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Energy Flows Modeling and Economic Evaluation of Watermelon Production in Fars Province of Iran

Sajad Rostami [1], Maryam Lotfalian [2], Bahram Hosseinzadeh Samani [3*] and Mahdi Ghasemi-Varnamkhasti [3]

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Abstract

This study aimed to evaluate the efficiency of energy consumption and economic analysis of different watermelon cultivation systems in Fars Province of Iran. Watermelon production systems were classified into five systems, namely, custom tillage (group 1), conservation tillage (group 2), traditional planting (group3), semi mechanized planting (group 4), and mechanized planting (group 5). Data were collected from 317 watermelon producers from different parts of the province through face to face interviews. Multi-Layer Perceptron artificial neural networks were used to model the energy flows of watermelon production. The results showed that the greatest energy consumption belonged to mechanized planting system with the value of 81317.72 MJha^{-1} and with the productivity of 0.61 kgha^{-1} and energy use efficiency of 1.17. Clustering function with three inputs (human resources, machines and diesel fuel) showed that the difference between groups 2 and 4 is more than the other groups. The least energy consumption belonged to the conservative agriculture as78163.86 MJha^{-1} and the energy productivity and energy use efficiency about 0.64 kgha^{-1} and 1.22, respectively. The results of energy modeling showed that an ANN model with 9-10-1 structure was determined to be optimal for energy flow modeling of this system. Generally, it was concluded that the artificial neural network models can be applicable to prognosticate the energy flows of watermelon production. From an economic point of view, the least net profit belonged to traditional planting with the value of 2618.14$, and the most net return belonged to mechanized planting with the value of 2752.88$/ha.

Keywords:
Artificial neural networks, Conservation, Energy use efficiency, Mechanized

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[1] *Associate professor, Department of Mechanical Engineering of Biosystems, Shahrekord University, Iran*
[2] *M.Sc. Student, Department of Mechanical Engineering of Biosystems, Shahrekord University, Iran*
[3] *Assistant Professor, Department of Mechanical Engineering of Biosystems, Shahrekord University, Iran*
** Corresponding author's email: b.hosseinzadehsamani@gmail.com*

INTRODUCTION

Energy is one of the main inputs of agricultural sector, and agricultural production is directly related to energy inputs worldwide (Singh, 1999). This made many researchers focus on energy management in agricultural ecosystems. Agriculture is an energy conversion process in which solar radiation and energies produced from fossil fuels, electricity, and human resources change into food and other required products. In other words, agriculture is both energy consumer and energy producer (Alam et al., 2005).

The amount of energy used in the production of agricultural products depends on arable land mechanization level and the number of agricultural workers (Topak et al., 2010). Energy consumption has increased in line with population growth. Limitation of agricultural land, the desire to raise the level of life standards in all societies by trying to improve performance or reducing the powerful activities or both led to increased energy consumption (Safa & Tabatabaeefar, 2002). In all societies, these factors result in increased energy consumption to maximize performance, and reducing worker costs (Esengun et al., 2007).

Agriculture was largely dependent on manpower and livestock in the past, while, nowadays, agricultural production relies on non-biodegradable fossil energy consumption. Excessive consumption of fossil fuels leads to harmful environmental consequences due to an increase in the production of CO_2 gas and other greenhouse gases in the air (Gundogmus, 2006). Machines, fossil fuels, and electricity login, which were accompanied by progress in science and technology, made a revolution in food production around the world (Mohammadi et al., 2008). However, due to the growing world population and increasing human needs for food, researchers cannot simply ignore the agricultural achievements. Nonetheless, the indiscriminate use of chemicals in agriculture certainly reduces the sustainability of farming systems and also increases the environmental hazards. In the last decade, agricultural land was one of the important resources of CO_2 and NO_2 emissions due to intensive use of chemical fertilizers, pesticides, and agricultural machines (BeheshtiTabar et al., 2010). The amount of diesel consumed in 3600 hectares of wheat and corn farms in Dire County, for instance, in Kermanshah Province of Iran, was estimated 403,852.6 liter per year, equivalent to 15,346,399 MJ. That is, burning this amount of diesel produces about 1,058,094 kg CO_2 per year (Afsharzade et al., 2016).

Production of systems with low energy input is not still accepted by farmers, but there is more tendency to more economical benefits than energy productivity and efficiency (Nautiyal et al., 2007; Omid et al., 2011). Analysis of input-output energy is usually used to evaluate the efficiency of energy consumption and the environmental impact of agricultural production. Energy analysis is used to identify more efficient productive systems and compliant with environment (Rathke & Diepenborck, 2006). Therefore, a main goal to improve the environmental performance of agricultural productions is minimizing the energy consumption (Deike et al., 2008). More than 0.9% of a Gross Domestic Product (GDP) belongs to the agricultural sector (Moazzen, 2012).

