



RESEARCH ARTICLE

Bio-efficacy and economic assessment of pre- and post-emergence herbicides in weed management of chickpea

Pritika Thakur¹, Amit Dhankar^{1*}, Shivani Sharma¹, Sonali Sharma¹, Abha Thakur¹, Sunitha Fogat², Kanika Shukla¹ & Diksha¹

¹Department of Agriculture, Maharishi Markandeshwar (Deemed to be University), Mullana 133 207, Ambala, Haryana, India

²Department of Soil Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar 125 004, Haryana, India

*Correspondence email - amitdhankarhau@gmail.com

Received: 23 July 2025; Accepted: 04 January 2026; Available online: Version 1.0: 24 March 2026

Cite this article: Pritika T, Amit D, Shivani S, Sonali S, Abha T, Sunitha F, Kanika S, Diksha . Bio-efficacy and economic assessment of pre- and post-emergence herbicides in weed management of chickpea. *Plant Science Today*. 2026; 13(sp1): 1-7. <https://doi.org/10.14719/pst.10836>

Abstract

A field investigation was conducted during two consecutive rabi seasons at Research Farm of Maharishi Markandeshwar (Deemed to be University), Ambala, Haryana, India to assess the efficacy of various herbicide treatments and their impact on weed control, yield and economics in chickpea cultivation. The experiment was laid out in a randomised block design (RBD) with three replications. Nine herbicidal treatments were evaluated, along with a weed free and weedy check. Among pre-emergence (PRE) herbicides pendimethalin, oxyfluorfen and pendimethalin + imazethapyr (RM) were applied alone or in combination with hand weeding (HW). Among post-emergence (PoE) herbicides oxyfluorfen, topramezone and imazethapyr + imazamox (RM) were applied. Among PRE herbicides, pendimethalin + imazethapyr (RM) followed by one HW (T₇) recorded with highest weed control efficiency (91.8 and 87.2) and percent weed control (86.5 and 86.4) during first and second year of experiment. While among PoE, Imazethapyr + imazamox (RM), PoE at 100 g ha⁻¹ (T₉) recorded with excellent weed control efficiency and percent weed control of narrow-leaf, broad-leaf and total weeds at all stages of crop growth during both years of experiment. Severe phytotoxicity (80 % and 85 %) to chickpea crop upon PoE application of oxyfluorfen (T₅). Application of pendimethalin + imazethapyr (RM) followed by one HW recorded with 56.1 and 52.7 % increase in seed yield over weedy check during first and second year of experiment, respectively. Maximum benefit to cost (B:C) was calculated from T₆- pendimethalin + imazethapyr (RM) PRE (2.04 and 1.77) followed by T₇ (1.98 and 1.82) and minimum from T₅ (0.64 and 0.59) during first and second year, respectively.

Keywords: chickpea; herbicides; phytotoxicity; weed control efficiency; yield and economics

Introduction

Chickpea (*Cicer arietinum* L.), commonly referred to as gram, is a vital pulse crop belonging to the family Fabaceae. Chickpea ranks third among food legumes cultivated globally and plays a significant role in contributing to global dietary protein intake (1). Nutritionally, chickpea is rich in protein (18–26 %), minerals such as Zn (3–43 mg), Fe (6–24 mg), Ca (160 mg), Mg (138 mg), K (875 mg) and Na (24 mg) per 100 g, along with lipids (6.6–6.73 g/100 g), folates (351.5–588.8 µg/100 g) and ash (3.15–3.48 g/100 g) (2). During the 2023–24 growing season, India reported a total chickpea cultivation area of 9.58 million hectares, with a production of 11.03 million tonnes and an average productivity of 1151 kg ha⁻¹. In Haryana, chickpea was grown over 10580 hectares, yielding 10870 tonnes with an average productivity of 1027 kg ha⁻¹ (3).

Despite its agronomic and nutritional significance, chickpea yields are often constrained by biotic stresses among which weed infestation is a major limiting factor (4). The first 60 days after sowing (DAS) are particularly critical for weed-crop competition, significantly impacting crop establishment and final yield. Traditionally, manual weeding and intercultural operations have been widely practiced in Indian chickpea cultivation systems. These practices includes, two hoeings at 30-day intervals, remain among

