Determination of Energy Balance of Wheat Production in Turkey: A Case Study of Eskil District of Aksaray Province

Osman GÖKDOĞAN[1,*] **Behlül SEVİM[2]**

[1]Nevşehir Hacı Bektaş Veli University, Faculty of Engineering-Architecture,
Department of Biosystem Engineering, Nevşehir, Turkey
[2]Eskil District Food, Agriculture and Livestock Directorate, Aksaray, Turkey
Corresponding author's e-mail: osmangokdogan@gmail.com

Geliş Tarihi (Received): 21.04.2016 Kabul Tarihi (Accepted): 23.07.2016

This study aims to make an energy balance of wheat production in Eskil district of Aksaray province in Turkey. In order to determine the energy balance of wheat, surveys have been conducted in 151 wheat farms, located around 12 villages of Eskil district and selected through simple random sampling method. During the production season in 2013, the energy input-output ratio of the 151 wheat farms have been determined through observations and face-to-face questionnaires. Regarding wheat production, energy input has been calculated as 25876.29 MJ ha^{-1}, while energy output has been calculated as 76990.96 MJ ha^{-1}, and energy output / input ratio has been defined as 2.97. The composition of energy inputs is 43.84% chemical fertilizers energy, 15.06% wheat seed energy, 13.93% water of irrigation, 13.07% diesel fuel energy, 11.10% electricity energy, 1.39% machinery energy, 0.92% transportation energy, 0.48% chemical energy and 0.20% human labour energy. Energy use efficiency, energy productivity, specific energy and net energy in wheat production have been calculated as 2.97; 0.20 kg MJ^{-1}; 4.94 MJ kg^{-1} and 51114.67 MJ ha^{-1}, respectively.

Key words: Energy input-output ratio, energy productivity, specific energy, wheat

Türkiye'de Buğday Üretiminde Enerji Bilançosunun Belirlenmesi: Aksaray İli Eskil İlçesi Örneği

Bu çalışmada, Türkiye'nin Aksaray ilinin Eskil ilçesinde buğday üretiminde enerji bilançosunun belirlenmesi amaçlanmıştır. Buğdayın enerji bilançosunu belirlemek için, basit tesadüfi örnekleme yöntemi vasıtasıyla seçilmiş ve Eskil ilçesinin 12 köyündeki 151 işletme ile çalışılmıştır. 2013 üretim sezonu boyunca 151 buğday işletmesi ile yüz yüze anket ve gözlem yapılarak enerji girdi-çıktı oranı belirlenmiştir. Buğday üretiminde enerji girdisi 25876.29 MJ ha^{-1}, enerji çıktısı 76990.96 MJ ha^{-1} olarak hesaplanmış ve enerji çıktı / girdi oranı 2.97 olarak belirlenmiştir. Enerji girdilerinin %43.84'ü kimyasal gübre enerjisi, %15.06'sı buğday tohumu enerjisi, %13.93'ü sulama enerjisi, %13.07'si yakıt enerjisi, %11.10'u elektrik enerjisi, %1.39'u makine enerjisi, %0.92'si taşıma enerjisi, %0.48'i kimyasal enerji ve %0.20'si insan işgücü enerjisinden oluşmaktadır. Buğday üretiminde enerji kullanım etkinliği, enerji verimliliği, spesifik enerji ve net enerji sırasıyla 2.97; 0.20 kg MJ^{-1}; 4.94 MJ kg^{-1} and 51114.67 MJ ha^{-1} olarak hesaplanmıştır.

Anahtar kelimeler: Enerji girdi-çıktı oranı, enerji verimliliği, spesifik enerji, buğday

Introduction

Efficient use of energy is one of the fundamental requirements of sustainable agriculture. Energy usage in agriculture has been rising in response to rising population, stinted supply of arable land. Continuous demand for raised food production has resulted in intense use of chemical fertilizers, pesticides, agricultural machinery and other natural resources. Efficient usage of energy in agriculture will minimize environmental causes, prevent destruction of natural resources and promote sustainable agriculture (Erdal et al., 2007). Akçaöz (2011) reported that "The issue of energy is comprehended from a different perspective by scientists, engineers, economists, environmentalists, industrialists, and farmers, not to mention the consumers (Schneeberger and Breimyer, 1974)". Namdari et al. (2011) reported that "Energy input-output analysis in agricultural systems has been widely used to determine the efficiency and the environmental impact (Bojaca and Schrevens, 2010)".

