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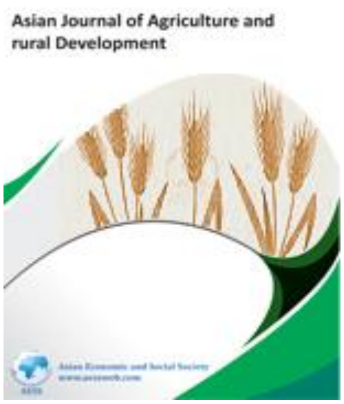

Estimation of a Mechanization Index and Its Impact on Energy and Economic Factors in Apple Orchard in Iran

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Abstract

This study was conducted in the 2008-9 production year in West Azerbaijan province (Uromia Township). The Energy Ratio, Energy Productivity, Economic Productivity and Mechanization Index were estimated for apple production. Data were collected using random sampling for 80 face-to-face respondents. Results showed that the highest share of energy consumption belongs to packaging (57%) followed by irrigation (16%). The highest share of expenses was found to be 34% and 30% for labour and packaging, respectively. Mechanization was considered at three levels including level 1 for spraying only, level 2 for spraying and plotting, and level 3 for spraying and fertilizing operations. The Energy Ratio was found to be less than one for all mechanization levels having the highest value in level 2 (0.58). The highest economic productivity was calculated as 1.9 for level 2. Results showed that increasing the Mechanization Index, will not necessarily increase energy ratio and economic productivity.

Keywords: Energy ratio, Economic productivity, apple, Mechanization index

Introduction

Nowadays, machinery and labour are the main resources for agricultural operations, but machinery is gradually replacing labour,, where savings in time and improving the quality of agricultural operations are mainly due to utilization of mechanical power, particular definition of mechanization only involves mechanical technology and machine-related issues, common definition of mechanization involves all issues related of agriculture and management of them (Almasi et al. 2008). Really, mechanization is benefiting of technology, as a result mechanization technology is location- specific and dynamic (Singh, 2006). At first, accessible indices are necessary to development in order to mechanization development. In this study, mechanization does not involve only machining agricultural operation rather every effective factor in energy and economic management and sustainable farming are considered mechanization. In developed country, the main object of mechanization utilization is decreasing expenses or labour energy, but in developing country, it is increasing production.

Apple is one of the superior productions in worldwide due to its nutrient and exporting value. In 2005, apple orchards' area was summed up to 201000 ha with total production of 2.66 million ton in Iran (Anonymous 2006a). The West Azarbaijan province is the leading apple (Delicious & Golden varieties with long legged, 277 trees per hectare) producer in Iran, with approximately 27.1% share of total apple orchard area and 29.8% share of total apple production in Iran (Anonymous 2006a). Also, about half of this province's apple production and apple orchard area is allocated to Oromieh Township (Anonymous 2005). Based on data from the Food and Agriculture Organization (FAO) of the United Nations in 2006, Iran is ranked third largest apple production in the world after China and USA (Anonymous 2006b) (Table1).

Table 1: The production of apples in some important apple producing countries in 2006 (Anonymous. 2006b)

Countries	Production quantity (ton)
China	26065500
USA	4568630
Iran	2661901
Poland	2304892
Italy	2112720
Turkey	2002033
India	1739000

Crop yields and food supplies are directly linked to energy and energy consumption. Energy use in agriculture has been developed in response to increasing populations, limited supply of arable land and a desire for higher standards of living. More intensive energy use of fossil fuel, chemical fertilizers, pesticides, machinery and electricity has brought some important human health and environmental problems. Thus, efficient use of energy inputs is of prompt importance in terms of sustainable farming.

An input–output energy analysis provides farm planners and policy makers an opportunity to evaluate economic intersection of energy use (Ozkan et al. 2004a). Apple is a crop requiring high-energy inputs for successful commercial production of a high-quality fruit. Considerable research studies have been conducted on energy use in agriculture, however, relatively little attention has been paid to apple production.

