E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(8): 85-88
Received: 01-05-2024
Accepted: 04-06-2024

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Phytotoxicity, yield and economics of castor as influenced by different weed management practices

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i8b.1190

Abstract
In *kharif* 2020, a field experiment on clay soils with the title "Studies on effect of weed management practices in castor (*Ricinus communis* L.)" was carried out at the Agricultural College Farm in Bapatla. The results showed that the treatment providing pre-emergence application of alachlor @ 1.5 kg a.i ha^{-1} *fb* chlorimuron @ 10 g + propaquizafop @ 63 g a.i ha^{-1} as post emergence at 30 DAS (T_9) as well as pre-emergence application of alachlor @ 1.5 kg a.i ha^{-1} *fb* halosulfuron @ 67.5 g a.i + propaquizafop @ 63 g a.i ha^{-1} as post emergence at 30 DAS (T_{10}) were significantly highest seed yield, gross return, net returns, and B:C ratio under the treatment hand weeding at 20 and 40 DAS (T_2). The treatments comprised of pre and post emergence herbicides like alachlor, chlorimuron, halosulfuron and propaquizafop were found to be selective to castor rendering no phyto toxicity sysmptoms and crop injury.

Keywords: Castor, weed management, herbicides, phytotoxicity, yield and economics

Introduction
The most archaic non-edible crop in the Euphorbiaceae family of oilseeds, castor (*Ricinus communis* L.) is cultivated in tropical, sub-tropical, and temperate climates. In terms of castor production and area, India comes in first position. India is the world's top producer of castor, with 68% and 85% of the world's total acreage and production, respectively, ahead of China and Brazil. With a productivity of 1500 kg ha^{-1}, India produces 11.97 lakh tons on an area of 7.51 lakh hectares. In contrast, Andhra Pradesh figures for area, production, and productivity are 37,000 hectares, 15.36 thousand tons, and 415 kg ha^{-1}, respectively (Ministry of Agriculture and Farmers Welfare, Government of India 2018-19). Gujarat state in India enjoys a delighted precedence in castor production with nearly 85 percent of output followed by Andhra Pradesh and Rajasthan. Anantapur, Kurnool, Guntur and Nellore are the major districts of Andhra Pradesh contributing substantially to castor production.
When available nutrients are rapidly depleted, weeds grow more quickly than castor crops. Therefore, one of the most important elements in the effective production of castor beans is weed control during the early stages of the crop. The manual weeding method works well for controlling weeds. It is not beneficial, though, as labor is scarce and it is more expensive and time-consuming. Within this framework, chemical weed control emerges as a substitute method better starting on the day of germination for the administration of herbicides, which can be extremely effective in controlling weeds. Whether used alone or in conjunction with other weed control techniques, herbicides are fast acting, selective, economical, and effective at controlling weeds while lowering the possibility of crop-weed competition. To improve weed control, herbicides may be used as pre-emergence treatments, either separately or in combination, and then one or more post-emergence treatments.

Materials and Methods
The current study was conducted in the *kharif* of 2020 at the Agricultural College Farm in Bapatla. The 10 treatments in the Randomized Block Design experiment, which was repeated three times, included T_1 –"Weedy check (or) control, T_2 - Hand weeding at 20 DAS and 40 DAS, T_3 - Alachlor @ 1.5 kg a.i ha^{-1} as PE, T_4 - Chlorimuron @ 10 g a.i ha^{-1} as PoE at 20 DAS,

T_5 - Halosulfuron @ 67.5 g a.i ha^{-1} as PoE at 20 DAS, T_6 - Propaquizafop @ 63 g a.i ha^{-1} as PoE at 30 DAS, T_7 - Alachlor @ 1.5 kg a.i ha^{-1} as PE *fb* Chlorimuron @ 10 g a.i ha^{-1} as PoE at 30 DAS, T_8 - Alachlor @ 1.5 kg a.i ha^{-1} as PE *fb* Halosulfuron @ 67.5 g a.i ha^{-1} as PoE at 30 DAS, T_9 - Alachlor @ 1.5 kg a.i ha^{-1}as PE fb Chlorimuron @ 10 g + Propaquizafop @ 63 g a.i ha^{-1} as PoE at 30 DAS, T_{10} - Alachlor @ 1.5 kg a.i ha^{-1} as PE *fb* Halosulfuron @ 67.5 g a.i + Propaquizafop @ 63g a.i ha^{-1} as PoE at 30 DAS."