Watermelon (Citrulluslanatus) is a member of the cucurbit family (Cucurbitaceae). The crop is grown commercially in areas with long frost free warm periods (Prohens & Nuez, 2008). Watermelons cultivation plays a key role in farmer's incomes in many countries including Iran, Afghanistan, Pakistan, India, Uzbekistan, Turkey, and Iraq (Moazzen, 2012). Iran is the third largest watermelon producer in the world after China and Turkey (FAO, 2010). In 2009, 3.07 million tons of watermelons have been produced in 13,0178 hectares in Iran (Namdari, 2011). In 2012-2013 crop year, harvested watermelon was estimated about 139,000 hectares, that is, 1.1% of the total harvest of crops and 39.5% of the total melons. The highest cultivation of watermelon belongs to Kerman, Khorasan and Khuzestan provinces, respectively. Fars Province with 15,139 hectares of watermelon cultivation is in the fourth largest watermelon cultivation area in Iran (Moazzen, 2012). The watermelon fruits are harvested by hand and human resources, 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 contains about 93% water and small amounts of the protein, fat, minerals, and vitamins (Prohens & Nuez, 2008).

In a study of watermelon production in the Kiashahr region of northern Iran, the total energy input for rain-fed watermelon production was reported to be 16594.74 MJ ha^{-1} and total energy output was 36275.24 MJ ha^{-1}. The results showed that the energy-use ratio was 2.19, energy productivity was 1.15 kg MJ^{-1}, energy intensity was 0.87 MJ kg^{-1}, and net energy gain was 19680.60 MJ ha^{-1}. Direct and indirect energies were calculated as 14.3% and 85.7%, respectively (Mohammadi-Barsari et al., 2016).

Another study was done 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, north of Iran. Input energy, energy efficiency and energy productivity for this study were calculated 30467 MJ ha^{-1}, 1.75 and 0.92 kg MJ^{-1}, respectively. Results of economic analysis showed the benefit to cost ratio in the studied farms was calculated to be 1.88 (Moraditochaee et al., 2013).

A research study was done on energy use patterns and energy input-output analysis of vegetables, such as tomato, melon, and watermelon, widely grown in the Antalya region, which is one of the most important agricultural centers in Turkey. The average yield of the melon and watermelon vegetables was found to be 35,000 kg ha^{-1} with energy ratios of 1.9 and 2.0 and specific energies of 0.98 and 0.97 $MJkg^{-1}$, respectively, while planting was done with worker (Canakci et al., 2005).

Energy inputs for watermelon production in Hamedan Province in Iran were calculated 67764.16 MJ ha^{-1}, and energy use efficiency and specific energy of watermelon production were obtained 1.20 and 1580.10 MJ $tonnes^{-1}$, respectively (Namdari et al., 2011). The total energy input, net energy specific energy, and energy productivity in the production of watermelon farm in Urunlu village of center district Kirklareli province were reported as 11219.66 MJ ha^{-1}, 41980.34 MJ ha^{-1}, 0.40 MJ kg^{-1} and 2.49 kg MJ^{-1}, respectively. Results showed that fertilizers had the highest rate of energy, and it was followed by fuel-oil and human energy consumption in watermelon production (Mehmet Firat & Gokdogan, 2014).

Cost evaluation of watermelon production in Hamadan Province, Iran, revealed that benefit-cost ratio in Group I (owner of machinery and high level of farming technology) and Group II (non-owner of machinery and low level of farming technology) were 2.61 and 2.06, respectively (Namdari et al., 2011).

In most of the studies, only one way of planting has been analyzed while considering various ways of planting is also important to choose a special way. This research aimed to present such a comparison. The main aim of this research was to analyze the energy consumption and energy efficiency in various ways of planting watermelon including: conventional planting, conservation tillage, conventional tillage, semi-mechanized planting, and mechanized cultivation through artificial neural networks.

MATERIALS AND METHODS

The case study and sample selection

This study was conducted in Fars Province of Iran. Fars Province is located in the south and southwest of the country between 50º 36 to 55º 35 east longitude and 27º 03 to 31º 40 north latitudes. The farms were randomly selected among different cities of the province such as Abadeh, Farashband, Eghlid, Khonj, Lar and Lamerd, as noticeable areas under watermelon. Farmers were also selected in such a way that the different planting methods in this study could be available to analyze and compare from the energy consumption point of view. The number of sample sizes was chosen from the formula of the Cochran's method

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

where: n: the number of required sample, N: the number of the target population (1800), t: is the t value (1.96 for 95% confidence level), S^2: the variance of yield is the studied qualification in population (0.25), d: precision $(\bar{x}-\bar{X})$. Permissible error in the sample size was defined to be 5% for 95% confidence.

Watermelons cultivation systems

The common watermelon production systems in Fars Province of Iran were classified into five systems as follows:

Group 1: Conventional tillage practices, planting and manure spreading in the traditional way and with workers and human resources.

Group 2: Conservational tillage methods (using combined tillage) planting and manure spraying in the traditional way and with the help of workers.

Group 3: Conventional tillage practices, planting in the traditional way and with workers and mechanized spraying of manure fertilizer.

Group 4: Conventional tillage practices, spraying manure in traditional way and with workers, mechanized planting (covering the plastics and planting the seeds by machine).

Group 5: Conventional tillage, spraying manure in the traditional way and with workers, and semi-mechanized planting (covering the plastics by machine and planting the seeds by hand)

Inputs energy in producing watermelon includes human resources, machines, diesel fuel, chemical fertilizers, farmyard manure, chemical and pesticides, plastics and polyethylene, seeds, and irrigation water, and the output was watermelon.