Azarpour (2012) reported that, "Wheat is one of the eight main food sources (wheat, rice, corn, sugar, cattle, sorghum, millet and cassava) which provides 70-90% of all calories and 66-90% of all the protein used up in developing countries. Most people use up wheat more than any other cereal grain (Safa et al., 2011)." Tipi et al. (2009) reported that, "Turkey has a total land area of 78 million hectares. The total utilized agricultural area in the world is 41 million hectares, which consists of arable land (23.8 million hectares), area used for permanent crops (2.8 million hectares), and permanent meadows and pastures (14.6 million hectares). Fallow land makes up more than 20 per cent of total arable cropland. Turkey is one of the leading actors of major cereal producing countries of the world. Cereal production takes place in 75% of Turkey's cropland (Anonymous, 2007)".

Researches have been conducted on energy analysis of agricultural products. For example, researches have been conducted on energy usage activities of wheat (Marakoğlu and Çarman, 2010), wheat (Kardoni et al, 2013), wheat (Çiçek et al., 2011), wheat (Tipi et al., 2009), wheat (Shahin et al., 2008), wheat (Azarpour, 2012), wheat and maize (Karaağaç et al., 2011), barley (Azizi and Heidari, 2013), miscanthus x giganteus (Acaroğlu and Aksoy, 2005), barley (Baran and Gökdoğan, 2014), lentil (Mirzaee et al., 2011), wheat (Ghorbani et al., 2011), chick pea (Marakoğlu et al., 2010), maize (Konak et al., 2004), canola (Baran et al., 2014), canola (Unakitan et al., 2010), corn (Öztürk et al., 2006), black carrot (Çelik et al., 2010), sugar beet (Hacıseferoğulları et al., 2003), sugar beet (Baran and Gökdoğan, 2016), sunflower (Uzunöz et al., 2008), cotton (Polat et al., 2006) etc. Wheat is the most important livelihood source within Eskil district in macro and micro terms and defining the related energy balance is the aim of this study.

Material and Method

Material

In order to determine the energy balances of wheat plant, observations and surveys have been done at wheat producing farms in Eskil region. Eskil is an important location for wheat production. One on one observation and surveys has been performed with 151 wheat growers, during the production season of 2013. The main material of the research has been composed of data gathered through one on one surveys with 151 wheat producers in Eskil district. Surveys have been conducted in a total of 12 villages in Eskil district, and the particular farms have been selected through simple random sampling method.

Method

According to Çiçek and Erkan (1996), the number of enterprises to be surveyed has been calculated through simple random sampling method, the formula of which has been given below.

$$n = \frac{N \times s^2 \times t^2}{(N-1)d^2 + (s^2 \times t^2)} \qquad (1)$$

$$n = \frac{12x(7924.79)^2 x(1.65)^2}{(11)x(367.67)^2 + ((7924.79)^2 \times (1.65)^2)}$$ = 12 villages have been surveyed.

$$n = \frac{435x(91.84)^2 x(1.65)^2}{(434)x(10.14)^2 + ((91.84)^2 \times (1.65)^2)}$$ **= 148, but** 151 wheat producers have surveyed.

In the formula; n, indicates the sample volume, N = total business number within the sampling framework, s = Standard deviation, t = 90% t table value corresponding to confidence limit (1.65), d = acceptable error (10% deviation). The work has been executed within the confidence limit of 90%, where the remaining 10% corresponds to the acceptable error. It has been calculated that the number of farms selected to be surveyed had to be 151, all of which have been randomly selected. Total energy input in unit area (ha) constitutes of the total energy inputs. Human labour, machinery, chemical fertilizers, chemicals, water of irrigation, electricity, diesel fuel, transportation and wheat seed have been the calculated inputs.