The soil under investigation was categorized as having a clay texture, being neutral in pH (7.3), having a medium amount of organic carbon (0.61%), having low available"nitrogen (210.5 kg ha^{-1}), medium levels of accessible phosphorus (25.1 kg ha^{-1}) and potassium (305.9 kg ha^{-1}). By hand dibbling, the castor hybrid (PCH-111) was sown at 90 cm x 60 cm spacing". Gap filling and thinning were completed at 10 DAS. A 60 kg N, 40 kg P_2O_5, and 30 kg K_2O ha^{-1} hybrid castor fertilizer dose was applied in the form of urea, single superphosphate, and potash muriate. Using the pocketing approach, nitrogen was supplied in three divided doses (30, 60, and 90 DAS), and potassium and phosphorus were applied basally at the time of planting. One day after seeding, pre-emergence herbicide Alachlor was sprayed, and at 20 and 30 DAS in the appropriate treatments, post-emergence herbicides (chlorimuron, halosulfuron, and propaquizafop) were sprayed using a backpack sprayer equipped with a flood jet nozzle. Using a phytotoxicity score card (Table 1), the injury effects of any herbicides sprayed on the castor crop in each treatment were visually evaluated at 7 and 14 days following crop spraying. Based on the current market prices for various inputs and products, the cost of cultivation and gross return were computed. The F-test was used to assess for statistical significance at the 0.05 probability level.

Table 1: Qualitative description of treatment effects on crop in the visual scoring scale of 0-10 which is equal to 0 to 100%

Effect	Rating	Description
None	0	No injury, normal
	1	Slight stunting, injury or discolour
Slight	2	Some stand loss, stunting/discolour
	3	Injury more pronounced but not persistent
	4	Moderate injury, recovery possible
Moderate	5	Injury more persistent, recovery doubtful
	6	Near severe injury, stand loss
	7	Severe injury, stand loss
Severe	8	Almost destroyed, a few plants surviving
	9	Very few plants alive
Complete	10	Complete destruction

Results and Discussion

Phytotoxic Effect on Crop

Phytotoxic effect of herbicides on castor recorded at 7 and 14 days after application is presented in the form of score card (crop score injury) in Table 2. Among the herbicides, alachlor and propaquizafop were found to be categorized as impregnable herbicides for castor crop, as there was no phytotoxic symptom observed after their application. Chlorimuron @ 10 g a.i ha^{-1} applied as post-emergence spray, corroborated mild discoloration on younger leaves at 7 days after application; however their symptoms later disappeared at 14 DAA owing to the chemical's rapid metabolism. Halosulfuron @ 67.5 g a.i ha^{-1} spray as post-emergence application caused diminutive stand loss coupled with gentle discoloration of younger plants at 7 DAA. However, these snipper symptoms got recovered within one week i.e. 14 DAA and the crop exhibited normal healthy growth. These findings are in accordance with the results of Valdinei *et al.* (2012) [16], Costa *et al.* (2015) [4], Kowser *et al.* (2018) [8] and Gupta *et al.* (2019) [9].

