Indian Journal of Agronomy 70 (3): 299–305 (September 2025)
DOI: 10.59797/ija.v70.i3.5620

Research Paper

Evaluation of Pre and Post-emergence Herbicides for Weed Management in Soybean (*Glycine max*)

M.D. GIRI[1], C.P. JAYBHAYE[2] AND D.G. KANWADE[3]

Agriculture Research Station, Buldana, Maharashtra 443 001

Received: December 2025; Revised accepted: June 2025

ABSTRACT

Heavy infestation of weeds with grasses, broad-leaved, and sedges poses a big challenge for soybean production. This crop's initially slow growth, good sunshine, and intermittent rains during the rainy season further provide a congenial environment for the excessive growth of weeds. Recognising the importance of timely weed management in soybean, this investigation was undertaken to study the effect of pre- and post-emergence herbicides on growth, yield, and weed management in the soybean crop. The experiment was conducted from 2018 at 2020 at Agriculture Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Buldana (Maharashtra). The experiment was laid out in a randomised block design with ten weed management options (T_1: weedy check; T_2: weed-free; T_3: pendimethalin @ 0.677 kg a.i./ha PE; T_4: diclosulam 84% WDG @ 0.026 kg a.i./ha as PE; T_5: imazethapyr 10% SL @ 0.075 kg a.i./ha at 21 DAS as PoE; T_6: propaquizafop @ 0.050 kg a.i. + imazethapyr @ 0.075 kg a.i./ha at 21 DAS as PoE (RM); T_7: propaquizafop 10% EC @ 0.075 kg a.i./ha at 21 DAS as PoE; T_8: imazamox @ 0.035 kg a.i + imazethapyr @ 0.035 kg a.i./ha at 21 DAS as PoE (RM); T_9: quizolofop ethyl 5% EC @ 0.05 kg a.i. + imazethapyr 10% SL @ 0.075 kg a.i./ha at 21 DAS PoE (tank mix) and T_{10}: imazethapyr 10% SL @ 0.075 kg a.i./ha at 21 DAS PoE + propaquizafop 10% EC @ 0.075 kg a.i./ha at 35 DAS). The Results showed that pre-emergence application of diclosulam (0.026 kg a.i./ha) and pendimethalin (0.677 kg a.i./ha) significantly reduced weed density at 30 DAS, with diclosulam showing the lowest weed count (35.56 weeds/m²). At 60 DAS, a sequential post-emergence application of imazethapyr and propaquizafop showed superior control (46.22 weeds/m²). The weedy check treatment had the highest weed density at all growth stages, culminating 387.56 weeds/m² at harvest. Effective weed management positively influenced growth and yield parameters of soybean. The weed-free treatment resulted in the highest number of branches (6.73/plant) and pods (22.82/plant), with a seed yield of 7.15 g/plant, which was significantly higher than the weedy check. Among chemical treatments, the post-emergence application of propaquizafop and imazethapyr (0.050 kg and 0.075 kg a.i./ha, respectively) at 21 DAS yielded the highest seed production (2031 kg/ha), close to the weed-free treatment. Economic analysis revealed that the weed-free treatment achieved the highest gross monetary returns (Rs. 80,873/ha). However, the propaquizafop and imazethapyr post-emergence applications had the highest benefit-cost ratio (3.01), demonstrating cost-effectiveness by minimizing weed competition and maximizing economic return. In contrast, the weedy check had the lowest returns and a B: C ratio 1.04. These results suggest that combining imazethapyr and propaquizafop post-emergence is an effective and economical strategy for weed management in soybean production.

***Key words*:** Benefit cost ratio, Herbicides, Seed yield, Soybean, Weed management

Soybean, a wonder crop, is an important oil seed crop in India and the world. Commercial cultivation began in India in the late 1960s, and the crop is now cultivated on around 13 million hectares with a production of 12.5 million tonnes (IIMR, 2024). In a very short period, farmers adopted soybeans as a major *Kharif* crop in Madhya Pradesh. Afterwards, the acreage increased in Maharashtra, Rajasthan, Chhattisgarh, Northern Karnataka, Gujarat, and Northern Telangana. Presently, soybean contribute 42 per cent of total oilseed production and 22 per cent to total oil production in the country. With the growing population, the demand for edible oil is increasing. Domestic Oilseed crops meet about 40% of this demand, while the remaining 60% is fulfilled through imports. The cost of importing edible oil puts high pressure on India's foreign exchange. Among all the oilseed crops, soybean has the highest potential to meet the challenge of being self-sufficient in producing edible oil. Globally, soybean is cultivated in 140