Energy analysis

Energy used in agriculture sector can be classified into direct and indirect energy and also as renewable energy and non-renewable energies (Khojastehpour et al., 2015). Indirect energy for watermelon production comprised chemical fertilizers, farmyard manure, chemicals and pesticides, plastics and polyethylene, seeds and machines; direct energy also included human resources, fuel and irrigation water required for producing watermelon.

Non-renewable energy inputs for watermelon production included fuel, fertilizers, chemicals and pesticides, plastics and polyethylene, machines, while renewable energy included human resources, seeds, farmyard manure, and irrigation water (Yilmaz et al., 2005).

The amount of energy consumption in each group of inputs was calculated from the multiplication of the amount of the input consumption and its energy equivalent per unit (extracted from scientific sources). Table 1 shows the energy equivalents used for calculating input and output energies in producing watermelon.

Then, according to energy inputs and output, energy use efficiency, energy productivity, specific energy, and net energy were calculated based on the following equations (Demircan et al., 2006; Soltanali et al., 2006):

Table 1
Energy Equations of Inputs and Output in Agricultural Productions

Particulars	Unit	Energy equivalent (MJ. unit $^{-1}$)	Reference
A.Inputs			
1. Human resources	H	1.96	(Canakci et al., 2005)
2. Machines	H	62.7	(Canakci et al., 2005)
3. Diesel fuel	L	56.31	(Singh et al., 2008)
4. Biocide	Kg	120	(Singh., 2002)
5. Farmyard manure	Kg	0.3	(Canakci et al., 2005)
6. Chemical fertilizers			
Nitrogen (N)	Kg	66.14	(Sheresta., 2002)
Phosphate (P2O5)	Kg	12.44	(Sheresta., 2002)
Potassium (K2O)	Kg	11.15	(Sheresta., 2002)
Sulphur (S)	Kg	1.12	(Nagi., 1999)
Micronutrient fertilizers	Kg	120	(Singh., 2002)
7. Plastics and polyethylene	Kg	92.32	(Tiwari, 2003)
8. Water for irrigation	m3	1.02	(Yaldizet al., 1993)
9. Seed (watermelon)	Kg	1.9	(Canakci et al., 2005)
B. Outputs			
1. Watermelon	Kg	1.9	(Canakci et al., 2005)

Energy use efficiency=Energy output (MJ.ha^{-1}) /Energy inputs (MJ.ha^{-1}) (2)

Energy productivity=Watermelon production (Kg.ha^{-1})/Energy inputs (MJ.ha^{-1} (3)

Specific energy=Energy inputs (MJ.ha^{-1})/watermelon production (kg.ha^{-1}) (4)

Net energy = Energy output (MJ.ha^{-1}) – Energy inputs (MJ. ha^{-1}) (5)

The fuel for the operation of agricultural machineries per hectare was calculated via following equation (Siemence et al., 1999).

Fuel consumption (gallons per hour) = PTO (hp) * power transmission efficiency ×0.06 × 0.73 (6)

By multiplying equation (6) in 3.78, the amount of the fuel consumption is determined in liters per hour.

It is worth noting that, in Fars Province, tractors with the average power of 65-110 horsepower are mainly used, which are mainly Romanian, four cylinders Ferguson, six cylinders Ferguson and six cylinders John Deere with 65, 75, 110 horsepower, respectively. All required data was collected orally from the agriculture organization of Fars Province, Iran.

Average power of tractors was estimated to be 80 horsepower with the efficiency of 75%.

Development of artificial neural network model

Among various ANN models, Multilayer Perceptron has maximum practical importance (Rohani et al., 2011). MLP is a feed-forward layered network with an input layer, some hidden layers, and one output layer (Rohani et al., 2011). A computer code was developed in MATLAB (2014b) software to implement the ANN models.

Four criteria were used to evaluate the performance of the model. These evaluation criteria included coefficient of determination) R2(, the root mean squared error (RMSE), mean absolute percentage error (MAPE), and model efficiency (EF). These are defined as equations 1-4:

$$R^2 = \frac{\left(\sum_{i=1}^{n}(E_{ai} - \overline{E_{a\imath}}) \times (E_{pi} - \overline{E_{p\imath}})\right)^2}{\sum_{i=1}^{n}(E_{ai} - \overline{E_{a\imath}})^2 \times \sum_{i=1}^{n}(E_{pi} - \overline{E_{p\imath}})^2} \quad (7)$$

$$\mathrm{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}\left(E_{ai} - E_{pi}\right)^2}{n}} \quad (8)$$

$$\mathrm{MAPE} = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{E_{ai} - E_{pi}}{E_{ai}}\right| \times 100 \quad (9)$$

$$\mathrm{EF} = 1 - \frac{\sum_{i=1}^{n}\left(E_{ai} - E_{pi}\right)^2}{\sum_{i=1}^{n}\left(E_{ai} - \overline{E_{p\imath}}\right)^2} \quad (10)$$

where, Ea and Ep are the actual (desired) and the predicted (fitted) energy flow, respectively, and i (1,..., n) is the number of patterns. The model with the smallest RMSE and MAPE, but the largest EF and R^2 is considered to be optimal.

