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Integrated weed management in sunflower under low land paddy fallow situation of coastal Odisha

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Abstract
A field experiment was conducted during *summer* 2022 at Bhubaneswar to study the effect of integrated weed management in sunflower under lowland paddy- fallow situation in randomized block design with eight treatments replicated thrice. The treatments are: T_1-Paraquat spray before sowing +one intercultivation at 35 DAS T_2-Paraquat spray before sowing + pendimethalin @ 1.0 kg ha^{-1} as pre emergence + Quizalofop ethyl @ 37.5 g ha^{-1} at 20 DAS as post emergence spray, T_3- Pendimethalin@ 1.0 kg ha^{-1} as pre emergence + one intercultivation at 30DAS, T_4-Pendimethalin @1.0 kg ha^{-1} as pre emergence +Quizalofop ethyl @ 37.5 g ha^{-1} at 20 DAS as post emergence spray, T_5-2 intercultivation at 20 and 40 DAS, T_6- One intercultivation at 20DAS+ one hand weeding at 30 DAS,T_7- Weed free (Three HW at 15, 30 and 45 DAS) and T_8-Unweeded control. The test hybrid "DRSH-1" was sown on 30.01.2022 and harvested on 02.05.2022. The soil was sandy loam in texture, with pH-6.08, low organic carbon (0.59%), medium available nitrogen (118 kg ha^{-1}), low available phosphorus (7.6 kg ha^{-1}) and low available potassium status (262.3 kg ha^{-1}). The results revealed that, weed free treatment (T_7) recorded maximum seed yield (2158.89 kg ha^{-1}), stover yield (4315.00 kg ha^{-1}), HI (32.44%), and oil yield (751.72 kg ha^{-1}) which was at par with T_5, having seed yield (2036.67 kg ha^{-1}), stover yield (4224.00kg ha^{-1}), HI (32.52%) and oil yield (784.66 kg ha^{-1}). Similarly weed free treatment recorded highest gross return (Rs.129844.00/ha) and highest net return (Rs.81134.00/ha). However, Paraquat spray before sowing + pendimethalin@1.0 kg ha^{-1} as pre emergence + Quizalofop ethyl @37.5g ha^{-1} at 20 DAS as post emergence spray recorded the highest B:C ratio (1.96) and recommended as an effective method of integrated weed management in sunflower under low land paddy-fallow situation in coastal Odisha.

Keywords: Paddy- fallow sunflower, integrated weed management

1. Introduction
Sunflower is an important annual edible oilseed crop in India. It is recommended for cultivation round the year in India, however it thrives well when sown in *rabi* or early summer season. In coastal Odisha under paddy- fallow situation sunflower area is increasing in recent years. Sunflower is a weak competitor with weeds because of its slow initial growth and wider row spacing. Weeds compete with it for moisture, nutrients, light and space resulting in economic losses to growers through reduced yields as well as lower efficiency of other inputs used (Suresh and Reddy, 2010) [26]. Reduction in yield varies with weed density, weed spectrum, time and length of weed competition, etc. (Carranza *et al*., 1995) [27]. Under unfavourable weather condition and labour shortage period chemical weed control can be adopted. Keeping all these facts in mind a field experiment on integrated weed management have been tried for increasing productivity of sunflower under paddy fallow situation in coastal Odisha.

2. Materials and Methods
A field experiment was carried out at Instructional Farm of Odisha University of Agriculture & Technology (OUAT), Bhubaneswar during *summer* season of 2022. The soil of the experimental field was sandy loam in texture, slightly acidic (pH 6.08), medium in organic carbon (0.59%), medium in available nitrogen (118 kg ha^{-1}), low in available phosphorous (7.6 kg ha^{-1}) and medium in available potassium (262.30 kgha^{-1}). During the crop growth period, total rainfall received (January to April) was 70.2 mm with 6 rainy days. The mean maximum and minimum temperature observed was 32.2 degree Celcius and 20.2 degree Celcius respectively. The mean relative humidity ranged from 94% to 95%. The bright sunshine hours varied between 5.9 hrs/day to 6.5 hrs/day. Wind velocity during the crop growth period ranged from 3.5 km/hr to 20.3 km/hr. Hence, all the meteorological parameters prevailing during the crop growth period were satisfactory for growth and development of the crop.

