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Study of energy utilization pattern under different weed management practices in onion crop of Chhattisgarh

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Abstract
Energy utilization pattern is the vital characteristic for successful crop production. The aim of this study is to determine the energy input and output analysis of onion under different weed management practices has been studied at the Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur (C.G.). Energy values were calculated by multiplying the amounts of inputs and outputs by their energy equivalents with the use of related conversion factors. The output/input ratio was determined by dividing the output value by the input. The highest bulb yield (28.33 and 25.33 t/ha) and energy output (mean 43728 MJ/ha) were registered with the stale seed bed followed by pre-emergence application of pendimethalin 750 g/ha during the year 2018-19 and 2019-20. It was also found that the pre-emergence application of oxyfluorfen 120 g/ha could be very effective in terms of energy efficiency (2.02 MJ/ha/day) and energy productivity (1.26 kg/MJ) among the different weed management practices.

Keywords: Energy utilization pattern, weed management practices, onion crop

Introduction
In the field of agriculture, energy is embodied in all of the equipment, inputs, and products. Agriculture both uses and supplies energy in the form of bioenergy and food. The amount of energy used in agriculture has grown substantially, and currently, the agri-food chain accounts for 30 percent of the total energy used around the world (Vourdoubas *et al.*). Power is mainly required for tillage, irrigation, harvesting and threshing etc. Increase in the productivity requires additional mechanical and as well as electrical power. Thus, energy input is one of the key factors for successful crop production. The production of crops with high yield targets can be accomplished with higher energy inputs to the system. Current agricultural systems are heavily dependent on fossil energy resources. Energy analysis allows the quantification of the amounts of energy used for agricultural production and can be used to optimize energy consumption and increase energy efficiency to move agriculture closer towards sustainability.
Energy conservation and effective utilization of available resources is of major concern for every economic activity. Energy utilization pattern is a key development indicator in any sector in the current scenario. The worldwide energy crisis caused by fuel shortage and high prices of petroleum has adversely affected the world economy. In order to mitigate the hardship, it is necessary to conserve utilize non renewable energy sources wherever possible, failing which; make efficient use of available conventional energy sources. Energy input-output analysis is usually used to evaluate the efficiency and environmental impacts of production systems. This analysis is important to perform necessary improvements that will lead to a more efficient and environment-friendly production system (Ozkan *et al.*, 2003, 2004) [5, 6].
Energy requirements for crop production system have been witnessing a dramatic diversification in agriculture (Dhaliwal and Kler, 1995) [2]. Agricultural intensification requires more energy and energy input pattern for crop production depends on economic, technological and social constraints. Commercial and non-commercial energy are available for agricultural operations. Commercial energy inputs arrive on farm in many different forms, e.g. fuel, irrigation water, chemical fertilizer, machinery and pesticides (Khan and Hussain, 2007) [3]. Among field crops, legumes require less energy input than cereals and oilseeds.

Onion (*Allium cepa* L.) is a short duration and quick growing crop having various uses such as vegetables, spices and medicinal. It is commonly called as "Queen of kitchen" for its unique usage throughout the year in the form of salads, condiments or for cooking with other vegetables. It is used as best remedy against sunstroke during summer. It is also helpful in fever, dropsy, catarrh and chronic bronchitis. The green leaves and immature and mature bulbs are eaten as raw or used for preparing chutneys, pickles, curries, soups, sauces and seasoning of foods. Now a days, dehydrated bulbs or onion powder is in great demand, which reduces transport cost and storage losses.

India is the large producer of onion as compared to other bulb crops and grown in an area of 1284.99 thousand hectare with production of 23262.33 thousand MT and productivity of 18.10 million tonne ha^{-1}. In Chhattisgarh, onion is generally grown as *rabi* crop after rice and its sowing is dependent on *kharif* season harvesting. In Chhattisgarh, onion crop is cultivated in an area of 25.54 thousand hectares with a production of 421.21 thousand MT, and productivity is 16.49 million tonne ha^{-1}.

Energy use analysis in production agriculture is essential for development of more efficient production systems. Looking to the problem of weeds and also to study the energy utilization pattern, a field experiment was conducted with five weed management treatments in onion crop.

