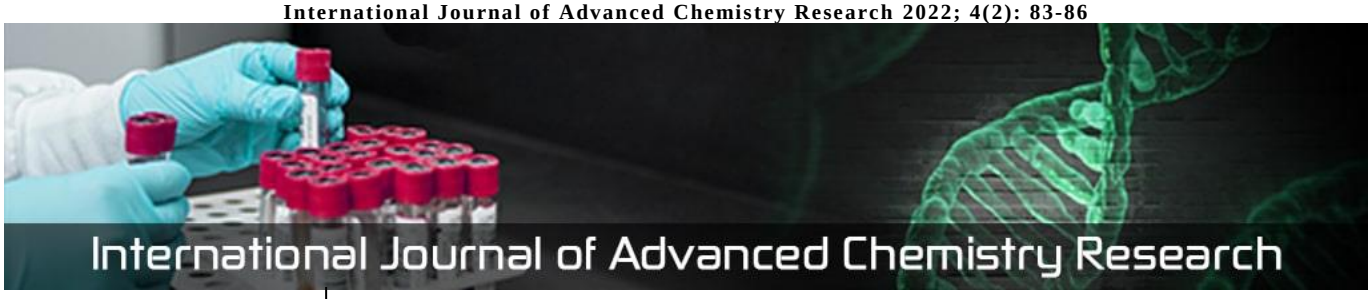

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Productivity improvement of sesame by weed management through plastic mulch and herbicides

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Abstract
A field experiment was conducted during the summer season of 2020 and 2021 at Agricultural Experimental Farm of Calcutta University, Baruipur, South 24 Parganas, West Bengal to find out the effect of plastic mulch and herbicides on weed dynamics, productivity and economics of sesame. Among different weed management treatments, plastic mulch was found very effective in reducing weed density and dry weight at 30 and 60 DAS and registered highest weed control efficiency at 30 DAS in 2020 and 60 DAS in both the years and lowest weed index. Sequential application of pendimethalin + imazethapyr 250g / ha at 2 DAS fb pendimethalin + imazethapyr+ fenoxaprop-p-ethyl 100 g a.i./ ha at 20 DAS recorded significantly lower density and dry weight of weeds than application of pendimethalin 750 g/ ha at 2 DAS, pendimethalin + imazethapyr 250g/ ha at 2 DAS and fenoxaprop-p-ethyl 100 g/ ha at 20 DAS. Weed free resulted in maximum seed yield which did not vary significantly from plastic mulch during both the years. The uninterrupted weed growth caused 49.37% and 46.67% yield loss in sesame during 2020 and 2021, respectively. However, the highest B:C ratio was 2.00, observed in plastic mulch + dibbling (considering only 2021, as the yield was highly damaged by "Amphun storm") which was closely followed by weed free plot (1.69 and 1.14 in both the years 2020 and 2021 respectively).

Keywords: Fenoxaprop-p-ethyl, imazethapyr, mulch, pendimethalin, sesame, weed

Introduction
Oilseeds occupy an important place in Indian economy. In India, sesame is grown in an average area of 17.46 lakh ha with a production of 8.28 lakh tonnes with an average productivity of 413 kg/ha (Anonymous, 2017) [1]. In India the total area, production and productivity under oilseed crops is 24.65 million ha, 31.31 million tonnes and 1229 kg/ha, respectively (DES, 2018) [3]. West Bengal marked as highest productivity region with an average yield of 951 kg/ha in India.

In our country, West Bengal stands next to Gujarat in sesame production. Sesame (*Sesamum indicum* L.), commonly known as til, tilly or gingelly, is an important oilseed crop in India and is often called as the 'queen of oilseeds'. India ranks first both in area and production of sesame in the world. Sesame seeds are rich in antioxidants and also a rich source of edible oil (48-55%). Sesame oil has excellent nutritional, medicinal, cosmetic and cooking qualities and is good for heart patients. Sesame cake is used as a nutritious cattle feed and can also be used as manure. Being a short duration crop, sesame fits well into various cropping systems. In West Bengal it is mostly grown as a catch crop after harvest of potato on residual soil fertility. Weeds are serious pest damage for the most crops caused by competition on light, nutrients, moisture and space and this lead to enormous reduction in crop yield (Lahmod and Alsadaawi, 2014) [5]. Severe competition of weeds with sesame for growth resources reduces the yield of the crop to a great extent. The initial slow growth, small size of the seedlings, prevalent high atmospheric temperature, frequent rainfall etc. aggravate the weed problem more in the initial stages of crop growth. Uncontrolled weed growth resulted 65.98% yield loss in summer sesame (Chaudhuri and Ghosh, 2020) [2].

