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Energy Use Efficiency of Mandarin Production: A Case Study from Adana Province

Mehmet Emin Bilgili[1]

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Abstract

In this research was aimed to define the energy use efficiency of mandarin production for the 2017 production seasons in Adana province in Turkey. A survey data were compiled in 2017 and the farms were chosen according to the simple random sampling method and the survey were done to these farms. In order to define the energy use efficiency in the production of mandarin, a survey was done with 142 farmers in Adana province. According to results of research, human labour energy, machinery energy, chemical fertilizers energy, chemicals energy, farmyard manure energy, diesel fuel energy, irrigation water energy and lime energy were calculated as energy inputs. Mandarin fruit was calculated as output.

In mandarin production, total input energy was calculated as 38,303.09 MJ ha^{-1} and total energy output was calculated as 59,850 MJ ha^{-1}. The energy inputs in mandarin production were calculated respectively as chemical fertilizers energy 15,568.80 MJ ha^{-1} (40.65%), farmyard manure energy 5781 MJ ha^{-1} (15.09%), diesel fuel energy 5034.11 MJ ha^{-1} (13.14%), irrigation water energy 4095 MJ ha^{-1} (10.69%), machinery energy 3207.60 MJ ha^{-1} (8.37%), human labour energy 3039.18 MJ ha^{-1} (7.93%), chemicals energy 1518 MJ ha^{-1} (3.96%) and lime energy 59.40 MJ ha^{-1} (0.16%). The energy use efficiency, specific energy, energy productivity and net energy calculations were calculated in mandarin production respectively as 1.56, 1.22 MJ kg^{-1}, 0.82 kg MJ^{-1} and 21,546.91 MJ ha^{-1}.

Keywords Energy use efficiency · Energy productivity · Mandarin · Turkey

Effizienz der Energienutzung in der Mandarinenproduktion: Eine Fallstudie aus der Provinz Adana

Schlüsselwörter Energienutzungseffizienz · Energieproduktivität · Mandarine · Türkei

Introduction

Citrus fruits are between the most plenty crops in the world with an annual production of over 88 million tons. Almost 33% of the crops, inclusive orange, lemons, grapefruit and mandarins are industrially processed for juice production, where about half of the processed citrus inclusive peels, segment membrane and seeds end up as wastes (Lohrasbi et al. 2010; Mohammadshirazi et al. 2012). In Adana has been produced 526,468 tons of mandarin in 2017 and 34% of Turkey production.

✉ Mehmet Emin Bilgili
eminbilgili@gmail.com

[1] Eastern Mediterranean Agricultural Research Institute, Adana, Turkey

Energy in agriculture is significant in terms of crop production and agro processing for value addition. Human, animal and machinery is broadly used for crop production in agriculture. Energy use relies on mechanization level, the quantity of active agricultural worker and cultivable land. Energy requirements in agriculture are divided into two groups being direct and indirect. Direct energy is required to done various tasks related to crop production processes such as land preparation, irrigation, inter cultural operations; threshing, harvesting and transportation of agricultural inputs and farm produce (Singh 2000; Banaeian and Zangeneh, 2011).

In agricultural production, different energy studies were done on energy use efficiency. For example, studies were performed on energy use efficiency analysis of mandarin (Özkan et al. 2004), apricot (Gezer et al. 2003), peach (Göktolga et al. 2006), pomegranate (Akçaöz et al. 2009), kiwi (Mohammadi et al. 2010), lemon (Bilgili 2012), plum (Tabatabaie et al. 2012), peanut (Nabavi-Pelesaraei et al. 2013), pear (Tabatabaie et al. 2013), nectarine (Qasemikordkheili et al. 2013), avocado (Astier et al. 2014), mango (Ram and Verma 2015), orange (Mohammadshirazi et al. 2015), watermelon (Nabavi-Pelesaraei et al. 2016), grape (Koçtürk and Engindeniz 2009; Baran et al. 2017a), apple (Çelen et al. 2017), strawberry (Baran et al. 2017b), olive (Gökdoğan and Erdoğan 2018) etc. In this study, it was aimed to define the energy use efficiency of mandarin production.

