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Integrated weed management in mustard

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ABSTRACT

A field experiment was conducted with fourteen treatments (oxadiarzyl 0.180 kg/ha, pendimethalin 1.50 kg/ha, trifluralin 1.50 kg/ha and isoproturon 1.25 kg/ha alone and at half rate with hand weeding (HW), oxadiarzyl, pendimethalin and trifluralin each at half rate followed by (*fb*) isoproturon 0.75 kg/ha (post), pendimethalin *fb* clodinafop each at half rate, hand weeding twice and weedy check) at Palampur during *Rabi* 2006-2007 and 2007-08. *Phalaris minor* (28.2%), *Avena ludoviciana* (25.2%) and *Lolium temulentum* (19.2%) were the predominant grassy weeds. The broad-leaved weeds (*Vicia sativa, Coronopus didymus* and *Anagallis arvensis*) as a whole constituted 26.7% of the total weed flora. Hand weeding twice and pendimethalin *fb* isoproturon were more effective in reducing the population of *P. minor*. Pendimethalin + hand weeding and hand weeding twice were effective against *A. ludoviciana.* Similarly integration of one hand weeding with isoproturon and trifluralin and hand weeding twice effectively taken care of *L. temulentum*. Pendimethalin + isoproturon and hand weeding twice reduced N and S removal by weeds. Pendimethalin *fb* isoproturon and trifluralin *fb* isoproturon resulted in significantly higher yield attributes (silique/plant, seeds/silique, 1000-seed weight), seed yield and seed N per cent of mustard. Trifluralin + HW and pendimethalin *fb* isoproturon gave higher gross and net returns due to weed control over other treatments. Isoproturon resulted in highest net return per rupee invested on weed control (18.5).

Key words: Chemical control, Integrated weed management, Mustard, Yield

Among various components of production technology, weed control in Indian mustard needs due attention. As this crop is grown in poor soils with poor management practices, weed infestation is one of the major causes of low productivity (Singh 1992). Yield losses due to crop-weed competition in rapeseed and mustard have been estimated to the tune of 10-58% (Gill *et al*. 1989, Bhan 1992, Banga and Yadev 2001) or even beyond 23-70% depending upon the type, intensity and duration of competition in gobhi sarson (Chopra and Saini 2007). Competition by weeds at initial stages is a major limiting factor to its productivity. Manual weeding at 3-4 weeks after sowing, is the most common practice to control weeds in Indian mustard. But increasing wages and scarcity of labour compel to search for other alternatives. The most common herbicidal weed control measure recommended in Indian mustard is the pre-emergence application of pendimethalin. Farmers and extension functionaries require information on post-emergence herbicidal weed control due to one or other reason, if pre-emergence application of herbicide was not made. Under situations when weeds are not taken care completely by pre-emergence application of herbicides, post-emergence herbicides may have an added economic advantage over super imposition of hand weeding. Therefore, it is imperative to find out an alternative weed management strategy for achieving season long weed control in Indian mustard.

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MATERIALS AND METHODS

A field experiment was conducted during *Rabi* 2006-07 and 2007-08 at Palampur (32^0 6' N latitude, 76^0 3' E longitude and 1280 m altitude). The soil of the experimental site was silty clay loam in texture, acidic in reaction, medium in available N (210.0 kg/ha) and P (18.8 kg/ha) and high in K (225.0 kg/ha). Fourteen treatments *viz.*, pre-emergence application of oxadiargyl 0.180 kg/ha, pendimethalin 1.50 kg/ha, trifluralin 1.50 kg/ha and post-emergence application of isoproturon (IPU) 1.250 kg/ha alone; their half dose in integration with one hand weeding after one month and their half doses in integration with isoproturon 0.75 kg/ha (35 DAS), pendimethalin (pre) *fb* clodinafop (35 DAS) each at half the dose, hand weeding twice (30 and 60 DAS) and unweeded check were tested in a randomized block design (RBD) with three replications. The seeds of mustard variety '*KBS-3*' were sown in rows 30 cm apart on October 17, 2006 and October 15, 2007 using 6 kg/ha. The crop was fertilized with 60 kg N, 40 kg P_2O_5 and 30 kg K_2O/ha as basal dose. Required

