.29%) fuel energy, 1640.64 MJ ha^{-1} (6.83%) irrigation water energy, 1539 MJ ha^{-1} (6.41%) machine energy, 508.02 MJ ha^{-1} (%2.11) chemical energy, 180.35 MJ ha^{-1} (0.75%) human labour energy and 43.33 MJ ha^{-1} (0.18%) farm manure energy. Production outputs have been calculated as 14,679.52 MJ ha^{-1}. Following the energy calculations, the output/input ratio, specific energy, energy efficiency and net energy calculations have been calculated respectively as 0.61, 30.20 MJ kg^{-1}, 0.03 kg MJ^{-1} and –9313.02 MJ ha^{-1}. Benefit-cost ratio was calculated as 1.88, by dividing the gross value of production by the total cost of production per hectare in walnut production.

✉ Mehmet Fırat Baran
mbaran@adiyaman.edu.tr

[1] Faculty of Technology, Department of Energy Systems Engineering, Adıyaman University, Adıyaman, Turkey

[2] Faculty of Engineering-Architecture, Department of Biosystem Engineering, Nevşehir Hacı Bektaş Veli University, Nevşehir, Turkey

Keywords Benefit-cost ratio · Energy use efficiency · Specific energy · Walnut · Turkey

Untersuchung der Energienutzungseffizienz im Walnussanbau (*Juglans regia* L.) in der Türkei

Schlüsselwörter Kosten-Nutzen-Verhältnis · Energienutzungseffizienz · Spezifische Energie · Walnuss · Türkei

Introduction

Gündoğmuş (2013) reported that, "Turkey is ranked third in the world after China and the USA in walnut production (FAO 2011). The annual production of walnut was about 177,000 tons in Turkey and the harvested land area was 86,000 ha in 2009. Walnuts do not only supply healthy fatty acids and high calorie, they are also rich in vitamins and minerals which help us to stay healthy (Koyuncu et al. 2004)". Walnut is a type of fruit that has been known and produced for a long time. Walnut's fruit is among the hard shelled nuts family. Walnut is a valuable nutrition source that can substitute animal protein sources and it contains high levels of unsaturated fatty acidic contents. It is rich in many vitamins containing thiamine, vitamin B6, folacin as well as iron, zinc, copper, magnesium, phosphor and potassium. Walnut does not contain cholesterol and its unsaturated fat rate is high. It is also highly rich in linoleic acid and linolenic acid which are required for a health life (Haskınacı 2003).

Various researches have been conducted on energy analysis of agricultural products. For example, researches have been conducted on energy usage activities of walnut (Ba-

Table 1 Energy equivalents in walnut production

Inputs and outputs	*Unit*	*Energy equivalent (MJ/unit)*	*Sources*
Human labour	h	1.96	Mani et al. 2007; Karaağaç et al. 2011
Machinery	h	64.80	Singh 2002; Kızılaslan 2009
Chemical fertilizers			
Nitrogen	kg	60.60	Singh 2002
Phosphorous	kg	11.10	Singh 2002
Potassium	kg	6.70	Singh 2002
Farmyard manure	kg	0.30	Singh 2002
Chemicals	kg	101.20	Yaldız et al. 1993
Diesel fuel	l	56.31	Singh 2002; Demircan et al. 2006
Water of irrigation	m^3	4.20	Mrini et al. 2002; Mrini 1999
Outputs	*Unit*	*Values (MJ/unit)*	*Sources*
Walnut kernel	kg	26.15	Gündoğmuş, 2013; Banaeian and Zangeneh 2011
Wooden shell	kg	10	Gündoğmuş 2013; Banaeian and Zangeneh 2011

naeian and Zangeneh 2011), walnut (Gündoğmuş 2013), wheat (Marakoğlu and Çarman 2010), grape (Özkan et al. 2007), wheat (Çiçek et al. 2011), miscanthus x giganteus (Acaroğlu and Aksoy 2005), maize (Konak et al. 2004), corn (Öztürk et al. 2006), black carrot (Çelik et al. 2010), sugar beet (Hacıseferoğulları et al. 2003), sunflower (Uzunöz et al. 2008), cotton (Polat et al. 2006) etc. Although many experimental works have been conducted on energy use in agriculture, there is no study on the energy and economic analysis of walnut production (Banaeian and Zangeneh 2011). The number of studies on the energy balance of walnut is highly limited in Turkey and in the world. In this study, it is targeted to reveal the energy balance and economic analysis of walnut.

