



Efficacy of Pre and Post-emergence Herbicides on Weed Dynamics, Growth, Yield and Economics of Summer Cowpea [*Vigna unguiculata* (L.) Walp.]

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10.18805/ag.D-6334

ABSTRACT

Background: A field study was conducted during the *summer* season, 2023 to evaluate the impact of pre-emergence and post-emergence herbicides on the growth, yield and weed dynamics of cowpea (*Vigna unguiculata* L.). Poor weed management during the crop's critical growth phase often results in substantial yield reductions ranging from 25% to 76%. Herbicide application offers a cost-effective alternative to manual weeding, particularly as labor costs continue to rise.

Methods: The study was designed in completely randomized block design comprising of ten treatment groups, incorporating combinations of two PE and POE herbicide application in addition to the treatments, one weed-free check completely weeding (manual weeding) and one weedy check treatment (unweeded control) were included for comparison.

Result: The experiment results indicated that the combination of pendimethalin @ 750 g ha⁻¹ (pre-emergence) and quizalofop-p-ethyl @ 80 g ha⁻¹ (post-emergence) applied 20 days after sowing (DAS) recorded the lowest weed density, biomass and weed index. This treatment also registered the higher crop growth, yield parameters and weed control efficiency and was statistically on par with the weed-free control and the sequential application of Pendimethalin at 750 g/ha + Fenoxaprop-P-ethyl at 100 g/ha applied at 20 days after sowing (DAS). The highest net income was recorded with the sequential application of (PE) Pendimethalin (750 g ha⁻¹) + (PoE) Fenoxaprop-p-ethyl (100 g ha⁻¹) at 20 DAS, with a marginal difference observed in comparison to (PE) Pendimethalin (750 g ha⁻¹) + (PoE) Quizalofop-p-ethyl (80 g ha⁻¹) at 20 DAS. Based on availability, either of these two herbicide combinations can be recommended to the farmers for efficient weed control in cowpea. These results highlight the effectiveness of certain herbicide combinations in enhancing weed management and boosting cowpea yield.

Key words: Grain yield, Pre-and post-emergence weed biomass, Weed control efficiency, Weed density, Weed index.

INTRODUCTION

Cowpea one of most important pulse crop belonging to the family Fabaceae, plays a significant role in agricultural systems worldwide. In India, cowpea cultivation spans 1.5 million hectares, yielding 0.88 million tons with a productivity of 350 kg ha⁻¹ (Anonymous, 2024). In Odisha state, cowpea is cultivated in 64.65 hectares, with a production of 48.04 metric tons and productivity of 43 kg ha⁻¹ (Odisha Agriculture Statistics, 2018-2019). Cowpea is primarily grown to enhance soil nitrogen (N) levels through biological N fixation, reducing the dependence on costly nitrogenous fertilizers. As a sustainable and affordable approach to improving soil fertility, this practice is widely adopted to boost crop yields (Sathiya, 2025). Cowpea serves as an essential food source and is commonly consumed in various forms, including Nifro (boiled grains), Kita (bread) and sauces like Shiro Wot, particularly in northern Ethiopia (Mulugeta *et al.*, 2016). Additionally, the crop thrives well in semi-arid regions, demonstrating resilience to low-input conditions (Boukar *et al.*, 2018). However, drought particularly during the pre-flowering stage, significantly hampered growth and development, reducing yields by as much as 360 kg ha⁻¹ (He *et al.*, 2017; Blum *et al.*, 2019). Weeds pose a significant challenge to cowpea production

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How to cite this article: Saisindhu, A., Kalasare, R.S., Mahapatra, A., Pholane, L.P., Mondal, T., Raghava, C.V. and Mahto, R.K. (2025). Efficacy of Pre and Post-emergence Herbicides on Weed Dynamics, Growth, Yield and Economics of Summer Cowpea [*Vigna unguiculata* (L.) Walp.]. *Agricultural Science Digest*. 1-8. doi: 10.18805/ag.D-6334.

Submitted: 25-03-2025 **Accepted:** 25-06-2025 **Online:** 14-07-2025

and field yield losses ranging from 25%-76%, depending on the cultivar and growing season (Chopra *et al.*, 2017). Manual weeding is time-consuming, labor-intensive and inefficient for large area farming and it can damage crops and disturb soil structure (Sahrawat *et al.*, 2024). Due to these limitations, herbicides are needed for quicker, more

effective weed control, improving crop yields and reducing labor costs, especially in commercial agriculture where efficiency is crucial (Hirwe *et al.*, 2025). Addressing this challenge is essential to optimize cowpea productivity and to ensure its sustainability as a critical crop in various regions.