Energy output / input ratios of the enterprises comprised in wheat agriculture have been calculated. Energy balance calculations have been made to determine the productivity level of wheat production. The units shown in Table 1 have been used to calculate the values of the inputs of wheat production. Previous energy analysis studies (sources) have been used when determining the energy equivalent coefficients. By adding energy equivalents of all inputs in MJ unit, the total energy equivalent has been found. In order to determine the energy usage efficiency in wheat production, Mohammadi et al. (2010) reported that, "Energy use efficiency), energy productivity, specific energy and net energy have been calculated by using the following formulates (Mandal et al., 2002; Mohammadi et al., 2008)".

$$\text{Energy use efficiency} = \frac{\text{Energy output } (\frac{MJ}{ha})}{\text{Energy input } (\frac{MJ}{ha})} \quad (2)$$

$$\text{Energy productivity} = \frac{\text{Wheat output } (\frac{kg}{ha})}{\text{Energy input } (\frac{MJ}{ha})} \quad (3)$$

$$\text{Specific energy} = \frac{\text{Energy input } (\frac{MJ}{ha})}{\text{Wheat output } (\frac{kg}{ha})} \quad (4)$$

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

Table 1. Energy equivalents in wheat 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
Harvesting (Combine)	h	87.63	Hetz, 1992; Çanakcı, 2005; Tipi et al., 2009
Transportation	MJ t^{-1} km^{-1}	4.50	Fluck and Baird, 1982; Kitani, 1999
Chemical fertilizers			
Nitrogen	kg	60.60	Singh, 2002
Phosphorous	kg	11.10	Singh, 2002
Sulphur	kg	1.12	Nagy, 1999; Mohammadi et al., 2010
Chemicals	kg	101.20	Yaldız et al., 1993
Diesel fuel	l	56.31	Singh, 2002; Demircan et al., 2006
Water of irrigation	m^3	1.02	Acaroğlu, 1998; Azizi and Heidari, 2013
Electricity	kWh	3.60	Özkan et al., 2004
Wheat seed	kg	15.70	Singh, 2002; Çiçek et al., 2011
Outputs	Unit	Values (MJ / unit)	Sources
Wheat grain	kg	14.70	Singh, 2002; Çiçek et al., 2011

For calculating the quantities of inputs used for wheat production, the energy equivalences set forth Table 1 have been used. Quantities of inputs have been calculated in accordance with area (hectare), and then they have been multiplied by the equivalence of these inputs. Resources of previous researches have been used for determining the coefficients of energy equivalence. By considering the inputs, data analysis has been conducted by using Microsoft Excel program, before the results have been tabulated Table 2 and Table 3. Studies related to wheat input-output values and relevant calculations have been provided in Table 4.

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 the 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 input of wheat production, in the form of direct and direct, as well as renewable and non-renewable energy has been given in Table 5.

Results and Discussion

During the studies in the enterprises, the average amount of wheat produced per hectare during the 2013 production season has been calculated as 5237.48 kg. Average land size of a farm was 9.76 ha. In terms of wheat production, it is noteworthy that chemical fertilizers, wheat seed and irrigation have been the highest inputs. The cause for chemical fertilizers energy being so high is that instead of farm fertilizers, chemical fertilizers have been used. In relation to this study, practices for wheat production and the energy balance of wheat production in 2013 have been given in Table 2. Glancing at these, it can be seen that the highest energy inputs in wheat production are as follows: chemical fertilizers energy by 43.84%, wheat seed energy by 15.06%, irrigation water energy by 13.93%, diesel fuel energy by 13.07%, electricity energy by 11.10%, machinery energy by 1.39%, transportation energy by 0.92%, chemicals energy by 0.48% and human labour energy by 0.20%.

Investigating the values in Table 2, chemical fertilizers energy, wheat seed energy and irrigation water energy are among the top wheat production inputs. The amount of chemical fertilizers, wheat seed and diesel fuel used for wheat production was 268.48 kg ha^{-1}, 248.28 kg ha^{-1}, 3534.79 m^3 ha^{-1}, respectively. If the average values are examined by referring to Table 2, it can be seen that the highest energy inputs in wheat production are 11345.05 MJ ha^{-1} chemical fertilizers energy, 3898 MJ ha^{-1} wheat seed energy, 3605.48 MJ ha^{-1} irrigation water, 3383.10 MJ ha^{-1} diesel fuel energy, 2871.93 MJ ha^{-1} electricity energy, 358.61 MJ ha^{-1} machinery energy, 238.72 MJ ha^{-1} transportation energy, 123.46 MJ ha^{-1} chemicals energy, and 51.94 MJ ha^{-1} human labour energy. In this research, fertilizer application energy had the biggest share by 44.11%. Similarly, in previous studies related to wheat production, Shahin et al. (2008) calculated that the fertilizer application energy had the biggest share by 38.45%, Kardoni et al. (2013) calculated that fertilizer application energy had the biggest share by 44.11%, Çiçek et al. (2011) calculated that fertilizer application energy had the biggest share by 36.48%, Baali and Quwerkerk (2005) calculated that fertilizer application energy had the biggest share by 62.90%, Karaağaç (2011) calculated that fertilizer application energy had the biggest share by 58.21%.

