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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^{0}C 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) 2007-08	S uptake (kg/ha) 2007-08
	2006-07		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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Effect of integrated weed management practices on sugarcane ratoon and associated weeds

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ABSTRACT

A field experiment was conducted during 2008-09 and 2009-10 at G.B. Pant University of Agriculture & Technology, Pantnagar (Uttarakhand). The soil of the experimental field was clay loam texture, medium in organic carbon (0.66%), available phosphorus (27.5 kg P/ha) and potassium (243.5 kg K/ha) with pH 7.2. Experiment consisted of six treatments were laid out in randomized block design with four replications. In the experimental field *Cyperus rotundus*, *Ehinochloa colona*, *Brachiaria reptans*,*Commelina benghalensis*, *Ipomoea* spp. and *Parthenium hysterophorus* were major weeds in both the years. Beside these, *Digitaria sanguinalis* was also observed as major weed during 2009-10. Other weeds were *Cleome viscosa*, *Corchorus acutangulus*, *Dactyloctenium aegyptium* and *phylanthus niruri*. Lowest density as well as dry weight of total weeds were recorded under the treatment of three hoeing at 30, 60 and 90 days after harvesting (DAH) of main crop which was at par with per-emergence application of metribuzin 0.88 kg/ha followed by (*fb*) hoeing at 45 DAH *fb* 2,4-D 1.0 kg/ha at 90 DAH. The highest cane yield was recorded with the execution of three hoeings at 30, 60 and 90 DAH treatment which was closely *fb* metribuzin at 0.88 kg/ha at 3 DAH *fb* hoeing at 45 DAH *fb* 2,4-D 1.0 kg/ha at 90 DAH of main crop.

Key words: Chemical control, Integrated weed management, Sugarcane ratoon

Sugarcane crop faces tough competition with weeds between 60 to 120 days of its planting which causes heavy reduction in cane yield ranging from 40-67% (Chauhan and Srivastava 2002).Sugarcane ratoon occupies about 50% of total sugarcane area, though its productivity is 45 t/ha against 70 t/ha productivity of main planted crop. This low productivity is mainly due to heavy weed infestation (Srivastava *et al.* 2002). Widely spaced crop of sugarcane allows wide range of weed flora to grow profusely in the interspaces between the rows. Frequent irrigations and fertilizer application during early growth stages, increase the weeds menace by many folds in the crop (Singh *el al.* 2008). It is well-established that cultural method of weed management is most effective to control weeds but timely availability of agricultural labours is a problem. Herbicidal control of weeds has been suggested to be economical in sugarcane (Chauhan *el al*. 1994). Several herbicides have, however, been tried in sugarcane ratoon with varying degree of success but the information on the combined use of chemical and cultural practices are scarce. The present investigation was undertaken to study the effect of different integrated weed control practices on the management of weeds in sugarcane ratoon crop.

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MATERIALS AND METHODS

A field experiment was conducted during 2008-09 and 2009-10 at Norman E. Borlaug, Crop Research Centre, G.B. Pant University of Agriculture & Technology, Pantnagar (Uttarakhand). The soil of experimental field was clay loam in texture, medium in organic carbon (0.66 %), available phosphorus (27.5 kg P/ha) and potassium (243.5 kg K/ha) with pH 7.2. Experiment consisted of six treatments, *viz.* atrazine 2.0 kg/ha at 3 days after harvesting (DAH), atrazine 2.0 kg/ha at 3 DAH followed by (*fb*) 2,4-D 1.0 l/ha at 90 DAH, 2,4-D 1.0 l/ha (90 DAH), metribuzin 0.88 kg/ha at 3 DAH *fb* hoeing at 45 DAH *fb* 2,4-D 1.0 l/ha at 90 DAH, hand weeding at 30, 60 and 90 DAH with weedy check (Table 1) were laid out in randomized block design with four replications. Three budded setts of sugarcane variety '*Co. Pant 90223*' was harvested on March 30, 2008 and March 01, 2009. Herbicides as per treatments were applied as spray using 600 litres of water per hectare. The crop was harvested on February 11, 2009 during first year and March 05, 2010 during second year, respectively. Data pertaining to density and dry matter accumulation by weeds were subjected to log transformation by adding 1.0 to original values prior to statistical analysis.

RESULTS AND DISCUSSION

In the experimental field, *Cyperus rotundus Echinochloa colona*, *Brachiaria reptans, Commelina benghalensis, Ipomoea* spp. and *Parthenium hysterophorus were* major weeds in both the years. Beside these, *Digitaria sanguinalis* was also observed as major weed during 2009-10. Other weeds with very low density were *Cleome viscosa*, *Corchorus acutangulus, Dactyloctenium aegypticum* and *Phylanthus niruri.* All the weed control measures led to significant reduction in density and dry matter accumulation by total weeds during both the years (Table 1). Lowest density (Table 1) as well as dry weight (Table 2) of total weeds were recorded under the treatment of three hoeing at 30, 60 and 90 DAH of main crop which was at par with pre-emergence application of metribuzin at 0.88 kg/ha at 3 DAH *fb* hoeing at 45 DAH *fb* 2,4-D 1.0 kg/ha at 90 DAH. Application of atrazine 2.0 kg/ha at 3 DAH *fb* 2,4-D 1.0 kg/ha at 90 DAH recorded significantly lower density and dry weight of total weeds than alone application of 2,4-D 1.0 kg/ha at 90 DAH and atrazine 2.0 kg/ha at 3 DAH.