Van Den Berg et al. (2007) reported that increasing of farm size requires mechanization utilization, on the other hand these two factors are considerable in farmer s̓ production and income. Nkakini et al. (2006) investigated that mechanized methods require less energy than manual methods. Chen et al (2008) revealed that mechanization utilization has caused to productivity growth in agriculture in Chin at 1990- 2003 years. Furthermore, this study considered the energy and economic matters in apple orchards, Strapatsa et al. (2006), determined the amount of energy consumption from which one kilogram apple is produced along with energy indices in apple production in 1999-2000 for Greece. Hasanzadeh & Rahbar (2005) studied energy use for apple production in Iran. Funt (1980) conducted a study to optimize the energy inputs for apple in Eastern U.S. conditions. Baldini et al. (1982), investigated energy utilization in apple in Italy.

The aims of this study were to estimation of a mechanization index and its impact on energy and economic factors. The study also sought to determine input–output energy use in apple production to investigate the efficiency of energy consumption and to make an economic analysis in apple production in Oromieh Township in Iran.

Materials and Methods

The West Azarbaijan province is located in the northwestern of Iran, with 37 590 km2 area (except Oromieh lake), within 44° 3' to 47° 24' eastern longitude, and 36° 5' to 39° 46' northern latitude. Neighboring with three foreign countries, it is considered an important province with regard to export.
Data were collected from 80 apple orchard in the Oromieh Township of West Azarbijan province by using a face to face questionnaire in 2008. Information was sought on inputs used for production of apple as well as economic characteristics of the orchards. Sample orchards were randomly selected from the villages in the study area by using a stratified random sampling technique. The sample size was calculated using the Cochran method as in Eq. 1:

$$n = Nt^2S^2/(Nd^2+t^2S^2) \qquad (1)$$

where:

d – the precision where (x - X) or mid-confidence interval

n – the required sample size

N – the number of holdings in target population

S2 – the variance of surveyed factor of population (energy and economic productivity)

t – the reliability coefficient (1.96 which represents the 95% confidence interval)

The permissible error in the sample size was defined to be 5% for 95% confidence. The sample size was calculated as 77 orchards and increased to 80 to improve accuracy. Farmers' responses were obtained through face to face interviews, in production year in 2008. Before collecting data, the survey form was pre-tested by a group of randomly selected farmers and these pre-tested surveys were not included in the final data set.

A mechanization index based on the matrix of use of animate and mechanical energy inputs could be given by incorporating energy and cost factors in to Eqs (2) and (3) respectively (Singh, 2006):

$$Im = EEM / (EEM+EEA+EEH) \quad (2)$$

$$Im = CEM / (CEM+CEA+CEH) \quad (3)$$

Where: Im is the mechanization index of the apple crop in the Oromieh Township; EEM and CEM are the energy and cost of use of machinery; EEA and CEA are the energy and cost of use of animal labour; EEH and CEH are the energy and cost of use of human labour (in this research, no animal energy is used).

Based on the energy equivalents of the inputs and outputs (table 2), the metabolisable energy was calculated. Energy ratio (energy use efficiency) and energy productivity were calculated (Mandal et al. 2002):

Output - input ratio (ER) = Energy output (MJ/ha) / Energy input (MJ/ha) (4)

Energy productivity (EP) = Total output (kg/ha) / Energy input (MJ/ha) (5)

Table 2: Energy equivalents of inputs and output in agricultural production

Inputs (unit)	Energy equivalent (MJ/unit)	Reference
1. Chemical fertilizers (kg)		
(a) Nitrogen	78.1 MJ/kg	Kitani, 1999
(b) Phosphate (P2O5)	17.4 MJ/kg	Kitani, 1999
(c) Potassium (K2O)	13.7 MJ/kg	Kitani, 1999
(d) Superior Chemical	120 MJ/kg	Singh & Mittal, 1992
2. Farmyard manure (kg)	0.0303 MJ/kg	Singh & Mittal, 1992
3. Chemical biocides (L)		
(a) Insecticides	199 MJ/L	Helsel, 1992
(b) Benomyl	397 MJ/L	Kitani, 1999
(c) Captan	115 MJ/L	Kitani, 1999
(d) Other fungicides	92 MJ/L	Helsel, 1992
4. Diesel fuel (L)	47.8 MJ/L	Kitani, 1999
5. Electricity (kWh)	12 MJ/kWh	Kitani, 1999
6.Wood (packaging) (kg dry mass)	18 MJ/kg	Singh & Mittal, 1992
7. Transportation (t.km)	2.6 MJ/t.km	Kitani, 1999
8. Tractor (kg)	138 MJ/kg	Kitani, 1999
9. Fertilizer (sprayer) (kg)	129 MJ/kg	Kitani, 1999
10. Disk harrow (kg)	149 MJ/kg	Kitani, 1999
11. Human labour (h)	0.27 MJ/h	Kitani, 1999
12. Apple (kg)	1.9 MJ/kg	Singh & Mittal, 1992
13. Refrigerating (t.day)	1.151 MJ/t.day	Anonymous., 2007