Clustering function

Principal component analysis

Principal Component Analysis (PCA) is founded on the fact that many types of vector-space data are compressible (Rokach & Oded 2005). PCA is a technique that can be used to simplify a dataset. It is a linear transformation that chooses a new coordinate system for the data set such that greatest variance by any projection of the data set comes to lie on the first axis (then called the first principal component) and the second greatest variance on the second axis, and so on. PCA can be used for reducing dimensionality by eliminating the later principal components (Rokach & Oded, 2005). The present research has used PCA for clustering of mentioned groups and determining distance between studied groups.

Clustering method

Agglomerative hierarchical is utilized where clusters have sub-clusters and it should be noted this method is bottom-up clustering. The outcomes of hierarchical clustering are commonly offered in a dendrogram. It should be noted that the present research has used Minitab 16 software for data analyzing and clustering.

Economic analysis

Finally, an economic analysis has been employed in various watermelons production systems. For this purpose, gross production value, net profit and profit-cost ratio were calculated through the following equations (Mohammadi et al., 2008):

Gross value of production ($\$.\ ha^{-1}$) = production (kg. ha^{-1}) × Sale price ($\$.\ kKg^{-1}$) (11)

Net profit ($. ha-1) = Gross value of production ($\$.\ ha^{-1}$) – Total costs of production ($\$.\ ha^{-1}$) (12)

Profit to cost ratio=Gross value of prodution ($\$.ha^{-1}$)/Total cost of production ($\$.ha^{-1}$) (13)

RESULTS AND DISCUSSION

Energy flows of watermelon production

The results showed that the total energy consumption during watermelon production in the traditional group (group 1) was 79601.66 MJha-1. The highest energy consumption was attributed to diesel fuel, nitrogen fertilizers, plastics and polyethylene materials with the shares of 49.73%, 22.72%, 15.87%, respectively, and the lowest energy consumption was attributed to watermelon seed, sulfur and potash fertilizer, with the values of 0%, 0.09% and 0.3%, respectively. Energy consumption during watermelon production in Guilan province was reported 40228.98 $MJha^{-1}$, and the highest energy consumption belonged to nitrogen fertilizers and diesel fuel with shares of 69.6% and 8.6%, respectively, and the lowest energy consumption belonged to watermelon seed (Nabavi-Pelesaraei et al., 2014).

Table 4 shows the energy indices of watermelon production in Fars province of Iran. In group 1, energy productivity for the farms under study was 0.63, indicating that each unit of energy consumption produces 0.63 units of energy. Specific energy and net energy in watermelon production for group 1 were determined to be 1.6 $MJkg^{-1}$ and 15018.34 MJha-1, respectively. Energy use efficiency was also calculated 1.19 MJ for group 1.

Table 5 shows the shares of energy in form of direct, indirect, renewable, and non-renewable. 54.94% of the total energy consumption belongs to direct energy, 45.06% to indirect energy, 6.58% to renewable energy, and 93.42% to non-renewable energy.

Total energy consumption for watermelon production was determined to be 78163.86 $MJha^{-1}$

Table 2

Description of Household Characteristics

Input/output	Quantity per unit area(ha)					
	Unit	Group 1	Group 2	Group 3	Group 4	Group 5
Inputs						
1. Human labor	h	299.91	299.91	284.04	191.01	239.50
2. Machinery	H	6.32	4.01	8.03	9.42	9.09
3. Diesel fuel	L	703.06	680.10	720.06	733.87	730.59
4. Chemicals	kg	2.06	2.06	2.06	2.06	2.06
5. Farmyard manure	kg	3660	3660	3660	3660	3660
6. Chemical fertilizers						
Nitrogen (N)	Kg	273.39	273.39	273.39	273.39	273.39
Phosphate (P2O5)	Kg	91.61	91.61	91.61	91.61	91.61
Potassium (K2O)	Kg	21.68	21.68	21.68	21.68	21.68
Sulphur (S)	Kg	63.55	63.55	63.55	63.55	63.55
Micronutrient fertilizers	Kg	16.32	16.32	16.32	16.32	16.32
7. Plastic and polyethylene	Kg	136.86	136.86	136.86	136.86	136.86
8. Water for irrigation	m3	3482.59	3482.59	3482.59	3482.59	3482.59
9. Seeds (watermelon)	Kg	1.53	1.53	1.53	1.53	1.53
Output						
1. Watermelon	Kg	49800	50050	49900	50000	50100

for group 2, while the highest energy consumption in this group belonged to diesel fuel, nitrogen fertilizer, plastics and polyethylene materials, with the values of 49%, 23.13%, and 16.16%, respectively. The lowest energy consumers were seed, sulfur and potash fertilizer with values of 0%, 0.09%, and 0.3%, respectively. Total energy consumption of watermelon production in Hamedan province was 46348.35 MJha^{-1}. The highest energy consumption belonged to nitrogen fertilizers, water irrigation and diesel fuel with values of 61.6%, 20% and 8.6% respectively and the lowest energy consumption belongs to watermelon seed and chemical with values of 0% and 0.6% respectively (Banaeian & namdary, 2011).

