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Sequential use of pre-and post-emergence herbicides for weed management in castor (*Ricinus communis*)

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ABSTRACT

Castor oil is an industrially significant product that serves as a chemical platform for the production of numerous products and their derivatives, including sebacic acid. Although the output of castor (*Ricinus communis* L.) is still significantly hampered by weed competition, resulting in 28–30% yield losses. This study sought to assess the effectiveness of herbicides on rainfed castor throughout the rainy (*kharif*) seasons of 2022–23 and 2023–24. The experiment comprised 12 treatments, one weed-free check; one weedy check; one mechanical weed management; and nine herbicide treatments [includes three pre-emergence (PE) applications (diclosulam, metribuzin, and pendimethalin), one early post-emergence (EPOE) (imazethapyr), and one post emergence herbicide (POE) (quizalofop ethyl)]. The PE spray of diclosulam 84% WDG at 20 g/ha on 3 days after sowing (DAS), trailed by an EPOE of imazethapyr 10% SL at 100 g/ha on 15 DAS, and supplemented with power weeding on 30 DAS, generated the least number of weeds of 3.24, 3.84, and 4.06 weeds/m^2 at 25, 50, and 75 DAS, respectively (as per two-year pooled data). The total dry weight of weed was recorded as 2.24, 2.87, and 3.51 g/m^2 at 25, 50, and 75 DAS, in that order. The highest weed control index (WCI) was reported by this combination of 83.8, 83.9 and 84.8% on 25, 50, and 75 DAS, respectively, with corresponding weed control efficiency (WCE) values of 76.7, 76.5 and 83.2%, respectively. With a castor yield of 1,735 kg/ha, a net revenue of ₹75,540/ha, and a benefit cost ratio (BCR) of 2.64, this treatment produced the lowest weed index (4.9%), the highest herbicide efficiency index (6.93%), and the lowest weed persistence index (0.46). Following this, diclosulam 84% WDG was applied PE on 3rd DAS @20 g/ha. On 15 DAS, imazethapyr 10% SL was applied as an EPOE herbicide @100 g/ha, and on 30 DAS, quizalofop ethyl 5% EC was applied POE @50 g/ha. The number of spikes/plant (13.9), effective spike length (57.7 cm), yield of castor (1,779 kg/ha), net revenue (₹77,760/ha), and BCR (2.69) were all higher after power weeding at 20, 40, and 60 DAS.

Keywords: Herbicide efficiency index, Imazethapyr, Weed control, Weed persistence index

Castor (*Ricinus communis* L.) is a significant oilseed crop predominantly cultivated during the *kharif* season under rainfed conditions. India is the leading producer of castor, followed by China and Brazil (FAO 2015). The castor plant utilises a C_3 photosynthetic pathway, which is characterised by slow initial growth and limited competitive ability with other species (Azevedo *et al.* 2007). Crop yield is predisposed by several agronomic factors, with one of the most crucial elements for exploiting castor yield being weed control. Because castor grows slowly at first and its big leaves are ineffective at absorbing light, it is especially vulnerable to weed competition (Valdinei *et al.* 2012). During the first 30 to 40 days post-germination, weeds can proliferate rapidly and significantly impede the growth and yield of castor crops if not effectively managed.

When sown with wide spacing, castor grows slowly during the rainfed period, allowing weeds to proliferate, especially during the first two months of crop growth. For effective weed control in castor, two hand weeding is recommended as the best practice, resulting in increased castor yield (Ahmed *et al.* 2001). However, owing to rising labour costs and shortages, manual weed control has become challenging and can increase production costs by 40–60% (Etagegnehu and Fufa 2016). Additionally, manual weeding is impractical for progressive farmers who manage large-scale farms. In such cases, for cost reduction and increased castor production, chemical weed control is a superior choice. Selective herbicides are an effective alternative to manual weeding (Abd-El-Razik 2006).

In this experiment, sequential applications of pre-emergence (diclosulam, metribuzin, and pendimethalin)

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followed by (~fb) post-emergence, imazethapyr and quizalofop ethyl was studied for better weed management and weed shift. Pre-emergence herbicide of pendimethalin has been shown to effectively control early weeds (Panwar *et al.* 1989) by minimising early competition among weeds. However, late-emerging weeds become a bigger problem when PE herbicides lose their effectiveness after a few weeks. Combining pre-plant or pre-emergent herbicides with manual or chemical approaches is crucial for managing these weeds that emerge late and guaranteeing efficient weed resistor throughout the crop's growth. Therefore, this study aimed to investigate the effects of various herbicide combinations on different weed species and their influence on the growth and productivity of castor plants.

