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Optimization of weed management measures for enhanced growth and profitability of summer sesame in red and lateritic soils of West Bengal

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Abstract
A field investigation was carried out during the summer season of 2019 to study the performance of summer sesame under different weed management practices in red and lateritic soil of West Bengal, India. The experiment was laid out in randomised block design consisting of eight treatments *viz*., pendimethalin @ 750 g ha^{-1} as pre-emergence (PE) (T_1), butachlor @ 1000 g ha^{-1} as PE (T_2), pendimethalin @ 750 g ha^{-1} as PE followed by (fb) hand weeding (HW) at 30 days after sowing (DAS) (T_3), butachlor @ 1000 g ha^{-1} as PE fb HW at 30 DAS (T_4), hand weeding at 15 DAS (T_5), hand weeding at 15 and 30 DAS (T_6), weed free check (T_7) and weedy check (T_8) which were replicated thrice. The weeds found in the experimental field were *Digitaria sanguinalis*, *Echinochloa colona*, *Cynodon dactylon*, *Dactyloctenium aegyptium*, *Eleusine indica*, *Cyperus rotundus*, *Cyperus esculentus*, *Trianthema portulacastrum*, *Alternanthera sessilis*, *Euphorbia hirta*, *Cleome viscosa* and *Heliotropium indicum*. Sole application of pendimethalin and butachlor (T_1 and T_2) significantly reduced the population and dry weight of grass and broadleaved weeds than weedy check. The dry weight of sedges was not reduced significantly by the sole application of pendimethalin and butachlor as pre-emergence over weedy check. These herbicides when followed by one hand weeding at 30 DAS reduced the weed population and dry weight at later stage and thereby resulted higher growth parameters than their sole application. Uninterrupted weed infestation resulted 62.66% yield loss in summer sesame. The highest net return was observed in sole application of pendimethalin @ 750 g ha^{-1} as PE (Rs.43570 ha^{-1}) which was statistically at par with T_2, T_3 and T_4 but was significantly higher than T_5, T_6 and T_7.

Keywords: Herbicides, pendimethalin, butachlor, hand weeding

Introduction
India still is one of the largest vegetable oil importing countries. The oil extracted from oilseeds forms an important item of human diet. Oilseeds are the source of energy and nutrition. India is among the largest vegetable oil economies in the world next only to USA and China. The country has launched a promising national scheme on oilseeds named, "National Food Security Mission on Oilseeds and Oilpalm (NMOOP)" to meet the demand and supply gap in edible oil production in the country (Mathur *et al*., 2023) [8]. Amongst oilseeds, sesame (*Sesamum indicum* L.) plays a vital role in meeting oilseed production due to its quality oil and protein rich seeds. It is also a successful rainfed crop with resilience to drought and adaptability to diverse agro-climatic conditions. Farmers of states like West Bengal, grow sesame as a major oilseed crop and its cultivation contributes significantly to the state's agricultural economy (Debnath *et al*., 2022) [3]. The red and lateritic soils of West Bengal pose a set of challenges for sesame cultivation due to poor nutrient retention capacity, low water-holding capacity and high susceptibility to erosion in such soils (Ghosh, 2019) [5]. This necessitates development of specialized agricultural practices to optimize crop production and productivity. Despite these challenges, sesame remains a promising crop for farmers in these regions due to its climate resilience and potential for high benefit to cost ratio.

However, weeds in sesame result in extreme crop losses if not managed properly (Dawar *et al*., 2025) [2]. This is due to severe crop-weed competition for soil nutrients, moisture, space and light under the given agro-climate and poor soil conditions. Thus, development of research based effective, efficient and replicable integrated weed management strategies is

pivotal for not only enhancing sesame productivity and production but also ensuring sustainable development agriculture through reduced reliance on chemical herbicides that can cause harmful damage to environment in these areas. While various weed management approaches have been studied in different crops, there is a knowledge gap regarding effective weed management tactics in summer grown sesame in red and lateritic soil of West Bengal. There is a need for location-specific research to develop effective weed management strategies that account for regional soil characteristics, climate, and crop-specific requirements (Fatima *et al*., 2020) [4]. Investigating the performance of summer sesame under diverse weed management practices in this region could help lakhs of farmers of the region to sustain their livelihood thorough improvement in sesame production and productivity. It would also help the policymakers to adopt and enact more productive and environmentally friendly practices.

The current study aims to assess the efficacy of different weed management practices on summer sesame in West Bengal's red and lateritic soils and to find the most effective weed management approach.

