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Full Length Research Paper

Energy use pattern and economic analyses of pomegranate cultivation in Turkey.

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The objective of this study was; to determine the energy usage, to find the output-input energy ratio and their relationships, and to analyse the economic variables in pomegranate cultivation in Turkey. Antalya region, which is one of the most important native lands of the pomegranate cultivation and agricultural centre in Turkey, was selected as the research area. The energy use pattern and economic item values were determined by a survey including 92 farms from three zones having various geographical and land properties. Three zones were selected since pomegranate fruit cultivation is realized in different areas such as coastline and mountainous terrain. Energy and economic variables were calculated using standard equations. The findings showed that the energy requirements were between 32619.0 and 44462.7 MJ ha^{-1} and the energy ratios of three different zones varied from 1.25 to 1.94. Total net return and benefit-cost ratio ranges were found to be 4427 - 11693 $ ha^{-1} and 1.43 - 1.73, respectively.

Key words: Energy usage, pomegranate cultivation, economic analyses, Turkey.

INTRODUCTION

Energy in one form or another is a crucial input to agricultural production. Continually rising prices, increasing proportion of commercial energy in the total energy input to agriculture and the growing scarcity of commercial energy sources, such as fossil fuels and fertilizers, have necessitated the more efficient use of these sources for different crops (Singh et al., 1999). Energy is used in mechanized agricultural production for machinery, transport, irrigation, fertilizers, pesticides, and other management tools (Pimentel et al., 1973). Energy use in agricultural production has been increasing faster than that in many other sectors of the world economy. Because agricultural production has become more mechanized and use of substitutes for land, such as commercial fertilizers has increased (Karkacier and Goktolga, 2004). The pomegranate (*Punica granatum* L.) is an old world fruit originating in the Middle East and Orient, where it enjoys popularity to this day (Anonymous, 2002). Also, the pomegranate is named a functional fruit because it contains antioxidant, polyphonic matters and vitamin C. Apart from being a preferred fruit in the markets, the fruit is used in the industries of medical and food processing (fruit juice, sweet, cream cake, citric acid and vinegar) (Yazici and Sahin, 2008). The cultivation of the pomegranate is mainly confined to the tropics and subtropics and it grows well in arid and semi-arid climates. The best climatic conditions are found in the Middle East Asia. Favorable growth takes place where winters are cool and summers are hot. It is evergreen in the tropics and deciduous in the subtropics. It has the ability to withstand frosty conditions, but below −10°C the hardiness is poor. A temperature of 38°C and a dry climate during fruit development produces best quality fruits. Areas with high relative humidity or rain are totally unsuitable for its cultivation, as fruits produced under such conditions tend to taste less sweet. In Turkey, the Mediterranean, Aegean and South East regions have suitable climates for pomegranate growing. The Mediterranean and Aegean regions have a typically Mediterranean climate that is rainy and warm in winter, hot and dry in summer (Ozguven and Yilmaz, 2000). Turkey is an important country in pomegranate production of the world and its production has increased over the years. While the amount of the production was 55000 ton in 1998, this value has risen to 106 500 ton in 2007. Higher amount of pomegranate production is seen in the Mediterranean (61.8%) and

Table 1. Properties of the subregions in the research region (Anonymous 1993, 2008).

Properties	Subregions		
	Zone I	Zone II	Zone III
Soil	Alluvial	Red mediterranean	Brown forest
Altitude, m	20-100	100-300	300-700
Slope, %	0-2	0-2	5-15
Rainfall, mm year^{-1}	1078	1064	928
Average temperature*, °C	17.8	18.0	18.2

*Annual

Aegean (23.3%) regions. Antalya, which was determined as the research area for this study yields 38% of the total pomegranate production of Turkey (Yazici and Sahin, 2008).