[1]**Corresponding author's Email:** mdgiri@pdkv.ac.in
[1]Assistant Professor (Agronomy); [2]Associate Professor (Agronomy); [3]Assistant Professor (Agril. Botany), Agriculture Research Station, Buldana, Maharashtra 443 00

million ha with an annual production of 394 million tonnes, with a global productivity of 2.8 tonnes/ha. The national productivity of soybean of 1 tonne/ha is relatively lower than the world average of 2.8 tonnes/ha (IISR, 2024).

Heavy infestation of weeds, including grasses, broad-leaved weeds, and sedges, poses a big challenge for soybean production (Sharma *et al.,* 2016). The soybean crop's initially slow growth, coupled with little lateral spread, allows these specific weed species to occupy vacant spaces between rows easily and offer serious competition with the crop. Good sunshine and intermittent rains during the rainy season further provide a congenial environment for the excessive growth of weeds. The emergence and rapid growth of many weed species and the soybean crop caused severe crop-weed competitions and reduced crop yields to 30-80%, depending on the weed flora type and density (Kurchania *et al.,* 2001). This reduced yield due to weed competition highlights the critical need for effective weed management in soybean farming.

With heavy and continuous rainfall in *Kharif*, increasing labour wages, and labour shortages, today's farmers are increasingly interested in using herbicides to control weeds. They urge reducing cultivation costs due to labour shortages and high costs (Ahirwar & Ahirwar, 2023). Therefore, chemical weed management offers farmers both effective weed control under adverse weather situations and a significant reduction in the cost of production, providing them with much-needed economic relief.

Recognising the critical role of timely weed management in soybean, this investigation was undertaken. This study aimed to comprehensively understand the effect of pre- and post-emergence herbicides on growth, yield, and weed management in the soybean crop.

MATERIALS AND METHODS

The field experiment was conducted at the Agriculture Research Station, Buldana (Maharashtra), during the rainy seasons of 2018, 2019, and 2020. The soil of the experimental plot was clayey (35.8% sand, 30.3% silt, 42.3% clay) in texture, with a *p*H of 8.1 (1:2.5 soil to water) and an EC of 0.37. The soil contained 0.39% organic carbon, 242 kg/ha of alkaline $KMnO_4$ oxidizable available nitrogen, 21 kg/ha of 0.5 M $NaHCO_3$ extractable phosphorus, and 336 kg/ha of NHOAc extractable potassium.

The experiment was laid out in a randomised block design with ten weed management options (T_1: weedy check; T_2: weed-free; T_3: pendimethalin @ 0.677 kg a.i./ ha as pre-emergence application; T_4: diclosulam 84% WDG @ 0.026 kg a.i./ ha as pre-emergence; T_5: imazethapyr 10% SL @ 0.075 kg a.i./ ha at 21 DAS as post-emergence; T_6: propaquizafop @ 0.050 kg a.i. + imazethapyr @ 0.075 kg a.i./ha at 21 DAS as post-emergence (RM); T_7: propaquizafop 10% EC @ 0.075 kg a.i./ ha at 21 DAS as post-emergence; T_8: imazamox @ 0.035 kg a.i + imazethapyr @ 0.035 kg a.i./ ha at 21 DAS as post-emergence (RM); T_9: quizolofop ethyl 5% EC @ 0.05 kg a.i. + imazethapyr 10% SL @ 0.075 kg a.i./ ha at 21 DAS post-emergence (tank mix) and T_{10}: imazethapyr 10% SL @ 0.075 kg a.i./ ha at 21 DAS post-emergence + propaquizafop 10% EC @ 0.075 kg a.i./ ha at 35 DAS). The treatments were replicated three times. The plot size was 3.0 m (length) x 3.6 m (width). The plot consisted of eight crop rows planted at 45 cm x 5 cm. The gross plot size was 10.8 m^2.

