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Effect of different herbicide based weed management practices on energy analysis of rice crop in Chhattisgarh

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Abstract
Energy utilization pattern is the vital characteristic for successful crop production. In the present paper energy analysis of rice under herbicide- based weed management practices has been studied at 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 grain yield (5.04 and 4.63 t/ha) and energy output (mean 143074.5 MJ/ha) were registered with the penoxsulam + cyhalofop-butyl 135 g/ha PoE during the year 2019 and 2020. It was also found that the application of post-emergence penoxsulam + cyhalofop-butyl 135 g/ha could be a very effective in terms of energy efficiency (12.82 MJ/ha/day) and energy productivity (0.43 g/MJ) among the herbicide- based weed management practices.

Keywords: Herbicide based weed, energy analysis, rice crop

Introduction

In the field of agriculture, energy utilization can be seen in all the farm practices including the use of farm equipment, application of irrigation and pesticides, transportation and food processing. Obviously, this entails the farmer to increase power availability to increase the productivity in the farm. 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.

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 requirements for crop production system have been witnessing a dramatic diversification in agriculture. Agricultural intensification requires more energy and energy input pattern for crop production depends on economic, technological and social constraints. Commercial and noncommercial 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) [4].

Rice (*Oryza sativa* L.) is a monocot type plant of the Oryza genus under the Poaceae family. Rice is the world's most extensively grown crop and the primary staple food of over 60 percent of the world's population. Under diversified conditions, rice occupies a major role among food crops. Approximately 90% of the world's rice is produced and consumed in Asia. The world's total rice area is 167.0 mha and production is about 769.6 mt with productivity of 4.6 t per ha however, as per as estimate, about 40% of rice yield lost due to various pest, of which weeds have the most potential for loss as 32%. Because of the prevalence of congenial environment during the kharif season weeds posed a big problem in rice production.

Direct seeded rice (DSR) provides a good crop establishment as well as good yield potential if adequately kept under weed free environment (Rao *et al*. 2007) [9]. On the other hand, rice yield reduced by 35-100 per cent in direct seeded rice in the absence of proper weed control

(Kumar *et al*., 2008) [6]. In Chhattisgarh, area under direct seeded rice is increasing considerably due to availability of new seeding implements, use of pre emergence herbicide and non availability of labour during transplanting. DSR also gives higher yield with less cost of cultivation. However energy use analysis in production agriculture is essential for development of more efficient production systems.

Materials and Methods

The experiment was conducted at the IGKV, Raipur (C.G.) during *kharif* 2019 and 2020 to analyse the energy requirements and output of rice crop under different herbicide weed management practices in Chhattisgarh. The experiment consisted of 10 treatments replicated 3 times in a randomized block design. The treatments were: pre-emergence application (PE) of pretilachlor 750 g/ha; post-emergence application (PoE) of bispyribac-sodium 25 g/ha, fenoxaprop-p-ethyl 56.25 g/ha PoE; cyhalofop-butyl 80 g/ha PoE; penoxsulam + cyhalofop-butyl (1.02 + 5.1%) (ready-mix) 135 g/ha PoE; penoxsulam 22.5 g/ha PoE; metsulfuron- methyl 20 g/ha PoE; 2,4-D ethyl ester 750 g/ha PoE; weed free by hand weeding thrice at 20, 40 and 60 days after seeding (DAS) and weedy check. The pre- emergence application of pretilachlor was done 3 DAS. The post-emergence application of herbicides was done at 22 days after sowing of rice, except penoxsulam which was applied at 16 DAS.

Energy values for various input and outputs used in the experimentation are given in Table 1 (Singh and Mittal, 1992) [10]. 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 an 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) [3].

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

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 rice production

Energy inputs for rice as required in different herbicide based weed management practices under the study was ranged between 11348.5 to 10547.26 MJ/ha. Under fixed energy for all herbicide treatments, fertilizer accounted for a major share of energy input (68%), followed by seed and sowing (21%), field preparation (9.3%) and harvesting (1.6%). The energy input through herbicides (126.8 MJ) was minimum under penoxsulam 22.5 g/ha. The highest energy input was recorded in the treatment of hand weeding followed by penoxsulam + cyhalofop-butyl 135 g/ha.

