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RESEARCH ARTICLE

Integrated weed management and productivity of mustard in coastal zone of Odisha

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ABSTRACT

A field study was carried out during 2023-2024 and 2024-2025 at Agriculture research station, Binjhagiri, Chatabar, Faculty of Agricultural Sciences, SOADU, Bhubaneswar with an objective to evaluate the effect of integrated use of closer spacing, herbicide and mulch on weed growth and yield of mustard. The soil of the experimental field was sandy loam in texture. The experiment comprised of twelve treatments, *viz*. pre-emergence application (PE) of pendimethalin at 0.75 kg/ha; mulching with rice straw 4 t/ha; mulching with biomass of *Chromolaena odorata* 20 t/ha; pendimethalin 0.75kg/ha PE followed by (*fb*) mulching with rice straw 4 t/ha; pendimethalin at 0.75kg/ha PE *fb* mulching with biomass of *C. odorata* 20 t/ha; closer spacing of mustard (30 cm x 10 cm) + pendimethalin 0.75 kg/ha PE; closer spacing + mulching with rice straw 4 t/ha; closer spacing + mulching with *C. odorata* 20 t/ha; closer spacing + pendimethalin 0.75 kg/ ha PE+ mulching with rice straw 4 t/ ha; closer spacing + pendimethalin 0.75 kg/ ha PE + mulching with *C. odorata* 20 t/ha; hand weeding twice at 20 and 40 days after seeding (DAS) and weedy check. A randomized block design with three replications was used. The hand weeding twice at 20 and 40 DAS registered significantly lower total weed density and biomass with higher values of yield attributes and yield of mustard. It was closely followed by closer spacing + pendimethalin at 0.75 kg/ha PE + mulching with rice straw 4 t/ha which recorded maximum net return and returns/rupee invested and was found to be promising for realising effective weed management, higher productivity and profitability in mustard.

Keywords: Closer crop spacing, *Chromolaena odorata*, Integrated weed management, Mulching, Mustard, Pendimethalin, Rice straw

INTRODUCTION

Mustard (*Brassica juncea* (L.) Czern.), belonging to Cruciferae or Brassicaceae family, is one of the major *Rabi* oilseed crops of India. India is one of the largest producers of mustard in the world. The oil content in mustard seeds varies from 37-49% (Bhowmik *et al.* 2014). Among numerous constraints of mustard production technology, weed infestation is one of the major causes of low mustard productivity. Weed management aims to minimize weed growth and competition and thus helping to increase crop yield and improve profitability (Rao 2022). Manual weeding is labour intensive and tiresome. The continuous use of herbicides to control weeds may be causing weeds developing resistance to herbicides used. Thus, it is essential to identify effective alternatives to use as components of integrated weed management (IWM). Mulching may be one of the important components of IWM in mustard. Using weeds that are common in the local area as a natural organic mulch to manage other weeds is an option as straw mulch helps to control weeds, improves soil moisture levels, and increases crop production (Choudhary and Bhagawati 2019). Alternative weed management methods, such as using straw (Fatima *et al.* 2020) and weed mulch (Sar *et al*. 2025) as part of integrated weed management, have proven effective in crops like sesame and mustard (Fatima and Duary 2020, Fatima *et al.* 2020, Fatima *et al*. 2021, Sar *et al.* 2025). The research to develop effective, ecologically safe, economical and practical method for managing weeds in mustard is limited. Thus, a field study was carried to study efficacy and economic feasibility of the integrated use of closer spacing, herbicide use and mulch on weed growth and yield of mustard.

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MATERIALS AND METHODS

A field experiment was conducted during *Rabi* at Agricultural Research station, Faculty of Agricultural Sciences, Siksha 'O' Anusandhan Deemed University (SOADU), Bhubaneswar during 2023-24 and 2024-25. The soil of the experimental field was sandy loam in texture. The experiment comprised of twelve treatments, *viz*. pre-emergence application (PE) of pendimethalin 0.75 kg/ha;