On an average, presence of total weeds throughout the crop period caused 55.94% reduction in the ratoon cane yield when compared with the execution of three hoeing given at 30, 60 and 90 DAH stages (Table 2). The highest

Table 1. Effect of weed management on weed density at 120 days after harvesting (DAH) of main crop in sugarcane ratoon during 2008-09 and 2009-10

Treatment	Dose (kg/ha)	Application stage (DAH)	Weed density (no./m^2)															
			C. rotundus		*E. colona*		*B. raptens*		*D. sanguinalis*		*C. benghalensi*		*Ipomoea* spp.		*P. hysterophorus*		Total	
			I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Atrazine	2.0	3	3.72 (42)	3.33 (28)	2.45 (11)	1.90 (9)	2.26 (10)	1.71 (8)	0.0 (0)	2.15 (9)	2.51 (13)	2.15 (9)	2.35 (11)	1.95 (10)	2.15 (9)	2.51 (13)	4.64 (104)	4.56 (98)
Atrazine *fb* 2,4-D	2.0 *fb* 1.0	3 *fb* 90	3.22 (25)	2.82 (17)	2.66 (14)	1.90 (9)	2.06 (8)	1.75 (8)	0.0 (0)	2.20 (10)	1.10 (4)	0.95 (9)	0.0 (0)	0.40 (10)	0.0 (0)	0.40 (1)	4.02 (55)	4.02 (55)
2,4-D	1.0	90	3.29 (27)	3.33 (28)	3.25 (28)	3.37 (31)	3.08 (22)	2.68 (19)	0.0 (0)	2.59 (15)	1.50 (5)	1.35 (4)	0.40 (1)	0.80 (2)	0.0 (0)	0.95 (3)	4.47 (88)	4.69 (110)
Metribuzin *fb* hoeing *fb* 2,4-D	0.88 *fb* 1.0	3 *fb* 45 *fb* 90	3.00 (20)	2.37 (11)	2.00 (7)	1.45 (5)	1.59 (6)	1.04 (4)	0.0 (0)	1.45 (5)	0.95 (3)	0.55 (2)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	3.63 (39)	3.40 (30)
Hand weeding	-	30, 60 and 90	2.50 (12)	1.90 (09)	0.4 (1)	0.95 (3)	0.80 (2)	0.80 (2)	0.0 (0)	0.95 (3)	0.80 (2)	0.0 (0)	0.95 (3)	0.80 (2)	0.0 (0)	0.0 (0)	3.15 (23)	2.52 (21)
Weedy check	-	-	3.68 (40)	3.33 (29)	3.35 (30)	3.41 (33)	2.84 (20)	2.97 (21)	0.0 (0)	2.66 (18)	2.60 (16)	2.31 (12)	2.53 (15)	2.46 (13)	2.51 (13)	2.79 (17)	4.98 (149)	5.08 (163)
LSD (P= 0.05)	-	-	0.55	1.09	0.77	1.59	1.13	1.74	-	1.34	1.30	1.14	0.97	1.14	0.53	0.82	0.53	1.05

I- Year 2008-09, II –Year 2009-10, DAH- Days after harvesting, *fb* – Followed by, Original values are given in parentheses

Table 2. Effect of weed management on weed dry weight, yield attributing characters and cane yield in sugarcane ratoon during 2008-09 and 2009-10

Treatment	Dose (kg/ha)	Application stage (DAH)	Weed dry weight (g/m^2) at 120 DAH		Cane length (cm)		Cane girth (cm)		Millable cane (,000/ha)		Cane yield (t/ha)	
			2008-2009	2009-2010	2008-2009	2009-2010	2008-2009	2009-2010	2008-2009	2009-2010	2008-2009	2009-2010
Atrazine	2.0	3	195	148	161	153	6.5	6.7	128	125	58	53
Atrazine *fb* 2,4-D	2.0 *fb* 1.0	3 *fb* 90	107	86	165	157	6.6	6.7	145	137	65	61
2,4-D	1.0	90	188	154	156	150	6.4	6.6	105	100	55	48
Metribuzin *fb* hoeing *fb* 2,4-D	0.88 *fb* 1.0	3 *fb* 45 *fb* 90	52	43	168	160	6.6	6.7	163	153	72	70
Hand weeding	-	30, 60 and 90	22	21	170	164	6.7	6.9	168	157	76	74
Weedy check	-	-	299	234	154	147	5.9	6.4	80	73	32	34
LSD (P= 0.05)	-	-	15.1	24.7	NS	4.1	NS	NS	10.2	14.1	39	47

ratoon cane yield was obtained with the execution of three hoeing at 30, 60 and 90 DAH which was closely followed by pre-emergence application of metribuzin 0.88 kg/ha at 3 DAH followed by hoeing at 45 DAH followed by 2,4-D 1.0 kg/ha at 90 DAH of main crop. The higher cane yield under these treatments was due to higher value of cane length and millable cane per hectare.

It was concluded that application of metribuzin at 0.88 kg/ha at 3 DAH followed by hoeing at 45 DAH followed by 2,4-D at 1.0 kg/ha at 90 DAH of main crop was found most effective treatment for control of weeds in sugarcane ratoon.

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Effect of monsoon and weed management on growth and yield of direct-seeded rice

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ABSTRACT

A field study was conducted during 2008 and 2009 at G.B. Pant University of Agriculture and Technology, Pantnagar to evaluate the effect of two seeding time (before and after onset of monsoon) and six methods of weed control in direct dry seeded rice. Among the weed control treatments, butachlor applied 1.5 kg/ha in year 2008 and broadcasting of *Sesbania* knocked down by the application of 2, 4-D (brown manuring) at 30 days after sowing in 2009 recorded lowest weed dry weight. Pre-emergence application of butachlor 1.5 kg/ha yielded highest followed by the application of pretilachlor 0.5 kg/ha and broadcasting of *Sesbania* knock down with 2,4-D 0.5 kg/ha at 30 DAS which were at par with each other during both the year of experimentation.