amount of N, P and K was supplied through urea, single super phosphate and muriate of potash, respectively. The recommended cultural practices and plant protection measures were followed to raise the healthy crop. Weeding was done manually with the help of hand tool 'Khunti'. Weed counts was recorded by placing 25 x 25 cm quadrates at two random places in each plot and after drying them in hot air oven (70 ± 1^0C for 72 h), weed dry weight was recorded. Herbicides were applied with the help of Maruyama Power Sprayer using flat fan nozzle. Yields were harvested from net plot. Economics of the treatments was computed based on the prevalent market prices.

RESULTS AND DISCUSSION

Effect on weeds

The experimental field was predominantly infested with *Phalaris minor* (28.2%), *Avena ludoviciana* (25.2%) and *Lolium temulentum* (19.2%). The broad leaved weeds like *Vicia sativa, Coronopus didymus* and *Anagallis arvensis* as a whole constituted 26.7% of total weed flora.

Hand weeding twice (30 and 60 DAS) being statistically similar to pendimethalin *fb* isoproturon during both the years and pendimethalin *fb* clodinafop, trifluralin *fb* isoproturon, pendimethalin, pendimethalin + HW, trifluralin + HW and isoproturon + HW were found to be more effective treatments in reducing the population of *Phalaris minor* (Table 1). The superior performance of these treatments could be ascribed to effective elimination by pulling and combined pre- and post-emergent herbicidal activity. These findings are in close conformity with those of Mehra *et al.* (1989). Pendimethalin *fb* one hand weeding being at par with hand weeding twice was more effective in reducing population of *Avena ludoviciana.* Chauhan *et al.* (2005) reported similar effects of pendimethalin and hand weeding. Isoproturon + hand weeding and trifluralin + hand weeding both being statistically similar with hand weeding twice were found to be more effective in reducing the count of *Lolium temulentum* during 2006-07 and 2007-08, respectively. These results are in accordance with the findings of Sharma *et al*. (2007). Effect of treatments on broad leaf weeds was not very conspicuous during 2006-07, however, during 2007-08, all treatments were significantly superior to weedy check in reducing their population. Pendimethalin 0.75 kg/ha *fb* clodinafop 0.60 kg/ha being statistically alike with hand weeding twice was more effective in reducing the population of broad-leaved weeds. The effective control of broad-leaved weeds due to combined activity of pre- and post-emergence herbicides has also been documented by Sharma *et al.* (2007).

Due to species-wise suppression of weeds, all weed control treatments brought about significant reduction in the total weed dry weight during both the years (Table 2). Pendimethalin + hand weeding were at par with pendimethalin, trifluralin, trifluralin + HW, isoproturon + HW, isoproturon, trifluralin *fb* isoproturon, handweeding twice and oxadiargyl + HW was more effective in reducing total weed dry weight during 2006-07. While, pendimethalin *fb* isoproturon and hand weeding twice remained at par resulted in significantly lower total weed dry weight over rest of the treatments during 2007-08. Since uptake is a function of dry matter and content of the nutrients, it follows the trend of dry matter. Thus nitrogen and sulphur uptake by weeds was significantly affected under weed control treatments. Because of effective control of weeds, pendimethalin *fb* isoproturon and handweeding twice remained at par resulted in significantly lower N and S removal by weeds (Table 2). However, trifluralin *fb* isoproturon, pendimethalin *fb* clodinafop and oxadiarzil *fb* isoproturon were as effective as pendimethalin *fb* isoproturon and hand weeding twice in influencing S removal by weeds. The lower uptake of N and S by weeds was due to their effective control by pre- and post-emergence herbicide activity (Nepalia and Jain 2000).