Energy productivity was calculated as 0.64 for the farms under study in group 2; it means that, for every unit of energy consumption, 0.64

Table 3

Amounts of Energy Inputs and Output in Watermelon Production

Input/output	**Group 1**		**Group 1**		Group 3		**Group 4**		**Group 5**	
	Total energy equivalent (Mj.ha^{-1})	**Percentage of the total energy input %**	**Total energy equivalent (Mj.ha^{-1})**	**Percentage of the total energy input %**	**Total energy equivalent (Mj.ha^{-1})**	**Percentage of the total energy input %**	**Total energy equivalent (Mj.ha^{-1})**	**Percentage of the total energy input %**	**Total energy equivalent (Mj.ha^{-1})**	**Percentage of the total energy input %**
Inputs										
1. Human labor	587.82	0.74	587.82	0.75	556.72	0.69	374.38	0.46	469.42	0.59
2. Machinery	396.26	0.5	251.43	0.32	503.48	0.62	590.63	0.73	569.94	0.71
3. Diesel fuel	39589.35	49.73	38296.40	49.00	40546.48	50.28	41324.49	50.82	41139.78	5135.00
4. Chemicals	274.20	0.31	274.20	0.32	274.20	0.31	274.20	0.30	274.20	0.31
5. Farmyard manure	1098.00	1.38	1098.00	1.40	1098.00	1.36	1098.00	1.35	1098.00	1.35
6. Chemical fertilizers										
Nitrogen (N)	18082.01	22.72	18082.01	23.13	18082.01	22.42	18082.01	22.24	18082.01	22.57
Phosphate (P_2O_5)	1139.63	1.43	1139.63	1.46	1139.63	1.41	1139.63	1.40	1139.63	1.42
Potassium (K_2O)	241.73	0.30	241.73	0.31	241.73	0.30	241.73	0.30	241.73	0.30
Sulphur (S)	71.18	0.09	71.18	0.09	71.18	0.09	71.18	0.09	71.18	0.09
Micronutrient fertilizers	1958.40	2.46	1958.40	2.51	1958.40	2.43	1958.40	2.41	1958.40	2.44
7. Plastic and polyethylene	12634.92	15.87	12634.92	16.16	12634.92	15.67	12634.92	15.54	12634.92	15.77
8. Water for irrigation	3552.24	4.46	3552.24	4.54	3552.24	4.41	3552.24	4.37	3552.24	4.43
9. Seeds (watermelon)	2.91	0.00	2.91	0.00	2.91	0.00	2.91	0.00	2.91	0.00
Total energy input	79601.66		78163.86		80634.89		81317.72		80110.46	
Outputs										
1. watermelon	94620.00		95095.00		94810.00		95000.00		95190.00	
Total energy output	94620.00		95095.00		94810.00		95000.00		95190.00	

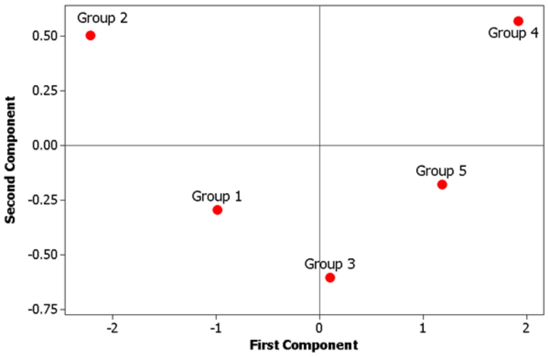

Figure 1: Comparison between different planting methods such as custom tillage (group1), conservation tillage (group2), traditional planting (group3), semi-mechanized planting (group4) and mechanized planting (group5)

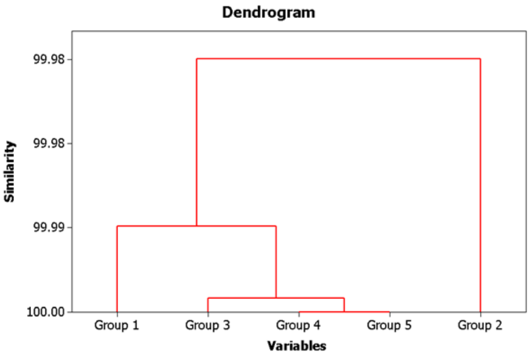

Figure 2: Dendrogram obtained by clustering analysis of direct and indirect as well as renewable and non-renewable.

units of energy would be produced. Specific energy and net energy in watermelon production in group 2 were estimated 1.56 MJkg^{-1} and 16931.14 MJha^{-1}, respectively. Specific energy and net energy in producing watermelon in Guilan province reported 1.47 MJ kg^{-1} and 11733.46 MJ ha^{-1}, respectively (Nabavi-Pelesaraei et al., 2014). In this group, reduced tillage operations and the use of conservation agriculture led to lower energy consumption.

Energy use efficiency was also obtained 1.22 which means that for each MJ of energy consumption 1.22 MJ energy would be produced. In group 2, 54.29% of the total energy consumption is direct energy, 45.71% is indirect energy, 6.71% is renewable energy, and 93.29% is non-renewable energy.

