Indian Journal of Weed Science (2022) **54**(3): 279–282
http://dx.doi.org/10.5958/0974-8164.2022.00050.8

RESEARCH ARTICLE

Efficacy of sequential application of pre- and post-emergence herbicides for weed management in sesame

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Received: 31 March 2022 | Revised: 7 August 2022 | Accepted: 9 August 2022

ABSTRACT

A field experiment was conducted during rainy (*Kharif*) seasons of 2019 and 2020 to assess the efficacy of the sequential application of pre- and post-emergence herbicides for managing complex weed flora in line sown sesame (*Sesamum indicum* L.) at Agriculture Research Sub-Station, Sumerpur, Pali. There were nine weed control treatments replicated thrice in a randomized complete block design. Hand weeding twice recorded the highest values of growth parameters and seed yield (1.25 t/ha) which was at par with pre-emergence application (PE) of pendimethalin 750 g/ha followed by (*fb*) quizalofop-p-ethyl 40 g/ha at 20 days after seeding (DAS). The uncontrolled weeds in weedy check caused 50% sesame seed yield reduction. The post-emergence application (PoE) of quizalofop-p-ethyl 40 g/ha at 20 DAS and sequential application of pre-emergence application (PE) of pendimethalin 750 g/ha PE followed by (*fb*) quizalofop-p-ethyl 40 g/ha at 20 DAS recorded the highest weed control efficiency, sesame seed yield, net return and benefit cost ratio and were observed to be superior than the recommended practice of pendimethalin 1000 g/ha PE *fb* hand weeding at 25 DAS.

Keywords: Fenoxaprop-p-ethyl, Quizalofop-p-methyl, Pendimethalin, Sesame, Weed management

INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the important oilseed crop of India. Globally, India is the largest producer, consumer, and exporter of sesame. India ranks first in the world with respect to area under sesame cultivation with an area of 16.22 lakh hectares, production of 6.57 MT and productivity of 405 kg/ha during 2019-2020. In Rajasthan, sesame was cultivated in 2.70 lakh hectares with a production of 0.78 lakh tonnes and productivity of 289 kg/ha during 2019-20 (Anonymous 2020). Among the several constraints in sesame production, heavy weed infestation is one of the major factors limiting the yield of sesame. Being a slow growing crop during seedling phase, weeds affect the growth of sesame and reduced the yield. The loss of seed yield due to uncontrolled weed growth in sesame has been reported as high as 50 to 70% in sandy loam soils (Dungarwal *et al*. 2003, 2006). Though manual weeding is effective and eco-friendly yet they are tedious, time consuming and costly due to non-availability of labour in time. Thus, herbicides use is preferred as it is effective, quick in action, selective in nature, cost effective and efficient to control weeds during the critical period (Rao and Nagamani 2010), even though the indiscriminate use of chemicals often leads to environmental pollution (Omezzine *et al.* 2011), and development of resistance by weeds against herbicides. Due to involvement of high cost and scarcity of labour for manual weeding, for effective and economic weed control during the critical period, there is a need of evaluation of pre-emergence (PE) and post-emergence (PoE) herbicides in sesame. Hence, an experiment was conducted to evaluate the effect of sequential application of pre- and post-emergence herbicides on weeds, growth, and grain yield of sesame.

MATERIALS AND METHODS

Field studies were conducted during rainy (*Kharif*) season of 2019 and 2020 at Agriculture Research Sub-Station, Sumerpur, Pali, Rajasthan. The soil of experimental field was sandy silty clay loam with P^H 7.98, available nitrogen 143.5 kg/ha, available phosphorus 44.2 kg/ha and available potassium 256 kg/ha with low organic carbon content (0.22%). There were nine treatments (**Table 1**). The experiment was laid out in randomized block design

