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Energy balance in production of chickpea in Turkey: A study performed in Adıyaman Province

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Abstract. In this study, it has been aimed to form the energy balance in the production of chickpea (*Cicer arietinum* L.) in Adıyaman province of Turkey. The material of the research consists of the chickpea enterprises in the center of Adıyaman province in the scope of the production season of 2015–2016. In this study, the number of enterprises for which is required to be made the study has been computed as 67 according to the simple random sampling method. Survey and observation studies have carried out in these designated enterprises. The energy equivalence of the chickpea samples taken from the enterprises has been determined by the calorimeter device. According to results of the study; the total energy input has been computed as 12,225.69 MJ ha^{-1} and the total energy output has been computed as 31,527.52 MJ ha^{-1}. The energy inputs in the production of chickpea have been 3,575.69 MJ ha^{-1} (29.25%), 3,523.08 MJ ha^{-1} (28.82%), 3,280.32 MJ ha^{-1} (26.83%), 1,230.39 MJ ha^{-1} (10.07%), 358.20 MJ ha^{-1} (2.93%), 131.52 MJ ha^{-1} (1.08%) and 126.50 MJ ha^{-1} (1.03%) as fuel energy, chemical fertilizers energy, seed energy, machinery energy, farmyard manure energy, human labour energy and chemicals energy inputs, respectively. In this study, indicators showing the energy ratio, specific energy, energy productivity and net energy were determined as 2.58, 7.07 MJ kg^{-1}, 0.14 kg MJ^{-1} and 19,301.83 MJ ha^{-1}, respectively. According to the results of the study, it is clear that chickpea production is an economical production for the 2015–2016 production seasons.

Key words: Adıyaman, chickpea, energy balance, specific energy, Turkey.

INTRODUCTION

Among the edible grain legumes in Turkey, chickpea makes up 52.5% of the total cultivation areas and 44% of the total edible grain legume production. At the same time, chickpea is ranked first among edible legumes, in terms of both cultivation area and production level in Turkey. With a total chickpea production of 535,000 tons, Turkey is ranked third in the world, following India and Australia (Anonymous, 2014; Küçükalbay & Akbolat, 2015). Chickpea appears as an important vegetable product to meet the protein need in nutrition, against the increasing population in Turkey and in the world. Because the dry grains of chickpea contain 18–31% protein, depending on the cultivar characteristics, environmental conditions of the cultivation area and the applied cultivation techniques. In addition, chickpea also has high biologic value. Digestible protein ratio is around 76–78% (Akçin, 1988; Erdin & Kulaz, 2014). Plant residues with low C/N coefficient rupture rapidly and increase soil fertility. By taking into crop alternation, it will lead to a great increase in the amount of product to be removed from the field (Azkan, 1999; Erdin & Kulaz, 2014).

Computing energy inputs of agricultural production is more difficult than the industry production due to the high number of factors affecting the production (Yaldız et al., 1993; Mohammadi & Omid, 2010). The main objective in agricultural production is to increase yield and decrease costs. Energy budget is important. Energy budget is the comparison of the relationship between energy input-output of a system in terms of energy units (Gezer et al., 2003; Mohammadi & Omid, 2010). In general, increases in the agricultural production on a sustainable basis and at a competitive cost are important to improve the enterprises' economic condition (De et al., 2001; Mohammadi & Omid, 2010).

Many researches have been done on energy balance analysis in several type of agricultural products, animal products etc. such as on energy balance activities of chick pea (Yaldız et al., 1993; Marakoglu et al., 2010), miscanthus x giganteus (Acaroğlu & Aksoy, 2005), vetch (Kökten et al., 2016), soybean (Mandal et al., 2002), wheat (Gökdoğan & Sevim, 2016), corn (Öztürk et al., 2006), corn silage (Barut et al., 2011; Pisghar-Komleh et al., 2011), cotton (Polat et al., 2006), sugar beet (Hacıseferoğulları et al., 2003), black carrot (Çelik et al., 2010), barley (Baran & Gökdoğan, 2014), maize (Konak et al., 2004), sweet cherry (Demircan et al., 2006), walnut (Baran et al., 2017a), dryland wheat (Ghorbani et al., 2011), rainfed wheat (Houshyar & Kiani, 2012), canola (Mousavi-Avval et al., 2011), orange (Nabavi-Pelesaraei et al., 2014), rice (Pishgar-Komleh et al., 2011), apple (Rafiee et al., 2010), orobanche (Semerci, 2013), pear (Tabatabaie et al., 2013), organic grape (Baran et al., 2017b), lamb (Köknaroğlu et al., 2007), beef cattle (Demircan & Köknaroğlu, 2007), broiler (Atılgan & Köknaroğlu, 2006), organic broiler (Inci et al., 2016) etc. In this study, the purpose is to determine the energy balance of chickpea production in Adıyaman province.