The studies of energy analyses have been focused on field crops cultivation in general and several studies were conducted on the areas of vegetable crops (Onal and Tozan, 1986; Triolo et al., 1987; Hetz, 1992; Yaldiz et al., 1993; Singh et al., 1997; Singh et al., 2000; Singh et al., 2003; Canakci et al., 2005; Canakci and Akinci, 2006; Polat et al., 2006; Nautiyal et al., 2007; Mihov et al., 2008) However, the research studies related to the energy and economic analyses in fruit production are very limited. Hetz (1998) conducted studies to analyze the utilization of energy in fruit production (grape, raspberry, orange, lemon, plum, pear and apple) in Chile in order to improve the energy efficiency. Gezer et al. (2003) determined and compared the energy input and output of the apricot farms in the Malatya region of Turkey. Ozkan et al. (2004) examined the energy requirements of the inputs and output in citrus production (orange, lemon and mandarin) in the Antalya region of Turkey. Polat et al. (2007) studied some working parameters and energy usage in a pistachio nut processing plant. Esengün et al. (2007) determined energy usage in dry apricot production, investigated the efficiency of energy consumption, and conducted economic analyses of dry apricot production of Turkey. Kocturk and Engindeniz (2009) examined energy and cost analyses of sultana grape growing for Manisa region of Turkey. Although the review of the literature revealed some studies on the energy analyses concerning fruit production, it was seen that specific studies related to the energy and economic analysis of pomegranate production were very limited. Therefore, research and economic analysis in the area of pomegranate cultivation is needed to evaluate and improve its energy usage. Consequently, the main goals of this study are:

1. To determine the energy usage patterns of pomegranate cultivation,
2. To investigate the energy indicators
3. To conduct economic analyses of pomegranate cultivation in the Antalya region of Turkey in order to improve its energy efficiency.

MATERIALS and METHODS

This study was carried out in Antalya region which is an important agricultural production area in Turkey. The region is located in the south-west of Turkey between 36° 7′ and 37° 26′ north latitude and 29° 17′ and 32° 44′ east longitude. Different geographical and climatic characteristics increase the variety of crop patterns and some fruits are cultivated together with other agricultural crops. In the region, a typical Mediterranean climate is seen with dry and hot summers and rainy and mild winters. Annual average temperature and total rainfall are approximately 18°C and 1000 mm, respectively (Anonymous, 2008). In this research, a survey was conducted to collect data from pomegranate farms. The Neyman method shown in below was applied to determine the farm number (Yamane, 1967; Yilmaz et al., 2005; Bayramoglu and Gundogmus, 2009). In the research, the farms were classified into three groups as I. group (0.1–1.0 ha), II. (1.1-2.5 ha) and III. group (2.6 ha and more).

$$n = \frac{\left(\sum N_h S_h\right)^2}{\left(N^2 D^2 + \sum N_h S_h{}^2\right)}$$

Where n is the required sample size; N is the number of total farms in population; N_h is the number of the population in h stratification (I, II or III); S_h^2 is the variance of h stratification; $D^2 = d^2/z^2$; d is the permissible error; z is the reliability coefficient.

The permissible error was defined as 5%, and the sample size was calculated to be 92 farms for 95% reliability. The study was carried out in Center, Serik, Manavgat and Finike districts in which regular pomegranate orchards exist in high density. Pomegranate production is realized in three geographical structures and conditions in the regions. Production parameters such as fruit yield and quality show variation among these sub regions which are defined as Zone I, Zone II and Zone III (Table 1). For each zone, the popular cultivation systems were determined. Then all inputs and outputs of the systems were identified and quantified, and later they were transformed into energy units. The energy equivalents of the inputs and outputs are seen in Table 2. The main energy sources are man-power, machinery, diesel, plastic, water, fertilizer, manure and chemicals. Energy is primarily used in agricultural operations for tillage, fertilization, manure application, ridging, irrigation, spraying, pruning, pruned brush removal from orchard, and harvesting. The energy consumption of tractors and other agricultural machinery were calculated using the following equation.

$$M_{pe} = \frac{G \cdot M_p}{T \cdot C_{ef}}$$

Table 2. Energy equivalences of inputs and outputs.