Energy consumption of watermelon production in farms under study in group 3 was 80634.89 MJha^{-1}. Like previous groups, the highest energy

Table 4
Energy Input-Output Ratio in Watermelon Production

Items	Group 1	Group 2	Group3	Group 4	Group 5
Energy use efficiency	1.19	1.22	1.18	1.17	1.19
Energy productivity	0.63	0.64	0.62	0.61	0.63
Specific energy	1.60	1.56	1.62	1.63	1.60
Net energy	15018.34	16931.14	14175.11	13682.28	15079.54

Scale: 1=Very Little to 5=Very Much

Table 5
Total Energy Input in the Form of Direct, Indirect, Renewable and Nonrenewable for Watermelon Production (MJ ha^{-1})

	Group 1		Group 1		Group 3		Group 4		Group 5	
Form of energy (MJ. ha^{-1})	Amount of energy	Percentage	Amount of energy	Percentage	Amount of energy	Percentage	Amount of energy	Percentage	Amount of energy	Percentage
Indirect energy	35872.24	45.06	35727.40	45.71	35979.45	44.62	36066.61	44.35	34949.01	44.39
Direct energy	43729.42	54.94	42436.46	54.29	44655.44	55.38	45251.11	55.65	45161.44	55.61
Nonrenewable Energy	74360.68	93.42	72922.89	93.29	75425.02	93.54	76290.19	93.82	76084.79	93.69
Renewable energy	5240.97	6.58	5240.97	6.71	5209.87	6.46	5027.53	6.18	4025.67	6.31

Table 6

Optimal Results for Different Arrangements of Models to Predict the Energy Flows of Watermelon

Evaluation criteria	Training	Testing	Total
R^2	0.99	0.99	0.99
RMSE (MJ)	2751.03	3402.42	32063.28
MAPE (%)	31.42	21.64	32.28
EF	0.98	0.99	0.99

Table 7

Economic Analysis of Watermelon

Cost and return component	Group 1	Group 2	Group3	Group 4	Group 5
Yield (kg. ha^{-1})	49,800.00	50,050.00	49,900.00	50,000.00	50,100.00
Sale price ($. kg^{-1})	0.11	0.11	0.11	0.11	0.11
Gross value of production ($. ha^{-1})	5478	5505.5	5489	5500	5511
Cost of human labor ($. ha^{-1})	609.38	609.38	578.13	385.94	487.50
Cost of machinery ($. ha^{-1})	93.75	50.00	125.00	203.13	171.88
Cost of diesel fuel ($. ha^{-1})	67.47	74.39	67.51	68.80	68.49
Cost of chemical, fertilizer and seed ($. ha^{-1})	1151.76	1151.76	1151.76	1151.76	1151.76
Cost of water and land ($. ha^{-1})	937.50	937.50	937.50	937.50	937.50
Total cost of production ($. ha^{-1})	2859.86	2823.02	2859.89	2747.12	2817.13
Net profit ($. ha^{-1})	2618.14	2682.48	2629.11	2752.88	2693.87
Profit to cost ratio	1.91	1.95	1.92	2.00	1.96

consumption belonged to diesel fuel, nitrogen fertilizer, plastic, and polyethylene materials with values of 50.28%, 22.42%, and 15.67%, respectively. The lowest shares were attributed to watermelon seed, sulfur and potash fertilizers with values 0%, 0.09%, and 0.3%, respectively. The highest energy consumption during watermelon production in Kerman Province belonged to water irrigation, plastics and polyethylene materials and nitrogen fertilizers with values of 61%, 9% and 14%, respectively, and the lowest one belonged to watermelon seed, Potassium Fertilizer and farmyard manure with value 0% (Khoshnevisan et al., 2015). As noted, the high consumption of nitrogen fertilizers and irrigation as well as high energy equivalent of nitrogen in the production process played an important role in energy consumption. Specific energy and net energy for watermelon production in group 3 was calculated 1.62 $MJkg^{-1}$ and 14175.11 $MJha^{-1}$, respectively.

Energy use efficiency was also calculated as 1.18 for this group. It means for each MJ of energy consumption 1.18 MJ energy would be produced. Energy productivity was calculated as 0.62 for the farms of this group. It means that for every unit of energy consumption, 0.62 units of energy would be produced. As it was shown in Table 5, 55.38% of the total energy consumption is direct energy, 44.62% is indirect energy, 6.46% is renewable energy and 93.54% is non-renewable energy. Non-renewable energy of watermelon production in Guilan Province was reported 96.24% (Nabavi-Pelesaraei et al., 2014). High consumption of diesel fuel, fertilizers and agricultural machinery led to higher percentage of none renewable energy in watermelons production

Total energy consumed during watermelon production period was 81317.72 $MJha^{-1}$ for group 4. Specific energy and net energy in watermelon production of this group were determined to be 1.63 $MJkg^{-1}$ and 13682.28 $MJha^{-1}$, respectively. Specific energy and net energy in watermelon production in Guilan Province were reported 0.87 MJ kg^{-1} and 19880.6 MJ ha^{-1}, respectively (Mohammadi-Barsari et al., 2016). Energy use efficiency was calculated 1.17 for this group. It means that for every unit of energy consumption, 1.17 units of energy would be produced. Energy productivity also obtained 0.61 which means that for each MJ of energy consumption, 0.61 MJ of energy would be produced.