Key words: Brown manuring, Chemical control, Direct dry-seeded rice, Sowing time, Weed control

Rice (*Oryza sativa* L.) is a major food grain crop of the world and more than half of the population subsists on it. It is the main livelihood of rural population living in subtropical and tropical Asia and hundreds of millions people living in Africa and Latin America. In India wheat, rice is the second important food crop next to. India is the second largest rice producing country in the world. The area and production under rice is 44.1 m/ha and 99.5 mt, respectively (http.//ffymag com/admin/issuepdf/Rice.pdf). The common method of rice cultivation in India is transplanting of the seedlings from nursery to main field which is very tedious and time consuming job. The higher cost and unavailability of farm labours invariably delay transplanting and often leads to transplanting of aged seedlings. The method of direct seeding escapes the transplanting and puddling operations which is an attractive and sustainable alternative to traditional transplanting of rice. DSR covers 26 and 28% of the total rice area in South Asia and India, respectively (Pandey and Velasco 1999).

Direct dry seeding offers such advantages as faster and easier planting, reduced labour, earlier crop maturity by 7–10 days, more efficient water use and higher tolerance of water deficit, less methane emission and often higher profit in areas with an assured water supply (Balasubramanian and Hill 2002). Early seeding of rice plays vital role in improving its growth and increasing the yield. The delayed sowing results in the poor emergence and reduced heading panicle per meter square and spikelets per panicle and ultimately yield is affected (Hayat *et al*. 2003). Due to poor emergence of crop, the weeds cause drastic reduction in crop productivity since they get sufficient space and time for vigourous growth. Therefore, the present study was undertaken to evaluate the effect of sowing time and weed control method on the density and productivity of direct seeded rice.

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MATERIALS AND METHODS

A field experiment was conducted at N. E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture &Technology, Pantnagar (Uttarakhand) during *Kharif* 2008 and 2009. The experiment was stipulated in split plot design with three replications. Rice crop was established by direct dry seeding method at the rate of 60 kg/ha. The treatment comprised of two seeding time (pre and post-monsoon) of direct seeded rice in main plot and six methods of weed control, *viz*. pretilachlor 0.5 kg/ha, butachlor 1.5 kg/ha each applied as pre-emergence and fenoxaprop 0.06 kg/ha as post-emergence, broadcasting of *Sesbania* and knocked down with application of 2-4-D 0.5 kg/ha at 30 DAS, weedy and weed free. Soil at the site was a heavy silt loam with pH 7.1, organic carbon 0.73%, low in available N, medium in available P_2O_5 and high in available K_2O.

In 2008, rice variety '*Sarjoo 52*' was sown on 19th June and 8th July, while in 2009, rice variety '*Govind*' was sown on 4th June and 1st August in rows 20 cm apart. The crop was harvested on 17th October and 5th November in 2008 and 26th September and 30th October in 2009. All the herbicides were sprayed by using water 500 l/ha with the help of Maruti foot sprayer fitted with flat fan nozzle. Weed density were recorded at 60 DAS by placing a quadrate of 0.25 x 1.0 m randomly in the experimental plot. The samples taken out were oven dried for about one week and dry weight was recorded. All the other recommended package of practices except weed control was followed to raise the direct dry seeded crop.

RESULTS AND DISCUSSION

The experimental field was mainly infested with *Eleusine indica* and *Echinochloa* spp. among grasses, *Celosia argentia* and *Cleome viscosa* among broad-leaved weeds and *Cyperus* spp. among sedges, both before and after monsoon during both the years. However, *Panicum* spp, *Digitaria sanguinalis* and *Alhagi camelorum* were found only in before monsoon seeded crop.

Weed density and dry weight

The total weed density and dry weight recorded at 60 days after sowing were not influenced significantly due to sowing dates, except total weed density in 2009. The total weed density and dry weight reduced in post monsoon sown crop, but the differences were non significant. In 2009, post monsoon sown crop recorded significantly lower total weed density (63.8/m^2) than pre monsoon (74.1/m^2) sown crop. The reduction in weed density and dry weight in post monsoon seeded crop was due to emergence of most of the weeds after monsoon showers and the emerged weeds were controlled through tillage operations at final field preparation before seeding of rice seed.

Both, total weed density and dry weight recorded at 60 DAS were influenced significantly due to weed management practices during both the years (Table1). Among the weed control treatments, broadcasting of *Sesbania* knocked down by the application of 2,4-D 0.5 kg/ha at 30 DAS recorded the lowest weed density and was at par with application of other herbicidal treatments except application of fenoxaprop 60 g/ha applied as post-emergence which was found at par with weedy check in the years of 2008. Same trend was also noticed during 2009, however, broadcasting of *Sesbania* integrated with 2,4-D 0.5 kg/ha at 30 DAS was found significantly superior over application of pretilachlor 0.5 kg/ha and fenoxaprop 60 g/ha against weed population during this season. All the treatments gave significantly superior dry matter accumulation of rice over weedy plot. On an average heavier biomass of weeds were recorded during *Kharif* 2008 in weedy plot which might be due to late seeding of pre-monsoon crop compared to *Kharif* 2009 which results in heavy flush of weeds in the direct dry seeded rice field. Among the herbicidal treatments, butachlor applied 1.5 kg/ha recorded significantly lowest weed biomass which was followed by *Sesbania* knocked out with 2,4-D 0.5 kg/ha at 30 DAS, pretilachlor 0.5 kg/ha and fenoxaprop 0.06 kg/ha which were at par with each other in 2008. Similar trend in weed dry accumulation was noticed during *Kharif* 2009 except then *Sesbania* knocked out with 2,4-D 0.5 kg/ha which resulted significantly lower weed dry weight over the application of other herbicides. No significant difference recorded with application of butachlor 1.5 kg/ha and pretilachlor 0.5 kg/ha fenoxaprop 0.06 kg/ha. However, the significant differences on weed dry weight was ob-

Table 1. Effect of sowing time and weed control measures on total weed density and dry weight at 60 DAS and grain yield of rice

