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Estimate energy, energy balance and economic indices of watered farming watermelon production in North of Iran

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Abstract

Efficient use of energy in agriculture is one of the conditions for sustainable production. The aim of this study was to determine the amount of input-output energy used in watermelon production and to make an economic analysis of watermelon production under watered farming in Guilan province, Iran. In this article, evaluation of energy balance and energy indices under watered farming watermelon in north of Iran (Guilan province) were investigated. Data were collected from 72 farms by used a face to face questionnaire method during 2010 year in Guilan province. By using of consumed data as inputs and total production as output, and their concern equivalent energy, energy balance and energy indices were calculated. Energy efficiency (energy output to input energy ratio) for yield in this study was calculated 1.75; showing the affective use of energy in the agro ecosystems watermelon production. Energy balance efficiency (production energy to consumption energy ratio) for yield in this study was calculated 0.55; showing the affective use of energy in the agro ecosystems watermelon production. Results of economic analysis showed the benefit to cost ratio in the studied farms was calculated to be 1.88. Therefore watermelon production was a cost effective business based on the data of the 2010 season of watermelon production under watered farming in north of Iran.

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Introduction

Energy in agriculture is important in terms of crop production and agro processing for value adding. Human, animal and machinery is extensively used for crop production in agriculture. Energy use depends on mechanization level, the quantity of active agricultural worker and cultivable land. Efficient use and study impacts of these energies on crop production help to achieve increased production and productivity and help the economy, profitability and competitiveness of agricultural sustainability of rural communities. Watermelon (Citrullus lanatus (Thunb.), family Cucurbitaceae) is a vine-like (scrambler and trailer) flowering plant originally from southern Africa. Its fruit, which is also called watermelon, is a special kind referred to by botanists as a pepo, a berry which has a thick rind (exocarp) and fleshy center (mesocarp and endocarp). Pepos are derived from an inferior ovary, and are characteristic of the Cucurbitaceae. The watermelon fruit, loosely considered a type of melon – although not in the genus Cucumis – has a smooth exterior rind (green, yellow and sometimes white) and a juicy, sweet interior flesh (usually deep red to pink, but sometimes orange, yellow and even green if not ripe). The crop is grown commercially in areas with long frost free warm periods (Prohens *et al.,* 2008). China, Turkey, Iran, Brazil, United States, Egypt and Russian Federation are the major watermelon producers (Fao, 2010). Watermelon is utilized for the production of juices, nectars and fruit cocktails, etc (Wani *et al.,* 2008). Management of plant pests is essential during the production period. The fruit are harvested by hand, with the most experienced workers doing the cutting (removal of the fruit from the vine) and the others loading the bins or trucks. The watermelon fruit is 93% water, with small amounts of protein, fat, minerals, and vitamins. The major nutritional components of the fruit are carbohydrates, vitamin A, and lycopene, an anticarcinogenic compound found in red flesh watermelon. Lycopene may help reduce the risk of certain cancers, such as prostate, pancreas, and stomach. As with many other fruits, it is a source of vitamin C. Watermelon is also contains large amounts of beta carotene (Prohens *et al.,* 2008; Wani *et al.,* 2008). Iran is the 3th largest producer of watermelon in the world after China and Turkey, respectively. In 2010, Iran produced about 3466883 tones of watermelon in 135962 hectares; Guilan province is a one of most important watermelon producers in Iran (Moazzen, 2010). Watermelon quality during consumption mainly depends on the ripeness of the fruit. Typically optimum quality watermelon fruits for eating feature an appropriate balance among sugar, flavour, colour and texture. Watermelons are usually harvested from the farm only one or two times according to their weight at harvest. Decreasing labor costs and increasing harvesting speed are the two main reasons that explain this harvesting strategy. This may result in watermelons with varying degrees of ripeness reaching the market. Many consumers dispose of the watermelons that are immature, of poor-quality, or spoiled. However, if it were possible to identify those lower quality watermelons and remove them from the distribution system, this would result into increased consumer satisfaction. The determination of watermelon ripeness on the basis of its apparent properties such as size or skin colour is very difficult.