The critical period of crop-weed competition in sesame is 15-30 DAS during which weed management is very important to increase the yield of sesame. The cost of sesame crop production was highly influenced by the weed management options due to high infestation of weeds and increased labour cost. integrating herbicide and hand weeding provided the highest net profit due to increased yield at a relatively low cost. Highest gross return, net

return and benefit cost ratio were obtained with the application of pendimethalin 30 EC @ 0.75 kg a.i./ha as pre emergence followed by one hand weeding at 30 DAS. (K, *et. al.* 2019) [4].

There are different methods of weed management in sesame. Hand weeding is the most common method of weed management practiced by the farmers. But it is laborious, costly, time consuming and may not be possible in all situations such as unavailability of labour or occurrence of rainfall at the time of weeding etc. On the other hand, use of herbicides provides cheaper, effective and selective control of weeds. But all the herbicides are not effective against all categories of weeds. This calls for sequential application of herbicides or use of herbicide mixtures in order to achieve broad spectrum weed control. Plastic mulching is also a good non-chemical weed management option in sesame. In addition to weed suppression, it conserves soil moisture, reduces soil erosion etc. Therefore, a field experiment was conducted at the Agricultural Experimental Farm of Calcutta University, Baruipur, South 24 Parganas, West Bengal during summer season of 2020 and 2021 to find out the effect of plastic mulch and herbicides on weed dynamics, productivity and economics of sesame.

Materials and Methods

A field experiment was conducted at Agricultural Experimental Farm of Calcutta University, Baruipur, South 24 Parganas, West Bengal during summer season of 2020 and 2021 to find out the the effect of plastic mulch and herbicides on weed dynamics, productivity and economics of sesame. The experimental site was situated at 22°22'N latitude and 88°28'E longitude and 9 m above the mean sea level in the Eastern Agro-Climatic Zone of West Bengal. The soil of the experimental site was medium in fertility status and clay loam in texture with a pH of 6.5.

The experiment was laid out in Randomised Block Design with three replications and comprised of eight treatments, *viz*. plastic mulch+dibbling, pendimethalin 38.5 EC @ 750 g/ ha at 2 DAS, pendimethalin 30 EC + imazethapyr 2% SL 250 g / ha at 2 DAS, fenoxaprop-p-ethyl 9 EC 100 g/ ha at 20 DAS, pendimethalin 30 EC + imazethapyr 2% SL 250 g/ ha at 2 DAS fb fenoxaprop-p-ethyl 9 EC 100 g/ ha at 20 DAS, pendimethalin 30 EC + imazethapyr 2% SL 250 g/ ha at 2 DAS fb one hand weeding at 20 DAS, weed free and weedy check.

Seeds of sesame var. SWB-32-10-1 (Savitri) were sown @ 5 kg/ha on 4th March in 2020 and 4th March in 2021 at a spacing of 30 cm (r-r) x 15 cm (p-p). Except weed management practices, all the recommended package of practices were followed uniformly in all the experimental plots during the entire span of experimentation. The recommended dose of fertilizers 80 kg N/ha, 40 kg P_2O_5/ha and 40 kg K_2O/ha were applied to the sesame crop through urea, single super phosphate and muriate of potash, respectively. Half N, full P_2O_5 and K_2O were applied basal during final land preparation. Rest half N was applied at 30 DAS.

Spraying of the herbicides was done 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, the weeds were removed from the plots manually at 20, 40 and 60 DAS. Weed density was recorded by counting the number of weeds with the help of a quadrate of 0.5 m x 0.5 m and were converted to the density/ m^2. The weeds were then removed and cleaned thoroughly in clear water. After that the weeds were dried in sun for two days and then dried in oven at 65°C for 72 hours till constant weight was achieved to get the weed dry weight data. Weed control efficiency was computed using the dry weight of weeds from the following formula and expressed in percentage –

$$WCE\ (\%) = \frac{WDW_c - WDW_t}{WDW_C} \times 100$$

Where, WCE = Weed control efficiency, WDW_C = Weed dry weight in weedy check plot and WDW_t = Weed dry weight in treated plot.