Table 1: Equivalents for various sources of energy

Particulars Inputs (MJ)	Units	Equivalent energy MJ
Human labour	Man-hour	1.96 Mittal *et al*, 1985 [7]
Diesel (3.5 lit/hours)	Litre	56.31 Venturi & Vanturi 2003 [11]
Cultivator	hr^{-1}	220.00 Dagistant *et al*, 2009, Mittal *et al*, 1985 [2, 7]
Seeder	ha^{-1}	338.83
Harvester	hr^{-1}	151.64 MJ/ha Putri R E (2020) [8].
Rice	kg	14.7 Singh and Mittal 1992 [10]
Straw	kg	12.5 Yadav *et al*, 2013 [12]
Chemical fertilizer		
N	Kg	60.60 Baishya & Sharma
P_2O_5	Kg	11.10 Baishya & Sharma 1990 [1]
K_2O	Kg	6.70 Mittal *et al*, 1985 [7]
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 Kitani 1999

Energy output of rice crop under different herbicide based weed management practices

Total energy output was computed from grain yield of different herbicide based weed management practices and it ranged from 136018 to 143074.5 MJ/ha as per two years production (Table 4). The mean of 2 years revealed that the highest total energy output was obtained from application of penoxsulam + cyhalofop-butyl 135 g/ha PoE.

Energy-output efficiency and energy productivity

Among the herbicide treatments it was observed that application of penoxsulam+ cyhalofop-butyl 135 g/ha PoE resulted in the highest energy output efficiency (1142.98 & 1091.79MJ/ ha/day), for both the years. However, cyhalofop butyl 80 g/ha was less efficient in energy output efficiency (877.95 & 562.40 MJ/ha/day), as compared to other herbicide based weed management practices. Maximum energy productivity was obtained in penoxsulam + cyhalofop-butyl 135 g/ha might be due to its higher grain yield.

Table 2: Calculation of input energy for rice crop under different herbicide based weed management practices in Chhattisgarh

Particulars	Unit required		Total energy MJ
Field preparation tractor	per ha		
2 Ploughing	4 hours		880
Diesel consumption	3.5 lit/ha		14
Driver	4 hours		78.4
	Sub total		975.9
Seed and sowing			
Rice	100 kg		147.0
Seed drill	2 hour		377.66
Diesel consumption	3.5 lit/ha		1225.0
Driver	2 hour		39.2
	Sub total		2193.86
Fertilizer			
Nitrogen 80 kg/ha	60.60/kg		6060
P_2O_5 50 kg/ha	11.10		666
K_2O 80 kg/ha	6.7		268
Split application			
Labour	2		98
	Sub total		7092
Harvester 1 hour	151.64 / hours		151.64
Driver	1.96 /hours		19.6
	Sub total		171.24
	Grand total		10429.5
Treatment Herbicide application	2 Labours per application		98
	a.i.	Product	
Pretilachlor	750 g/ha	1500 g/ha	530
Bispyribac sodium	25 g/ha	250 g/ha	170
Fenoxaprop-p-ethyl	56.25 g/ha	600 g/ha	270.8
Cyhalofop Butyl	80 g/ha	800 g/ha	328.4
Penoxsulam + Cyhalofop	235 g/ha	2205 g/ha	733.04
Penoxsulam	22.5 g/ha	100 g/ha	126.8
Metsulfuron methyl	4 g/ha	20 g/ha	103.76
2,4-D Ethyl Ester	750 g/ha	1290 g/ha	469.52
Hand weeding		38 labour	1862

Table 3: Grain yield, straw yield and energy input requirement in rice crop under different herbicide based weed management practices in Chhattisgarh

Treatment	Grain yield (t/ha)		Straw yield (t/ha)		Input Energy (MJ/ha)	
	2019	2020	2019	2020	Treatment	Total
Pretilachlor 750 g ha^{-1} PE	3.83	2.94	4.99	4.45	530.00	10959.50
Bispyribac sodium 25 g ha^{-1} PoE	4.63	4.25	5.84	5.38	170.00	10599.50
Fenoxaprop-p-ethyl 56.25 g ha^{-1} PoE	3.74	2.29	4.95	3.53	270.80	10700.30
Cyhalofop Butyl 80 g ha^{-1} PoE	3.64	2.04	4.85	3.27	328.40	10757.90
Penoxsulam + Cyhalofop 135 g ha^{-1} PoE	5.04	4.63	5.96	5.56	733.40	11162.90
Penoxsulam 22.5 g ha^{-1} PoE	4.65	4.14	5.85	5.31	126.80	10556.30
Metsulfuron methyl 4 g ha^{-1} PoE	3.96	3.56	5.12	4.73	103.76	10533.26
2,4-D Ethyl Ester 750 g ha^{-1} PoE	4.04	4.00	5.15	5.14	469.52	10899.02
hand weeding 38 labour ha^{-1}	5.08	4.98	6.00	5.92	1862.00	12291.50
weedy check	1.78	1.94	2.96	2.13	-	11348.5