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with three replications. Sesame variety "*RT-351*" was sown on 08/07/2018 during 2018 and 11/07/2019 during 2019 in row 45 cm apart, using 2.5 kg/ha seed rate with plot size 5m x 4.5 m. Crop was fertilized with 40 kg/ha nitrogen and 25 kg/ha phosphorus and 20 kg/ha potash as basal dose. NPK contents were applied through urea and NPK mixture (12:32:16), respectively. The half dose of nitrogen along with entire dose of phosphorus and potassium were applied as basal at the time of sowing and the remaining half of the dose of nitrogen was top dressed at 30 DAS. For good yield of crop, 250 kg/ha gypsum was also applied at the time of sowing. The crop was irrigated whenever needed. The pre-emergence application (PE) of pendimethalin was done at 2^{nd} day after sowing (DAS) along with irrigation and post-emergence application (PoE) of imazethapyr, quizalofop-p-ethyl, fenoxaprop-p-ethyl herbicides was done at 20 DAS while tembotrione was applied at 10 DAS as early post-emergence application (EPoE). A knap sack sprayer fitted with flat fan nozzle and 500 l/ha of water was used for herbicides spray. Weed density and weed dry weight (biomass) were recorded at 45 and 60 DAS, with the help of 0.5 x 0.5 m quadrat by randomly placing at three places in each plot. Weeds were removed and counted species wise. After drying in hot air oven (60 ± 1^0 C for 24 hours), weed biomass was recorded and reported as per square meter. Weed density and biomass data was subjected to square root "(x + 0.5) transformation before statistical analysis. Weed control efficiency was also calculated as suggested by Maity and Mukherjee (2011). The economics was calculated based on prevailing market rates of agriculture produced and cost of cultivation treatment wise.

RESULTS AND DISCUSSION

Effect on weeds

The major weed flora observed in experimental field was *Cyperus rotundus*, *Cynodon dactylon*, *Amaranthus viridis*, *Dactyloctenium aegyptium*, *Digitaria sanguinalis*, *Phyllanthus niruri*, *Commelina benghalensis* and *Digera arvensis.* All the weed control treatments proved significantly effective in reducing the weed density and biomass as compared to weedy check. Hand weeding twice at 20 and 40 DAS significantly reduced weed density at 45 and 60 DAS compared to rest of the treatments and was found at par with pendimethalin PE followed by (*fb*) quizalofop-ethyl PoE. Weed biomass at 45 DAS was significantly lower with this treatment and 60 DAS it was *on par* with other treatments. Yadav (2004) also reported lowest weed biomass and highest weed control efficiency with pendimethalin 0.5 kg/ha PE *fb* 1 HW at 40 DAS. Among the sequential application of herbicides, the lowest density and biomass of grasses was recorded with pendimethalin 0.75 kg/ha PE *fb* quizalofop-p-ethyl 40 g/ha PoE 20 DAS, which was *on par* with other weed control treatments. However, hand weeding twice at 20 and 40 DAS has recorded significantly lower grassy weed density and biomass than rest of the treatments (**Table 1**). Pendimethalin controlled most of the annual grasses and broad-leaved weed seeds and the later emerged grassy weeds were effectively controlled by quizalofop-p-ethyl or fenoxaprop-p-ethyl conforming the findings of Sivasankar and Subramanyam (2011). The lowest density and biomass of sedges was recorded with fenoxaprop-p-ethyl 70 g/ha PoE and pendimethalin 750 g/ha PE *fb* fenoxaprop-p-ethyl 70 g/ha PoE 20 DAS. Both the treatments were at par with each other. This might be due to effective control of annual sedges by the fenoxaprop-p-ethyl 70 g/ha PoE, which was more effective in suppressing the weed growth compared to pendimethalin 750 g/ha PE. The broad-leaved weeds were effectively controlled by imazethapyr 60g/ha 20 DAS and tembotrione 100 g/ha EPoE at 10 DAS but also caused the crop plants mortality and hence could not be used. Therefore, quizalofop-p-ethyl 40 g/ha and fenoxaprop-p-ethyl 70 g/ha PoE 20 DAS could be used to control annual and perennial grassy weeds. *Argemone Mexicana* was not effectively controlled by pendimethalin 750 g/ha in comparison to rest of the herbicides tested. The lowest total weed biomass with higher weed control efficiency was recorded with hand weeding twice at 20 and 40 DAS due to complete effective removal of all the categories of weeds including *Cyperus iria* which accounted for 25% of the total weed density in the experimental field. The next best treatment that recorded lower weed biomass and higher weed control efficiency was pendimethalin 750 g/ha PE *fb* quizalofop-p-ethyl 40 g/ha PoE at 20 DAS. These results conformed the findings of Vafaei *et al.* (2013) in sesame. Pendimethalin 750 g/ha PE or in combination with post-emergence herbicides quizalofop-p-ethyl 40 g/ha or fenoxaprop-p-ethyl 70 g/ha at 20 DAS was more effective like sole application of quizalofop-p-ethyl PoE or fenoxaprop-p-ethyl PoE in sesame.