Effect on crop

Plant height of mustard was significantly influenced under weed control treatments (Table 3). Significantly taller plants were recorded under pendimethalin 0.75 kg/ha *fb* isoproturon 0.75 kg/ha, trifluralin 0.75 kg/ha *fb* isoproturon 0.75 kg/ha, trifluralin 0.75 kg/ha *fb* one hand weeding and hand weeding twice. However, all treatments were superior to untreated control. Singh *et al.* (2000) had also obtained more plant height with weed control treatments over untreated control. Weed control treatments did not significantly influence plant population flowering and mustard. However, better growth and development of the crop under competition free environment with effective control of weeds due to different treatments showed influence on the formation of higher yield contributing characters. The yield contributing characters *viz*., siliquae per plant, seeds per plant and 1000 seed weight increased with herbicide combinations and sequential application. Pendimethalin 0.75 kg/ha *fb* isoproturon 0.75 kg/ha remaining statistically at par with trifluralin 0.75 kg/ha (pre) *fb* isoproturon 0.75 kg/ha resulted in significantly higher yield attributes. Hand weeding was superior treatment in the order. Yadav *et al.* (1997) reported similar results.

The growth and yield attributes were reflected in yield of Indian mustard. Significantly higher seed yield was

Table 1. Effect of different treatments on species-wise weed count (no./m^2) at 90 DAS in mustard

Treatment	*Phalaris*		*Avena*		*Lolium*		BLW	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
Oxadiargyl 0.180 kg/ha (pre-emergence)	4.0 (14.7)	9.4 (88.0)	6.9 (46.7)	9.5 (90.0)	2.5 (5.3)	10.2 (103.3)	2.7 (6.1)	10.6 (111.3)
Oxadiargyl 0.90 kg/ha (pre-emergence) + HW (30 DAS)	2.2 (3.7)	9.5 (90.0)	2.7 (6.7)	9.5 (91.0)	2.2 (4.0)	9.7 (92.7)	2.4 (4.7)	10.6 (112.0)
Pendimethalin 1.5 kg/ha (pre-emergence)	1.4 (1.3)	8.8 (76.7)	6.1 (36.0)	8.7 (74.7)	2.2 (4.0)	8.9 (79.7)	2.6 (6.0)	10.4 (106.7)
Pendimethalin 0.75 kg/ha (pre-emergence) + HW (30 DAS)	1.2 (0.4)	8.8 (76.3)	2.0 (3.2)	5.5 (29.0)	2.1 (4.0)	9.3 (86.0)	2.5 (5.8)	10.3 (106.0)
Trifluralin 1.5 kg/ha (PPI)	3.2 (9.3)	9.5 (89.0)	4.9 (22.7)	9.2 (84.3)	2.2 (4.0)	8.8 (77.3)	2.6 (6.0)	10.4 (107.0)
Trifluralin 0.75 kg/ha (PPI) + HW (30 DAS)	1.2 (0.6)	8.4 (70.0)	2.7 (6.7)	9.1 (81.3)	2.1 (4.0)	4.6 (20.0)	2.6 (6.0)	9.8 (95.7)
Isoproturon 1.25 kg/ha (35 DAS)	2.9 (8.0)	10.0 (98.3)	5.4 (28.0)	10.3 (105.3)	2.5 (5.3)	10.7 (114.3)	2.4 (5.0)	9.8 (95.0)
Isoproturon 0.6 kg/ha (35 DAS) + HW (60 DAS)	1.2 (0.4)	9.9 (98.0)	3.2 (9.3)	10.4 (106.7)	1.0 (0.0)	10.3 (106.0)	2.4 (5.1)	10.8 (116.7)
Oxadiargyl 0.90 kg/ha (pre-emergence) *fb* IPU 0.75 kg/ha (post-emergence)	4.4 (18.7)	8.7 (74.3)	7.1 (49.3)	9.0 (80.7)	3.4 (10.7)	9.6 (92.0)	2.7 (6.4)	9.4 (88.0)
Pendimethalin 0.75 kg/ha (pre-emergence *fb* IPU 0.75 kg/ha (post-emergence)	1.3 (0.6)	4.6 (20.0)	7.5 (54.7)	8.8 (77.3)	2.7 (6.7)	9.6 (92.0)	3.0 (7.9)	9.7 (94.3)
Trifluralin 0.75 kg/ha (PPI) *fb* isoproturon 0.75 kg/ha (post-emergence)	1.3 (0.6)	8.8 (76.7)	6.4 (40.0)	7.7 (59.0)	2.1 (4.0)	9.2 (83.7)	2.7 (6.6)	9.8 (95.7)
Pendimethalin 0.75 kg/ha (Pre-emergence) *fb* clodinafop 60 g/ha	1.4 (1.3)	8.7 (75.7)	6.4 (40.0)	7.9 (61.7)	1.9 (4.0)	8.7 (74.0)	2.8 (6.9)	6.0 (35.7)
Hand weeding twice (30 and 60 DAS)	1.2 (0.5)	4.4 (18.0)	2.5 (5.3)	5.6 (30.0)	1.1 (0.3)	4.7 (21.0)	2.4 (5.3)	6.3 (39.0)
Unweeded check	6.1 (38.0)	13.2 (172.7)	6.7 (44.0)	12.0 (144.0)	3.0 (8.0)	11.9 (140.3)	2.5 (5.6)	13.9 (193.3)
LSD (P=0.05)	0.6	1.1	0.5	1.0	0.3	1.0	0.1	0.9