Table 4: Energy output in rice crop under different herbicide based weed management practices in Chhattisgarh

Treatment	Output energy (MJ/ha)					
	Grain yield		Straw yield		Total output	
	2019	2020	2019	2020	2019	2020
Pretilachlor 750 g ha^{-1} PE	56301	43218	62375	55625	118676	98843
Bispyribac sodium 25 g ha^{-1} PoE	68061	62475	73000	67250	141061	129725
Fenoxaprop-p-ethyl 56.25 g ha^{-1} PoE	54978	33663	61875	44125	116853	77788
Cyhalofop Butyl 80 g ha^{-1} PoE	53508	29988	60625	40875	114133	70863
Penoxsulam + Cyhalofop 135 g ha^{-1} PoE	74088	68061	74500	69500	148588	137561
Penoxsulam 22.5 g ha^{-1} PoE	68355	60858	73125	66375	141480	127233
Metsulfuron methyl 4 g ha^{-1} PoE	58212	52332	64000	59125	122212	111457
2,4-D Ethyl Ester 750 g ha^{-1} PoE	59388	58800	64375	64250	123763	123050
hand weeding 38 labour ha^{-1}	74676	73206	75000	74000	149676	147206
weedy check	26166	13818	37000	26625	63166	40443
Note - Equivalent Energy (MJ) for rice grain = 14.7 /kg and straw = 12.5/kg						

Table 5: Energy efficiency, energy output efficiency and energy productivity by rice crop under different herbicide based weed management practices in Chhattisgarh

Treatment	Energy efficiency (MJ/ha/day)		Energy output efficiency (MJ/ha/day)		Energy productivity (Kg/MJ)	
	2019	2020	2019	2020	2019	2020
Pretilachlor 750 g ha^{-1} PE	10.83	9.02	912.89	784.47	0.35	0.27
Bispyribac sodium 25 g ha^{-1} PoE	13.31	12.24	1085.08	1029.56	0.44	0.40
Fenoxaprop-p-ethyl 56.25 g ha^{-1} PoE	10.92	7.27	898.87	617.37	0.35	0.21
Cyhalofop Butyl 80 g ha^{-1} PoE	10.61	6.59	877.95	562.40	0.34	0.19
Penoxsulam + Cyhalofop 135 g ha^{-1} PoE	13.31	12.32	1142.98	1091.75	0.45	0.41
Penoxsulam 22.5 g ha^{-1} PoE	13.40	12.05	1088.31	1009.79	0.44	0.39
Metsulfuron methyl 4 g ha^{-1} PoE	11.60	10.58	940.09	884.58	0.38	0.34
2,4-D Ethyl Ester 750 g ha^{-1} PoE	11.36	11.29	952.02	976.59	0.37	0.37
hand weeding 38 labour ha^{-1}	12.18	11.98	1151.35	1168.30	0.41	0.41
weedy check	5.57	3.56	485.89	320.98	0.16	0.17

Conclusion

Based on the experiments conducted as detailed above, it is observed that among the herbicide treatments penoxsulam + cyhalofop-butyl 135 g/ha produced the highest energy output efficiency (1142.98 & 1091.79MJ/ ha/day), for both the years. However, application of cyhalofop butyl 80 g/ha, was found to be less efficient in energy output efficiency (877.95 & 562.40 MJ/ha/day) as compared to other herbicides weed management practices. It was further noticed that the maximum energy productivity obtained for penoxsulam + cyhalofop-butyl 135 g/ha PoE might be due to its higher grain yield (5.04 and 4.63 t/ha). On the basis of this study, it is concluded that the penoxsulam + cyhalofop-butyl 135 g/ha may be a competent weed control option to produce more grain yield and energy productivity under different herbicides based 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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