In order to calculate inputs energy needed for irrigation (required energy for pumping water), Eq. (4) was used (Kitani, 1999):

$$DE = \frac{\gamma g H Q}{\varepsilon_p \varepsilon_q} \quad (6)$$

where:

DE – direct energy (J/ha)

g – acceleration due to gravity (m/s2)

H – total dynamic head (m)

Q – volume of required water for one cultivating season (m3/ha)

γ – density of water (kg/m3)

ε_p – pump efficiency (70-90%)

ε_q – total power conversion efficiency (18-20%) (Ercolia et al.1999)

This study, required water was estimated 7000 m3 for one cultivating season. The output/input analysis was also applied in economic benefits analysis. The process was similar with energy balance analysis. The economic (or energy) inputs of this system include costs of human labour, chemical fertilizers, chemicals biocides, packaging, transportation, refrigerating, fixed costs and agricultural machinery. The economic (or energy) outputs of this system include main and secondary yields. All considered prices of inputs and outputs were averaged market prices in production year of 2008-2009. The economic analysis include ratio of total outputs to total inputs. All estimations were carried out using the SPSS16 software and Excel program.

Results and Discussion

Economic analysis of apple production

The costs of each input and gross production values calculated in apple production are given in Table 3. Fixed and variable costs within total production costs were calculated independent from each other. The gross value of production (13 873 $/ha) was found by multiplying the apple yield (primary and secondary) (19 447 kg/ha, 4 335 kg/ha) to their corresponding prices (0.7 $/kg, 0.06 $/kg) and summing the results. The total mean production cost was 7816 $/ha, where 92.1% was the share of variable costs, and 7.9% fixed costs. Several studies report that the ratio of variable cost was higher than that of fixed cost in cropping systems (Esengune et al. 2007; Cetin and Vardar, 2008; Mohammadi et al. 2008). Based on these results, the benefit–cost ratio from apple production in the surveyed orchards was calculated to be 1.8. The research results were consistent with the findings reported by other researchers for other orchard crops, such as 2.37 for orange, 1.89 for lemon and 1.88 for mandarin (Ozkan et al. 2004b), The gross return (6 673 $/ha) was calculated by subtracting the variable cost of production per hectare (7 200 $/ha) from the gross value of production (13 873 $/ha). The productivity (2.5 kg/$) was obtained by dividing apple yield (19 447 kg/ha) by total production costs (7 816 $/ ha).

Table 3: Economic analysis of apple production

Cost and return components	Unit	Value
Yield (main)	kg/ha	19447
Sale price (main)	$/kg	0.7
Yield (secondary)	kg/ha	4335
Sale price (secondary)	$/kg	0.06
Gross value of production	$/ha	13873
Variable cost of production	$/ha	7200
Fixed cost of production	$/ha	616
Total cost of production	$/ha	7816
Total cost of production (only main)	$/kg	0.4
Total cost of production (main and secondary)	$/kg	0.33
Gross return	$/ha	6673
Net return	$/ha	6057
Benefit to cost ratio	-	1.8
Productivity (only main)	kg/$	2.5
Productivity (main and secondary)	kg/$	3

Fig 1 shows that the percentage share of each input from the total energy input As can be seen from Fig. 1, of all the inputs, the human labour expenses has the biggest share of 34%. The majority of manual labour in the orchards was spent during harvesting, irrigating, pruning, fertilizing orchard operations, respectively. Almost in all surveyed orchards, most operation were performed by manual labour, due to lack of machineries suitable for tall trees. Also, some farmers were concerned about the soil compaction resulting from machinery traffic.

