Advances in Environmental Biology, 8(11) Special 2014, Pages: 85-92

AENSI Journals

Advances in Environmental Biology

ISSN-1995-0756 EISSN-1998-1066

Journal home page: http://www.aensiweb.com/aeb.html

Evaluation of Energy Productivity in different Tillage Methods of Irrigated Wheat in Fars, Khuzestan and Esfahan Provinces

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ARTICLE INFO

Article history:
Received 15 April 2014
Received in revised form 22 May 2014
Accepted 25 May 2014
Available online 15 June 2014

Key words:
Conservational tillage, Energy productivity, Esfahan, Fars, Khuzestan

ABSTRACT

Using conservational tillage in preparing seedbed is aimed to maintain soil fertility, reduce energy consumption, alleviate machineries depreciation, and save operations time. In this regard, identifying and using resources management and inputs suited tillage type is a big step toward optimizing energy consumption and promoting productivity. In this study, in addition to determining energy consumption in different tillage methods for cultivating wheat in Fars, Khuzestan, and Esfahan provinces, the effect of various factors on energy productivity were also studied. Accordingly, 337 questionnaires were distributed in farms under conservational and conventional tillage in different areas of 12 cities. Results showed that maximum energy consumption is related to chemical fertilizers. The average energy consumption in these methods was %63 and %46, respectively. Maximum amount was in Khuzestan. But, maximum energy consumption in Esfahan and Fars provinces was related to irrigation. It was also determined that average energy productivity was 0.15Kg.MJ-1 and 0.11 Kg.MJ-1 in conservational and conventional methods, respectively. Energy consumption proportion in both methods was gained by carrying out ANCOVA on factors affecting energy productivity, climate, soil texture, soil structure, and residue management. In a separate examination, maximum energy productivity was obtained in cold climate, medium soil texture, and high organic content. Maximum energy productivity was obtained in different methods of managing crop residues by in total stand-up residue maintenance with flooding irrigation.

To Cite This Article: Shahrzad Azari Mobarake, Morteza Almassi, Abbas Hemmat, Reza Moghaddasi, Maryam Zekri, Evaluation of Energy Productivity in different Tillage Methods of Irrigated Wheat in Fars, Khuzestan and Esfahan Provinces. ***Adv. Environ. Biol., 8(11)**, 85-92, 2014*

INTRODUCTION

Today, agriculture sector considerably depends on energy consumption to appropriately and adequately respond increasing food demand for the growing population of the world. Limited natural resources and the adverse effect of improper energy consumption on environment and human's health require the examination of energy consumption patterns in agriculture sector [10]. Research showed that with the growth of mechanization and use of chemicals in agriculture, energy efficiency has been gradually decreased. As time passes by, again energy consumption efficiency of agricultural systems has reduced. Early agriculture has had higher energy efficiency as well as better sustainability as compared to modern intensive agriculture.

At the time, little tillage and no tillage are widely done across the world in preparing seedbed. Beside fertilizing and stabilizing soil, it leads to lower energy consumption, less machineries depreciation, and shorter execution time [12]. Energy analysis plays a significant role in agriculture regarding the development of human's view toward arable ecosystems. Hence, it results in the qualitative promotion of decision makings and planning in the management and development of agriculture sector [16]. Although energy analysis cannot provide us with full understanding of an agricultural ecosystem, it can affect the qualitative improvement of development decision makings and planning by expanding human's view to these arable ecosystems [14].

Energy resources management in agriculture must be designed so as to barely harm production resources (e.g. soil and climate). Tillage is a critical part of production operation. Tillage requirements of a cultivation system in a certain area depend on the relationship between water, soil, air and management factors.

