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Bio-efficacy of Propaquizafop 10% EC on Weeds and Yield in Soybean

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

A field experiment was conducted during kharif 2018 at the Experimental Farm, College of Agriculture, Jabalpur, Madhya Pradesh, to evaluate the bio-efficacy and phytotoxicity of Propaquizafop 10% EC in soybean and its residual effect on succeeding mustard. The experiment was laid out in a randomised block design with seven treatments and three replications. Propaquizafop 10% EC was applied post-emergence at different doses, and weed populations, weed dry weight, weed control efficiency, soybean growth and yield, soil biological properties, and residual effects on mustard were assessed. Propaquizafop 10% EC at 750 ml ha^{-1} consistently reduced the density and dry weight of major grassy weeds and recorded high weed control efficiency. This treatment produced a soybean grain yield of 2265 kg ha^{-1}, compared with 867 kg ha^{-1} in the unweeded check, while hand weeding at 20 and 40 days after sowing produced the highest grain yield of 2456 kg ha^{-1}. No phytotoxic symptoms were observed at the tested doses. The measured bacterial and actinomycetes populations did not show pronounced adverse changes at harvest. The succeeding mustard crop showed no residual phytotoxicity, and germination, plant height and seed yield did not differ significantly among treatments. Under the conditions of this study, Propaquizafop 10% EC at 750 ml ha^{-1} provided effective grassy-weed control while maintaining soybean crop safety and showing no evident adverse residual effect on the succeeding mustard crop.

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Keywords: Propaquizafop 10% EC; soybean; grassy weeds; post-emergence herbicide; weed control efficiency; phytotoxicity; grain yield; soil biological properties; residual effect; mustard.

1. Introduction

Soybean (*Glycine max* L. Merrill) is one of the world's most important oilseed and protein-rich legume crops, contributing significantly to food, feed and industrial sectors. It is valued for its high nutritional quality, containing approximately 38–42% protein and 18–22% oil, making it an excellent source of edible oil and plant-based protein. Besides its economic importance, soybean improves soil fertility through biological nitrogen fixation in association with *Bradyrhizobium* species, thereby reducing dependence on synthetic nitrogen fertilisers and enhancing the sustainability of cropping systems (Ciampitti & Salvagiotti, 2018). Owing to its short duration, adaptability to diverse agro-climatic conditions and compatibility with various crop rotations, soybean has become an integral component of intensive agricultural production systems. Recent literature also characterises soybean as a multipurpose legume with substantial nutritional, agronomic and industrial importance (Mishra et al., 2024 and Jha et al., 2014).

India is one of the leading soybean-producing countries, where the crop occupies a prominent position among kharif oilseeds. Soybean is cultivated predominantly in the states of Madhya Pradesh, Maharashtra and Rajasthan, which together contribute the major share of the country's acreage and production. In Madhya Pradesh, popularly known as the "Soybean State of India," the crop plays a crucial role in improving farmers' income and supporting the edible oil industry. Among the improved cultivars, JS 20-34 has gained considerable popularity due to its high yield potential, early maturity, lodging tolerance and adaptability to the soybean-growing regions of central India. The variety also exhibits desirable seed quality traits, making it suitable for commercial cultivation under both irrigated and rainfed conditions (Lodhi et al., 2023).

Soybean productivity remains constrained by severe weed infestation during the early stages of crop growth. Soybean exhibits slow initial growth and relatively poor canopy development, allowing weeds to establish rapidly and compete aggressively for moisture, nutrients, light and space. The critical period of crop–weed competition generally extends from 20 to 45 days after sowing, during which uncontrolled weed growth can cause substantial reductions in seed yield and economic returns. The extent of yield loss depends on weed flora, infestation intensity and duration of competition, with reported losses ranging from 30 to 80% under severe infestations (Kumar & Rana, 2022 and Parmar et al.,2017).

Soybean fields are infested with a complex spectrum of grassy, broad-leaved and sedge weeds. Among these, grassy weeds are particularly competitive and often remain inadequately controlled by broad-spectrum broadleaf herbicides. Effective management of grassy weeds is therefore essential to achieve optimum crop productivity and maintain favourable crop growth conditions (Kumar & Rana, 2022; Panda et al., 2015). Post-emergence herbicides belonging to the aryloxyphenoxypropionate (FOP) group have emerged as valuable options for selective control of annual and perennial grassy weeds in soybean. Recent field studies further indicate that soybean weed-control efficacy and crop safety can vary with herbicide choice, application timing and prevailing field conditions, reinforcing the value of locally validated weed-management programmes (Pamungkas et al., 2025; Arshad et al., 2025).