Yield (t ha^{-1})

With the exception of the pre-emergence applications of alachlor @ 1.5 kg a.i ha^{-1} *fb* chlorimuron @ 10 g + propaquizafop @ 63 g a.i ha^{-1} as PoE at 30 DAS (T_9) and alachlor @ 1.5 kg a.i ha^{-1} fb halosulfuron @ 67.5 g a.i + propaquizafop @ 63 g a.i ha^{-1} as PoE at 30 DAS (T_{10}), which had a comparable seed yield of 2.39 and 2.33 t ha^{-1}, respectively, when hand weeding practice was employed between 20 and 40 DAS (T_2). With weedy check (T_1), the lowest seed yield (1.35 t ha^{-1}) was observed and reported in Table 3. The crop's full usage of growth nutrients and decreased weed competition during the key period may have contributed to the higher yield in these treatments. Higher yields may also have been the consequence of improved crop growth metrics, such as plant height and dry matter buildup, sufficient nutrient uptake, and improved soil physical conditions. The lower yield in weedy check may be caused by intense weed competition, ineffective weed control (as seen by maximum weed density and dry weight), and yield-attributing characteristics that resulted in decreased crop growth and dry matter.

Economics

From Table 3. the highest gross return (Rs. 93013 ha^{-1}) was registered under hand weeding at 20 and 40 DAS (T_2), and was closely followed by the treatment comprising "spraying pre-emergence application of alachlor @ 1.5 kg a.i ha^{-1} fb chlorimuron @ 10 g + propaquizafop @ 63 g a.i ha^{-1} as PoE at 30 DAS (T_9) as well as pre-emergence application of alachlor @ 1.5 kg a.i ha^{-1} fb halosulfuron @ 67.5 g a.i + propaquizafop @ 63 g a.i ha^{-1} as PoE at 30 DAS (T_{10})"for obtaining gross returns of Rs. 89490 ha^{-1} and Rs. 87178 ha^{-1} respectively. This can be attributed to better weed control achieved in these treatments resulting in higher seed yield. Even though the highest gross return Rs. 93013 ha^{-1} was recorded under hand weeding at 20 and 40 DAS (T_2), the highest net return (Rs. 62276 ha^{-1}) was however recorded with"pre-emergence application of alachlor @ 1.5 kg a.i ha^{-1} fb chlorimuron @ 10 g + propaquizafop @ 63 g a.i ha^{-1} as PoE at 30 DAS (T_9), which was however on a par with hand weeding at 20 and 40 DAS (T_2), pre-emergence application of alachlor @ 1.5 kg a.i ha^{-1} fb halosulfuron @ 67.5 g a.i + propaquizafop @ 63 g a.i ha^{-1} as PoE at 30 DAS (T_{10}) as well as pre-emergence application of alachlor @ 1.5 kg a.i ha^{-1} fb chlorimuron @ 10 g a.i ha^{-1} as PoE at 30 DAS (T_7), with"net returns of Rs. 60895, 56589 and 53429 ha^{-1} respectively.

The monetary beneficial behavior among the treatments mentioned above could be attributed to difference in cost of cultivation. The lower cost of herbicides in T_9 owing to the decreased cost of cultivation resulted in increased net returns, whereas the higher cost of labour escalated the cost of cultivation recorded under hand weeding practice at 20 and 40 DAS (T_2) that lead to reduced net returns. The highest benefit cost ratio (2.29) recorded under"pre-emergence application of alachlor @ 1.5 kg a.i ha^{-1} *fb* chlorimuron @ 10 g + propaquizafop @ 63 g a.i ha^{-1} as PoE at 30 DAS (T_9)"indicated the cost effectiveness of timely weed control leading to higher production of net return and B: C ratio as observed in the present study confirms with the findings of Pathak (2007) [12], Sankar and Subramanyam (2011) [15], Kalhapure *et al.* (2013) [7], Das *et al.* (2014) [5], Panda *et al.* (2015) [11], Bhimwal *et al.* (2019) [2] and Ambika and Sundari (2019) [1].