Effect on crop

The yield components and seed yield of sesame were significantly influenced by the sequential application of pre- and post-emergence herbicides

(**Table 2**). The highest number of leaves/plant, number of capsules/plant, number of seeds/capsule, test weight and seed yield of sesame were recorded with pendimethalin 750 g/ha PE *fb* quizalofop-p-ethyl 40 g/ha PoE at 20 DAS and it was closely followed by hand weeding twice at 20 and 40 DAS which recorded an yield increase of 93.63% and 85.52%, respectively compared to control. This might be due to decreased competition for growth resources by weeds resulting in better photosynthesis and resultant partitioning in crop manifested to increase all the yield components. These results are in conformity with those of Sootrakar *et al.* (1995). The highest net returns were obtained with pendimethalin 750 g/ha PE *fb* quizalofop-p-ethyl 40 g/ha PoE at 20 DAS and the highest benefit cost ratio was obtained with quizalofop-p-ethyl 40 g/ha PoE at 20DAS. Both these treatments recorded higher net returns and benefit cost ratio than hand weeding twice due to reduced cost of cultivation and increased seed yield. Lowest yield components, seed yield and net returns were recorded with fenoxaprop-p-ethyl 70 g/ha at 20 DAS, among herbicide-based treatments, due to poor weed control. Imazethapyr 60 g/ha PoE at 20 DAS and tembotrione 100 g/ha PoE at 20 DAS caused phytotoxicity rating of 10.0 (in 0-10 scale where, '0' indicates no injury and normal growth and '10' indicates complete destruction of sesame crop plants Nehra and Jagannath (2011) also reported the phytotoxicity effect of imazethapyr on germination and early seedling growth of sunflower and maize.

Table 1. Effect of different treatments on density and biomass of grasses, sedges and broad-leaved weeds (BLW) and weed control efficiency (WCE) in Sesame (pooled data of two years)

Treatment	Weed density (no./m^2)				Weed biomass (g/m^2)				WCE (%)
	Grasses	Sedges	BLW	Total	Grasses	Sedges	BLW	Total	
Head weeding (HW) at 20 and 40 days after sowing (DAS)	6.13 (2.65)	18.80 (4.44)	19.27 (4.50)	44.20 (6.72)	5.39 (2.51)	6.70 (2.77)	14.66 (3.95)	26.78 (5.25)	45.52 (6.81)
Imazethapyr 60 g/ha PoE at 18-20 DAS	3.63 (2.15)	3.24 (2.05)	8.15 (3.02)	15.01 (3.99)	2.74 (1.92)	1.38 (1.54)	6.85 (2.80)	19.96 (3.45)	81.63 (9.01)
Quizalofop 10.8 240 g/ha PoE at 20 DAS	6.03 (2.64)	5.56 (2.56)	21.27 (4.71)	32.86 (5.81)	5.13 (2.46)	2.11 (1.76)	16.76 (4.21)	23.99 (4.99)	59.74 (7.79)
Fenoxaprop-p-ethyl 70 g/ha PoE at 20 DAS	11.67 (3.56)	0.15 (1.07)	25.09 (5.10)	36.91 (6.15)	9.96 (3.31)	0.05 (1.02)	19.19 (4.49)	29.20 (5.50)	54.63 (7.45)
Pendimethalin 0.75 kg/ha PE *fb* HW at 25 DAS	6.24 (2.70)	2.67 (1.91)	39.99 (6.40)	48.89 (7.06)	5.06 (2.46)	1.02 (1.42)	32.66 (5.81)	38.74 (6.30)	39.86 (6.38)
Pendimethalin 0.75 kg /ha (PE) *fb* quizalofop-p-methyl 40 g/ha at 20 DAS	2.43 (1.84)	1.76 (1.65)	30.32 (5.60)	34.51 (5.95)	1.78 (1.66)	0.86 (1.36)	24.94 (5.07)	27.58 (5.34)	57.69 (7.65)
Pendimethalin 0.75 kg /ha (PE) *fb* fenoxaprop-p-ethyl 70 g/ha at 20 DAS	3.75 (2.18)	0.41 (1.18)	38.09 (6.25)	42.25 (6.57)	2.88 (1.96)	0.14 (1.06)	33.15 (5.83)	35.97 (6.08)	47.99 (6.98)
Tembotrione 100 g/ha EPoE at 10 DAS	6.45 (2.73)	17.12 (4.25)	11.27 (3.50)	34.85 (5.98)	5.37 (2.52)	6.22 (2.68)	8.21 (3.03)	19.87 (4.56)	57.35 (7.63)
Control	13.20 (3.76)	25.89 (5.20)	42.39 (6.60)	81.59 (9.08)	11.69 (3.55)	8.48 (3.01)	35.18 (6.00)	55.35 (7.50)	0.00 (1.00)
LSD (p=0.05)	0.36	0.35	0.64	0.49	0.40	0.17	0.60	0.57	0.54

