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EVALUATING THE IMPACT OF WEED MANAGEMENT PRACTICES ON ENERGY BUDGETING IN RAINFED CASTOR

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ABSTRACT

A field experiment was done at Regional Agricultural Research Station (RARS), Palem during *kharif*, 2023 to evaluate the different weed management practices on energy budgeting in rainfed castor. The experiment was carried out in randomized block design with nine treatments and three replications. The results of the study revealed that higher input energy (10169 MJ ha^{-1}), output energy (70868 MJ ha^{-1}) and net energy (60699 MJ ha^{-1}) was obtained with weed free (Hand weedings) but the higher energy use efficiency (7.2) and energy productivity (0.54 kg MJ^{-1}) was recorded in case of treatment with - diclosulam 84 % WDG 31 g *a.i.* ha^{-1} as PE *fb* quizalofop-p-ethyl 15 % EC 50 g *a.i.* ha^{-1} as PoE at 30 DAS (T_1) and was on par with diclosulam 84 % WDG 31 g *a.i.* ha^{-1} as PE *fb* intercultivation with power weeder at 30 DAS (T_3).
***Keywords* :** Diclosulam, Energy budgeting, Energy input, Energy output, Energy use efficiency

Introduction

Castor (*Ricinus communis* L.) an important non-edible oilseed crop primarily grown in two different production environments in India, the highly irrigated areas of North West India and the rainfed regions of the Southern Peninsula (includes Telangana). Due to its high market value, relatively low production costs, climate resilience and drought tolerance nature castor is an attractive option for small and marginal rainfed farmers looking to incorporate it into their cropping systems (Kumar and Yamanura, 2019; Ramanjaneyulu *et al.*, 2013). Weeds are the prime factors for lower castor productivity particularly in rainfed systems where resource limitations can significantly affect crop performance. The losses due to the weeds in castor reaches 70 to 80 percent if not controlled during critical period of 40 to 60 days after sowing (Dungarwal *et al.*, 2002). Usually, farmers of rainfed regions utilize hand weedings and intercultivation with cattle drawn implements for weed control which consumes higher energy, economics and makes them non profitable. Whereas the herbicides application along with integrated approach have advantages over the existing practices (Imran *et al.*, 2024) Therefore, understanding the effects of various weed management practices on the energy dynamics of rainfed castor cultivation is essential for optimizing resource use and improving overall productivity. Energy budgeting is a vital aspect of sustainable agriculture, as it assesses the energy inputs and outputs associated with crop production. Effective weed control strategies not only enhance crop yield but also contribute to energy savings, which is particularly important in regions where inputs are limited.

Material and Methods

The study was done at Regional Agriculture Research Station (RARS), Palem during kharif, 2023 to evaluate the different weed management practices and its effect on the energy budgeting in castor under rainfed conditions. The experiment was planned with nine treatments which replicated thrice and laid out in the randomized block design. Treatments includes T_1- PE- Diclosulam 84 % WDG - 31 g *a.i.* ha^{-1} *fb* quizalofop-p-ethyl 5% EC - 50 g *a.i.* ha^{-1} as PoE at 30

DAS; T_2- PE- Diclosulam 84 % WDG - 31 g *a.i.* ha^{-1} *fb* direct spraying of glufosinate ammonium 13.5% SL - 375 g *a.i.* ha^{-1} as PoE at 30 DAS; T_3- PE- Diclosulam 84 % WDG - 31 g *a.i.* ha^{-1} *fb* intercultivation with power weeder at 30 DAS; T_4- PE- Pendimethalin 38.7% CS - 677.25 g *a.i.* ha^{-1} *fb* quizalofop-p-ethyl 5% EC - 50 g *a.i.* ha^{-1} as PoE 30 DAS; T_5 - PE- Pendimethalin 38.7% CS - 677.25 g *a.i.* ha^{-1} fb direct spraying of glufosinate ammonium 13.5% SL 375 g *a.i.* ha^{-1} as PoE at 30 DAS; T_6 - PE- Pendimethalin 38.7% CS - 677.25 g *a.i.* ha^{-1} fb intercultivation with power weeder at 30 DAS; T_7 - Intercultivation with power weeder at 20 and 40 DAS; T_8 -Weed free (3 Hand weedings); T_9 - Unweeded check. Crop was sown during the 15th July, 2023 and recommended cultural practices were adopted.