Treatment	Total weed density (no./m^2)		Total weed dry weight (g/m^2)		Grain yield (t/ha)	
	2008	2009	2008	2009	2008	2009
Time of sowing						
Before onset of monsoon	69	74.1	431.9	371.2	1.53	1.39
After onset of monsoon	69	63.8	307.8	300.3	1.64	1.14
LSD (P=0.05)	NS	8.3	NS	NS	NS	0.13
Weed control treatments						
Pretilachlor	78	78.8	459.9	408.2	0.95	0.74
Butachlor	70	70.0	86.1	358.2	3.04	2.18
Fenoxaprop	97	88.5	504.2	440.6	0.32	0.34
Sesbania + 2,4-D	64	63.0	455.9	325.6	0.84	0.64
Weedy	106	113.2	713.1	483.0	0.29	0.19
Weed free	0	0.0	0.0	0.0	4.06	3.49
LSD (P=0.05)	27	8.8	114.8	24.5	0.43	0.15

tained between these herbicides in the year 2009. Significant reduction in weed dry matter accumulation due to broadcasting of *Sesbania* knocked out with 2,4-D 0.5 kg/ha was also reported by Dhyani *et al.* (2009).

Grain yield

Higher grain yield was recorded in post-monsoon compared to pre-monsoon seeded crop during *Kharif* 2008, however, just reverse trend was obtained during *Kharif* 2009, while the difference was significant only in 2009 (Table 1). None of the weed management treatments could reach up to the higher level of weed free treatment in respect to grain yield of rice. Among the different weed control treatments application of butachlor (1.5 kg/ha), produced the highest grain yield followed by pretilachlor 0.5 kg/ha, broadcasting of *Sesbania* knock down with 2,4-D 0.5 kg/ha which were at par during both the year of experimentation. Highest grain yield with application of butachlor was found might be due to better control of heavy flush of weeds as early stage of crop growth whereas broadcasting of *Sesbania* knock down with 2,4-D 0.5 kg/ha recorded the lower weed dry weight at 60 days stage of crop yet it recorded the lower grain yield might be due to re-growth of some of the weeds and also suppression of same rice seedlings by *Sesbania* in early stage. Fenoxaprop 0.06 kg/ha was found poor control of weeds, thus produced the lowest grain yield during both the years. In 2008, application of fenoxaprop 0.5 kg/ha was at par with weedy check

Interaction effect

Significant differences were observed in weed dry weight at 60 DAS due to different weed management practices and dates of sowing during both the years. Application of fenoxaprop 60g/ ha and broadcasting of *Sesbania fb* by 2,4-D 0.5 kg/ha at 60 DAS were proved effective against weeds as it recorded significantly lower weed dry matter in post monsoon seeded crop as compared to before seeding monsoon crop during both the years. During *Kharif* 2009, significantly lower weed dry weight was recorded among all the weed control treatments in post monsoon seeding crop whereas in *Kharif* 2008, higher weed dry weight was recorded with the application of butachlor 1.5 kg/ha in post monsoon seeded crop compared to pre monsoon seeded crop, however, the differences was non-significant (Fig. 1 and 2). It might be due

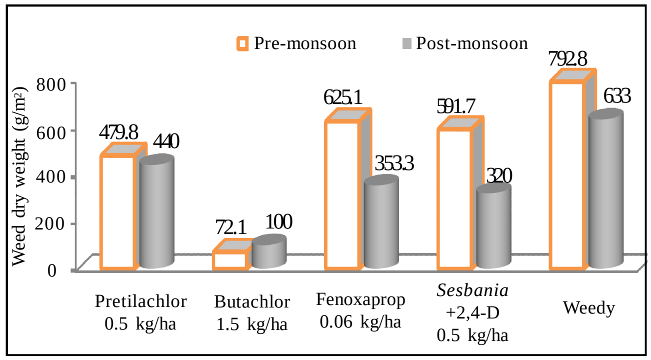

Fig. 1. Interaction effect of sowing time and weed control treatments on total weed dry weight at 60 DAS (2008)

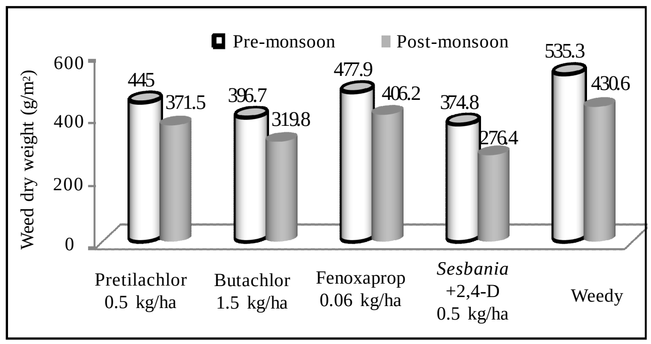

Fig. 2. Interaction effect of sowing time and weed control treatments on total weed dry weight at 60 DAS (2009)

Table 2. Interaction effect of sowing time and weed control treatments on grain yield (t/ha) of rice

Date of sowing	Pretilachlor 0.5 kg/ha		Butachlor 1.5 kg/ha		Fenoxaprop 0.06 kg/ha		*Sesbania* + 2,4-D 0.5 kg/ha		Weedy		Weed free	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Pre-monsoon	0.41	0.88	3.31	2.24	0.20	0.38	0.59	0.74	0.13	0.21	4.52	3.77
Post-monsoon	1.48	0.60	2.76	2.12	0.44	0.30	1.10	0.53	0.44	0.17	3.60	3.21
LSD (P= 0.5)											2008	2009
To compare time of sowing at same or different weed control											0.60	0.21
To compare wed control at same or different time of sowing											0.83	0.22

to late emergence of weeds in monsoon season. Application of butachlor 1.5 kg/ha recorded 84 and 25% lower weed dry weight, respectively during 2008 and 2009, compared to weedy check when the crop was seeded after monsoon.

