Erwerbs-Obstbau (2019) 61:211–216
https://doi.org/10.1007/s10341-019-00418-4

ORIGINAL ARTICLE

Evaluation of Energy and Economic Analysis of Chestnut (*Castanea Sativa* Mill.) Fruit Production in Turkey

Osman Gökdoğan[1] · Oktay Erdoğan[1] · Engin Ertan[2] · Ferit Çobanoğlu[3]

Received: 22 September 2017 / Accepted: 10 January 2019 / Published online: 7 February 2019

Abstract

The purpose of this study is to determine and evaluate the energy use efficiency analysis of chestnut fruit production. The evaluation of situation was done for 2016 production season in Aydın province of Turkey. The agricultural input energies and output energies used in chestnut production were calculated to determine the energy use efficiency analysis. According to the study findings, the energy inputs in chestnut production were calculated respectively as 3175.20 MJ ha^{-1} (51.53%) chemical fertilizers energy, 1621.51 MJ ha^{-1} (26.32%) human labour energy, 675 MJ ha^{-1} (10.95%) petrol/gasoline energy, 450 MJ ha^{-1} (7.30%) farmyard manure energy, 213.11 MJ ha^{-1} (3.46%) animal labour energy and 27 MJ ha^{-1} (0.44%) transportation energy. Total input energy and output energy were calculated as 6161.82 MJ ha^{-1} and 70,800 MJ ha^{-1}. The energy output/input ratio, chestnut fruit (yield), specific energy, energy productivity and net energy were calculated respectively as 11.49, 6000 kg ha^{-1}, 1.02 MJ kg^{-1}, 0.97 kg MJ^{-1} and 64,638.18 MJ ha^{-1}. The performed total energy input in chestnut production could be classified as 40.73% direct, 59.27% indirect, 37.08% renewable and 62.92% non-renewable. Benefit-cost ratio was calculated as 3.29 for chestnut fruit.

Keywords Benefit-cost ratio · Chestnut fruit · Energy use efficiency · Energy productivity

Bewertung von Energiebilanz und Wirtschaftlichkeitsberechnung in der Esskastanien-Produktion (*Castanea sativa* Mill.) der Türkei

Schlüsselwörter Nutzen-Kosten-Verhältnis · Esskastanie · Energieeffizienz · Energieproduktivität

Introduction

The natural range of chestnut in the world are Eastern Asia (China, Korea, Japan), Turkey, Southern Europe and North America. In the Northern hemisphere, it is grown naturally in chestnuts forests, along with local species. The main countries growing are China, Korea, Japan and Mediterranean countries. In Turkey, located in Mediterranean basin, *Castanea sativa* Mill. (European chestnut) type of chestnut is naturally grown under the humid conditions of forests in Black Sea, Marmara and Aegean Regions of Anatolia (Subaşı 2004; Karadeniz 2013). Chestnuts and many temperate fruit tree species have been grown in Anatolia since ancient times (Soylu 1984; Ertan et al. 2007). The major chestnut fruit growing areas in Aydın province of Turkey, which yield nearly 35% of Turkey's production (Erincik et al. 2008). According to FAO (2009) data (chestnut fruit), Turkey is the third in the World (Atasoy and Altıngöz 2011). According to 2017 data, Aydın province of Turkey is the first on chestnut with 68,477 decares and 25,423 tons production (TUIK 2017).

Agricultural sector has become more energy-intense to supply more food to rising population and ensure sufficient and adequate nutrition. However, considering restricted natural resources and the impact of using different energy sources on environment and human health; it is important to

✉ Osman Gökdoğan
osmangokdogan@gmail.com

1 Department of Biosystem Engineering, Faculty of Engineering-Architecture, University of Nevşehir Hacı Bektaş Veli, Nevşehir, Turkey

2 Department of Horticulture, Faculty of Agriculture, University of Aydın Adnan Menderes, Aydın, Turkey

3 Department of Agricultural Economics, Faculty of Agriculture, University of Aydın Adnan Menderes, Aydın, Turkey

investigate energy use patterns in agriculture (Hatırlı et al. 2005). Energy is a basic component of economic development because it ensures essential services maintaining the economic activity and increasing the quality of human life. At the farm level, energy use can be classified into four categories: direct, indirect, renewable, and non-renewable resources (Thankappan et al. 2005; Azizi and Heidari 2013). The energy balance is defined as the difference between gross energy of useful products divided by non-renewable energies used to produce them (Risoud 2000; Azizi and Heidari 2013). All inputs and outputs of a cropping system can be expressed in terms of energy. Energy input and output analysis is used to determine the energy efficiency and environmental impact of crop production. This analysis is important to make necessary improvements that will lead to a more efficient and environment-friendly production system (Bojaca and Schrevens 2010; Mobtaker et al. 2010).