MATERIALS AND METHODS

The study was carried out during rainy (*kharif*) season of 2022–23 and 2023–24 at Tapioca and Castor Research Station (Tamil Nadu Agricultural University, Coimbatore Tamil Nadu), Yethapur, Tamil Nadu. The agro-ecological zone receives a substantial amount of pre-monsoon rainfall during April and May. The total monsoon rainfall during the crop growing season in 2022–23 was 642.8 mm, whereas it was 612.0 mm in 2023–24. The experiment included 12 treatments, i.e. Pre-emergence (PE) herbicide of diclosulam 84% WDG @20 g/ha on 3 days after sowing (DAS) (T_1); PE herbicide of metribuzin 70% WP @750 g/ha on 3 DAS (T_2); PE herbicide of pendimethalin 30% EC @1500 g/ha on 3 DAS (T_3); T_1+ imazethapyr 10% SL @100 g/ha as early post-emergence (EPOE) herbicide on 15 DAS and power weeder weeding on 30 DAS (T_4); T_2 + imazethapyr 10% SL 100 g/ha as EPOE herbicide on 15 DAS and power weeder weeding on 30 DAS (T_5); T_3 + imazethapyr 10% SL @100 g/ha as EPOE application on 15 DAS and power weeder weeding on 30 DAS (T_6); T_1 + imazethapyr 10% SL @100 g/ha as EPOE herbicide on 15 DAS and POE application of quizolofop ethyl 5% EC 50 g ha on 30 DAS (T_7); T_2 + imazethapyr 10% SL @100 g/ha as EPOE herbicide on 15 DAS and post-emergence (POE) herbicide of quizolofop ethyl 5% EC 50 g ha on 30 DAS (T_8); T_3 + imazethapyr 10% SL 100 g/ha as EPOE herbicide on 15 DAS and POE herbicide of quizolofop ethyl 5% EC 50 g ha on 30 DAS (T_9); Mechanical control of weeds at 20, 40, and 60 DAS with power weeder (T_{10}); Weedfree check (T_{11}) and Weedy check (T_{12}).

Red, non-calcareous soil with low nitrogen (216 kg/ha), high phosphorus (21.0 kg/ha), and high potassium (452 kg/ha) content made up the experimental field. The *p*H and electrical conductivity (EC) were 6.95 and 0.38, respectively, and the amount of organic carbon was low (0.25%). The castor hybrid YRCH 1 was sown in the second half of August each season, with a dibbling method spacing of 120 cm × 90 cm. A battery-powered knapsack sprayer with a flat-fan nozzle was used to apply herbicides, with a 500 L/ha spray volume. A quadrant was randomly positioned at five points inside each plot to capture the dry weight and weed density at 25, 50 and 75 DAS. After transforming the data using the square root to reduce the range of variation, the data analyses were conducted year-by-year for the weed density and above ground weed biomass per m^2.

The data were analysed using randomised block design (RBD) with ANOVA. The critical difference (CD) values are calculated to compare the treatments (Gomez and Gomez 1984). The following indices were found by applying standard processes to a variety of indices created by Mishra *et al.* (2016). The primary difference lies in the parameter they measure:

Weed control efficiency: Weed control efficiency (WCE) is a metric used to measure the efficacy of weed management techniques. It is computed using the following formula and given as a percentage:

$$WCE = WC–WT/WC \times 100$$

Where, WC, Dry weight of weed in the control and WT, Dry weight of weed in the treatment.

Weed index: Weed Index quantifies the extent to which the treatment affects the potential yield of a crop and is calculated as:

$$WI = YWF – YT/ YWF \times 100$$

Where YWF, Weed free plot yield and YT, Treated plot yield.

Weed persistence index: The weed persistence index (WPI) accounts for both the dry weight and population of weeds.

$$WPI = WT / WC \times WPC / WPT$$

Where WC, Control plot weed dry weight; WT, Treatment plot weed dry weight; WPC, Control plot weed population and WPT, Treatment plot weed population.