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Energy productivity indicates the quality of production process. This shows the amount of crop (Kg) produced for an energy unit (MJ). Enhancing efficiency and productivity of energy are the main objectives of energy analyses. In input/output energy analysis in a case farm in Yazd, total energy input and output in straw production were respectively estimated as 83 and 111GJ.hec$^-$. In this study, nitrogen fertilizer and electricity were inputs used most. Changing present irrigation system was suggested to improve energy efficiency [4]. In a work on wheat production in Morocco (average crop=2500kg.hec$^-$), energy input was reported as 14GJ.hec$^-$. In this study, chemical fertilizer and fuel with respectively %60 and %24 of total energy consumption were inputs with maximum energy consumption [3].

In a comprehensive study on agriculture energy efficiency in 75 countries, energy efficiency in Iran agriculture was reported 1.79 (no unit) [6]. Raei Jadidi et al carried out a study on tomato crop in Marand. They concluded that energy input for this crop was 65.2GJ.hec$^-$. Of this amount, %51 was related to chemical fertilizers and %21 to irrigation. They estimated energy efficiency and productivity as 0.6 and 0.74kg/MJ, respectively [15. In assessing energy consumption regarding wheat production in Savojbolagh, energy consumption coefficient in hectare was obtained as 51870MJ. And, energy productivity and value-added were calculated as 0.9kg/MJ and 13099MJ.hec$^-$, respectively [21]. In a study on irrigate wheat energy consumption in Eastern Khuzestan, Attar gained total energy required as 42481MJ.hec$^-$, and efficiency index and value-added as 1.56 (no unit) and 23819MJ.hec$^-$, respectively [2].

In Iran, regarding the problems of conventional tillage operation (e.g. increasing instability of soil and water resources), replacement, development, and promotion of a variety of conservational tillage methods – no tillage and little tillage – are included in Agriculture Jihad Department formula. Obviously, identifying and applying resources management and inputs appropriate for tillage method can be a great step toward the optimal use of energy and its efficiency. Accordingly, this study intended to determine factors affecting energy productivity in various tillage methods of irrigated wheat in Fars, Khuzestan, and Esfahan provinces in arable year between 2011 and 2012. Besides, it examined factors affecting energy productivity.

MATERIALS AND METHODS

This field study was conducted on 337 farms in 12 towns of these three provinces. Conservational tillage (low tillage and no tillage) was carried out on selected farms under the supervision of Agricultural Jihad Organization and by the consultation of each area mechanization officials. Data collection was done by face-to-face interviewing farmers and mechanization coordinators of each area. Questionnaire information included climate, soil texture and structure, area under cultivation, crop type, rotation, residue management and density method, tillage and cultivation method, tillage time, depth and width of tillage and cultivation machine, type and amount of chemical fertilizers and pesticides, irrigation method, efficiency and amount of water consumption, and crop yield. Direct cultivation machines were used in farms without tillage. Yet, shallow tillage tools such as chisel with and without roller and packer chisel were applied to conservational tillage (little tillage).

In agricultural system, energy productivity is calculated through dividing yield by total energy consumption (input). Total input energy includes machine, fuel, irrigation, fertilizer, pesticide, and seed.

To calculate total energy input in irrigated wheat, equivalent amounts of each input (i.e. chemical fertilizers, seed, and pesticides) were determined using information and coefficients listed in Table 1. To set energy inputs, all operations required were listed.

Fuel Energy:

Equations below were used for calculating fuel energy consumption (l.ha$^-$):

$$SFCv=2/64X+3/91-0/203(173+738X)^{1/2} \quad (1)$$

$$X = \frac{(P.T.O)_{pu}}{(P.T.O)_{max}} \quad (2)$$

$$Q_l = SFC_v * P_t \quad (3)$$

Where:

X: is load factor; the ratio of axial power to maximum P.T.O power existing. Variable amounts between 0.2 (for light operation) and 0.85 (for heavy operation) were assigned for X.