Different researches were performed on energy use efficiency analysis of fruit products in Turkey and in the world. For example, studies of fruit were performed on energy use efficiency analysis analysis of citrus (Ozkan et al. 2004a), sweet cherry (Demircan et al. 2006), peach (Göktolga et al. 2006), apricot (Esengün et al. 2007), cherry (Kızılaslan 2009), pomegranate (Canakcı 2010), banana (Akçaöz 2011), nectarine (Qasemi-Kordkheili et al. 2013), apple (Yılmaz et al. 2010), quince (Gündoğmuş 2013), almond (Beigi et al. 2016), walnut (Baran et al. 2017a),

Table 1 Energy equivalents in agriculture production

Inputs and outputs	Unit	Energy equivalent (MJ unit^{-1})	References
Human labour	h	1.96	Mani et al. 2007; Karaağaç et al. 2011
Animal labour	h	10.10	Ozkan et al. 2004b
Chemicals fertilizers			
Nitrogen	kg	60.60	Singh 2002
Phosphor	kg	11.10	Singh 2002
Potassium	kg	6.70	Singh 2002
Farmyard manure	kg	0.30	Singh 2002
Petrol/gasoline	l	43.54	Anonymous 2017
Transportation	MJ (ton km)$^{-1}$	4.50	Fluck and Baird 1982; Kitani 1999
Outputs	Unit	Energy equivalent (MJ/unit)	Reference
Chestnut	kg	11.80	Hatırlı et al. 2005

Table 2 Energy analysis in chestnut fruit 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	827.30	1621.51	26.32
Animal labour	h	10.10	21.10	213.11	3.46
Chemical fertilizers			121.50	3175.20	51.53
Nitrogen	kg	60.60	40.50	2454.30	39.83
Phosphor	kg	11.10	40.50	449.55	7.30
Potassium	kg	6.70	40.50	271.35	4.40
Farmyard manure	kg	0.30	1500	450	7.30
Petrol/gasoline[a]	l	43.54	15.50	675	10.95
Transportation[b]	MJ (ton km)$^{-1}$	4.50	6	27	0.44
Total inputs	–	–	–	6161.82	100.00
Outputs	Unit	Energy equivalent (MJ/unit)	Output per hectare (unit ha^{-1})	Energy value (MJ ha^{-1})	Ratio (%)
Chestnut fruit yield	kg	11.80	6000	70,800	100.00
Total output	–	–	–	70,800	100.00

[a] Pruning operation was performed motor which use with human labour
[b] Transportation distance was considered as 1 km

plum (Baran et al. 2017b) etc. Although many experimental studies were performed on energy use efficiency analysis in fruit field but there has no study on energy use efficiency evaluation on chestnut fruit production in literature. In this study, it was aimed to perform the energy use efficiency analysis of chestnut fruit production.

Materials and Method

Aydın province is located within the Aegean region of Turkey. Aydın has productive plains in central and western sections, is surrounded by mountains in north and south. It is located on the Great Menderes basin, covering an area of 8007 km^2. 55% of the population is depending on farming for their livelihood. Aydın has a major role in Turkey in terms of national agriculture, as indicated by the fact that the province is ranked within the top ten producers in 25 different products (Anonymous 2015). In this study, data acquired and compiled through interviews with chestnut growers from the villages of Nazilli district of Aydın province, where chestnut growing is common, has been used as material.

By calculating the agricultural input energies and output energies were used in chestnut fruit production, the energy use efficiency analysis was done. Total energy input in unit area (ha) constitutes the total energy inputs. Human labour energy, animal labour energy, chemical fertilizers, farmyard manure energy, petrol/gasoline energy and transportation energy were calculated as inputs. The units shown in Table 1 were used to calculate the values of the inputs of chestnut fruit production. Previous energy analysis studies were used when determining the energy equivalent coefficients. The total energy equivalent was calculated by adding energy equivalents of all inputs in MJ unit. In order to determine the energy input-output in chestnut fruit production, "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, 2010)".