Soybean seeds of the genotype JS-335 were sown (27 June 2018, 29 June 2019, and 29 June 2020). Before sowing, the seeds were inoculated with *Rhizobium* bacteria inoculum (25 g/ kg seed). The recommended dose of fertilizer (30 kg/ha N, 70 kg/ha P_2O_5, and 30 kg/ha K_2O) for soybean was applied as a basal dose at the time of sowing and was supplied through urea, single super phosphate, and muriate of potash. Weed management was followed as per the treatments. The final harvesting was done on 13th October 2018, 10th October 2019, and 18th October 2020. The seeds were obtained manually by threshing the soybean crop, and the final seed weight was recorded.

The weed count was taken by establishing three 25 cm^2 quadrants in each plot. The weed counts were taken 30 days after sowing (DAS), 60 DAS, and at harvest.

The data were statistically analyzed using OPSTAT, following the randomized block design (RBD) of the experiment (Sheron et al., 1998). Data on various parameters were recorded from the field experiment and statistically analysed. The critical difference (C.D.) values were worked out whenever the results were significant at 5% probability level.

RESULTS AND DISCUSSION

Effect of different pre-and post-emergence herbicides on weed count in soybean crop

In the present investigation, the predominant weed flora observed in the experimental field were *Cynodon dactylon, Dactyloctenium aegyptium*, *Echinochloa colona*, *Brachiaria sp*., *Cyperus rotundus*, *Commelina diffusa*, *Amaranthus viridis*, *Digera arvensis*, *Phyllanthus niruri, and Parthenium hysterophorus.* The effect of pre-and post-emergence herbicides on weed count was significant (Table 1).

At 30 DAS among the chemical pre- and post-emergence herbicides, the application of diclosulam 84% WDG @ 0.026 kg a.i./ ha as pre-emergence recorded the lowest weed count (35.56 weeds/m^2). It was at par with Imazethapyr 10% SL @ 0.075 kg a.i./ ha at 21 DAS post-

Table 1. Effect of different pre- and post-emergence herbicides on weed count and weed index in soybean (pooled means of 3 years)

Treatment	Weed Count/m²			Weed index
	30 DAS	60 DAS	harvest	
Weedy check	144.00[c] (12.44)	177.78[d] (13.70)	387.56[d] (20.39)	72.57
Weed-free	0.00[a] (0.71)	0.00[a] (0.71)	0.00[a] (0.71)	0.00
Pendimethalin @ 0.677 kg a.i./ha as PE	40.89[b] (7.01)	58.67[c] (8.12)	108.44[b] (11.01)	13.02
Diclosulam 84% WDG @ 0.026 kg a.i./ha as PE	35.56[b] (6.56)	51.56[b] (7.50)	97.78[b] (10.49)	10.55
Imazethapyr 10% SL @ 0.075 kg a.i./ha at 21 DAS as PoE	55.11[c] (7.81)	58.67[c] (8.15)	106.67[b] (10.96)	9.21
Propaquizafop @ 0.050 kg a.i. + Imazethapyr @ 0.075kg a.i./ha at 21 DAS as PoE (ready mix)	60.44[c] (8.28)	53.33[b] (7.74)	97.78[b] (10.52)	7.60
Propaquizafop 10% EC @ 0.075 kg a.i./ha at 21 DAS PoE	48.00[b] (7.57)	62.22[c] (8.31)	108.44[c] (11.05)	11.35
Imazamox @ 0.035 kg a.i + Imazethapyr @ 0.035 kg a.i./ha at 21 DAS PoE (ready mix)	53.33[c] (7.91)	60.44[b] (8.03)	104.89[b] (10.79)	10.30
Quizolofop ethyl 5% EC @ 0.05 kg a.i. + Imazethapyr 10% SL @ 0.075 kg a.i./ha at 21 DAS PoE (tank mix)	55.11[c] (7.98)	62.22[c] (8.28)	101.33[b] (10.69)	10.87
Imazethapyr 10% SL @ 0.075 kg a.i./ha at 21 DAS PoE + Propaquizafop 10% EC @ 0.075 kg a.i./ha at 35 DAS	39.11[b] (6.86)	46.22[b] (7.14)	92.44[b] (10.23)	8.59
SEm±	(0.36)	(0.31)	(0.27)	-
CD (P=0.05)	(1.08)	(0.91)	(0.80)	-

The transformed values are shown in parentheses. Means followed by the same letter do not differ significantly at the 0.05 probability level.

emergence + Propaquizafop 10% EC @ 0.075 kg a.i./ ha at 35 DAS (39.11 weeds/ m²) pendimethalin @ 0.677 kg a.i./ ha as pre-emergence (40.89 weeds/ m²), post-emergence application of propaquizafop 10% EC @ 0.075 kg a.i./ ha at 21 DAS (48 weeds/ m²). The highest weed count was observed with weedy check treatment (144 weeds/ m²).