SFC_7: fuel special consumption amount (L/kw.h)

Q_1: fuel consumption (L/h) [1]

Irrigation Energy:

Irrigation energy was determined by equation below [17]:

$$E_W = (W*P_e *3/6)/ E_{in} \quad (4)$$

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Where:
E_W: irrigation energy in respective operation (MJ/ha)
W: water consumption (m^3/ha)
P_e: electromotor power (kWh)
Q: well Debi (m^3/h)

Machine Energy:

Machine energy of each operation was set by equation (5):

$$E_M = \frac{62/7}{Ca_t} \tag{5}$$

Where:
E_M: machine energy of operation under study (MJ/ha)
Ca_t: farm capacity

RESULTS AND DISCUSSION

Table 2 lists average irrigated wheat yield and energy consumption amounts in various conservational and conventional tillage methods in Esfahan, Khuzestan, and Fars Provinces. Average energy consumption is %17 lower in conservational tillage as compared to conventional method.

Figure 1 displays different energy inputs proportion in both methods. In these methods, maximum energy consumption was related to chemical fertilizer with average consumption %63 and %24, respectively (Figure 1). As seen, maximum amount of fertilizer consumption in conservational methods is considerably increased due to farmers' fear of yield loss. Among provinces under study, minimum consumption is related to Fars and maximum to Khuzestan. It can be resulted from Fars province farmers' use of conservational methods and their trust in the outcome. Yet, regarding energy consumption, Esfahan and Fars provinces had the highest proportion of irrigation energy. It was because of deep wells and use of ground irrigation methods with low efficiency.

Table 1: Energy equivalents of inputs and outputs [7,18,20, 8,5,11,9,19].

Energy	Unit	Energy equivalents (MJ/Unit)
machinery	h	62.7
diesel fuel	l	56.31
chemical fertilizer	kg	
nitrogen		66.14
phosphorus		12.44
potasssium		11.15
superphosphate		6.52
full fertilizer		0.15
sulfur		1.12
cattle fertilizer		0.3
Pesticides	kg	
herbicide		288
fungicide		196
insecticide		237
Seed	kg	14.7
Straw	kg	12.15

Table 2: Data of biomass yield and energy consumption in provinces under study.

	Khuzestan	Fars	Esfahan
biomass yield in conventional tillage	6350	9800	6500
biomass yield in conservational tillage	6300	9700	7500
energy consumption in conventional tillage	137000	61200	47800
energy consumption in conservational tillage	126000	41000	43300

Based on results, average energy productivity was 0.15kg/MJ in conservational tillage. Maximum amount was related to Fars Province (0.24kg/MJ) and minimum to Khuzestan Province (0.05kg/MJ).

The higher the efficiency is, the further the production or the less the energy consumption will be. Or, both may be the reasons that this subject is in the line with the sustainable development of agriculture which is finally aimed at lower energy consumption. High productivity of this crop in Fars Province is also resulted from its lower energy consumption as compared to the other two.