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

$$\text{Specific energy} = \frac{\text{Energy input } \left(\frac{\text{MJ}}{\text{ha}}\right)}{\text{Chestnut fruit output } \left(\frac{\text{kg}}{\text{ha}}\right)} \tag{2}$$

$$\text{Energy productivity} = \frac{\text{Chestnut fruit output } \left(\frac{\text{kg}}{\text{ha}}\right)}{\text{Energy input } \left(\frac{\text{MJ}}{\text{ha}}\right)} \tag{3}$$

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

Table 3 Energy analysis indicators in chestnut fruit production

Calculations	Unit	Values
Fruit-chestnut yield	kg ha^{-1}	6000
Energy input	MJ ha^{-1}	6161.82
Energy output	MJ ha^{-1}	70,800
Energy use efficiency	–	11.49
Specific energy	MJ kg^{-1}	1.02
Energy productivity	kg MJ^{-1}	0.97
Net energy	MJ ha^{-1}	64,638.18

Table 4 Energy inputs in the forms of energy for chestnut fruit production

Energy groups	Energy input (MJ ha^{-1})	Ratio (%)
Direct energy [a]	2509.62	40.73
Indirect energy [b]	3652.20	59.27
Total	6161.82	100.00
Renewable energy [c]	2284.62	37.08
Non-renewable energy [d]	3877.20	62.92
Total	6161.82	100.00

[a] Includes human labour, animal labour and diesel
[b] Includes chemical fertilizers, farmyard manure and transportation
[c] Includes human labour, animal labour and farmyard manure
[d] Includes diesel, chemical fertilizers and transportation

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

Costs and return components	Value
Yield (kg ha^{-1})	6000
Sale price (TL kg^{-1})	10
Gross value of production (TL ha^{-1})	60,000
Variable cost of production (TL ha^{-1})	14,869.60
Fixed cost of production (TL ha^{-1})	3325.20
Total cost of production (TL ha^{-1})	18,194.80
Total cost of production (TL kg^{-1})	3.03
Gross return (TL ha^{-1})	45,130.40
Net return (TL ha^{-1})	41,805.20
Benefit-cost ratio	3.29

1 US$ = 3.02 TL in 2016 (on average)

The results were tabulated in Table 2 and related to chestnut fruit production input-output values and the relevant calculations were given 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 petrol, 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 chestnut fruit production, in the form of direct and direct, as well as renewable and non-renewable energy were given in Table 4. Economic analysis of chestnut fruit production was given in Table 5.

Results and Discussion

The average amount of chestnut fruit produced per hectare for 2016 production season was calculated as 6000 kg. As it can be evaluated in Table 2, energy inputs in chestnut fruit production were as follows, respectively: 3175.20 MJ ha^{-1} (51.53%) chemical fertilizers energy, 1621.51 MJ ha^{-1} (26.32%) human labour energy, 675 MJ ha^{-1} (10.95%) petrol/gasoline energy, 450 MJ ha^{-1} (7.30%) farmyard manure energy, 213.11 MJ ha^{-1} (3.46%) animal labour energy and 27 MJ ha^{-1} (0.44%) transportation energy. Total input energy was calculated as 6161.82 MJ ha^{-1}. Production output chestnut fruit yield and output energy were calculated as 6000 kg ha^{-1} and 70,800 MJ ha^{-1}. In terms of chestnut fruit production, it is noteworthy that chemical fertilizers, human labour energy and petrol/gasoline energy were the highest input.

Similarly, in previous studies related to fruit studies, Demircan et al. (2006) calculated that the fertilizer application energy had the biggest share by 45.35% in sweet cherry, Banaeian and Zangeneh (2011) calculated that fertilizer application energy had the biggest share by 41.50% in walnut, Qasemi-Kordkheili et al. (2013) calculated that fertilizer application energy had the biggest share by 36.93% in nectarine, Mohammadi et al. (2010) calculated that fertilizer application energy had the biggest share by 47.23% in kiwifruit, Canakcı (2010) calculated that fertilizer application energy had the biggest share by 57.40 in pomegranate etc. The results evaluated that 827.30 h of human labour energy is required per hectare of chestnut fruit production. Human labour energy and petrol/gasoline energy were used for farm operations and pruning motor.

