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Integrated use of herbicide and straw mulch in suppressing the weed species in summer sesame (*Sesamum indicum*)

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ABSTRACT

A field experiment was conducted during the summer (pre-*kharif*) season of 2016 at the Agricultural Farm of the Institute of Agriculture (Palli Siksha Bhavana), Visva-Bharati, Sriniketan, Birbhum, West Bengal. The experiment comprising two factors; three cultivars and five weed management practices was laid out in a factorial randomized block design with three replications. *Digitaria sanguinalis,* among the grasses; *Cyperus rotundus,* among the sedges and *Spilanthes acmella,* among the broadleaved weeds were predominant throughout the cropping period of sesame (*Sesamum indicum* L.). The cultivar Rama recorded significantly the lower values of weed density, dry weight; higher values of capsules per plant (40), seeds per capsule(53) and seed yield (1181 kg ha^{-1}) of sesame. Among the weed control treatments, integrated use of pendimethalin at 1.0 kg ha^{-1} at 1 PE + straw mulching at 3.5 t ha^{-1} at 15 DAS registered the lower weed density as well as dry weight of grassy, broadleaved, sedge and total weeds at 45 and 60 DAS; higher number of capsules plant^{-1} (41), seeds capsule^{-1}(49), seed yield (1123 kg ha^{-1}) and higher weed control efficiency (94.36%) at 60 DAS. The cultivar Rama with pendimethalin at 1.0 kg ha^{-1}at PE + straw mulching at 3.5 t ha^{-1} was found to be effective in controlling composite weed flora. Lower values of weed density and weed dry weight; higher values of yield and yield attributes of sesame and weed control efficiency were registered with combination of cultivar Rama and pendimethalin at 1.0 kg ha^{-1} at PE + straw mulching at 3.5 t ha^{-1} at 15 DAS. The treatment straw mulching at 3.5 t ha^{-1} was found to be effective in controlling broadleaved weeds. Thus, integrated use of weed competitive cultivar Rama along with pendimethalin at 1.0 kg ha^{-1} at PE + straw mulching at 3.5 t ha^{-1} at 15 DAS appeared to be the most promising approach for effective weed management and obtaining higher productivity of summer sesame.

Key words: Cultivars, Pendimethalin, Pre-emergence herbicide, Sesame, Straw mulching, Weed management

Sesame (*Sesamum indicum* L.) seed, commonly known as til in India, is largely produced for its oil and also used as a flavouring agent. The seeds come in several colours like red, white, black, yellow depending upon the variety. The seeds have high oil content of around 55%. Sesame is cultivated mainly in pre-*kharif* season in India during warm and humid months of the year. Weed competition is considered to be one of the most important factors responsible for low productivity of sesame. Early slow crop growth, frequent rainfall, high temperature and adequate soil moisture provide unique opportunity to weeds to emerge and exploit the sesame habitat. In most of the areas sesame crop is heavily infested by weeds and thereby resulting in heavy yield loss ranging from 50-75 % in sesame (Bhadauria *et al.* 2012; Duary and Hazra 2012). Considering the diversity of weed problem, no single method of weed management can reach the desired level of efficiency under all situations. Integrated method of weed management may prove beneficial in the long run to keep the weed population below threshold level. As an important component of Integrated Weed Management (IWM), increasing crop cultivar competitiveness may be an attractive low cost weed management strategy, which is easy to deliver to the farmer. Mulching is one of the important components of integrated weed management in sesame. Use of locally available straw or weeds as bio-organic mulch to suppress the growth of other weeds is a vital option. Crop residues hold a great prospect for meeting some of those demands and are more readily applicable in diverse agro-ecosystems (Alsaadawi *et al.* 2013). This approach of crop residue application can be used in weed management by two ways; it can be used by selecting an appropriate residue of crop then incorporating it in soil. It can also be used by applying residues or straw as mulches on soil surface in a rotational sequence that allows residues to remain in the field (Alsaadawi and Dayan 2009). The germination of various weed species can be reduced in the presence of crop residues (Chauhan and Johnson 2010). Use of competitive cultivars can also be a good option in