MATERIALS AND METHODS

A field experiment was carried out during the *summer* season from January to April 2023 at the PG Research Farm of the M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha, India. The study aimed to evaluate the effects of pre-emergence and post-emergence herbicides on plant growth and yield attributes, yield and weed dynamics of the high-yielding cowpea variety DC-15. During the cropping period, the recorded maximum temperature ranged from 28.4°C to 35.6°C, while the minimum temperature varied between 13.1°C and 19.4°C. The total rainfall received was 35 mm. The experimental soil was characterized by a sandy-loam texture, a pH of 6.4, an electrical conductivity of 0.25 dS m⁻¹ and an organic C content of 0.32%. The available nutrient status of the soil were 198, 17 and 192 kg ha⁻¹ of N, P₂O₅ and K₂O, respectively. The experiment was conducted a randomized block design (RBD) with three replications and consisted of ten treatments, each comprising different combinations of pre-emergence and post-emergence herbicides. Statistical analysis was performed using covariance and critical difference (CD) at a 5% significance level to determine treatment effects. The treatments applied were:

T₁: Pendimethalin (PE 750 g/ha) + Fenoxaprop-p-ethyl (PoE 100 g/ha) at 20 DAS, T₂: Pendimethalin (PE 750 g/ha) + Quizalofop-p-ethyl (PoE 80 g/ha) at 20 DAS, T₃: Alachlor (PE 750 g/ha) + Fenoxaprop-p-ethyl (PoE 100 g/ha) at 20 DAS, T₄: Alachlor (PE 750 g/ha) + Quizalofop-p-ethyl (PoE 80 g/ha) at 20 DAS, T₅: Pendimethalin (PE 750 g/ha), T₆: Alachlor (PE 750 g/ha), T₇: Fenoxaprop-p-ethyl (PoE 100 g/ha) at 20 DAS, T₈: Quizalofop-p-ethyl (PoE 80 g/ha) at 20 DAS, T₉: Weed-free check (manual weeding as required), T₁₀: Weedy check (no weed control). This study provides insights into the effectiveness of various herbicide treatments in weed control and their effect on the growth and yield performance of cowpea cultivars.

RESULTS AND DISCUSSION

Weed composition and growth stages: The primary weed species identified in the experiment site comprised grasses, including *Eleusine indica* and *Echinochloa colona*; sedges, such as *Cyperus iria* and *Cyperus difformis* and broadleaf weeds (BLWs) like *Sonchus oleraceus*, *Chenopodium album* and *Amaranthus palmeri*. During the initial stages of crop growth, *E. indica* was more dominant, whereas *E. colona* gained prevalence in the later stages.

Growth parameters

The crop growth parameters, including plant height (cm), number of leaves per plant, leaf area index and dry matter accumulation (g m⁻²) at harvest, were recorded (Table 1). The highest values for all these parameters were observed in the weed-free control plot. Among the herbicide treatments, application of pendimethalin (PE 750 g ha⁻¹)

Table 1: Effect of pre and post-emergence herbicides application on the growth parameters of cowpea during summer season.