The highest energy consumption in this group belonged to diesel fuel, nitrogen fertilizer, plastics and polyethylene materials, with the values of 50.82%, 22.24%, and 15.54%, respectively, and the lowest one belongs to watermelon seed, sulfur and potash fertilizer and chemicals with values of 0%, 0.09%, 0.3%, and 0.3%, respectively. 55.65% of the total energy consumption is direct energy, 44.35% is indirect energy, 6.18% is renewable energy, and 93.82% is non-renewable energy. Non-renewable energy of seedy watermelon production in Iran reported 71.48% with the highest share of non-renewable belonging to nitrogen fertilizer (Moradi et al., 2015). High consumption of diesel fuel, fertilizers, and agricultural machinery has increased the percentage of non-renewable energy. The highest share in non-renewable belonged to diesel fuel because of full mechanized planting, and nitrogen fertilizers in this group.

In group 5, the total energy consumed during the watermelon production period was 80110.46 MJha^{-1}. The highest energy consumption in this group belonged to diesel fuel, nitrogen fertilizer, plastics and polyethylene materials, with the values of 51.35%, 22.57%, and 15.77%, respectively, and the lowest one belongs to watermelon seed, sulfur and potash fertilizer with values of 0%, 0.09%, and 0.3%, respectively. In this group, 55.61% of the total energy consumption is direct energy, 44.39% is indirect energy, 6.31% is renewable energy, and 93.69 % is non-renewable energy. Energy productivity was also obtained 0.63 which means that for each MJ of energy consumption, 0.63 MJ of energy would be produced. Specific energy and net energy in watermelon production of this group were obtained 1.6 MJkg^{-1} and 15079.54 MJha^{-1}, respectively. Energy use efficiency was calculated 1.19 for this group. It means that for every unit of energy consumption, 1.19 units of energy would be produced.

The highest energy consumption for watermelons production was related to mechanized system. In this method, at all stages of plating, including covering plastics and tapes as well as seeding, seeder machine and plastic device replace workers and, consequently, fuel consumption and machine's performance increase and, as it was shown in Table 1, energy equivalent of fuel and machine is considerably more than the energy equivalent of worker, and a significant share of energy input is assigned to them. Therefore, the maximum energy consumption was observed in group 4.

Group 2 had the lowest energy consumption than the others. In this group, replacing traditional tillage with conservation tillage caused reduction in the use of machines and fuel consumption. The energy of these is substantial; therefore, reduction in tillage was followed by reduction in energy consumption.

Due to numerous benefits of conservation agriculture, including increased soil moisture retention, reduced water and wind erosion, reduced energy consumption in farms (Munawar et al., 1990), increased water consumption efficiency by plants, increased soil organic matter (Asae & Pikul, 1995) and, on the other hand, considering the results of this research, it also caused an increase in the efficiency and productivity of energy consumption. Therefore, the method of the second group and using conservation agriculture would be a suitable alternative for traditional agriculture from the point of view of energy efficiency and sustainable agriculture.

Generally, according to the results of Table 3 and studies on different groups, it was found that removing the workers and replacing them with machines and equipment would increase energy consumption due to high energy consumption of machines compared to the energy use by human.

Energy consumption of watermelon production in Hamedan Province with planting method similar to the first group of this research was 68,788 MJha^{-1} (Namdari, 2011), which demonstrates a significant difference with the value calculated in this research.

This difference may be due to the traditional method that is used in Fars province. Because in this province, watermelon has been planted under plastic covering and irrigated by low pressure irrigation and with the help of tape. Energy equivalent of polyethylene average of the five groups was obtained 15.8% of the input energy, which would be added to the energy consumption of watermelon production in present research compared to Hamedan Province.

As it was displayed in Table 3, except for the human resources input, machines and diesel fuel, consumption amount of other factors were equal. Clustering function with three mentioned inputs showed that the difference between groups 2 and 4 is more comparable to other groups, and the process of energy consumption in these 3 inputs is different from the other groups (Figure 1). The maximum utilization of machines and fuel in group 4 was due to eliminating human resources in planting stage (such as planting seed and covering plastics) and replacing it with "melon seeder and mulch layer machine" against minimum utilization of machines and fuel in group 2, using minimum tillage and non-mechanized planting methods.

Figure 1: Comparison between different planting methods such as custom tillage (group1), conservation tillage (group2), traditional planting (group3), semi-mechanized planting (group4) and mechanized planting (group5)

Maximum productivity was 0.64 that belonged to group 2, and the minimum was 0.61 that belonged to group 4 which includes the maximum use of machines.

Figure 2 shows that there is no difference between groups 4 and 5 in terms of direct, indirect, renewable and non-renewable energy. Also, these two groups are similar to group 3. Most of the difference is related to group 2. It can be due to replacing conservation tillage system with conventional tillage in addition to planting seed and covering plastics by workers. These reduce the use of machines and diesel fuel which have a significant effect on non-renewable energy use.

In Turkey, it was demonstrated that 38% of higher energy input was used on conventional apricot farming than the use on organic farms. The energy ratios of 2.22 and 1.45 were achieved under the organic and conventional farming systems, respectively. The share of renewable energy in the production of organic apricot is higher than the conventional way. Furthermore, it was also shown in this study that the share of direct energies in organic production was close to 60% of the total input energy whereas in the conventional method, this amount was decreased to 40% (Gundogmus, 2006).