mulching with paddy rice straw 4 t/ha; mulching with biomass of *Chromolaena odorata* 20 t/ha; pendimethalin 0.75 kg/ha PE followed by (*fb*) mulching with rice straw 4 t/ha; pendimethalin 0.75kg/ha PE *fb* mulching with *C. odorata* 20 t/ha; closer spacing of mustard (30 x 10 cm) + pendimethalin 0.75 kg/ha PE; closer spacing + mulching with rice straw 4 t/ha; closer spacing + mulching with *C. odorata* 20 t/ha; closer spacing + pendimethalin 0.75 kg/ ha PE + mulching with rice straw 4 t/ha; closer spacing + pendimethalin 0.75 kg/ ha PE+ mulching with *C. odorata* 20 t/ha; hand weeding (HW) twice at 20 and 40 days after seeding (DAS) and weedy check. A randomized block design with three replications was used. Mustard seeds were sown on November 7, 2023-24 and 2024-25 using seed rate of 6kg /ha maintaining a spacing of 40cm x10cm. The recommended dose of fertiliser was 80:40:40 kg/ ha of N, P and K which was given in form of urea, SSP and MOP respectively. Mulching materials was applied to the respective plots as per the treatment at 10 DAS. Pendimethalin was sprayed using hand operated knapsack sprayer at 1 DAS. All other recommended agronomic practices were followed and plant protection measures were adopted as per need. Weed density of different species was counted by placing the quadrat (50 cm × 50 cm) randomly in the sampling area and after drying sampled weeds in a hot air oven at 70-72°C for 72 hours, the dry weight of weeds (weed biomass) was recorded. The yield attributing characters such as siliqua length, number of siliqua per plant, test weight and yield like seed yield, and stover yield was recorded and analysed. Weed control efficiency (%) was computed using the weed biomass of different category of species.

RESULT AND DISCUSSION

Effect on weeds

The experimental field was infested with eleven weed species. The most common weeds in mustard field were: *Digitaria sanguinalis, Echinochloa colona, Cynodon dactylon* among the monocots and *Cleome viscosa, Physalis minima, Spilanthes calva, Oldenlandia corymbosa, Solanum nigrum, Indigofera hirsute, Gnaphalium purpureum* and *Ageratum conyzoides* among dicots. The highest density and biomass of broad-leaved, grasses, and total weed density was recorded in weedy plots, whereas lowest weed density and biomass was recorded with hand weeding twice at 20 and 40 DAS which was at par with closer spacing + pendimethalin 0.75 kg/ha PE + mulching with rice straw 4 t/ha **(Table 1** and **2)** as reported by Sar *et al.* (2025). Pendimethalin PE applied alone was not adequate to manage the weeds in mustard. Pendimethalin PE *fb* manual weeding performed better against diverse weed flora as compared to pendimethalin PE used only. Although the HW twice treatment proved to be superior to all others tested treatments, it was comparable with closer spacing *fb* pendimethalin, rice straw or *C. odorata* mulching in lowering total weed density and biomass in mustard. Closer spacing along with pendimethalin at 0.75 kg/ha PE + mulching with rice straw 4 t/ha recorded 86.7 and 89.26 % lower density of total weeds at 45 DAS over weedy check. Integrated use of pendimethalin at 0.75 kg/ha PE *fb* mulching rice straw or *C. odorata* reduced the density of grasses by 71.00-87.00 and 76.03-89.72%, of broad-leaved by 75.00-86.00 and 77.23-88.90% and of total weeds by 73.00-86.00 and 76.68-89.26% in 2023-24 and 2024-25 respectively

Table 1. Weed density at 45 days after seeding (DAS) in mustard as affected by weed management treatments