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integrated weed management. Some cultivars of sesame are available that have early growth and ability to cover the soil within a short period of time and exerts smothering effect on weeds. This approach is feasible and can be easily adopted by the farmers. Besides, there are some cultivars which may have allelopathic influence with which they can compete with weeds and keep their population at threshold level. Seeds with high vigor and improved canopy architecture of crop cultivars, including hybrids, can strengthen the weed competitiveness of a crop thereby reducing light availability at the soil surface which restrict germination and subsequent growth of weed seedlings (Chauhan *et al.* 2012). So, screening of those weed competitive cultivars and their subsequent use as an integral part of IWM will make the Integrated Weed Management cost effective. There is also scope of integrating herbicides with residue retention to achieve season-long weed control. However, in high-residue situations, it will also be important to determine that this amount of residue does not hinder crop emergence (Chauhan *et al.* 2012). There are many pre emergence herbicides successfully used in sesame such as alachlor, butachlor, metolachlor, fluchloralin, pendimethalin, *etc* (Mondal *et al.* 2008). With this perspective the present experiment was carried out in the Lateritic belt of West Bengal to study the effect of competitive cultivars and different weed management practices on population and growth of different weed species and productivity of summer sesame.

MATERIALS AND METHODS

A field experiment was conducted during summer season of 2016 in the Agricultural Farm of Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, Birbhum, West Bengal ($23^0 40.190'$ N latitude and $87^0 39.485'$ E longitude; altitude 60 m above mean sea level) during summer season. The soil of the experimental field was sandy loam (Ultisol) in texture, medium in phosphorus and low in nitrogen and potash with pH 6.2 and organic carbon content of 0.46%. The experimental field was ploughed first by a tractor-drawn harrower for breaking the crust followed by double ploughing and laddering to provide a fine tilth. Sesame was sown manually in line with a row spacing of 30 cm with a seed rate of 4.5 kg ha^{-1}. Factor cultivars having three levels (Tilottoma, Rama, Savitri), whereas factor weed management having five levels (pendimethalin at 1.0 kg ha^{-1} at PE, straw mulching @ 3.5 t ha^{-1}, pendimethalin at 1.0 kg ha^{-1}at PE + straw mulching @ 3.5 t ha^{-1}, weedy check, weed free check) were arranged in a factorial randomized block design and replicated thrice. The recommended dose of 80 kg nitrogen, 40 kg P_2O_5 and 40 kg K_2O per ha in the form of urea, single super phosphate and muriate of potash were applied for sustaining the normal growth of sesame. After 15 days of sowing, seedlings of sesame plants were thinned as and where required to keep an intra-row spacing of 10 cm. Pendimethalin @ 1.0 kg ha^{-1} was sprayed at 1 DAS with a knapsack sprayer. Straw mulch @ 3.5 t ha^{-1} was applied 15 DAS in between the crop rows. Weed density and biomass were evaluated at 45 and 60 DAS by placing two 1m×1m quadrats in each plot. At crop maturity, the number of capsules was counted from four randomly selected 1-m rows. The gross plot size was 12 m^2 and the crop was harvested from a 4-m^2 area. Grain yield was converted to kg ha^{-1}. Weed control efficiency (WCE) was calculated using the formula given by Mani *et al.* (1981) and expressed in per cent.

$$\text{WCE} = \frac{\text{WDW}_c - \text{WDW}_t}{\text{WDW}_c} \times 100$$

where, WCE = Weed control efficiency, WDW_c= Weed dry matter (aerial parts) production in weedy check, WDW_t = Dry matter (aerial parts) production in treated plot.