Table 2. Energy balance in wheat 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	26.50	51.94	0.20
Machinery			5.27	358.61	1.39
Machinery	h	64.80	4.52	292.89	1.13
Harvesting (Combine)	h	87.63	0.75	65.72	0.26
Chemical fertilizers			268.48	11345.05	43.84
Nitrogen	kg	60.60	170.42	10327.45	39.91
Phosphorous	kg	11.10	90.96	1009.65	3.90
Sulphur	kg	1.12	7.10	7.95	0.03
Chemicals	kg	101.20	1.22	123.46	0.48
Water of irrigation	m^3	1.02	3534.79	3605.48	13.93
Electricity	kWh	3.60	797.76	2871.93	11.10
Diesel fuel	l	56.31	60.08	3383.10	13.07
Transportation	MJ t^{-1} km^{-1}	4.50	53.05	238.72	0.92
Wheat seed	kg	15.70	248.28	3898	15.06
Total				25876.29	100
Outputs	**Unit**	**Energy equivalent (MJ / unit)**	**Output per hectare (unit ha^{-1})**	**Energy value (MJ ha^{-1})**	**Ratio (%)**
Wheat grain	kg	14.70	5237.48	76990.96	100

On average, tillage operations have been performed 1.74 times a year using agricultural machinery. Sowing, fertilizer machine and irrigation have been used to apply chemical fertilizers. Chemicals have been sprayed once a year. Wheat fields in the region have been irrigated (3.28 times a year) through sprinkler irrigation system. Sprinkler irrigation powered by electricity has used for irrigation in wheat production. Wheat has been harvested by combined harvester. Trucks have been used for transportation of wheat grain. As indicated in Table 3, wheat production output / input ratio has been defined as 2.97. This value indicates that the wheat production was a productive one. Wheat grain, energy input, energy output, energy use efficiency, energy productivity, specific energy and net energy in wheat production have been calculated as 5237.48 kg ha^{-1}, 25876.29 MJ ha^{-1}, 76990.96 MJ ha^{-1}, 2.97; 0.20 kg MJ^{-1}; 4.94 MJ kg^{-1} and 51114.67 MJ ha^{-1}, respectively. In previous studies related to wheat production, Shahin et al. (2008) calculated energy output / input ratio as 3.13, Marakoğlu and Çarman (2010) calculated energy output / input ratio as 2.81, Çiçek et al. (2011) calculated energy output / input ratio as 2.51 and 2.43, Ramah and Baali (2013) calculated energy output / input ratio as 3.30, Baali and Quwerkerk (2005) calculated energy output / input ratio as 4.90, Moghimi et al. (2013) calculated energy output / input ratio in their study as 2.28, Ghorbani et al. (2011) calculated energy output / input ratio as 3.38 and 1.44, Karaağaç et al. (2011) calculated energy output / input ratio (for wheat and maize) as 3.50 and 6.54 etc. In previous some studies of wheat energy analysis, Tipi et al. (2009), Shahin et al. (2008), Kardoni et al. (2013), Karaagac et al. (2011) and Moghimi et al. (2013) have calculated that energy analysis in wheat production (Table 4).

Table 3. Energy balance calculations in wheat production

Calculations	Unit	Values
Wheat grain	kg ha^{-1}	5237.48
Energy input	MJ ha^{-1}	25876.29
Energy output	MJ ha^{-1}	76990.96
Energy use efficiency		2.97
Energy productivity	kg MJ^{-1}	0.20
Specific energy	MJ kg^{-1}	4.94
Net energy	MJ ha^{-1}	51114.67

Table 4. In previous some studies of wheat energy analysis

Studies	Yield (kg ha^{-1})	Total energy input (MJ ha^{-1})	Total energy output (MJ ha^{-1})	Output and input ratio
In this study	5237.48	25876.29	76990.96	2.97
Tipi et al. (2009)	4346	20653.54	63886.20	3.09
Shahin et al. (2008)	6357	38356.39	120097.90	3.13
Kardoni et al. (2013)	4285	35605	62989.50	1.76
Karaağaç et al. (2011)	2587.20	16553.94	63886.20	3.09
Moghimi et al. (2013)	5537.50	42998.44	97935.53	2.28