Energy budgeting

To calculate the energetics of castor weed management, a comprehensive inventory of all crop inputs and outputs was prepared. Direct energy inputs comprise the total quantity of fossil fuel used in land preparation, harvesting, human labour and electricity. While indirect energy inputs are, energy used in the production of machinery and raw materials such as mineral fertilizers, pesticides, seed and transportation. A complete inventory of all crop inputs (fertilizers, seeds, plant protection chemicals, fuels, human labour and, machinery power) and outputs of both castor seed and stalk yields were recorded. The energy equivalent of different inputs and output were collected from the literature and they used for determining the energy values for corresponding inputs and outputs (Table -1).

Table 1 : Energy conversion factors used in the present study

Input		Equivalent energy	Reference
Machinery	Tractor	64.8 MJ h^{-1}	Parihar *et al.* (2018)
	Cultivator	22.8 MJ h^{-1}	Dagistan *et al.* (2009)
	Rotavator	20.72 MJ h ^{1}	Devasenapathy *et al.* (2009)
	Sprayer	0.94 MJ h^{-1}	Pimental. (1988)
	Power weeder	64.80 MJ h^{-1}	Devasenapathy *et al.* (2009)
	Thresher	200 MJ h^{-1}	Kitani. (1999)
Inputs	Fuel	56.31	Devasenapathy *et al.* (2009)
	Water	1.02 m^{-3}	Mandal *et al.* (2002)
	Seed	14.7 MJ kg^{-1}	Devasenapathy *et al.* (2009)
Human labour	Men	1.96 MJ h^{-1}	Mittal and Dhawan (1998)
	Women	1.57 MJ h^{-1}	Mittal and Dhawan (1998)
Fertilizers	N	60.6 MJ kg^{-1}	Devasenapathy *et al.* (2009)
	P_2O_5	11.1 MJ kg^{-1}	Devasenapathy *et al.* (2009)
	K_2O	6.7 MJ kg^{-1}	Devasenapathy *et al.* (2009)
Herbicides	Diclosulam	691 MJ kg^{-1} *a.i.*	Green. (1987)
	Pendimethalin	150.9 MJ kg^{-1} *a.i.*	Green. (1987)
	Quizalofop-p-ethyl	518 MJ kg^{-1} *a.i.*	Choudary *et al.* (2017)
	Glufosinate ammonium	454 MJ kg^{-1} *a.i.*	Green. (1987)
	Profenophos	184.63 MJ kg^{-1} *a.i.*	Parihar *et al.* (2018)
Output energy			
Castor seed yield		14.7 MJ kg^{-1}	Devasenapathy *et al.* (2009)
Castor stalk yield		12.5 MJ kg^{-1}	Devasenapathy *et al.* (2009)

Energy indices

Based on energy input and output, the following indices were calculated using the formulas suggested by Mittal and Dhawan (1988) and Burnett (1982):

Net Energy (MJ ha^{-1}) = Total Energy Output (MJ ha^{-1}) - Total Energy Input (MJ ha^{-1})

$$\text{Energy use efficiency} = \frac{\text{Total energy output}}{\text{Total energy input}}$$

$$\text{Energy Productivity (MJ kg}^{-1}\text{)} = \frac{\text{Total yield}}{\text{Total energy input}}$$

These calculations provide valuable insights into the energetics of rainfed castor cultivation under different weed management practices, enabling better decision-making for improving sustainability and productivity.