All data were analysed using analysis of variance ANOVA to evaluate differences between treatments, and the means were separated using LSD at 5% as described by Gomez and Gomez (2010). Weed density and biomass data were subjected to square root ($\sqrt{X + 0.5}$) transformation and the transformed data was used for analysis.

RESULTS AND DISCUSSION

Weed flora

The experimental field was infested with three categories of weeds under four families. The total number of weed species was 6 out of which *Cynodon dactylon, Echinochloa colona* and *Digitaria sanguinalis* among the grasses; *Cyperus rotundus* among the sedges; and *Spilanthes acmella* and *Malvastrum coromandalianum* among the broadleaved weeds were present as major weeds. *Digitaria sanguinalis* and *Cynodon dactylon* dominated during the entire cropping season among the grasses. Whereas, *Echinochloa colona* appeared at later stage of crop growth. *Spilanthes acmella* and *Malvastrum coromandalianum* were dominant broadleaved weeds during the entire period of crop growth. *Cyperus rotundus* was the only sedge in the experimental field which was not present up to 45 DAS (days after sowing) but after that it was observed in some of the plots where weed management treatments were not undertaken.

Effects on weed

Among the different varieties, lowest weed density of all weeds was found in cultivar Rama (V_2) at both 45 and 60 DAS. There was no significant difference among the cultivars at 45 DAS in the density of *Spilanthes calva* and *Malvastrum coromandalianum*. Among the different treatments highest weed density was recorded in unweeded control at both 45 DAS and 60 DAS. Among the herbicidal treatments, application of Pendimethalin @ 1.0 kg ha^{-1}at PE + straw mulching @ 3.5 t ha^{-1} (W_3) recorded lowest weed density at both 45 and 60 DAS (Table 1). No *Malvastrum coromandalianum* at 45 DAS was registered in the treatments Pendimethalin @ 1.0 kg ha^{-1}at PE + straw mulching @ 3.5t ha^{-1} (W_3) and straw mulching @ 3.5 t ha^{-1} (W_2). The lowest density of *Digitaria sanguinalis* was recorded in the treatment Pendimethalin @ 1.0 kg ha^{-1}at PE+ straw mulching

Fig 1 A closer view of of pendimethalin at 1.0 kg ha^{-1} + straw mulching at 3.5 t ha^{-1} in Rama cultivar at 45 DAS.

Fig 2 A closer view of weedy check in Rama cultivar at 45 DAS.

@ 3.5 t ha^{-1} (W_3) followed by treatment Pendimethalin @ 1.0 kg ha^{-1}at PE (W_1). However, at 60 DAS there was no significant difference between the treatments Pendimethalin @ 1.0 kg ha^{-1}at PE+ straw mulching @ 3.5 t ha^{-1} (W_3) and straw mulching @ 3.5 t ha^{-1} (W_2) in the case of *D. sanguinalis*. At 45 DAS and 60 DAS lowest density of *Spilanthes calva* was registered in the treatment straw mulching @ 3.5 t ha^{-1} (W_2) which was statistically at par with the treatment Pendimethalin @ 1.0 kg ha^{-1}at PE + straw mulching @ 3.5 t ha^{-1} (W_3). At 60 DAS lowest density of *Malvastrum coromandalianum* was recorded in the treatment Pendimethalin @ 1.0 kg ha^{-1}at PE + straw mulching @ 3.5 t ha^{-1} (W_3) followed by treatment straw mulching @ 3.5 t ha^{-1} (W_2). In the case of total weeds, lower weed density was registered in the treatment Pendimethalin @ 1.0 kg

Table 1 Effect of treatments on density of different weed species (no. m^{-2}) at 45 and 60 DAS of sesame

