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Evaluation the Effect of Conservation Tillage on Sunflower Yield and Energy Productivity

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ABSTRACT

The development of cultivation and sustainable production of sunflower is one of the important issues in agriculture. In this research, the effect of conservation tillage on energy consumption and sunflower yield in the Kalpoush dryland region of Shahrood was studied. An experimental design RCBD with five replications and four treatments was selected. The treatments were no-tillage (T1), reduced tillage (T2) and two conventional tillage without and with gathering residue (T3 and T4). Results showed that moisture content difference was significant at 0-30cm of soil depth. Sunflower yield difference was significant (P<1%). Maximum and minimum sunflower yield was related to reduced and conventional tillage with gathering residue, respectively. Between no-tillage and reduced tillage, Sunflower yield difference wasn't significant (P<5%). Reduced and conventional tillage with gathering residue (T2 and T4) had the maximum and minimum energy efficiency and energy productivity, respectively. Regarding conservation tillage advantages (soil moisture maintenance and energy saving), for sunflower production (dryland), it may be recommended that plowing can be replaced by conservation tillage (chisel-packer or no-tillage). Application of conservation tillage for sunflower production compared with moldboard plough, in addition to increase of crop yield, increased energy productivity.

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1. Introduction

In recent decades, the yield of agricultural products has increased with the direct and indirect application of chemical fertilizers, fossil fuels and electricity. Fossil energy inputs in crop production have increased more than 100-fold during the past 75 years (Abdolmaleky *et al.*, 2022; Bolandnazar *et al.*, 2020). About 60% of consumed mechanical energy in agriculture is related to tillage operation. It is very important to pay attention to the application and number of operations of tillage equipment (Chekusov *et al.*, 2022; Mahmoodi and Mohammadi-Nashali, 2007).

It was reported (Hatirli *et al.*, 2006) in turkey, 34.4% of total consumed energy was related to diesel fuel. Results of research in Iran showed that energy efficiency in 1971 was 2.52. In 1987, energy efficiency decreased to 1.32. From 1971-1987, the energy efficiency mean was 1.42 (Bolandnazar *et al.*, 2020; Mehrabi-Boshrabadi and Esmaaeli, 2012). It was compared (Hatirli *et al.*, 2006) different tillage methods (Moldboard plowing, disking, harrowing and minimum tillage) on sunflower yield. It was reported that the maximum (1840kg/ha) and minimum (1360kg/ha) of sunflower yield were related to disking and moldboard plowing, respectively. The efficiency of agricultural practices can be computed in more than one way (Hatirli *et al.*, 2006; Shaban *et al.*, 2015).

Most people have calculated the efficiency of agricultural processes by converting the agricultural production into energy as an output, and only the commercial energy in the form of energy from human, animal, machinery fuel, fertilizer, pesticides and irrigation fuel in the form of petroleum and electricity and energy from seed (Rana *et al.*, 2021). It was reported (Hasan and Ammenberg, 2019) that machinery fuel energy, fertilizer energy, pesticide energy and irrigation

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(petroleum and electricity) energy consumption in the agriculture sector has greatly increased in recent years, and agriculture output increased.

Energy flow is an important component of agricultural ecosystems and many serious environmental problems are related to fossil energy utilization. Many calculations of the energy output/input ratio of different agricultural ecosystems have been made. The main objective of this investigation was to find out the energy efficiency of rainfed sunflower and save agricultural machinery energy.

2. Materials and methods

In this study, the effect of conservation tillage on fuel consumption and sunflower yield in the Kalpoush dryland region of Shahrood was evaluated. The experimental design was RCBD with five replications and four treatments. The treatments were no-tillage (T1), minimum tillage (T2) and two conventional tillage without and with residue gathering (T3 and T4). Sunflower were planted at May and harvested at autumn. In all treatments, Plant protection operations were the same. Human labor, machinery, petroleum, seed, fertilizer and pesticide have been included to estimate the inputs energy.

The energy equivalents of Human labor (1.96MJ/hr), and machinery (497.9MJ/hr) used for the computation have been estimated (Akdemir, 2013). Machinery consumed energy (MJ/ha) calculated by multiplying the operation time (hr/ha) with its corresponding energy equivalent (MJ/hr). The total energy input from fertilizer was calculated from the chemical energy released by the different elements of the fertilizer usage. The energy contributions from the pesticide were also calculated (Hamedani *et al.*, 2011).

In this study, sunflower seed yield was considered as output in the energy estimation. Output energy was calculated by multiplying the sunflower yield with its corresponding energy equivalent (11.8 MJ/kg) (Mehrabi-Boshrabadi and Esmaaeli, 2012).

Energy efficiency, energy productivity, energy intensity and energy gain were calculated based on the energy equivalents of the inputs and output as below:

$$E_e = \frac{E_O}{E_I} \quad (1)$$

Where, Ee = energy efficiency, EO = output energy (MJ/ha) and EI = input energy (MJ/ha).

$$E_p = \frac{Y}{E_I} \quad (2)$$

Where, Ep = energy productivity (MJ/kg), Y = crop yield (kg/ha) and EI = input energy.

$$E_T = \frac{E_I}{Y} \quad (3)$$

Where, ET = energy intensity (kg/MJ), Y = crop yield (kg/ha) and EI = input energy.

$$N_e = E_O - E_I \quad (4)$$

Where, N_e=energy gain (MJ/ha), E_O=output energy (MJ/ha) and E_I = input energy (MJ/ha).

3. Results and discussion

Based on the results, sunflower yield difference was significant among tillage treatments (P<1%). Maximum and minimum sunflower yield were related to reduced tillage (chisel-packer) and conventional tillage with residue gathering no-tillage, respectively (Fig. 1).