Herbicide efficiency index: Herbicide efficiency index (HEI) is used to assess the effectiveness of herbicide application and is calculated as:

$$HEI = YT – YC/YC / WT/WC$$

Where YT, Treatment plot yield; YC, Control plot yield; WC, Control plot weed dry weight and WT, Treatment plot dry weight of weed.

RESULTS AND DISCUSSION

Weed flora: The experimental field has a mixed flora of monocot and dicot weeds. During both research years, sedges dominated, trailed by dicots and grasses. *Cyperus rotundus* was the sole sedge found. The common dicot weeds were *Borreria diffusa, Trianthema portulacastrum*, *Euphorbia hirta, Digera arvensis*, and *Acalypha indica*. The grassy weeds commonly found were *Echinochloa colona, Perotis indica* and *Chloris barbata*.

Total weed density: According to the pooled mean for 2022–2023 and 2023–2024, the treatment with mechanical weeding had the lowest weed density, with values of 3.11, 3.41, and 3.75 weeds/m^2 at 25, 50, and 75 DAS, respectively. This treatment was conducted three times at 20, 40, and 60 DAS. The PE spray of diclosulam 84% WDG

at 20 g/ha, given 3rd DAS trailed by EPOE imazethapyr 10% SL at 100 g/ha on 15 DAS, in conjunction with power weeding on 30 DAS, demonstrated more efficacy in weed control than a single herbicide. This regimen ensued in the lowermost weed densities of 3.24, 3.84, and 4.06 weeds/m^2 at 25, 50, and 75 DAS, respectively. The PE spray of diclosulam 84% WDG at 20 g/ha on 3rd DAS, trailed by the EPOE of imazethapyr 10% SL at 100 g/ha on 15 DAS and the POE of quizalofop ethyl 5% EC at 50 g/ha on 30 DAS, was statistically equivalent to this treatment. Diclosulam was the most effective PE herbicide at controlling both monocot and dicot weeds. The unweeded control had greater weed densities at 25, 50, and 75 DAS, with 7.89, 9.20, and 10.20 weeds/m^2, respectively. EPOE herbicide application inhibits the emergence of a second flush of weeds by preventing soil disturbance, which lowers grass density. The effective application of several weed control strategies to reduce weeds throughout the critical phase of crop-weed competition led to a lower total weed density by Hariharasudhan *et al.* (2017)

Total weed dry weight: In the pooled mean of 2022–23 and 2023–24, mechanical weeding, led to noticeably decreased weed dry weights of 2.35, 2.63, and 3.10 g/m^2 at 25, 50, and 75 DAS, respectively. The herbicide actions that effectively controlled weeds were diclosulam 84% WDG applied PE at 20 g/ha on 3 DAS, imazethapyr 10% SL applied as EPOE at 100 g/ha on 15 DAS, and power weeding on 30 DAS. This resulted in significantly lower weed dry weights of 2.24, 2.87, and 3.51 g/m^2 at 25, 50, and 75 DAS, respectively. In comparison to the unweeded control, which displayed weed dry weights of 4.46, 5.79, and 8.18 g/m^2 at the same intervals in the pooled mean, this was comparable to the treatment that involved PE application of diclosulam 84% WDG at 20 g/ha on 3 DAS, followed by imazethapyr 10% SL at 100 g/ha as EPOE on 15 DAS, and POE application of quizalofop ethyl 5% EC at 50 g/ha on 30 DAS. Poor weed growth could be the cause of the decreased weed biomass during the interventions. Vaghasia *et al.* (2015) similarly showed similar results in castor.

This may be explained by the successful weed control attained by combining intercultural activities with the successive application of PE and POE herbicides. Castor crops were able to grow more quickly thanks to this method, which produced higher plants with more branches and a wider crop canopy. Through suffocation, the thick canopy successfully inhibited the growth of weeds. Several researchers have reported similar results, such as Patel and Virdia (2011) and Tomer and Tomer (2014), who found that successive use of herbicides dramatically decreased the weeds dry weight.