Treatment	*D. sanguinalis*		*S. calva*		*M. coromandalianum*		Others		Total	
	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS
Cultivar(V)										
V_1- Tilottoma	3.29 (10.33)	3.58 (12.30)	1.14 (0.81)	1.71 (2.41)	1.21 (0.95)	1.84 (2.88)	1.45 (1.61)	1.90 (3.11)	3.77 (13.72)	4.61 (20.74)
V_2- Rama	3.01 (8.55)	3.46 (11.46)	1.07 (0.65)	1.27 (1.11)	1.13 (0.77)	1.71 (2.42)	1.35 (1.31)	1.87 (2.98)	3.43 (11.23)	4.30 (17.96)
V_3- Savitri	2.94 (8.16)	3.69 (13.11)	1.08 (0.67)	1.60 (2.06)	1.10 (0.71)	2.10 (3.93)	1.91 (3.16)	2.31 (4.82)	3.61 (12.54)	4.92 (23.75)
SEm (±)	0.1	0.06	0.05	0.04	0.03	0.05	0.05	0.04	0.08	0.07
LSD(P=0.05)	0.3	0.18	NS	0.12	NS	0.15	0.15	0.13	0.22	0.20
Weed management (W)										
W_1- Pendimethalin @ 1.0 kg ha^{-1}PE	2.51 (5.83)	2.73 (6.94)	1.30 (1.20)	2.03 (3.61)	1.62 (2.12)	2.58 (6.16)	1.45 (1.60)	1.80 (2.75)	3.39 (11.00)	4.50 (19.73)
W_2- Straw mulching @ 3.5t ha^{-1}	3.97 (15.28)	5.28 (27.37)	0.80 (0.15)	1.39 (1.42)	0.71 (0)	1.86 (2.97)	1.83 (2.83)	2.62 (6.34)	4.37 (18.64)	6.26 (38.64)
W_3- Pendimethalin @ 1.0 kg ha^{-1} PE+ straw mulching @ 3.5 t ha^{-1}	1.97 (3.38)	2.54 (5.97)	0.88 (0.27)	1.28 (1.14)	0.71 (0)	1.57 (1.95)	1.36 (1.34)	1.65 (2.21)	2.39 (5.22)	3.46 (11.50)
W_4- Weedy check	6.24 (38.42)	6.62 (43.30)	1.80 (2.75)	2.22 (4.43)	1.98 (3.43)	2.70 (6.79)	2.51 (5.81)	3.35 (10.73)	7.15 (50.60)	8.12 (65.49)
W_5- Weed free check	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)
SEm (±)	0.11	0.08	0.06	0.05	0.04	0.07	0.07	0.06	0.10	0.09
LSD (P=0.05)	0.33	0.24	0.17	0.15	0.11	0.19	0.20	0.17	0.28	0.26

ha^{-1}at PE + straw mulching @ 3.5 t ha^{-1} (W_3) followed by treatment Pendimethalin @ 1.0 kg ha^{-1}at PE (W_1) followed by the treatment straw mulching @ 3.5 t ha^{-1} (W_2) at 45 and 60 DAS (Table 1). Similar trend was observed in case of dry weight of these species at 45 DAS and 60 DAS. Among the different cultivars, Rama (V_2) registered lowest dry weight of all the weed species at both 45 DAS and 60 DAS followed by cultivar Tilottoma (V_1). However, at 45 DAS, lowest dry weight of *Spilanthes calva* was registered with the cultivar Savitri (V_3). Among the different weed management practices, the treatment Pendimethalin @ 1.0 kg ha^{-1} at PE + straw mulching @ 3.5 t ha^{-1} (W_3) recorded lower dry weight of *Digitaria sanguinalis, Spilanthes calva, Malvastrum coromandalianum* and total weeds (Table 2) and higher weed control efficiency of 94.36 % (Table 3) on account of its broad spectrum weed control. At 45 DAS, the treatment straw mulching @ 3.5 t ha^{-1} (W_2) registered lower dry weight of *Spilanthes calva* and no dry weight of *Malvastrum coromandalianum.* Since these two weeds are broadleaved, it can be emphasised that straw mulching treatment is more effective in controlling broadleaved weeds. These results suggest that on account of its dense foliage and greater plant height, cultivar Rama was able to suppress weed growth more effectively as compared to other cultivars and the combined application of Pendimethalin @ 1.0 kg ha^{-1} at PE + straw mulching @ 3.5 t ha^{-1} (W_3) was effective in controlling the complex weed flora. Pendimethalin suppressed early weed growth, whereas straw mulching had smothering effect on the weeds (Duary *et al.* 2014, Kumar *et al.* 2005).