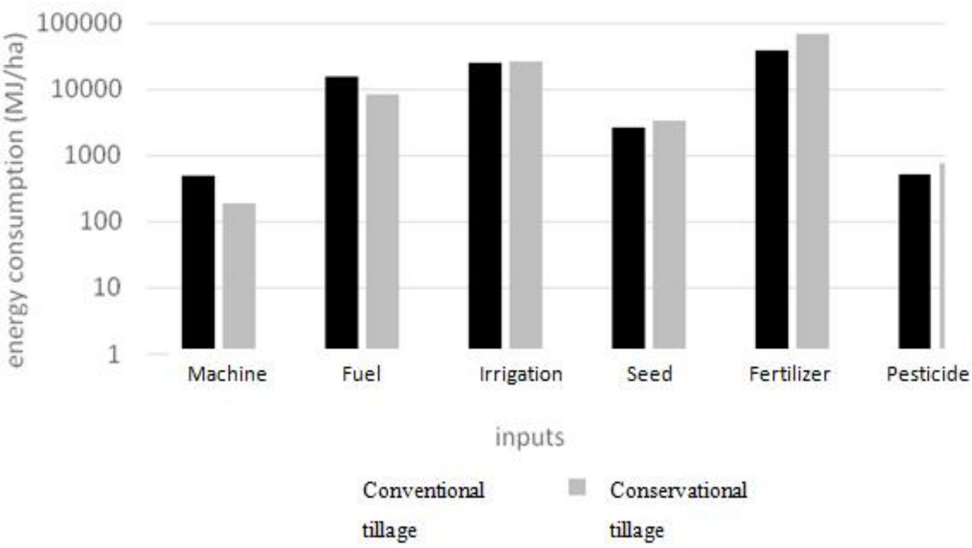

Fig. 1: Each energy input proportion in energy consumption regarding conservational and conventional tillage

Average energy productivity in conventional tillage method is 0.11kg/MJ. It was expected that the difference between conventional and conservational tillage methods is more. Yet, due to the excessive use of chemical fertilizer and application of flooding methods in many farms under study, irrigation energy consumption was significantly increased. Results show that high energy consumption in Khuzestan Province is due to the excessive use of chemical fertilizer; especially, nitrogen and potash fertilizers. To enhance their yield, farmers tend to the excessive use of chemical fertilizers. It brings about environmental consequences as well as economic losses. This excessive use is resulted from receiving subsidiary chemical fertilizer, ignoring the recommended amount, and doing based on personal experiences.

Ground irrigation methods (especially flooding) need further labor and time for leveling and more manpower for consistent irrigation. Losing a part of land due to irrigation streams and ground runoffs also leads to energy loss and consequently productivity reduction.

Effective factors on energy productivity discussed in this study include: tillage method, climate, soil texture, soil structure, residue management method, irrigation method, tillage time, cultivation time, and cultivation machine power.

Regarding the matter that other factors also exist in examining variables which may possibly affect total energy productivity, the analysis of covariance (ANCOVA) is used after determining these variables. Besides, since data distribution is not normal, $y = -\sqrt[3]{x}$ was used for data normalization. In the successive tests of ANCOVA, tillage time (0.438), cultivation time (0.087), and cultivation machine power (0.318) variables were not significant and omitted from the model. Table 3 shows ANCOVA results.

Table 3: Covariance analysis of factors affecting energy productivity.

Dependent Variable:r3neg					
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	13357.551[a]	16	834.847	20.698	.000
Intercept	30455.175	1	30455.175	755.074	.000
tillage	297.718	2	148.859	3.691	.026
climate	5803.292	4	1450.823	35.970	.000
soil texture	747.780	2	373.890	9.270	.000
soil structure	1010.557	5	202.111	5.011	.000
residue management	589.906	2	294.953	7.313	.001
irrigation method	232.329	1	232.329	5.760	.017
Error	9720.501	241	40.334		
Total	499262.520	258			
Corrected Total	23078.052	257			
a. R Squared = .579 (Adjusted R Squared = .551)					

Results of examining different variables affecting energy productivity are illustrated in Figure 2 to 6. Figures 2 to 4 display a comparison of energy productivity among various natural factors including climate and soil. In Figure 2, different areas in five climates (cold, dry and cold, temperate, dry and warm, and warm) were examined. Maximum productivity is related to cold climate yet minimum to warm and dry. It can be because of faster evaporation of water from soil surface, shorter irrigation periods due to further irrigation energy consumption, and not controlling crop residue in warm and dry climate.