On an average higher rice grain yield was recorded in pre-monsoon seeded compared to post-monsoon seeded crop in weed free treatment during both the years. Weed free recorded 20.3 and 14.9% higher grain yield in pre-monsoon sown compared to post-monsoon crop during 2008 and 2009, respectively. Pre-monsoon seeded crop recorded higher grain yield due to better growth and development of crop. Better growth in *Kharif* 2008 as compared to 2009 was mainly due to availability of more rainfall, proper distribution of rain and congenial temperature in pre-monsoon season (30.7^{0}C average maximum temperature) compared to post- monsoon season (33.4^{0}C average maximum temperature). Complete failure of the crop (about 90%) was found due to absence of weed control methods (weedy check) during both the years and seeding dates also. Application of butachlor 1.5 kg/ha gave higher grain yield compared to other herbicidal treatments during both the years. However, it was followed by broadcasting of *Sesbania* knocked down with 2,4-D at 0.5 kg/ha in pre-monsoon seeding of rice and with application of pretilachlor 0.5 kg/ha in post monsoon seeding in the year of 2008. During *Kharif* 2009, application of pretilachlor 0.5 kg/ha was the second highest grain yield producer after application of butachlor 1.5 kg/ha. Application of fenoxaprop 0.5 kg/ha was found inferior against weeds as it recorded lowest grain yield during both the dates of sowing and years, among the herbicidal treatments.

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Performance of onion under weed and fertilizer management

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ABSTRACT

In the new alluvial soil of Navsari (Gujarat), a field experiment was conducted in *Rabi* season to study the yield, quality and post harvest life of onion (*Allium cepa* L.) cv. '*Gujarat Onion White-1*' as affected by weed management and fertilizer levels during two conjunctive years of 2008-09 and 2009-10. Weed population were decreased significantly with application of pendimethalin 1 kg/ha or oxyfluorfen 0.24 kg/ha supplement with one hand weeding at 40 DAT during both the season of investigation. *Echinochloa* spp., *Trianthema portulacastrum, Digera arvensis*. *Physalis minima*. and *Cynodon dactylon*. were found as major weeds in experiment field. Further, pendimethalin 1.0 kg/ha followed by one hand weeding produced higher onion bulb yield of 39.3, 36.6 and 38.0 t/ha during both years as well as in pooled, respectively and found at par with oxyflourfen 0.24 kg/ha + one hand weeding at 40 DAT and weed free treatments. In pooled, increasing fertilizer rate from 75% to 125% of RDF was found effective and the higher level of fertilizer (125% RDF) gave the highest bulb yield, which was 10.52 and 19.43% more than of the F_2 and F_1 levels respectively. Regarding post harvest life of bulbs, weight losses (%), black mould development (%) and sprouting (%) were remained unaffected by weed management and fertilizer levels except significantly higher weight losses (%) was observed under weed management treatment. On the basis of interaction, it is inferred that the treatment combination of (pendimethalin 1 kg/ha *fb* one hand weeding at 40 days after transplanting supplement with 100% RDF) found most appropriate (39.86 t/ha) and profitable not only to secure the net return of ₹ 2,69,422/ha with 7.85 BCR per unit cost of onion production but also save 25% of fertilizer.

Key words: Fluazifop-p-butyl, Pendimethalin, Quality, Onion, Oxyfluorfen, Weed management

Onion (*Allium cepa*) is one of the most important bulb crop having huge export potential, growly in country. With export earning worth ₹ 1816.14 crores, onion and garlic become major foreign exchange earners for India among vegetables standing second rank in the world. India produces 7729.13 MT of onion from 554.15 ('000 ha) of area (Anon. 2010). In spite of being a major onion producing country , India has very low productivity as compared to many other countries. Among several factors, weed and fertilizer management are two important aspects for proper growth and yield of the crop. Onion has very poor comparative ability with weeds due to its inherent characteristics such as short stature, non branching habit, sparse foliage, shallow root system and extremely slow growth during initial stage. Yield losses due to weeds infestation in onion were as high as 82.2% (Tewari *et al.* 2003). Hand weeding, is effective, but it is time consuming and uneconomical. Further, onion requires higher levels of N, P and K fertilizer for maximum yields then most of other vegetable crops. The shallow root and dense population of onion make them responsive to fertilizers. Since fertilizer is a major input in the production process, there is a need to rationalize its use as an underutilization can lead to sub optimal yield. Moreover, the recommendation is based on several factors such as previous cropping, soil type, fertility level and variety to be grown. On the other hand, when used excessively, it can reduce yield, affect post harvest quality and constitute a threat to the environment with respect to surface and ground water pollution. This study was undertaken to assess the need for developed effective weed and fertilizer management strategies for onion bulb crop.

MATERIALS AND METHODS

A field experiment was conducted during 2008-09 and 2009-10 at the research farm of Navsari agricultural University, Navsari (20^o 57' N latitude, 72^o 54' E longitude) Gujarat. The soil was clay in texture, having 0.59% organic C, medium in available nitrogen (224 kg/ha) and phosphorus (40 kg/ha), fairly rich in available potassium

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(362 kg/ha) and slightly alkaline in reaction (pH 7.6) with normal electrical conductivity. There were thirty treatment combinations consisting of ten treatments of weed management, *viz.* W_1: Pendimethalin 1 kg/ha as pre-emergence, W_2: Oxyfluorfen 0.24 kg/ha as pre-emergence, W_3: Pendimethalin 1 kg/ha pre-emergence + fluazifop-p-butyl 0.25 kg/ha at 40 DAT, W_4: Oxyfluorfen 0.24 kg/ha pre-emergence + fluazifop-p-butyl 0.25 kg/ha at 40 DAT, W_5: Pendimethalin 1 kg/ha pre-emergence + one hand weeding at 40 DAT, W_6: Oxyfluorfen 0.24 kg/ha pre-emergence + one hand weeding at 40 DAT, W_7: Hand weeding at 20 DAT + fluazifop-p-butyl 0.25 kg/ha at 40 DAT, W_8: Two hand weeding at 20 and 40 DAT, W_9:Weed free control (hand weeding at 20, 40 and 60 DAT), W_{10}: Weedy check and three treatments of fertilizer levels, *viz.* F_1: 75% RDF (75:37.50:37.50, $N:P_2O_5:K_2O$ kg/ha), F_2: 100% RDF (100:50:50, $N:P_2O_5:K_2O$ kg/ha), F_3:125 % RDF (125:62.5:62.5, $N:P_2O_5:K_2O$ kg/ha). These treatment combinations were laid out in randomized block design with factorial having three replications.