Notations	Treatments	Plant height (cm)	No. of leaves plant ⁻¹	Leaf area index	Dry matter accumulation (g m ⁻²)
T ₁	Pendimethalin (PE) @ 750 g ha ⁻¹ + Fenoxaprop-p-ethyl (PoE) @ 100 g ha ⁻¹ at 20 DAS	71.7 ^b	122.3 ^{ab}	1.9 ^b	106.4 ^{ab}
T ₂	Pendimethalin (PE) @ 750 g ha ⁻¹ + Quizalofop-p-ethyl (PoE) @ 80 g ha ⁻¹ at 20 DAS	72.0 ^b	123.7 ^{ab}	1.9 ^b	106.7 ^{ab}
T ₃	Alachlor (PE) @ 750 g ha ⁻¹ + Fenoxaprop-p-ethyl (PoE) @ 100 g ha ⁻¹ at 20 DAS	65.4 ^{bc}	105.5 ^{bc}	1.8 ^b	94.4 ^b
T ₄	Alachlor (PE) @ 750 g ha ⁻¹ + Quizalofop-p-ethyl (PoE) @ 80 g ha ⁻¹ at 20 DAS	66.6 ^{bc}	106.5 ^{bc}	1.9 ^b	95.1 ^b
T ₅	Pendimethalin (PE) @ 750 g ha ⁻¹	58.8 ^c	95.7 ^c	1.8 ^b	94.0 ^b
T ₆	Alachlor (PE) @ 750 g ha ⁻¹	57.0 ^c	94.3 ^c	1.4 ^c	8.8 ^b
T ₇	Fenoxaprop-p-ethyl (PoE) @ 100 g ha ⁻¹ at 20 DAS	58.0 ^c	95.0 ^c	1.5 ^c	91.0 ^b
T ₈	Quizalofop-p-ethyl (PoE) @ 80 g ha ⁻¹ at 20 DAS	58.0 ^c	95.0 ^c	1.6 ^{bc}	91.4 ^b
T ₉	Weed free check (complete weed free through hand weeding as and when required)	87.7 ^a	140.4 ^a	2.6 ^a	124.4 ^a
T ₁₀	Weedy check	34.3 ^d	70.3 ^d	0.9 ^d	62.6 ^c
	S.Em. (±)	4.3	6.4	0.1	6.6
	CD (5%)	12.8	19.0	0.3	19.7

*DAS: Days after sowing; PE: Pre emergence; PoE: Post emergence.

combined with quizalofop-p-ethyl (PoE 80 g ha⁻¹) at 20 DAS resulted in superior growth of cowpea. This improvement can be attributed to reduced crop-weed competition, which enhanced nutrient uptake due to effective weed control. These results were statistically comparable to those obtained with pendimethalin (PE 750 g ha⁻¹) combined with fenoxaprop-p-ethyl (PoE 100 g ha⁻¹) at 20 DAS (T₁). Similar findings have been reported by Choudhary *et al.* (2023); Khose *et al.* (2023); Tiwari *et al.* (2023) and Patil *et al.* (2020).

Yield attributes

The data on number of clusters plant⁻¹, number of pods cluster⁻¹, pod length (cm) and test weight have been summarized in Table 2. Significantly, higher values for the yield attributes were recorded in the weed-free check. The lower weed infestation observed in the weed-free plot was likely due to reduced crop-weed competition, which facilitated plant growth. Additionally, wider spacing contributed to a higher no. of clusters plant⁻¹ (9.4), more

Table 2: Effect of Pre and post-emergence herbicide application on the yield attributes of cowpea during summer season.

Notations	Treatments	No. of clusters plant ⁻¹	No. of pods cluster ⁻¹	Pod length (cm)	Test weight (g)
T ₁	Pendimethalin (PE) @ 750 g ha ⁻¹ + Fenoxaprop-p-ethyl (PoE) @ 100 g ha ⁻¹ at 20 DAS	7.2 ^b	13.2 ^b	25.7 ^{ab}	13.1 ^b
T ₂	Pendimethalin (PE) @ 750 g ha ⁻¹ + Quizalofop-p-ethyl (PoE) @ 80 g ha ⁻¹ at 20 DAS	7.9 ^b	13.3 ^b	25.8 ^{ab}	13.1 ^b
T ₃	Alachlor (PE) @ 750 g ha ⁻¹ + Fenoxaprop-p-ethyl (PoE) @ 100 g ha ⁻¹ at 20 DAS	4.9 ^c	10.7 ^c	21.4 ^{bc}	10.6 ^c
T ₄	Alachlor (PE) @ 750 g ha ⁻¹ + Quizalofop-p-ethyl (PoE) @ 80 g ha ⁻¹ at 20 DAS	5.3 ^c	11.0 ^c	21.8 ^{bc}	10.7 ^c
T ₅	Pendimethalin (PE) @ 750 g ha ⁻¹	3.8 ^d	8.5 ^d	20.2 ^c	9.1 ^{cd}
T ₆	Alachlor (PE) @ 750 g ha ⁻¹	2.6 ^e	6.8 ^e	19.4 ^c	8.7 ^d
T ₇	Fenoxaprop-p-ethyl (PoE) @ 100 g ha ⁻¹ at 20 DAS	2.9 ^{de}	8.0 ^{de}	20.1 ^c	8.8 ^d
T ₈	Quizalofop-p-ethyl (PoE) @ 80 g ha ⁻¹ at 20 DAS	3.3 ^{de}	8.2 ^{de}	20.1 ^c	8.9 ^{cd}
T ₉	Weed free check (complete weed free through hand weeding as and when required)	9.4 ^a	16.5 ^a	29.7 ^a	15.1 ^a
T ₁₀	Weedy check	0.8 ^f	3.6 ^f	17.4 ^c	6.6 ^e
	S.E.m. (±)	0.4	0.6	1.6	0.6
	CD (5%)	1.0	1.6	4.7	1.8