Energy Source	Units	MJ	References
Human hour	kg	1.96	[De et al., 2001; Singh 2002]
N	kg	60.60	[De et al., 2001; Singh 2002]
P_2O_5	kg	11.10	[De et al., 2001; Singh 2002]
K_20	kg	6.70	[De et al., 2001; Singh 2002]
Diesel	Litre	47.80	[Hetz 1992; 1998]
Tractor	kg	93.61	[Hetz 1992; 1998]
Agricultural machinery	kg	62.70	[De et al., 2001; Singh 2002]
Polyethylene plastic	kg	92.32	[Tiwari 2003]
Chemical	kg	120.00	[Singh 2002]
Farmyard Manure	kg	0.30	[Singh 2002]
Water	m^3	0.63	[Yaldiz et al., 1993]
Stalks	kg	18.00	[Singh 2002]
Output	kg	1.90	[Singh 2002]

Where M_{pe} is the energy consumption of the machine per unit area, MJ ha^{-1}; G is the mass of the machine, kg; M_p is the production energy consumption of the machine, MJ kg^{-1}; T is the economic life, h; and C_{ef} is the effective field capacity, ha h^{-1}.

Other energy input and output values were determined with evaluation of the survey data. Stalk energy gained after the pruning operation was also taken into consideration in this study. Energy output-input ratio, specific energy, energy productivity and energy density were determined by using standard equations (Mandal et al., 2002; Gezer et al., 2003).

$$ER = \frac{EO}{EI} \qquad (3)$$

Where ER is the energy ratio; EO is the energy output, MJ ha^{-1}; EI is the energy input, MJ ha^{-1}.

$$SE = \frac{EI}{Y} \qquad (4)$$

Where SE is the specific energy, MJ t^{-1}; Y is pomegranate yield, th^{-1}.

$$EP = \frac{Y}{EI} \qquad (5)$$

Where EP is the energy productivity, kg MJ^{-1}.

$$E_{int} = \frac{EI}{PC} \qquad (6)$$

Where E_{int} is the energy intensiveness, MJ $\$^{-1}$; PC is the production cost, \$ ha^{-1}.

In the economic analyses, total costs including the fixed and variable inputs were considered (Yilmaz et al., 2005; Canakci and Akinci, 2006; Esengun et al., 2007).

RESULTS AND DISCUSSION

Agricultural operations and use of power sources

In this study, 92 farms cultivating regular pomegranate in orchards were considered. Utilized agricultural operations and sources of power are shown in Table 3. In the production, the main operations were tillage, fertilization, farmyard manure application, ridging, irrigation, spraying, pruning, brush removal and harvesting. While some operations are realized using machinery powered by a tractor, some operations such as pruning and harvesting are done manually. In Zone I, the tillage operation is carried out by a disc harrow for mixing, airing of soil and disposal of herbs. Structure of Zone II and Zone III are not suitable for tillage operations. In all Zones, granule fertilizers are applied and spread manually and the application time per area for Zone I, Zone II and Zone III were obtained as 13.6, 13.6 and 14.3 h ha^{-1}, respectively. Application of manure is done in the pomegranate orchards in these Zones. In Zone II, man, tractor and diesel are utilized intensively with the values of 57.7, 4.8 h ha^{-1} and 8.7 L ha^{-1}, respectively.

Pomegranate orchards of Zone I and Zone II are irrigated by surface method and the water was distributed using open canal systems. Prior to irrigation operation, a ridger is used for bund making in the cultivation of these Zones. For the ridging operation in these Zones, man-power, tractor and diesel usage were 1.7, 1.7 h ha^{-1} and 6.9 L ha^{-1}, respectively. In Zone III, a mini sprinkler system is used for irrigation operation and the water is taken from closed and pressured canal and machinery was not used to prepare the soil for irrigation before the operation. In this system, times of irrigation per season and irrigation time per area were determined as 14 and 10 h ha^{-1}, respectively.