Packaging (30%) and refrigerating (19%) expenses are followed by fixed costs (7%). Results revealed that harvesting and postharvest operations are the most important expenses with a 65.6 %, labour expenses share for harvesting (43%), irrigation (21.7%), pruning (21.5%), fertilization (8.8 %), sprayer (3%) and plotting (2%) operation were found. Results revealed that Due to low mechanization level in apple orchard, human energy is accounted for 34% and that of machineries for 1% of total costs. Postharvesting (53.62%), irrigating (12.3%), harvesting (12%), fertilization (6.2%), plotting (1.2%), pruning (6%), fixed cost (6%) and sperying (4.1%) operations also accounted for most of expenses in surveyed apples orchard.

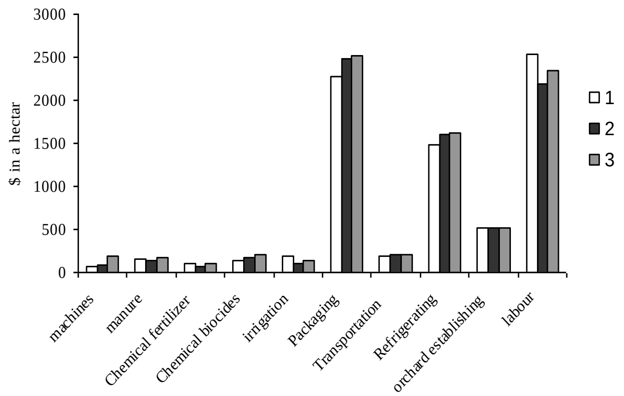

Fig 1: The percentage share of each input of the total expenses

Analysis of input–output energy use in apple production

The yield in apple orchard is generally carried out by human labour energy in the research area and the number of large orchard holdings using modern technology is very limited. The average size in the surveyed orchards has been found to be 1.2 ha with a range from 0.1 up to 5 ha. Machine power was used for only sprayer (in all orchards), and fertilizing and plotting (in few orchards) due to the fact that most apple orchards are designed in a conventional way in which machineries traffic is really limited. The source of labour in the surveyed orchards is from either family members or mainly from hired (seasonal) labours and most of the machineries are mainly provided by rent. The energy consumption and its sources for apple production are presented in Table 4. Total physical energy input consists of diesel, fertilizer, chemicals, human power, machinery, irrigation, packaging, refrigerating and transportation.

As can be seen from Table 4, the total energy used in various farm inputs is 101 505 MJ/ha. The last column in Table 4 gives the percentage share of each input from the total energy inputs. Of all the inputs, wood packaging has the largest share (57%), apples are packaged with wood because owners of apple orchards are believed that wooden boxes that store more power box than plastics or other types of packing boxes. Packaging energy is followed by the irrigation energy (16%), based on duration of irrigation (5-24h for one ha); irrigation methods were conventional or semi-mechanized (mostly with electric pump and conventional), an apple orchard is irrigated 8 to 10 times a year. One group of orchards was irrigated only the water supplied through the permanent river, another group was irrigated 2 to 3 times with seasonal rivers, and others only with well. Energy for diesel is ranked third (10%). The diesel energy was mainly utilized for operating tractors, (mostly Messy Ferguson (MF) & Goldoni in the surveyed apple orchards), fuel consumption of Goldoni type is less than that of MF, in spite of being conventional, diesel energy was accounted for 10% of total energy inputs. The level of technology in the studied orchards was very low.