*DAS: Days after sowing; PE: Pre emergence; PoE: Post emergence.

Table 3: Effect of pre and post-emergence herbicide application on the yield of cowpea during summer season.

Notations	Treatments	Seed yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)	Biological yield (kg ha ⁻¹)	Harvest index (%)
T ₁	Pendimethalin (PE) @ 750 g ha ⁻¹ + Fenoxaprop-p-ethyl (PoE) @ 100 g ha ⁻¹ at 20 DAS	1091 ^b	2200 ^b	3291 ^b	33
T ₂	Pendimethalin (PE) @ 750 g ha ⁻¹ + Quizalofop-p-ethyl (PoE) @ 80 g ha ⁻¹ at 20 DAS	1100 ^b	2208 ^b	3308 ^b	33.2
T ₃	Alachlor (PE) @ 750 g ha ⁻¹ + Fenoxaprop-p-ethyl (PoE) @ 100 g ha ⁻¹ at 20 DAS	890 ^c	2108 ^{bc}	2998 ^c	29.7
T ₄	Alachlor (PE) @ 750 g ha ⁻¹ + Quizalofop-p-ethyl (PoE) @ 80 g ha ⁻¹ at 20 DAS	900 ^c	2133 ^{bc}	3033 ^c	29.6
T ₅	Pendimethalin (PE) @ 750 g ha ⁻¹	853 ^c	2033 ^{bc}	2886 ^c	29.6
T ₆	Alachlor (PE) @ 750 g ha ⁻¹	701 ^d	1967 ^c	2668 ^d	26.3
T ₇	Fenoxaprop-p-ethyl (PoE) @ 100 g ha ⁻¹ at 20 DAS	830 ^c	2000 ^c	2830 ^{cd}	29.4
T ₈	Quizalofop-p-ethyl (PoE) @ 80 g ha ⁻¹ at 20 DAS	836 ^c	2001 ^c	2838 ^{cd}	29.5
T ₉	Weed free check (complete weed free through hand weeding as and when required)	1250 ^a	2450 ^a	3700 ^a	33.8
T ₁₀	Weedy check	603 ^d	1573 ^d	2176 ^e	27.8
	S.E.m.(±)	12	62	70	7.64
	CD (5%)	42	185	208	NS

*DAS: Days after sowing; PE: Pre emergence; PoE: Post emergence

Pods cluster⁻¹ (16.5), increased pod length (29.7 cm) and higher test weight (15.1 g), ultimately improving yield. Among the herbicide-treated plots, Pendimethalin (PE 750 g ha⁻¹) + Quizalofop-p-ethyl (PoE 80 g ha⁻¹) applied 20 days after sowing (DAS) (T₂) recorded values clusters plant⁻¹, number of pods cluster⁻¹, pod length (cm) and test weight (7.9, 13.3, 25.8 cm and 13.1 g, respectively). In contrast, the lowest values for these attributes were observed with Alachlor (PE 750 g ha⁻¹), which yielded 2.6, 6.8, 19.4 cm and 8.7 g, respectively. Similar were recorded by Maurya *et al.* (2023), Priya *et al.* (2023) and Khose *et al.* (2022).

Grain yield and harvest index

Data on grain, straw, biological yield and harvest index is presented in Table 3. Among the herbicidal treatments, application of pendimethalin (PE 750 g ha⁻¹) combined with Quizalofop-p-ethyl (PoE 80 g ha⁻¹) at 20 DAS (T₂) resulted in the highest seed, haulm, biological yield and harvest index (1100, 2208, 3308 kg ha⁻¹ and 33.2%, respectively). These results were statistically comparable to the pendimethalin (PE 750 g ha⁻¹) and Fenoxaprop-p-ethyl (PoE 100 g ha⁻¹) at 20 DAS, which yielded 1091 kg ha⁻¹ of seed, 2200 kg ha⁻¹ of haulm, 3291 kg ha⁻¹ of biological yield and a harvest index of 33%.