Also, this mechanism is used as a fertili-zation system, and nutrients required during the growing period are released into the soil together with irrigation water. In the

Table 3. Use of power sources for pomegranate cultivation.

Operations	Zone I	Zone II	Zone III
Tillage			
Man, h ha^{-1}	2.5	-	-
Tractor, h ha^{-1}	2.5	-	-
Diesel, L ha^{-1}	13.2	-	-
Fertilization			
Man, h ha^{-1}	13.6	13.6	14.3
Manure application			
Man, h ha^{-1}	18.0	57.7	27.0
Tractor, h ha^{-1}	1.5	4.8	2.3
Diesel, L ha^{-1}	2.7	8.7	4.1
Ridging			
Man, h ha^{-1}	1.7	1.7	-
Tractor, h ha^{-1}	1.7	1.7	-
Diesel, L ha^{-1}	6.9	6.9	-
Irrigation			
Man, h ha^{-1}	75.9	64.3	46.7
Mini sprinkler system, h ha^{-1}	-	-	140.0
Spraying			
Man, h ha^{-1}	29.4	130.0	200.0
Tractor, h ha^{-1}	6.4	35.0	35.0
Diesel, L ha^{-1}	33.6	63.0	63.0
Knapsack sprayer, h ha^{-1}	16.7	25.0	25.0
Pruning			
Man, h ha^{-1}	411.5	389.3	507.2
Brush Removal			
Man, h ha^{-1}	48.6	46.8	85.5
Tractor, h ha^{-1}	4.1	3.9	4.3
Diesel, L ha^{-1}	7.3	7.0	7.7
Harvesting			
Man, h ha^{-1}	500.5	439.7	1309.7

pomegranate cultivation, orchard sprayers driven by tractor PTO are used to dispose of plant disease and pests. The spraying operation is performed approximately 7 times a season in the regions. In Zone II, PTO driven and aided air draft sprayer are used. In the other zones, PTO driven mechanic orchard sprayers are utilized together with a few human workers excluding the tractor operator. While three human workers are engaged in the Zone II, in Zone III, five humans are employed due to steeper land slope (Table 1). At the same time, leaf fertilizer applications can be combined with the spraying operation. In the pomegranate orchards, knapsack sprayers are used for weed control at 2 to 3 times per season. In fact, field capacities of this kind of sprayers that are powered manually are very low and application of the operation is difficult and tiresome but necessity of precise application hinders the use of other tractor PTO driven sprayers in herbicide applications.

In the research region, the pruning operation, which is one of the most important operations, is done manually between December and February. The value of manpower used is determined to be between 389.3 - 507.2 h ha^{-1} in the operation. And then pruned brushes are removed from the orchard and burned. In the brush removal

Table 4. Energy use pattern for pomegranate cultivation.