Propaquizafop 10% EC is a selective post-emergence herbicide belonging to the aryloxyphenoxypropionate group. It inhibits the enzyme acetyl-CoA carboxylase (ACCase), disrupting fatty acid biosynthesis and ultimately leading to the death of susceptible grassy weeds while exhibiting high selectivity towards broadleaf crops such as soybean. Owing to its excellent efficacy against a wide range of grass weeds, propaquizafop has become an important component of integrated weed management programmes. However, herbicide performance under field conditions depends on application dose, weed growth stage and prevailing environmental conditions. Therefore, evaluation of its bio-efficacy under local agro-climatic conditions is essential before recommending its widespread use. Recent field evidence in soybean has also shown effective weed suppression from herbicide programmes that include propaquizafop-based post-emergence treatment (Thakur et al., 2025). Mechanistic research further demonstrates that selected ACCase-inhibiting herbicides can exhibit soybean crop selectivity, supporting careful evaluation of efficacy and crop safety within this herbicide class (Lee et al., 2025).

Apart from weed control efficiency, assessment of herbicide phytotoxicity and persistence has become increasingly important for sustainable crop production. Herbicides applied to soybean may sometimes produce transient phytotoxic effects on the crop itself or leave residues that adversely affect the establishment and growth of succeeding crops. In soybean-based cropping systems, mustard is one of the most common rabi follow-up crops in central India. Therefore, information regarding the residual influence of propaquizafop on mustard assumes considerable practical significance for ensuring safe crop rotation and preventing carry-over injury.

The available background does not establish how Propaquizafop 10% EC performs under the local agro-climatic conditions of Jabalpur when weed-control efficacy, soybean phytotoxicity and residual effects on succeeding mustard are evaluated together. Therefore, a location-specific assessment of these linked efficacy and safety aspects is required.

1.1 Objective

Keeping these aspects in view, the present investigation entitled Bio-efficacy of Propaquizafop 10% EC on Weeds in Soybean was undertaken to evaluate weed control efficiency.

2. Methodology

The experiment was conducted during the kharif season of 2018 at the Experimental Farm, College of Agriculture, Jabalpur, Madhya Pradesh, India. The experiment was carried out on soil ranging from loamy sand to clay loam to evaluate the bio-efficacy of

Propaquizafop 10% EC against weeds in soybean, its phytotoxicity on the crop, and its residual effect on the succeeding mustard crop. The experiment was laid out in a randomised block design (RBD) comprising seven treatments with three replications, resulting in a total of twenty-one experimental plots. Each plot measured 5.0 m × 3.0 m. Soybean variety JS 2034 was sown on 22 June 2018 at a spacing of 30 cm × 10 cm following the recommended agronomic practices. The recommended dose of fertilisers consisting of 150 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1} was applied uniformly to all treatments. The post-emergence application of Propaquizafop 10% EC and other herbicides was made on 10 July 2018 (18 days after sowing) when the weeds were at the 1–3 leaf stage. Herbicide treatments were applied using a knapsack sprayer fitted with a flood-jet nozzle at a spray volume of 500 L/ha to ensure uniform coverage. All cultural practices other than weed management were followed uniformly in accordance with the recommended package of practices for soybean cultivation. The soybean crop was harvested on 24 September 2018 after attaining physiological maturity. Mustard was grown as the succeeding crop and was sown on the 15th.

3. Results and Discussion

3.1 Effect on Weeds

The application of Propaquizafop 10% EC significantly reduced the populations of *Echinochloa crus-galli*, *Echinochloa colona*, *Digitaria sanguinalis*, *Dactyloctenium aegyptium*, and *Eleusine indica* compared with the unweeded check at all observation stages. Among the herbicidal treatments, Propaquizafop 10% EC at 750 ml/ha consistently recorded the lowest weed population and remained statistically at par with T_3- Imazethapyr 10% SL @ 0.075 kg a.i./ha for most observations. The unweeded check recorded the maximum weed population throughout the crop period, whereas hand weeding at 20 and 40 DAT effectively reduced weed populations after weeding operations. Overall, Propaquizafop 10% EC applied at 750 ml/ha proved highly effective in suppressing the major grassy weed species in soybean (Kumar et al., 2018; Panda et al., 2015).