The total energy equivalent of chemical fertilizers consumption placed fourth among the energy inputs and constituted (9%) of the total energy input, and nitrogen (7%) was in the first place followed by phosphate (1%), potassium (0.7%) and superior chemical (0.3%). The most frequently used fertilizer is farmyard manure and even in some orchards chemical fertilizers is not used because of soil structure and soil nutrients preservation. The contribution of transportation, farmyard manure and machinery energies remained at low level of 1% (in total) as indirect energy inputs. Hasanzadeh and Rahbar (2005), reported that the most energy consuming input for apple production in West Azarbaijan province was that for irrigation, nitrogen chemical fertilizing and chemical biocides, respectively. According to Kisilaslan (2009), percentage shares for fertilizers (42%), electricity (22%) and fuel (21%) showed highest from total energy used in cherry production in Turkey. Strapatsa et al. (2006), calculated that the most energy inputs for orchard apple production in Greece were fuel (33%), machinery (25%) and fertilizers (15%), mainly N (where orchards were irrigated 1-2 times a year), respectively. In Italy, in a similar study in apple cultivation carried out by Baldini et al. (1982), fuel and fertilizers (mainly N) accounted for most of total energy inputs (46.4 and 20.9%, respectively). In eastern U.S. in apple orchards (Funt, 1980), fuel and machinery accounted for around 70%, fertilizers 10.3%, and biocides 14.7% of total energy inputs, while human labour was not included in the energy analysis. in all studies sited, postharvest operation were not included.

Table 4: Amounts of inputs, output and energy inputs and output in apple production

Inputs (unit)	Total energy equivalent (MJ/ha)	Apple	Percentage (%)
A. Inputs			
Nitrogen (kg)	7105		7
Phosphate (P2O5) (kg)	1015		1
Potassium (K2O) (kg)	710		0.7
Superior Chemical (kg)	305		0.3
Water for irrigation (m^3)	16241		16
Chemical biocides (L)	2030		2
Wood Packaging (kg)	57858		57
Refrigerating (ton.day)	2030		2
Disel(L)	10151		10
Human labour (h)	3045		3
Transportation (ton.km) + Farmyard manure (kg) + Machinary (h)	1015		1
Total energy input (MJ)	101505		100
B. Outputs			
Yield (main) (kg)	19447		
Yield (secondary) (kg)	4335		
Yield (main & secondary) (kg)	23782		
Output Energy (main) (MJ)	36949		
Total energy output (main & secondary) (MJ)	45185		
C. Items			
Energy use efficiency (main)		0.36	
Energy productivity (main) (kg/MJ)		0.19	
Net energy (main) (MJ/ha)		-64556	
Energy use efficiency (main & secondary)		0.44	
Energy productivity (main & secondary) (kg/MJ)		0.23	
Net energy (main & secondary) (MJ/ha)		-56320	
Total energy input (MJ/ha)			100

Output–input ratio is one of the essential indicators that provide an understanding of the efficiency of orchard holdings. The energy use efficiency, energy productivity and net energy of apple production in the Oromieh Township are tabulated in Table 4. Energy use efficiency (energy ratio) was calculated as 0.36 and varied from 0.23 to 0.52 in the sampled orchard holdings, showing the inefficient use of energy in the orchard apple production. It is noteworthy that the ratio can be increased by increasing the crop yield (energy equivalent of apple is low relatively) and/or by decreasing energy inputs consumption (input management). Similar results have been reported for different orchard plants such as 0.96 for cherry (Kizilaslan, 2009) and 0.97 for apple (Hasanzadeh and Rahbar, 2005) (postharvest operation were not included), some higher energy ratios have been reported such as 1.00 for apple (Strapatsa et al. 2006) and 3.37 for apricot (Gezer et al. 2003) in the literature.

The results indicate that energy productivity and net energy were 0.19 kg/MJ and -64 556 MJ/ha, respectively. This means that 0.19 units output was obtained per unit energy. Calculation of energy productivity is well documented in the literature for different crops such as soybean (0.18) (De et al. 2001), potato (0.35) (Mohammadi et al. 2008) and cherry (0.51) (Kizilaslan, 2009). The calculated net energy is negative (less than zero) implying that in apple production, energy has been lost. Results showed that economic productivity is better than energy productivity, which means that only economic issue is more important for farmers in the region. At first glance, this seems natural, since farmers think only of their immediate income and future effects of this negative energy gain is not obvious. This is something that governments should take into consideration by taking some steps such as managing or removing subsidies for agricultural inputs (fuel, fertilizers, biocides…), training farmers, introducing newer technologies and etc. to make the task beneficial both from economical and energetical points of views.

The results revealed that the share of human energy and human expenses were 3% of total energy and 34% of total expenses, respectively (human energy is valuable energy). Strapatsa et al. (2006), estimated human energy as 2.7% of total inputs energy. Postharvesting (41%), fertilization (35%), plotting (13%), irrigating (9%) and spraying (2%) operations also accounted for most of energy inputs in surveyed apple orchards. Strapatsa et al. (2006) reported that pest controlling (40%), harvesting and transportation (21.6%) and fertilization (16.8%) operations have the most share of energy inputs.

