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Study The Effects of Conventional and Low Input Production System on Energy Efficiency of *Silybum marianum* L.

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Abstract**—**Medicinal plants are most suitable crops for ecological production systems because of their role in human health and the aim of sustainable agriculture to improve ecosystem efficiency and its products quality. Calculations include energy output (contents of energy in seed) and energy inputs (consumption of fertilizers, pesticides, labor, machines, fuel and electricity). The ratio of output of the production to inputs is called the energy outputs / inputs ratio or energy efficiency. One way to quantify essential parts of agricultural development is the energy flow method. The output / input energy ratio is proposed as the most comprehensive single factor in pursuing the objective of sustainability. *Sylibum marianum* L. is one of the most important medicinal plants in Iran and has effective role on health of growing population in Iran. The objective of this investigation was to find out energy efficiency in conventional and low input production system of Milk thistle. This investigation was carried out in the spring of 2005 – 2007 in the Research Station of Rangelands in Hamand - Damavand region of IRAN. This experiment was done in split-split plot based on randomized complete block design with 3 replications. Treatments were 2 production systems (Conventional and Low input system) in the main plots, 3 planting time (25 of March, 4 and 14 of April) in the sub plots and 2 seed types (Improved and Native of Khoozestan) in the sub-sub plots. Results showed that in conventional production system energy efficiency, because of higher inputs and less seed yield, was less than low input production system. Seed yield was 1199.5 and 1888 kg/ha in conventional and low input systems, respectively. Total energy inputs and out puts for conventional system was 10068544.5 and 7060515.9 kcal. These amounts for low input system were 9533885.6 and 11113191.8 kcal. Results showed that energy efficiency for seed production in conventional and low input system was 0.7 and 1.16, respectively. So, milk thistle seed production in low input system has 39.6 percent higher energy efficiency than conventional production system. Also, higher energy efficiency were found in sooner planting time (25 of March) and native seed of Khoozestan.

Keywords**—** energy efficiency, milk thistle, production system.

I. Introduction

SUSTAINABLE development is defined as development that meets the needs of present without compromising the ability of future generation to meet their own needs [12].

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Agricultural production sustainability is a complex concept embracing issues relating to the biophysical, social and economic environment. The meaning of sustainability is strongly dependent on the context in which it is applied and on whether its use is based on a social, economic or a ecological perspective [4].

Energy analysis of agricultural ecosystems seems to be a promising approach to investigate and assess environmental problems and their relations to sustainability [5]. The predominant feature for increasing crop production is use of large amount of energy either directly or indirectly in the form of oil and electricity and fertilizers. Fossil energy inputs in corn production have increased more than 100-fold during the past 75 years [5]. There is worldwide trend towards increasing consumption of fossil energy in the production of necessary foodstuffs and this is the main reason for the increase in yield per hectare. This energy use creates two problems related to agricultural sustainability. First, fossil energy is a limited resource and will eventually be exhausted. The other problem is that serious environmental impacts are related to energy use such as acidification, higher level of CO2, eutrophication, loss of biodiversity, soil losses, mining of water, and pollution [7], [12], [13]. *Sylibum marianum* L. is one of the most important medicinal plants and has effective role on health of growing population in Iran. Milk thistle is one of the most important medicinal crops in Iran and due its role on health of growing population, area under cultivation and its yield is increasing rapidly [2]. There has been increasing use of fertilizers, chemical pesticides to increase seed yield per hectare [13].

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 [5], [3], [8] and the main objective of this investigation was to find out energy efficiency in conventional and low input production system of Milk thistle.

II. Methods and Materials

This investigation was carried out in the spring of 2005 – 2007 in the Research Station of Rangelands in Hamand - Damavand region of IRAN. This experiment was done in split-split plot based on randomized complete block design with 3 replications. Treatments were 2 production systems (Conventional and Low input system) in the main plots, 3 planting time (25 of March, 4 and 14 of April) in the sub plots

and 2 seed types (Improved and Native of Khoozestan) in the sub-sub plots. In this study all operations and inputs per one hectare of milk thistle were measured and converted into the calories units [1]. The main inputs were consisted of: fertilizers, pesticides, fungicides, herbicides, fuel, machines, electricity and seed (table 1). Average energy output calculated from converting seed yield of one hectare to calories.

For calculating input energies, following formula were used:

$$Effective\ Capacity\ of\ Plough = \frac{Width(m) \times speed(km/hr) \times efficiency}{1000} \quad (1)$$

Width of plough area is 90 cm and its speed of ploughing is 4.5 km per hour. Efficiency of machines for plough is 70 percent. Then:

$$Effective\ Capacity\ of\ Plough = \frac{0.90 \times 4.5 \times 70}{1000} = 0.28\ ha/hr$$

Power of tractors is 65-horse power then fuel consumption is calculated as:

PTO (HP) x 0.06 x 0.73 x 40 = 65 x 0.06 x 0.73 x 4 = 11.4 lit/hr

$$Effective\ Capacity\ of\ Disk = \frac{2 \times 6 \times 75}{1000} = 0.9\ ha/hr \quad (2)$$

30 kg seed were used for planting in one hectare. Each kilogram of seed will produce 5886 kcal after putting them into the caloric bomb. Then, we entered 17580 kcal to one hectare. According to the type of fertilizer, the amount of energy varies. One hg N, P2O5 and K2O fertilizers are produced 17600, 3190 and 2116 kcal. Herbicide, water energies and other converting values for inputs were obtained from [7]. Energy output is calculated by converting seed yield in each production systems to calories. As it is mentioned, each kg of seed will produce 5886 kcal.