The lowest yield and harvest index were recorded in the untreated weedy check. This could be attributed to increased weed accumulation at 60 DAS and at harvest, leading to lower seed yield owing to higher crop weed competition. Effective weed management facilitated better pod formation, resulting in a greater number of grains per pod and higher stover yield. These findings are consistent with the previous studies by Bhosale *et al.* (2023); Chovatia

et al. (2023); Dash *et al.* (2023); Khose *et al.* (2023); Priya *et al.* (2023); Sethi *et al.* (2021) and Sharma *et al.* (2019).

Weed density and biomass

The weed density and biomass was furnished in Table 4. The untreated control (weedy check, W₁₀) exhibited the highest weed density and biomass. Among the herbicide treatments, the lowest weed density was observed with spraying of pendimethalin (PE 750 g ha⁻¹) combined with quizalofop-p-ethyl (PoE 80 g ha⁻¹) at 20 DAS, with values of 4.4 and 3.9 per m², respectively. This was statistically comparable to the pendimethalin (PE 750 g ha⁻¹) and fenoxaprop-p-ethyl (PoE 100 g ha⁻¹) at 20 DAS, which recorded values of 4.4 and 4.0 per m², respectively. Both treatments were equally effective in weed control at 30 and 60 DAS. The reduction in weed density may be attributed to frequent hand weeding at regular intervals, which helped to deplete the weed seed bank, ensured effective weed management, reduces crop-weed competition and prevents weed proliferation. Findings of Chovatia *et al.* (2023); Dash *et al.* (2023) and Singh *et al.* (2022) supported these results.

Relationship between weed parameters and grain yield

The relationships among weed parameters, including weed density, weed biomass, weed control efficiency and grain yield, have been analyzed. Efforts were made to establish this relationship at both 30 days after sowing (DAS) and 60 DAS. Based on the analysis presented in Fig 1, it was observed that the coefficient of determination (R²) was highest at 60 DAS. This indicated a stronger correlation between weed parameters and seed yield at this stage compared to 30 DAS. The higher R² value (0.85) at 60 DAS suggested that the data closely aligned with the regression

Table 4: Effect of pre and post-emergence herbicide application on weed parameters of cowpea during summer season.

Notations	Treatments	Total weed density (no. m ⁻²)		Total weed biomass (g m ⁻²)	
		30 DAS	60 DAS	30 DAS	60 DAS
T ₁	Pendimethalin (PE) @ 750 g ha ⁻¹ + Fenoxaprop-p-ethyl (PoE) @ 100 g ha ⁻¹ at 20 DAS	7.0(49.1)	4.4(19.1)	4.8(23.0)	4.0(15.9)
T ₂	Pendimethalin (PE) @ 750 g ha ⁻¹ + Quizalofop-p-ethyl (PoE) @ 80 g ha ⁻¹ at 20 DAS	6.9(48.6)	4.4(18.7)	4.8(22.8)	3.9(14.9)
T ₃	Alachlor (PE) @ 750 g ha ⁻¹ + Fenoxaprop-p-ethyl (PoE) @ 100 g ha ⁻¹ at 20 DAS	7.3(52.2)	4.7(21.2)	6.2(37.7)	4.1(16.5)
T ₄	Alachlor (PE) @ 750 g ha ⁻¹ + Quizalofop-p-ethyl (PoE) @ 80 g ha ⁻¹ at 20 DAS	7.2(51.4)	4.6(20.4)	5.7(32.3)	4.0(16.0)
T ₅	Pendimethalin (PE) @ 750 g ha ⁻¹	7.3(53.4)	4.7(21.9)	6.4(39.9)	4.2(17.5)
T ₆	Alachlor (PE) @ 750 g ha ⁻¹	8.3(69.0)	5.6(30.4)	7.1(49.3)	4.4(19.1)
T ₇	Fenoxaprop-p-ethyl (PoE) @ 100 g ha ⁻¹ at 20 DAS	8.3(68.8)	5.3(28.1)	6.7(45.0)	4.4(18.6)
T ₈	Quizalofop-p-ethyl (PoE) @ 80 g ha ⁻¹ at 20 DAS	8.1(65.5)	5.3(27.4)	6.4(40.9)	4.2(17.5)
T ₉	Weed free check (complete weed free through hand weeding as and when required)	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.7(0.0)
T ₁₀	Weedy check	9.4(87.8)	6.1(36.9)	8.0(63.9)	5.2(26.3)
	S.Em. (±)	0.3	0.1	0.2	0.2
	CD (5%)	0.8	0.3	0.6	0.5