Materials and Methods

In order to determine the energy balance of walnut, observations and surveys were done at walnut producing farms in Kırşehir, Konya, Nevşehir and Niğde provinces. Observations and surveys were done in 28 walnut farms, in 2015 for 2014–2015 production seasons. Data were collected from 28 walnut farms in Kırşehir, Konya and Nevşehir and Niğde provinces. Neyman method (Yamane 2001; İkiz and Demircan 2013) has been used for the selection of the farms. In the study, a total of 28 walnut cultivation facilities, yielding walnut, have been selected through Neyman method and surveys and observations have been performed in these facilities. 7 gardens have been selected from each province, all of which represent the relevant ecology. Walnut gardens with a size of 10 decares and more have been taken into consideration and surveys have been performed. By calculating the agricultural input energies and output energies used in walnut cultivation, the energy use efficiency has been defined.

Total energy input in unit area (ha) constitutes the total energy inputs. Human labour, machinery, chemical fertilizers, farmyard manure, chemicals, irrigation water and diesel fuel have been calculated as inputs. The units shown in Table 1 were used to calculate the values of the inputs of walnut production. Previous energy analysis studies were used when determining the energy equivalent coefficients. The total energy equivalent was found by adding energy equivalents of all inputs in MJ unit. In order to determine the energy usage efficiency in walnut production, Mohammadi et al. (2010) reported that, "Energy use efficiency, energy productivity, specific energy and net energy were calculated by using the following formulates (Mandal et al. 2002; Mohammadi et al. 2008)".

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

$$\text{Energy productivity} = \frac{\text{Walnut output } (\frac{\text{kg}}{\text{ha}})}{\text{Energy input } (\frac{\text{MJ}}{\text{ha}})} \quad (2)$$

$$\text{Specific energy} = \frac{\text{Energy input } (\frac{\text{MJ}}{\text{ha}})}{\text{Walnut output } (\frac{\text{kg}}{\text{ha}})} \quad (3)$$

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

For calculating the quantities of inputs used for walnut production, the energy equivalences set forth in Table 1 were used. By considering the inputs, data analysis was conducted by using Microsoft Excel program; before the results were tabulated in Table 2 and related to walnut in-

Table 2 Energy balance in walnut production

Inputs	Unit	Energy equivalent (MJ/unit)	Input used per hectare (unit ha^{-1})	Energy value (MJ ha^{-1})	Ratio (%)
Human labour	h	1.96	92.02	180.35	0.75
Machinery	h	64.80	23.75	1539	6.41
Chemical fertilizers				17,851.33	74.40
Nitrogen	kg	60.60	257.24	15,588.74	64.97
Phosphorous	kg	11.10	194.38	2157.61	8.99
Potassium	kg	6.70	15.67	104.98	0.44
Farmyard manure	kg	0.30	144.44	43.33	0.18
Chemicals	kg	101.20	5.02	508.02	2.11
Water of irrigation	m^3	4.20	390.63	1640.64	6.83
Diesel fuel	l	56.31	39.60	2229.87	9.29
Total				23,992.54	100
Outputs	Unit	Energy equivalent (MJ/unit)	Output per hectare (unit ha^{-1})	Energy value (MJ ha^{-1})	Ratio (%)
Walnut kernel	kg	26.15	417.06	10,906.12	74.29
Wooden shell	kg	10	377.34	3773.40	25.71
Total			794.40	14,679.52	100