Table 2: Phytotoxic effect of different herbicidal treatments on castor

Treatments	Pre-emergence spray		Post-emergence spray	
	7 DAS	14 DAS	7 DAS	14 DAS
T_1 - Weedy check (or) control	-	-	-	-
T_2 - Hand weeding at 20 DAS and 40 DAS	-	-	-	-
T_3 - Alachlor @ 1.5 kg a.i ha^{-1} as PE	0	0	-	-
T_4 - Chlorimuron @ 10 g a.i ha^{-1} as PoE at 20 DAS	-	-	1	0
T_5 - Halosulfuron @ 67.5 g a.i ha^{-1} as PoE at 20 DAS	-	-	2	0
T_6 - Propaquizafop @ 63 g a.i ha^{-1} as PoE at 30 DAS	-	-	0	0
T_7 - Alachlor @ 1.5 kg a.i ha^{-1} as PE fb Chlorimuron @ 10 g a.i ha^{-1} as PoE at 30 DAS	0	0	1	0
T_8 - Alachlor @ 1.5 kg a.i ha^{-1} as PE fb Halosulfuron @ 67.5 g a.i ha^{-1} as PoE at 30 DAS	0	0	2	0
T_9 - Alachlor @ 1.5 kg a.i ha^{-1}as PE fb Chlorimuron @ 10 g + Propaquizafop @ 63 g a.i ha^{-1} as PoE at 30 DAS	0	0	1	0
T_{10} - Alachlor @ 1.5 kg a.i ha^{-1} as PE fb Halosulfuron @ 67.5 g a.i + Propaquizafop @ 63g a.i ha^{-1} as PoE at 30 DAS.	0	0	2	0

Rating 1= Slight stunting, injury or discolour
Rating 2 = some stand loss, stunting/discolour

Table 3: Yield and economics of different weed management practices in castor

Treatments	Seed yield (t ha^{-1})	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	Benefit: Cost ratio
T_1 - Weedy check (or) control	1.35	23718	50660	26942	1.14
T_2 - Hand weeding at 20 DAS and 40 DAS	2.48	32118	93013	60895	1.90
T_3 - Alachlor @ 1.5 kg a.i ha^{-1} as PE	1.62	25518	60805	35287	1.38
T_4 - Chlorimuron @ 10 g a.i ha^{-1} as PoE at 20 DAS	1.88	24091	70600	46509	1.93
T_5 - Halosulfuron @ 67.5 g a.i ha^{-1} as PoE at 20 DAS	1.83	27466	68513	41047	1.49
T_6 - Propaquizafop @ 63 g a.i ha^{-1} as PoE at 30 DAS	1.94	25041	72699	47658	1.90
T_7 - Alachlor @ 1.5 kg a.i ha^{-1} as PE fb Chlorimuron @ 10 g a.i ha^{-1} as PoE at 30 DAS	2.12	25891	79320	53429	2.06
T_8 - Alachlor @ 1.5 kg a.i ha^{-1} as PE fb Halosulfuron @ 67.5 g a.i ha^{-1} as PoE at 30 DAS	2.07	29266	77396	48130	1.64
T_9 - Alachlor @ 1.5 kg a.i ha^{-1}as PE fb Chlorimuron @ 10 g + Propaquizafop @ 63 g a.i ha^{-1} as PoE at 30 DAS	2.39	27214	89490	62276	2.29
T_{10} - Alachlor @ 1.5 kg a.i ha^{-1} as PE fb Halosulfuron @ 67.5 g a.i + Propaquizafop @ 63g a.i ha^{-1} as PoE at 30 DAS.	2.33	30589	87178	56589	1.85
SEm±	0.08	-	2959.1	2959.1	0.10
CD (P=0.05)	0.3	-	9466	9466	0.33

Conclusion

Based on a field experiment, it was determined that, out of all the weed management techniques, pre- and post-emergence herbicides were selective for castor, causing no harm to the crop. Pre-emergence application of alachlor @ 1.5 kg a.i ha^{-1} fb chlorimuron @ 10 g + propaquizafop @ 63 g a.i ha^{-1} as PoE at 30 DAS (T_9) recorded the highest net return with a B: C ratio were found to be superior to hand weeding at 20 and 40 DAS (T_2) due to lower herbicide costs that decreased the cost of cultivation and contributed to the highest net returns. The highest seed yield and gross return were recorded under hand weeding at 20 and 40 DAS (T_2).

Acknowledgements

I express my gratitude to my chairperson Dr. P.V.N. Prasad and every faculty members of Department of Agronomy for constant support and guidance to hold out the entire experimental research study.

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