Table 2 : Common input energy in castor cultivation under rainfed conditions

Inputs	Units	Quantity ha^{-1}	Energy (MJ ha^{-1})
Tractor (Ploughing + spraying + transport)	Hours	8	518.4
Cultivator	Hours	2	45.6
Rotavator	Hours	2	13.4
Sowing	Hours	48	75.4
Fertilizers application (women)	Hours	80	125.6
Insecticide spraying (men)	Hours	16	25.1
Harvesting (women)	Hours	128	201.0
Threshing (women)	Hours	80	125.6
Cleaning & packing (women)	Hours	40	62.8
Seed	Kg	5	73.5
Profenophos	Kg	1.5	277.4
Cattle	Hours	2	30.3
Diesel	Litre	24	1351.4
N	Kg	80	4848
P	Kg	40	444
K	Kg	30	201
Power Thresher	Hours	5	1000
Electricity	Hours	5	59.7
Water for spraying	m^3	1	1.02
Total			**9479.0**

Table 3 : Energy input used for weed management treatments in rainfed castor

Treatment	Dosage (g *a.i.* ha^{-1})	Energy used in herbicide (MJ kg^{-1})	Energy used Spraying (Sprayer + men + women + water)	Energy used in Inter-cultivation with power weeder	Energy used in Hand weedings	Total energy used for treatment
T_1- Diclosulam *fb* quizalofop ethyl	31 + 50	47.3	65.0	-	-	112.3
T_2- Diclosulam *fb* glufosinate ammonium	31 + 375	191.7	65.0	-	-	256.7
T_3- Diclosulam *fb* power weeder	31	21.4	32.5	297.6	-	351.5
T_4- Pendimethalin *fb* quizalofop ethyl	677.25 + 50	128.1	65.0	-	-	193.1
T_5- Pendimethalin *fb* glufosinate ammonium	677.25 + 375	272.5	65.0	-	-	337.5
T_6- Pendimethalin *fb* power weeder	677.25	102.1	32.5	297.6	-	432.2
T_7- Power weeder 20 and 40 DAS	-	-	-	595.2	-	595.2
T_8- Weed free (3 hand weedings)	-	-	-	-	690.8	690.8
T_9- Unweeded check	-	-	-	-	-	-

Results and Discussion

The energy input for common production practices (Table-2) and weed management treatments (Table-3) were summed up to get the total input energy per ha.

Total input energy (MJ ha^{-1})

Among weed management treatments, higher energy input (10169 MJ ha^{-1}) was recorded with weed free (T_8), wherein the higher labour requirement for hand weedings is needed, followed by T_7-intercultivation with power weeder at 20 and 40 DAS (10074 MJ ha^{-1}), T_6- pendimethalin 38.7% CS - 677.25 g *a.i.* ha^{-1} as PE *fb* intercultivation with power weeder at 30 DAS (9911 MJ ha^{-1}), T_3-diclosulam 84 % WDG - 31 g *a.i.* ha^{-1} as PE *fb* intercultivation with power weeder at 30 DAS (9830 MJ ha^{-1}).

The treatments which include hand weeding and mechanical weedings requires higher amount of energy for labour, machinery and fuel than the herbicidal applications.

Total energy output (MJ ha^{-1})

Significantly higher output energy was recorded with T_8- weed free (70868 MJ ha^{-1}) and was on par with T_3- diclosulam 84 % WDG 31 g *a.i.* ha^{-1} as PE *fb* intercultivation with power weeder at 30 DAS (69922 MJ ha^{-1}), T_1- diclosulam 84 % WDG 31 g *a.i.* ha^{-1} as

PE *fb* quizalofop-p-ethyl 15 % EC 50 g *a.i.* ha^{-1} as PoE at 30 DAS (69489 MJ ha^{-1}). This is correspondence to the higher seed yield recorded in these treatments. Whereas the significantly lower energy output was observed in unweeded check (22810 MJ ha^{-1}) due to realizing the lower yields.