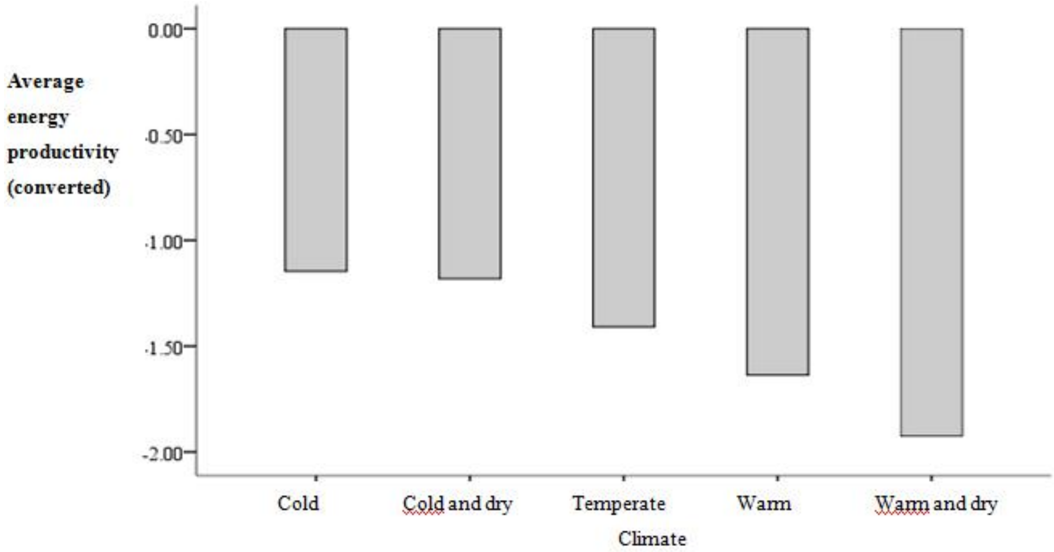

Fig. 2: Comparison of average energy productivity (converted) in different climates (kg/MJ).

In Figure 3, cold areas soils were examined. They are divided into three groups: light, medium, and heavy. Maximum productivity was gained in medium soil texture.

Soil structure was divided into seven groups in various areas (Figure 4). As expected, maximum productivity was related to good soils with high organic content. By crop residue management in conservational tillage methods and also using proper crop rotation, it is possible to improve the organic content of soil. This will lead to higher energy productivity in future.

In figures 5 and 6, management factors including the pattern of residue and irrigation method are studied. Maintaining suitable crop residue is one of the main factors in successful conservational tillage. Results showed that maintaining total residue on the ground led to maximum energy productivity in conservational tillage methods (Figure 5). Similarly, pressurized irrigation methods had less energy consumption as compared to ground (flooding) methods. In pressurized irrigation methods, energy productivity was %18 higher than flooding methods.

