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Weed management in sunflower through sequential application of herbicides in Western Odisha

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ABSTRACT

Field experiment was conducted during the winter seasons of 2014-15 and 2015-16 to study the effect of sole and sequential application of herbicides on weed growth and productivity of sunflower (*Helianthus annuus* L.). *Echinochloa colona, Digitaria sanguinalis* and *Dactyloctenium aegyptium* among grasses; *Cyperus rotundus* and *Cyperus difformis* among sedges and *Cleome viscosa, Euphorbia hirta* and *Borreria hispida* among broad-leaved weeds, were predominant throughout the cropping period. Weed competition resulted in 31.3% yield loss in sunflower. Sequential application of oxyfluorfen 250 g/ha at 3 days after seeding (DAS) followed by (*fb*) quizalofop-ethyl 50 g/ha at 20 DAS resulted in the lowest weed density (41/m^2), total weed biomass (19.37 g/m^2), maximum nutrient uptake, yield (2.1 t/ ha) and benefit:cost ratio (1.82).

Sunflower is the most important oilseed crop of India. It is cultivated in an area of 4.0 lakh ha with a production of about 2.2 lakh tonnes and productivity of 555 kg/ha, which is lower than the world average of 1808 kg/ha (FAO 2017), indicating wider scope for improving the yield potential. Weed infestation is a major constraint causing lower sunflower yield. Uncontrolled weeds in sunflower caused yield loss of up to 62% (Sumathi *et al.* 2009). Heavy weed infestation in sunflower is mainly due to wider spacing, slower crop growth during early stages, higher fertilizers use and frequent irrigation. Manual weeding is difficult as it is highly labour intensive and time consuming. Herbicides are effective and viable option for weed management in sunflower (Shylaja and Sundari 2008). Several pre- and post-emergence herbicides have been reported (Singh and Singh 2006) to provide a good degree of weed control but the information on their efficacy in *Rabi* sunflower is inadequate. The application of herbicide once at pre-emergence stage may be inadequate in managing the whole spectrum of weeds. Sequential application of different herbicides ensures effective management (Tadavi *et al.* 2017) of composite weed flora. Hence, the present experiment was conducted to study the effectiveness of sole and sequential application of different herbicides for effectively managemenr of weeds and enhance productivity of *Rabi* sunflower.

The study was undertaken at Regional Research and Technology Transfer Station, OUAT, Chiplima, Sambalpur, Odisha during *Rabi* 2014-15 and 2015-16. The soil of the experimental field was sandy clay loam with pH 6.6, organic carbon 0.43% and available N ($KMnO_4$ method), P (Olsen) and K (NH_4OHC method) content of 268, 13.4 and 132 kg/ ha, respectively. Eight treatments consisting of oxyfluorfen 250 g/ha at 3 days after seeding (DAS), oxadiargy l75 g/ha at 3 DAS, pendimethalin 1000 g/ha at 3 DAS, oxyfluorfen 250 g/ha at 3 DAS followed by (*fb*) quizalofop-ethyl 50 g/ha at 20 DAS, oxadiargy l75 g/ha at 3 DAS *fb* quizalofop-ethyl 50 g/ha at 20 DAS, pendimethalin 1000 g/ha at 3 DAS *fb* quizalofop-ethyl 50 g/ha at 20 DAS, weed free check and weedy control were tested in randomized block design with 3 replications. All data were analyzed through analysis of variance (ANOVA) using standard variance techniques suggested by Gomez and Gomez (1984). Sunflower cultivar '*Arjun*' was sown on 15 November, 2014 and 25 November, 2015 at a spacing of 60x30 cm and was harvested on 18, February, 2015 and 28 February 2016. A common fertilizer dose of 60 kg N + 90 kg P_2O_5 + 60 kg K_2O/ha was applied. Full dose of P_2O_5 and half dose of K_2O and N were applied as basal and remaining N and K_2O were top-dressed at 30 DAS. Required quantities of herbicides were applied as per treatment with manually operated knapsack sprayer fitted with flat-fan nozzle using a spray volume of 500 L of water/ha. Weed density (no./m^2) and weed biomass (g/m^2) were taken from random samples at 2 places in the field with the help of 1 m^2 quadrate at 50 DAS.