Weed Control Index: Table 1 displays the weed control index (WCI) values for 2022–2023 and 2023–2024 for 25, 50, and 75 DAS. The findings showed that diclosulam 84% WDG PE application at 20 g/ha on 3 DAS; imazethapyr 10% SL as EPOE at 100 g/ha on 15 DAS, and power weeding on 30 DAS, were associated with higher WCIs of 83.8%, 83.9%, and 84.8% at 25, 50, and 75 DAS, respectively. PE application of diclosulam 84% WDG at 20 g/ha on 3 DAS, trailed by imazethapyr 10% SL at 100 g/ha as EPOE on 15 DAS, and PE application of quizalofop ethyl 5% EC at 50 g/ha on 30 DAS statistically comparable to this treatment. The application of weed control treatments considerably decreased weed competition, with diclosulam used pre-emergence showing a considerable advantage over the other treatments. The information is consistent with Nandaji (2019) findings.

Weed control efficiency: The findings demonstrated that higher weed control efficiency (WCE) values of 76.7%, 76.5%, and 83.2% at 25, 50, and 75 DAS, respectively, PE spray of diclosulam 84% WDG at 20 g/ha on 3 DAS; imazethapyr 10% SL at 100 g/ha as EPOE on 15 DAS, and power weeding on 30 DAS. This was statistically comparable to the POE spray of quizalofop ethyl 5% EC at 50 g/ha on 30 DAS, trailed by the PE application of diclosulam 84% WDG at 20 g/ha on 3 DAS and imazethapyr 10% SL at 100 g/ha as EPOE on 15 DAS. Lower dry weight of the weeds may be the cause of the greater WCE seen in the treatments. This explained by the ongoing struggle for moisture and nutrients between castor crops and bothersome weed species. Singh *et al.* (2013) noted similar patterns in herbicide efficacy in castor and Dubey *et al.* (2010) in groundnut.

Weed index: The PE application of diclosulam 84% WDG at 20 g/ha on 3 DAS, trailed by imazethapyr 10% SL at 100 g/ha as EPOE on 15 DAS, and power weeding on 30 DAS, resulted in the lowermost WI (4.9%) among the herbicidal treatments, according to the data. The unweeded check had the highest WI (57.26), most likely because of the weeds' increased dry matter buildup from season long competition, which drastically decreased crop production. The WI decreased because of the effective control of all weed species, which led to a significant reduction in crop weed competition. This enables the crop to make effective use of the resources that are available, including space, light, nutrients, and moisture (Gupta *et al.* 2013). According to Har *et al.* (2020), a decreased weed index was obtained by applying pendimethalin first, followed by imazethapyr 25th DAS.

Herbicide efficiency index: The most efficacious approach involved a sequential application strategy comprising a pre-emergence treatment with Diclosulam 84% WDG at 20 g/ha administered 3rd DAS, followed by an early POE spray of Imazethapyr 10% SL at 100 g/ha on the 15th DAS, and culminating in a mechanical intervention via power weeding on the 30th DAS. At 6.93%, this integrated weed management strategy produced the greatest herbicide efficiency index. A remarkable herbicide efficiency index (HEI) of 6.04% was then demonstrated with a treatment regimen that included POE quizalofop ethyl 5% EC at 50 g/ha on the 30th DAS; EPOE imazethapyr 10% SL at 100 g/ha on the 15 DAS, and PE pendimethalin 30% EC at 1500 g/ha on the three DAS. The broad-spectrum weed control that these herbicides offered in castor was the reason for the increased herbicide efficiency index since it dramatically decreased the biomass of weeds in the treated plots.

Table 1 Effect of herbicides application on total weed density, total dry weight, WCI and WCE in castor during 2022–23 and 2023–24 (Pooled mean)