Values given in parentheses are original means, BLW- broad-leaved weeds, DAS - days after sowing, PPI - Pre-plant incorporation

Table 2. Effect of different treatments on total dry weight, nitrogen and sulphur uptake by weeds in mustard

Treatment	Total weed dry weight (g/m^2)				N uptake (kg/ha)	S uptake (kg/ha)
	2006-07		2007-08		2007-08	2007-08
	90 DAS	At harvest	90 DAS	At harvest		
Oxadiargyl 0.180 kg/ha (pre-emergence)	4.1 (15.9)	5.3 (27.2)	81.3	73.6	19.74	3.05
Oxadiargyl 0.90 kg/ha (pre-emergence) + HW (30 DAS)	2.2 (3.4)	5.0 (24.2)	71.1	66.3	17.45	3.15
Pendimethalin 1.5 kg/ha (pre-emergence)	2.3 (4.3)	4.5 (19.2)	74.4	63.1	17.51	3.21
Pendimethalin 0.75 kg/ha (pre-emergence) + HW (30 DAS)	2.1 (3.8)	3.6 (11.8)	73.4	69.7	13.35	2.75
Trifluralin 1.5 kg/ha (PPI)	1.9 (2.5)	4.1 (16.2)	62.9	59.7	16.67	2.67
Trifluralin 0.75 kg/ha (PPI) + HW (30 DAS)	2.2 (3.3)	3.7 (12.5)	61.7	56.1	18.90	2.64
Isoproturon 1.25 kg/ha (35 DAS)	2.1 (3.6)	4.3 (17.8)	64.7	60.3	19.62	3.11
Isoproturon 0.6 kg/ha (35 DAS) + HW (60 DAS)	2.1 (3.6)	5.4 (28.2)	68.8	60.4	16.85	2.94
Oxadiargyl 0.90 kg/ha (pre-emergence) *fb* IPU 0.75 kg/ha (post-emergence)	2.9 (7.5)	5.1 (25.0)	68.3	57.2	16.89	2.45
Pendimethalin 0.75 kg/ha (pre-emergence *fb* IPU 0.75 kg/ha (post-emergence)	3.5 (11.1)	5.2 (26.4)	41.6	36.8	9.95	1.97
Trifluralin 0.75 kg/ha (PPI) *fb* isoproturon 0.75 kg/ha (post-emergence)	2.4 (4.6)	3.9 (13.8)	70.1	62.0	11.84	2.21
Pendimethalin 0.75 kg/ha (Pre-emergence) *fb* clodinafop 60 g/ha	2.6 (6.0)	4.9 (22.8)	64.4	62.0	11.92	2.29
Hand weeding twice (30 and 60 DAS)	2.4 (4.6)	3.8 (13.5)	40.1	33.8	7.83	2.13
Unweeded check	5.5 (29.7)	5.8 (33.0)	175.3	170.3	21.63	4.28
LSD (P=0.05)	0.4	1.0	9.9	7.6	1.18	0.66