The experiment was laid out in randomized block design with eight treatments and three replications *viz*, T_1-Paraquat spray before sowing +one intercultivation at 35 DAS,T_2- Paraquat spray before sowing+ pendimethalin @ 1.0 kg ha^{-1} as pre emergence + Quizalofop ethyl @ 37.5 g ha^{-1} at 20 DAS as post emergence spray, T_3- Pendimethalin @ 1.0 kg ha^{-1}as pre emergence spray+ one intercultivation at 30DAS,T_4- Pendimethalin @ 1.0 kg ha^{-1} as pre emergence + Quizalofop ethyl @ 37.5 g a.i.ha^{-1} at 20 DAS as post emergence spray, T_5-2 Intercultivation at 20 and 40 DAS,T_6- One Intercultivation at 20 DAS+ one hand weeding at 30 DAS,T_7- Weed free (Three HW at 15, 30 and 45 DAS) and T_8- Unweeded control.

Dry weight of weeds was recorded at 60 DAS and at harvest. The weeds were uprooted from the destructive sampling area of one square metre and were oven dried at 70 °C for obtaining a constant weight and the dry weight of weeds was expressed in g m^{-2}.

Weed control efficiency was calculated by the help of formula given by Mani *et al.*1973 [20].

$$WCE=\frac{X-Y}{X}\times 100$$

Where,
X: Weed dry matter production in weedy plot
Y: Weed dry matter production in treated plot

Weed index indicates the extent of reduction in yield due to crop weed competition. It was worked out for different treatments by adopting the formula given by Gill and Kumar (1969) [10].

$$\text{Weed index} =\frac{A-B}{A}\times 100$$

Where
A: Seed yield of the weed free treatment,
B: Seed yield of the particular treatment for which the index is computed.

3. Results and Discussion

Weed Density

Data on weed density are presented in Table 1. At all the growth stages, treatments which received sequential application of herbicides and cultural practices recorded lower weed population than weedy check. Pre-emergence herbicide lead to the inhibition of weed germination at initial crop growth stages and post emergence herbicide led to inhibition of weeds in later growth stages by inhibiting the process of photosynthesis and growth of roots with rapid translocation in the xylem and phloem to the meristemtic region where the herbicide accumulates.

At all the growth stages, weed free (Three hand weeding at 15, 30 and 45 DAS) treatment recorded significantly lower weed population as compared to other weed control methods. The next best treatments were farmers' practice (Two intercultivation at 20 and 40 DAS) and integrated weed management practice of Pendimethalin @1.0 kg ha^{-1} as pre emergence spray+ one inter-cultivation at 30 DAS.

3.1. Weed dry weight

Total dry weight of weeds at different days after sowing varied significantly due to various weed control treatments. At all the growth stages of sunflower, the maximum weed dry weight was recorded with unweeded control. It was mainly due to higher and uninterrupted growth of weeds. On the other hand, minimum weed dry weight was recorded with weed free treatment at all crop growth stages. It was almost at par with treatment of farmers' practice (Two intercultivation at 20 and 40 DAS and supplemented with one hand weeding at 30 DAS) The next best treatment was application of Pendimethalin @1.0kg ha^{-1} as pre emergence spray+ one inter-cultivation at 30 DAS. This could be attributed to the cumulative effect of herbicides which resulted in reducing dry matter production in weeds. Similar findings were also recorded by Bhan and Kolhe (2008) [3].

3.2. Weed Control Efficiency (WCE %) and Weed Index (WI)

Data on weed control efficiency and weed index are presented in Table 2.Weed control efficiency (WCE) indicates the magnitude of effective reduction of weed dry weight by weed control treatments over unweeded control. This was highly influenced by different weed control treatments. Performance of the crop is directly proportional with the improvement in WCE. In the present study, weed free treatment recorded maximum WCE at all the stage of sunflower with timely control of weeds. The next best treatments were farmers' practice (Two intercultivation at 20 and 40 DAS supplemented with one hand weeding at 30 DAS) and the treatment with Pendimethalin @1.0 kg ha^{-1} as pre emergence spray+ one inter-cultivation at 30 DAS. The extent of yield reduction due to weed competition as assessed through weed index (WI) was evidently indicated the suppressing effect of weed free check (T_7) which had minimum weed competition and maximum seed yield. After weed free treatment, the lowest weed index (10.3%) was recorded in farmers' practice (Two intercultivation at 20 and 40 DAS supplemented with one hand weeding at 30 DAS). The lower value of weed index was due to less weed infestation resulting in higher seed yield of sunflower. Similar favourable results were also observed by Vikram *et al.* (2020) [30]. In un weeded control (weedy) plot the profuse weed growth restricted the vegetative growth and nutrient availability to the crop, there by caused the highest yield reduction. Similar reports were noticed by Chandrika (2004) [31].