Materials and Method

The province of Adana has located in the Mediterranean region and mathematically the location of the province has between 35° 38' latitudes and 34° 46'east longitudes. The land area of the province is 17,253 km². The average temperature in Adana for the year (37 yearly average) has 12 °C, while average total precipitation has 625 mm (Anonymous 2019). This study was defined the energy use efficiency mandarin production for the 2017 production season in Adana province in Turkey. A survey data were compiled in 2017 and the farmers were chosen according to the simple random sampling method (Çiçek and Erkan 1996) and the survey was done (face to face) to these farmers.

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)
Machinery	h	64.80	Singh (2002); Kızılaslan (2009)
N	Kg	60.60	Singh (2002)
P	Kg	11.10	Singh (2002)
K	Kg	6.70	Singh (2002)
Lime	Kg	1.32	Pimentel (1980); Ekinci et al. (2005)
Farmyard manure	Kg	0.30	Yaldız et al. (1993)
Chemicals	Kg	101.20	Yaldız et al. (1993)
Diesel fuel	l	56.31	Singh (2002); Demircan et al. (2006)
Irrigation water	m^3	0.63	Yaldız et al. (1993)
Outputs	*Unit*	*Energy equivalent (MJ unit^{-1})*	*References*
Mandarin fruit	MJ kg^{-1}	1.90	Singh and Mittal (1992); Mohammadshirazi et al. (2012)

Table 1 was used to calculate the values of the inputs of mandarin production. Research results were tabulated in Table 2 and related to mandarin production energy use efficiency values were given in Table 3. Energy species were given in Table 4. In order to define the energy use efficiency analysis in mandarin 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)".

$$\text{Energy efficiency} = \text{Energy output} \left(\text{MJ ha}^{-1}\right) / \text{Energy input}(\text{MJ ha}^{-1}) \tag{1}$$

$$\text{Energy productivity} = \text{Mandarin output} \left(\text{kg ha}^{-1}\right) / \text{Energy input}(\text{MJ ha}^{-1}) \tag{2}$$

$$\text{Specific energy} = \text{Energy input} \left(\text{MJ ha}^{-1}\right)/ \text{Mandarin output}(\text{kg ha}^{-1}) \tag{3}$$

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

Results and Discussion

In the mandarin farmers, the average amount of mandarin produced per hectare for 2017 production seasons was calculated as 31,500 kg. According to the research results (Table 2) the energy inputs in mandarin production were calculated respectively as chemical fertilizers energy 15,568.80 MJ ha^{-1} (40.65%), farmyard manure energy 5781 MJ ha^{-1} (15.09%), diesel fuel energy 5034.11 MJ ha^{-1} (13.14%), irrigation water energy 4095 MJ ha^{-1} (10.69%), machinery energy 3207.60 MJ ha^{-1} (8.37%), human labour energy 3039.18 MJ ha^{-1} (7.93%), chemicals energy 1518 MJ ha^{-1} (3.96%) and lime energy 59.40 MJ ha^{-1} (0.16%). Similarly, in previous agricultural studies related to fruit production, Mohammadshirazi et al. (2012) calculated that the fertilizer application energy had the biggest share by 52.40% in mandarin production, Özkan et al. (2004) calculated that fertilizer application energy had the biggest share by 45.79% in mandarin production, Demircan et al. (2006) calculated that fertilizer application energy had the biggest share by 45.35% in sweet cherry production.

Mandarin fruit, energy input, energy output, energy output-input ratio, specific energy, energy productivity and net energy in mandarin production were calculated as 31,500 kg ha^{-1}, 38,303.09 MJ ha^{-1}, 59,850 MJ ha^{-1}, 1.56, 1.22 MJ kg^{-1}, 0.82 kg MJ^{-1} and 21,546.91 MJ ha^{-1}, respectively (Table 3). In previous agricultural production studies, Özkan et al. (2004) calculated (mandarin) energy output-input ratio as 1.17, Yılmaz et al. (2010) calculated (apple) energy output-input ratio as 2.69, Mohammadshirazi et al. (2012) calculated (mandarin) energy output-input ratio as 0.87, Mo-