The amount of energy used in agricultural production, processing and distribution is significantly high. Sufficient supply of the right amount of energy and its effective and efficient use are necessary for an improved agricultural production. It has been realized that crop yields and food supplies are directly linked to energy (Stout, 1990). In the developed countries, increase in the crop yields was mainly due to increase in the commercial (but often subsidized) energy inputs in addition to improved crop varieties (Faidley, 1992). Calculating energy inputs of agricultural production is more difficult than the industry sector due to the high number of factors affecting the production (Yaldiz *et al.,* 1993). The main objective in agricultural production is to increase yield and decrease costs. In this respect, the energy budget is important. Energy budget is the numerical comparison of the relationship between input and output of a system in terms of energy units (Gezer *et al.,* 2003). In general, increases in the agricultural production on a sustainable basis and at a competitive cost are vital to improve the farmer's economic condition (De *et al.,* 2001). Although many experimental works have been conducted on energy use in agriculture (Singh *et al.,* 1988; Singh *et al., 2004*), there are few studies on the energy and economical analysis of greenhouse crops production. The main aim of this study was to determine energy use in watermelon production, to investigate the efficiency of energy consumption and to make an energy balance indices, energy indices analysis and economic analysis of watermelon under watered farming in Guilan province of Iran.

Materials and methods

Materials

In order to gather the required data in this study, information related to 72 farms in Guilan province during the agricultural year 2010 was studied. The location of studied region in north of Iran was presented in figure 1. The random sampling of production agro ecosystems was done within whole population and the size of each sample was determined by using bottom Equation (Kizilaslan, 2009).

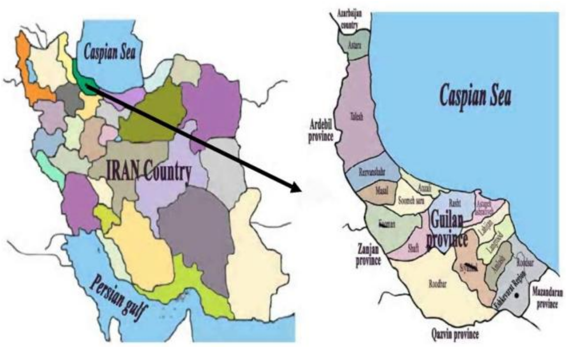

Fig. 1. Location of the study area.

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

In the formula, n is the required sample size, s is the standard deviation, t is the t value at 95% confidence limit (1.96), N is the number of holding in target population and d is the acceptable error.

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Method to calculate the energy

In order to calculate input-output ratios and other energy indicators, the data were converted into output and input energy levels using equivalent energy values for each commodity and input. Energy equivalents shown in table 1 were used for estimation (Azarpour, 2012; Azarpour *et al.,* 2012; Namdari, 2001; Namdari *et al.,* 2001). Firstly, the amounts of inputs used in the production of watermelon were specified in order to calculate the energy equivalences in the study. Energy input include water, human labor, machinery, diesel fuel, chemical fertilizers, poison fertilizers, farmyard manure and seed and output yield include fruit yield of watermelon. The energy use efficiency, energy specific, energy productivity and net energy gain were calculated according to bottom equations (Azarpour, 2012; Azarpour *et al.,* 2012; Namdari, 2001; Namdari *et al.,* 2001).

$$\text{Energy ratio} = \frac{\text{Output energy (Mj/ha)}}{\text{Input energy (Mj/ha)}}$$

$$\text{Energy productivity} = \frac{\text{Fruit yield (Kg/ha)}}{\text{Input energy (Mj/ha)}}$$

$$\text{Energy intensity} = \frac{\text{Input energy (Mj/ha)}}{\text{Fruit yield (Kg/ha)}}$$

$$\text{Water and energy productivity} = \frac{\text{Fruit output (Kg/ha)}}{\text{Water applied (M}^3\text{/ha)} \times \text{Input energy (Mj/ha)}}$$

$$\text{Net energy gain} = \text{Output energy (Mj/ha)} - \text{input energy (Mj/ha)}$$

The input energy was divided into direct, indirect, renewable and non-renewable energies (Yilmaz *et al.,* 2005). Direct energy covered water, human labor and diesel fuel, used in the watermelon production while indirect energy consists of seed, chemical fertilizers, farmyard manure, poison fertilizers, and machinery energy. Renewable energy consists of water, human labor, farmyard manure and seed; and nonrenewable energy includes chemical fertilizers, poison fertilizers and machinery energy.