Common application of well decomposed FYM 10 t/ha was uniformly applied to all the experimental units before transplanting. The basal dose of fertilizers, consisting of full dose of P_2O_5 through SSP and K_2O through MOP, half dose of N through urea as per the treatment was applied manually. The remaining dose of N was supplied at 30 days after transplanting. The onion cv '*Gujarat Onion White-1*' was sown on 21st may and 23rd may, 2009 and 2010, respectively. Row-to-row spacing was maintained at 15 cm, whereas plant-to-plant spacing was 10 cm. All the agronomic management practices were followed as per the standard recommendations. Herbicide was spray according to treatment. All the herbicides were applied as pre-emergence using knapsack sprayer fitted with flat fan nozzle attached with the hood of sprayer by mixing in 500 L of water/ha as per treatment. Onion was harvested when the tops begin to fall and the bulbs were mature. The concentration of various nutrients like N, P, K and S in onion bulb crop was estimated by methods as given by Prasad *et al.* (2006). The nutrient uptake was determined by multiplying the concentration with their dry matter accumulation.

Data on weeds population were recorded at 20 and 40 days after sowing. The observations of weed density and their dry matter were taken randomly from 1.0 m^2 quadrate from net plot area. Same were harvested and then oven dried for 48 hours at 70 ^{0}C. Weed control efficiency (WCE) was calculated on the basis of formula suggested as per bellowed.

Biometric observations on onion bulb crop *viz.*, weight, volume and diameter of bulb and dry weight of weeds were recorded at harvest of the crop and weed count at 40 days after transplanting. Sale price of output was: onion bulb, ₹ 8/kg; input price (kg): FYm, ₹ 1; Pendimethalin, ₹ 360; oxyfluorfen, ₹ 480; fluziffop-p-butyl, 1330; urea, ₹ 5.57; SSP, ₹ 4.21 and MOP, ₹ 5.34; labour wage, ₹ 100/man/day.

Data on weed density and dry weight was subjected to square root transformation before analysis. Treatment effects in both years were same so pooled analysis of data was made. The data recorded were statistically analyzed using MSTATC Software. The purpose of analysis of variance was to determine the significant effect of treatments on weeds and maize. LSD test at 5% probability level was applied when analysis of variance showed significant effect for treatments (Steel and Torrie 1980).

RESULTS AND DISCUSSION

Effect on weeds

The dominant weeds identified in the experimental plots during the course of investigation were *Echinochloa crusgalli* and *Echinochloa colonum*, *Eleusine indica*, *Eragrostis major* among monocots, while *Trianthema* ssp., *Amaranthus* spp., *Eclipta alba*, among dicot weeds. *Cyperus rotundus* was the only sedge found throughout the growing season. Grasses, broad-leaved weeds and sedges accounted about 67, 29 and 4% of the total weeds in weedy plot at 40 days after sowing

Implementation of various weed management treatments had greater influenced over the total weed population during the crop growth. Among the treatment tested the W_{10}: (weedy check) treatment recorded the highest weed density and dry matter of weeds (Table 1). The maximum dry weight of weeds may be due to the increased weed population and continuous growth and may also be due to the higher amount of nutrient removal. Application of either pendimethalin at 1.0 kg/ha or oxyfluorfen at 0.24 kg/ha supplement with one hand weeding at 40 days after transplanting recorded the least weed population. All the treatments applied with herbicides conjunction with one hand weeding resulted in significantly reduce dry weight of weeds. The population of sedge weed (*Cyperus rotundus*) was not influenced more due to different weed management treatments. Because, perennial nature and under ground net-work of this weed. Effectiveness of various herbicides against different weed species in onion crop has been reported by many workers including Kathiresan *et al.* (2004) and Tripathi *et al.* (2008).

Different fertilizer levels had significant effect on total weed population. At 40 days after transplanting, increased rates of fertilizer simultaneously increased the total weeds population being lowest with F_1 (75% RDF) and highest with F_3 (125% RDF) during both years of experimentation. Moreover, dry weight of weeds was significantly influenced by fertilizer levels at 40 DAT and at harvest. Dry weight remained lowest in F_1 treatment (Table 1). Data clearly indicated that increasing the fertilizer rate, increased the availability of nutrients for growth and development of weeds ultimately dry weight of weeds was increased.

Effect on onion

Significantly the highest weight, volume and diameter of onion bulb was recorded under treatment W_5 (pendimethalin 1.0 kg/ha + one hand weeding at 40 DAT) which was remained at par with treatment W_6 (oxyfluorfen 0.24 kg/ha + one hand weeding at 40 DAT) during both the years. While weedy check (W_{10}) recorded the lowest weight and volume of onion bulb during both the years (Table 2). The superiority of all these yield attributing characters under W_5 or W_6 may be due to timely and effective control of broad spectrum of weeds in the critical stage of competition which reduce crop-weed competition for space, light, moisture and nutrients. However, treatment W_{10} had suppressing effect on onion crop because higher weed population and dry weight of weeds leads to more crop-weed competition for nutrients, space, light and water.