Chestnut fruit yield, energy input, energy output, energy output/input ratio, specific energy, energy productivity and net energy in chestnut fruit production were calculated as 6000 kg ha^{-1}, 6161.82 MJ ha^{-1}, 70,800 MJ ha^{-1}, 11.49, 1.02 MJ kg^{-1}, 0.97 kg MJ^{-1} and 64,638.18 MJ ha^{-1}, respectively (Table 3). As specific energy, 1.02 MJ of energy is obtained of 1 kg chestnut fruit. In previous fruit studies, Gezer et al. (2003) calculated (apricot) energy use efficiency as 3.37, Göktolga et al. (2006) calculated (peach) energy use efficiency as 0.93, Esengün et al. (2007) calculated (dry apricot) energy use efficiency as 1.24 and 1.31, Demircan et al. (2006) calculated (sweet cherry) energy use efficiency as 1.23, Kızılaslan (2009) calculated (cherry) energy use efficiency as 0.96, Canakcı (2010) calculated (pomegranate) energy use efficiency as 1.25–1.94, Beigi et al. (2016) calculated (almond) energy use efficiency as 0.62, 1.12 and 0.81, Gökdoğan and Erdoğan (2017) calculated (organic olive) energy use efficiency as 2.72, Baran et al. (2017a) calculated (walnut) energy use efficiency as 0.61 and Baran et al. (2017b) calculated (plum) energy use efficiency as 1.39.

The distribution of inputs was used for the production of chestnut fruit, in accordance to direct, indirect, renewable and non-renewable energy groups is given in Table 4. The consumed total energy input in chestnut fruit production could be classified as 40.73% direct, 59.27% indirect, 37.08% renewable and 62.92% non-renewable. In this study, non-renewable energy sources composed 62.92% (3877.20 MJ ha^{-1}) of the total energy input, which was higher than that of the renewable resources 37.08% (2284.62 MJ ha^{-1}). Energy use efficiency was increased, because usage of farmyard manure were used instead of chemical fertilizers for energy equivalent of chemicals fertilizers is high. Similarly, fruit studies on lemon, mandarin, orange (Ozkan et al. 2004a), sweet cherry (Demircan et al. 2006), kiwifruit (Mohammadi et al. 2010), pomegranate (Çanakcı 2010), walnut (Banaeian and Zangeneh 2011), nectarine (Qasemi-Kordkheili et al. 2013), quince (Gündoğmuş 2013), plum (Baran et al. 2017b) etc. resulted where the ratio of non-renewable energy was higher than the ratio of renewable energy.

Economic analysis of chestnut fruit production was given in Table 5. The total cost of chestnut fruit production per kg was explained in Turkish Lira (TL), which was equal to 0.33 US dollars (US$) in 2016 (on average). Demircan et al. (2006) reported that, "The net return was calculated by subtracting the total cost of production per hectare (variable + fixed cost) fom the gross value of production". The gross return was calculated by subtracting the variable cost of production per hectare (14,869.60 TL ha^{-1}) from the gross value of production (60,000 TL ha^{-1}) and was calculated as 45,130.40 TL ha^{-1}. In the evaluation study, the profit margin per kg of chestnut fruit (TL kg^{-1}) was calculated as 6.97. According to evaluation results, the net return in the chestnut fruit production was at a satisfying level. It can be explained that the net return of 3.29 TL was obtained per 1 TL invested and was a cost effective business for 2016 season of chestnut fruit production. In previous fruit studies, Demircan et al. (2006) calculated (sweet cherry) benefit-cost ratio as 2.53, Esengün et al. (2007) calculated (dry apricot) benefit-cost ratio as 1.11 and 1.19, Beigi et al. (2016) calculated (almond) benefit-cost ratio as 4.19, 6.30 and 4.76, Baran et al. (2017a) calculated (walnut) benefit-cost ratio as 1.88 and Mohammadi et al. (2010) calculated (kiwifruit) benefit-cost ratio as 1.94.