3.3. Seed yield

Seed yield was significantly influenced by the different weed management practices. The maximum seed yield was obtained from weed free treatment (2159 $kgha^{-1}$) followed by two IC at 20 and 40 DAS (1937 $kgha^{-1}$). The minimum yield was from un-weeded control (843 kg ha^{-1}). The weed free treatment and two IC at 20 and 40 DAS recorded 156.11% and 129.77% higher seed yield over un-weeded control. The minimum seed yield (843 kg/ha) was obtained in weedy check as a consequence of highest removal of nutrient and moisture by weed and severe crop weed competition resulting in poor source- sink relationship with poor yield components. Similar type of results were also reported by Channappagoudar *et al.* (2008) [5], Sumathi *et al.* (2010) [28]

3.4. Stover yield

From the data on stover yield presented in Table 3 significant influence of different weed management practices was

observed. The maximum stover yield was obtained from weed free (three hand weeding at 15, 30, and 45 DAS) (4729 kgha^{-1}) followed by 2 IC at 20 and 40 DAS (4469 kg ha^{-1}). The lowest yield was from un-weeded control (2363 kgha^{-1}). The weed free (three hand weeding at 15, 30, 45 DAS) and 2 Intercultivation at 20 and 40 DAS recorded 100.12% and 86.75% higher yield than un-weeded control. Increase in stover yield may be attributed to higher dry matter production and its accumulation in leaves, stem, reproductive parts and also other growth attributes such as plant height, number of leaves, leaf area and leaf area index. Similar conducive effect of weed free treatment and pre emergence herbicide + hand weeding was obtained by Bhan and Kolhe (2008) [3], Nagamani *et al.* (2011) [21], Soumen *et al. (*2018) [29].

3.5. Harvest index

The harvest index (%) refers to efficiency of biomass being converted to economic product. The data pertaining to harvest index (%) attributable to different weed management practices was presented in table 3. The weed free treatment (Three HW at 15, 30 and 45 DAS) had the highest harvest index (31.36%) and the lowest harvest index was recorded from un-weeded control (26.68%).

3.6. Oil yield

The results relating to oil yield as influenced by integrated weed management options on sunflower are presented in table 3. Significantly highest oil yield was obtained from Weed free (807 kgha^{-1}). Followed by 2 IC at 20 and 40 DAS (784 kgha^{-1}). The lowest oil yield was obtained from un-weeded control (328 kgha^{-1}). Weed free treatment (Three HW at 15, 30 and 45 DAS) and 2 IC at 20 and 40 DAS had 146.03% and 127.43% more oil yield than un-weeded control.

3.7. Economics

The results revealed that economics of sunflower crop varied significantly due to different weed management practices. Maximum gross return (Rs. 129844 ha^{-1}) was recorded with weed free treatment which was at par with 2 Intercultivation at 20 and 40 DAS. Maximum net return (Rs 61134 ha^{-1}) was recorded with Weed free (Three HW at 15,30 and 45 DAS). Highest B: C ratio was observed with Paraquat spray before sowing+pendimethalin@1.0 kg ha as pre emergence + Quizalofop ethyl @37.5g ha^{-1} at 15 -20 DAS as directed post emergence spray on weeds (1.96) followed by 2 intercultivation at 20 and 40 DAS(1.91) making it a feasible option. The lowest B:C ratio was seen in unweeded control (0.96).

Table 1: Total weed population (no.m^{-2}) and weed dry weight (g m^{-2}) at different growth stages of sunflower as influenced by weed management methods

	Treatments	Weed population (no.m^{-2})			Weed dry weight (gm^{-2})
		30 DAS	60 DAS	Harvest	Harvest
T_1	Paraquat spray before sowing +one intercultivation at 35 DAS	9.1 [83.33]	8.9 [78.67]	9.3 [87.67]	40.8
T_2	Paraquat spray before sowing+pendimethalin @1.0 kg as pre emergence + Quizalofop ethyl @ 37.5 g ha^{-1} at 20 DAS as post emergence spray	8.4 [71.00]	8.5 [72.33]	8.4 [70.67]	36.4
T_3	Pendimethalin @ 1.0 kg ha^{-1} as pre emergence +one intercultivation at 30 DAS	9.6 [92.00]	9.6 [92.67]	9.8 [96.00]	43.5
T_4	Pendimethalin @ 1.0 kg ha^{-1} as pre emergence + Quizalofop-ethyl @ 37.5 g ha^{-1} at 20 DAS as post emergence spray	9.9 [98.33]	9.7 [95]	10.4 [108.67]	49.6
T_5	2 Intercultivation at 20 and 40 DAS	8.0 [64.33]	7.6 [57.67]	7.4 [54.33]	27.3
T_6	One Intercultivation at 20DAS+ one hand weeding at 30 DAS	8.1 [66.00]	8.4 [70.67]	7.7 [59.33]	33.2
T_7	Weed free (Three HW at 15, 30 and 45 DAS)	7.8 [60.67]	5.9 [39.5]	6.7 [45.33]	11.3
T_8	Unweeded control	10.8 [116.67]	10.0 [101.33]	11.5 [132.00]	90.1
	SEm(±)	0.08	0.09	0.04	2.3
	CD (p=0.05)	0.2	0.3	0.1	6.9