*DAS: Days after sowing; PE: Pre emergence; PoE: Post emergence.

trend line, although one data point deviates significantly, potentially influencing the observed correlation. These findings emphasized the critical role of effective weed management during later stages of crop development to enhance grain yield.

Regression between weed biomass and seed yield at 30 and 60 DAS

Fig 2 illustrates the regression between weed biomass and seed yield at 30 and 60 DAS. From the data, we observed that the coefficient of determination (R^2) was highest at 30 DAS, with a value of 0.96. This higher R^2

value can be attributed to the fact that two data points deviate significantly from the trend line, which indicated stronger crop-weed competition at this stage than at 60 DAS. Consequently, the 30 DAS data showed a more robust relationship between weed biomass and grain yield.

Weed control efficiency

The data on weed control efficiency (WCE) and the weed index were presented in Table 5. The highest WCE and weed index were recorded in the weedy check (W_{10}). Among all herbicide treatments, the highest WCE was observed in the treatment with Pendimethalin (PE 750 g ha⁻¹) +

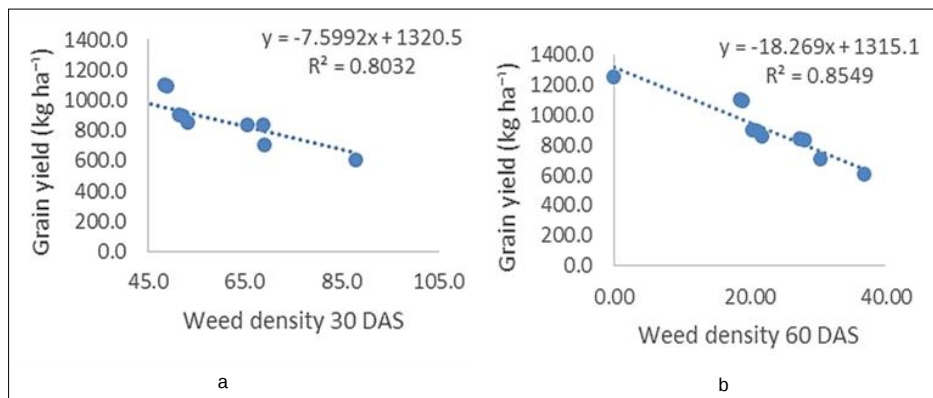


Fig 1: Regression between weed density and seed yield at 30 and 60 DAS.

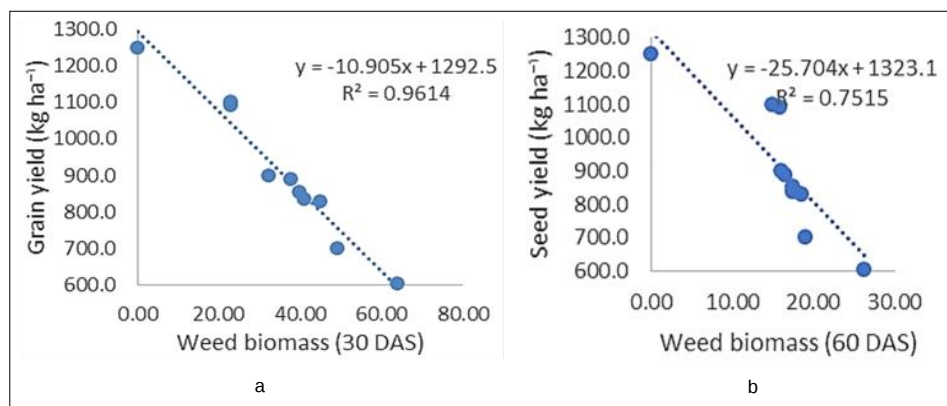


Fig 2: Regression between weed biomass and seed yield at 30 and 60 DAS.

