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

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ABSTRACT

Development of cultivation and sustainable production of sunflower is one of the important issues in agriculture. In this research, effect of conservation tillage on energy consumption and sunflower yield in Kalpoush dryland region of Shahrood was studied. An experimental design RCBD with five replications and four treatments 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 at the 0-30cm of Soil depth, moisture content difference was significant. Sunflower yield difference was significant (P<1%). Maximum and minimum of sunflower yield was related to reduced tillage 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 of energy efficiency and energy productivity, respectively. Regarding to conservation tillage advantages (soil moisture maintaining 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.

Keywords: Energy, Soil moisture content, Tillage, Sunflower yield

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 (Haj Seyed Hadi, 2012). About 60% of consumed mechanical energy in agriculture is related to tillage operation. It is very important to take attention to the application and number of operation of tillage equipment's (Mahmoudi and Mohammadi-Nashali, 2007). Hatirli et al., (2006) reported in turkey, 34.4% of total consumed energy was related to diesel fuel. Results of a research in Iran showed that energy efficiency in 1971 was 2.52. In 1987, energy efficiency decreased to 1.32. In 1971-1987, energy efficiency mean was 1.42 (Mehrabi-boshrabadi and Esmaeli, 2011). Bonciarelli (1991) compared different tillage methods (Moldboard plowing, disking, harrowing and minimum tillage) on sunflower yield. He reported that, maximum (1840kg/ha)

and minimum (1360kg/ha) of sunflower yield was related to disking and moldboard plowing, respectively. The efficiency of agricultural practices can be computed in more than one way. Most people have calculated the efficiency of agricultural processes by converting the agricultural production into energy as output, and only the commercial energy in the form of energy from human, animal, machinery fuel, fertilizer, pesticide and irrigation fuel in the form of petroleum and electricity and energy from seed (Iqbal, 2007). Alam and Islam (2005) reported that machinery fuel energy, fertilizer energy, pesticide energy and irrigation (petroleum and electricity) energy consumption in agriculture sector have greatly increased in recent years, and the output of the agriculture increased. Energy flow is an important component of agricultural ecosystems and many serious environmental problems are relates to fossil energy utilization. Many calculation of energy output/input ratio of different agricultural ecosystems have been made and the main objective of this investigation was to find out energy efficiency of rainfed sunflower and saving agriculture machinery energy.

METHODS AND MATERIALS

In this study, the effect of conservation tillage on fuel consumption and sunflower yield in Kalpoush dryland region of Shahrood 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 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), machinery (497.9MJ/hr) used for the computation have been estimated (Almassi *et al*., 2003). 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 element of the fertilizer usage. The energy contributions from the pesticide were also calculated (Mohammadi *et al*., 2008). 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 Esmaeli, 2011).

Energy efficiency, energy productivity, energy intensity and energy gain calculated, based on the energy equivalents of the inputs and output as below (Mohammadi et al., 2008):

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

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).

RESULTS AND DISCUSSIONS

Based on results, sunflower yield difference was significant among tillage treatments (P<1%). Maximum and minimum of sunflower yield was related to reduced tillage (chisel-packer) and conventional tillage with residue gathering no-tillage, respectively (Figure1). Higher soil moisture content, was the main reason of higher sunflower yield in conservation tillage compared with conventional tillage. Therefore, that at the depth of 10-30 cm, soil moisture content in conservation tillage was 1.5% more than conventional tillage. Liu et al., 2020, reported similar results.

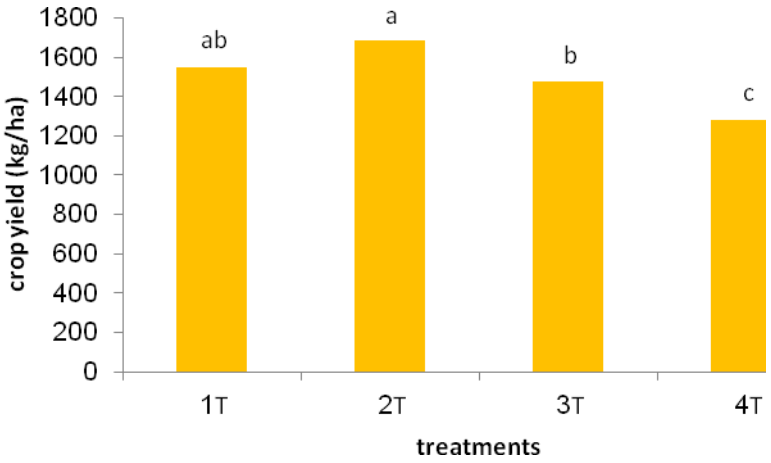

Figure1. Sunflower yield in various tillage treatments

In this study, all operations and inputs per one hectare of sunflower were measured and converted into the MJ units. The main inputs were consisted of fertilizers, pesticides, fuel, machines and seed (Table 1). Machine operation consists the highest portion of direct energy inputs and average direct energy was about 4357 MJ (Table 1). Fertilizer consists the highest portion of indirect energy inputs and average indirect energy was about 4238MJ (Table 1). Total energy input in one hectare of rainfed sunflower was 9587MJ (Table 1). Average output energy per hectare calculated 17656 MJ. Similar results reported by other researchers (Sayfi *et al.,* 2010).

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

Average energy output calculated from converting sunflower seed yield of one hectare to MJ (Table 2).

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

Energy efficiency, energy productivity, energy intensity and energy gain has 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, how much product is produced.

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 of input energy was related to T4 and T2, respectively. Unlike, maximum and minimum of sunflower yield was related to T2 and T4, respectively. Thus, maximum and minimum of energy efficiency and energy productivity was related to T2 and T4. 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, so there is energy inefficient. According to this information, average energy gain was 8510 MJ. This value is a high-energy gain. Regard to higher sunflower yield and lower of energy consumption in conservation tillage methods, it may be recommended that conventional tillage can be replaced by conservation tillage.

CONCLUSION

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 of production could be allocated for edible oil. The other step is to reduce the fossil energy inputs specially those related to diesel fuel and fertilizers application. Similar results reported by other researchers (Rahimi-zadeh *et al.,* 1997). Application of conservation tillage in addition to saving energy, reduce soil erosion and increase crop production. 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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