Material and Methods

The experiment was conducted at IGKV, Raipur (C.G.) during *rabi* 2018-19 and 2019-20 to analyse the energy requirements and output of onion crop under different weed management practices in Chhattisgarh. The experiment was carried out in randomized block design with five treatments replicated four times. The treatments involved (T_1) pre-emergence application of oxyfluorfen 120 g/ha, (T_2) pre-emergence application of oxadiargyl 90 g/ha, (T_3) Stale seed bed followed by pendimethalin 750 g/ha, (T_4) post-emergence application of imazethapyr 75g/ha and (T_5) weedy check.

The energy use values were determined by multiplying by the associated energy equivalents/coefficients. Energy values for various input and outputs used in the experimentation are given in Table 1 (Singh and Mittal, 1992) [7]. The total energy input for a given crop was calculated by adding the energy requirement for human labour, diesel, herbicides, seed and fertilizers used, in that sequence.

The output: input ratio was worked out by dividing the total energy generated from main product and by- product by the total energy used for raising the crop in a unit area. The energy input and output were computed as Mega Joule (MJ) by using different formulae. The energy efficiency (EE) was worked out as per Dazhong and Pimental (1984) [1].

$$EE = \frac{\text{Energy output (MJ/ha)}}{\text{Energy input (MJ/ha)}}$$

Energy output efficiency (MJ/ha/day) and energy productivity were calculated by:

$$\text{Energy output efficiency} = \frac{\text{Energy output (MJ/ha)}}{\text{Duration of the system (days)}}$$

$$\text{Energy productivity} = \frac{\text{Yield (kg/ha)}}{\text{Energy input (MJ/ha)}}$$

Results and Discussion

Energy input in onion production

Energy inputs for onion as required in different weed management practices under the study was ranged between 23430.75 to 18007.75 MJ/ha. Under fixed energy for all treatments, irrigation accounted for a major share of energy input (34.5%), followed by fertilizer (33%), harvesting (12.24%), field preparation (12.1%) and seed sowing (8.16%). The energy input through herbicides (32.54 MJ) was minimum under oxadiargyl 90 g/ha. The highest energy input was recorded in the treatment of stale seed bed followed by pendimethalin 750 g/ha.

Table 1: Equivalents for various sources of energy

Inputs	Units	Equivalent energy (MJ)
Human labour	Man-hour	1.96 Mittal *et al*, 1985 [4]
Diesel (3.5 lit/hours)	litre	56.31 Mittal *et al*, 1985 [4]
Cultivator	hr^{-1}	220.00 Mittal *et al*, 1985 [4]
Seeder	ha^{-1}	338.83
Berseem (legume)	kg	14.7 Mittal *et al*, 1985 [4]
Chemical fertilizer		
N	kg	60.60 Mittal *et al*, 1985 [4]
P_2O_5	kg	11.10 Mittal *et al*, 1985 [4]
K_2O	kg	6.70 Mittal *et al*, 1985 [4]
Irrigation (each 7.5 cm); irrigation requires 10 hr/ha and irrigation pump is of 15 hp		
(i) Man	Man-hour	1.96
(ii) Electricity	KWh	11.93/hours
(iii) Submersible pump	HP	68.4/hp
Herbicide	kg a.i	288

Productivity of onion crop under different weed management practices

In case of bulb yield, highest (mean 27.33 t/ha) and lowest (mean 1.01 t/ha) value was obtained under the stale seed bed followed by pre-emergence application of pendimethalin 750 g/ha and post-emergence application of imazethapyr 75 g/ha (T_4), respectively during both the years. This is due to stale seed bed condition and pre emergence application of herbicides providing weed free condition offered a favorable environment to crops from weeds for light, nutrients and moisture. This results in increased crop growth and thus increases in bulb yield. Whereas, imazethapyr (PoE) 75 g/ha (T_4) and (T_2) PE application of oxadiargyl 90 g/ha showed phytotoxicity in onion crop.

Energy output of onion crop under different weed management practices

Total energy output was computed from bulb yield of different weed management practices and it ranged from 1616 to 43728 MJ/ha as per two years production (Table 2). The mean of 2 years revealed that the highest total energy output was obtained from application of stale seed bed followed by pendimethalin 750 g/ha PE. The lowest energy output was obtained from imazethapyr (PoE) 75 g/ha.