the most effective weed control measures. However, labour intensive weed control methods are becoming increasingly unsustainable due to rising labor costs and limited availability (5). Consequently, chemical weed management has gained importance. Pre-emergence (PRE) herbicides such as pendimethalin (1.0 kg ha⁻¹) and oxyfluorfen (100 g ha⁻¹) have demonstrated efficacy in controlling early emerging broadleaf and grassy weeds (6, 7). Nevertheless, their inability to control subsequent weed flushes necessitates the inclusion of post-emergence (PoE) herbicides. Imazethapyr, when applied as PoE has shown promising results in managing late-emerging weed species (8). Fluchloralin and trifluralin are also preferred pre-plant incorporated herbicides options for achieving season long weed suppression. However, the use of PoE herbicides in leguminous crops like chickpea is often constrained by crop sensitivity, with reports of herbicide induced phytotoxicity leading to growth suppression and yield penalties. Symptoms such as stunted growth, bushy appearance, chlorosis, necrosis and reduced leaf size have been commonly observed (9). Although some degree of crop recovery is possible as the crop approaches maturity, it is typically insufficient to restore optimal yield levels. Earlier studies have reported weed control efficiency as high as 76.2 % under pendimethalin application at 1000 g ha⁻¹, highlighting its

effectiveness in reducing weed density of broad and narrow leaf weeds at 60 DAS (10). However, for sustained and safe weed management, especially in chickpea, a strategic integration of PRE and PoE herbicides must be explored to ensure efficacy without compromising crop health.

Material and Methods

A field experiment was conducted during the rabi seasons of 2023-24 and 2024-25 at the Research Farm of Maharishi Markandeshwar (Deemed to be University), Ambala, Haryana (India). The experimental site is situated at 30°32'28" N latitude, 77°16'92" E longitude and an altitude of 264 m above mean sea level. The experimental field had a sandy loam texture with a slightly alkaline reaction (pH 8.13), low available nitrogen and medium levels of available phosphorus and potassium. The experiment was laid out in a RBD with 11 treatments replicated three times. The chickpea variety HC-7 was sown using a spacing of 30 cm between rows and 10 cm between plants. The details of different weed management treatments applied during course of experiment is given below (Table 1). Phytotoxicity symptoms on the crop were assessed at weekly intervals starting from seven days after herbicide application (DAHA) up to 28 DAHA, using a 0–10 visual rating scale, where 0 indicated no injury and 10 represented complete plant death (11). Weed density was determined by placing a 0.25 m² quadrat randomly at two locations per plot, identifying and counting all weed species within the quadrat. Data were expressed in number of weeds per square meter (m²) and subjected to square root transformation ($\sqrt{X + 1}$) before statistical analysis to normalise variance. For weed dry weight estimation, the weeds within the quadrat were uprooted, initially sun-dried and then oven-dried at 70 °C until a constant weight was achieved. The dried samples were weighed and expressed as g m². Weed control efficiency on dry weight basis and per cent weed control on weed density basis was calculated using the following formula (12):

$$\text{WCE (\%)} = \frac{\text{Weed dry weight in weedy plot} - \text{Weed dry weight in treated plot}}{\text{Weed dry weight in weedy plot}} \times 100 \quad (\text{Eqn. 1})$$

$$\text{Percent weed control} = \frac{\text{Weed density in weedy plot} - \text{Weed density in treated plot}}{\text{Weed density in weedy plot}} \times 100 \quad (\text{Eqn. 2})$$

Crop parameters

For plant population, plants were counted in 1 m row length from three randomly selected spots and then averaged out. Plant

population was recorded at 20 DAS and at harvest stage of the crop. After harvesting crops from the net plot area, the bundles of chickpea crop were sun dried and then weight was recorded and converted to kg ha⁻¹. Seeds were separated manually from biological yield obtained from each net plot area. The seed yield thus obtained from net plot area was converted into kg ha⁻¹.

Economic analysis

Economic analysis was performed by computing gross returns based on the total monetary value of grain and straw yield (₹ ha⁻¹). Net returns and benefit to cost (B:C) were calculated using the formulas given below:

$$\text{Net returns (₹ ha}^{-1}\text{)} = \text{Gross returns (₹ ha}^{-1}\text{)} - \text{Total cost of cultivation (₹ ha}^{-1}\text{)} \quad (\text{Eqn. 3})$$

$$\text{Benefit to cost ratio} = \frac{\text{Gross returns (₹ ha}^{-1}\text{)}}{\text{Total cost of cultivation (₹ ha}^{-1}\text{)}} \quad (\text{Eqn. 4})$$

All recorded data were subjected to appropriate statistical analysis by using OPSTAT to determine treatment differences.

Results and Discussion

Weed flora

The major weed flora observed in the experimental field comprised predominantly of broad-leaved species such as *Chenopodium album*, *Coronopus didymus*, *Rumex dentatus*, *Fumaria parviflora*, *Convolvulus arvensis*, *Anagallis arvensis* and *Melilotus alba*, exhibiting a relative density ranging from 48.6–62.7 %. Among the narrow-leaved weeds, *Cynodon dactylon*, *Polypogon monspeliensis* and *Phalaris minor* were present, with relative densities ranging between 19.2–25.6 %. Similar weed compositions were reported by earlier studies at comparable agro-ecological sites (13).

