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RESEARCH NOTE

Evaluation of the efficacy of pre- and post-emergence herbicides in *Rabi* sesame

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ABSTRACT

A field experiment was conducted at ICAR-Indian Institute of Oilseeds Research, Hyderabad during *Rabi* season of 2023-24 in a red sandy soil. The objective was to evaluate the effect of sequential application of pre-emergence (PE) and post-emergence (PoE) herbicides on weed management, sesame yield and to identify effective herbicides for weed management, yield preservation, and crop safety. Sesame (*Sesamum indicum* L.) cv "*CUMS 17*" was line-sown. Among the herbicides tested, pre-emergence application (PE) of pendimethalin 30% + imazethapyr 2% EC (pre-mix) (pendimethalin + imazethapyr) 750+50 g/ha achieved significantly highest weed control efficiency (WCE) at 60 DAS and sesame yield. The sequential application of pendimethalin 750 g/ha PE followed by (*fb*) post-emergence application (PoE) of haloxyfop-R-methyl 10.5% w/w EC (haloxyfop-R-methyl) 54 g/ha recorded the next highest yield. Pyroxasulfone 85% w/w WG (pyroxasulfone) 127.5 g/ha PE was statistically at par with above sequential application treatment. Bentazone, metribuzin, fluazifop-p-butyl + fomesafen, and propaquizafop + imazethapyr showed phytotoxicity and resulted in lower sesame yield. The uncontrolled weeds in weedy check limited sesame yield to just 33% of the weed free check. It could be concluded that pendimethalin + imazethapyr 750+50 g/ha PE was superior in terms of attaining higher yield of sesame and effective weed management, while pyroxasulfone PE, haloxyfop-R-methyl, and clethodim PoE demonstrated their potential to use for weed management in sesame.

Keywords: Clethodim, Haloxyfop-R-methyl, Pyroxasulfone, Pendimethalin + imazethapyr, Sesame, Weed management

Sesame (*Sesamum indicum* L.) is a highly valued oilseed crop, known for its adaptability to diverse agro-climatic conditions and its rich oil content (50-60%). The low productivity of sesame has zeroed-in on weed competition as the cause for the low productivity. The slow early growth of sesame led to significant decline in yield up to 50-80%, despite sesame yield potential (Karnas *et al.* 2019). Critical period for crop weed competition in sesame is 15-45 days. The poor competitive ability of sesame makes effective weed management crucial to ensuring optimal sesame productivity. In spite of new technological developments to improve sesame yield, the current crop management systems for sesame need to be further improvised to effectively manage the ever-adopting weeds that are competing with the crop. Currently, herbicide-based weed management strategies are widely used to control weeds in sesame. herbicides applied post-emergence (PoE) such as pendimethalin are commonly used to manage weeds early in the season, while post-emergence herbicides to manage weeds emerging later in the crop cycle. Many herbicides applied post-emergence (PoE), though effective at controlling weeds, can cause crop injury, resulting in stunted growth and yield losses (Grichar *et al.* 2009). This sensitivity has limited the development and adoption of integrated weed management strategies that include both PE and PoE herbicides.

The sensitivity of sesame to herbicides and the complexity of weed control during the crop's critical growth stages, emphasises the pressing need to identify PE and PoE weed management strategies that balance weed suppression with crop safety. Thus, screening herbicides for their efficacy and safety is essential for developing sustainable weed management strategies. This study aims to evaluate the effect of sequential application of pre-emergence and post-emergence herbicides on weed management, and sesame yield and to identify effective herbicides for optimal weed management without compromising the growth and productivity

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of the sesame crop.