All the weed management treatments produced significantly higher bulb yield than weedy check. The highest onion bulb yield (39.33, 36.60 and 37.97 t/ha, respectively) were obtained under treatment W_5 (pendimethalin 1 kg/ha supplement with one hand weeding) followed by treatments W_6 and W_9 during both the years as well as in pooled analysis, respectively (Table 2). These because of the fact that the weed population and weed growth remain low from initial crop growth as compared to weedy check. The reduced crop-weed competition provide better environment for proper development of growth as well as and yield attributes, *viz.* bulb diameter, bulb volume and bulb weight, ultimately leading to the enhanced bulb yield. This might be due to proper weed management treatments controlled weeds effectively, reduced the competition from the weeds to a greater extent and thus helped in faster growth and development of onion bulb crop, resulting in obtaining higher values of all yield attributing characters. The findings are in closely vicinity of those reported by Warade *et al.* (2006) and Saraf (2007) with respect to onion yield.

Yield obtained from weed free treatment (W_9) was lower as compared to treatments W_5 and W_6 due to disturbance of shallow root system by repeated hand weeding, being narrow spacing crop, manual hand weeding also damaged the leaves and plant parts, ultimately reduced the photosynthetic actively of plants. This finding is in conformity with those of Singh *et al*. (2001).

Different levels of RDF significantly altered the bulb weight, volume of bulb and diameter of bulb thereby increased the yield of onion (Table 1). The data regarding bulb yield showed that F_3 (125%) levels of RDF proved their superiority by producing significantly higher bulb yield to tune of 19.43 and 10.52%, respectively over F_2 and F_1. The increase in bulb yield could be attributed to increase in equatorial diameter of bulb recorded with the same level (F_3) of fertilizer and thereby increase in average bulb weight and volume. The better development of almost all yield parameters under F_3 treatment ultimately resulted into higher bulb yield. Higher dose of N promoting growth parameters might be due to fact that the net assimilation rate of the N fed to plants was accelerated due to increase in chlorophyll content and the absorbed N helped in formation of food reservoir due to higher photosynthetic activity, which increases the diameter of bulb. Further, P also influences the cellular activity in the roots and leaves which resulted in to increased yield. Similarly, the increased in growth and yield attributes may be due to encourageous effect of potassium on root development, formation of carbohydrates, regulation of water and translocation of photosynthates (Singh *et al*. 2004). The results of present investigation are also in agreement with the findings reported by Jayathilake *et al*. (2002).

Nutrient removal by weed and crop

More quantum of nutrients were taken up by weeds resulting in the reduction of availability of nutrients to the crop, which adversely affected the crop growth by creating greater competition and finally the reduction in yield of onion bulb and this was evidenced from the poor yield obtained in weedy check (W_{10}). The result of nutrient removed by weeds and crop are presented in Table 4.

Nitrogen, phosphorus, potassium and sulphur content of onion bulb and weeds did not differ significantly due to different weed management practices during both the years. Contrary to this, significantly the lowest uptake of nitrogen, phosphorus, potassium and sulphur by weeds were noted under treatment W_5 (pendimethalin 1 kg/ha + one hand wedding at 40 DAT) and found on same bar with treatments W_6, W_9, W_3 and W_4 during both the years of

Table 1. Weed growth and weed control efficiency as influenced by weed management and fertilizer levels

Treatment	Weed population/m^2				Dry weight of weeds (g/m^2)				WCE (%)		WCI (%)	
	At 20 DAT		At 40 DAT		At 40 DAT		At harvest					
	08-09	09-10	08-09	09-10	08-09	09-10	08-09	09-10	08-09	09-10	08-09	09-10
Weed management												
W_1	2.3 (4.6)	2.3 (4.4)	5.6 (30.2)	5.8 (32.33)	10.7	11.5	42.7	67.7	51.8	46.3	15.0	13.1
W_2	2.7 (6.6)	2.6 (5.8)	5.5 (30.0)	6.2 (36.78)	11.0	13.7	51.8	76.8	41.6	39.1	17.1	16.5
W_3	2.4 (4.9)	2.2 (3.9)	5.5 (30.0)	5.7 (30.89)	10.5	11.0	23.9	38.9	73.0	69.1	2.5	5.3
W_4	2.5 (5.6)	2.4 (4.7)	5.7 (32.0)	5.7 (31.78)	11.5	11.6	28.1	40.1	68.3	68.2	2.7	6.2
W_5	2.2 (3.9)	2.1 (3.9)	5.6 (30.0)	5.5 (28.89)	10.5	10.7	17.2	32.2	80.6	74.5	-5.2	-4.2
W_6	2.4 (4.9)	2.4 (5.0)	5.7 (31.3)	5.9 (34.22)	11.1	12.5	23.6	35.9	73.4	71.5	-4.1	-1.7
W_7	7.9 (60.8)	9.0 (80.2)	7.5 (57.9)	8.4 (70.67)	19.8	24.5	63.7	91.8	28.2	27.2	3.0	8.2
W_8	8.0 (62.6)	9.3 (86.2)	7.3 (53.3)	8.8 (77.11)	18.2	27.0	55.5	85.5	37.3	32.2	11.7	16.5
W_9	7.9 (61.0)	9.3 (86.6)	7.5 (55.7)	8.6 (73.78)	19.6	26.0	25.5	37.7	71.2	70.1	-	-
W_{10}	8.1 (64.1)	9.4 (87.8)	10.2 (103.2)	11.9 (142.0)	32.6	44.9	88.6	126.1	-	-	36.7	52.0
LSD P=0.05)	0.41	0.63	0.67	0.54	3.51	107.87	3.21	125.52				
Fertilizer levels												
F_1	4.5 (27.4)	4.8 (33.3)	6.2 (39.10)	6.9 (50.2)	13.5	17.5	36.8	56.7				
F_2	4.5 (26.9)	5.1 (37.4)	6.5 (43.3)	7.3 (57.0)	14.7	19.5	42	64.8				
F_3	4.8 (29.4)	5.4 (39.9)	7.1 (53.7)	7.5 (60.3)	18.5	21.0	47.4	68.3				
LSD P=0.05)	0.23	0.35	0.36	0.30	1.92	1.76	59.08	68.75				