Original values are given in parentheses, which were transformed to $\sqrt{X} + 0.5$

Table 2: Effect of weed management methods on weed control efficiency (WCE %) and weed index (WI)

	Treatments	Weed control efficiency (%)		Weed Index (%)
		60 DAS	Harvest	
T_1	Paraquat spray before sowing +one intercultivation at 35 DAS	59.4	54.8	18.6
T_2	Paraquat spray before sowing+pendimethalin @ 1.0 kga. i.ha^{-1} as pre emergence + Quizalofop ethyl @ 37.5 g a.i. ha^{-1} at 20 DAS as post emergence spray	62.3	59.6	13.6
T_3	Pendimethalin @1.0 kg ha^{-1} as pre emergence +one intercultivation at 30 DAS	56.4	51.7	22.3
T_4	Pendimethalin @ 1.0 kg ha^{-1} as pre emergence + Quizalofop ethyl @ 37.5g ha^{-1} at 20 DAS as post emergence	48.1	45.0	23.5
T_5	2 Intercultivation at 20 and 40 DAS	75.2	69.7	10.3
T_6	One Intercultivation at 20DAS+ one hand weeding at 30 DAS	69.1	63.2	12.3
T_7	Weed free (Three HW at 15, 30 and 45 DAS)	92.7	87.4	-
T_8	Unweeded control	-	-	60.93
	SEm(±)	-	-	3.442
	CD (p=0.05)	-	-	10.44

Table 4: Effect of weed management practices on seed and stover yield, harvest index, oil yield and economics of sunflower

Treatments		Seed yield (kgha^{-1})	Stover yield (kgha^{-1})	Harvest Index (%)	Oil content (%)	Oil yield (kgha^{-1})	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C Ratio
T_1	Paraquat spray before sowing +one intercultivation at 35 DAS	1758	4289	29.13	38.06	669	59245	105724	46479	1.78
T_2	Paraquat spray before sowing+pendimethalin @ 1.0 kg ha^{-1} as pre-emergence + Quizalofop ethyl @ 37.5 g ha^{-1} at 20 DAS as post emergence spray	1865	4456	29.52	37.05	690	57280	112200	54920	1.96
T_3	Pendimethalin @ 1.0 kg ha^{-1} as pre-emergence +one inter-cultivation at 30DAS	1678	4123	28.94	37.64	630	59245	100952	41707	1.70
T_4	Pendimethalin @ 1.0 kga.i.ha^{-1} as pre-emergence spray + Quizalofop ethyl @ 37.5 g a.i.ha^{-1} at 20 DAS as post emergence spray	1651	4086	28.77	39.21	648	55720	99308	43588	1.78
T_5	2 I ntercultivation at 20 and 40 DAS	1937	4413	30.28	38.52	746	60835	116491	55656	1.91
T_6	One Intercultivation at 20 DAS+ one hand weeding at 30 DAS	1893	4469	29.73	37.40	708	62410	113864	51454	1.82
T_7	Weed free (Three HW at 15, 30 and 45 DAS)	2159	4729	31.36	37.35	807	68710	129844	61134	1.89
T_8	Unweeded control	843	2363	26.68	38.92	328	52960	50727	2234	0.96
SEm(±)		83.811	207.59	0.88	0.48	31.106		-	5041.252	-
CD (p=0.05)		254.2	629.6	2.6	1.4	94.3				

4. Conclusion

It can be concluded that the weed free treatment in sunflower recorded maximum weed control efficiency, seed yield, gross and net return, and the highest B:C ratio as well and considering the integrated weed management practices, the treatment with Paraquat spray before sowing+ pendimethalin @ 1.0 kg ha^{-1} as pre emergence spray + Quizalofop ethyl @ 37.5 g a.i.ha^{-1} at 20 DAS as directed post emergence on weeds registered better results compared to others. Hence, the weed free treatment (Three hand weeding at 15, 30 and 45 DAS) was followed by the treatment involving Paraquat spray before sowing +pendimethalin @ 1.0 kg ha^{-1} as pre emergence spray + Quizalofop ethyl @ 37.5 g ha^{-1} at 20 DAS as directed post emergence spray can be considered as the best treatment combination for getting higher yield with effective and economical weed management approach in paddy-fallow sunflower in Odisha.

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