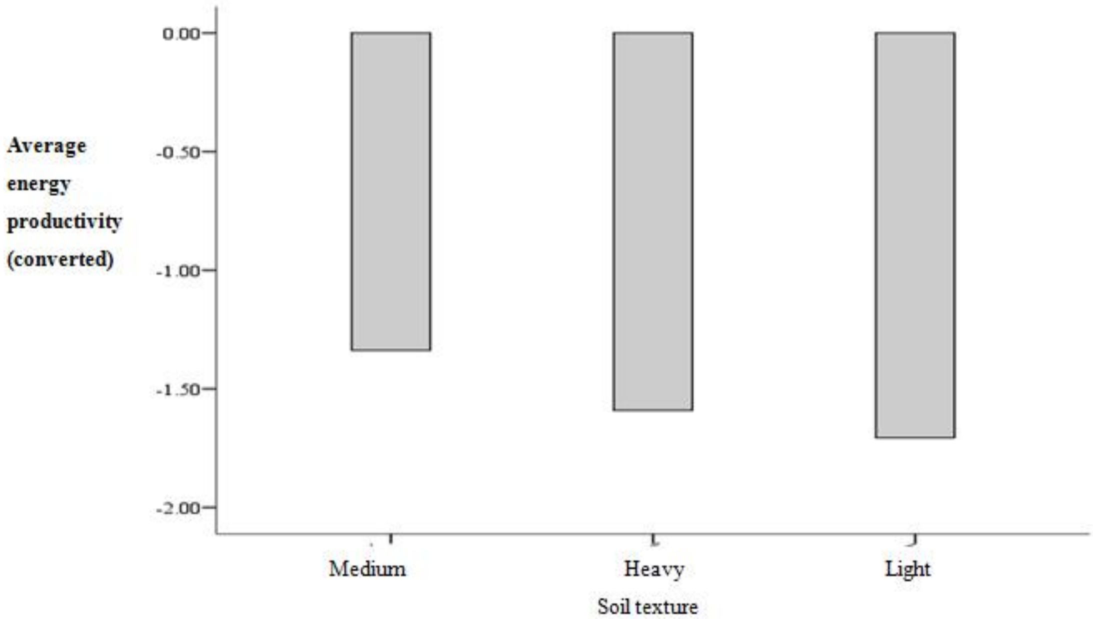

Fig. 3: Comparison of average energy productivity (converted) in different soil textures (kg/MJ).

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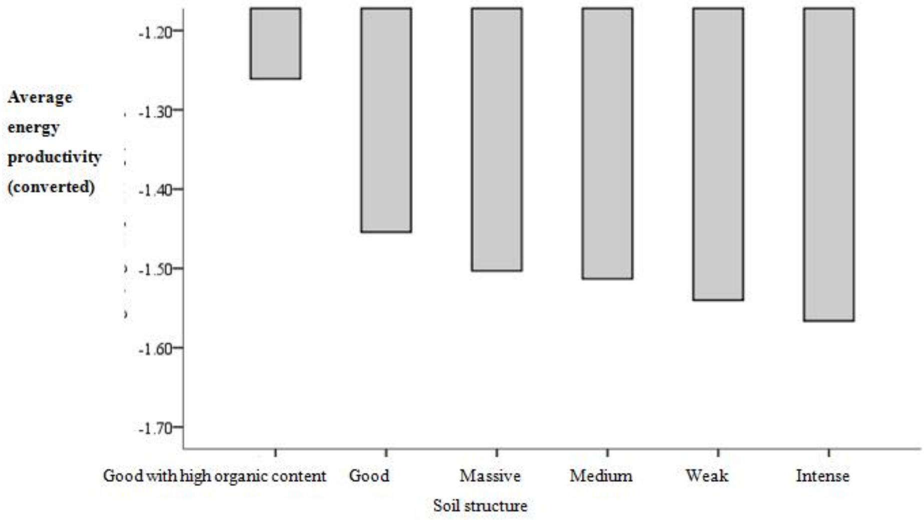

Fig. 4: Comparison of average energy productivity (converted) in different soil structures (kg/MJ).

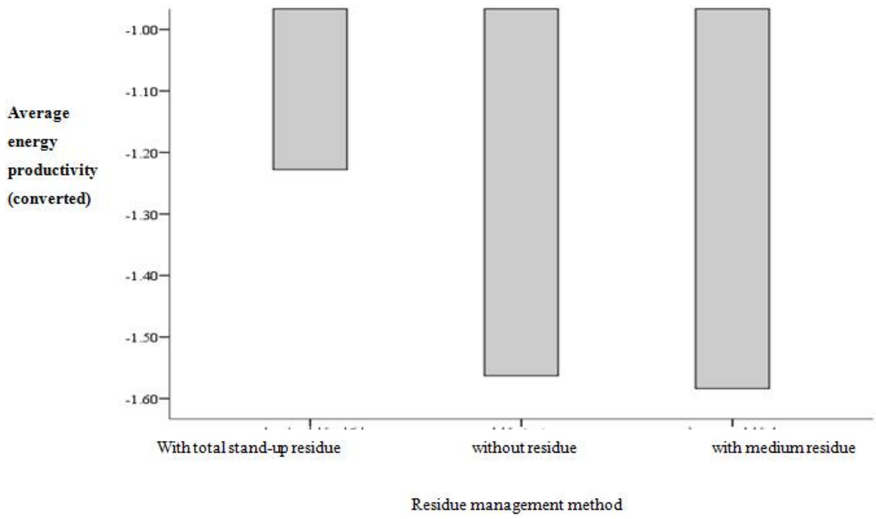

Fig. 5: Comparison of average energy productivity (converted) in different residue management methods (kg/MJ).