Table 3 Energy balance calculations in walnut production

Calculations	Unit	Values
Walnut kernel	kg ha^{-1}	417.06
Wooden shell	kg ha^{-1}	377.34
Energy input	MJ ha^{-1}	23,992.54
Energy output	MJ ha^{-1}	14,679.52
Energy use efficiency		0.61
Energy productivity	kg MJ^{-1}	0.03
Specific energy	MJ kg $^{-1}$	30.20
Net energy (–)	MJ ha^{-1}	9313.02

put-output values and the relevant calculations are provided in Table 3. Koçtürk and Engindeniz (2009) reported that, "The input energy is also classified into direct and indirect, and renewable and non-renewable forms. The indirect energy consists of pesticide and fertilizer, while the direct energy includes human and animal labour, diesel and electricity used during the production process. On the other hand, non-renewable energy includes patrol, diesel, electricity, chemicals, fertilizers, machinery, while renewable energy consists of human and animal labour (Mandal et al. 2002; Singh et al. 2003)". Energy inputs of walnut production, in the form of direct and direct, as well as renewable and non-renewable energy are given in Table 4.

Results and Discussion

During the studies in the walnut farms, the average amount of walnut produced per hectare during the 2014–2015 production seasons was calculated as 794.40 kg. As it can be seen in Table 1, the highest energy inputs in walnut production are as follows: chemical fertilizers energy by 17851.33 MJ ha^{-1} (74.40%), diesel fuel energy by 2229.87 MJ ha^{-1} (9.29%), water of irrigation energy by 1640.64 MJ ha^{-1} (6.83%), machinery energy by 1539 MJ ha^{-1} (6.41%), chemicals energy by 508.02 MJ ha^{-1} (2.11%), human labour energy by 180.35 MJ ha^{-1} (0.75%) and farmyard manure energy by 43.33 MJ ha^{-1} (0.18%).

If we were to analyse the values in Table 2, the amount of chemical fertilizers used for walnut production was 467.29 kg ha^{-1} (74.40%). In terms of walnut production, it is noteworthy that chemical fertilizers were the highest input. Similarly, in previous studies related to walnut production, Gündoğmuş et al. (2013) calculated that the fertilizer application energy had the biggest share by 46.70% and Banaeian and Zangeneh (2011) calculated that the fertilizer application energy had the biggest share by 41.50%. Similarly, in previous studies related to agricultural production, Kardoni et al. (2013) calculated that fertilizer application energy had the biggest share by 41.50%. Baali and Quwerkerk (2005) calculated that fertilizer application energy had the biggest share by 62.90%, Çiçek et al. (2011) calculated that fertilizer application energy had the biggest share by 36.48%, Karaağaç (2011) calculated that fertilizer application energy had the biggest share by 58.21%, Baran and Gökdoğan (2014) calculated that fertilizer application energy had the biggest share by 59.33% etc.

Walnut kernel, wooden shell energy input, energy output, energy use efficiency, energy productivity, specific energy and net energy in walnut production have been calculated as 417.06 kg ha^{-1}, 377.34 kg ha^{-1}, 23992.54 MJ ha^{-1}, 14679.52 MJ ha^{-1}, 0.61; 0.03 kg MJ^{-1}; 30.20 MJ kg^{-1}

Table 4 Energy input in the form of energy for walnut production

Walnut production	Energy input (MJ ha^{-1})	Ratio (%)
Direct energy [a]	4050.86	16.88
Indirect energy [b]	19,941.68	83.12
Total	23,992.54	100.00
Renewable energy [c]	1864.32	7.77
Non-renewable energy [d]	22,128.22	92.23
Total	23,992.54	100.00

[a] Includes human labour, diesel and water of irrigation
[b] Includes chemical fertilizers, chemicals, machinery and farmyard manure
[c] Includes human labour, water of irrigation and farmyard manure
[d] Includes diesel, chemicals, chemical fertilizers, machinery and transportation