Results revealed that orchard operations is carried out mostly by human energy and its share is insignificant (almost zero) in energy consumption compared to other energy inputs. Human energy is highly consumed in pruning and harvesting operations (pruning operation requires technical labour).

Mechanization analysis of apple production

Most agricultural operations are conducted using labour energy. In other words, the surveyed orchards are categorized as conventional. Therefore, the share of machine energy and its corresponding expenses were calculated to be insignificant at 1% probability level. The average mechanization index was calculated as 0.052 and 0.48 for expenses and energies, respectively.

According to results, orchardist does not utilize machines in order to prevent soil compaction and preserve soil structure. Even if fertilizing, plotting and other operations had been conducted by machines, mechanization index could not vary significantly due to the fact that the share of labour cost and energy of harvesting operation summed up to more than all other operations, Fadavi et al. (2010) and Fadavi et al. (2011), reported that by increasing mechanization index only, energy consumption will not decrease necessarily, and suggested that management of inputs consumption is more important.

Tractors are utilized in fertilizing, plotting and spraying operations. Agricultural experts of the region believe that the correct method of fertilizing to make nutrients available to the root, is fertilizer-pitting (burying fertilizer in depth of 30-40 cm of soil). In some of the orchards, fertilizing operation was implemented either by rotary tiller or manual on the surface of soil. In this case, fertilizer is not accessible to the root because of deep root of apple trees along with soil compaction due to the function and heavy weight of the rotary tiller. In the surveyed region, pitting operation was not mechanized; on the contrary, this was operated with labours leading to more expenses and time wasting.

Mechanization was considered in three levels that is level 1 for spraying only, level 2 for spraying and plotting and level 3 for spraying and fertilizing operations. Irrigating was carried out as semi- mechanized with deep wells or by river or dam in levels 2 and 3 while it was conventional in level 1.

Fig 2 shows that increasing mechanization index causes to increase in machine expense while this fact could not lead to decrease in labour expense.

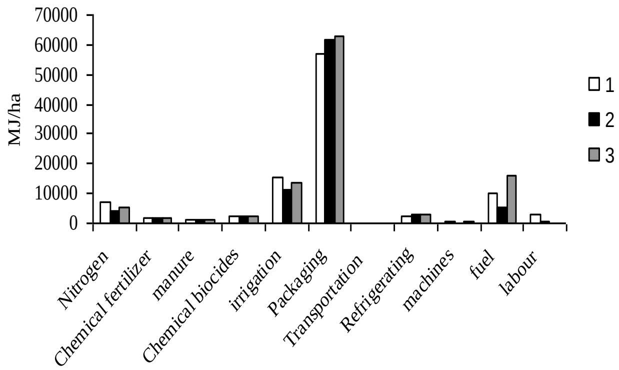

Fig 2: The percentage of the input energies in the mechanization levels

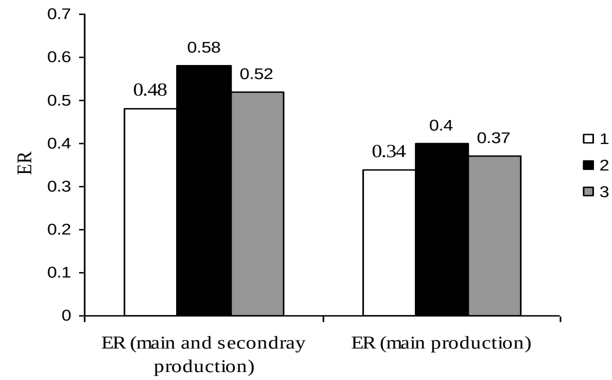

Fig 3: the energy ratio in levels of mechanization

The cost of irrigation is increased in level 1 due to applying conventional method. Costs of packaging, transportation and refrigerating are increased by going from mechanization level 1 to 3. This means that production is increased by increasing mechanization level (the method of packaging, transportation and refrigerating operation was similar in all apple orchards). Categorization of mechanization levels (based on mechanization index) is shown in table 5 and 6.