Similar trends were recorded in the dry weights of *Echinochloa crus-galli*, *Echinochloa colona*, *Digitaria sanguinalis*, *Dactyloctenium aegyptium*, and *Eleusine indica* compared with the unweeded check at all stages of observation. Among the herbicidal treatments, Propaquizafop 10% EC at 750 ml/ha recorded the lowest dry weight of weeds, with transformed values ranging from 0.78–1.75 for *E. crus-galli*, 0.87–1.64 for *E. colona*, 0.96–1.39 for *D. sanguinalis*, 0.88–1.36 for *D. aegyptium*, and 0.78–1.44 for *E. indica* across different observation periods, and remained statistically at par with the standard check Propaquizafop 10% EC at 500 ml ha^{-1} (T3) for most observations. In contrast, the unweeded check recorded the highest weed dry weight, with values reaching 3.62, 3.17, 2.80, 2.44, and 2.59, respectively, at 45 DAA. Hand weeding at 20 and 40 DAT also effectively reduced weed biomass after weeding operations. Overall, Propaquizafop 10% EC at 750 ml/ha effectively minimised weed biomass and provided superior control of the dominant grassy weeds in soybean (Kumar et al., 2018; Panda et al., 2015; Sharma & Renjith, 2016).

The weed control efficiency (WCE) differed markedly among the weed management treatments (Tables 5 and 6). Among the herbicidal treatments, Propaquizafop 10% EC at 750 ml/ha recorded consistently higher weed control efficiency against all major grassy weeds throughout the observation period and remained statistically comparable with the standard check Propaquizafop 10% EC at 500 ml/ha. At 45 DAA, the treatment recorded WCE values of 79.59, 77.31, 80.58, 74.74 and 74.67% against *Echinochloa crus-galli*, *E. colona*, *Digitaria sanguinalis*, *Dactyloctenium aegyptium* and *Eleusine indica*, respectively, whereas the standard check recorded comparatively higher values of 82.99, 82.50, 84.33, 78.81 and 76.74%, respectively. The lowest weed control efficiency was observed under the unweeded check, while hand weeding at 20 and 40 DAT also provided effective weed control after the weeding operations (Kheriya et al., 2016; Panda et al., 2015; Sharma & Renjith, 2016).

The higher weed control efficiency of Propaquizafop 10% EC may be attributed to its effective post-emergence control of annual grassy weeds through inhibition of the acetyl-CoA carboxylase (ACCase) enzyme, which suppresses fatty acid biosynthesis, arrests meristematic growth, and ultimately causes weed death. Better suppression of weed growth resulted in lower weed density and dry matter accumulation, thereby improving weed control efficiency. Similar findings on the superior efficacy of Propaquizafop against grassy weeds in soybean have been reported by Kumar et al. (2018), Panda et al. (2015), and Sharma and Renjith (2016).

3.2 Effect of Treatments on Yield Attributes and Yield of Soybean Crop

The weed management treatments significantly influenced the yield attributes and grain yield of soybean (Table 8). Among the herbicidal treatments, Propaquizafop 10% EC at 750 ml ha^{-1} (T2) recorded the highest plant height **(**587 mm), number of branches per plant (3.10), pods per plant (27.70), and grain yield (2265 kg ha^{-1}), and remained statistically comparable with hand weeding at 20 and 40 DAT, which produced the maximum grain yield (2456 kg ha^{-1}) along with the highest plant height (598 mm), branches per plant (3.28), and pods per plant (30.90). The unweeded check recorded the lowest plant height (461 mm), branches per plant (1.31), pods per plant (17.40), and grain yield (867 kg ha^{-1}) due to severe weed competition (Kumar et al., 2018; Saharan et al., 2015; Sharma & Renjith, 2016; Jha et al., 2013).

The improved growth and yield under Propaquizafop 10% EC at 750 ml ha^{-1} can be attributed to its effective suppression of grassy weeds, which minimised crop–weed competition for moisture, nutrients, light, and space during the critical period of crop growth (Kumar & Rana, 2022; Patidar et al.,2023, 2018; Panda et al., 2015). Reduced weed interference enhanced resource utilisation by soybean plants, resulting in better vegetative growth, higher pod formation, and ultimately greater grain yield. The poor performance of the unweeded check was primarily due to continuous weed competition throughout the crop growth period, which restricted crop development and reduced yield. Similar findings have been reported by Kumar et al. (2018), Panda et al. (2015), and Sharma and Renjith (2016), who observed that effective post-emergence grass weed control with ACCase-inhibiting herbicides significantly improved soybean growth and productivity.