Weed density and dry weight

Different weed management practices showed significant influence on weed density recorded at 30 and 60 DAS. Among all the weed control treatments, the minimum weed density was recorded in weed free (two HW at 30 and 60 DAS) and at the same time, the maximum weed density was recorded in weedy check treatment during both the years, however, among the herbicidal treatments, the minimum weed density was recorded under the pre-emergence application of pendimethalin + imazethapyr (RM) at 1000 g ha⁻¹ integrated with one HW at 30 DAS, closely followed by pendimethalin + imazethapyr (RM) at 1000 g ha⁻¹ during both the years (Tables 2 and 3). It might be due to its activity on the surface of the soil, where it controlled annual weeds as they germinated. The herbicidal application with one HW significantly reduced the total weed density in chickpea and in other crops (14,

Table 1. Details of weed management treatment applied in chickpea crop

Treatment details	Dose (g ha ⁻¹)	Time of application
T ₁ Pendimethalin	1000	Pre-emergence
T ₂ Pendimethalin + one hand weeding (HW)	1000	Pre-emergence followed by 30 DAS
T ₃ Oxyfluorfen	100	Pre-emergence
T ₄ Oxyfluorfen + one HW	100	Pre-emergence followed by 30 DAS
T ₅ Oxyfluorfen	100	30 DAS
T ₆ Pendimethalin + imazethapyr (RM)	1000	Pre-emergence
T ₇ Pendimethalin + imazethapyr (RM) + one HW	1000	Pre-emergence followed by 30 DAS
T ₈ Topramezone	20	30 DAS
T ₉ Imazethapyr + imazamox (RM)	100	30 DAS
T ₁₀ Weed free	-	30 and 60 DAS
T ₁₁ Weedy check	-	-

Table 2. Effect of different pre- and post-emergence herbicides on weed density and percentage of weed control at 30 DAS in chickpea

Treatment details	Dose (g ha ⁻¹)	Time of application	Weed density (No. m ⁻²)						Weed control (%)		
			2023-24		2024-25		2023-24		2024-25		
			Broad-leaf weeds	Narrow-leaf weeds	Total weeds	Broad-leaf weeds	Narrow-leaf weeds	Total weeds	Broad-leaf weeds	Narrow-leaf weeds	Total weeds
T ₁	Pendimethalin	1000	PRE	5.71 (31.6)	3.02 (8.1)	6.39 (39.7)	5.87 (33.5)	3.20 (9.2)	6.61 (42.7)	72.1	70.6
T ₂	Pendimethalin + one hand weeding (HW)	1000	PRE followed by 30 DAS	5.61 (30.5)	3.05 (8.4)	6.32 (38.9)	5.80 (32.6)	3.27 (9.7)	6.58 (42.3)	72.7	70.8
T ₃	Oxyfluorfen	100	PRE	5.13 (25.4)	3.69 (12.7)	6.25 (38.1)	5.90 (33.6)	3.80 (13.3)	6.92 (46.9)	73.3	67.7
T ₄	Oxyfluorfen + one HW	100	PRE followed by 30 DAS	5.23 (26.9)	3.80 (13.5)	6.43 (40.4)	5.62 (30.6)	4.09 (15.7)	6.88 (46.3)	71.6	68.1
T ₅	Oxyfluorfen	100	PoE	10.38 (106.8)	6.13 (36.6)	12.01 (143.4)	10.50 (109.4)	5.84 (33.2)	12.35 (152.6)	-	-
T ₆	Pendimethalin + imazethapyr (RM)	1000	PRE	3.66 (12.5)	(3.12 (8.8)	4.72 (21.3)	3.78 (13.3)	3.30 (9.9)	4.91 (23.2)	85.1	84.0
T ₇	Pendimethalin + imazethapyr (RM) + one HW	1000	PRE followed by 30 DAS	3.51 (11.4)	2.97 (7.9)	4.50 (19.3)	3.39 (10.5)	3.20 (9.3)	4.56 (19.8)	86.5	86.4
T ₈	Topramezone	20	PoE	10.30 (105.1)	6.36 (39.6)	12.06 (144.6)	10.44 (108.2)	6.024 (35.3)	12.38 (153.5)	-	-
T ₉	Imazethapyr + imazamox	100	PoE	10.29 (104.9)	6.15 (36.9)	11.94 (144.8)	10.36 (106.4)	5.97 (34.6)	12.29 (151.0)	-	-
T ₁₀	Weed free	-	Hoing at 30 and 60 DAS	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	100.0	100.0
T ₁₁	Weedy check	-	-	10.23 (103.8)	6.29 (38.7)	11.97 (142.5)	10.42 (107.7)	6.20 (37.4)	12.45 (155.1)	72.1	70.6
SEM ±				0.09	0.06	0.12	0.10	0.04	0.11	-	-
CD (P = 0.05)				0.26	0.18	0.38	0.29	0.13	0.32	-	-