At 60 DAS among the chemical pre- and post-emergence herbicides, application of imazethapyr 10% SL @ 0.075 kg a.i./ha at 21 DAS post-emergence + propaquizafop 10% EC @ 0.075 kg a.i./ ha at 35 DAS as post-emergence application recorded lowest weed count (46.22 weeds/m²) and it was at par with and diclosulam 84% WDG @ 0.026 kg a.i./ha as pre-emergence application (51.56 weeds/ m²) imazamox @ 0.035 kg a.i + imazethapyr @ 0.035 kg a.i./ha at 21 DAS as post-emergence (ready mix) (60.44 weeds/ m²). The highest weed density was observed with weedy check treatment (177.78 weeds/ m²).

At harvest among the chemical pre- and post-emergence herbicides, application of imazethapyr 10% SL @ 0.075 kg a.i./ ha at 21 DAS post-emergence + propaquizafop 10% EC @ 0.075 kg a.i./ ha at 35 DAS recorded lowest weed count (92.44 weeds/m²) and it was at par with all other chemical pre- and post-emergence herbicides except propaquizafop. The highest weed density was observed with weedy check treatment (387.56 weeds/ m²).

The lowest weed count at 30 DAS with diclosulam as a pre-emergence application (35.56 weeds/m²) indicates its strong initial control over emerging weed seedlings. This herbicide is known for its broad-spectrum activity and might have effectively inhibited weed emergence by targeting the germinating seeds and early seedlings. Pendimethalin, another pre-emergence herbicide, also performed well (40.89 weeds/m²) due to its mode of action that inhibits root and shoot development in seedlings, though it might be slightly less potent than diclosulam under the conditions of this experiment.

Propaquizafop (post-emergence) and imazethapyr + propaquizafop as a sequential post-emergence treatment also provided effective control, likely due to their ability to target weeds that escaped pre-emergence treatment or emerged later.

At 60 DAS, the sequential post-emergence application of imazethapyr + propaquizafop resulted in the lowest weed count (46.22 weeds/m²). This combination might have effectively managed both broadleaf and grass weeds that escaped or survived initial pre-emergence treatments. Imazethapyr's broad-spectrum activity, coupled with propaquizafops grass-specific action, likely reduced weed competition effectively.

Diclosulam continued to show residual control (51.56 weeds/m²), likely due to its persistence in the soil. However, its efficacy slightly decreased over time as some weeds might have germinated from deeper soil layers or in previously untreated spots.

At harvest, the sequential post-emergence application of imazethapyr + propaquizafop still recorded the lowest weed count (92.44 weeds/m²). The continued effectiveness of this combination suggests its strong residual activity, which possibly suppressed late-season weed emergence or regrowth.

The significantly higher weed density in the weedy check (387.56 weeds/m² at harvest) showed the effectiveness of the chemical treatments. This treatment provided no competitive check on weeds, allowing the natural growth cycle of the weeds to progress unhindered, resulting in substantial weed pressure on the crop.

Diclosulam was highly effective as a pre-emergence herbicide for early weed control, while the combination of imazethapyr and propaquizafop provided consistent, season-long weed suppression. The results of our study are in line with the results of Kumar *et al.* (2022) and Hajari and Patel (2020).

Weed Index

The effect of weed management treatments on the weed index was significant (Table 1). The post-emergence application of propaquizafop @ 0.050 kg a.i. + imazethapyr @ 0.075kg a.i./ha at 21 DAS as post-emergence (ready mix) recorded the lowest weed index (7.60), and the highest weed index was observed with weedy check treatment (72.57). The weed index indicates crop yield reduction due to competition relative to the best-performing treatment. The lower weed index (7.60) with herbicide application implies that the treatment nearly eliminated the yield loss due to weeds, while the high weed index in the weedy check demonstrates the significant negative impact of unchecked weed competition on crop yield. Propaquizafop is a selective post-emergence herbicide effective against grass weeds, whereas imazethapyr is a broad-spectrum herbicide that controls both broadleaf and grass weeds. This combination allows for broad-spectrum weed control, significantly reducing weed density and biomass in the treated plots. Consequently, the competition between weeds and the crop is minimized, leading to better crop growth and yield, reflected in the low weed index. Similar results were also reported by Hajari and Patel (2020).