Inputs	Zone I	%	Zone II	%	Zone III	%
Operations, MJ ha^{-1}						
Tillage	714.0	12.2	-	-	-	-
Fertilization	26.7	0.5	26.7	0.3	28.0	0.2
Manure application	237.1	4.0	760.2	9.8	355.6	2.8
Ridging	374.7	6.4	374.7	4.8	-	-
Irrigation	148.7	2.5	126.0	1.6	3575.6	28.4
Spraying	1939.4	33.0	4206.0	54.4	4343.2	34.5
Pruning	806.6	13.7	763.1	9.9	994.1	7.9
Brush removal	640.1	10.9	616.4	8.0	742.7	5.9
Harvesting	981.0	16.7	861.8	11.1	2566.9	20.4
Total	5868.3	100.0	7734.9	100.0	12606.2	100.0
Energy sources, MJ ha^{-1}						
Human	2159.3	6.6	2240.5	5.2	4293.0	9.7
Machines	664.6	2.0	1403.8	3.3	1256.2	2.8
Diesel	3044.4	9.3	4090.6	9.5	3572.8	8.0
Plastic	-	-	-	-	3484.2	7.8
Water	3452.4	10.6	4315.5	10.0	4365.9	9.8
Fertilizer	18723.3	57.4	23022.5	53.4	23260.6	52.3
Manure	1815.0	5.6	5460.0	12.7	1590.0	3.6
Chemicals	2760.0	8.5	2580.0	6.0	2640.0	5.9
Total	32619.0	100.0	43112.9	100.0	44462.7	100.0
Outputs						
Pomegranate, kg ha^{-1}	33366		28335		43655	
Brush, kg ha^{-1}	1670		1590		1750	
Energy output						
Pomegranate, MJ ha^{-1}	63395		53837		82945	
Brushes, MJ ha^{-1}	30060		28620		31500	
Total, MJ ha^{-1}	93455		82457		114445	
Net energy, MJ ha^{-1}	60836		39344		69982	
Energy ratio						
Pomegranate	1.94		1.25		1.87	
Stalks	0.92		0.66		0.71	
Total	2.87		1.91		2.57	
Specific energy, MJ t^{-1}	978		1522		1019	
Energy productivity, kg MJ^{-1}	1.02		0.66		0.98	
Energy intensiveness, MJ \$$^{-1}$	3.33		4.18		2.79	

operation, tractor and trailer are used together with human workers for transporting the pruned brushes out of the orchard. In the pomegranate cultivation, the maximum manpower usage is seen during the harvesting period. The usage of manpower in Zone I, Zone II and Zone III are determined as 500.5, 439.7 and 1309.7 h ha^{-1} respectively. In Zone III, high fruit yield and the necessity of precise operations increase the use of manpower.

Energy variables

Energy usage patterns and related findings for different zones were shown in Table 4. In the evaluation of energy usage, operational energy and energy sources were taken into consideration separately.

Operational energy

The total operational energy used for Zone I, Zone II and Zone III were 5868.3, 7734.9 and 12066.2 MJ ha^{-1}, respectively. Data in Table 4 indicates that the higher energy usage of irrigation and harvesting resulted in increased total value in Zone III with respect to the other zones. Out of all the agricultural operations, spraying had the highest energy ratio (33.0 - 54.5%) and the energy value changed from 1939.4 - 4343.2 MJ ha^{-1}. Usage of different orchard sprayers in Zone I decreased this operational energy use with respect to the other zones.

Tillage (which is not applied except for Zone I) operational energy usage is 714 MJ ha^{-1} with the ratio of 12.2%. Granule fertilization has the minimum operational energy usage due to usage of only manpower. Manure application energy consumption in Zone I, Zone II and Zone III were 237.1, 760.2 and 355.6 MJ ha^{-1}, respectively because of the different farmyard manure quantities. Ridging energy usage was calculated as 374.7 MJ ha^{-1} due to the equal amount of application seen in Zone I and Zone II. The irrigation energy usage values were found to be very close to each other in Zone I and Zone II because of use of a similar irrigation application method defined as surface irrigation. Yet, irrigation energy usage of Zone III was significantly greater than the others owing to utilization of the mini spring system. Pruning is an important operation that requires careful application and therefore done manually in pomegranate cultivation. The pruning energy usage varied between 763.1 - 994.1 MJ ha^{-1}, with the share of 7.9 -13.7% and brush removal energy usage was in the range of 616.4 - 742.7 MJ ha^{-1} with the ratio of 5.9 - 10.9%.

The harvesting energy usage in Zone I, Zone II and Zone III were calculated at 981.0, 861.8 and 2566.9 MJ ha^{-1}, respectively. Zone III has the highest energy usage due to higher fruit yield and the need for more precise operations.