III. Results

Results showed that in conventional production system energy efficiency, because of higher inputs and less seed yield, was less than low input production system. Seed yield was 1199.5 and 1888 kg/ha in conventional and low input systems, respectively. Total energy inputs and out puts for conventional system was 10068544.5 and 7060515.9 kcal. These amounts for low input system were 9533885.6 and 11113191.8 kcal. Kipper et al (1995) found that energy inputs by fertilizers in low input systems is 26 to 50 percent less than high input production system[7]. In another research, energy inputs by chemical fertilizers for corn production was 10163, 7427 and 1256 and for wheat production was 6323, 3162 and 1193 M Jul/ha for high input, low input and organic production systems, respectively [14]. Results showed that energy efficiency for seed production in conventional and low input system was 0.7 and 1.16, respectively. So, milk thistle seed production in low input system has 39.6 percent higher energy efficiency than conventional production system. Nguyan and Heyner (1995) indicated that energy efficiency in organic systems was more than conventional system [10]. Other researchers have found the same results ([9], [11]. Also, higher energy efficiency was found in sooner planting time (25 of March) and native seed of Khoozestan.

TABLE I
ENERGY INPUTS IN ONE HECTARE OF MILK THISTLE PRODUCTION

inputs	Conventional system	Low input system
Ploughing	3.6 hour	3.6 hour
Disk	1 hour	1 hour
Seed	30 kg	30 kg
Phosphate	150 kg	75 kg
Potassium	100 kg	50 kg
Nitrogen	200 kg	100 kg
Manure	-	15 ton
Labor	311.2 hour	484.2 hour
Herbicide	1 liters	-
Water	9500 m3	9500 m^3

TABLE II
DIRECT ENERGY INPUTS IN ONE HECTARE OF MILK THISTLE (KCAL)

Inputs	Conventional system			Low input system		
	Total hour	Fuel consumed	Energy consumed	Total hour	Fuel consumed	Energy consumed
Plough	3.6	43.2	493084.8	3.6	43.2	493084.8
Disk	1	12	136968	1	12	136968
Fertilizers	0.48	5.76	65744.64	0.24	2.88	32872.3
Planting	2	24	273936	2	24	273936
Spraying	1	12	136960	-	-	
Manure scattering	-	-		6	72	821808
Labor	311.2	-	144110.25	484.2	-	224213.7
Irrigation	70	-	6328572.	70	-	6328572.

TABLE III
INDIRECT ENERGY INPUTS IN ONE HECTARE OF MILK THISTLE (KCAL)

Inputs	Conventional system			Low input system		
	Kg/ha	Kcal/unit	Total	Kg/ha	Kcal/unit	Total
Seed	30	5886	17580	30	5886	17580
Phosphorous	150	3190	478500	75	3190	239250
Nitrogen	200	14700	2940000	50	14700	735000
Potassium	100	2116	211600	100	2116	211600
Herbicide	1	99910	99910	-	-	-
Manure	-	-	-	15 ton	1400	21000

TABLE IV
MILK THISTLE SEED YIELD (KG/HA) AND ENERGY OUTPUT (KCAL) IN ONE-HECTARE

	Conventional system	Low input system
Yield	1199.5	1888
Output	7060515.9	11113191.8

TABLE V
ENERGY EFFICIENCY IN ONE HECTARE OF MILK THISTLE PRODUCTION

	Conventional system	Low input system
Energy input	10068544.5	9533885.6
Energy output	7060515.9	11113191.8
Energy efficiency	0.7	1.16

IV. 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, a situation where the energy output in human foods equals the amount of fossil energy spent in producing it, does not seem to be ecologically sustainable [12].

There are two possible ways of reaching to reduce environmental stress while maintaining adequate seed yield. First, using appropriate production system and second, reducing the fossil energy input especially that related to fertilizers application [8]. The advantage of an energy output / input ratio approach is that farmers can maintain high degree of free choice in production while society obtains a more ecologically sustainable agriculture. In theory, it would be possible to reduce the use of fossil energy and close the nutrient circle because the farmers would realize an individual profit by partly replacing fertilizers and would still be able to produce a considerable amount of human food.

An increased energy output / input ratio provides the most comprehensive single factor in pursuing sustainable agriculture which might be acceptable to milk thistle farmers in Iran.

Results of this investigation showed that energy efficiency or energy output / input ratio decreased in response to higher energy application. It means sustainable production systems have higher energy efficiency.

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