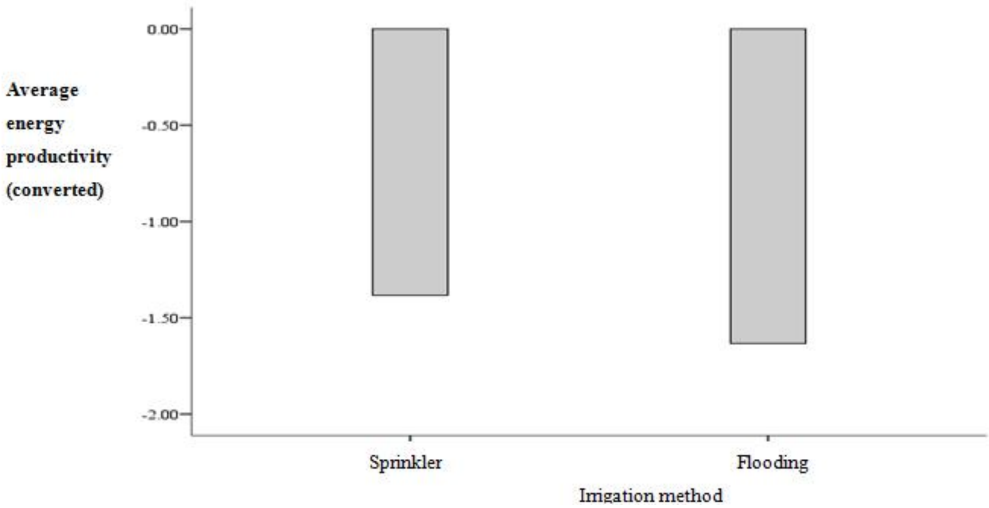

Fig. 6: Comparison of average energy productivity (converted) in different irrigation methods.

Conclusion and Suggestions:

- In this study, maximum energy consumption was related to chemical fertilizer and irrigation with average consumption %63 and %24, respectively. As well as the promotion of optimal chemical fertilizers use techniques, it is proposed that soil chemical test be conducted before arable operation. It is also suggested that excessive use of chemical fertilizers be prevented by rationing their distribution, if necessary.
- Productivity analysis results show that maximum productivity was related to average soil texture, good structure with high organic substances and cold climate. It is suggested that conservational methods be further promoted in areas with natural properties.
- Survival management method is one of the main factors in carrying out conservational tillage operation. Maximum productivity is related to farms established based on residue maintenance pattern and proper management. In irrigation, maximum productivity was related to sprinkler irrigation. Accordingly, it is proposed that subsidiary and governmental facilities be provided for farmers to facilitate the use of pressurized irrigation methods.
- Results indicated that Fars Province had maximum productivity (0.24kg/MJ) as compared to the average amount of total three provinces under study (0.15kg/MJ). Hence, it is suggested that the method used in Fars Province be considered and applied in other provinces with respect to similar climate conditions, as well as soil structure and texture to promote productivity level in wheat production.

REFERENCES

[1] Almassi, M., N. Loveimi and Sh. Kiani, 2009. Principles of agricultural mechanization. Forth edition. Jungle publication. Tehran, pp: 293. (In Farsi)

[2] Attar, S., 2011. Analysis of energy consumption of wheat production in eastern Khoozestan. First National Conference on Strategies for achieving sustainable agriculture. Khoozestan. Iran. (In Farsi)

[3] Balli, E.H., 2005. Energy balance of wheat production in Morocco. Conference on International Agricultural Research for Development S Stuttgart Hohenheim October, pp: 11-13.

[4] Beheshtitabar, I. and A. Keyhani, 2007. An input-output energy analysis in a wheat farm in the Khatam city of Yazd. 3th Student Conference on agriculture machinery engineering and mechanization. Shiraz. Iran, pp: 102-108. (In Farsi).