Table 1. Effect of treatments on weeds population at different days after herbicides application on soybean crop

Treatment	Dose (g ai /ha)	*Echinochloa crussgalli* (Number m^{-2})			*Echinochloa colona* (Number m^{-2})			*Digiteria sanguinalis* (Number m^{-2})		
		15 DAA	**30 DAA**	**45 DAA**	**15 DAA**	**30 DAA**	**45 DAA**	**15 DAA**	**30 DAA**	**45 DAA**
T_1- Propaquizafop 10% EC	0.50	1.51 (1.79)	1.85 (2.92)	1.88 (3.04)	1.46 (1.64)	1.59 (2.02)	1.81 (2.76)	1.52 (1.82)	1.73 (2.51)	1.65 (2.23)
T_2- Propaquizafop 10% EC	0.75	0.87 (0.32)	1.65 (2.23)	1.67 (2.33)	0.86 (0.30)	1.45 (1.62)	1.70 (2.41)	0.94 (0.49)	1.30 (1.19)	1.25 (1.07)
T_3- Imazethapyr 10% SL @ 0.075 kg a.i./ha	0.75	1.68 (2.35)	2.01 (3.53)	2.04 (3.65)	1.53 (1.83)	1.70 (2.38)	1.96 (3.34)	1.56 (1.95)	1.63 (2.15)	1.56 (1.95)
T_4- Imazamox @ + Imazethapyr	0.35 +0.35	0.71 (0.00)	1.59 (2.05)	1.59 (2.02)	0.85 (0.26)	1.33 (1.28)	1.54 (1.86)	0.87 (0.31)	1.20 (0.93)	1.16 (0.84)
T_5 - Fenoxaprop-p-ethyl 9.3% EC	0.50	1.58 (2.00)	1.96 (3.36)	1.97 (3.41)	1.22 (1.02)	1.62 (2.12)	1.89 (3.09)	1.49 (1.72)	1.62 (2.13)	1.56 (1.93)
T_6- HW at 20 & 40 DAT	-	3.02 (8.65)	1.97 (3.39)	2.25 (4.59)	2.76 (7.10)	1.64 (2.22)	1.91 (3.18)	2.29 (4.78)	1.34 (1.30)	1.29 (1.18)
T_7 – Unweeded check	-	3.10 (9.14)	3.62 (12.67)	3.80 (13.99)	2.63 (6.41)	3.14 (9.41)	3.33 (10.62)	2.23 (4.47)	2.85 (7.67)	2.72 (6.94)
SEm (±)	-	0.11	0.07	0.09	0.10	0.07	0.06	0.13	0.06	0.06
CD at 5%	-	0.33	0.22	0.26	0.30	0.22	0.18	0.38	0.17	0.18

**Figures in parentheses are the original values. The data was transformed to √(x+0.5) before analysis*

Table 2: Effect of treatments on weeds population at different days after herbicides application

Treatment	Dose (g ai /ha)	*Dactyloctenium eigyptium* (Number m^{-2})			*Eleusine indica* (Number m^{-2})		
		15 DAA	**30 DAA**	**45 DAA**	**15 DAA**	**30 DAA**	**45 DAA**
T_1- Propaquizafop 10% EC	0.50	1.29 (1.18)	1.80 (2.74)	1.91 (3.16)	1.45 (1.6)	1.69 (2.36)	1.9 (3.12)
T_2- Propaquizafop 10% EC	0.75	0.89 (0.37)	1.31 (1.22)	1.33 (1.26)	0.88 (0.32)	1.26 (1.10)	1.54 (1.87)
T_3- Imazethapyr 10% SL @ 0.075 kg a.i./ha	0.75	1.41 (1.49)	1.88 (3.04)	2.03 (3.61)	1.55 (1.93)	1.76 (2.60)	1.94 (3.26)
T_4- Imazamox @ + Imazethapyr	0.35 +0.35	0.89 (0.35)	1.27 (1.13)	1.37 (1.37)	0.85 (0.26)	1.24 (1.05)	1.53 (1.84)
T_5 - Fenoxaprop-p-ethyl 9.3% EC	0.50	1.35 (1.32)	2.00 (3.51)	2.06 (3.76)	1.31 (1.23)	1.61 (2.09)	1.86 (2.95)
T_6- HW at 20 & 40 DAT	-	1.64 (2.20)	1.29 (1.17)	1.60 (2.09)	1.91 (3.14)	1.74 (2.53)	1.55 (1.91)
T_7 – Unweeded check	-	1.66 (2.26)	2.38 (5.19)	2.55 (6.05)	1.91 (3.15)	2.23 (4.46)	2.50 (5.77)
SEm (±)	-	0.10	0.08	0.07	0.09	0.04	0.03
CD at 5%	-	0.30	0.24	0.22	0.28	0.12	0.08