Materials and Methods

A field experiment was carried out during summer 2019 in the Agricultural Farm, Institute of Agriculture (PSB), Visva-Bharati, Sriniketan, West Bengal characterised by tropical savanna climate. The experiment was laid out in a randomized block design with eight treatments and three replications. The weather parameters and soil conditions were suitable for growth of the sesame. The treatments comprised pendimethalin 750 g ha^{-1} as PE (T_1), butachlor 1000 g ha^{-1} as PE (T_2), pendimethalin 750 g ha^{-1} as PE fb HW at 30 DAS (T_3), butachlor 1000 g ha^{-1} as PE fb HW at 30 DAS (T_4), hand weeding at 15 DAS (T_5), hand weeding at 15 and 30 DAS (T_6), weed free check (T_7) and weedy check (T_8). The sesame variety, Rama was sown on 4th March, 2019 @ 7.5 kg ha^{-1} in rows 30 cm apart with continuous sowing in rows. After sowing, the rows were covered with soils. The fertilizers were applied at the recommended dose of 80, 40 and 40 kg ha^{-1} of N, P_2O_5 and K_2O, respectively through Urea, SSP and MOP, respectively. Half of total N along with full dose of P_2O_5 and K_2O were applied basal at final land preparation and rest half of N was applied at 30 DAS (days after sowing), just before first irrigation. The crop was harvested on 4th June, 2019. All other recommended package of practices were followed uniformly in all the plots except weed management practices which were applied as per the treatments of the experiment. The herbicidal treatments *viz*., pendimethalin @ 750 g ha^{-1} and butachlor @ 1000 g ha^{-1} were applied at 3 DAS as PE before the emergence of weeds in the field. Spraying of the herbicides was done at 4 pm (congenial time with maximum stomatal openings for quick transportation of herbicidal molecules into the plant system) with manually operated knapsack sprayer fitted with flat fan nozzle. Weeds were manually uprooted and removed from the plots in case of hand weeding. In case of weed free treatment, five hand weedings were done.

The weed count/ population and dry matter of different categories of weeds were recorded separately at 30 and 60 DAS. The weed population was recorded by counting the number of weeds using a quadrate of 0.5 m x 0.5 m and were converted to population m^{-2}. For recording dry matter, these weeds were removed separately category wise, cleaned thoroughly, sun dried initially and then oven dried at 65 °C for 72 hours till constant weight was obtained. The data on weed population and dry matter were subjected to statistical analysis after square root transformation with the formula, $\sqrt{(X + 0.5)}$ before statistical analysis.

Weed index is the measure of the efficiency of a particular treatment when compared with a weed free treatment. It is expressed as percentage of yield potential under weed free. Higher weed index means greater loss. Weed Index was calculated using the following formula:

$$\text{Weed Index (\%)} = \frac{\text{Yield from weed free plot} - \text{Yield from treated plot}}{\text{Yield from weed free plot}} \times 100$$

The plant height, number of branches per plant, dry matter accumulation of the plants were recorded at harvest from five plants randomly selected for each plot. Net return is obtained by subtracting cost of cultivation from gross return.

Results and Discussion

Weeds

Different categories of weeds infested the experimental field of sesame and are presented in Table 1. Similar observation was reported by (Ambika & Sundari, 2019) [1]. The lowest population of all categories of weeds was noticed in weed free treatment whereas, the weedy check treatment recorded the highest population at both 30 and 60 DAS (Table 2). At 30 DAS, hand weeded plots (T_5 and T_6) were at par and recorded significantly lower population of grass, sedge and broadleaved weeds than pendimethalin and butachlor treated plots (T_1 to T_4) but the herbicides could not lower the population of sedges significantly than weedy check (T_8). However, these herbicides were found effective against grasses and broadleaved weeds. T_3 was statistically at par with T_5 regarding broadleaved weed population. At 60 DAS, T_3, T_4 and T_6, where one more hand weeding was done at 30 DAS, were at par and significantly reduced the population of grasses, sedges and broadleaved weeds than T_1, T_2 and T_5. Similar observation was reported by Singh *et al*., 2018 [11]. Sole application of pendimethalin and butachlor (T_1 and T_2) failed to reduce the sedge weed population than weedy check. According to the data recorded at 30 and 60 DAS, weed free (T_7) recorded the minimum dry weight of all categories of weeds and weedy check (T_8) resulted the maximum values. At 30 DAS, T_5 and T_6, where one hand weeding was done at 15 DAS, were statistically at par and recorded significantly lower dry weight of grasses, sedges and broadleaved weeds than the herbicide treated plots (T_1, T_2, T_3 and T_4). The dry weight of sedges was not significantly reduced by the application of the pre-emergence herbicides, pendimethalin and butachlor (T_1 to T_4). However, at 60 DAS T_3 and T_4, where one hand weeding was carried out at 30 DAS after pre-emergence application of pendimethalin and butachlor, respectively, were at par with T_6 (two hand weedings at 15 and 30 DAS) and recorded significantly lower dry weight of all categories of weeds than the sole application of the herbicides (T_1 and T_2). Kamini were also of the similar observations. The dry

weight of sedges was not reduced significantly by the sole application of pendimethalin and butachlor as pre-emergence over weedy check.