Energy sources

The total energy usage utilizing various sources for Zone I, Zone II and Zone III of pomegranate cultivation were 32619.0, 43112.9 and 44462.7 MJ ha^{-1}, respectively (Table 4). It was determined that while in pomegranate cultivation energy usage is higher than that of apricot production (22341.0 MJ ha^{-1}, 17884.7 - 23217.3 MJ ha^{-1}), it is lower than energy usage in cultivation of other fruits like citrus (62 977.9 MJ ha^{-1}), grape (54300.0 - 60.600 MJ ha^{-1}) and raspberry (51400.0 - 60500.0 MJ ha^{-1}) (Hetz, 1998; Gezer at al., 2003; Ozkan et al., 2004; Esengun et al., 2007). The fertilizer and water energy inputs were found to be the sources of the highest energy usage among all inputs with shares in the range of 52.3 - 57.4% and 9.8 - 10.6%, respectively. With the highest ratio, findings for fertilizer application energy usage (application as granule and liquid having the maximum ratio) were similar to the findings in the literature. In some research, the share of the fertilizer energy varied between 50 - 90%, approximately (Hetz, 1992; Ozkan et al., 2004). Therefore, some factors like accurate fertilizer dose required per area and its application methods must be considered in terms of energy efficiency of agricultural production.

While manpower energy values were calculated at 2159.3 and 2240.5 MJ ha^{-1} in Zone I and Zone II, this value was found to be at 4293.0 MJ ha^{-1} in Zone III. The higher manpower energy consumption in Zone III was determined due to different land and soil properties and growing techniques. The energy consumption by machinery in all three Zones varied from 664.6 - 1403.8 MJ ha^{-1} with a share of 2 - 3% approximately. Diesel energy usage to operate agricultural machinery powered by a tractor was between 3000 - 4000 MJ ha^{-1} approximately. Plastic energy usage of the mini spring system (only in Zone III) was calculated as 3484.2 MJ ha^{-1}, with the share of 7.8%. In Zone II, manure energy usage (5460.0 MJ ha^{-1}) is determined to be higher than the other two zones so that the quantity of manure consumed per annum is more than that of the other zones in the orchards of Zone II. The chemical energy usage consisted of energy used for application of herbicides and other pesticides varied from 2580.0 - 2760.0 MJ ha^{-1} with the share of 7% approximately. Ratios of use of non-renewable energy (diesel, fertilizer, chemicals, machines, plastics) sources varied in the range of 70 - 75% and it was seen that most of the total energy input was from non-renewable sources. For sustainable agricultural production and a sustainable environment, this ratio needs to be decreased. Therefore, the interests in applications such as organic farming and good agricultural practices (GAP) have been increasing and more research has been carried out in this area in the recent years.

Energy indicators

The values of fruit yield and pruned brush obtained in pomegranate cultivation Zone I, Zone II and Zone III, were found to be in the ranges of 33366-1670, 28335-1590, 43655 -1750 kg ha^{-1}, respectively. In the same zones, the output energy findings were in the ranges of 63395 - 30060, 58837 - 28620 and 82945 - 31500 MJ ha^{-1}. Total bio energy defines the total energy output of the pomegranate fruit (economic product) and that of pruned brush (by-product). It was seen that in the Zone III, both energy values and their total were higher compared to that of the other zones. In the same zone, the net energy gain was

Table 5. Economic analyses of pomegranate cultivation.