Table 5 Net return and benefit-cost ratio of the walnut production

Cost and return components	Value
Yield (kg ha^{-1})	794.40
Sale price (TL kg^{-1})	26
Gross value of production (TL ha^{-1})	20,654.40
Variable cost of production (TL ha^{-1})	8483.39
Fixed cost of production (TL ha^{-1})	2504.50
Total cost of production (TL ha^{-1})	10,987.89
Total cost of production (TL kg^{-1})	13.83
Gross return (TL ha^{-1})	12,171.01
Net return (TL ha^{-1})	9666.51
Benefit-cost ratio	1.88

1 US$ = 2.72 TL in 2015 (average)

and -9313.02 MJ ha^{-1}, respectively. In previous studies related to walnut production, energy input, energy output, energy use efficiency, energy productivity, specific energy and net energy in walnut production have been calculated as 15,196.10 MJ ha^{-1}, 44,454.60 MJ ha^{-1}, 2.90; 0.3 kg MJ^{-1}; 3.40 MJ kg^{-1} and 29,258.50 MJ ha^{-1}, respectively by Banaeian and Zangeneh (2011). and energy input, energy output, energy use efficiency, energy productivity, specific energy and net energy in walnut production have been calculated as 42,092.86 MJ ha^{-1}, 73,161.88 MJ ha^{-1}, 1.74; 0.11 kg MJ^{-1}; 9.25 MJ kg^{-1} and 31,069.04 MJ ha^{-1}, respectively by Gündoğmuş (2013). One of the reasons for the energy benefit/cost ratio to be low in this study is that the chemical fertilizers, increasing energy input have been reduced while the use of organic and farm manure has been increased. By reducing the use of chemical fertilizers and increasing the use of farm and organic manure, energy benefit/cost ratio can be increased. The reason for low energy ratio and low output ratio is the low level of yield. And the reason for low yield level is associated with the fact that varieties did not conform to the region, and the abnormalities in climate. When we look at the amount of plantation area, there is a significant increase, however, despite these increase, there is no noteworthy increase in the amount of trees or production level.

The distribution of inputs used for the production of walnut, in accordance to direct, indirect, renewable, and non-renewable energy groups, is given in Table 4. The consumed total energy input in walnut production could be classified as 16.88% direct, 83.12% indirect, 7.77% renewable and 92.23% non-renewable. Similarly, in previous studies, walnut (Banaeian and Zangeneh 2011), walnut (Gündoğmuş 2013), sweet cherry (Demircan et al. 2006), sugar beet (Erdal et al. 2007), kiwifruit (Mohammadi et al. 2010), potato (Mohammadi et al. 2008) and wheat (Tipi et al. 2009) etc. were noted to have a ratio where indirect energy is higher than the ratio of direct energy. Similarly, walnut (Banaeian and Zangeneh 2011), walnut (Gündoğmuş 2013), sweet cherry (Demircan et al. 2006), sugar beet (Baran and Gökdoğan 2016), black carrot (Çelik et al. 2010), wheat (Tipi et al. 2009), lentil (Mirzaee et al. 2011), barley (Baran and Gökdoğan 2014) etc. yielded results where the ratio of non-renewable energy was higher than the ratio of renewable energy.

Economic analysis of walnut production is given in Table 5. The total cost of walnut production per kg was expressed in Turkish liras (TL), which was equal to 0.37 US dollars (US$) in 2015 (on average). Demircan et al. (2006) reported that, "The total figure was calculated by dividing the total cost of walnut production per hectare by the walnut yield per hectare. The net return was calculated by subtracting the total cost of production per hectare (variable + fixed cost) from the gross value of production". The gross return was found by subtracting the variable cost of production per hectare (8483.39 TL ha^{-1}) from the gross value of production (20,654.40 TL ha^{-1}), which yielded 12,171.01 TL ha^{-1}. In the study region, the profit margin per kg of walnut (TL kg^{-1}) was calculated as 12.17. According to these results, the net return from walnut production in the surveyed farms was at a satisfying level. It can be concluded that the net return of 1.88 TL was obtained per 1 TL invested, and was a cost effective business based on the data of the 2015 production season.