Effect of different pre-and post-emergence herbicides on growth and yield contributing parameters of soybean

The strategic use of pre-and post-emergence herbicides has been found to significantly improve the growth and yield parameters of soybean crop (Tables 2).

The weedy check treatment resulted in taller and lankier plants (50.58 cm), significantly higher than all other treatments. In contrast, the weed-free treatment recorded

Table 2. Effect of different pre- and post-emergence herbicides on growth parameters of soybean (pooled means of 3 years)

Treatment	Plant height (cm)	Branches/ plant	Pods/ plant	Seed yield/ plant (g)	Seed index (g)
Weedy check	50.58[a]	4.27[c]	7.84[b]	2.89[c]	9.71[a]
Weed-free	43.22[c]	6.73[a]	22.82[a]	7.15[a]	9.79[a]
Pendimethalin @ 0.677 kg a.i./ha as PE	42.71[c]	5.57[b]	20.69[a]	6.38[b]	9.74[a]
Diclosulam 84% WDG @ 0.026 kg a.i./ha as PE	44.09[b]	6.28[a]	21.09[a]	6.65[a]	9.75[a]
Imazethapyr 10% SL @ 0.075 kg a.i./ha at 21 DAS as PoE	45.51[b]	6.31[a]	21.58[a]	6.76[a]	9.74[a]
Propaquizafop @ 0.050 kg a.i. + Imazethapyr @ 0.075kg a.i./ha at 21 DAS as PoE (ready mix)	46.40[b]	6.46[a]	21.62[a]	6.78[a]	9.75[a]
Propaquizafop 10% EC @ 0.075 kg a.i./ha at 21 DAS PoE	44.71[b]	5.66[b]	21.11[a]	6.63[a]	9.73[a]
Imazamox @ 0.035 kg a.i + Imazethapyr @ 0.035 kg a.i./ha at 21 DAS PoE (ready mix)	44.38[b]	5.67[b]	21.09[a]	6.68[a]	9.74[a]
Quizolofop ethyl 5% EC @ 0.05 kg a.i. + Imazethapyr 10% SL @ 0.075 kg a.i./ha at 21 DAS PoE (tank mix)	45.78[b]	6.04[b]	21.51[a]	6.72[a]	9.74[a]
Imazethapyr 10% SL @ 0.075 kg a.i./ha at 21 DAS PoE + Propaquizafop 10% EC @ 0.075 kg a.i./ha at 35 DAS	46.49[b]	6.15[a]	21.84[a]	6.87[a]	9.73[a]
SEm±	0.93	0.20	0.73	0.18	0.03
CD (P=0.05)	2.76	0.60	2.18	0.54	NS

Means followed by the same letter do not differ significantly at the 0.05 probability level.

significantly more branches/plant (6.73), which was statistically at par with propaquizafop @ 0.050 kg a.i. + imazethapyr @ 0.075 kg a.i./ha (ready mix) applied post-emergence at 21 DAS (6.46 branches), diclosulam 84% WDG @ 0.026 kg a.i./ha applied pre-emergence (6.28 branches), imazethapyr 10% SL @ 0.075 kg a.i./ha applied post-emergence at 21 DAS (6.31 branches), and the combined application (tank mix) of imazethapyr 10% SL @ 0.075 kg a.i./ha at 21 DAS and propaquizafop 10% EC @ 0.075 kg a.i./ha at 35 DAS (6.15 branches). The weedy check treatment had the lowest branch count (4.27 branches/ plant). Taller plants in the weedy check treatment indicate that weed competition can promote soybean plant height, likely as the crop stretches to compete for light, water, and nutrients. The weed-free treatment and various herbicide applications (diclosulam and imazethapyr) led to significantly more branches/ plant than the weedy check. Reduced competition allows plants to allocate resources to branching, enhancing plant structure and yield potential. Amaregouda *et al.* (2013) and Kumar *et al.* (2022) also reported a similar response.