Treatment	Weed density (no./m^2) at 45 DAS					
	2023-24			2024-25		
	Grasses	Broad-leaved	Total	Grasses	Broad-leaved	Total
Pendimethalin 0.75 kg/ha PE	6.31(39.3)	6.70(44.3)	9.17(83.7)	5.96(35.0)	6.57(42.7)	8.84(77.7)
Mulching with rice straw 4 t/ha	6.12(37.0)	6.62(43.3)	8.99(80.3)	5.79(33.0)	6.47(40.7)	8.61(73.7)
Mulching with *Chromolaena odorata* 20 t/ha	6.15(37.3)	6.57(42.7)	8.97(80.0)	5.90(34.3)	6.52(41.3)	8.73(75.7)
Pendimethalin at 0.75 kg/ha PE *fb* mulching with paddy straw 4 t/ha	4.53(20.0)	4.67(21.3)	6.47(41.3)	4.18(17.0)	4.49(19.7)	6.09(36.7)
Pendimethalin t 0.75 kg/ha PE *fb* mulching with *Chromolaena odorata* 20 t/ha	5.08(25.3)	5.31(27.7)	7.31(53.0)	4.78(22.3)	4.98(24.3)	6.87(46.7)
Closer spacing + pendimethalin 0.75 kg/ha PE	5.68(32.0)	6.01(35.7)	8.25(67.7)	5.43(29.0)	5.78(33.0)	7.90(62.0)
Closer spacing + mulching with rice straw 4 t/ha	5.61(31.0)	5.96(35.0)	8.15(66.0)	5.30(27.7)	5.61(31.0)	7.69(58.7)
Closer spacing + mulching with *Chromolaena odorata* 20 t/ha	5.64(31.3)	5.99(35.3)	8.20(66.7)	5.34(28.0)	5.67(31.7)	7.75(59.7)
Closer spacing + pendimethalin at 0.75 kg/ha PE+ mulching with rice straw 4 t/ha	2.73(7.0)	3.08(9.0)	4.06(16.0)	2.34(5.0)	2.68(6.7)	3.48(11.7)
Closer spacing (30 cm x 10 cm) + pendimethalin at 0.75 kg/ha PE+ mulching with *Chromolaena odorata* 20 t/ha	3.98(15.3)	4.10(16.3)	5.67(31.7)	3.49(11.7)	3.76(13.7)	5.08(25.3)
Hand weeding twice at 20 and 40 DAS	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)
Weedy check	7.37(54.0)	8.1(66.7)	11.0(120.7)	7.00(48.7)	7.74(60.0)	10.4(108.7)
LSD (p=0.05)	0.43	0.54	0.64	0.37	0.50	0.59

Figures in parentheses are the original values. The data was transformed to SQRT ($\sqrt{x+0.5}$) before analysis; PE: pre-emergence application; *fb:* followed by

(Table 1). Sole application of pendimethalin or weed mulch was not effective to manage broad spectrum of weeds. Integration of both herbicide and weed mulch provided a broader spectrum of weed management as also observed by Duary *et al.* (2014), Fatima and Duary (2020). Amongst different weed management treatments, hand weeding twice at 20 and 40 DAS registered the highest WCE, followed by closer spacing + pendimethalin 0.75 kg/ha PE+ mulching with rice straw 4 t/ha at 45 DAS (**Figure 1**). Among other treatments, closer spacing (30 cm x 10 cm) + pendimethalin at 0.75 kg/ha PE+ mulching with *Chromolaena odorata* 20 t/ha effectively controlled the complex weed flora, registering the highest WCE against total weeds.

Effect on mustard

Hand weeding twice recorded significant increase in the mustard yield attributing characters such as the number of siliqua per plant, test weight and mustard seed yield over other weed management practices and it was at par with closer spacing along with pendimethalin 0.75 kg/ha PE + mulching with rice straw 4 t/ha, during both the years **(Table 3)**. All the weed management treatments significantly increased mustard seed yield over unweeded control. because these treatments-controlled weeds (Sar *et al.* 2025). Sar *et al*. (2025) also observed that weed free treatment recorded the highest seed yield over other treatments. Integrated use of closer spacing (30 cm x 10 cm) + pendimethalin at 0.75 kg/ha + mulching with

Table 2. Weed biomass at 45 days after seeding (DAS) in mustard as affected by weed management treatments