Table 4 : Effect of weed management treatments on energetics of rainfed castor

Treatments	EI (MJ ha^{-1})	EO (MJ ha^{-1})	Net energy (MJ ha^{-1})	EUE	EP (kg MJ^{-1})
T_1 - PE- Diclosulam 84 % WDG - 31 g *a.i.* ha^{-1} *fb* quizalofop-p-ethyl 5% EC - 50 g *a.i.* ha^{-1} as PoE at 30 DAS	9591	69489	59898	7.2	0.54
T_2 - PE- Diclosulam 84 % WDG - 31 g *a.i.* ha^{-1} *fb* direct spraying of glufosinate ammonium 13.5% SL - 375 g *a.i.* ha^{-1} as PoE at 30 DAS	9735	61063	51328	6.3	0.47
T_3 - PE- Diclosulam 84 % WDG - 31 g *a.i.* ha^{-1} *fb* intercultivation with power weeder at 30 DAS	9830	69922	60092	7.1	0.53
T_4 - PE- Pendimethalin 38.7% CS - 677.25 g *a.i.* ha^{-1} *fb* quizalofop-p-ethyl 5% EC - 50 g *a.i.* ha^{-1} as PoE 30 DAS	9672	53310	43638	5.5	0.41
T_5 - PE- Pendimethalin 38.7% CS - 677.25 g *a.i.* ha^{-1} *fb* direct spraying of glufosinate ammonium 13.5% SL 375 g *a.i.* ha^{-1} as PoE at 30 DAS	9816	45699	35883	4.7	0.35
T_6 - PE- Pendimethalin 38.7% CS - 677.25 g *a.i.* ha^{-1} *fb* intercultivation with power weeder at 30 DAS	9911	52670	42759	5.3	0.40
T_7 - Intercultivation with power weeder at 20 and 40 DAS	10074	61706	51632	6.1	0.46
T_8 - Weed free (3 Hand weedings)	10169	70868	60699	7.0	0.52
T_9 - Unweeded check	9479	22810	13331	2.4	0.18
SEm±	-	**2467**	**2430**	**0.17**	**0.02**
CD (P=0.05)	**-**	**7397**	**7284**	**0.52**	**0.04**
CV (%)	**-**	**9.6**	**8.6**	**8.2**	**8.6**

Net energy (MJ ha^{-1})

Among the weed management treatments, significantly higher net energy (60699 MJ ha^{-1}) was recorded with weed free (T_8) but was on par with T_3- diclosulam 84 % WDG 31 g *a.i.* ha^{-1} as PE *fb* intercultivation with power weeder at 30 DAS (60092 MJ ha^{-1}) and T_1- diclosulam 84 % WDG 31 g *a.i.* ha^{-1} as PE *fb* quizalofop-p-ethyl 15 % EC 50 g *a.i.* ha^{-1} as PoE at 30 DAS (59898 MJ ha^{-1}) being superior to all over treatments.

Energy use efficiency and energy productivity (kg MJ^{-1})

Despite recording higher output energy, net energy by weed free (T_8), significantly higher energy use efficiency (7.2) and energy productivity (0.54 kg MJ^{-1}) was recorded under T_1- diclosulam 84 % WDG 31 g *a.i.* ha^{-1} as PE *fb* quizalofop-p-ethyl 15 % EC 50 g *a.i.* ha^{-1} as PoE at 30 DAS but was on par with T_3- diclosulam 84 % WDG 31 g *a.i.* ha^{-1} as PE *fb* intercultivation with power weeder at 30 DAS (7.1 and 0.53, respectively) and T_8- weed free (7.0 and 0.52, respectively). This is attributed due to higher input energy was consumed with hand weedings for removing the weeds and Similar results were reported by Charitha *et al*. (2022).