In order to indicators of energy balance, Basic information on energy inputs were entered into Excel spreadsheets and then energy equivalent were calculated according table 2 (Azarpour, 2012; Azarpour *et al.,* 2012). By using of consumed data as inputs and total production as output, and their concern equivalent energy, indicators of energy balance were calculated. Energy input include human labor, machinery, diesel fuel, chemical fertilizers, poison fertilizers, machinery depreciation for per diesel fuel, farmyard manure and seed and output yield include yield of watermelon.

Method to calculate the economic analysis

In the last part of the study, the economic analysis of watermelon production was investigated. Net profit, gross profit, productivity and benefit to cost ratio was calculated. The gross value of production, net return and benefit to cost ratio were calculated using the following equations (Mohammai *et al.,* 2008; Zhang *et al.,* 2009).

$$\text{Gross value of production } (\$\ ha^{-1}) = \text{Yield } (kg\ ha^{-1}) \times \text{Sale price } (\$\ kg^{-1})$$

$$\text{Net return } (\$\ ha^{-1}) = \text{Gross value of production } (\$\ ha^{-1}) - \text{Total cost of production } (\$\ ha^{-1})$$

$$\text{Productivity}(kg/\$) = \frac{\text{Yield}(kg/ha)}{\text{Total cost of production } (\$/ha)}$$

$$\text{Benefit to cost ratio} = \frac{\text{Gross value of production } (\$\ ha^{-1})}{\text{Total cost of production } (\$\ ha^{-1})}$$

Results and discussion

Analysis of input–output energy use in watermelon production

The inputs used in watermelon production and their energy equivalents and output energy equivalent are illustrated in table 1. About 0.97 kg seed, 5 L chemical poison, 770 h human labor, 20 h machinery power and 184 L diesel fuel for total operations were used in agro ecosystems watermelon production on a hectare basis. The use of nitrogen fertilizer, phosphorus fertilizer and potassium fertilizer and farmyard manure were 195, 44, 6 and 5074 kg per one hectare respectively. The total energy equivalent of inputs was calculated as 30467 MJ/ha. The highest shares of this amount were reported for chemical fertilizer (42.67%) and diesel fuel (34.01%). The energy inputs of water (5.92%), farmyard manure (5%), human labor (4.96%), machinery (4.12%), chemical poison (1.97 %) and seed (0.01%) were found to be quite low compared to the other inputs used in watermelon production (fig. 2). The average yield of watermelon was found to be 28000 kg/ha and its energy equivalent was calculated to be 53200 MJ/ha (table 1).

Evaluation indicators of energy in watermelon production

The energy use efficiency, energy productivity, energy specific, energy productivity, net energy gain, and intensiveness of watermelon production were shown in table 3. Energy efficiency (energy output-input ratio) in this study was calculated 1.75; showing the affective use of energy in the agro ecosystems watermelon production. Energy specific was 1.09 MJ/kg this means that 1.09 MJ is needed to obtain 1 kg of watermelon. Energy productivity calculated as 0.92 Kg/MJ in the study area, this means that 0.92 kg of output obtained per unit energy. Net energy gain was 22733 MJ/ha.

This means that the amount of output energy is more than input energy and production in this situation is logical. Direct, indirect, renewable and non-renewable energy forms used in watermelon production are also investigated in table 3. The results show that the share of direct input energy was 44.88% (13604 MJ/ha) in the total energy input compared to 55.12% (16863 MJ/ha) for the indirect energy. On the other hand, nonrenewable and renewable energy contributed to 84.12% (25700 MJ/ha) and 15.88% (4767 MJ/ha) of the total energy input, respectively.