In this evaluation study, the energy use efficiency analysis of chestnut fruit production was done. According to the evaluation results, chestnut fruit production is a profitable activity in terms of energy use efficiency analysis (11.49) and economic analysis (3.29). Energy use efficiency analysis was calculated by dividing the energy output/energy input ratio. According to the given economic analysis results, the net return from chestnut fruit production, when compared to the total cost of production in the chestnut fruit producers 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 3.29. Chestnut fruit production is a cost effective business based on 2016 production season. In order to increase the profit margin and thus increase the revenue of manufacturers, it is important to establish organizations such as producer cooperatives and increase industrial establishments particularly based on agriculture (such as candied chestnut processing factory).

The use of chemical fertilizers, especially nitrogen was the most energy consuming input in chestnut fruit production (39.83%). The result indicated that most of the energy was consumed in the form of non-renewable energy, such as chemical fertilizers 51.53% of the total energy input. Demircan et al. (2006) reported that, "accurate fertilization management, taking the amount and frequency of fertilization (especially nitrogen) into account". Increasing the usage of renewable energy sources can make possible to supply sustainable energy development aims (Rafiee et al. 2010; Barut et al. 2011). Optimization of energy using in agricultural systems is arrived in two ways: an increase in productivity with the present 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 (Gündoğmuş 2013). It is obvious that by expecting to these suggestions yield and energy benefit-cost ratio will increase in chestnut fruit production.

Conflict of interest O. Gökdoğan, O. Erdoğan, E. Ertan and F. Çobanoğlu declare that they have no competing interests.