In this study, the energy balance of walnut production has been determined. According to the results, walnut production is not a profitable activity in terms of energy usage. Because, the most important reason for having a low yield per decare in the study areas is failing to select the right variety for the ecology, and extreme climate conditions. And as for inputs, it was caused by high non-renewable energy inputs. Gündoğmuş (2013) reported that, "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 achieved 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 the energy required should be economical, sustainable and productive". According to the given economic analysis results, the net return from walnut production, when compared to the total cost of production in the walnut farms, was at a satisfactory level. The benefit-cost ratio was calculated by dividing the gross value of production by the total cost of production per hectare, resulting in 1.88. Walnut production is a cost effective business based on the data from the 2015 production season.

According to the results of the observation and surveys; walnut producers have more awareness, compared to previous years, in terms of irrigation, plantation time, preparing the plantation area for plantation and other similar issues. However, there are deficiencies in terms of selecting the right variety to conform to the local ecology, plant feeding, trimming and cultivation, harvesting at the right time, organized production, conscious control against diseases and pests. As a suggestion; walnut cultivators need to be properly informed on the variety characteristics so they can select the right variety for the right ecology.

According to Göktolga et al. (2006), some of the benefits desired to be obtained through energy input/output analysis are summarized as: being able to determine whether energy has been used effectively or not. Once this is determined, then energy wastage will be prevented, as use of excessive energy will be prevented, which in turn, will lower the negative effects caused by environmental exposure of excessive energy (fertilizer, pesticide, fuel, etc.). Demircan et al. (2006) reported that, "Accurate fertilization management, knowing the correct amount and frequency of fertilization (especially nitrogen) (Kitani 1999) need to save non-renewable energy sources without impairing the yield or profitability, in order to improve the energy use efficiency of sweet cherry production". It is obvious that by abiding to these suggestions yield and energy benefit/cost ratio will increase in walnut cultivation.

References

Acaroğlu M, Aksoy AŞ (2005) The cultivation and energy balance of Miscanthus x giganteus production in Turkey. Biomass Bioenergy 29:42–48

Baali EH, Quwerkerk EV (2005) Energy balance wheat production in Morocco. Deutscher Tropentag, International Research on Food Security, Natural Resource Management and Rural Development, 11.–13. Oct, pp 1–6

Banaeian N, Zangeneh M (2011) Modeling energy flow and economic analysis for walnut production in Iran. Res J Appl Sci Eng Technol 3(3):194–201

Baran MF, Gökdoğan O (2014) Energy input-output analysis of barley production in Thrace region of Turkey. Am Eurasian J Agric Environ Sci 14(11):1255–1261

Baran MF, Gökdoğan O (2016) Determination of energy of sugar beet production in Turkey: a case study of Kırklareli province. Energy Effic 9(2):487–494

Çelik Y, Peker K, Oğuz C (2010) Comparative analysis of energy efficiency in organic and conventional farming systems: a case study of black carrot (Daucus carota L.) production in Turkey. Philipp Agric Sci 93(2):224–231

Çiçek A, Altıntaş G, Erdal G (2011) Energy consumption patterns and economic analysis of irrigated wheat and rainfed wheat production: case study for Tokat region, Turkey. Bulg J Agric Sci 17(3):378–388

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

Erdal G, Esengün K, Erdal H, Gündüz O (2007) Energy use and economical analysis of sugar beet production in Tokat province of Turkey. Energy 32:35–41

FAO (2011) Food and agricultural organization. www.fao.org. Accessed 15. Apr 2011

Göktolga ZG, Gözener B, Karkacıer O (2006) Energy use in peach production: case of Tokat province. J Agric Fac Turk 23(2):39–44 (In Turkish)

Gündoğmuş E (2013) Modelling and sensitivity analysis of energy inputs for walnut production. Actual Probl Econ 2(140):188–197