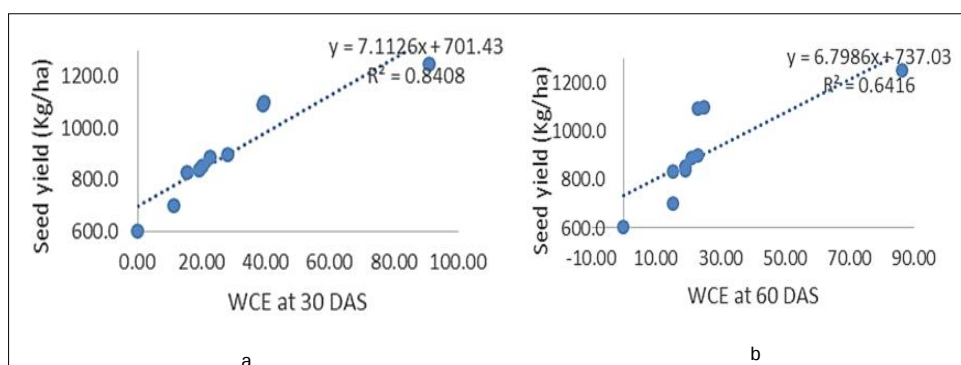


Fig 3: Regression between weed control efficiency and seed yield at 30 and 60 DAS.

Quizalofop-p-ethyl (PoE 80 g ha⁻¹) applied at 20 DAS (43.34% and 64.31%), which was statistically at par with Pendimethalin (PE 750 g ha⁻¹) + Fenoxaprop-p-ethyl (PoE 100 g ha⁻¹) applied at 20 DAS. Both treatments were equally effective in controlling weeds at 30 and 60 DAS.

Regression between weed control efficiency and seed yield at 30 and 60 DAS

In Fig 3, the weed control efficiency was observed at 30 and 60 DAS. The coefficient of determination (R^2) was highest at 30 DAS, likely due to four data points deviating significantly from the trend line. This deviation might have contributed to the stronger R^2 value (0.84), indicating increased crop-weed competition. Additionally, it was found that the regression graph exhibited a linear pattern.

Economics

The data illustrating the impact of weed management practices on economics of the crop is presented in Table 6.

The weed-free check (T_9) incurred the highest cultivation cost (Rs. 40,186 ha⁻¹) and gross returns (Rs. 65,371 ha⁻¹), whereas the weedy check treatment had the lowest cultivation cost (Rs. 26,936 ha⁻¹) and gross returns (Rs. 31,725 ha⁻¹). The highest net return was achieved in the herbicidal treatment involving pendimethalin (PE 750 g ha⁻¹) + Quizalofop-p-ethyl (PoE 80 g ha⁻¹) applied at 20 DAS, yielding Rs. 28,861 ha⁻¹. This was statistically at par with the treatment involving pendimethalin (PE 750 g ha⁻¹) + fenoxaprop-p-ethyl (PoE 100 g ha⁻¹) applied at 20 DAS, which recorded a net return of Rs. 28,908 ha⁻¹. The highest benefit-cost ratio was examined in the application with pendimethalin (PE 750 g ha⁻¹) + fenoxaprop-p-ethyl (PoE 100 g ha⁻¹) at 20 DAS (1.00), which was statistically at par with pendimethalin (PE 750 g ha⁻¹) + quizalofop-p-ethyl (PoE 80 g ha⁻¹) at 20 DAS (0.99). Despite of higher seed yields in the weed-free plots, net returns and the benefit-cost (B-C) ratio were lower due to the high cost of manual weeding, which increased cultivation expenses.

Table 5: Effect of pre and post-emergence herbicide application on weed control efficiency of cowpea during summer season.