*Values in parenthesis are subjected to square root transformation ($\sqrt{x+1}$)

Table 3. Effect of different pre- and post-emergence herbicides on weed density and percent weed control at 60 DAS in chickpea

Treatments	Dose (g ha ⁻¹)	Time of application	Weed density (No. m ⁻²)						Weed control (%)			
			2023-24		2023-24		2024-25		2023-24		2024-25	
			Broad-leaf weeds	Narrow-leaf weeds	Total weeds	Broad-leaf weeds	Narrow-leaf weeds	Total weeds	Broad-leaf weeds	Narrow-leaf weeds	Total weeds	
T ₁	Pendimethalin	1000	PRE	7.65 (57.5)	4.32 (17.7)	4.32 (17.7)	8.73 (75.2)	7.90 (61.4)	4.72 (22.3)	9.14 (82.7)	60.3	58.6
T ₂	Pendimethalin + one hand weeding (HW)	1000	PRE followed by 30 DAS	4.32 (17.7)	2.87 (7.3)	2.87 (7.3)	5.10 (25.0)	4.76 (21.6)	3.39 (10.5)	5.76 (32.1)	86.8	83.9
T ₃	Oxyfluorfen	100	PRE	6.91 (46.8)	4.86 (22.7)	4.86 (22.7)	8.40 (69.5)	7.03 (48.5)	5.14 (25.5)	8.66 (74.0)	63.3	63.0
T ₄	Oxyfluorfen + one HW	100	PRE followed by 30 DAS	4.52 (19.5)	3.12 (8.8)	3.12 (8.8)	5.41 (28.3)	4.84 (23.5)	3.34 (10.2)	5.80 (32.7)	85.1	83.6
T ₅	Oxyfluorfen	100	PoE	3.20 (9.3)	1.88 (2.7)	1.88 (2.7)	3.60 (12.0)	3.52 (11.5)	2.01 (3.1)	3.92 (14.6)	93.7	92.7
T ₆	Pendimethalin + imazethapyr (RM)	1000	PRE	4.90 (23.1)	4.17 (16.4)	4.17 (16.4)	6.36 (39.5)	5.12 (25.3)	4.44 (18.8)	6.71 (44.1)	79.2	77.9
T ₇	Pendimethalin + imazethapyr (RM) + one HW	1000	PRE followed by 30 DAS	3.79 (13.5)	2.79 (6.9)	2.79 (6.9)	4.62 (20.4)	4.29 (17.5)	3.23 (9.5)	5.28 (27.0)	89.2	86.5
T ₈	Topramezone	20	PoE	11.07 (121.7)	2.06 (3.4)	2.06 (3.4)	11.23 (125.1)	11.20 (124.6)	4.10 (15.8)	11.63 (134.4)	34.0	29.8
T ₉	Imazethapyr + imazamox	100	PoE	3.01 (8.1)	5.08 (24.8)	5.08 (24.8)	5.82 (32.9)	5.37 (11.5)	5.37 (27.8)	6.33 (39.3)	82.6	80.3
T ₁₀	Weed free	-	Hoing at 30 and 60 DAS	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	100.0	100.0	
T ₁₁	Weedy check	-	-	11.26 (125.7)	8.05 (63.8)	8.05 (63.8)	13.80 (189.5)	11.47 (130.5)	8.39 (69.4)	14.18 (199.9)	0.0	0.0
SEM ±				0.10	0.13	0.13	0.10	-	-	-	-	
CD (P = 0.05)				0.19	0.38	0.38	0.30	-	-	-	-	

*Values in parenthesis are subjected to square root transformation ($\sqrt{x+1}$)

15). Significant variation in total weed dry weight was recorded due to different weed-management practices at 30 and 60 DAS (Tables 4 and 5). A cursory glance at the data indicates that the maximum weed dry weight was recorded in weedy check treatment and minimum in HW treatment. However, among herbicidal treatments, the pre-emergence application of pendimethalin + imazethapyr + HW (RM) at 1000 g ha⁻¹ resulted in significantly minimum weed dry weight, which was significantly superior over other treatments during both the years.