Values given in parentheses are original means

Table 3. Effect of different treatments on growth yield attributes and quality of mustard

Treatment	Plant height (cm)	Plant population /m^2	Silique/ plant	Seeds/ silique	1000-seed weight (g)	N in seeds (%)	S in seeds (%)	Oil in seeds (%)
Oxadiargyl 0.180 kg/ha (pre-emergence)	173.4	31.3	223.8	14.9	2.9	2.95	0.31	40.8
Oxadiargyl 0.90 kg/ha (pre-emergence) + HW (30 DAS)	145.1	31.3	266.4	16.7	2.9	2.95	0.33	41.7
Pendimethalin 1.5 kg/ha (pre-emergence)	172.5	30.7	212.0	13.2	2.8	3.02	0.33	41.9
Pendimethalin 0.75 kg/ha (pre-emergence) + HW (30 DAS)	169.1	31.0	245.6	16.0	2.9	3.40	0.33	43.0
Trifluralin 1.5 kg/ha (PPI)	175.1	31.7	266.4	16.9	2.9	2.99	0.33	42.4
Trifluralin 0.75 kg/ha (PPI) + HW (30 DAS)	176.5	32.0	253.8	16.6	2.9	3.14	0.36	43.4
Isoproturon 1.25 kg/ha (35 DAS)	156.5	31.3	240.5	15.9	2.8	3.10	0.35	42.7
Isoproturon 0.6 kg/ha (35 DAS) + HW (60 DAS)	160.5	32.0	231.3	15.1	2.8	3.29	0.35	41.7
Oxadiargyl 0.90 kg/ha (pre-emergence) *fb* IPU 0.75 kg/ha (post-emergence)	144.9	32.3	212.0	14.7	2.8	3.58	0.33	40.4
Pendimethalin 0.75 kg/ha (pre-emergence *fb* IPU 0.75 kg/ha (post-emergence)	183.0	31.0	278.7	17.3	2.9	3.58	0.37	43.5
Trifluralin 0.75 kg/ha (PPI) *fb* isoproturon 0.75 kg/ha (post-emergence)	180.0	30.3	271.7	17.1	2.9	3.17	0.32	41.1
Pendimethalin 0.75 kg/ha (Pre-emergence) *fb* clodinafop 60 g/ha	159.0	32.0	237.6	16.6	2.9	2.95	0.34	41.0
Hand weeding twice (30 and 60 DAS)	174.8	31.3	246.4	15.7	2.8	3.25	0.35	42.7
Unweeded check	139.3	30.3	197.5	13.2	2.6	2.91	0.23	40.7
LSD (P=0.05)	28.7	NS	35.2	2.6	0.1	0.16	NS	NS