Table 5: Classification of mechanization levels based on mechanization index of cost

Levels of mechanization	Frequency	quantity	specification
Level 1	15	0.01-0.032	Spraying
Level 2	33	0.032-0.05	Spraying-plotting
Level 3	32	0.05-0.14	Spraying-fertilizing

Table 6: Classification of mechanization levels based on mechanization index of input energy

Levels of mechanization	Frequency	quantity	specification
Level 1	12	0.02-0.25	Spraying
Level 2	26	0.25 -0.49	Spraying-plotting
Level 3	42	0.49 -0.8	Spraying-fertilizing

Fig. 3 shows that the energy of nitrogen fertilizer level 2 is less than that of other levels due to better inputs management.

The result of Duncan test (using SPSS 16 software) is shown in table 7. It is clear that the mechanization index had significant effect on the energy ratio at 5% probability level.

Table 7: comparing the mean of energy ratio in the levels of mechanization index by using Duncan test (5%)

mechanization index	Frequency	Subcollection	
		1	2
Level 1	12	0.48	
Level 3	42	0.52	
Level 2	26		0.58

According to table 5, energy ratio is calculated less than 1 at all levels of mechanization, this means that energy is lost, but energy efficiency in level 2 is more than that of other levels. One reason for increasing energy ratio is reduction of irrigation energy and its corresponding electricity or fuel consumption. Also, in level 2, Goldoni tractor was utilized while in other levels MF285 tractor was used, where fuel consumption of Goldoni tractor is less than that of MF285. The energy ratio in mechanization levels are shown in Table 8 and Fig. 4.

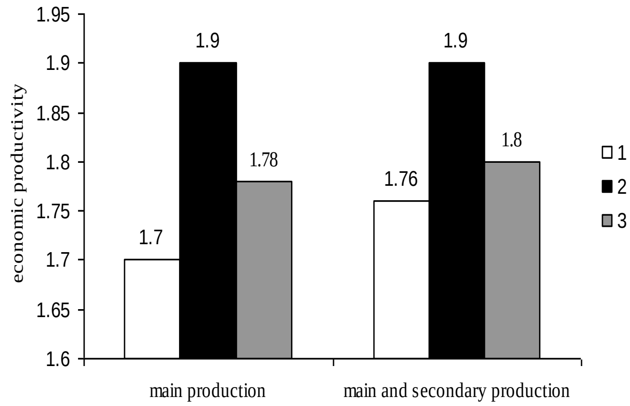

Fig 4: the economic productivity in levels of mechanization

Table 8: estimation of energy productivity and energy ratio in levels of mechanizati

Variable	Level 1	Level 2	Level 3
Input energy (main & secondary) (MJ/ha)	100681	93173	106898
Output energy (main & secondary) (MJ/ha)	47069	52688	53390
Energy use efficiency (main & secondary)	0.48	0.58	0.52
Energy productivity (main & secondary) (kg/MJ)	0.3	0.35	0.32
Net energy (main & secondary) (MJ/ha)	-53612	-40486	-53508
Input energy (main) (MJ/ha)	100633	93112	106842
Output energy (main) (MJ/ha)	33936	36993	37782
Energy use efficiency (main)	0.34	0.4	0.37
Energy productivity (main) (kg/MJ)	0.18	0.21	0.19
Net energy (main) (MJ/ha)	-66697	-56119	-69060

The result of Duncan test (using SPSS16 software) is shown in table 9, results showed that mechanization index had significant effect on the economic productivity at 5% probability level.

Table 9: comparing the mean of economic productivity in the levels of mechanization index by using Duncan test (5%)

mechanization index	Frequency	Subcollection	
		1	2
Level 1	15	1.76	
Level 3	32	1.79	
Level 2	33		1.9

According to table 9, economic productivity is calculated more than 1 at all levels of mechanization, but economic productivity in level 2 is more than other levels. The most of operation were conducted manually in level 1 as a result labour expense was increased; results show that management of inputs consumption in level 2 is better than other levels but unfortunately orchardists regard to neither energy nor environment only economic matters is important. Table 10 and fig 5 the economic productivity in mechanization levels is shown.