Treatment	Total weed density (No./m^2)			Total dry weight (g/m^2)			Weed control index (WCI)			Weed control efficiency (WCE)		
	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS
T_1	3.92^a (14.9)	6.18^b (37.8)	6.38^c (40.2)	2.46^a (5.6)	3.90^a (14.8)	5.07^c (25.2)	75.9^c	55.1^d	61.2^d	71.5^b	55.3^f	62.0^d
T_2	4.17^a (16.9)	5.86^a (33.9)	6.15^c (37.3)	3.42^b (11.3)	3.66^a (12.9)	4.64^b (21.0)	72.6^c	59.9^d	64.0^d	41.9^d	60.9^e	68.3^d
T_3	7.11^b (50.0)	6.57^b (42.7)	6.65^c (43.8)	4.23^c (17.4)	3.94^a (15.0)	5.60^c (30.9)	19.0^f	49.4^e	57.8^e	10.4^f	54.5^f	53.5^e
T_4	3.24^a (10.0)	3.84^a (14.3)	4.06^a (16.1)	2.24^a (4.6)	2.87^a (7.8)	3.51^a (11.8)	83.8^b	83.9^b	84.8^b	76.7^b	76.5^c	83.2^b
T_5	4.59^a (20.7)	5.48^a (29.6)	4.64^a (21.1)	4.15^c (16.8)	4.28^b (17.8)	6.2^d (38.0)	66.5^d	64.8^c	79.6^c	13.4^e	45.9^g	42.9^f
T_6	6.84^b (46.3)	6.56^b (42.6)	6.5^c (41.7)	4.24^c (17.5)	4.02^b (7.4)	5.41^c (28.8)	24.9^e	49.4^e	59.8^e	10.1^f	52.3^f	56.7^e
T_7	3.56^a (12.2)	4.00^a (15.6)	4.28^a (17.9)	2.26^a (4.6)	3.13^a (9.3)	4.01^b (15.6)	80.2^b	81.6^b	82.7^b	76.3^b	71.8^c	76.5^c
T_8	4.93^a (23.8)	5.47^a (29.5)	5.64^b (31.4)	2.86^a (7.7)	3.46^a (11.5)	4.83^b (23.3)	61.4^d	65.0^c	69.8^d	60.2^c	65.3^d	64.7^d
T_9	3.97^a (15.3)	3.75^a (13.6)	4.03^a (15.8)	3.48^b (11.6)	3.28^a (10.3)	3.41^a (11.2)	75.3^c	83.1^b	84.5^b	40.1^d	68.8^d	82.3^b
T_{10}	3.11^a (9.2)	3.41^a (11.2)	3.75^a (13.6)	2.35^a (5.1)	2.63^a (6.5)	3.10^a (9.2)	85.1^b	86.8^b	86.9^b	73.9^b	80.5^b	86.3^b
T_{11}	0.7^a (0.0)	0.7^a (0.0)	0.7^a (0.0)	0.7^a (0.0)	0.7^a (0.0)	0.7^a (0.0)	100.0^a	100.0^a	100.0^a	100.0^a	100.0^a	100.0^a
T_{12}	7.89^b (61.8)	9.20^b (84.3)	10.20^d (103.7)	4.46^c (19.5)	5.79^b (33.1)	8.18^d (66.5)	0.0	0.0	0.0	0.0	0.0	0.0
SEd	0.98	1.20	1.34	0.38	0.49	0.92	2.19	2.25	2.39	1.81	2.13	2.29
CD (p=0.05)	2.02	2.47	2.77	0.78	1.01	1.90	4.52	4.65	4.93	3.74	4.40	4.72

*, Data subjected to square root transformation (√X+0.5), value in parentheses represent original value. DAS, Days after sowing. Treatment details are given under Materials and Methods.

Weed persistence index: The treatment involving a PE spray of diclosulam 84% WDG at 20 g/ha, applied 3 DAS, followed by an EPOE spray of imazethapyr 10% SL at 100 g/ha on the 15th DAS, and supplemented with power weeding on the 30th DAS, presented the furthermost significant reduction in weed persistence among the variety of herbicide treatments evaluated. With a weed persistence index (WPI) of 0.46, this integrated strategy had the lowest score, suggesting that escaping weed species had not accumulated much dry matter. The treatment's broad-spectrum herbicidal action, which successfully suppresses both monocotyledonous and dicotyledonous weeds, is reflected in the much lower WPI. By focussing on any remaining weed populations that the chemical sprays were unable to suppress, the mechanical weed control component increased efficacy even more.