Figures in parentheses are the original values. The data was transformed to √(x+0.5) before analysis

Table 3. Effect of treatments on dry weight of weeds at different days after herbicides application

Treatment	Dose (g ai /ha)	*Echinochloa crussgalli* (Number m^{-2})			*Echinochloa colona* (Number m^{-2})			*Digiteria sanguinalis* (Number m^{-2})		
		15 DAA	**30 DAA**	**45 DAA**	**15 DAA**	**30 DAA**	**45 DAA**	**15 DAA**	**30 DAA**	**45 DAA**
T_1- Propaquizafop 10% EC	0.50	1.11 (0.74)	1.76 (2.62)	2.04 (3.68)	1.34 (1.31)	1.81 (2.79)	2.00 (3.49)	1.31 (1.22)	1.69 (2.36)	1.83 (2.84)
T_2- Propaquizafop 10% EC	0.75	0.78 (0.13)	1.48 (1.71)	1.75 (2.56)	0.87 (0.32)	1.40 (1.48)	1.64 (2.21)	0.96 (0.54)	1.25 (1.07)	1.39 (1.43)
T_3- Imazethapyr 10% SL @ 0.075 kg a.i./ha	0.75	1.21 (0.97)	1.90 (3.11)	2.20 (4.35)	1.40 (1.45)	1.84 (2.91)	2.07 (3.79)	1.40 (1.45)	1.77 (2.65)	1.86 (2.96)
T_4- Imazamox @ + Imazethapyr	0.35 +0.35	0.71 (0.00)	1.37 (1.39)	1.62 (2.13)	0.83 (0.21)	1.31 (1.21)	1.47 (1.68)	0.89 (0.36)	1.16 (0.84)	1.28 (1.15)
T_5 - Fenoxaprop-p-ethyl 9.3% EC	0.50	1.12 (0.76)	1.86 (2.99)	2.07 (3.80)	1.14 (0.82)	1.55 (1.91)	1.81 (2.79)	1.27 (1.12)	1.56 (1.93)	1.70 (2.4)
T_6- HW at 20 & 40 DAT	-	2.00 (3.51)	1.72 (2.45)	2.06 (3.76)	2.49 (5.69)	1.47 (1.66)	1.70 (2.40)	2.34 (5.00)	1.28 (1.14)	1.50 (1.74)
T_7 – Unweeded check	-	2.04 (3.66)	3.30 (10.41)	3.62 (12.61)	2.37 (5.13)	3.00 (8.51)	3.17 (9.59)	2.29 (4.76)	2.72 (6.94)	2.80 (7.37)
SEm (±)	-	0.06	0.06	0.06	0.08	0.07	0.06	0.12	0.06	0.05
CD at 5%	-	0.19	0.18	0.18	0.25	0.21	0.18	0.36	0.19	0.15

**Figures in parentheses are the original values. The data was transformed to √(x+0.5) before analysis*

Table 4. Effect of treatments on dry weight of weeds at different days after herbicides application