The distribution of inputs used for the production of wheat, in accordance to direct, indirect, renewable, and non-renewable energy groups, has been given in Table 5. As it is indicated in Table 5, the consumed total energy input in wheat production could be classified as 38.31% direct, 61.69% indirect, 29.20% renewable, and 70.80% non-renewable. Similarly, in previous studies, sugar beet (Erdal et al., 2007), kiwifruit (Mohammadi et al., 2010), canola (Unakıtan et al., 2010), potato (Mohammadi et al., 2008), wheat (Kardoni et al, 2013), wheat (Shahin et al., 2008), wheat (Çiçek et al., 2011), wheat (Tipi et al., 2009) and wheat and maize (Karaağaç et al., 2011) etc. have been noted to have a ratio where indirect energy is higher than the ratio of direct energy. Similarly, studies on maize (Vural and Efecan, 2012), black carrot (Celik et al., 2010), garlic (Samavatean et al., 2011), wheat (Çiçek et al., 2011), wheat (Tipi et al., 2009), wheat (Shahin et al., 2008), wheat (Azarpour, 2012), wheat (Kardoni et al, 2013), lentil (Mirzaee et al., 2011), wheat (Ghorbani et al., 2011), barley (Azizi and Heidari, 2013) etc. yielded results where the ratio of non-renewable energy was higher than the ratio of renewable energy.

Table 5. Energy input in the form of energy for wheat production

Wheat production	Energy input (MJ ha^{-1})	Ratio (%)
Direct energy [a]	9912.45	38.31
Indirect energy [b]	15963.84	61.69
Total	25876.29	100.00
Renewable energy [c]	7555.42	29.20
Non-renewable energy [d]	18320.87	70.80
Total	25876.29	100.00

[a] Includes human labour, diesel, electricity and water of irrigation; [b] Includes seed, chemical fertilizers, chemicals, machinery and transportation; [c] Includes human labour, seed, water of irrigation; [d] Includes diesel, chemicals, chemical fertilizers, machinery, electricity and transportation.

Conclusion

In this study, the energy balance of wheat production in Eskil district has been determined. According to the results, wheat production is a profitable activity in terms of energy usage. The study outcome indicates that the ratio of non-renewable energy is higher than the ratio of renewable energy, and the ratio of indirect energy is higher than the ratio of direct energy. In wheat production, chemical fertilizers make up an important portion of the input; therefore they can substitute by farm fertilizers. By doing so, the level of chemical fertilizer among the inputs could be decreased. 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 waste 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), and proper tractor selection and management of machinery to reduce 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 use efficiency of sweet cherry production". These may perform for wheat production of Eskil.

References

Acaroğlu, M. 1998. Energy from biomass and applications. Selçuk University, Graduate School of Natural and Applied Sciences, Textbook.

Acaroğlu, M. and A.Ş. Aksoy, 2005. The cultivation and energy balance of Miscanthus x giganteus production in Turkey. Biomass and Bioenergy, 29:42-48

Akçaöz, H. 2011. Analysis of energy use for banana production: A case study from Turkey. African Journal of Agricultural Research, 6(25):5618-5624

Anonymous, 2007. Türkiye İstatistik Kurumu (http://www.turkstat.gov.tr/VeriBilgi.do)

Azarpour, E. 2012. Determination of energy balance and energy indices in wheat production under watered farming in north of Iran. ARPN Journal of Agricultural and Biological Science, 7(4):250-255

Azizi, A. and S.Heidari, 2013. A comparative study on energy balance and economical indices in irrigated and dry land barley production systems. Int. J. Environ. Sci. Technol. 10:1019-1028

Baali, E.H. and E.V.Quwerkerk, 2005. Energy balance wheat production in Morocco. Deutscher Tropentag, International Research on Food Security, Natural Resource Management and Rural Development, 11-13 October 2005, s. 1-6

Baran, M.F. and O.Gökdoğan, 2014. Energy input-output analysis of barley production in Thrace region of Turkey. American-Eurasian J. Agric. & Environ. Sci. 14(11):1255-1261

Baran, M.F, O.Gökdoğan and H.A.Karaağaç, 2014. Kanola üretiminde enerji kullanım etkinliğinin belirlenmesi (Kırklareli ili örneği), Türk Tarım ve Doğa Bilimleri Dergisi, 1(3):331-337