Plant height of ten earmarked plants from each plot was measured with the help of a scale from ground level to tip of the plant. Then the average plant height was calculated for each plot. The crop was harvested at maturity stage and the data on yield components and yield were recorded. The average number of capsules per plant was counted from 5 randomly selected plants in each plot and the average value was calculated. The seeds were collected number of seeds per capsule was calculated. 1000 number of seeds, collected randomly from total produce from ten capsules randomly selected from each plot and counted at maturity. Then the average of each treatment, were counted and their weights were recorded and expressed in g for 1000 seeds. After sun drying, threshing and cleaning, seeds obtained from each plot were weighed for recording seed yield in each plot which was then converted into kg/ hectare for each plot. Weed Index for each treatment was computed from the following formula –

$$WI(\%) = \frac{Y_{WFC} - Y_{WT}}{Y_{WFC}} \times 100$$

Where, WI = Weed index, Y_{WFC} = Yield of the crop in weed free check, Y_T = Yield of the crop in plot under treatment.

The benefit: cost ratio (B: C ratio) was calculated on the basis of prevailing market price of different inputs and outputs. It was derived by using the following formula –

$$\text{Benefit cost ratio} = \frac{\text{Gross return/ha}}{\text{Total cost of cultivation/ha}}$$

Statistical Tests: The data on density of and dry weight of weeds were subjected to square root $\sqrt{(x+0.5)}$ transformation before statistical analysis to improve the homogeneity of the variance (ANOVA) separately for each year. The significant treatment effect was judged with the help of 'F' test at 5% level of significance.

Results and Discussion

Weed flora: The predominant weed flora observed in the experimental field were *Cynodon dactylon, Digitaria sanguinalis* among grasses; *Cyperus iria* and *Cyperus rotundus* among sedges; *Celosia argentea* and *Amaranthus viridis* among broad leaved weeds.

Weed density: The highest density of weeds was noticed in weedy check treatment at 30 and 60 DAS during 2020 and

2021. In contrast, the lowest density of weeds was observed under weed free during both the years (Table 1) which was statistically at par with pendimethalin + imazethapyr 250 g/ha at 2 DAS fb one hand weeding at 20 DAS. All the treatments applied for weed management in sesame recorded significantly lower weed density than weedy check. Among the herbicide treatments, sequential application of pendimethalin + imazethapyr at 2 DAS fb fenoxaprop-p-ethyl at 20 DAS recorded significantly lower weed density than application of pendimethalin, pendimethalin + imazethapyr and fenoxaprop-p-ethyl. Plastic mulch was found very effective in reducing weed density and was statistically at par with pendimethalin + imazethapyr 250g/ha fb fenoxaprop-p-ethyl 100 g/ha and pendimethalin + imazethapyr fb hand weeding during both the years. These results were in agreement with those of Punia, *et. al.* (2001) [6].

Weed dry weight: Weedy check recorded the highest dry weight of weeds which was significantly higher than all other treatments applied for weed management in sesame (Table 1). Weed free resulted the lowest dry weight of weeds which was statistically at par with plastic mulch in all observations. Among the other weed management treatments, the lowest dry weight of weeds were observed under pendimethalin + imazethapyr 250 g /ha fb one hand weeding which was statistically at par with pendimethalin + imazethapyr 250 g/ha fb fenoxaprop-p-ethyl 100 g/ha and was significantly lower than sole application of pendimethalin, pendimethalin + imazethapyr except at 30 DAS in 2021 and fenoxaprop-p-ethyl at both the observations during 2020 and at 30 DAS in 2021 only. The results are in conformity with the findings of Zubair, *et. al.* (2011) [7].

Weed Control Efficiency: Among the treatments applied for weed management in sesame, the highest weed control efficiency was noticed in plastic mulch at all observations which was closely followed by pendimethalin + imazethapyr 250g/ha at 2 DAS fb one hand weeding at 40 DAS (Table 1). Sequential application of pendimethalin + imazethapyr at 2 DAS fb fenoxaprop-p-ethyl at 20 DAS recorded higher weed control efficiency than sole application of pendimethalin, pendimethalin + imazethapyr and fenoxaprop-p-ethyl. Among all the weed management treatments fenoxaprop-p-ethyl as post-emergence resulted the lowest weed control efficiency during both 2020 and 2021. Punia, *et al.* (2001) [6] also reported similar findings.