Treatment	Dose (g ai /ha)	*Dactyloctenium eigyptium* (Number m^{-2})			*Eleusine indica* (Number m^{-2})		
		15 DAA	**30 DAA**	**45 DAA**	**15 DAA**	**30 DAA**	**45 DAA**
T_1- Propaquizafop 10% EC	0.50	1.14 (0.80)	1.44 (1.58)	1.75 (2.57)	0.93 (0.37)	1.46 (1.63)	1.96 (3.36)
T_2- Propaquizafop 10% EC	0.75	0.88 (0.34)	1.20 (0.94)	1.36 (1.36)	0.78 (0.13)	1.20 (0.94)	1.44 (1.57)
T_3- Imazethapyr 10% SL @ 0.075 kg a.i./ha	0.75	1.14 (0.80)	1.57 (1.97)	1.76 (2.59)	0.92 (0.35)	1.52 (1.83)	1.93 (3.23)
T_4- Imazamox @ + Imazethapyr	0.35 +0.35	0.85 (0.26)	1.11 (0.75)	1.28 (1.14)	0.75 (0.07)	1.08 (0.67)	1.39 (1.43)
T_5 - Fenoxaprop-p-ethyl 9.3% EC	0.50	1.07 (0.66)	1.42 (1.54)	1.64 (2.19)	0.93 (0.36)	1.37 (1.39)	1.83 (2.86)
T_6- HW at 20 & 40 DAT	-	1.88 (3.02)	1.20 (0.95)	1.38 (1.42)	1.40 (1.46)	1.15 (0.84)	1.42 (1.52)
T_7 – Unweeded check	-	1.88 (3.04)	2.27 (4.70)	2.44 (5.48)	1.40 (1.45)	2.23 (4.49)	2.59 (6.19)
SEm (±)	-	0.09	0.06	0.06	0.04	0.06	0.04
CD at 5%	-	0.29	0.17	0.18	0.14	0.18	0.13

Figures in parentheses are the original values. The data was transformed to √(x+0.5) before analysis

Table 5. Effect of different treatments on Weed Control Efficiency (%) against weeds

Treatment	Dose (g ai /ha)	*Echinochloa crussgalli*			*Echinochloa colona*			*Digiteria sanguinalis*		
		15 DAA	**30 DAA**	**45 DAA**	**15 DAA**	**30 DAA**	**45 DAA**	**15 DAA**	**30 DAA**	**45 DAA**
T_1- Propaquizafop 10% EC	0.50	79.51	74.67	70.65	74.55	66.95	63.50	74.32	65.21	61.03
T_2- Propaquizafop 10% EC	0.75	96.09	83.44	79.59	93.86	82.80	77.31	89.19	84.30	80.58
T_3- Imazethapyr 10% SL @ 0.075 kg a.i./ha	0.75	73.88	69.92	65.72	71.72	64.69	59.80	69.57	60.45	59.64
T_4- Imazamox @ + Imazethapyr	0.35 +0.35	100	86.67	82.99	95.96	85.44	82.50	92.68	87.77	84.33
T_5 - Fenoxaprop-p-ethyl 9.3% EC	0.50	79.12	71.37	69.79	83.99	77.49	70.94	76.17	71.37	66.90
T_6- HW at 20 & 40 DAT	-	-	76.31	70.07	-	80.54	74.82	-	83.21	76.03
T_7 – Unweeded check	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

**DAA Day after application*

Contd…

Treatment	Dose (g ai /ha)	*Dactyloctenium eigyptium*			*Eleusine indica*		
		15 DAA	**30 DAA**	**45 DAA**	**15 DAA**	**30 DAA**	**45 DAA**
T_1- Propaquizafop 10% EC	0.50	73.52	66.30	51.14	75.04	62.33	45.75
T_2- Propaquizafop 10% EC	0.75	89.20	80.10	74.74	90.79	78.13	74.67
T_3- Imazethapyr 10% SL @ 0.075 kg a.i./ha	0.75	73.57	56.94	51.87	75.88	58.98	47.68
T_4- Imazamox @ + Imazethapyr	0.35 +0.35	91.58	84.12	78.81	94.85	84.52	76.74
T_5 - Fenoxaprop-p-ethyl 9.3% EC	0.50	78.34	66.48	58.94	75.33	67.68	53.90
T_6- HW at 20 & 40 DAT	-	-	79.18	74.29	-	80.42	75.37
T_7 – Unweeded check	-	0.00	0.00	0.00	0.00	0.00	0.00

**DAA Day after application*

Table 6. Effect of treatments on yield attributes & yield of soybean crop

Treatments	Dose (g ai /ha)	Plant height (mm)	Average no. of branches/plant	Pods/plant	Grain yield (kg/ha)
T_1- Propaquizafop 10% EC	0.50	533	2.91	27.60	2054
T_2- Propaquizafop 10% EC	0.75	587	3.10	27.70	2265
T_3- Imazethapyr 10% SL @ 0.075 kg a.i./ha	0.75	527	2.55	24.80	2011
T_4- Imazamox @ + Imazethapyr	0.35 +0.35	566	2.80	24.80	2189
T_5 - Fenoxaprop-p-ethyl 9.3% EC	0.50	493	2.25	22.90	1976
T_6- HW at 20 & 40 DAT	-	598	3.28	30.90	2456
T_7 – Unweeded check	-	461	1.31	17.40	867
SEm (±)	-	21.7	0.18	1.53	87
CD at 5%	-	63.5	0.54	4.48	267