References

Akçaöz H (2011) Analysis of energy use for banana production: A case study from Turkey. Afr J Agric Res 6(25):5618–5624
Anonymous (2015) Türkiye Cumhuriyeti Aydın Valiliği. http://www.aydin.gov.tr/genel-bilgiler. Accessed 7 Aug 2017
Anonymous (2017) Türkiye Cumhuriyeti Enerji ve Tabii Kaynaklar Bakanlığı. http://www.eie.gov.tr/duyurular_haberler/document/SENVER_15_Usul_ve_Esaslar_Ek2.pdf. Accessed 9 Aug 2017
Atasoy E, Altıngöz Y (2011) Dünya ve Türkiye'de kestanenin önemi ve üretimi. Coğrafya Dergisi 22:1–13
Azizi A, Heidari S (2013) A comparative study on energy balance and economical indices in irrigated and dry land barley production systems. Int J Environ Sci Technol (Tehran) 10:1019–1028
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, Oğuz HI (2017a) Determining the energy usage efficiency of walnut (Juglans regia L.) cultivation in Turkey. Erwerbs-Obstbau 59:77–82
Baran MF, Oğuz HI, Gökdoğan O (2017b) Determiniation of energy input-output analysis in plum (Prunus domestica L.) production. Erwerbs-Obstbau 59(4):331–335. https://doi.org/10.1007/s10341-017-0332-z
Barut ZB, Ertekin C, Karaağaç HA (2011) Tillage effects on energy use for corn silage in mediterranean coastal of Turkey. Energy 36(9):5466–5475. https://doi.org/10.1016/j.energy.2011.07.035
Beigi M, Torki-Harchegani M, Ghanbarian D (2016) Energy use efficiency and economical analysis of almond production: A case study in Chaharmahal-Va-Bakhtiari province, Iran. Energy Effic 9:745–754
Bojaca CR, Schrevens E (2010) Energy assessment of peri-urban horticulture and its uncertainty: Case study for Bogota, Colombia. Energy 35:2109–2118
Canakcı M (2010) Energy use pattern and economic analyses of pomegranate cultivation in Turkey. Afr J Agric Res 5(7):491–499
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
Erincik O, Döken MT, Açıkgöz S, Ertan E (2008) Characterization of Cryphonectria parasitica isolates collected from Aydın province in Turkey. Phytoparasitica 36(3):249–259
Ertan E, Seferoğlu G, Günver Dalkılıç G, Tekintaş FE, Seferoğlu S, Babaeren F, Önal M, Dalkılıç Z (2007) Selection of chestnuts (Castanea sativa mill.) grown in Nazilli district, Turkey. Turk J Agric For 31:115–123
Esengün K, Gündüz O, Erdal G (2007) Input-output energy analysis in dry apricot production of Turkey. Energy Convers Manag 48:592–598
FAO (2009) FAO. www.fao.org
Fluck R, Baird CD (1982) Agricultural energetics. AVI, Connecticut
Gezer I, Acaroğlu M, Hacıseferoğulları H (2003) Use of energy and labor in apricot agriculture in Turkey. Biomass Bioenergy 24:215–219
Gökdoğan O, Erdoğan O (2017) Evaluation of energy balance in organic olive (Olea Europaea L.) production in Turkey. Erwerbs-Obstbau 60(1):47–52. https://doi.org/10.1007/s10341-017-0338-6
Göktolga ZG, Gözener B, Karkacıer O (2006) Şeftali üretiminde enerji kullanımı: Tokat ili örneği. Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi 23(2):39–44
Gündoğmuş E (2013) Energy use patterns and econometric models of quince production. Actual Probl Econ 5(143):236–246
Hatırlı SA, Ozkan B, Fert C (2005) An econometric analysis of energy input-output in Turkish agriculture. Renew Sustain Energy Rev 9(2005):608–623
Karaağaç MA, Aykanat S, Çakır B, Eren O, Turgut MM, Barut ZB, Oztürk HH (2011) Energy balance of wheat and maize crops production in Hacıali undertaking. 11th International Congress on Mechanization and Energy in Agriculture Congress, Istanbul, Turkey, 21–23 September, pp 388–391
Karadeniz V (2013) Türkiye'de kestane tarımı ve başlıca sorunları. Uluslararası Sosyal Araştırmalar Dergisi 6(27):280–291
Kitani O (1999) Energy for biological systems. In: The International Commission of Agricultural Engineering (ed) CIGR handbook of agricultural engineering: Energy and biomass engineering, vol V. St. Joseph, American Society of Agricultural Engineers, pp 13–42
Koçtürk 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
Kızılaslan H (2009) Input-output energy analysis of cherries production in Tokat province of Turkey. Appl Energy 86:1354–1358
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
Mobtaker HG, Keyhani A, Mohammadi A, Rafiee S, Akram A (2010) Sensitivity analysis of energy inputs for barley production in Hamedan Province of Iran. Agric Ecosyst Environ 137:367–372
Mohammadi A, Rafiee S, Mohtasebi SS, Rafiee H (2010) Energy inputs-yield relationship and cost analysis of kiwifruit production in Iran. Renew Energy 35(5):1071–1075. https://doi.org/10.1016/j.renene.2009.09.004
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
Ozkan B, Akçaöz H, Fert C (2004b) Energy input-output analysis in Turkish agriculture. Renew Energy 29:39–51
Ozkan B, Akçaöz H, Karadeniz F (2004a) Energy requirement and economic analysis of citrus production in Turkey. Energy Convers Manag 45:1821–1830
Qasemi-Kordkheili P, Kazemi N, Hemmati A, Taki M (2013) Energy consumption, input-output relationship and economic analysis for nectarine production in Sari region, Iran. Int J Agric Crop Sci 5(2):125–131
Rafiee S, Avval SHM, Mohammadi A (2010) Modeling and sensitivity analysis of energy inputs for apple production in Iran. Energy 35:3301–3306
Risoud B (2000) Energy efficiency of various French farming systems: questions and sustainability. In: International Conference "Sustainable energy: new challenges for agriculture and implications for land use" Wageningen University, Netherlands, May 18–20
Singh JM (2002) On garden energy use pattern in different cropping systems in Haryana, India. University of Flensburg, Flensburg
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
Soylu A (1984) Kestane yetiştiriciliği ve özellikleri vol 59. Atatürk Bahçe Kültürleri Araştırma Enstitüsü, Yalova
Subaşı B (2004) Istanbul Ticaret Odası Etüt Araştırma Şubesi Kestane Sektör Profili. http://www.ito.org.tr/DokumanSektor1-55.pdf
Thankappan S, Midmore P, Jenkins T (2005) Conserving energy in smallholder agriculture: A multi-objective programming casestudy of northwest India. Ecol Econ 56:190–208
TUIK (2017) Türkiye Istatistik Kurumu. https://biruni.tuik.gov.tr/bitkiselapp/bitkisel.zul. Accessed 7 Aug 2017
Yılmaz I, Ozalp A, Aydoğmuş F (2010) Antalya ili bodur elma üretiminde enerji kullanım etkinliğinin belirlenmesi: Elmalı ilçesi örneği. Akdeniz Univ Ziraat Fakültesi Dergisi 23(2):93–97