Effects on crop

Among the different cultivars, highest number of capsules per plant was recorded in the cultivar Rama (V_2) which was statistically at par with the cultivar Tilottoma (Table 3). On the other hand, the highest number of capsules per plant was registered in the treatment Pendimethalin @ 1.0 kg ha^{-1} at PE + straw mulching @ 3.5 t ha^{-1} (W_3) which was equal to the treatment weed free check (W_5) followed by Pendimethalin @ 1.0 kg ha^{-1}at PE (W_1) and straw mulching @ 3.5 t ha^{-1} (W_2). Also, the highest number of seeds per capsule was recorded in cultivar Rama (V_2) followed by cultivar Tilottoma (V_1). The weed management practice Pendimethalin @ 1.0 kg ha^{-1} at PE + straw mulching @ 3.5 t ha^{-1} (W_3) recorded highest number of seeds per capsule which was comparable to weed free check (W_5). The test weight of sesame varied significantly in case of cultivars while it was non-significant in the case of weed management treatments. The highest test weight was recorded in the cultivar Savitri (V_3) which was

Table 2 Effect of treatments on dry weight of different weed species (g m^{-2}) at 45 and 60 DAS of sesame

					M. coromandalianum					
	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS
Cultivar(V)										
V_1- Tilottoma	5.48 (29.55)	7.35 (53.49)	1.23 (1.02)	1.88 (3.04)	1.01 (0.51)	2.51 (5.79)	1.58 (1.98)	2.41 (5.31)	5.73 (32.32)	8.28 (67.98)
V_2- Rama	4.07 (16.03)	7.11 (50.10)	1.00 (0.51)	1.55 (1.91)	0.85 (0.23)	2.12 (4.01)	1.32 (1.25)	2.26 (4.61)	4.26 (17.66)	7.85 (61.06)
V_3- Savitri	5.61 (30.92)	8.46 (71.09)	0.82 (0.17)	2.01 (3.55)	0.98 (0.46)	3.22 (9.86)	2.44 (5.46)	3.20 (9.77)	6.09 (36.60)	9.80 (95.52)
SEm (±)	0.16	0.19	0.04	0.05	0.04	0.08	0.07	0.07	0.15	0.18
LSD(P=0.05)	0.46	0.54	0.13	0.15	0.12	0.23	0.21	0.20	0.44	0.51
Weed management (W)										
W_1- Pendimethalin @1.0 kg ha^{-1}PE	3.72 (13.37)	5.49 (29.67)	1.00 (0.50)	2.06 (3.75)	1.14 (0.80)	3.76 (13.61)	1.40 (1.46)	1.96 (3.36)	4.00 (15.53)	7.19 (51.14)
W_2- Straw mulching @3.5 t ha^{-1}	5.69 (31.87)	9.81 (95.72)	0.74 (0.04)	1.56 (1.95)	0.71 (0)	2.19 (4.29)	1.96 (3.33)	3.25 (10.05)	6.01 (35.66)	10.63 (112.57)
W_3- Pendimethalin @1.0 kg ha^{-1} PE+ straw mulching @3.5 t ha^{-1}	2.95 (8.21)	3.58 (12.34)	0.87 (0.27)	1.31 (1.23)	0.71 (0)	1.83 (2.83)	1.32 (1.25)	0.71 (0)	3.28 (10.24)	4.43 (19.11)
W_4- Weedy check	12.18 (147.88)	18.61 (345.83)	1.77 (2.64)	3.43 (11.26)	1.48 (1.68)	4.61 (20.75)	3.51 (11.85)	5.4 (29.68)	12.80 (163.34)	20.25 (409.38)
W_5- Weed free check	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)
SEm (±)	0.21	0.24	0.06	0.07	0.05	0.10	0.09	0.09	0.20	0.23
LSD (P=0.05)	0.60	0.70	0.16	0.20	0.15	0.30	0.27	0.26	0.57	0.66