*Figures in parenthesis are the square root transformed ("x+0.5) values; PE = pre-emergence application; PoE = post-emergence application, EPoE = early post-emergence application, *fb* = followed by

Table 2. Effect of different treatments on growth, yield attributing characters of sesame (pooled data of two years)

Treatment	Height at 60 DAS (cm)	Height at harvest (cm)	No. of leaves/ plant	No. of capsules/ plant	No. of grains/ capsule
Head weeding (HW) at 20 and 40 days after sowing (DAS)	124.0	155.1	68.1	35.9	36.7
Imazethapyr 60 g/ha PoE at 18-20 DAS	0 .00	0 .0	0 .0	0 .0	0 .0
Quizalofop 10.8 240 g/ha PoE at 20 DAS	121.2	149.1	58.9	32.5	33.2
Fenoxaprop-p-ethyl 70 g/ha PoE at 20 DAS	117.8	141.2	53.7	26.3	31.3
Pendimethalin 0.75 kg/ha (PE) *fb* HW at 25 DAS	121.1	148.7	54.4	29.2	32.7
Pendimethalin 0.75 kg /ha (PE) *fb* quizalofop-p-methyl 40 g/ha at 20 DAS	127.1	158.2	69.9	36.4	41.3
Pendimethalin 0.75 kg /ha (PE) *fb* fenoxaprop-p-ethyl 70 g/ha at 20 DAS	121.9	152.4	65.9	33.9	35.4
Tembotrione 100 g/ha EPoE at 10 DAS	0	0	0	0	0
Control	113.9	134.1	44.8	24.7	29.7
LSD (p=0.05)	12.5	15.4	11.7	6.7	5.5

Table 3. Effect of different treatments on yield and economics of Sesame

Treatment	Grain yield (t/ha)			Cost of cultivation ($x10^3$ `/ha)			Gross returns ($x10^3$ `/ha)			Net returns ($x10^3$ `/ha)			B:C ratio		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Hand weeding (HW) at 20 and 40 days after sowing	1.25	1.24	1.25	21.05	21.05	21.05	81.45	84.86	83.16	60.40	63.81	62.11	2.87	3.03	2.95
Imazethapyr 60 g/ha PoE at 18-20 DAS	0.00	0.00	0.00	12.44	12.44	12.44	0	0	0	-12.44	-12.44	-12.44	-1.00	-1.00	-1.00
Quizalofop 10.8 240 g/ha PoE at 20 DAS	1.23	1.20	1.22	12.43	12.43	12.43	80.28	82.33	81.31	67.85	69.90	68.87	5.46	5.62	5.54
Fenoxaprop-p-ethyl 70 g/ha PoE at 20 DAS	0.92	0.96	0.94	13.03	13.03	13.03	59.99	65.88	62.93	46.96	52.85	49.90	3.60	4.06	3.83
Pendimethalin 0.75 kg/ha (PE) FB HW at 25 DAS	1.13	1.07	1.10	18.50	18.50	18.50	73.09	73.21	73.15	54.58	54.71	54.65	2.95	2.96	2.95
Pendimethalin 0.75 kg /ha (PE) FB quizalofop-p-methyl 40 g/ha at 20 DAS	1.34	1.31	1.32	14.88	14.88	14.88	86.77	89.59	88.18	71.89	74.71	73.30	4.83	5.02	4.93
Pendimethalin 0.75 kg /ha (PE) FB fenoxaprop-p-ethyl 70 g/ha at 20 DAS	1.10	0.96	1.03	15.48	15.48	15.48	71.53	66.01	68.77	56.05	50.54	53.29	3.62	3.26	3.44
Tembotrione 100 g/ha at 10 DAS	0.00	0.00	0.00	15.60	15.60	15.60	0	0	0	-15.60	-15.60	-15.60	-1.00	-1.00	-1.00
Control	0.78	0.68	0.69	11.05	11.05	11.05	45.26	46.96	46.11	34.21	35.91	35.06	3.10	3.25	3.17
LSD (p=0.05)	0.12	0.16	0.09												

Conclusion

The weeds in line sown sesame can be managed with pendimethalin 750 g/ha PE *fb* quizalofop-p-ethyl 40 g/ha PoE at 20 DAS effectively and economically to attain higher sesame productivity.

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