In Spain, it was reported that the difference in the amount of direct and renewable energies in common agriculture in contrast to the agriculture was based on organic inputs to production of olive (Guzman & Alonso, 2008).

The results of this research demonstrated that, in each of the five groups under study, the highest non-renewable energy belonged to diesel fuel. It seems that, to improve the energy efficiency and energy productivity in watermelon production, the diesel can be replaced by electricity in water pumping from wells and use conservation agriculture.

Among the non-renewable energies after diesel, the total consumer chemicals were on the next place, especially, nitrogen fertilizer that will result in reduced energy efficiency as well as pollution of water and soil resources.

It seems that, in the watermelon production, like other crops, by using soil tests to apply the fertilizer only when it is needed and by optimizing fertilizer consumption or using of biological fertilizer in addition to maintaining soil characteristics and reducing pollutions, we can increase energy efficiency and reducetotal energy consumption.

ANN results

To apply the most appropriate ANN model, several network structures were tested to find the best topology. The results showed that the ANN model with 9-10-1 structure was the best one to predict the energy flow of Iranian watermelon production. It means that the best developed model consisted of an input layer with nine input variables, one hidden layers with ten neurons in each layer, and an output layer with a output variable. The best developed model to predict Iranian tangerine yields based on the energy inputs was reported to be an ANN model with 10-8-5 structure (Nabavi-Pelesaraei et al., 2014). Mardani and Taghavifar, (2016) developed an ANN model with one hidden layers (14 neurons) and two output layers that could predict Iranian grape production.

Table 6 shows the best result of different arrangements of models to predict the energy flows of Iranian watermelon production. The best topology had the lowest amounts of RMSE and MAPE and the highest amounts of R^2 and EF to predict the energy flow. In this study, the coefficient of determination (R^2) of the developed ANN model was 0.99. In addition, the RMSE, MAPE and EF for the optimal model were determined to be 32063 MJ, 32.28% and 0.99%, respectively.

Economic analysis of watermelon production

The total amount of watermelon production costs and calculated gross production value for each of the five groups are shown in Table 7. According to different climates in different cities and different planting times and consequently different watermelon harvest times in Fars province, product price is different depending on the time to market. In this study, the average sales price during the time to market was considered 0.11$ for each kilogram.

As shown in Table 7, most costs are related to groups 3 and 1 equal to 2859.89 and 2859.86 $, respectively, and the lowest net profit belongs to groups 1 and 3 in the amount of 2618.14 and 2629.11 $, respectively, in each hectare. The lowest cost belongs to group 4 with value of 2747.12 $, and the most net profit belongs to this group with the value of 2752.88 $ in each hectare. The lowest net profit ratio to production cost is 1.91 and 1.92 and belongs to groups 1 and 3, respectively, and the highest one is 2 and it is related to group 4.

Considering that human resources are one of the most expensive inputs of watermelon production, most human resources are used to cover the rows with plastic, dripping tapes and planting seeds; therefore, in group 4, it was observed that, by eliminating human resources and using full-mechanized planting method, the costs were decreased and the net profit and profit-cost ratios were increased.

After group 1, the most profit belonged to group 2. In this group, automation of covering the rows with plastic and dripping tapes caused a reduction in costs.

In group 2, replacing conventional farming with conservation agriculture and reducing intensity and number of tillage operations reduced machinery and fuel costs. These factors also resulted in reduced costs and increased net profit compared to groups 1 and 3.

In groups 1 and 3, due to the traditional way of covering the rows with plastic, dripping tapes and planting seeds and using the conventional method of agriculture, production cost was high and the lowest amount of net profit would be obtained. Net return of watermelon production in Hamedan Province of Iran was 3158061 $ha-1, and benefit to cost ratio was reported 2.06. Net return of watermelon production in Hamedan Province of Iran was 3158061 $.ha^{-1} benefit to cost ratio was reported 2.06 (Namdari, 2001). In another research the net return of seedy watermelon production in Iran with two Irrigation methods including full and reduced irrigation systems was reported 2115.9$.ha-1 and 589.9$.ha-1, respectively (Moradi et al. 2015).

CONCLUSIONS

The results of the research are the following:

Group 4 had the greatest amount of energy consumption (81317.72 MJha^{-1}) with productivity of 0.61, and energy efficiency of 1.17. Group 2 had the minimum amount of energy consumption (78163.86 MJha^{-1}) with productivity of 0.64 and energy efficiency of 1.22. Group 3 had the highest percentage of renewable energy among the groups under study (6.71 percent). Group 4 had the most amount of the net profit (2752.88$) and group 1 had the lowest amount of net profit (2618.14$) in each hectare. The highest percentage of energy inputs for all evaluated watermelon production systems were attributed to diesel fuel and chemical fertilizers, respectively.

According to conclusions and observations of this research, it can be concluded that, through using conservation agriculture and mechanized planting simultaneously, it becomes possible to access considerable level of energy use efficiency in addition to raising the net return, which is the best situation in both economic and energy consumption.

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