Namdari *et al.* (2001) analyzed the energy indices of watermelon production in Hamedan, Iran, and found that total energy input and output in these production systems were 67764.16 and 81483.21 MJ/ha, respectively. The highest share of input energy was recorded for Chemical fertilizer (44.83%)

which is a nonrenewable resource. Energy use efficiency and energy productivity of watermelon production agro ecosystems were 1.20 and 0.63 kg/MJ respectively. Canakci *et al.* (2005) concluded that total energy input, energy use efficiency and specific energy for two group watermelon production were 14192.9 MJ/ha, 2.0, and 0.97 MJ/kg, respectively. Namdari (2001) concluded that for watermelon production were direct energy (49.59% and 49.12%), indirect energy (50.41% and 50.88%), renewable energy (21.03% and 19.94%) and nonrenewable energy (78.97% and 80.60%).

Table 1. Amounts of inputs and output and their equivalent energy from calculated indicators of energy under watered farming in north of Iran.

Parameter	Unit	Quantity per hectare	Energy equivalents	Total energy equivalents	Percent
Inputs					
Water	M^3/ha	1700	1.02	1734	5.92
Human labor	h/ha	770	1.96	1509.20	4.95
Machinery	h/ha	20	62.7	1254	4.12
Diesel fuel	L/ha	184	56.31	10361.04	34.01
Nitrogen	Kg/ha	195	66.14	12869.52	42.24
Phosphorus	Kg/ha	44	12.44	548.60	1.80
Potassium	Kg/ha	6	11.15	66.90	0.22
Poison	L/ha	5	120	600	1.97
Farmyard manure	Kg/ha	5074	0.3	1522.20	5.00
Seed	Kg/ha	0.97	1.9	1.84	0.01
Output					
yield	Kg/ha	28000	1.9	53200	100

Analysis of energy balance in watermelon production

The inputs used in watermelon production and their energy equivalents and output energy equivalent are illustrated in table 2. About 0.97 kg seed, 5 L chemical poison, 770 h human labor, 20 h machinery power and 184 L diesel fuel for total operations were used in agro ecosystems watermelon production on a hectare basis. The use of nitrogen fertilizer, phosphorus fertilizer and potassium fertilizer and farmyard manure were 195, 44, 6 and 5074 kg per one hectare respectively. Also 154.56 L depreciation power in this system was used.

Table 2. Amounts of inputs and their equivalent energy from calculated indicators of energy balance under watered farming in north of Iran.

Parameter	Unit	Quantity per hectare	Energy equivalents	Total energy equivalents	Percent
Inputs					
Water	M^3/ha	1700	272.7	463590	4.23
Human labor	h/ha	770	500	385000	3.48
Machinery	h/ha	20	90000	1800000	16.25
Diesel fuel	L/ha	184	9237	1699608	15.34
Nitrogen	kg/ha	195	17600	3424608	30.91
Phosphorus	kg/ha	44	3190	140679	1.27
Potassium	kg/ha	6	1600	9600	0.09
Poison	L/ha	5	27170	135850	1.23
Farmyard manure	kg/ha	5074	303.1	1537929.40	13.88
Seed	kg/ha	0.97	300	291.00	0.003
Depreciation for per diesel fuel	L	154.56	9583	1481148.48	13.37

The total energy equivalent of inputs was calculated as 11078304 MJ/ha. The highest shares of this amount were reported for chemical fertilizer (32.2 7%), machinery (16.25%), diesel fuel (15.34%), farmyard manure (13.88%) and depreciation for per diesel fuel (13.37%).

Table 3. Analysis of energy indices in watermelon production under watered farming in north of Iran.

Item	Unit	Watermelon
Yield	Kg/ha	28000
Input energy	Mj/ha	30467
Output energy	Mj/ha	53200
Energy use efficiency	-	1.75
Energy specific	Mj/Kg	1.09
Energy productivity	Kg/Mj	0.92
Net energy gain	Mj/ha	22733
Direct energy	Mj/ha	13604 (44.88%)
Indirect energy	Mj/ha	16863 (55.12%)
Renewable energy	Kg/Mj	4767 (15.88%)
Nonrenewable energy	Mj/ha	25700 (84.12%)

Table 4. Analysis of energy balance indices in watermelon production under watered farming in north of Iran.