The weed-free treatment recorded significantly more pods/ plant (22.82 pods/ plant) than the weedy-check treatment (7.84 pods/ plant), but it was statistically at par with the other treatments. The weed-free treatment recorded a significantly higher seed yield (7.15 g/plant) compared to the weedy check (2.89 g/plant), and pendimethalin applied as a pre-emergence at 0.677 kg a.i./ha (6.38 g/plant). The weed-free treatment produced the highest pod count, reflecting the positive impact of minimal weed interference. This treatment was comparable to other herbicide applications, showing that effective weed control increases reproductive growth. The improvement in the growth and yield contributing parameters with weed-free treatment resulted in higher seed yield. Ahirwar and Ahirwar (2023) also reported similar results.

The effect of the various weed management treatments on the seed index of soybeans was found to be non-significant.

Seed and stalk yield (kg/ ha)

The effect of various weed management treatments on seed and stalk yield was significant (Table 3). The weed-free treatment recorded a significantly higher seed yield (2180 kg/ha) than all other treatments. Among the chemical weed management treatments, the post-emergence application of propaquizafop @ 0.050 kg a.i. + imazethapyr @ 0.075kg a.i./ha at 21 DAS as post-emergence (ready mix) resulted in the highest seed yield (2031 kg/ha), and it was at par with the other chemical treatments pendimethalin @ 0.677 kg a.i./ ha as pre-emergence application (1896 kg/ha), diclosulam 84% WDG @ 0.026 kg a.i./ ha as pre-emergence (1949 kg/ha), Imazethapyr 10% SL @ 0.075 kg a.i./ha at 21 DAS as post-emergence (1965 kg/ ha), propaquizafop 10% EC @ 0.075 kg a.i./ ha at 21 DAS

Table 3. Effect of different pre and post-emergence herbicides on the seed, stalk yield, and economics of soybean cultivation (pooled means of 3 years)

Treatment	Seed yield (kg/ha)	Stalk yield (kg/ha)	Cost of cultivation (× 10^3 Rs/ha)	GMR (× 10^3 Rs/ha)	NMR (× 10^3 Rs/ha)	Gross B: C ratio
Weedy check	574^c	754^c	20.48	21.30^c	0.81^b	1.04
Weed-free	2180^a	2814^a	30.57	80.87^a	50.30^a	2.64
Pendimethalin @ 0.677 kg a.i./ ha as PE	1896^b	2490^b	24.46	70.34^b	45.88^a	2.87
Diclosulam 84% WDG @ 0.026 kg a.i./ha as PE	1949^b	2541^b	24.44	72.30^b	47.86^a	2.96
Imazethapyr 10% SL @ 0.075 kg a.i./ha at 21 DAS as PoE	1965^b	2546^b	24.50	72.92^b	48.42^a	2.97
Propaquizafop @ 0.050 kg a.i. + Imazethapyr @ 0.075 kg a.i./ha at 21 DAS as PoE (ready mix)	2031^b	2614^b	25.02	75.35^b	50.33^a	3.01
Propaquizafop 10% EC @ 0.075 kg a.i./ha at 21 DAS PoE	1934^b	2496^b	24.73	71.74^b	47.01^a	2.90
Imazamox @ 0.035 kg a.i + Imazethapyr @ 0.035 kg a.i./ha at 21 DAS PoE (ready mix)	1956^b	2501^b	24.89	72.58^b	47.69^a	2.92
Quizolofop ethyl 5% EC @ 0.05 kg a.i. + Imazethapyr 10% SL @ 0.075 kg a.i./ha at 21 DAS PoE (tank mix)	1943^b	2482^b	25.01	72.09^b	47.08^a	2.88
Imazethapyr 10% SL @ 0.075 kg a.i./ha at 21 DAS PoE + Propaquizafop 10% EC @ 0.075 kg a.i./ha at 35 DAS	1985^b	2543^b	25.37	73.64^b	48.28^a	2.90
SEm±	48	64	-	1.78	1.61	-
CD (P=0.05)	142	189	-	5.28	4.78	-

The soybean market price considered for the GMR calculation was Rs. 3710/q.
Means followed by the same letter do not differ significantly at the 0.05 probability level.

as post-emergence (1934 kg/ ha), imazamox @ 0.035 kg a.i + imazethapyr @ 0.035 kg a.i./ ha at 21 DAS as post-emergence (ready mix), quizolofop ethyl 5% EC @ 0.05 kg a.i. + imazethapyr 10% SL @ 0.075 kg a.i./ha at 21 DAS post-emergence (tank mix) (1943 kg/ha), and imazethapyr 10% SL @ 0.075 kg a.i./ha at 21 DAS post-emergence + propaquizafop 10% EC @ 0.075 kg a.i./ha at 35 DAS (1985 kg/ha). Additionally, the weed-free treatment produced a significantly higher stalk yield (2814 kg/ha) than all other treatments.