Energy-output efficiency and energy productivity

It was observed that stale seed bed followed by pre-emergence application of pendimethalin 750 g/ha resulted in the highest energy output efficiency (335.76 & 312.06 MJ/ ha/day), for both the years. However, post-emergence application of imazethapyr 75 g/ha was less efficient in energy output efficiency (12.09 & 11.85 MJ/ha/day) as compared to other weed management practices. Maximum energy productivity was obtained in stale seed bed followed by pre-emergence application of pendimethalin 750 g/ha might be due to its higher bulb yield.

Table 2: Input energy calculation for onion crop under different weed management practices in Chhattisgarh

Particulars	Unit required		Total energy (MJ)
Field preparation tractor	per ha		
2 Ploughing + 1 planking	5 hours		1100.00
Diesel consumption	3.5 lit/ha		985.25
Driver	5 hours		98.00
	Sub total		2177.25
Seed and sowing			
Onion	10 kg		147.0
Seed bed	2 labours		98.0
Planting	25 labours		1225.0
	Sub total		1470.0
Fertilizer			
Nitrogen 80 kg/ha	60.60/kg		4848.0
P_2O_5 50 kg/ha	11.10		555.0
K_2O 80 kg/ha	6.7		536.0
	Sub total		5939.0
Irrigation			
Labour	2 per irrigation		98.00
Electricity	11.93/hours		119.30
Submersible pump (15hp)	68.4/hp (10 hours/irrigation)		1026.00
	Sub total		1243.3
(Total 5 irrigations)			6216.5
Forage cutting			
Harvesting and transporting	45 labours		2205
	Sub total		2205.00
	Grand total		18007.75
Herbicide application	2 labours per application		98
	a.i.	Product	
1. Stale seed bed followed by pendimethalin (PE)	750 g/ha	2500 g/ha	5383.8 (two times preparation for SB 4663.85)
2. Oxyfluorfen (PE)	120 g/ha	511 g/ha	147.2
3 Oxadiargyl (PE)	90 g/ha	112.5 g/ha	32.54
4. Imazethapyr (PoE)	75g/ha	750 g/ha	216

Table 3: Energy input requirement and output in onion crop under different weed management practices in Chhattisgarh

Treatment	Bulb yield (t/ha)		Energy (MJ/ha)			
			Input		Output	
	2018-19	2019-20	Treatment	Total	2018-19	2019-20
Stale seed bed followed by pendimethalin 750 g/ha (PE)	28.33	26.33	5481.8	23430.75	45328	42128
Oxyfluorfen 120 g/ha (PE)	23.69	22.13	245.2	18194.15	37904	35408
Oxadiargyl 90 g/ha (PE)	10.18	9.89	130.54	18079.49	16288	15824
Imazethapyr 75 g/ha (PoE)	1.02	1.00	314	18262.95	1632	1600
Weedy check	3.63	3.25	0	18007.75	5808	5200

Table 4: Energy efficiency, energy output efficiency and energy productivity by onion crop under different weed management practices in Chhattisgarh

Treatment	Energy efficiency (MJ/ha/day)		Energy output efficiency (MJ/ha/day)		Energy productivity (kg/MJ)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Stale seed bed followed by pendimethalin 750 g/ha (PE)	1.93	1.80	335.76	312.06	1.21	1.12
Oxyfluorfen 120 g/ha (PE)	2.08	1.95	280.77	262.28	1.30	1.22
Oxadiargyl 90 g/ha (PE)	0.90	0.88	120.65	117.21	0.56	0.55
Imazethapyr 75 g/ha (PoE)	0.09	0.09	12.09	11.85	0.06	0.05
Weedy check	0.32	0.29	43.02	38.52	0.20	0.18

Conclusion

Based on the experiments conducted as detailed above, it is observed that stale seed bed followed by pre-emergence application of pendimethalin 750 g/ha produced the highest energy output efficiency (335.76 & 312.06 MJ/ ha/day), for both the years. However, post-emergence application of imazethapyr (PoE) 75 g/ha was found to be less efficient in energy output efficiency (12.09 & 11.85 MJ/ha/day) as compared to other weed management practices. It was further noticed that the maximum energy productivity obtained for stale seed bed followed by pre-emergence application of pendimethalin 750 g/ha might be due to its higher bulb yield (28.33 and 26.33 t/ha). On the basis of this study, it is concluded that the stale seed bed followed by pre-emergence application of pendimethalin 750 g/ha may be a competent weed control option to produce more bulb yield and energy productivity under different weed management practices in Chhattisgarh. It can also be concluded from the research output that proper management of resources and their application at the right time can improve efficiency in the use of farm inputs.

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