Crop growth and economics

The lowest plant height, number of branches plant^{-1}, dry matter accumulation and net return was observed under weedy check. It might be due to severe crop-weed competition between weeds and sesame crop for growth resources. The highest values of plant height, number of branches plant^{-1} and dry matter accumulation these parameters were recorded by the weed free treatment which did not vary significantly from pendimethalin @ 750 g ha^{-1} as PE fb HW at 30 DAS, butachlor @ 1000 g ha^{-1} as PE fb HW at 30 DAS and hand weeding at 15 and 30 DAS. Integrating of one hand weeding at 30 DAS after pre-emergence application of the herbicides, pendimethalin (T_3) and butachlor (T_4) or hand weeding at 15 DAS (T_6) resulted the higher growth parameters than their sole or single application (T_1, T_2 and T_5). All the weed management treatments significantly increased the growth parameters than weedy check. It might be due to controlling weeds effectively and thereby making growth resources more available to the sesame crop. This corroborates with the findings of Rekhasree, *et al*., 2025 [9]. Uncontrolled weed growth resulted yield reduction of summer sesame by 62.66% (Table 4). The lowest weed index was found under pendimethalin @ 750 g ha^{-1} as PE fb HW at 30 DAS (8.27%) which was closely followed by hand weeding at 15 and 30 DAS (10.74%) and butachlor @ 1000 g ha^{-1} as PE fb HW at 30 DAS (12.92%). Weeds resulted 19.79, 26.94 and 37.15% yield loss in summer sesame in the treatments receiving pendimethalin and butachlor or hand weeding at 15 DAS *i.e.*, T_1, T_2 and T_5, respectively. Similar results were revealed by Mane *et al*., 2017 [7]. The lowest net return was observed under weedy check (Rs.9348 ha^{-1}). The highest net return was recorded by sole application of pendimethalin 750 g ha^{-1} as PE (Rs. 43570 ha^{-1}) which was statistically at par with T_2, T_3 and T_4 but was significantly higher the treatments where hand weeding was used for weed management in summer sesame (T_5, T_6 and T_7). Similar findings were obtained by Sangeetha *et al.*, 2019 [10].

Table 1: Weed flora found in the experimental field of summer sesame

Botanical Name	Common Name	Family
Grass		
Digitaria sanguinalis	Large crabgrass	Poaceae
Echinochloa colona	Jungle rice	Poaceae
Cynodon dactylon	Bermuda grass	Poaceae
Dactyloctenium aegyptium	Crowfoot grass	Poaceae
Eleusine indica	Goose grass	Poaceae
Sedge		
Cyperus rotundus	Purple nutsedge	Cyperaceae
Cyperus esculentus	Yellow nutsedge	Cyperaceae
Broadleaved weeds (BLW)		
Trianthema portulacastrum	Horse purslane	Aizoaceae
Alternanthera sessilis	Pig weed	Amaranthaceae
Euphorbia hirta	Garden spurge	Euphorbiaceae
Cleome viscosa	Cleome	Cleomaceae
Heliotropium indicum	Indian heliotrope	Boraginaceae

Table 2: Effect of treatments on population of weeds in summer sesame

Treatments	Grasses (No.m^{-2})		Sedges (No.m^{-2})		Broadleaved weeds (No.m^{-2})	
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
T_1 - Pendimethalin 750 gha^{-1} as PE	5.24 (27.00)	7.27 (52.33)	6.01 (35.67)	7.34 (53.33)	3.72(13.33)	5.02 (24.67)
T_2 - Butachlor 1000 gha^{-1} as PE	5.55 (30.33)	7.49 (55.67)	6.20 (38.00)	7.47 (55.33)	3.76 (13.67)	5.24 (27)
T_3 - Pendimethalin 750 gha^{-1} as PE fb HW at 30 DAS	4.85 (23.00)	6.18 (37.67)	6.01 (35.67)	4.98 (24.33)	3.63 (12.67)	4.10 (16.33)
T_4 - Butachlor 1000 gha^{-1} as PE fb HW at 30 DAS	5.08 (25.33)	6.31 (39.33)	6.18 (37.67)	5.18 (26.33)	3.85 (14.33)	4.34 (18.33)
T_5 - Hand weeding at 15 DAS	3.94 (15.00)	7.76 (59.67)	4.71 (21.67)	6.60 (43)	3.14 (9.33)	5.34 (28)
T_6 - Hand weeding at 15 and 30 DAS	3.44 (11.33)	6.18 (37.67)	4.45 (19.33)	4.85 (23)	2.92 (8)	4.42 (19)
T_7 - Weed free check	0.71 (00)	0.71 (00)	0.71 (00)	0.71 (00)	0.71 (00)	0.71 (00)
T_8 - Weedy check	7.34 (53.33)	9.76 (94.67)	6.34 (39.67)	7.73 (59.33)	4.42 (19)	6.28 (39)
S.Em(±)	0.24	0.33	0.23	0.29	0.19	0.21
CD at 5%	0.72	0.99	0.69	0.41	0.55	0.62
CV(%)	9.28	8.87	7.89	8.89	10.13	8.35