[5] Bhat, N.R., M. Albaho, M.K. Suleiman, L. Al-Mulla, A. Christopher, B. Thomas, S. Isath Ali, P. George, V.S. Lekha, S. Jacob, M. Al-Zalzaleh and R. Bellen, 2007. Standardization of growing substrates and fertilizer application for organic greenhouse vegetable production. Kuwait Institute for Scientific Research, Report No. KISR 8912, Kuwait.

[6] Comforti, P.M. Giampietro, 1997. Fossil Energy Use in Agriculture : An International Comparison Agric . Ecosystems and Environment, 65: 231–243.

[7] Erdal, G., K. Esengun, H. Erdal and O. Gunduz, 2007. Energy use and economical analysis of sugar beet production in Tokat province of Turkey. Energy, 32: 35-41.

[8] Esengun, K., O. Gunduz and G. Erdal, 2007. Input-output energy analysis in dry apricot production of Turkey. Energy Conversion Management, 48: 592-598.

[9] Green, M.B., 1987. Energy in pesticide manufacture, distribution and use. Energy in Plant Nutrition and Pest Control. Elsevier, Amsterdam: pp: 165-177.

[10] Hatirli, S.A., B. Ozkan and K. Fert, 2005. An econometric analysis of energy input output in Turkish agriculture, Renewable and Sustainable Energy Reviews, 9: 608-623.

[11] Heidari, M.D., M. Omid, A. Mohammadi, 2012. Measuring productive efficiency of horticultural greenhouses in Iran: A data envelopment analysis approach. Expert Syst Appl, 39: 1040-1045.

[12] Lindwall, CW., F.G. Larney and JM. Carefoot, 1995. Rotation, tillage and seeder effects on winter wheat performance and soil moisture regime. Can. J. Soil Sci., 75: 109-116.

[13] imentel, D., 1999. Energy inputs in production agriculture. In: Fluck, R. C. (Ed), Energy in Farm Production, Elsevier, Amsterdam, pp: 13-29.

[14] Rahimizadeh, M., H. Madani, S. Rezadoust, A. Mehraban and A. Marjani, 2007. Analysis of energy in agroecosystems and methods of increasing energy efficiency. In: The 6th National Energy Congress.

[15] Raei Jadidi, M., M. Sabouhi Sabouni and V. Kheradmand, 2010. Analysis of energy ratio and productivity in tomato production(case study for Marand). Journal of Agricultural economics and development, 24(3): 363-370. (In Farsi)

[16] Rathke, G.W. and W. Diepenbrock, 2006. Energy balance of winter oil seed rape cropping as related to nitrogen supply and preceding crop. European Journal of Agronomy, 24: 35-44.

[17] Rezadoust, S., 1999. Energy flow in sustainable agriculture. Second National Conference on Energy.Tehran. Iran. (In Farsi).

[18] Singh, H., D. Mishra and NM. Nahar, 2002. Energy use pattern in production agriculture of a tuypical village in Arid Zone India- Part I. Energy Convers Manag, 43(16): 2275-2286.

Advances in Environmental Biology, 8(11) Special 2014, Pages: 85-92

[19] Yaldiz, O., H.H. Ozturk, Y. Zeren and A. Bascetomcelik, 1993. Energy usage in production of field crops in Turkey. In: Fifth international congress on mechanization and energy use in agriculture. Kusadasi, Turkey.
[20] Yilmaz, I., H. Akcaoz and B. Ozkan 2005. An analysis of energy use and input costs for cotton production in Turkey. Renewable Energy, 30: 145-155.
[21] Zooleh, M., M. Behrouzi Lar and Z. Khodarahmpour, 2011. Evaluating and improving energy efficiency in wheat production in Savojbolagh. First National conference on modern agricultural sciences & technologies. Zanjan. Iran. (In Farsi).