Item	Percent of compositions	Energy per gram (kcal)	Amounts (kg/ha)	production energy (kcal/ha)	Production energy/ Consumption energy	Consumption energy/ Production energy
Proten	0.4	4	112	448000	0.04	24.73
Fat	0.2	9	56	504000	0.05	21.98
Starch	4.6	4	1288	5152000	0.47	2.15
Item	yield (kg/ha)	consumption energy (kcal/ha)	production energy (kcal/ha)	Energy per unit (kcal)	production energy/ consumption energy	Consumption energy/ production energy
	28000	11078304	6104000	218	0.55	48.86

The energy inputs of water (4.23%), human labor (3.48%), chemical poison (1.23%) and seed (0.003%) were found to be quite low compared to the other inputs used in watermelon production (fig. 3).

The highest percent of compositions (4.6%), Amounts (1288 kg/ha), production energy (5152000 kcal/ha) and production energy to consumption energy ratio (0.47) in watermelon were obtained from starch as compared with fat and protein, The lowest consumption energy to production energy ratio (2.15) in watermelon was obtained from starch as compared with fat and protein (table 4).

Table 5. Economic analysis of watermelon under watered farming in north of Iran.

Cost and return components	
Yield (kg/ha)	28000
Sale price ($/kg)	0.18
Gross value of production ($/ha)	5040
Total cost of production ($/ha)	2675
Net return ($/ha)	2365
Benefit to cost ratio	1.88
Productivity (kg/ha)	10.47

Evaluation indicators of energy balance in watermelon production

The consumption energy (11078304 kcal/ha), production energy (6104000 kcal/ha), energy per unit (218 kcal), production energy to consumption energy ratio (0.55) and consumption energy to production energy ratio (48.86) of watermelon production were shown in table 4. Energy balance efficiency (production energy to consumption energy ratio) in this study was calculated 0.55; showing the affective use of energy in the agro ecosystems watermelon production.

Economic analysis of watermelon production

The Economic analysis of watermelon production were calculated and shown in table 5. In the research area, the watermelon sale price (0.18 $/kg), gross value of production (5040 $/ha), total cost of production (2675 $/ha), productivity (10.47 kg/ha) and net return (2365 $/ha) were calculated. Results showed the benefit to cost ratio in the studied farms was calculated to be 1.88. Therefore watermelon production was a cost effective business based on the data of the 2010 season of watermelon production under watered farming in north of Iran. This means economic success increased by using high level of farming technology.

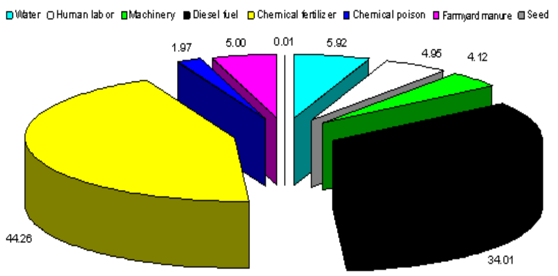

Fig. 2. The share (%) production inputs in watermelon (energy) under watered farming in north of Iran.

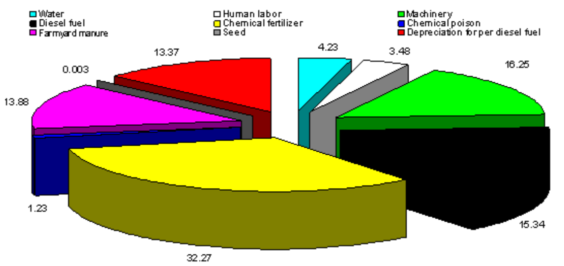

Fig. 3. The share (%) production inputs in watermelon (energy balance) under watered farming in north of Iran.

Namdari (2001) concluded that for watermelon production were gross value of production (6432.88 $/ha), total cost of production (2780.54 $/ha), net return (3652.34 $/ha), and benefit to cost ratio (2.33).

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