Crop growth and yield components: The highest plant height was observed in plastic mulch which was statistically at par with weed free, pendimethalin + imazethapyr 250g/ha fb hand weeding, pendimethalin + imazethapyr 250g/ha fb fenoxaprop-p-ethyl 100g/ha and pendimethalin + imazethapyr 250g/ha during both the years (Table 2). Among the weed management traetments, the lowest plant height was found in fenoxaprop-p-ethyl in both the years. The lowest values were recorded under weedy check plots. Among the yield components, the maximum number of capsules/plant and number of seeds/capsule were found in weed free plots which was closely followed by plastic mulch, pendimethalin + imazethapyr 250g/ha fb fenoxaprop-p-ethyl 100g/ha and pendimethalin + imazethapyr 250g/ha fb hand weeding. Among the weed management treatments, the minimum number of capsules/plant and number of seeds/capsule were recorded by sole application of fenoxaprop-p-ethyl 100g/ha followed by pendimethalin 750g/ha. The minimum number of capsules/plant and seeds/capsule were observed in weedy check plots. No significant difference was observed among the treatments regarding test weight. Similar results were reported by Chaudhuri and Ghosh (2020) [2].

Productivity and Economics: All the weed management treatments resulted in significant increase in seed yield of sesame over weedy check (Table 2). The maximum seed yield 750 and 1160 kg/ha in 2020 and 2021 respectively during both the years was obtained from weed free, plastic mulch+dibbling which was statistically at par with and closely followed by pendimethalin + imazethapyr 250g/ha fb hand weeding and pendimethalin + imazethapyr 250g/ha fb fenoxaprop-p-ethyl 100 g/ha. The weedy check treatment, in both the years, resulted the minimum seed yield of sesame 400 and 600 kg/ha in 2020 and 2021, respectively. The uncontrolled weed growth in sesame resulted 49.37% and 46.67% yield loss of sesame in 2020 and 2021, respectively. The lowest weed index was found in plastic mulching + dibbling. The highest B:C ratio (2.00) was recorded in mulching (considering only 2021, as the yield was highly damaged by "Amphun strom") which was closely followed by weed free plot (1.69 and 1.14 in both the years 2020 and 2021 respectively). K, *et. al.* (2019) [4] also reported similar findings.

Table 1: Effect of weed management practices on density and biomass of weeds and weed control efficiency in sesame

Treatments	Dose (g a.i/ha)	Weed density (no./m^2)				Weed dry weight (g/m^2)				WCE (%)			
		30 DAS		60 DAS		30 DAS		60 DAS		30 DAS		60 DAS	
		2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
T_1 - Plastic mulch + Dibbling	-	1.68 (2.33)	1.36 (1.34)	2.75 (7.07)	2.44 (5.47)	2.43 (5.42)	1.72 (2.45)	3.19 (9.66)	2.94 (8.14)	67.45	76.38	67.46	69.74
T_2 - Pendimethalin at 2 DAS	750	3.18 (9.59)	2.79 (7.3)	4.57 (20.39)	4.39 (18.79)	3.63 (12.68)	3.19 (9.69)	5.19 (26.48)	5.04 (24.91)	51.43	56.11	46.97	48.11
T_3 - Pendimethalin + imazethapyr at 2 DAS	250	2.91 (7.97)	2.49 (5.68)	4.34 (18.3)	4.15 (16.7)	3.40 (11.06)	2.93 (8.1)	4.89 (23.39)	4.72 (21.82)	54.52	59.68	50.10	51.36
T_4 - Fenoxaprop-p-ethyl at 20 DAS	100	5.35 (28.07)	5.13 (25.78)	7.72 (59.09)	7.64 (57.89)	5.64 (31.27)	5.37 (28.29)	8.04 (64.19)	7.95 (62.69)	24.60	26.22	17.88	18.17
T_5 - Pendimethalin + imazethapyr at 2 DAS fb fenoxaprop-p-ethyl at 20 DAS	250 fb 100	2.17 (4.21)	1.56 (1.92)	3.24 (9.97)	3.01 (8.57)	2.79 (7.3)	2.21 (4.37)	4.31 (18.06)	4.15 (16.76)	62.64	69.66	56.01	57.23
T_6 - Pendimethalin + imazethapyr at 2 DAS fb one hand weeding at	250	1.89 (3.09)	1.14 (0.8)	2.42 (5.37)	2.04 (3.67)	2.58 (6.18)	1.93 (3.21)	3.45 (11.37)	3.22 (9.87)	65.43	73.51	64.82	66.85