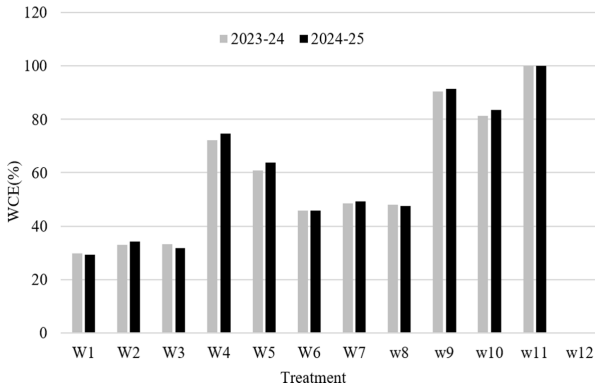
Treatment	Weed biomass (g/m^2) at 45 DAS					
	2023-24			2024-25		
	Grasses	Broad-leaved	Total	Grasses	Broad-leaved	Total
Pendimethalin 0.75 kg/ha PE	5.82(33.3)	6.39(40.3)	8.61(73.7)	5.61(31.0)	6.20(38.0)	8.33(69.0)
Mulching with rice straw 4 t/ha	5.61(31.0)	6.31(39.3)	8.42(70.3)	5.39(28.7)	6.01(35.7)	8.05(64.3)
Mulching with *Chromolaena odorata* 20 t/ha	5.64(31.3)	6.26(38.7)	8.40(70.0)	5.49(29.7)	6.12(37.0)	8.19(66.7)
Pendimethalin at 0.75 kg/ha PE *fb* mulching with paddy straw 4 t/ha	3.81(14.0)	3.98(15.3)	5.46(29.3)	3.49(11.7)	3.67(13.0)	5.02(24.7)
Pendimethalin t 0.75 kg/ha PE *fb* mulching with *Chromolaena odorata* 20 t/ha	4.45(19.3)	4.71(21.7)	6.44(41.0)	4.10(16.3)	4.41(19.0)	5.98(35.3)
Closer spacing + pendimethalin 0.75 kg/ha PE	5.12(26.0)	5.60(31.0)	7.58(57.0)	4.97(24.3)	5.40(28.7)	7.31(53.0)
Closer spacing + mulching with rice straw 4 t/ha	5.05(25.0)	5.43(29.0)	7.38(54.0)	4.85(23.0)	5.21(26.7)	7.08(49.7)
Closer spacing + mulching with *Chromolaena odorata* 20 t/ha	5.08(25.3)	5.46(29.3)	7.43(54.7)	4.91(23.7)	5.30(27.7)	7.20(51.3)
Closer spacing + pendimethalin at 0.75 kg/ha PE+ mulching with rice straw 4 t/ha	2.34(5.0)	2.34(5.0)	3.23(10.0)	2.20(4.3)	2.10(4.0)	2.96(8.3)
Closer spacing (30 cm x 10 cm) + pendimethalin at 0.75 kg/ha PE + mulching with *Chromolaena odorata* 20 t/ha	3.13(9.3)	3.29(10.3)	4.49(19.7)	2.79(7.3)	3.02(8.7)	4.05(16.0)
Hand weeding twice at 20 and 40 DAS	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)
Weedy check	6.88(47.0)	7.60(58.0)	10.2(105.0)	6.61(43.3)	7.35(54.3)	9.86(97.7)
LSD (p=0.05)	0.48	0.60	0.66	0.42	0.68	0.72

Figures in parentheses are the original values. The data was transformed to SQRT ($\sqrt{x+0.5}$) before analysis; PE: pre-emergence application; *fb:* followed by

Table 3. Yield attributes and yield of mustard as affected by weed management treatments