Hacıseferoğulları H, Acaroğlu M, Gezer I (2003) Determination of the energy balance of the sugar beet plant. Energy Sources 25:15–22

Haskınacı Ş (2003) Walnut sector research, Turkey. http://www.ito.org.tr/Dokuman/Sektor/1-17.pdf. Accessed 24. Apr 2016

İkiz M, Demircan V (2013) Comparative economic analysis of organic and conventional rose oil (Rosa damascenae Mill.) cultivation in Lakes Region, Turkey. J Essent Oil Bear Plants Teop 16(3):352–363

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

Kardoni F, Parande S, Jassemi K, Karami S (2013) Energy input-output relationship and economical analysis of wheat production in Khuzestan province of Iran. Int J Agron Plant Prod 4(9):2187–2193

Kitani O (1999) Energy for biological systems. In: International Commission of Agricultural Engineering (ed) CIGR handbook of agricultural engineering: energy and biomass engineering, vol V. American Society of Agricultural Engineers, Niles, pp 13–42

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

Konak M, Marakoğlu T, Özbek O (2004) Energy balance at corn production. Agric Fac J 18(34):28–30 (In Turkish)

Koyuncu MA, Ekinci K, Sarvan E (2004) Cracking characteristics of walnut. Biosys Eng 87:305–311

Koçtürk OM, Engindeniz S (2009) Energy and cost analysis of sultana grape growing: A case study of Manisa, west Turkey. African 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
Marakoğlu T, Çarman K (2010) Energy balance of direct seeding applications used in wheat production in middle Anatolia. Afr J Agric Res 5(10):988–992
Mirzaee E, Omid M, Asakereh A, Safaieenejad M, Dalvand MJ (2011) 11th International Congress on Mechanization and Energy in Agriculture Congress, İstanbul, 21.–23. Sep, pp 383–387
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
Mrini, M. (1999). Le cout energetique de l'irrigation des cultures sucrieres au Gharb, 2eme rapport d'atat d'avancement, Ecole Doctorale. Institut Agronomique et Veterinaire Hassan II. BP 6202, Rabat, Morocco
Mrini M, Senhaji F, Pimentel D (2002) Energy analysis of sugar beet production under traditional and intensive farming systems and impacts on sustainable agriculture in Morocco. Research, reviews, practices, policy and technology. J Sustain Agric 20(4):5–28
Özkan B, Fert C, Karadeniz CF (2007) Energy and cost analysis for greenhouse and open-field grape production. Energy 32(2007):1500–1504
Öztürk HH, Ekinci K, Barut ZB (2006) Energy analysis of the tillage systems in second crop Corn production. J Sustain Agric 28(3):25–37
Polat R, Çopur O, Sağlam R, Sağlam C (2006) Energy use pattern and cost analysis of cotton agriculture: A case study for Sanliurfa, Turkey. Philipp Agric Sci 89(4):368–371
Singh H, Mishra D, Nahar NM, Ranjan M (2003) Energy use pattern in production agriculture of 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. International Institute of Management University of Flensburg, Sustainable Energy Systems and Management. Master of Science, Germany
Tipi T, Çetin B, Vardar Ç (2009) An analysis of energy use and input costs for wheat production in Turkey. J Food Agric Environ 7(2):352–356
Uzunöz M, Akçay M, Esengün K (2008) Energy input-output analysis of sunflower seed (Helianthus annuus L.) oil in Turkey. Energy Sour Part B Econ Plan Policy 3:215–223
Yaldız O, Öztürk HH, Zeren Y, Başçetinçelik A (1993) Energy usage in production of field crops in Turkey. 5th international congress on mechanization and energy in agriculture, Kuşadası, 11.–14. Oct 1993, pp 527–536 (In Turkish)
Yamane T (2001) Basic sampling methods. Translators: A. Esin, M. A. Bakir, C. Aydin, E. Gurbuzsel, vol. 53. Publishing of Literature, İstanbul. ISBN 975843134X