Castor's growth and yield characteristics: Due in large part to better soil aeration and efficient weed control, the results demonstrated that the weed-free treatment had the largest plant height (133.3 cm), the longest effective spike length (60.0 cm), and the greatest number of spikes/plant (14.4); with a plant height of 102.1 cm, 6.3 spikes/plant, and an effective spike length of 45.0 cm. The unweeded control treatment, on the other hand, displayed noticeably lower figures. Among the different herbicide treatments, the PE application of diclosulam 84% WDG at 20 g/ha on 3 DAS, followed by imazethapyr 10% SL at 100 g/ha as EPOE on 15 DAS, and power weeder weeding on 30 DAS produced the best results, with a plant height of 125.8 cm, 13.2 spikes/plant, and an effective spike length of 57.2 cm (Table 2). Reduced weed competition during crucial growth times may have contributed to the higher yield seen in these treatments by enabling the crop to make the most of the growth nutrients that were available. Higher

Table 2 Effect of herbicides application on WI, HEI, WPI, yield parameters and economics in castor during 2022–23 and 2023–24 (Pooled mean)

Treatment	Weed index (WI)	Herbicide efficiency index (HEI)	Weed persistence index (WPI)	Plant height (cm)	No. of spikes/ plant	Effective spike length (cm)	Yield (kg/ ha)	Net income (₹/ha)	B:C ratio
T_1	24.8^{d}	2.01^{d}	0.98^{c}	119.3^{b}	10.6^{e}	53.5^{b}	1373^{g}	58900	2.51
T_2	33.3^{b}	1.78^{e}	0.98^{c}	113.5^{c}	7.4^{f}	49.6^{d}	1218^{h}	49220	2.06
T_3	29.2^{c}	1.42^{e}	1.10^{b}	117.2^{b}	9.7^{e}	52.2^{b}	1292^{h}	53580	2.24
T_4	4.9^{j}	6.93^{b}	0.46^{d}	125.8^{a}	13.2^{b}	57.2^{b}	1735^{b}	75540	2.64
T_5	19.4^{e}	1.56^{e}	1.81^{a}	118.1^{b}	11.4^{d}	55.7^{b}	1472^{e}	59570	2.07
T_6	15.0^{f}	2.29^{d}	1.08^{c}	115.1^{c}	12.4^{c}	56.5^{b}	1551^{d}	64170	2.22
T_7	9.2^{i}	4.80^{c}	1.36^{b}	125.7^{a}	13.0^{b}	56.9^{b}	1657^{c}	71860	2.61
T_8	19.4^{e}	2.71^{d}	1.17^{b}	114.8^{b}	11.5^{d}	56.4^{b}	1471^{f}	60380	2.17
T_9	14.0^{f}	6.04^{b}	1.11^{b}	125.4^{a}	11.8^{d}	56.2^{b}	1570^{d}	66220	2.37
T_{10}	2.6^{k}	9.48^{a}	1.05^{c}	129.9^{a}	13.9^{b}	57.7^{b}	1779^{b}	77760	2.69
T_{11}	0.0	0.00	1.00^{c}	133.3^{a}	14.4^{a}	60.0^{a}	1826^{a}	79580	2.66
T_{12}	57.26^{a}	0.00	0.0	102.1^{d}	6.3^{g}	45.0^{c}	779^{i}	24640	1.11
SEd	0.61	0.71	0.07	3.91	0.29	1.76	47.29		-
CD (p=0.05)	1.35	1.52	0.13	8.08	0.59	2.64	97.6		-

Treatment details are given under Materials and Methods.

yields were also probably caused by better growth factors, such as increased height of plant and dry matter buildup, improved soil physical conditions, and effective nutrient uptake. However, as seen by the greater weed density and dry weight, which adversely impacted crop development, dry matter accumulation, and yield-related attributes, the lower yields in the weedy check were probably caused by fierce weed competition and inadequate weed control. These findings are consistent with those reported by Kowser *et al.* (2018) and Rahil *et al.* (2019). In a variety of field crops and forestry applications, diclosulam, that belongs to the triazolopyrimidine sulfonamide family, is very successful at controlling broadleaf weeds (Singh *et al.* 2009). It functions by preventing cell division and weed development by blocking the acetolactate synthase (ALS) enzyme.

The highest castor production of 1,826 kg/ha was obtained by the weed-free treatment, according to the results. The complete elimination of weed competition for essential growth resources throughout the critical crop weed interaction period, which encourages improved plant growth and development, is the main factor contributing to the enhanced seed output in the weed free check. The power weeder treatment, which was applied at 20, 40, and 60 DAS, came next and produced 1779 kg/ha. The PE application of diclosulam 84% WDG at 20 g/ha on 3 DAS, trailed by imazethapyr 10% SL at 100 g/ha as EPOE on 15 DAS and power weeding on 30 DAS, significantly produced higher yield of 1,735 kg/ha among the herbicide treatments, according to the pooled mean yield.