Cost Items	Zone I	%	Zone II	%	Zone III	%
Variable Costs, \$ ha^{-1}						
Manure	161.3	1.6	364.0	3.5	141.3	0.9
Fertilizer	486.7	5.0	491.7	4.8	568.7	3.6
Chemicals	335.3	3.4	306.7	3.0	330.7	2.1
Water	146.7	1.5	320.0	3.1	186.7	1.2
Diesel	122.1	1.2	164.0	1.6	143.3	0.9
Worker	2448.2	25.0	2540.2	24.6	4867.3	30.5
Repair and maintenance	72.2	0.7	167.0	1.6	220.2	1.4
Operating interest charges	269.5	2.8	311.0	3.0	461.3	2.9
Total	4042.0	41.3	4664.5	45.3	6919.4	43.4
Fixed Costs, \$ ha^{-1}						
Depreciation	69.2	0.7	157.7	1.5	355.1	2.2
Interest	40.5	0.4	89.6	0.9	181.8	1.1
Land lease	5333.3	54.5	5066.7	49.2	8000.0	50.1
Housing	19.7	0.2	44.0	0.4	40.2	0.3
General overhead costs	280.4	2.9	285.0	2.8	458.9	2.9
Total	5743.1	58.7	5643.0	54.7	9036.0	56.6
Total cost of production, \$ ha^{-1}	9785.1	100.0	10307.6	100.0	15955.4	100.0
Pomegranate, kg ha^{-1}	33366		28335		43655	
Price, \$ kg^{-1}	0.44		0.52		0.63	
Total Return, \$	14681		14734		27648	
Net return, \$ ha^{-1}	4896		4427		11693	
Benefit/cost ratio	1.50		1.43		1.73	

found to be higher than that of the others. Therefore, pomegranate cultivation in Zone III was found to provide superior energy gain compared to Zone I and Zone II.

For the pomegranate fruit (economic product), the energy ratio has the highest value in the Zone I followed by Zone III and Zone II. The values were calculated as 1.94, 1.87 and 1.25, respectively. The efficiency of total (fruit and pruned brush) energy usage of Zone I was higher than the other zones with the value of 2.87 and for Zone II and Zone III, the total energy ratios were found to be 1.91 and 2.57, respectively. The lower fruit yield (energy output) and the highest energy usage during the cultivation season (energy input) resulted in the minimum energy ratio in pomegranate production in Zone II. The specific energy requirement for fruit per mass has the highest value (1522 MJ t^{-1}) in Zone II, followed by Zone III (1019 MJ t^{-1}) and Zone I (978 MJ t^{-1}). The fruit energy productivity depended on the specific energy in the pomegranate cultivation changed between 0.66-1.02 kg MJ^{-1}. The energy density related to production cost data was higher (4.18 MJ \$$^{-1}$) in Zone II followed by Zone I (3.33 MJ \$$^{-1}$) and Zone III (2.79 MJ \$$^{-1}$).

Economic analyses

The findings related to economic and return on investment are shown in the Table 5. The total cost production of Zone I, Zone II and Zone III were calculated at 9785.1, 10307.6 and 15955.4 \$ ha^{-1}, respectively and the ratio of variable and fixed cost items were 41 - 45% and 55 - 59%, approximately. The total variable cost for Zone I, Zone II and Zone III were 4042.0, 4664.5 and 6919.4 \$ ha^{-1}, respectively. The labour cost was the highest component in the total cost because of high man-power usage and was about 25 - 30% of total production cost and it has the highest value (4867.2 \$ ha^{-1}) in Zone III. It can be said that land properties, usage of conscious and sensitive methods increased the labour cost and its ratio in this zone.

Fertilizer cost follows labour cost with the approximate ratio of 3 - 5% and this cost component was an important item in the total cost of the production. These variable items are followed by chemicals, operating interest charges, water, farmyard manure, diesel, and repair and maintenance, respectively. It can be seen said that less use of mechanization decreases the ratio of the related values like diesel, lubricant, repair and maintenance since some operations like granule fertilizer application, harvesting, and pruning were done manually. Total fixed cost of Zone I, Zone II and Zone III were determined at 5743.1, 5643.0 and 9036.0 \$ ha^{-1}, respectively. The maximum cost item among the fixed costs was calculated as the cost of land lease. This cost item constituted about