Baran M.F. and O.Gökdoğan, 2016. Determination of energy of sugar beet production in Turkey: A case study of Kırklareli province. Energy Efficiency, 9(2):487-494

Bojaca, C.R., and E.Schrevens, 2010. Energy assessment of peri-urban horticulture and its uncertainty: Case study for Bogota, Colombia. Energy, 35:2109-2118

Çanakcı, M., M.Topakcı, İ.Akıncı and A.Özmerzi, 2005. Energy use pattern of some field crops and vegetable production: case study for Antalya Region, Turkey. Energy and Conversion Management, 46(4):655-666

Çelik, Y., K.Peker and C.Oğuz, 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 Scientist, 93(2):224-231

Çiçek, A., and O. Erkan. 1996. Tarım Ekonomisinde Araştırma ve Örnekleme Yöntemleri. Gaziosmanpaşa Üniversitesi, Ziraat Fakültesi Yayınları, No: 12, Ders Notları No: 6, Tokat, Türkiye

Çiçek, A., G.Altıntaş and G.Erdal, 2011. Energy consumption patterns and economic analysis of irrigated wheat and rainfed wheat production: case study for Tokat region, Turkey. Bulgarian Journal of Agricultural Science, 17(3):378-388

Demircan, V., K.Ekinci, H.M. Keener, D.Akbolat and Ç.Ekinci, 2006. Energy and economic analysis of sweet cherry production in Turkey: A case study from Isparta province. Energy Conversion and Management, 47:1761-1769

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

Fluck, R. and C.D.Baird, 1982. Agricultural Energetics. Connecticut: AVI.

Ghorbani, R., F.Mondani, S.Amirmoradi, H.Feizi, S.Khorramdel, M.Teimouri, S.Sanjani, S.Anvarkhah and H.Aghel, 2011. A case study of energy use and economical analysis of irrigated and dryland wheat production systems. Applied Energy, 88:283-288

Göktolga, Z.G., B.Gözener and Karkacıer, O, 2006. Energy use in peach production: case of Tokat province. Gaziosman Paşa University, Journal of Agriculture Faculty Turkey, 23(2):39-44

Hacıseferoğulları, H., M.Acaroğlu and İ.Gezer, 2003. Determination of the energy balance of the sugar beet plant. Energy Sources, 25:15-22

Hetz, E.J. 1992. Energy utilization in Chilean agriculture. Agr. Mech. Asia Africa Latin America (AMA), 23(2):52-56

Işık, A. and A.Sabancı, 1991. A research on determining basic management data and developing optimum selection models of farm machinery and power for the mechanization planning in the irrigated farming of the Çukurova region. Turkish Journal Agric. Forestry, 15:899-920

Karaağaç, M.A., S.Aykanat, B.Çakır, Ö.Eren, M.M.Turgut, Z.B.Barut and H.H.Öztürk, 2011. Energy balance of wheat and maize crops production in Hacıali undertaking. 11th International Congress on Mechanization and Energy in Agriculture Congress, 21-23 September, Istanbul, Turkey, 388-391

Kardoni, F., S.Parande, K.Jassemi and S.Karami, 2013. Energy input-output relationship and economical analysis of wheat production in Khuzestan province of Iran. International Journal of Agronomy and Plant Production, 4(9):2187-2193

Kitani, O. 1999. Energy for biological systems. In: The International Commission of Agricultural Engineering, editor, CIGR Handbook of Agricultural Engineering: Energy and Biomass Engineering, Vol. V. American Society of Agricultural Engineers, 13-42

Kızılaslan, H. 2009. Input-output energy analysis of cherries production in Tokat province of Turkey. Applied Energy, 86:1354-1358

Koçtürk, O.M. and S.Engindeniz. 2009. Energy and cost analysis of sultana grape growing: A case study of Manisa, west Turkey. African Journal of Agricultural Research, 4(10): 938-943

Konak, M., T.Marakoğlu and O.Özbek, 2004. Mısır üretiminde enerji bilançosu. Selçuk Üniversitesi, Ziraat Fakültesi Dergisi, Konya, Türkiye, 18(34):28-30

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

Mandal, K.G., K.P.Saha, P.K.Ghosh, K.M.Hati and K.K.Bandyopadhyay, 2002. Bioenergy and economic analysis of soybean based crop production systems in central India. Biomass and Bioenergy, 23:337-345