Weed control efficiency and percent weed control

The maximum weed control efficiency was attained with the application of PRE herbicide pendimethalin + imazethapyr (RM) at 1000 g ha⁻¹ + HW. However, the minimum weed control efficiency was recorded in weedy check during both the years at 30 and 60 DAS (Table 4 and 5). Integration of one HW with PRE herbicides proved extremely effective in controlling the weed density as compared to application of herbicides alone, thus the percent weed control was found higher in these treatments. Broad-spectrum nature of pendimethalin, which killed the weeds by inhibiting cell division and elongation thereafter coincided with imazethapyr, which acted as inhibitor of three branched-chain amino-acids and thus resulted in lesser weed counts and ultimately produced lower weed dry weight. Imazethapyr emerged as promising herbicide in reducing weed density and dry matter accumulation (16, 17).

Crop phytotoxicity

Crop phytotoxicity was recorded in post-emergence treatment of oxyfluorfen at 100 g ha⁻¹ during both years. In the year 2023–24, the phytotoxicity was 80 % at seven DAHA and 75 % at 14 DAHA and in the year of 2024–25, the phytotoxicity was 85 % at 7 DAHA and 80 % at 14 DAHA. Crop plants and weeds were both destroyed after the application of oxyfluorfen. The major effect occurred due to the rainfall.

Growth and yield

The plant population was found non-significant at 20 DAS during both the years and at harvest, while at harvest stage among all the treatments maximum plant height was noted under weed free and minimum under weedy check plot. However, among herbicidal treatments maximum plant population was found in pre-emergence application of pendimethalin + imazethapyr at 1000 g ha⁻¹ + one HW at 30 DAS and minimum under PoE application of oxyfluorfen at 100 g ha⁻¹ (Table 6).

The significant maximum seed yield (1839 and 1569) was found in treatment pre-emergence application of pendimethalin + imazethapyr (RM) at 1000 g ha⁻¹ + HW at 30 DAS and minimum in post-emergence treatment of oxyfluorfen at 100 g ha⁻¹ (Table 6). The maximum yield under HW might be due to the early removal of weeds from the crop, which minimised crop weed competition, creating a weed-free environment (18).

Economics

Cost of cultivation was calculated based on prices prevailing in the market during experiment. It was recorded maximum in treatment weed free (T₁₀) (₹58440 and ₹59440 ha⁻¹) and minimum in weedy check (T₁₁) (₹42440 and ₹43440 ha⁻¹) and among the herbicidal treatments, the maximum cost of cultivation was recorded under the treatment Pendimethalin + one HW at 1000 g ha⁻¹ (T₂) (₹53773

and ₹54956 ha⁻¹), followed by Pendimethalin + imazethapyr (RM) at 1000 g ha⁻¹ as pre-emergence + one HW at 30 DAS (T₇) (₹53033 and ₹54176 g ha⁻¹) during the year 2023–24 and 2024–25, respectively (Table 7). The gross returns (₹108759 and ₹100185 ha⁻¹) were obtained maximum from weed free treatment, while among the herbicidal treatments, the maximum gross returns was obtained from pre-emergence application of pendimethalin + imazethapyr (RM) at 1000 g ha⁻¹ + HW (₹104779 and ₹98424 ha⁻¹) during the year 2023–24 and 2024–25, respectively. Pre-emergence application of pendimethalin + imazethapyr (RM) at 1000 g ha⁻¹ + HW resulted in maximum net returns (₹51746 and ₹44248 ha⁻¹ during 2023–24 and 2024–25, respectively as compared to other treatments. The maximum B:C ratio was registered with pre-emergence application of pendimethalin + imazethapyr (RM) at 1000 g ha⁻¹ + HW (2.04 and 1.82 during 2023–24 and during 2024–25, respectively) as compared to other treatments.

Conclusion

Based on two years of field experimentation, the pre-emergence application of pendimethalin + imazethapyr (RM) 1000 g ha⁻¹ combined with one HW at 30 DAS proved to be the most effective treatment for managing the mixed weed flora in chickpea. This was closely followed by pendimethalin at 1000 g ha⁻¹ + one HW at 30 DAS and post-emergence application of imazethapyr + imazamox (RM) at 100 g ha⁻¹. Among the various PRE and PoE herbicide treatments evaluated, the post-emergence application of oxyfluorfen caused severe phytotoxicity (85 and 80 %) and substantial crop stand loss during the years 2023–24 and 2024–25, respectively. The maximum B:C was registered with pendimethalin + imazethapyr (RM) at 1000 g ha⁻¹, closely followed by pendimethalin + imazethapyr (RM) at 1000 g ha⁻¹ + one HW.

Acknowledgements

The authors gratefully acknowledge the Faculty of Agriculture, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, Haryana, India for providing necessary research facilities, technical assistance and financial support throughout the course of the study.

Authors' contributions

AD was responsible for the planning, execution of the experiment and writing of the manuscript. PT, KS and D contributed to data recording and compilation. SS¹ and SF performed the statistical analysis and lab analysis of soil samples. SS² and AT were involved in proofreading and finalizing the manuscript. All authors read and approved the final manuscript. [SS¹ stands for Shivani Sharma and SS² stands for Sonali Sharma].