A field experiment was conducted at Narkhoda Farm, ICAR-Indian Institute of Oilseeds Research, Hyderabad. The experiment was laid in a Randomized Block Design (RBD), replicated thrice and comprised of 22 treatments (**Table 1**). Sesame variety *"CUMS-17"* was sown on 02/01/2024 in rows spacing of 45 cm and harvested on 10/04/2024. The plot size was 5.0 × 4.0 m. The recommended fertiliser dosage rate of 40:20:20 kg NPK/ha was applied in the form of urea, di-ammonium phosphate (DAP) and muriate of potash. Need based irrigation and plant protection measures were carried out. The pre-emergence application (PE) of herbicides was done on second day after sowing (DAS) following irrigation and post-emergence application (PoE) was done at two leaf stage of weeds using a flat fan type nozzle fitted knapsack sprayer and using 500 liter of water/ha at 18-20 DAS. The treatments include: pendimethalin 30% EC (pendimethalin) 750 g/ha as PE, pendimethalin 750 g/ha PE followed by (*fb*) bentazone 480 g/L SL (bentazone) PoE 960, 760 and 480 g/ha PoE, pendimethalin750 g/ha PE *fb* clethodim 25% EC (pendimethalin + clethodim) 120, 90 and 60 g/ha PoE, pendimethalin *fb* haloxyfop-R-methyl 10.5% w/w EC (haloxyfop-R-methyl) 108, 81 and 54 g/ha PoE, pendimethalin *fb* metribuzin 70% WP (metribuzin) 525, 400 and 300 g/ha PoE, pendimethalin *fb* fluazifop-p- butyl 11.1% w/w + fomesafen 11% w/w SL (fluazifop-p-butyl + fomesafen) 187.5 and 125 g/ha, pendimethalin *fb* propaquizafop 2.5% + imazethapyr 3.75% (propaquizafop + imazethapyr) 37.5+56.25 PoE and 25+37.5 g/ha, pyroxasulfone 85% w/w WG (pyroxasulfone) 127.5 g/ha PE, pendimethalin 30% + imazethapyr 2% EC as PE (pre-mix) (pendimethalin + imazethapyr) 750+50 g/ha PE, pendimethalin *fb* pyrithiobac-sodium 6% w/w +quizalofop ethyl 4% w/w EC (pyrithiobac-sodium + quizalofop-ethyl) 60+40 g/ha PoE at 2-3 leaf stage of weed, weed free and weedy check. The data related to weed density and weed dry weight (weed biomass) was recorded at 60 DAS. Prior to statistical analysis, the weed density and biomass data were subjected to a square root transformation ($\sqrt{x+0.5}$). Phytotoxicity rating (0-100) of herbicides on crop in terms of yellowing, stunting and necrosis was recorded at 15 days after PoE spray as per earlier reported methodology (Vanhala *et al.* 2004). Weed indices were calculated according to the methodologies described by Poddar *et al.* (2017). Statistical procedures followed the guidelines of Gomez *et al.* (1984).

Weed flora

The experimental field was infested with a diverse weed flora dominated by sedges and broad-leaved weed species. Notably, no grassy weeds were observed. *Cyperus rotundus* was the predominant sedge species. Among the broad-leaved weeds, dominant species were: *Amaranthus viridis*, *Argemone mexicana*, *Alternanthera paronychioides*, *Boerhavia diffusa*, *Euphorbia hirta*, *Trianthema portulacastrum*, *Parthenium hysterophorus*, *Phyllanthus maderaspatensis* and *Phyllanthus niruri*.

Phytotoxicity on sesame

The pre-emergence application of pendimethalin, pyroxasulfone and pendimethalin + imazethapyr (pre-mix) did not exhibit any phytotoxicity symptoms on sesame. On the other hand, post-emergence over-the-top herbicides, *viz.* bentazone, metribuzin, fluazifop-p-butyl + fomesafen (pre-mix), propaquizafop + imazethapyr (pre-mix) have shown slight to moderate injury on sesame which includes leaf necrosis to reduction in crop stand. However, the crop has recovered from the damage.

Pendimethalin 750 g/ha PE *fb* pyrithiobac-sodium + quizalofop-ethyl (pre-mix) 60+40 g/ha PoE at 2-3 leaf stage of weed had detrimental effect of complete loss of crop stand. Thus, as this treatment has no potential in sesame weed management, it will not be discussed further.

Weed control

The tested treatments exhibited significant variation in their effectiveness in terms of weed density and biomass (**Table 1**). However, there was no statistically significant difference among the treatments in controlling the density of broad-leaved weeds specifically.