Treatment	No. of siliqua / plant		No. of seeds / siliqua		Test weight (g)		Seed yield (kg/ha)		Net returns (Rs./ha) (pooled mean)	Returns / rupee Invested (pooled mean)
	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25		
Pendimethalin 0.75 kg/ha PE	66	70	13	16	3.38	3.99	724	849	7639	1.22
Mulching with rice straw 4 t/ha	67	72	14	17	3.43	4.08	754	867	3654	1.09
Mulching with *Chromolaena odorata* 20 t/ha	67	71	14	16	3.40	4.04	740	859	7231	1.20
Pendimethalin at 0.75 kg/ha PE *fb* mulching with paddy straw 4 t/ha	93	99	21	23	4.27	4.58	1134	1246	24664	1.58
Pendimethalin t 0.75 kg/ha PE *fb* mulching with *Chromolaena odorata* 20 t/ha	85	97	19	22	4.20	4.46	1019	1158	22212	1.58
Closer spacing + pendimethalin 0.75 kg/ha PE	75	88	16	19	3.78	4.20	879	1059	16882	1.48
Closer spacing + mulching with rice straw 4 t/ha	77	90	17	20	3.83	4.29	906	1074	12668	1.31
Closer spacing + mulching with *Chromolaena odorata* 20 t/ha	76	89	17	19	3.80	4.23	900	1067	16751	1.46
Closer spacing + pendimethalin at 0.75 kg/ha PE+ mulching with rice straw 4 t/ha	108	110	26	29	4.67	4.97	1401	1523	40531	1.95
Closer spacing (30 cm x 10 cm) + pendimethalin at 0.75 kg/ha PE+ mulching with *Chromolaena odorata* 20 t/ha	100	104	23	27	4.34	4.71	1248	1359	35867	1.93
Hand weeding twice at 20 and 40 DAS	109	114	26	31	4.79	5.23	1434	1561	40714	1.91
Weedy check	58	61	9	12	3.00	3.40	492	633	-4545	0.87
LSD (p=0.05)	7	8	1.5	3.5	0.35	0.58	111	130	-	-

PE: pre-emergence application; *fb:* followed by



W_1- pendimethalin at 0.75 kg/ha PE, W_2- mulching with rice straw 4 t/ha, W_3- mulching with *Chromolaena odorata* 20 t/ha, W_4-pendimethalin at 0.75kg/ha followed by (*fb*) mulching with rice straw 4 t/ha, W_5- pendimethalin at 0.75kg/ha *fb* mulching with *Chromolaena odorata* 20 t/ha, W_6-closer spacing (30 × 10 cm) + pendimethalin at 0.75 kg/ha PE, W_7- closer *fb* spacing + mulching with rice straw 4 t/ha, W_8-closer spacing + mulching with *Chromolaena odorata* 20 t/ha, W_9-closer spacing + pendimethalin at 0.75 kg/ha PE + mulching with rice straw 4 t/ha, W_{10}- closer spacing + pendimethalin at 0.75 kg/ ha PE + mulching with *Chromolaena odorata* 20 t/ha, W_{11}-hand weeding twice at 20 and 40 days after seeding and W_{12}- weedy check.

Figure 1. Weed control efficiency (%) as affected by weed management treatments

rice straw increased mustard seed yield by 86%,75.66% and 93.50%,79.38% over sole application of paddy straw mulch and pendimethalin in 2023-24 and 2024-25 respectively **(Table 3)**. Paddy straw or *Chromolaena odorata* mulching with closer spacing recorded at par value of seed yield of mustard. Hand weeding twice at 20 and 40 DAS recorded highest harvest index. Mulching conserved soil moisture and increased in yield of mustard (Regar *et al*. 2007 and Saikia *et al*. 2014). Mustard seed yield reduction due to weeds was 65.69 and 59.44 % in 2023-24 and 2024-25, respectively. Pendimethalin PE alone registered 47.15 and 34.12% yield increase over unweeded control in 2023-24 and 2024-25, respectively. Similarly, *Chromolaena odorata* mulching alone was able to improve yield by 50.40-53.25 % and 35.70-36.96% over unweeded control in 2023-24 and 2024-25, respectively. This could be because the weed mulch helps keep the soil moist, adds nutrients, and provides other things that helped improved mustard growth. However, integrated use of herbicide and weed mulch along with closer spacing resulted in 153-185 and 114.69-140.60% higher yield over unweeded control in 2023-24 and 2024-25, respectively due to reduced competition between the crops and weeds from the early stages of the crop's growth until it was fully mature. Due to minimised weed competition, the crops had better access to nutrients and water, faster photosynthesis, more space to grow properly, and this led to more dry matter being stored and higher overall yields. The maximum net return and returns/rupee invested was recorded with closer spacing along with pendimethalin at 0.75 kg/ha PE + mulching with rice straw **(Table 3)**.

Conclusion

The closer spacing of mustard (30 cm x 10 cm) along with pendimethalin at 0.75 kg/ha PE + mulching with rice straw 4 t/ha was found to be promising for effective weed management and higher mustard productivity and monetary returns.

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