MATERIALS AND METHODS

The study has been done in Adıyaman province of Turkey. The province of Adiyaman is located at the Southeast Anatolia Region of Turkey (Anonymous, 2015). Surveys and observations have been done face to face with 67 chickpea enterprises, in production season during in 2015–2016 in Adıyaman province. Total energy input in unit area (ha) constitutes of each total of input's energy. Fuel energy, chemical fertilizers energy, seed energy, machinery energy, farmyard manure energy, human labour energy and chemicals have been computed as energy inputs. Chickpea grain was computed as output. The surveys done to the enterprises have been computed by using the Simple Random Sampling method proposed by Çiçek & Erkan (1996). The formula was provided as below. In the formula; n, is the required sample size; N, the number of total enterprises in the area; s, standard deviation; t, the reliability coefficient (1.96 which represents, 95% confidence); d, acceptable error (5% deviation). The acceptable error value has been defined to be 5%, and the sample size has been calculated as 67 (50 da ≤ enterprises), to achieve 95% reliability.

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

$n = \frac{73x(105.49)^2x(1.65)^2}{(72)x(6.08)^2+((105.49)^2\times(1.65)^2)}$ = 67 chickpea enterprises have been determined.

Energy balance computations have been made to determine the chickpea production productivity. The unit shown in Table 1 has been used to compute the values of the inputs in chickpea production. Input amounts have been computed and then these inputs data have been multiplied by the energy equivalent coefficient. By adding energy equivalents of all inputs in MJ unit, the total energy equivalent has been found. The energy ratio (energy use efficiency), energy productivity, specific energy and net energy have been computed using the following formulates (Mandal et al., 2002; Mohammadi et al., 2008; Mohammadi et al., 2010).

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

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

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

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

Table 1. Energy equivalents in agriculture production

Inputs and outputs	Unit	Energy equivalent (MJ per unit)	References
Human labour	h	1.96	Mani et al., 2007; Karaağaç et al., 2011
Machinery			
Machinery	h	64.80	Singh, 2002; Kızılaslan, 2009
Combine harvester	h	87.63	Hetz, 1992; Çanakcı et al., 2005; Tipi et al., 2009
Chemical fertilizers			
Nitrogen	kg	60.60	Singh, 2002
Phosphorous	kg	11.10	Singh, 2002
Diesel fuel	l	56.31	Singh, 2002; Demircan et al., 2006
Farmyard manure	kg	0.30	Singh, 2002
Chemicals	kg	101.20	Yaldız et al., 1993
Seed	kg	18.224	Measured
Output	Unit	Energy equivalent (MJ per unit)	References
Chickpea grain	kg	18.224	Measured

The results have been tabulated after the analysis of data has been done using Microsoft Excel program considering the inputs. Examining the values of chickpea input-output and computations have been given in Table 2. The indirect energy consists of pesticide and fertilizer while the direct energy includes human and animal power, diesel and electricity energy used in the production process. On the other hand, non-renewable energy includes petrol, diesel, electricity, chemicals, fertilizers, machinery and renewable energy consists of human and animal (Mandal et al., 2002; Singh et al., 2003; Koçtürk & Engindeniz, 2009). Energy input-output and energy use efficiency computations in chickpea production have been given in Table 3. Direct, indirect, renewable and non-renewable energy forms have been given Table 4. For calorific values of chickpea IKA brand C200 model bomb calorimeter device has been used. For measuring purposes, the amount of fuel (~ 0.1 g) has been combusted inside the calorimeter bomb. The device has been measured a calorific value in MJ kg^{-1} unit. For samples, reading of the calorific value has been measured repetitively for 3 times and then the average value have been reported in chickpea study.

RESULTS AND DISCUSSION

In the enterprises, the amount of chickpea produced per hectare during the 2015–2016 production seasons have been computed as an average of 1,730 kg. In chickpea production, it is noteworthy that and diesel fuel energy, chemical fertilizers energy and seed energy have been used as the highest input. In this study, the energy input-output analysis of chickpea production in 2015–2016 has been given in Table 2. It can be seen that the first, second and third of the highest energy of inputs in chickpea production are 29.25% diesel fuel energy, 28.82% chemical fertilizers energy and 26.83% seed energy have been the inputs computed. In Table 2, The energy inputs in the production of chickpea have been 3,575.69 MJ ha^{-1} (29.25%), 3,523.08 MJ ha^{-1} (28.82%), 3,280.32 MJ ha^{-1} (26.83%), 1,230.39 MJ ha^{-1} (10.07%), 358.20 MJ ha^{-1} (2.93%), 131.52 MJ ha^{-1} (1.08%) and 126.50 MJ ha^{-1} (1.03%) as diesel fuel energy, chemical fertilizers energy, seed energy, machinery energy, farmyard manure energy, human labour energy and chemicals energy inputs, respectively.