Marakoğlu, T. and K.Çarman, 2010. Energy balance of direct seeding applications used in wheat production in middle Anatolia. African Journal of Agricultural Research, 5(10):988-992

Marakoğlu, T., O.Özbek and K. Çarman. 2010. Nohut üretiminde farklı toprak işleme sistemlerinin enerji bilançosu. Tarım Makinaları Bilimi Dergisi, 6(4):229-235

Mirzaee, E., M.Omid, A.Asakereh, M.Safaieenejad and M.J.Dalvand, 2011. 11th International Congress on Mechanization and Energy in Agriculture Congress, 21-23 September, Istanbul, Turkey, 383-387

Moghimi, M.R., B.M.Alasti and M.A.H.Drafshi, 2013. Energy input-output and study on energy use efficiency for wheat production using DEA technique. International Journal of Agriculture and Crop Sciences, 2064-2070

Mohammadi A., A.Tabatabaeefar, S.Shahin, S.Rafiee and A.Keyhani, 2008. Energy use and economical analysis of potato production in Iran a case study: Ardabil province. Energy Conversion Management, 49:3566-3570

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

Nagy, C.N. 1999. Energy coefficients for agriculture inputs in western Canada. (http://www.csale.usask.ca/PDFDocuments/energyCoefficientsAg.pdf)

Namdari, M., A.A.Kangarshahi and N.A.Amiri, 2011. Input-output energy analysis of citrus production in Mazandaran province of Iran. African Journal of Agricultural Research, 6(11):2558-2564

Özkan, B., A.Kürklü and H.Akçaöz, 2004. An input-output energy analysis in greenhouse vegetable production: A case study for Antalya region of Turkey. Biomass and Bioenergy, 26:89-95

Öztürk, H.H., K.Ekinci and Z.B. Barut, 2006. Energy Analysis of the Tillage Systems in Second Crop Corn Production, Journal of Sustainable Agriculture, 28(3):25-37

Polat, R., O.Çopur, R.Sağlam and C.Sağlam, 2006. Energy use pattern and cost analysis of cotton agriculture: A case study for Şanlıurfa, Turkey. The Philippine Agricultural Scientist, 89(4):368-371

Ramah, M. and E.H.Baali, 2013. Energy balance of wheat and barley under Moroccan conditions. Journal of energy Technologies and Policy, 3(10):20-27

Safa, M., S.Samarasinghe and M.Mohssen, 2011. A field study of energy consumption in wheat production in Canterbury, New Zealand. Energy Conversion and Management, 52(7):2526-2532

Schneeberger, K.C. and H.F.Breimyer, 1974. Agriculture in an energy-hungry world. Southern J. Agric. Econ. 193-197

Samavatean, N., S.Rafiee, H.Mobli and A.Mohammadi, 2011. An analysis of energy use and relation between energy inputs and yield, costs and income of garlic production in Iran. Renewable Energy, 36:1808-1813

Shahin, S., A.Jafari, H.Mobli, S.Rafiee and M.Karimi, 2008. Effect of farm size on energy ratio for wheat production: A case study from Ardabil province of Iran. American-Eurasian J. Agric. & Environ. Sci., 3(4):604-608

Singh, J.M. 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

Singh, H., D.Mishra, N.M.Nahar and M. Ranjan, 2003. Energy use pattern in production agriculture of a typical village in Arid Zone India (Part II). Energy Conversion and Management, 44:1053-1067

Tipi, T., B.Çetin and A.Vardar, 2009. An analysis of energy use and input costs for wheat production in Turkey. Journal of Food, Agriculture & Environment, 7(2):352-356

Unakıtan, G., H.Hurma and F.Yılmaz, 2010. An analysis of energy use efficiency of canola production in Turkey. Energy, 35:3623-3627

Uzunöz, M., Y.Akçay and K.Esengün, 2008. Energy input-output analysis of sunflower seed (Helianthus annuus L.) oil in Turkey. Energy Sources, Part B: Economics, Planning and Policy, 3:215-223

Vural, H. and İ.Efecan, 2012. An analysis of energy use and input costs for maize production in Turkey Journal of Food, Agriculture & Environment, 10(2):613-616

Yaldız, O., H.H.Öztürk, Y.Zeren and A.Başçetinçelik, 1993. Energy usage in production of field crops in Turkey. 5th International Congress on Mechanization and Energy in Agriculture, Kuşadası, Turkey. 11-14 October 1993, 527-536