(The data were subjected to $\sqrt{(x + 0.5)}$ transformation before analysis and values in parentheses are original values)

Table 3: Effect of treatments on dry weight of weeds in summer sesame

Treatments	Grasses (g m^{-2})		Sedges (g m^{-2})		Broadleaved weeds (g m^{-2})	
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
T_1 - Pendimethalin 750 gha^{-1} as PE	3.41 (11.25)	5.82 (33.87)	3.82 (14.2)	7.01 (48.84)	3.10 (9.14)	5.78 (33.40)
T_2 - Butachlor 1000 gha^{-1} as PE	3.54 (12.53)	6.09 (37.08)	4.01 (15.57)	6.77 (45.44)	3.12 (9.26)	6.16 (37.53)
T_3 - Pendimethalin 750 gha^{-1} as PE fb HW at 30 DAS	3.38 (11.42)	3.73 (13.91)	3.81 (14.12)	3.86 (14.48)	3.05 (8.82)	3.78 (13.88)
T_4 - Butachlor 1000 gha^{-1} as PE fb HW at 30 DAS	3.25 (10.56)	3.95 (15.12)	3.96 (15.2)	3.58 (12.48)	3.15 (9.42)	3.97 (15.40)
T_5 - Hand weeding at 15 DAS	2.37 (5.61)	4.42 (19.54)	2.35 (5.12)	4.76 (22.32)	2.17 (4.27)	4.99 (24.40)
T_6 - Hand weeding at 15 and 30 DAS	2.16 (4.67)	3.94 (15.52)	2.17 (4.21)	3.29 (10.52)	1.88 (3.04)	3.83 (14.16)
T_7 - Weed free check	0.71 (00)	0.71 (00)	0.71 (00)	0.71 (00)	0.71 (00)	0.71 (00)
T_8 - Weedy check	5.26 (27.67)	8.57 (73.44)	4.09 (16.23)	7.20 (51.31)	3.60 (12.46)	7.89 (61.68)
S.Em(±)	0.25	0.21	0.19	0.23	0.14	0.25
CD at 5%	0.73	0.63	0.55	0.68	0.42	0.72
CV(%)	14.38	7.97	10.40	8.16	9.82	9.80

(The data were subjected to $\sqrt{(x + 0.5)}$ transformation before analysis and values in parentheses are original values)

Table 4: Effect of treatments on growth parameters and economics of summer sesame

Treatments	Plant height (cm) at harvest	Number of branches plant^{-1} at harvest	Dry matter accumulation (g m^{-2}) at harvest	Weed index (%)	Net return (Rs. ha^{-1})
T_1 - Pendimethalin 750 g ha^{-1} as PE	77.33	6.00	438.30	19.79	43570
T_2 - Butachlor 1000 gha^{-1} as PE	76.67	5.89	429.08	26.94	37822
T_3 - Pendimethalin 750 gha^{-1} as PE fb HW at 30 DAS	85.70	7.22	482.40	8.27	43383
T_4 - Butachlor 1000 gha^{-1} as PE fb HW at 30 DAS	83.67	7.11	461.46	12.92	39750
T_5 - Hand weeding at 15 DAS	78.34	5.89	404.18	37.15	20968
T_6 - Hand weeding at 15 and 30 DAS	85.70	7.22	467.64	10.74	33345
T_7 - Weed free check	90.67	7.45	508.20	-	22611
T_8 - Weedy check	65.30	3.45	285.40	62.66	9348
S.Em(±)	3.54	0.35	18.14	-	2698.10
CD at 5%	10.36	1.01	53.07	-	7893.37
CV(%)	7.63	9.57	7.23	-	14.72

Conclusion

It may be concluded from the experiment that sole application of pendimethalin as pre-emergence is promising for effective and more remunerative weed management of summer grown sesame in the red and lateritic soil of West Bengal, India.

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