The weed samples collected in paper bags were air dried in shade initially followed by oven drying at 65^{0}C for 48 hours till they attain constant weight to determine biomass in g/m^2. Data on individual and total weed density and biomass were subjected to square root transformation ($\sqrt{x+1}$). Weed control efficiency (WCE) and weed index (W.I.) were calculated based on the weed biomass and sunflower seed yield, respectively. At the harvest, yield and yield-attributes of sunflower were recorded. Economics was computed using the prevailing market prices for inputs and outputs such as sunflower seed (₹ 37000/t), and manual labour (₹ 187/day); input price (₹/kg): sunflower seed, 700; urea, 5.52; diammonium phosphate, 24.45; muriate of potash, 17.44; oxyfluorofen, ₹ 180/100 ml; pendimethalin ₹ 400/l; oxadiargyl ₹ 300/50 g; quizalofop-ethyl ₹ 174/100 ml.

The predominant weeds of the experimental field were *Echinochloa colona, Digitaria sanguinalis, Dactyloctenium aegyptium, Brachiaria reptans* among the grasses; *Cyperus rotundus, Cyperus difformis* among the sedges and *Cleome viscose*, *Euphorbia hirta, Boerhavia erecta, Euphorbia thymifolia, Celosia argentea, Commelina benghalensis, Phylanthus niruri* among the broad-leaved weeds during both the years of study. The composition of grasses, sedges and broad-leaved weeds in weedy check plot was 25.1, 27.5 and 44.9%, respectively. Emergence of sedges and broad-leaved weeds were noticed earlier as compared to grasses.

Oxyfluorfen at 250 g/ha applied alone, effectively reduced density and biomass of the sedges (29.73/m^2 and 11.38 g/m^2) and broad-leaved weeds (65.16/m^2 and 20.99 g/m^2) (**Table 1**) as compared to pendimethalin and oxadiargyl. Pre-emergence application (PE) of pendimethalin 1000 g/ha was not much effective against broad-leaved weeds, but was effective against grasses (25.87/m^2 and 18.18 g/m^2).

Sequential application of oxyfluorfen at 250 g/ha *fb* quizalofop-ethyl at 50 g/ha recorded the lowest total weed density and biomass (41.04/m^2, 19.4 g/m^2), the highest weed control efficiency (84.1%) and the lowest weed index (7.1%), and uptake of N, P and K (8.33, 2.36 and 8.22 kg/ha) by weeds. The next best treatment was pendimethalin at 1000 g/ha *fb* quizalofop-ethyl at 50 g/ha (53.94/m^2, 21.45 g/m^2). Oxifluorfen or pendimethalin (PE) caused reduction in germination of emerging weed during initial period of growth, further post-emergence application of quizalofop-ethyl 50 g/ha has controlled the late emerging grassy weeds. These results were in agreement with Wanjari *et al*. (2000) and Sivasankar and Subramanyam (2011).

Oxadiargy at l75 g/ha PE (43.2%) alone or in combination with post-emergence application (PoE) of quizalofop-ethyl 50 g/ha applied at 20 DAS (71.8%) was not effective as that of oxyfluorfen or pendimethalin applied alone or in combination with PoE of quizalofop-ethyl in controlling weeds. The uptake of N, P and K by weeds was 23.0, 8.28 and 22.27 kg/ha respectively, in weedy control treatment due to heavy weeds infestation (**Table 3**).