The highest seed yield (2180 kg/ha) and stalk yield (2814 kg/ha) under the weed-free treatment highlight the importance of completely removing weed competition, allowing for optimal resource utilization by the crop. This treatment likely eliminates all weeds early on, ensuring no weed-crop competition throughout the crop's growth period, which maximizes yield. The post-emergence application of propaquizafop @ 0.050 kg a.i. + imazethapyr @ 0.075kg a.i./ha at 21 DAS as post-emergence (ready mix) produced the highest seed yield among chemical treatments (2031 kg/ha). This combination targets grass and broadleaf weeds, effectively reducing weed competition early in the crop's growth cycle and yielding 3.5 times higher seed yield than the weedy check. Although this treatment did not achieve yields as high as the weed-free treatment, it was at par with other chemical treatments, suggesting that various chemical approaches provide similar levels of weed control. Similar results were also reported by Hajari and Patel (2020) and Kumar *et al.* (2022).

Effect of different pre- and post-emergence herbicides on the economics of soybean production

The effect of pre and post-emergence herbicides on soybean production economics was significant (Table 3).

The weed-free treatment recorded significantly higher gross monetary returns (Rs. 80873/ ha) than all other treatments. Amongst the herbicides, the post-emergence application of propaquizafop @ 0.050 kg a.i. + imazethapyr @ 0.075kg a.i./ha at 21 DAS as post-emergence (ready mix) recorded higher gross monetary returns (Rs. 75353/ ha). The lowest gross monetary returns were observed with the weedy check treatment (Rs. 21298/ ha).

Post-emergence application of propaquizafop @ 0.050 kg a.i. + imazethapyr @ 0.075kg a.i./ha at 21 DAS as post-emergence (ready mix) recorded significantly higher net monetary returns (Rs. 50331/ ha) over the weedy check treatment (Rs. 814/ ha).

The post-emergence application of propaquizafop @ 0.050 kg a.i. + imazethapyr @ 0.075 kg a.i./ha at 21 DAS as post-emergence (ready mix) recorded a higher gross B: C ratio (3.01). The lowest gross B: C ratio was observed with the control treatment (1.04).

The weed-free treatment provided the highest gross monetary returns (Rs. 80,873/ha) due to eliminating competition from weeds, which allowed the soybean crop to maximize its growth potential and yield. Without weeds, the crop likely received optimal access to water, nutrients, and sunlight, resulting in higher yields and, thus, higher returns. Among chemical weed control methods, the post-emergence application of propaquizafop @ 0.050 kg a.i. + imazethapyr @ 0.075 kg a.i./ha at 21 DAS as post-emergence (ready mix) led to high gross monetary returns (Rs. 75,353/ha). This treatment's effectiveness likely lies in its timing and targeted action. By applying the herbicide post-emergence, weeds germinating along with the crop are effectively controlled, reducing early-stage competition and allowing the crop to establish. Two herbicides propaquizafop (grass-selective) and imazethapyr (broad-spectrum) also offer a comprehensive weed control approach by targeting grass and broadleaf weeds. The weedy check treatment resulted in the lowest gross monetary returns (Rs. 21,298/ha) and net economic returns (Rs. 814/ ha). Without weed control, weeds would have aggressively competed with the soybean crop for essential resources, reducing plant growth and yield. This high competition impacts gross returns due to lower yields and net returns, as crop revenue does not sufficiently compensate input costs. The post-emergence application of propaquizafop @ 0.050 kg a.i. + imazethapyr @ 0.075 kg a.i./ha at 21 DAS as post-emergence (ready mix) achieved the highest gross benefit-cost (B: C ratio) of 3.01. This high ratio indicates that the revenue generated per unit cost is maximized with this treatment. The timing and efficacy of this herbicide combination likely minimize yield loss effectively while keeping herbicide application costs in balance with economic returns. In contrast, the weedy check barely covers the production costs with a B: C ratio of 1.04, as the low yield does not justify the input expenses. Similar results were also reported by Sharma *et al.,* 2016, Jadhav and Kashid, 2019.