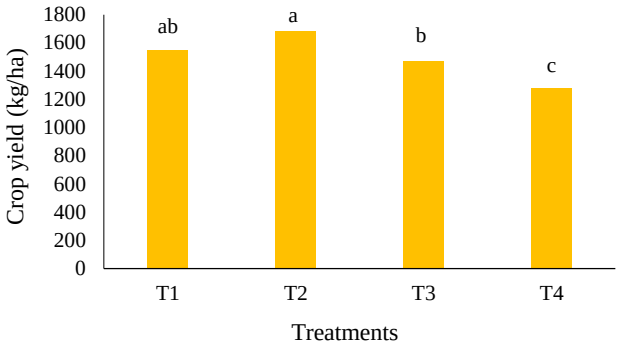

Figure1. Sunflower yield in various tillage treatments.

In this study, all operations and inputs per one hectare of sunflower were measured and converted into the MJ units. The main inputs consisted of fertilizers, pesticides, fuel, machines and seeds (Table 1). Machine operation consists of the highest portion of direct energy inputs and the average direct energy was about 4357 MJ (Table 1). Fertilizer consists of the highest portion of indirect energy inputs and the average indirect energy was about 4238MJ (Table 1).

The average energy output was calculated by converting the sunflower seed yield of one hectare to MJ (Table 2).

Energy efficiency, energy productivity, energy intensity and energy gain have been showed (Table 3). In fact, energy efficiency is energy output per MJ of energy input. Higher value for this ratio indicates higher efficiency of energy consumption. Energy productivity indicates Energy consumption per unit, and how much product is produced.

Table 1. Input energy in one hectare of sunflower.

Source of energy	Unit	Amount per hectare	Energy equivalent (MJ)	Sum of energy (MJ)	Share of Energy consumption (%)
plowing	hr	3	497.9	1493.7	15.6
disking	hr	1.35	497.9	672.2	7.0
Leveler	hr	1.4	497.9	697.06	7.3
planting	hr	1	497.9	497.9	5.2
harvesting	hr	1	497.9	497.9	5.2
Transporting	hr	1	497.9	497.9	5.2
labor	hr	80	1.96	156.8	1.6
seed	kg	8	11.8	94.4	1.0
Nitrogen	kg	50	66.14	3307	34.5
Potassium	kg	50	11.15	557.5	5.8
Phosphorus	kg	30	12.44	373.2	3.9
Pesticide	kg	2	365	730	7.6
Total				9575.53	100.0

Table 2. Sunflower yield (kg/ha) and output energy (MJ) in one hectare.

	(T1)	(T2)	(T3)	(T4)
Yield (kg/ha)	1549	1683	1474	1279
Energy equivalent (MJ/kg)	11.8	11.8	11.8	11.8
Energy output (MJ/ha)	18278.2	19859.4	17393.2	15092.2

Table 3. Energy efficiency in one hectare of sunflower production.

	(T1)	(T2)	(T3)	(T4)
Input energy (MJ/ha)	8754	8405.4	9575.53	9575.53
Output energy (MJ/ha)	18278.2	19859.4	17393.2	15092.2
Energy efficiency	2.09	2.36	1.82	1.58
Energy gain (MJ/ha)	9524.2	11454	7817.67	5516.67
Yield (kg/ha)	1549	1683	1474	1279
Energy productivity (kg/MJ)	0.18	0.20	0.15	0.13
Energy intensity (MJ//kg)	5.65	4.99	6.50	7.49

Maximum and minimum input energy was related to T4 and T2, respectively. Unlike, maximum and minimum sunflower yield were related to T2 and T4, respectively. Thus, the maximum and minimum energy efficiency and productivity were related to T2 and T4.

Higher soil moisture content was the main reason for higher sunflower yield in conservation tillage compared with conventional tillage. Therefore, at a depth of 10-30 cm, the soil moisture content in conservation tillage was 1.5% more than in conventional tillage. It was reported (Liu *et al.*, 2020) similar results like this.

The total energy input in one hectare of rainfed sunflower was 9587MJ (Table 1). The average output energy per hectare was calculated at 17656 MJ. Similar results were reported by other researchers (Sayfi *et al.*, 2010).

The problems of deciding on the appropriate energy ratio and which parameters should be included in the energy flow are primarily political and social. However, in various crop production methods, only regard to crop yield isn't sufficient, but topics of energy and environment should be considered. There are two possible ways of reaching to reduce environmental stress while maintaining adequate sunflower production. First, more production could be allocated for edible oil. The other step is to reduce the fossil energy inputs, especially those related to diesel fuel and

fertilizers application. Similar results were reported by other researchers (Kumar *et al*., 2022).

The energy gain is the output energy from the farm. If the value of farm output energy is less than the amount of energy entering the field, energy is inefficient. According to this information, the average energy gain was 8510 MJ. This value is a high-energy gain. With regard to higher sunflower yield and lower energy consumption in conservation tillage methods, it may be recommended that conventional tillage can be replaced by conservation tillage.

4. Conclusion

Application of conservation tillage, saving energy, reducing soil erosion, and increasing crop production. Application of conservation tillage for sunflower production compared with moldboard plough, in addition to the increase of crop yield, increased energy productivity.

Conflict of interests

The author declares no conflict of interest.

Ethics approval and consent to participate

No humans or animals were used in the present research.

Consent for publications

The author read and approved the final manuscript for publication.

Availability of data and material

All the data are embedded in the manuscript.

Authors' contributions

The author had a role in study design, work, statistical analysis, and manuscript writing.

Informed consent

The author declares not to use any patients in this research.

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