The higher yield observed with the pre and post emergence herbicide treatments is due to higher plant growth, as demonstrated by more branches, longer spikes, more capsules per spike and more spikes per plant as compared to the control and other herbicide treatments. Crop plants had extreme competition for growth resources, which resulted in lower yield-attributing characteristics and a minimum seed output. These outcomes closely match those of the castor crop studies by Dubey *et al.* (2010) and Singh *et al.* (2013). The PE diclosulam 84% WDG at 20 g/ha on 3 DAS, the POE application of quizalofop ethyl 5% EC at 50 g/ha on 30 DAS (1,657 kg/ha), and the imazethapyr 10% SL at 100 g/ha as EPOE on 15 DAS all produced yields that were equivalent to this one. Associated to the yield in control, i.e. 779 kg/ha, both treatments were noticeably greater. Crop plants had extreme competition for growth resources which resulted in lower yields and, ultimately, lower seed yields. These findings closely align with previous groundnut crop research by Bhale *et al.* (2012) and Malunjkar *et al.* (2012).

Castor weed management economics: The power weeder treatment, had the greatest benefit:cost ratio (BCR) (2.69), while the unweeded control had a BCR of 1.11. A higher BCR of 2.64 was attained by the herbicide treatments that applied diclosulam 84% WDG PE at 20 g/ha on 3 DAS, imazethapyr 10% SL as EPOE at 100 g/ha on 15 DAS, and power weeding on 30 DAS. Improved growth and output due to better soil aeration and efficient weed control were credited with this high BCR. This was similar to the BCR obtained with the PE spray of diclosulam 84% WDG at 20 g/ha on 3rd DAS, trailed by the POE application of quizalofop ethyl 5% EC at 50 g/ha on 30 DAS, and the imazethapyr

10% SL at 100 g/ha as EPOE on 15 DAS (2.61). According to earlier reports by Price *et al.* (2002) and Har *et al.* (2020), the weedy check had the lowest BCR, whereas larger values were noted with the administration of PE of pendimethalin and POE herbicide 20–30 DAS. Additionally, Kalaichelvi and Kumar (2016) found that combining PE herbicide with hand weeding in castor increased the B:C ratio.

Pre-emergence spray of diclosulam 84% WDG at 20 g/ha on 3 DAS, trailed by an EPOE application of imazethapyr 10% SL at 100 g/ha on 15 DAS, and mechanical intervention through power weeding on the 30th DAS comprised the most effective treatment among the different weed management strategies evaluated. The lowest weed density and weed dry matter accumulation were consistently achieved with this combined method. Additionally, throughout all phases of crop development, this treatment had the highest WCE and WCI values. This herbicide-mechanical combination's broad-spectrum activity and long-term suppression of both early-emerging and late-germinating weed species are responsible for its exceptional performance. The treatment substantially decreased weed pressure during the crop's critical growth stages, which improved crop vigour and production potential in addition to reducing competition for essential resources including nutrients, light, and moisture.

REFERENCES

Abd-El-Razik M A. 2006. Effect of some weed control treatments on growth, yield and yield components and some seed technological characters and associated weeds of faba bean plants. *The Journal of Agricultural Sciences* **31**: 6283–92.

Ahmed S A, El-Din S A and El-Metwally I M. 2001. Influence of some micro elements and some weed control treatments on growth, yield and its components of soybean plants. *Annals of Agricultural Sciences* **39**: 805–23.

Azevedo D M P, Beltrão N E M, and Severino L S. 2007. Weed control. *(In) The Castor Bean Agribusiness in Brazil*, 2nd edn, pp. 333–59. Azevedo D M P and Beltrão N E M (Eds). Embrapa Cotton, Campina Grande.

Bhale V M, Karmore J V, Patil Y R and Deshmukh P. 2012. Integrated weed management in groundnut. *Pakistan Journal of Weed Science Research* **18**: 733–39.

Dubey M, Singh S, Kewat M L and Sharma J K. 2010. Efficacy of imazethapyr against monocot weeds in groundnut. *Indian Journal of Weed science* **42**: 27–30.

Etagegnehu G, Mariam and Amare Fufa. 2016. Effect of different time and frequency of weeding on castor (*Ricinus communis* L.) in Central Rift Valley of Ethiopia. *International Journal of Research in Agriculture and Forestry* **3**(7): 31–37.