The application of pre- and post-emergence herbicides significantly influenced weed control, growth, yield, and the economics of soybean production. Among the herbicides tested, diclosulam, when applied as a pre-emergence treatment, demonstrated strong initial weed control, while the combination of imazethapyr and propaquizafop as post-emergence treatments effectively suppressed both broadleaf and grass weeds, leading to sustained weed control throughout the growing season. This combination of herbicides provided the lowest weed count at 60 DAS and at harvest, highlighting its effectiveness in maintaining low weed pressure.

Weed control had a direct impact on growth and yield. The weed-free treatment produced the highest yields and growth parameters, as the crop faced no competition for resources. Herbicide treatments, especially the combination of propaquizafop and imazethapyr, also significantly improved soybean growth compared to the weedy check, with higher branch counts, pod numbers, and seed yields. The highest seed yield (2180 kg/ha) was observed in the weed-free treatment, while the chemical treatments still provided high yields (up to 2031 kg/ha), demonstrating the effectiveness of herbicide applications in reducing weed competition.

The post-emergence application of propaquizafop + imazethapyr (ready mix) also yielded substantial returns (Rs. 75,353/ha) and a high benefit-cost ratio (3.01), making it the most economically viable herbicide treatment. In contrast, the weedy check treatment resulted in the lowest returns (Rs. 21,298/ha), highlighting the negative economic impact of unchecked weed competition on crop yield.

The findings indicate that effective weed management, through the strategic use of herbicides like diclosulam, propaquizafop, and imazethapyr, not only improves soybean growth and yield but also enhances the economic viability of soybean production by significantly reducing weed-induced yield loss and increasing returns.

REFERENCES

Ahirwar, S.K. and Ahirwar, Aruna Devi. 2023. Effect of integrated weed management on yield and economics of soybean in Satpura plateau region of Madhya Pradesh. The Pharma Innovation Journal **12**(4): 309–314.

Amaregouda, A., Jadhav, J., Chetti, M.B., Nawalagatti. 2013. Effect of weedicides on physiological parameters, growth, yield and yield components of soybean (*Glycine max.* L) and weed growth. Journal of Agriculture and Allied Sciences **2**(4): 12–15.

Hajari, R.V. and Patel, G.J. 2020. Effect of Different Weed Management Practices on Growth and Yield in Soybean Pigeonpea Intercropping System and its Residual Effect on Succeeding Crops. International Journal of Current Microbiology and Applied Science (9): 2,328–2,337.

IISR. 2024. All India Coordinated Research Project on Soybean. Annual report 2023–2024. ICAR, Indian Institute of Soybean Research, Indore (Madhya Pradesh), India. P. 79.

Jadhav, V.T. and Kashid, N.V. 2019. Integrated weed management in soybean., Indian Journal of Crop and Weed **51**(1): 81–83.

Kumar, H., Savu, R.M., Tiwari, N., Gupta, S., Sukla, A., Rajwade, O.P, and Chandra, C.S. 2022. Effect of weed management practices on growth, yield and economics of soybean [*Glycine max* (L.) Merrill]. The Pharma Innovation Journal **11**(1): 648–651.

Kurchania, S.P., Rathi, G.S., Bhalla, C.S. and Mathew, R. 2001. Bioefficacy of post emergence herbicides for weed control in soybean [*Glycine max* (L.) Merril.] Indian Journal of Weed Science **33**: 34–35.

Patel, B.D., Chaudhari, D.D., Patel, R.B., Patel, V.J. and Darji, V.B. 2016. Comparative efficacy of different herbicides on Bt. cotton and their residual effect on succeeding crops. Research on Crops **17**(1): 106–111.

Sharma, N.K., Mundra, S.L. and Kalita, S. 2016. Effect of weed control on growth and productivity of soybean. Indian Journal of Weed Science **48**(1): 90–92.

Sheoran, O.P., Tonk, D.S., Kaushik, L.S., Hasijam R.C., Pannu, R.S. 1998. Statistical Software Package for Agricultural Research Workers. Recent Advances in information theory, Statistics & Computer Applications Department of Mathematics Statistics, CCS HAU, Hisar, India: 139–43.