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

Table 4. Effect of different pre- and post-emergence herbicides on dry weight and weed control efficiency at 30 DAS in chickpea

Treatments	Dose (g ha ⁻¹)	Time of application	Weed dry weight (gm ⁻²)						Weed control efficiency		
			2023-24		2024-25		Total weeds	2023-24	2024-25	2024-25	
			Broad-leaf weeds	Narrow-leaf weeds	Broad-leaf weeds	Narrow-leaf weeds					
T ₁	1000	PRE	3.85 (13.9)	1.43 (1.13)	4.00 (15.0)	4.51 (19.3)	1.51 (1.3)	4.65 (20.6)	74.0	72.6	
T ₂	1000	PRE followed by 30 DAS	3.75 (13.10)	1.51 (1.34)	3.92 (14.5)	4.54 (19.6)	1.61 (1.6)	4.71 (21.2)	75.0	71.8	
T ₃	100	PRE	3.44 (10.9)	1.61 (1.65)	3.68 (12.6)	4.79 (21.9)	1.93 (2.7)	5.06 (24.6)	78.2	67.2	
T ₄	100	PRE followed by 30 DAS	3.50 (11.30)	1.64 (1.76)	3.74 (13.1)	3.66 (12.4)	1.74 (2.0)	3.94 (14.5)	77.4	80.7	
T ₅	100	PoE	7.18 (49.1)	2.82 (6.95)	7.56 (56.1)	7.16 (50.3)	3.50 (11.3)	7.91 (61.6)	-	-	
T ₆	1000	PRE	2.17 (3.9)	1.43 (1.14)	2.43 (5.0)	3.05 (8.3)	1.49 (1.2)	3.24 (9.5)	91.3	87.4	
T ₇	1000	PRE followed by 30 DAS	2.12 (3.6)	1.43 (1.11)	2.37 (4.8)	3.10 (8.6)	1.42 (1.0)	3.26 (9.6)	91.8	87.2	
T ₈	20	PoE	7.17 (50.4)	2.84 (7.11)	7.65 (57.6)	7.27 (51.9)	2.90 (7.4)	7.77 (59.4)	-	-	
T ₉	100	PoE	7.09 (49.3)	2.76 (6.64)	7.55 (55.9)	7.61 (57.0)	2.85 (7.1)	8.07 (64.1)	-	-	
T ₁₀	-	Hoing at 30 and 60 DAS	1.00 (0.0)	1.00 (0.00)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	100.0	100.0	
T ₁₁	-	-	7.20 (50.9)	2.82 (6.97)	7.67 (57.8)	7.99 (62.8)	3.64 (12.3)	8.72 (75.1)	0.0	0.0	
SEM ±			0.08	0.06	0.10	0.08	0.06	0.09	-	-	
CD (P = 0.05)			0.24	0.20	0.28	0.24	0.20	0.28	-	-	

*Values in parenthesis are subjected to square root transformation ($\sqrt{x+1}$)

Table 5. Effect of different pre- and post-emergence herbicides on weed dry weight and weed control efficiency at 60 DAS

Treatments	Dose (g ha ⁻¹)	Time of application	Weed dry weight (gm ⁻²)						Weed control efficiency (%)		
			2023-24		2024-25		Total weeds	2023-24	2024-25	2024-25	
			Broad-leaf weeds	Narrow-leaf weeds	Broad-leaf weeds	Narrow-leaf weeds					
T ₁	1000	PRE	8.87 (77.8)	5.36 (27.79)	10.32 (105.6)	9.60 (91.2)	5.59 (30.3)	11.07 (121.5)	62.6	59.1	
T ₂	1000	PRE followed by 30 DAS	3.75 (13.1)	1.75 (2.26)	4.04 (15.4)	4.42 (18.5)	2.06 (3.3)	4.77 (21.8)	94.6	92.7	
T ₃	100	PRE	9.25 (84.6)	6.07 (35.87)	11.02 (120.5)	8.56 (72.3)	6.43 (40.3)	10.66 (112.6)	57.3	62.1	
T ₄	100	PRE followed by 30 DAS	4.21 (16.8)	2.31 (4.49)	4.71 (21.3)	4.74 (21.5)	2.49 (5.2)	5.26 (26.7)	92.5	91.0	
T ₅	100	PoE	3.85 (13.9)	1.98 (3.11)	4.23 (17.0)	4.25 (17.1)	2.93 (7.6)	5.07 (24.67)	94.0	91.7	
T ₆	1000	PRE	5.87 (33.5)	4.69 (20.99)	7.45 (54.5)	6.38 (39.7)	5.01 (24.1)	8.04 (63.7)	80.7	78.5	
T ₇	1000	PRE followed by 30 DAS	3.24 (9.6)	1.74 (2.28)	3.58 (11.9)	3.66 (12.4)	2.03 (3.1)	4.07 (15.6)	95.8	94.7	
T ₈	20	PoE	14.03 (195.9)	2.23 (4.11)	14.18 (200.1)	14.20 (200.6)	2.83 (7.0)	14.44 (207.6)	29.1	30.1	
T ₉	100	PoE	3.14 (8.9)	6.32 (38.94)	6.99 (47.8)	3.70 (12.7)	6.68 (43.7)	7.57 (56.3)	83.1	81.0	
T ₁₀	-	Hoing at 30 and 60 DAS	1.00 (0.0)	1.00 (0.00)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	100.0	100.0	
T ₁₁	-	-	13.90 (192.30)	9.54 (89.9)	16.83 (282.3)	14.15 (199.1)	9.94 (97.9)	17.26 (296.9)	0.0	0.0	
SEM ±			0.14	0.08	0.07	0.16	0.12	0.07	-	-	
CD (P = 0.05)			0.41	0.26	0.22	0.50	0.37	0.22	-	-	