Table 7. Effect of treatments on biological properties of soil

Treatments	Dose	Bacterial population x CFU x 10^5/ g of soil		Actinomycetes population CFU x 10^3/g of soil	
		Before spraying of herbicide	At harvest	Before spraying of herbicide	At harvest
T_1- Propaquizafop 10% EC	500	38.85	35.34	33.39	30.89
T_2- Propaquizafop 10% EC	750	38.85	36.57	33.39	32.65
T_3- Std. Check Propaquizafop 10% EC (Market sample)	500	38.85	35.29	33.39	31.38
T_4- Std. Check Propaquizafop 10% EC (Market sample)	750	38.85	36.25	33.39	30.95
T_5 - Std. Check Fenoxaprop-p-ethyl 9.3% EC	1111	38.85	37.71	33.39	31.74
T_6- HW at 20 & 40 DAT	-	38.85	36.68	33.39	31.96
T_7 – Unweeded check	-	38.85	37.26	33.39	32.74

**All data are mean of three replications*

3.3 Effect of Propaquizafop 10% EC on Biological Properties of Soil

The application of Propaquizafop 10% EC did not cause any appreciable adverse effects on the physical and biological properties of soil. The bacterial population decreased slightly from 38.85 × 10^3 CFU/g soil before spraying to 35.29–37.71 × 10^3 CFU/g soil at harvest, while the actinomycetes population varied from 30.89 to 32.74 × 10^3 CFU/g soil compared with the initial population of 33.39 × 10^3 CFU/g soil. The relatively small changes observed across herbicidal, hand-weeding and unweeded treatments indicate that Propaquizafop did not exert any pronounced detrimental effect on the measured soil properties. Similar findings were reported by Sharma and Renjith (2016) in soybean, where herbicide application temporarily suppressed soil microbial populations at 30 DAS, but the microbial population recovered by harvest. The absence of a pronounced residual effect may also be related to the relatively rapid degradation of propaquizafop in soil. Cheng et al. (2023) reported that propaquizafop was readily degradable in different agricultural soils, with a half-life ranging from 1.41 to 7.75 days, and indicated that microbial activity was one of the factors contributing to its degradation. Thus, the present findings suggest that Propaquizafop 10% EC at the tested doses did not cause any substantial or persistent disturbance in soil physical properties or the populations of bacteria and actinomycetes (Ramprakash et al., 2016; Sharma & Renjith, 2016, Pahade et al., 2023).

4. Conclusion

The field study showed that post-emergence Propaquizafop 10% EC effectively reduced the density and dry weight of the dominant grassy weeds in soybean. Among the tested doses, 750 ml ha^{-1} provided stronger weed suppression and higher weed control efficiency than the lower dose, with corresponding improvements in crop growth and grain yield. Soybean grain yield reached 2265 kg ha^{-1} under this treatment, compared with 867 kg ha^{-1} in the unweeded check, although hand weeding at 20 and 40 days after sowing produced the highest yield of 2456 kg ha^{-1}. No visible phytotoxic symptoms were recorded at the tested doses. The measured bacterial and actinomycetes populations in soil showed no pronounced adverse changes at harvest. In addition, the succeeding mustard crop exhibited no residual phytotoxicity, and its germination, plant height and seed yield were statistically comparable among treatments. Therefore, within the agro-climatic conditions and management practices of this experiment, Propaquizafop 10% EC at 750 ml ha^{-1} was an effective post-emergence option for managing grassy weeds in soybean without evident adverse effects on the succeeding mustard crop.

5. Limitations

The findings are specific to a single kharif season, one experimental location at Jabalpur, one soybean variety, and the tested treatment rates. Consequently, extrapolation to other soils, seasons, soybean cultivars or agro-climatic regions should be made cautiously. Soil biological assessment was limited to the measured bacterial and actinomycetes populations, while residual crop safety was evaluated using succeeding mustard under the same experimental conditions.

Declaration of AI Use

This manuscript was prepared through the intellectual contributions of the author(s) to the study design, data analysis, interpretation of results, and scholarly content. Grammarly and ChatGPT were used solely to assist with grammatical refinement and reference formatting during manuscript revision. The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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