Data presented are (√ x+0.5)1/2 transformed values; Figures in parentheses are original values.

Table 3 Effect of treatments on yield attributes, seed yield and weed control efficiency of sesame

Treatment	No. of capsules plant^{-1}	No. of seeds capsule^{-1}	Test weight (g)	Seed yield (kg ha^{-1})	Weed control efficiency (%) 60 DAS
Cultivar (V)					
V_1- Tilottoma	39	46	2.55	1014	-
V_2- Rama	40	53	2.95	1181	-
V_3- Savitri	22	42	2.98	487	-
SEm (±)	0.57	0.80	0.06	17.49	-
LSD(P=0.05)	1.66	2.32	0.18	50.67	-
Weed management (W)					
W_1- Pendimethalin @ 1.0 kg ha^{-1} PE	31	47	2.91	849	77.62
W_2- Straw mulching @ 3.5 t ha^{-1}	31	47	2.71	911	28.03
W_3- Pendimethalin @ 1.0 kg ha^{-1} PE+ straw mulching @ 3.5 t ha^{-1}	41	49	2.82	1123	94.36
W_4- Weedy check	23	41	2.74	367	0.0
W_5- Weed free check	41	50	2.95	1219	100
SEm (±)	0.74	1.03	0.08	22.58	-
LSD (P=0.05)	2.14	2.99	NS	65.42	-

statistically at par with cultivar Rama (V_2). The cultivar Rama (V_2) registered highest seed yield (1181 kg ha^{-1}) which was significantly higher than other cultivars (Table 3). The weed management treatment Pendimethalin @ 1.0 kg ha^{-1} at PE + straw mulching @ 3.5 t ha^{-1} (W_3) recorded higher seed yield of sesame over other treatments. Higher weed control efficiency in this treatment facilitated better availability of space, light and nutrients resulting in higher values of yield attributes and ultimately higher yield. Integrated use of mulch and herbicides can help weed control and increase crop yield in sesame.These results support previous suggestions that integrating herbicide use with other weed management strategies could result in a greater yield advantage over the use of herbicide alone (Chauhan and Abugho 2013).The use of rice straw as mulch can suppress seedling emergence and weed growth (Chauhan and Mahajan 2012).

Conclusion

Thus, it could be concluded that the cultivar Rama (V_2) recorded significantly the lower values of weed density, dry weight and higher values of capsules per plant, seeds per capsule and seed yield of sesame. The treatment Pendimethalin @ 1.0 kg ha^{-1} at PE+ Straw mulching @ 3.5 t ha^{-1} (W_3) considerably reduced the weed infestation registering lower weed density, dry weight, higher weed control efficiency and increased the values of yield attributes and yield of sesame. Integrated use of pendimethalin @ 1.0 kg ha^{-1} at PE+ straw mulching @ 3.5 t ha^{-1} at 15 DAS registered the lower number as well as dry weight of grassy, broadleaved, sedge and total weeds at 45 and 60 DAS. The treatment straw mulching at 3.5 t ha^{-1} was quite effective against broadleaved weeds.Thus, combined application of pendimethalin @ 1.0 kg ha^{-1} at PE + straw mulching @ 3.5 t ha^{-1} at 15 DAS and cultivar Rama appeared to be the most promising for higher weed control efficiency and productivity of summer sesame in lateritic soil of West Bengal.

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