Notations	Treatments	WCE (%)	
		30 DAS	60 DAS
T_1	Pendimethalin (PE) @ 750 g ha ⁻¹ + Fenoxaprop-p-ethyl (PoE) @ 100 g ha ⁻¹ at 20 DAS	39.54	64
T_2	Pendimethalin (PE) @ 750 g ha ⁻¹ + Quizalofop-p-ethyl (PoE) @ 80 g ha ⁻¹ at 20 DAS	43.54	64.31
T_3	Alachlor (PE) @ 750 g ha ⁻¹ + Fenoxaprop-p-ethyl (PoE) @ 100 g ha ⁻¹ at 20 DAS	37.26	41
T_4	Alachlor (PE) @ 750 g ha ⁻¹ + Quizalofop-p-ethyl (PoE) @ 80 g ha ⁻¹ at 20 DAS	39.16	49
T_5	Pendimethalin (PE) @ 750 g ha ⁻¹	33.46	37
T_6	Alachlor (PE) @ 750 g ha ⁻¹	27.37	22.84
T_7	Fenoxaprop-p-ethyl (PoE) @ 100 g ha ⁻¹ at 20 DAS	29.27	29.57
T_8	Quizalofop-p-ethyl (PoE) @ 80 g ha ⁻¹ at 20 DAS	33.46	35.99
T_9	Weed free check (complete weed free through hand weeding as and when required)	100	100
T_{10}	Weedy check	0	0

*DAS: Days after sowing; PE: Pre emergence; PoE: Post emergence.

Table 6: Effect of pre and post emergence herbicide application on economics of cowpea during summer season.

Notations	Treatments	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
T_1	Pendimethalin (PE) @ 750 g ha ⁻¹ + Fenoxaprop-p-ethyl (PoE) @ 100 g ha ⁻¹ at 20 DAS	28942	57850	28908	1.00
T_2	Pendimethalin (PE) @ 750 g ha ⁻¹ + Quizalofop-p-ethyl (PoE) @ 80 g ha ⁻¹ at 20 DAS	28956	57637	28681	0.99
T_3	Alachlor (PE) @ 750 g ha ⁻¹ + Fenoxaprop-p-ethyl (PoE) @ 100 g ha ⁻¹ at 20 DAS	29062	46610	17548	0.60
T_4	Alachlor (PE) @ 750 g ha ⁻¹ + Quizalofop-p-ethyl (PoE) @ 80 g ha ⁻¹ at 20 DAS	29076	47135	18059	0.62
T_5	Pendimethalin (PE) @ 750 g ha ⁻¹	28086	44685	16599	0.59
T_6	Alachlor (PE) @ 750 g ha ⁻¹	28206	37068	8863	0.31
T_7	Fenoxaprop-p-ethyl (PoE) @ 100 g ha ⁻¹ at 20 DAS	27792	43502	15710	0.57
T_8	Quizalofop-p-ethyl (PoE) @ 80 g ha ⁻¹ at 20 DAS	27806	43853	16048	0.58
T_9	Weed free check (complete weed free through hand weeding as and when required)	40186	65371	25185	0.62
T_{10}	Weedy check	26936	31725	4789	0.18

*DAS: Days after sowing; PE: Pre emergence; PoE: Post emergence.

CONCLUSION

The study on efficacy of herbicides in cowpea using pre- and post-emergence herbicides during the *summer* season demonstrated that the application of pendimethalin (750 g ha⁻¹) as a pre-emergence treatment, followed by fenoxaprop-p-ethyl (100 g ha⁻¹) as a post-emergence treatment at 20 DAS, resulted in significantly lower weed density and dry matter, along with higher weed control efficiency compared to other treatments. This effectiveness is attributed to the pre-emergence herbicide controlling the first flush of weeds, which competes with the crop during its early growth stage, while the sequential application of the post-emergence herbicide managed the second flush of weeds. The highest net income was recorded with the application of (PE) pendimethalin (750 g ha⁻¹) + (PoE) fenoxaprop-p-ethyl (100 g ha⁻¹) at 20 DAS, with a marginal difference with (PE) Pendimethalin (750 g ha⁻¹) + (PoE) Quizalofop-p-ethyl (80 g ha⁻¹) at 20 DAS. Depending on availability, either of these above herbicide combinations can be recommended to farmers for effective weed management in cowpea.

ACKNOWLEDGEMENT

We extend our sincere gratitude to Centurion University of Technology and Management for providing the necessary facilities and financial support, which played a crucial role in the successful completion of this research.

Disclaimers

The views, interpretations and conclusions expressed in this article are entirely those of the authors and do not necessarily represent the perspectives of their affiliated institutions. While we have taken great care to ensure the accuracy and completeness of the information, we bear no responsibility for any direct or indirect consequences resulting from its use.

Informed consent

Not applicable.

Conflict of interest

The authors declare that there are no conflicts of interest related to this publication. Additionally, no external funding or sponsorship influenced the study's design, data collection, analysis, decision to publish or manuscript preparation.

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