Pendimethalin 750 kg/ha PE followed by propaquizafop + imazethapyr 37.5 + 56.25 g/ha PoE significantly reduced the density of sedges and total weeds, achieving the highest weed control efficiency (WCE) of 78.32%. The use of same treatment at lower rates resulted in a reduced WCE of 62.09%. The treatments using sole PE herbicides, such as pendimethalin at 750 g/ha and pyroxasulfone at 127 g/ha were less effective, in reducing the density of both sedges and broad-leaved weeds, with WCE of 53.8% and 51.37%, respectively. The bentazone 960 g/ha and 760 g/ha recorded WCEs of 75.43%, effectively

Table 1. Effect of herbicides on sesame seed yield and on associated weed density, biomass and weed indicators at 60 DAS

Treatment	Weed density (no./m^2)			WCE (%)	Weed biomass (g/ m^2)	WCI	Phyto-toxicity score	Sesamum seed yield (t/ha)
	Sedges	BLW	Total					
Pendimethalin 750 g/ha PE	5.33 (3.11)	17.33(4)	22.67 (6.18)	53.79	9.33 (2.18)	53.99	0	0.30
Pendimethalin 750 g/ha PE *fb* bentazone 960 g/ha PoE	6.67(2.2)	5.33(2.39)	12 (5.04)	75.43	4.4(2.65)	79.74	20	0.15
Pendimethalin PE *fb* bentazone 760 g/ha PoE	2.67(2.61)	9.33(3.13)	12(4.78)	75.43	6.67(1.65)	67.76	20	0.20
Pendimethalin PE *fb* bentazone 480 g/ha PoE	16(2.87)	10.67(3.24)	26.67(7.5)	43.36	7.87(4.26)	62.84	20	0.22
Pendimethalin 750 g/ha PE *fb* clethodim 120 g/ha PoE	5.33(2.46)	9.33(2.77)	14.67(4.95)	70.42	5.87(2.18)	70.87	0	0.26
Pendimethalin 750 g/ha PE *fb* clethodim 90 g/ha PoE	17.33(3.1)	5.33(2.39)	22.67(6.49)	54.44	9.47(4.11)	53.43	0	0.30
Pendimethalin 750 g/ha PE *fb* clethodim 60 g/ha PoE	13.33(3.68)	16(3.87)	29.33(7.85)	40.80	13.07(3.71)	38.97	0	0.33
Pendimethalin 750 g/ha PE *fb* haloxyfop-R-methyl 108 g/ha PoE	9.33(2.74)	5.33(2.39)	14.67(5.42)	69.48	7.47(3.03)	66.38	0	0.30
Pendimethalin 750 g/ha PE *fb* haloxyfop-R-methyl 81 g/ha PoE	18.67(2.86)	4(1.92)	22.67(6.41)	53.79	8(4.5)	59.89	0	0.38
Pendimethalin 750 g/ha PE *fb* haloxyfop-R-methyl 54 g/ha PoE	10.67(2.85)	2.67(1.65)	13.33(4.95)	73.70	8.13(3.3)	63.79	0	0.42
Pendimethalin 750 g/ha PE *fb* metribuzin 525 g/ha PoE	12 (15)	6.67(15)	18.67(15)	60.13	4.93(15)	75.93	20	0.14
Pendimethalin 750 g/ha PE *fb* metribuzin 400 g/ha PoE	12 (2.56)	6.67(2.39)	18.67(6.52)	60.93	6.27(3.96)	68.70	20	0.18
Pendimethalin 750 g/ha PE *fb* metribuzin 300 g/ha PoE	12 (2.97)	10.67(2.86)	22.67(6.37)	54.69	8.4(3.51)	59.47	20	0.17
Pendimethalin 750 g/ha PE *fb* fluazifop-p-butyl + fomesafen 187.5 g/ha PoE	1.33(2.11)	17.33(3.96)	18.67(5.14)	59.88	4.27(1.18)	78.26	20	0.16
Pendimethalin 750 g/ha PE *fb* fluazifop-p-butyl + fomesafen 125 g/ha PoE	9.33(2.94)	9.33(2.92)	18.67(5.64)	62.23	8.4(2.72)	58.26	20	0.15
Pendimethalin 750 g/ha PE *fb* propaquizafop 2.5% + imazethapyr 37.5+56.25 g/ha PoE	5.33(2.29)	5.33(2.12)	10.67(4.51)	78.32	5.47(2.39)	76.94	20	0.12
Pendimethalin 750 g/ha PE *fb* propaquizafop + imazethapyr 25+37.5 g/ha PoE	12(2.52)	9.33(2.77)	25.33(6.67)	62.09	7.73(3.41)	65.26	20	0.07
Pyroxasulfone 127.5 g/ha PE	17.33(3.17)	6.67(2.65)	24(7.38)	51.37	6.27(4.73)	55.71	0	0.41
Pendimethalin + imazethapyr 750+50 g/ha PE	6.67(2.58)	10.67(3.33)	17.33(6.66)	65.12	21.6(3.33)	71.17	0	0.56
Pendimethalin 750 g/ha PE *fb* pyrithiobac-sodium +quizalofop-ethyl 60+40 PoE	-	-	-	-	-	-	100	-
Weed free	-	-	-	100	-	100	-	0.63
Weedy check	30.67(4.69)	18.67(4.37)	49.33(8.77)	0	21.6(1.82)	0	-	0.21
LSD (p=0.05)	1.14	2.03	2.49	27.21	1.82	19.29	-	0.07