Table 2 Energy use efficiency in mandarin 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*	*1550.60*	*3039.18*	*7.93*
Tillage I	h	1.96	8.50	16.66	0.04
Tillage II	h	1.96	2.70	5.29	0.01
Fertilizing	h	1.96	42.80	83.39	0.22
Spraying	h	1.96	27	52.92	0.14
Hoeing	h	1.96	270.60	530.38	1.38
Irrigation	h	1.96	21.10	100.16	0.26
Pruning	h	1.96	82.30	161.31	0.42
Liming	h	1.96	7.70	15.09	0.04
Harvesting	h	1.96	680.80	1334.37	3.48
Cleaning	h	1.96	335.80	658.17	1.72
Loading	h	1.96	30	58.80	0.15
Transportation	h	1.96	11.30	22.15	0.06
Machinery	*h*	*64.80*	*49.50*	*3207.60*	*8.37*
Tillage I	h	64.80	8.50	550.80	1.44
Tillage II	h	64.80	2.70	174.96	0.46
Spraying	h	64.80	27	1749.60	4.57
Transportation	h	64.80	11.30	732.24	1.91
Chemical fertilizers			*533*	*15,568.80*	*40.65*
N	Kg	60.60	211	12,786.60	33.38
P	Kg	11.10	142	1576.20	4.12
K	Kg	6.70	180	1206	3.15
Farmyard manure	*Kg*	*0.30*	*19270*	*5781*	*15.09*
Chemicals	*Kg*	*101.20*	*15*	*1518*	*3.96*
Irrigation water	*m^3*	*0.63*	*6500*	*4095*	*10.69*
Lime	*Kg*	*1.32*	*45*	*59.40*	*0.16*
Diesel fuel	*l*	*56.31*	*89.40*	*5034.11*	*13.14*
Total inputs	–	–	–	*38,303.09*	*100.00*
Outputs	**Unit**	**Energy equivalent (MJ/unit)**	**Output per hectare (unit ha^{-1})**	**Energy value (MJ ha^{-1})**	**Ratio (%)**
Mandarin	*Kg*	*1.90*	*31,500*	*59,850*	*100.00*
Total output	–	–	–	*59,850*	*100.00*

Table 3 Energy use efficiency values in mandarin production

Calculations	Unit	Values
Mandarin fruit	Kg ha^{-1}	31,500
Energy input	MJ ha^{-1}	38,303.09
Energy output	MJ ha^{-1}	59,850
Energy use efficiency	–	1.56
Specific energy	MJ kg^{-1}	1.22
Energy productivity	Kg MJ^{-1}	0.82
Net energy	MJ ha^{-1}	21,546.91

Table 4 Energy input in the forms energy for mandarin production

Type of energy	Energy input (MJ ha^{-1})	Ratio (%)
Direct energy[a]	12,168.29	31.77
Indirect energy[b]	26,134.80	68.23
Total	*38,303.09*	*100.00*
Renewable energy[c]	12,915.18	33.72
Non-renewable energy[d]	25,387.91	66.28
Total	*38,303.09*	*100.00*

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

hammadi et al. (2010) calculated (kiwi) energy output-input ratio as 1.54.

The total energy forms input depleted could be classified as renewable 33.72%, non-renewable 66.28%, direct 31.77% and 68.23% indirect in mandarin production (Table 4). Renewable energy has smaller than non-renewable energy in mandarin production. Similarly, in previous studies, it have been defined that the ratio of renewable energy has smaller than the ratio of non-renewable energy in mandarin (Özkan et al. 2004), mandarin (Mohammadshirazi et al. 2012) and kiwi (Mohammadi et al. 2010).

According to research results were drawn in following conclusions.

In this research, the energy use efficiency in mandarin production was defined. According to the results, mandarin production has a profitable activity in terms of energy output-input ratio (1.56). The inputs used for mandarin production, the highest input is chemical fertilizers with a ratio of 40.65%.

Energy output-input ratio, specific energy, energy productivity and net energy in mandarin production were calculated as 1.56, 1.22 MJ kg^{-1}, 0.82 kg MJ^{-1} and 21,546.91 MJ ha^{-1}.

The non-renewable form of energy input was 66.28% of the total energy input used in the mandarin production compared to 33.72% for the renewable form.

It is clear that the use of renewable energy in mandarin production has low, showing mandarin production relies mostly on fossil fuels.

It implies that Turkish citrus production is very sensible to possible changes in prices and supply presence of fossil fuels. On the other hand, the consumption of fossil energy results in direct negative environmental effects through release of CO_2 and other combustion gases (Özkan et al. 2004).

Conflict of interest M. E. Bilgili declares that he/she has no competing interests.

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