*Values in parenthesis are subjected to square root transformation ($\sqrt{x+1}$)

Table 6. Effect of different pre- and post-emergence herbicides on plant population, seed yield and biological yield of chickpea

Treatments	Dose (g ha ⁻¹)	Time of application	Plant population (No. m ⁻²)				Seed yield (kg ha ⁻¹)				Biological yield (kg ha ⁻¹)	
			2023-24		2024-25		2023-24		2024-25		2023-24	2024-25
			20 DAS	Harvest	20 DAS	Harvest	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25
T ₁	Pendimethalin	PRE	24.6	19.2	23.1	18.2	1522	1237	3843	3247		
T ₂	Pendimethalin + one hand weeding (HW)	PRE followed by 30 DAS	24.9	21.5	24.5	20.4	1763	1480	4375	3814		
T ₃	Oxyfluorfen	PRE	24.4	18.5	22.8	17.6	1247	967	3189	2572		
T ₄	Oxyfluorfen + one HW	PRE followed by 30 DAS	25.3	21.2	23.9	20.1	1733	1435	4365	3757		
T ₅	Oxyfluorfen	PoE	24.1	4.9	22.7	4.7	457	416	1245	1181		
T ₆	Pendimethalin + imazethapyr (RM)	PRE	25.6	20.4	23.3	19.4	1623	1301	4077	3397		
T ₇	Pendimethalin + imazethapyr (RM) + one HW	PRE followed by 30 DAS	25.0	22.2	23.6	21.1	1839	1569	4530	4013		
T ₈	Topramezone	PoE	25.5	21.6	24.1	20.5	1359	1071	3450	2826		
T ₉	Imazethapyr + imazamox	PoE	24.3	20.9	22.9	19.9	1543	1285	3848	3329		
T ₁₀	Weed free	Hoing at 30 and 60 DAS	25.6	22.4	24.2	21.3	1917	1608	4531	3941		
T ₁₁	Weedy check	-	24.4	18.6	23.0	17.7	807	742	2079	1989		
SEM ±			0.37	0.38	0.30	0.26	26.33	27	53.97	58		
CD (P = 0.05)			NS	1.12	NS	0.78	78	80	160	171		

Table 7. Effect of different pre- and post-emergence herbicides on economics of chickpea crop

Treatments	Cost of cultivation (₹ ha ⁻¹)				Gross returns (₹ ha ⁻¹)				Net returns (₹ ha ⁻¹)		B:C
	2023-24		2024-25		2023-24		2024-25		2023-24	2024-25	
	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	
T ₁	Pendimethalin	45773	46956	86032	77929	40259	30973	1.88	1.66		
T ₂	Pendimethalin + one hand weeding (HW)	53773	54956	100321	92958	46548	38001	1.87	1.69		
T ₃	Oxyfluorfen	44076	45166	69543	61055	25467	15889	1.58	1.35		
T ₄	Oxyfluorfen + one HW	52076	53166	98757	90364	46681	37198	1.90	1.70		
T ₅	Oxyfluorfen	44076	45166	28010	26555	-16066	-18611	0.64	0.59		
T ₆	Pendimethalin + imazethapyr (RM)	45033	46176	92066	81890	47033	35714	1.94	1.77		
T ₇	Pendimethalin + imazethapyr (RM) + one HW	53033	54176	104779	98424	51746	44248	2.04	1.82		
T ₈	Topramezone	47680	48968	76235	67531	28555	18563	1.60	1.38		
T ₉	Imazethapyr + imazamox (RM)	46987	48237	87121	80779	40134	32541	1.85	1.67		
T ₁₀	Weed free	58440	59440	108759	100185	50319	40745	1.86	1.69		
T ₁₁	Weedy check	42440	43440	48966	46915	6526	3475	1.15	1.08		