*Figures in parentheses are transformed values; PE = pre-emergence application; PoE = post-emergence application, *fb* = followed by, DAS = days after seeding

controlling both types of weeds. Clethodim 120 g/ha also showed a reasonably good WCE (70.42%). Among the PoE treatments, metribuzin and fluazifop-p-butyl + fomesafen included treatments recorded higher weed densities.

Sesame yield attributes and yield

Among the tested herbicide treatments, pendimethalin 750 g/ha + imazethapyr 50 g/ha (pre-mix) PE and pyroxasulfone 127.5 g/ha PE produced sesame yield statistically comparable to the weed-free check. Variation was observed in grain yield across the treatments.

Among the pre-emergence herbicides, pendimethalin at 750 g/ha, pyroxasulfone 127.5 g/ha, pendimethalin 750 g/ha + imazethapyr 50 g/ha (pre-mix) showed no phytotoxicity symptoms on the sesame crop with fairly higher control of total weeds, demonstrating their potential as safe pre-emergence herbicides for managing weeds in sesame fields as observed earlier by Singh *et al.* (2018).

PoE herbicides at higher dosages were effective in reducing weed biomass. However, PoE herbicides, *viz*. bentazone (Grichar *et al*. 2002), metribuzin (Grichar *et al.* 2009), fluazifop-p-butyl + fomesafen (pre-mix), and propaquizafop + imazethapyr (pre-mix) (Ghadiya *et al.* 2024), caused slight to moderate crop injury and reductions in crop stand. Although, the crop recovered, there was a yield penalty.

Among the post-emergence herbicide treatments, clethodim 120 g/ha and haloxyfop-R-methyl 108 g/ha recorded WCE of 71% and 64%, respectively with sesame yield higher than pendimethalin PE. Ismail *et al.* (2024) demonstrated earlier the effective use of PoE application of clethodim and haloxyfop-R-methyl in sesame.

The results of this study highlight an interesting disparity between weed control efficiency and crop yield in case of PoE herbicide treatments which might be due to their detrimental effects on the crop despite their effectiveness against weeds. Phytotoxicity can lead to reduced crop growth, which offsets the benefits of improved weed control (Grichar *et al.* 2011). Some herbicides for instance, bentazone and fluazifop-p-butyl + fomesafen, while effective in controlling weeds, caused some degree of crop injury, affecting overall yield. The variation in yield and its relationship with WCE in the case of PoE herbicides can be better understood through a more in-depth study of phytotoxicity and the factors influencing the efficacy of herbicide.

The use of pendimethalin at 750 g/ha PE and pyroxasulfone at 127.5 g/ha PE, alone, was effective during initial phase of crop growth. These results highlight the need for integration of weed management practices including the use of post-emergence herbicides and hand weeding or hoeing which could be more effective in reducing overall weed populations.

Pendimethalin at 750 g/ha + imazethapyr at 50 g/ha (pre-mix) PE was the only treatment which exhibited the least yield reduction due to effective weed control. This can be explained by complementary action of pendimethalin, which is effective during germination and establishment whereas imazethapyr particularly effective after emergence of crop due to its soil action. However, results of this study show that premix PE herbicide could not suffice the entire critical period of crop weed competition necessitating the integration of weed management practises.

This research serves as a basis for future research on sesame weed management, focusing on optimizing herbicide use to minimize crop injury and maximize yield. Future studies should examine herbicide toxicity, soil residue, and sustainable strategies such as integrated weed management (IWM).

Conclusion

Based on weed control, crop safety and yield parameters, the combination of pendimethalin + imazethapyr 750+50 g/ha PE is most promising recording effective weed control and higher sesame yield with minimal yield losses due to weeds followed by pyroxasulfone 127.5 g/ha PE.

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