20 DAS													
T_7 - Weed free	-	1.36 (1.34)	1.13 (0.78)	1.94 (3.28)	1.61 (2.08)	2.22 (4.43)	1.41 (1.49)	2.82 (7.46)	2.54 (5.96)	70.30	80.60	71.19	73.83
T_8 - Weedy check	-	7.13 (50.29)	6.96 (48)	9.16 (83.34)	9.07 (81.84)	7.48 (55.38)	7.27 (52.39)	9.79 (95.43)	9.71 (93.86)	0.00	0.00	0.00	0.00
S.Em(±)		0.20	0.20	0.20	0.35	0.26	0.35	0.41	0.20	-	-	-	-
CD at 5%		0.62	0.60	0.62	1.07	0.80	1.07	1.24	0.61				
CV(%)		10.97	12.24	7.80	14.28	12.15	18.70	13.63	6.90				

Note: Original data given in the $(X+0.5)\sqrt{}$ parentheses were subjected to square root transformation before analysis; fb-Followed by.

Table 2: Effect of weed management practices on plant height, yield components, yield and economics of sesame

Treatments	Dose (g a.i /ha)	Plant height at harvest (cm)		No. of capsules/ plant		No. of seeds/ capsule		1000 seed weight (g)		Yield (kg/ha)		Weed Index(%)		B:C ratio	
		2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
T_1 - Plastic mulch+Dibbling	-	93.11	96.33	60.83	61.25	76.97	77.11	2.90	3.01	767	1125	2.91	3.02	-0.23	2.00
T_2 - Pendimethalin at 2 DAS	750	81.88	82.51	50.77	50.88	68.87	69.01	2.62	2.73	550	908	30.38	19.29	1.26	1.61
T_3 - Pendimethalin + imazethapyr at 2 DAS	250	88.83	89.46	57.88	58.63	71.89	72.03	2.65	2.76	630	918	20.25	18.40	1.53	1.60
T_4 - Fenoxaprop-p-ethyl at 20 DAS	100	81.79	82.42	49.12	49.91	68.00	68.14	2.62	2.73	520	872	34.18	22.49	1.10	1.48
T_5 - Pendimethalin+imazethapyr at 2 DAS fb fenoxaprop-p-ethyl at 20 DAS	250 fb 100	89.97	90.60	59.89	59.97	72.77	72.91	2.66	2.77	700	950	11.39	15.56	1.53	1.37
T_6 - Pendimethalin + imazethapyr at 2 DAS fb one hand weeding at 20 DAS	250	91.23	91.86	60.53	61.24	73.91	74.05	2.69	2.80	723	990	8.48	12.00	1.71	1.54
T_7 - Weed free	-	93.21	96.84	61.50	64.88	77.00	77.16	2.89	3.00	790	1160	0.00	0.00	1.69	1.14
T_8 - Weedy check	-	79.67	80.63	41.50	45.00	63.00	63.14	2.52	2.63	400	600	49.37	46.67	0.00	0.85
S.Em(±)		3.09	3.33	4.10	2.66	2.61	2.75	0.20	0.08	30.86	41.55	-	-	-	-
CD at 5%		9.36	10.09	12.43	8.05	7.90	8.33	NS	NS	93.61	126.02	-	-	-	-
CV(%)		6.12	6.49	12.85	8.14	6.31	6.64	13.07	5.19	8.42	7.66	-	-	-	-

Note: fb-Followed by.

Conclusion

The cost of sesame crop production was highly influenced by the weed management options due to high weed infestation and increased labour cost. On the basis of field experimentation, it can be concluded that the organic herbicide provided the higher B: C ratio net profit due to increased yield at a relatively low cost. In the first year plastic mulch + dibbling did not show good result due to Amphan storm but result was obtained in the second year. Highest benefit cost ratio were obtained with the application of pendimethalin 38.5 EC @ 750 g/ha as pre emergence. The research found that pendimethalin a suitable herbicide for weed control in sesame in the Eastern Agro-Climatic Zone of West Bengal.

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