Fig. 5. (here)

Table 10: estimation of expense, production and economic productivity in levels of mechanization

variable	Level 1	Level 2	Level 3
Expense in a ha (main & secondary) ($)	7612.2	7555	8020.2
Income in a ha (main & secondary) ($)	13390.3	14304.7	14559.2
Economic productivity (main & secondary)	1.76	1.9	1.8
The expense for one kg apple (main & secondary) ($)	0.43	0.39	0.41
Expense in a ha (main) ($)	7425	7362.8	7840.8
Income in a ha (main) ($)	12748.5	13680.2	13954
Economic productivity (main)	1.7	1.9	1.78
The expense for one kg apple (main)	0.4	0.38	0.39

Conclusions

Data used in this study were collected from 80 farmers located in the Oromieh Township of West Azerbaijan province in Iran. Orchard production consumed a total of

101 505.5 MJ/ha energy and energy output was calculated as 45 185.135 MJ/ha. The results revealed that wooden packaging (57%), irrigation (16%), fuel (10%) and chemical fertilizer (9%) were the major contributors of total energy use in apple orchards. Energy productivity, net energy gain and output–input energy were calculated 0.23 kg/MJ, -56320MJ/ha and o.44 respectively. In this study, energy management is important, Therefore, policies should emphasize on development of new technologies (application of new technologies such as packaging and irrigation are encouraged) and provide with alternative energy resources aiming efficient use of energy (use of Goldoni tractors instead of other common tractors can be saved in fuel consumption and also prevent of soil compaction). The results derived from this study can be used by policy makers and other relevant agencies for recommendations to farmers in order to use energy more efficiently.

The benefit–cost ratio was found to be 1.77. The mean net return from apple production was obtained as 6049.8 $/ ha. human labour (34%) and Packaging (30%) expenses are followed by the refrigerating (19%). Due to low mechanization level in apple orchards, human expense accounted for 34% and machine 1% of total costs. Postharvesting (41%), irrigating (9%), fertilization (35%), plotting (13%), and sperying (2%) operations also accounted for most energy consumptions. Also, postharvesting (53.62%), irrigating (12.3%), harvesting (12%), fertilization (6.2%), plotting (1.2%), pruning (6%), fixed cost (6%) and spraying (4.1%) operations accounted for most of expenses in surveyed apple orchards. The mean of mechanization index was calculated 0.052 and 0.48 for expenses and energies respectively in apple orchards due to being conventional orchards, Mechanization was considered in three levels including level 1 for spraying only, level 2 for spraying and plotting and level 3 for spraying and fertilizing operations. Energy ratio was found to be less than one for all mechanization levels having the highest value in level 2 (0.58). The highest economic productivity was calculated as 1.9 for level 2. Results showed that by increasing Mechanization Index, energy ratio and economic productivity will not increase necessarily.

At all levels of mechanization, energy ratio was calculated less than 1 and if this trend continues to be a serious threat to environmental sustainability. Mechanization index had significant effect on the energy ratio and economic productivity at 5% probability level due to difference of management and method of inputs utilizing.

Energy management is an important issue in terms of efficient, sustainable and economical use of energy. These results indicate that energy use in apple production is not efficient, leading to many environmental problems and detrimental to the natural resources by excess use of inputs. all these inputs would be useful not only for reducing negative effects to environment, human health, maintaining sustainability and decreasing production costs, but also for providing higher energy use efficiency.

list of selected symbols

n – required sample size
N – number of holdings in target population
d – precision where (x - X)
t – reliability coefficient (1.96 in the case of 95% reliability)
S2 – variance of surveyed factor of population
ER – energy ratio
EP – energy Productivity (kg/MJ)
I_m – mechanization index
E_{EM} – energy of use of machinery
C_{EM} – cost of use of machinery
E_{EA} – energy of use of animal labour
C_{EA} – cost of use of animal labour
E_{EH} – energy of use of human labour
C_{EH} – cost of use of human labour
ε_p – pump efficiency
ε_q – total energy and power conversion efficiency
γ– density of water (kg/m3)

H – total dynamic head (m)
g – gravitational acceleration (m/s2)
Q – volume of required water for one cultivating season (m3/ha)

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