Table 2. Energy balance in chickpea production

Inputs and outputs	Unit	Energy equivalent (MJ per unit)	Input used per hectare (unit ha^{-1})	Energy value (MJ ha^{-1})	Ratio (%)
Human labour	h	1.96	67.10	131.52	1.08
Machinery				1,230.39	10.07
Machinery	h	64.80	17.50	1,134	9.28
Combine harvester	h	87.63	1.10	96.39	0.79
Chemical fertilizers				3,523.08	28.82
Nitrogen	kg	60.60	39.60	2,399.76	19.63
Phosphorous	kg	11.10	101.20	1,123.32	9.19
Diesel fuel	l	56.31	63.50	3,575.69	29.25
Farmyard manure	kg	0.30	1194	358.20	2.93
Chemicals	kg	101.20	1.25	126.50	1.03
Seed	kg	18.224	180	3,280.32	26.83
Total				12,225.69	100.00
Output	Unit	Energy equivalent (MJ per unit)	Output per hectare (unit ha^{-1})	Energy value (MJ ha^{-1})	Ratio (%)
Output-Chickpea grain	MJ kg^{-1}	18.224	1,730	31,527.52	100.00

Energy input, energy output, energy use efficiency, energy productivity, specific energy and net energy in chickpea production have been computed as 12,225.69 MJ ha^{-1}, 31,527.52 MJ ha^{-1}, 2.58; 0.14 kg MJ^{-1}; 7.07 MJ kg^{-1} and 19,301.83 MJ ha^{-1}, respectively (Table 3). In previous studies, Yaldız et al. (1993), computed energy use efficiency in chickpea study as 3.33, Marakoğlu et al. (2010) computed energy use efficiency in chickpea study as 0.205–2, Baran & Gökdoğan (2016) computed energy use efficiency in sugar beet study as 8.35, Mobtaker et al. (2010) computed energy use efficiency in barley study as 2.86, Bayhan (2016) computed energy use efficiency in sunflower study 9.57–11.82, Yıldız (2016) computed energy use efficiency in wheat study 2.36.

Table 3. Energy balance computations in chickpea production

Computations	Unit	Values
Chickpea grain	kg ha^{-1}	1,730
Energy input	MJ ha^{-1}	12,225.69
Energy output	MJ ha^{-1}	31,527.52
Energy use efficiency		2.58
Energy productivity	kg MJ^{-1}	0.14
Specific energy	MJ kg^{-1}	7.07
Net energy	MJ ha^{-1}	19,301.83

The total energy input consumed could be classified as renewable 30.84%, non-renewable 69.16%, direct 30.32% and 69.68% indirect in chickpea production (Table 4). Renewable energy has smaller than non-renewable energy. Similarly, in previous studies, it has been determinated that the ratio of renewable energy has smaller than the ratio of non-renewable energy in sugar beet (Erdal et al., 2007), cucumber (Mohammadi & Omid, 2010), maize (Vural & Efecan, 2012), vetch (Kökten et al., 2016) and lentil (Asakereh et al., 2010).

Table 4. Energy input in the forms energy for chickpea production

Type of energy		Energy input (MJ ha^{-1})	Ratio (%)
Direct energy [a]		3,707.20	30.32
Indirect energy [b]		8,518.49	69.68
	Total	12,225.69	100.00
Renewable energy [c]		3,770.04	30.84
Non-renewable energy [d]		8,455.66	69.16
	Total	12,225.69	100.00

[a]Includes human labour and diesel; [b]Includes seed, farmyard manure, chemical fertilizers, chemicals and machinery; [c]Includes human labour, farmyard manure and seed; [d]Includes diesel, chemical fertilizers, chemicals and machinery.

CONCLUSIONS

Based on this study, following conclusions are explained:

1. Chickpea production consumed a total energy of 12,225.69 MJ ha^{-1}, which has the highest due to diesel fuel (29.25%). The energy input of chemical fertilizers (28.82%) and seed (26.83%) have the second and third share within the total energy inputs.

2. Energy use efficiency, energy productivity, specific energy and net energy have been determined as 2.58, 0.14 kg MJ^{-1}, 7.07 MJ kg^{-1} and 19,301.83 MJ ha^{-1}.

3. The renewable and non-renewable energy inputs were 30.84% and 69.16% of the total energy input, respectively.

4. Decreasing of diesel fuel and nitrogen consumption are important for energy management. Suitable combine machines may be used and farm fertilizer using may be increased.

5. In this study, the energy balance of chickpea production in the Adıyaman province has been determined. According to the evaluated results, chickpea production is an economic production in terms of energy efficiency (2.58).

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