Table 4. Effect of different treatments on yield and economics of mustard

Treatment	Seed yield (kg/ha)			Cost of weed control (₹/ha)	Gross returns ($x10^3$₹/ha)	Gross returns due to weed control ($x10^3$₹/ha)	Net returns due to weed control ($x10^3$₹/ha)	Net returns per rupee invested on weed control (₹/ha)
	2006-07	2007-08	Mean					
Oxadiargyl 0.180 kg/ha (pre-emergence)	1190	1220	1205	1,200	26.51	8.25	7.05	5.88
Oxadiargyl 0.90 kg/ha (pre-emergence) + HW (30 DAS)	1403	1834	1619	3,275	35.62	17.36	14.08	4.30
Pendimethalin 1.5 kg/ha (pre-emergence)	1303	1678	1419	2,800	32.80	14.54	11.74	4.19
Pendimethalin 0.75 kg/ha (pre-emergence) + HW (30 DAS)	1455	1861	1658	4,050	36.48	18.22	14.17	3.50
Trifluralin 1.5 kg/ha (PPI)	1277	1837	1557	1,725	34.25	15.99	14.27	8.27
Trifluralin 0.75 kg/ha (PPI) + HW (30 DAS)	1980	1883	1932	3,613	42.50	24.24	20.63	5.71
Isoproturon 1.25 kg/ha (35 DAS)	1355	1785	1570	833	34.54	16.28	15.45	18.54
Isoproturon 0.6 kg/ha (35 DAS) + HW (60 DAS)	1132	1837	1485	3,056	32.67	14.41	11.35	3.72
Oxadiargyl 0.90 kg/ha (pre-emergence) *fb* IPU 0.75 kg/ha (post-emergence)	1260	1685	1473	1,395	32.41	14.15	12.75	9.14
Pendimethalin 0.75 kg/ha (pre-emergence *fb* IPU 0.75 kg/ha (post-emergence)	1455	2096	1776	2,170	39.07	20.81	18.64	8.59
Trifluralin 0.75 kg/ha (PPI) *fb* isoproturon 0.75 kg/ha (post-emergence)	1367	1839	1603	1,733	35.27	17.01	15.27	8.81
Pendimethalin 0.75 kg/ha (Pre-emergence) *fb* clodinafop 60 g/ha	1229	1744	1487	2,050	32.71	14.4	12.40	6.05
Hand weeding twice (30 and 60 DAS)	1260	1893	1577	9,500	34.69	16.43	6.93	0.73
Unweeded check	697	962	830	-	18.26	-	-	-
LSD (P=0.05)	348	412	-					

recorded in trifluralin + hand weeding in 2006-07 and with pendimethalin 0.75 kg/ha *fb* isoproturon 0.75 kg/ha in 2007-08, (Table 4). Improvement in yield contributing characters and thereby seed yield under treatments may be attributed to low weed pressure. However, oxadiargyl + HW, pendimethalin + HW, trifluralin alone and with HW, isoproturon alone + HW, oxadiargyl *fb* isoproturon, trifluralin *fb* isoproturon, pendimethalin *fb* clodinafop and HW twice were at par with pendimethalin *fb* 1 HW during 2007-08. Untreated check had lowest seed yield due to higher weed count and dry matter. Weeds in unweeded check reduced seed yield of mustard by 64.8% in 2006-07 and 54.1% in 2007-08.

Weed control treatments significantly influenced nitrogen content in mustard seeds (Table 3). Because of absence of competition by weeds, pendimethalin 0.75 kg/ha *fb* isoproturon 0.75 kg/ha being at par with oxadiargyl 0.90 kg/ha *fb* isoproturon 0.75 kg/ha resulted in significantly higher seed nitrogen content. Untreated check resulted in lowest N content probably owing to rigorous competition induced by weeds (Singh *et al*. 2008). Oil and S content were not significantly influenced due to weed control treatments.

Economics

The viability of any practice depends on its economic feasibility. A better treatment in terms of weed control if not fetching good returns may not be acceptable to the farmers. Trifluralin 0.75 kg/ha (PPI) + HW resulted in highest gross and net return due to weed control over other treatments (Table 3). This was followed by pendimethalin 0.75 kg/ha *fb* isoproturon 0.75 kg/ha. The higher returns under these treatments were attributed to higher seed yield of mustard owing to better control of weeds. Because of low cost of the herbicide, isoproturon 1.25 kg/ha (30 DAS) resulted in highest net return per rupee invested on weed control (18.54). Isoproturon 1.25 kg/ha was followed by oxadiargyl *fb* isoproturon (9.14), trifluralin *fb* isoproturon (8.81) and pendimethalin *fb* isoproturon (8.59).

Hand weeding was costly, therefore, all herbicidal treatments were superior to it in influencing net return due to weed control and net return per rupee invested on weed control. It is also to mention that gross and net return due to integration of hand weeding with low dose of oxadiargyl, pendimethalin and trifluralin were higher than their respective higher dose alone. However, higher cost of handweeding brought down net return per rupee invested on weed control under all integrated weed management treatments than their alone application at higher doses.

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