References

- Sharma S, Sharma R. Chickpea economy in India. In: Singh M, Upadhyaya HD, Kumar S, editors. Chickpea: Crop wild relatives for enhancing genetic gains. Academic Press; 2020. p. 225–50. <https://doi.org/10.1016/B978-0-12-818299-4.00009-9>
- Sandhu JS, Tripathi S, Chaturvedi SK. Chickpea nutritional status and value chain for sustainable development. In: Sustainable food value chain development: Perspectives from developing and emerging economies. Singapore: Springer Nature; 2023. p. 175–83. https://doi.org/10.1007/978-981-19-6454-1_8
- Indiastat. State-wise area, production and productivity of chickpea crop in India. 2025.
- Sethi IB, Singh H, Kumar S, Jajoria M, Jat LK, Kumar N, et al. Effect of post-emergence herbicides in chickpea. Indian J Weed Sci. 2021;53(1):49–53. <http://doi.org/10.5958/0974-8164.2021.00006.X>
- Xuan TD, Khanh TD, Minh TT. Implementation of conventional and smart weed management strategies in sustainable agricultural production. Weed Biol Manag. 2025;25(1):e70000.
- Singh A, Jain N. Integrated weed management in chickpea. Indian J Weed Sci. 2017;49(1):93–94. <http://doi.org/10.5958/0974-8164.2017.00024.7>
- Patel BD, Patel BJ, Patel JB, Patel RB. Effect of fertilizers and weed management practices on weed control in chickpea (*Cicer arietinum* L.). Indian J Crop Sci. 2006;1(1-2):180–83
- Rathod S, Pandit S, Patil DH, Dodamani BM. Integrated weed management in chickpea under rainfed conditions. Legume Res. 2017;40(3):580–85. <https://doi.org/10.18805/lr.v0i0F.9611>
- Gairola A, Kumar S. Efficacy of various herbicides for weed management in irrigated chickpea (*Cicer arietinum* L.). Indian J Agron. 2024;69(3):340–43. <https://doi.org/10.59797/ija.v69i3.5532>
- Kumar TMN, Sharma AR. Effect of tillage and herbicides on growth, weed control and energetics of chickpea (*Cicer arietinum* L.) grown in sequence with sorghum (*Sorghum bicolor*). Indian J Agron. 2022;67(3):320–23.
- Rao VSP, Rao VS. Principles of weed science, technology and engineering. Jodhpur: Scientific Publishers; 2000. p. 59–67.
- Mani VS, Pandita MS, Gautam KC, Das B. Weed killing chemicals in wheat cultivation. Pest Artic News Summ. 1973;23:17–18.
- Niranjan IK, Tyagi S, Kumar B, Pradhan AK. Evaluation of different post-emergence herbicides in chickpea (*Cicer arietinum* L.). Int J Agric Appl Sci. 2020;1(1):87–91. <https://doi.org/10.52804/ijaas2020.1117>
- Patil R, Namdeo S. Effect of pre- and post-emergence herbicides on chickpea crop production. Int J Curr Microbiol Appl Sci. 2021;10(2):318–30. <https://doi.org/10.20546/ijcmas.2021.1002.037>
- Dewangan MAP, Singh T, Chowdhury D, Kumar B. Management of complex weed flora in chickpea. Indian J Weed Sci. 2016;48(1):79–82. <http://doi.org/10.5958/0974-8164.2016.00019.8>
- Shiv S, Agarwal SB, Verma B, Yadav PS, Singh R, Porwal M, et al. Weed dynamics and productivity of chickpea as affected by weed management practices. EM Int. 2023;42(2):201–04. <http://doi.org/10.53550/PR.2023.v42i02.004>
- Kalyani D. Integrated weed management in chickpea (*Cicer arietinum* L.). [MSc thesis]. Hyderabad: ANGRAU; 2011.
- Yadav VL, Shukla UN, Raiger PR, Mandiwal M. Efficacy of pre- and post-emergence herbicides on weed control in chickpea (*Cicer arietinum* L.). Indian J Agric Res. 2019;53(1):112–15. <http://doi.org/10.18805/IJARE.A-5102>

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc
See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

Copyright: © The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited (<https://creativecommons.org/licenses/by/4.0/>)

Publisher information: Plant Science Today is published by HORIZON e-Publishing Group with support from Empirion Publishers Private Limited, Thiruvananthapuram, India.