Effect on crop

The sunflower yield and yield parameters were the highest under weed free treatments which were at par with herbicidal treatment of oxyfluorfen at 250 g/ha *fb* quizalofop-ethyl 50 g/ha at 20 DAS, and was significantly superior to pendimethalin 1000 g/ha at 3 DAS *fb* quizalofop–ethyl 50 g/ha at 20 DAS (**Table 2**). Overall seed yield was lower in 2015-16 than 2014-15. Plant height and hundred seed weight did not vary significantly among the treatments. Weed infestation caused 31.3% reduction in mean seed yield of *Rabi* sunflower. Similar yield reduction in *Rabi* sunflower due to weed competition was also reported by Pannacci *et al*. (2007) and Selvakumar *et al.* (2018). Weedy control recorded the lowest seed yield (1.6 t/ha).

Table 1. Effect of different weed management treatments on weed density and biomass, weed control efficiency at 50 days after seeding in *Rabi* sunflower (mean data of two years)

Treatment	Weed density (no/m^2)				Weed biomass(g/m^2)				W.C.E (%)	W.I. (%)
	Grasses	Sedges	BLWs	Total	Grasses	Sedges	BLWs	Total		
Oxyfluorfen 250 g/ha (PE)	5.27(27.6)	5.50(29.7)	8.13(65.2)	11.11(122.5)	4.43(18.7)	3.51(11.4)	4.68(21.0)	7.21(51.0)	58.1	15.6
Pendimethalin 1000 g/ha (PE)	5.16(25.9)	5.75(33.8)	8.38(69.3)	11.37(128.2)	4.37(18.2)	3.77(13.3)	4.93(23.3)	7.47(54.8)	54.9	20.1
Oxadiargyl 175 g/ha (PE)	6.52(42.3)	6.31(38.9)	9.76(94.3)	13.29(175.5)	4.60(20.5)	4.02(15.2)	5.86(33.4)	8.37(69.1)	43.2	23.3
Oxyfluorfen250 g/ha (PE) *fb* quizalofop-ethyl 50 g/ha (PoE)	4.54(20.6)	4.32(18.0)	1.82(2.5)	6.48(41.0)	3.54(11.6)	2.81(7.0)	1.33(0.8)	4.51(19.4)	84.1	7.1
Pendimethalin 1000 g/ha (PE) *fb* quizalofop-ethyl 50 g/ha (PoE)	3.98(15.1)	4.91(24.1)	3.96(14.7)	7.41(53.9)	2.86(7.3)	3.25(9.6)	2.37(4.6)	4.74(21.4)	82.4	8.3
Oxadiargyl 175 g/ha (PE) *fb* quizalofop-ethyl 50 g/ha (PoE)	5.02(24.6)	5.25(28.2)	5.66(31.1)	9.21(83.8)	3.99(15.0)	3.40(10.7)	3.10(8.6)	5.94(34.3)	71.8	13.8
Weed free check	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	1.00(0)	100	0
Weeedy control	8.96(79.4)	9.79(94.8)	16.89(142.4)	17.82(316.7)	6.28(38.4)	6.19(37.4)	6.84(45.9)	11.08(121.7)	0.00	31.3
LSD (p=0.05)	1.47	1.68	1.19	2.87	1.67	1.04	0.59	1.96		

Data subjected to square root transformation ($\sqrt{x+1}$), original value are in parentheses

Table 2. Effect of different weed management treatments on yield attributes, yield and economics of *Rabi* sunflower