FAO. 2015. *FAOSTAT*. Food and Agricultural Organisation, Rome.

Gomez K A and Gomez A A. 1984. Statistical Procedures for Agricultural Research. *An International Rice Research Institute Book,* 2nd edn. A Wiley-Inter-science Publication, John Wiley & Sons, New York.

Gupta V, Singh M, Kumar A, Sharma B C and Kher D. 2013. Influence of weed management practices on weed dynamics and yield of urd bean (*Vigna mungo*) under rainfed condition of Jammu. *Indian Journal of Agronomy* **58** (2): 220–25.

Har N M, Ranjeet S Y, Navin K J and Mayank Y. 2020. A novel pre-emergence herbicide (Diclosulam) as an environmentally friendly weed management option in peanut and its Phytotoxicity evaluation. *Weed Biology and Management* **21**: 19–27. https://doi.org/10.1111/wbm.12219

Hariharasudhan V, Chinnusamy C and Prabhakaran N K. 2017. Optimum time of sowing and weed management methods on weeds interference and productivity and profitability of *Bt* cotton hybrid in western zone of Tamil Nadu. *International Journal of Chemical Studies* **5**(3):793–79.

Kalaichelvi K and Kumar S G. 2016. Chemical weed management in castor. *Indian Journal of Weed Science* **48**(1): 95–96.

Kowser T, Halepyati A S, Chittapur B M, Channabasavanna A S, Goud S I and Gowda B. 2018. Phytotoxicity and weed control efficiency of castor (*Ricinus communis* L.) as influenced by weed management practices. *Journal of Pharmacognacy and Phytochemistry* **7**(1): 126–31.

Malunjkar B D, Mulik B B, and Patil S C. 2012. Evaluation of post-emergence herbicides in rainy season groundnut. *Indian Journal of Weed Science* **44**: 95–97.

Mishra M M, Dash R and Mishra M. 2016. Weed persistence, crop resistance and phytotoxic effects of herbicides in direct seeded rice. *Indian Journal of Weed Science* **48**(1): 13–16.

Nandaji J J. 2019. "Efficacy of different pre and post emergence herbicides on weed control in maize (*Zea mays* L.)". PhD Thesis. Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra.

Panwar R S, Malik R K, BhanV M and Malik R S. 1989. Evaluation of pre-and post-emergence herbicides in cotton. *Haryana Agricultural University Journal of Research* **21**: 235–39.

Patel A J and Virdia H M 2011. Effect of weed management on weeds and nutrient uptake in rabi castor (*Ricinus communis* L.) under south Gujarat conditions. *Advance Research Journal of Crop Improvement* **2**(2): 147–50.

Price A J, Wilcut J W and Swann C W. 2002. Weed management with diclosulam in peanut (*Arachis hypogaea*). Weed Technology **16**: 724–30.

Rahil A, Shanwad U K, Koppalkar B G, Desai B K and Kenganal M. 2019. Effect of pre and post emergent herbicides on growth and yield of sunflower (*Helianthus annuus* L.). *Journal of Farm Science* **32** (1): 22–26.

Singh Ishwar, Rathore M S, Mehriya M L, Chawra R S and Chandawat M S. 2013. Weed management in irrigated castor through herbicides. *Journal of Oilseeds Research* **30**: 150–53.

Singh S P, Singh V P, Nainwal R C, Tripathi N and Kumar A. 2009. Efficacy of diclosulam on weeds and yield of soybean. *Indian Journal of Weed Science* **41**(3–4): 170–73.

Tomer S K and Tomer T S. 2014. Effect of herbicides and their tank mixture on weed dynamics and yield of zero tilled wheat (*Triticum aestivum*) under rice (*Oryza sativa*)–wheat cropping system of Eastern Uttar Pradesh. *Indian Journal of Agronomy* **59**(4): 624–28.

Vaghasia P M, Bhalu V B and Kavani R H. 2015. Evolution of herbicides for effective weed control in irrigated castor (*Ricinus comminis* L.). *Journal of Oilseeds Research* **32**(2): 132–35

Valdinei S, Liv S S, Franklin M O S, Vivianny N B S and Giovani G B. 2012. Pre- and post-emergence herbicides for weed control in castor crop. *Industrial Crops and Products* **37**: 235–37.