Conclusion

The studies on energetics of rainfed castor has significance effect on the adoption of the weed management technology. Among the different treatments weed free (Hand weedings) required higher input energy (10169 MJ ha^{-1}) but produced higher output (70868 MJ ha^{-1}) and net energy (60699 MJ ha^{-1}). However, the higher energy use efficiency (7.2) and energy productivity (0.54 kg MJ^{-1}) was observed with T_1- diclosulam 84 % WDG 31 g *a.i.* ha^{-1} as PE *fb* quizalofop-p-ethyl 15 % EC 50 g *a.i.* ha^{-1} as PoE at 30 DAS. The treatments where hand weeding intercultivation requires higher input energy and simultaneously will need higher costs. From this it is evident that diclosulam 84 % WDG 31 g *a.i.* ha^{-1} as PE *fb* quizalofop-p-ethyl 15 % EC 50 g *a.i.* ha^{-1} as PoE at 30 DAS can be used as a best option for weed management in castor under rainfed conditions.

References

Burnett, M. (1982). Energy analysis of three agro-eco systems. p. 183–95. In, Second International Conference on Basic Techniques in Ecological Farming. (Ed. Hill Stuart B). Montreal, IFO.

Charitha, N., Madhavi, M., Pratibha, G and Ramprakash, T. (2024). Energy Budgeting of Integrated Weed Management in Rabi Groundnut Using New Generation Herbicides. *Plant Archives*. **24**(1), 1301-1304.

Chaudary, K.K., Singh S.S., Pratibha G., Ranjan B., Shamim M., Srinivas L and Patel A. (2017). Energy conservation and greenhouse gas mitigation under different production systems in rice cultivation. Energy, **130**, 307-314.

Dagistan, E., Akcaoz, H., Demirtas, B and Yilmaz, Y. (2009). Energy usage and benefit-cost analysis of cotton production in Turkey. *African Journal of Agricultural Research*. **4**(7), 599-604.

Devasenapathy, P., Senthil Kumar, G and Shanmugam, P.M. (2009). Energy management in crop production. *Indian Journal of Agronomy*. **54** (1), 80-90.

Dungarwal, H.S., Chaplot, P.C and Nagda, B.L. (2002). Weed control in Castor (*Ricinus communis*). *Indian Journal of Agricultural Science*. **72**(9), 525-527.

Green, M.R. (1987). Energy in pesticide manufacture, distribution and use. *Energy world Agriculture*. 166-177.

Imran, G.M., Nalini, N., Suresh, G and Saritha, J.D. (2024). Effect of weed management practices on growth and yield of rainfed castor. *International Journal of Research in Agronomy*. **7**(9S), 856-859.

Kitani, O. (1999). CIGR Handbook of Agricultural Engineering, Energy and Biomass Engineering, Natural Energy and Biomass. *Biomass Resources*. **5**(1), 1-3.

Kumar, R.M., Yamanura. (2019). Constraints in castor production and strategies to bridge yield gap in traditional and non-traditional tract of Karnataka. *Mysore Journal of Agriculture. Sciences*, **53**, 49–53.

Mandal, K.G., Saha, K.P., Ghosh, P.K., Hati, K.M and Bandyopadhyay, K.K. (2002). Bioenergy and economic analysis of soybean-based crop production systems in central India. *Biomass and Bioenergy*. **23**(5), 337-345.

Mittal, J.P and Dhawan, K.C. (1988). Energy requirements in agricultural sector. Punjab Agricultural University, Ludhiana.

Parihar, C.M., Jat, S.L., Singh, A.K., Kumar, B., Rathore, N.S., Jat, M.L., Saharawat, Y.S and Kuri, B.R. (2018). Energy auditing of long-term conservation agriculture based irrigated intensive maize systems in semi-arid tropics of India. *Energy*. **142**, 289-302.

Pimentel, D. (1993). Economics and energetics of organic and conventional fanning. *Journal of Agricultural and Environmental Ethics*. **6**, 53-60.

Ramanjaneyulu, A.V., Vishnuvardhan Reddy, A and Madhavi, A. (2013). The impact of sowing date and irrigation regime on castor (*Ricinus communis* L.) seed yield, oil quality characteristics and fatty acid composition during post rainy season in South India. *Industrial Crops and Products*. **44**, 25–31.