50 - 55% of the total production cost. The other fixed cost components such as depreciation, interest, housing and general overhead costs were lower than 3% of total cost production. Prices of the pomegranate fruit cultivated in the three zones were different from each other. The price values per kilogram in Zone I, Zone and Zone III were found to be 0.44, 0.52, 0.63 $ kg^{-1}, respectively. It can be said that, land properties, climatic conditions and cultivation techniques affected the quality of the fruit and its price. Total cost and net return values of Zone I, Zone II and Zone III were 14681 - 4896, 14734 - 4427 and 27648 -11693 $ ha^{-1}, respectively. The comparison of the economic results revealed that the net return values of pomegranate cultivation in regular orchards were higher than some other fruits like apricot and citrus. Net return values of citrus and apricot production were determined as 1788 - 3398 $ ha^{-1} and 415-496 $ ha^{-1}, respectively (Ozkan et al., 2004; Esengun et al., 2007). The benefit-cost ratio for the Zone I, Zone II and Zone III production were found at 1.50, 1.43 and 1.73, respectively. As seen in Table 5, the most investment intensive cultivation were done in Zone III, also the values of total return, net return, benefit-cost ratio were higher in Zone III compared to the other zones. Therefore, it can be concluded that Zone III has better properties in terms of land, soil and geographical factors in pomegranate cultivation compared to Zone I and Zone II. The suitable conditions resulted in higher net return (two times) than the other Zones. Finally, the economic indicators showed that the most efficient area for pomegranate cultivation was Zone III.

Conclusions

In the pomegranate production, the main operations were tillage, fertilization, farmyard manure application, ridging, irrigation, spraying, pruning, brush removal and harvesting. While some operations are realized using machinery powered by a tractor, some operations such as pruning and harvesting are done manually. The total operational energy consumption for Zone I, Zone II and Zone III were 5868.3, 7734.9 and 12066.2 MJ ha^{-1}, respectively. The total energy usage utilizing various sources for Zone I, Zone II and Zone III of pomegranate cultivation were 32619.0, 43112.9 and 44462.7 MJ ha^{-1}, respectively. The values of fruit yield and pruned brush gained in pomegranate cultivation Zone I, Zone II and Zone III, were in the ranges of 33366-1670, 28335-1590, 43655-1750 kg ha^{-1}, respectively.

For the pomegranate fruit (economic product), the energy ratio has the highest value in the Zone I followed by Zone III and Zone II. The values were determined as 1.94, 1.87 and 1.25, respectively. The efficiency of total (fruit and pruned brush) energy usage of Zone I was higher than the other zones with the value of 2.87 and for Zone II and Zone III, the total energy ratios were 1.91 and2.57, respectively.

Total cost and net return values of Zone I, Zone II and Zone III were 9785.1 - 4896, 10307.6 - 4427 and 15955.4 -11693 $ ha^{-1}, respectively. The economic indicators showed that the most efficient area for pomegranate cultivation was Zone III because of better properties in terms of land, soil, geographical factors, and growing techniques.

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Abbreviations: **n**, Required sample size; **N**, number of total farms in population; **S_h**, standart deviation; **N_h**, number of the population in h. stratification; **S_h^2**, variance of h. stratification; **d**, permissible error; **z**, reliability coefficient, **M_{pe}**, energy consumption of the machine per unit area, MJ ha^{-1}; **G,** mass of the machine, kg; **M_p**, production energy consumption of the machine; MJ kg^{-1}; **T,** economic life, h; **C_{ef}**, effective field capacity, ha h^{-1}.; **ER**, energy ratio; **EO,** energy output, MJ ha^{-1}; **EI,** energy input, MJ ha^{-1}, **SE,** specific energy, MJ t^{-1} ;**Y**, pomegranate yield, t h^{-1}; **EP,** energy productivity, kg MJ^{-1}; **E_{int},** energy intensiveness, MJ $$^{-1}$; **PC**, production cost, $ ha^{-1}.

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