Treatment	Plant height (cm)	Capitulum dia. (cm)	100 seed wt.(g)	Seeds/ capitulum	Seed yield (t/ha)			Stover yield (t/ha)			Cost of cultivation ($x10^3$ ₹/ha)	Net returns ($x10^3$ ₹/ha)	B:C ratio
					2014-15	2015-16	Mean	2014-15	2015-16	Mean			
Oxyfluorfen 250 g/ha (PE)	126.5	13.36	4.02	892	2.1	1.7	1.9	4.0	3.8	3.9	44.04	26.93	1.61
Pendimethalin 1000 g/ha (PE)	125.2	13.02	4.01	850	2.0	1.6	1.8	3.9	3.4	3.7	40.84	26.35	1.64
Oxadiargyl 175 g/ha (PE)	123	12.89	4.03	826	1.9	1.6	1.7	3.8	3.2	3.5	38.74	25.74	1.66
Oxyfluorfen250 g/ha (PE) *fb* quizalofop-ethyl 50 g/ha (PoE)	131	14.79	4.54	981	2.3	1.9	2.1	4.4	4.0	4.2	42.84	35.29	1.82
Pendimethalin 1000 g/ha (PE) *fb* quizalofop-ethyl 50 g/ha (PoE)	129.6	14.42	4.51	950	2.3	1.9	2.1	4.2	4.0	4.1	46.52	30.68	1.65
Oxadiargyl 175 g/ha (PE) *fb* quizalofop-ethyl 50 g/ha (PoE)	127.4	13.58	4.51	918	2.1	1.8	2.0	4.2	3.9	4.1	42.04	30.46	1.72
Weed free check	134.7	15.16	4.54	987	2.5	2.1	2.3	4.6	4.2	4.4	50.54	33.60	1.66
Weedy control	120.4	12.55	3.5	778	1.7	1.4	1.6	3.3	3.2	3.2	38.64	19.15	1.49
LSD (p=0.05)	NS	0.91	NS	40.33	0.4	0.2	0.4	0.9	0.2	0.4	3.50	2.38	0.63

Table 3. Effect of weed management treatments on NPK uptake by weeds and sunflower at harvest (data is mean of 2 years)

Treatment	Nutrient uptake by weeds (kg/ha)			Nutrient uptake by the crop (kg/ha)		
	N	P	K	N	P	K
Oxyfluorfen 250 g/ha (PE)	8.33	2.36	8.22	50.42	16.07	69.0
Pendimethalin 1000 g/ha (PE)	10.1	2.96	11.03	45.94	11.31	66.2
Oxadiargyl 175 g/ha (PE)	12.1	4.35	13.89	41.14	9.95	63.5
Oxyfluorfen250 g/ha (PE) *fb* quizalofop-ethyl 50 g/ha (PoE)	3.29	0.58	3.08	63.05	24.7	79.5
Pendimethalin 1000 g/ha (PE) *fb* quizalofop-ethyl 50 g/ha (PoE)	3.73	0.82	3.60	58.81	15.91	73.2
Oxadiargyl 175 g/ha (PE) *fb* quizalofop-ethyl 50 g/ha (PoE)	5.97	1.54	6.45	51.29	13.68	71.1
Weed free check	0.00	0.00	0.00	66.55	25.56	79.9
Weedy control	23.00	8.28	22.27	33.53	9.00	56.8
LSD (p=0.05)	2.19	1.28	1.88	4.04	3.48	6.09

Pre-emergence application of oxyfluorfen 250 g/ha *fb* quizalofop-ethyl 50 g/ha at 20 DAS resulted in the highest uptake of N, P and K (63.05, 24.7, 79.5 kg/ha) and was at par with weed free check. Higher dry matter production of crop and corresponding nutrient contents of the tissues in these treatments resulted negligible competition offered by weeds for N, P and K uptake (**Table 3**).

Sequential application of oxyfluorfen 250 g/ha *fb* quizalofop-ethyl 50 g/ha at 20 DAS recorded the highest values of net return (₹ 35.28 x 10^3/ha) and benefit: cost ratio (1.82), which was closely followed by pendimethalin 1000 g/ha at 3 DAS *fb* quizalofop-ethyl 50 g/ha at 20 DAS (**Table 2**), and significantly superior to the weed free check.

It was concluded that broad-spectrum weed control throughout the crop growth period and the highest seed yield and maximum economic returns in *Rabi* sunflower may be obtained with oxyfluorfen 250 g/ha as PE *fb* quizalofop-ethyl 50 g/ha at 20 DAS.

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