Data in parentheses indicate actual values and outside parentheses indicate ($\sqrt{X+1}$) transformed values

WCE: weed control efficiency, WCI: weed control index

W_1: Pendimethalin 1 kg/ha as pre-emergence, W_2: Oxyfluorfen 0.24 kg/ha as pre-emergence, W_3: Pendimethalin 1 kg/ha pre-emergence + fluazifop-p-butyl 0.25 kg/ha at 40 DAT, W_4: Oxyfluorfen 0.24 kg/ha pre-emergence + Fluazifop-p-butyl 0.25 kg/ha at 40 DAT, W_5: Pendimethalin 1 kg/ha pre-emergence + One hand weeding at 40 DAT, W_6: Oxyfluorfen 0.24 kg/ha pre-emergence + One hand weeding at 40 DAT, W_7: Hand weeding at 20 DAT + fluazifop-p-butyl 0.25 kg/ha at 40 DAT, W_8: Two hand weeding at 20 and 40 DAT, W_9: Weed free control (Hand weeding at 20, 40 and 60 DAT), W_{10}: Weedy check

F_1: 75% RDF (75:37.50:37.50, N:P_2O_5:K_2O kg/ha), F_2 : 100% RDF (100:50:50, N:P_2O_5:K_2O kg/ha), F_3 : 125% RDF (125:62.5:62.5, N:P_2O_5:K_2O kg/ha).

experimentation, except W_4 during second year. The highest uptake of nutrients, *viz.* N, P, K and S by weeds and lowest by crop were registered under treatment weedy check (W_{10}) because of maximum dry weight of weeds may be due to the higher weed population and continuous growth of weeds throughout crop period. Nutrients depletion was decreased with the adoption of weed control programme might be due to lower dry matter production.

In majority of the cases the different levels of RDF failed to produce any significant effect on macronutrient content (N, P, K and S) in weeds during both the years. On an average, uptake of major nutrients by weeds was found significantly and the highest and lowest value was noted under treatment F_3 and F_1, respectively. This was because increase in the rate of fertilizer simultaneously increased

Table 2. Yield attributes, yield and economics of onion bulb crop as influenced by weed management and fertilizer levels

Treatment	Volume of bulb (cm^3)		Diameter of bulb (cm)		Bulb yield (t/ha)			Net realization ($x10^3$ ₹/ha)	B:C ratio
	08-09	09-10	08-09	09-10	08-09	09-10	Pooled		
Weed management									
W_1	50.13	41.09	5.85	4.82	31.8	30.2	31.0	215.66	6.67
W_2	49.36	39.81	5.92	4.76	31.0	29.0	30.0	208.45	6.59
W_3	56.14	48.47	6.52	6.01	36.5	32.9	34.7	242.00	6.83
W_4	55.58	47.44	6.28	5.90	36.4	32.6	34.5	240.05	6.72
W_5	58.29	52.01	7.42	6.36	39.3	36.6	38.0	269.42	7.85
W_6	57.56	51.40	7.17	6.31	38.9	35.3	37.1	263.41	7.83
W_7	55.46	46.27	6.06	5.63	36.3	31.9	34.1	236.89	6.63
W_8	54.49	44.26	5.93	5.17	33.0	29.0	31.0	213.43	6.16
W_9	56.44	48.81	7.00	6.08	37.4	34.8	36.1	251.91	6.87
W_{10}	38.36	26.34	4.73	2.90	23.7	16.7	20.2	130.71	4.26
LSD P=0.05)	3.40	3.52	0.46	0.48	2.60	2.35	1.76		
Fertilizer levels									
F_1	50.19	38.75	5.66	4.82	31.9	27.9	29.9	206.32	6.28
F_2	53.47	44.91	6.36	5.41	34.1	30.5	32.3	224.86	6.69
F_3	55.88	50.10	6.85	5.95	37.3	34.2	35.7	251.32	7.31
LSD P=0.05)	1.86	1.93	0.25	0.26	1.42	1.29	0.94		

Table 3. Interaction effect of weed management and fertilizer levels on onion bulb yield (t/ha)

Fertilizer level	Weed management									
	W_1	W_2	W_3	W_4	W_5	W_6	W_7	W_8	W_9	W_{10}
Weight of bulb (g/bulb)										
2008-2009										
F_1	63.0	53.9	75.1	67.8	71.0	73.1	65.4	63.4	69.0	44.3
F_2	72.1	63.8	76.6	77.0	82.9	80.4	72.3	64.1	80.1	45.0
F_3	58.8	72.1	77.9	81.4	86.2	84.4	80.2	75.3	84.2	46.2
LSD (P=0.05)	8.46									
2009-2010										
F_1	56.5	48.0	68.9	61.4	64.7	67.3	59.4	57.4	61.8	38.3
F_2	66.1	57.8	70.3	71.0	76.6	74.4	66.3	58.2	72.8	39.0
F_3	52.8	65.9	71.7	75.4	80.2	78.0	73.8	68.8	77.1	40.2
LSD (P=0.05)	8.62									
Bulb yields (t/ha)										
2008-09										
F_1	31.47	26.54	35.86	33.34	33.57	36.34	33.10	31.57	33.59	23.60
F_2	27.74	29.67	36.48	36.21	41.24	39.38	36.92	31.27	38.63	23.26
F_3	36.14	36.73	37.03	39.52	43.19	41.04	38.77	36.20	39.92	24.09
LSD (P=0.05)	4.50									
2009-10										
F_1	28.63	25.42	32.80	29.93	31.48	31.24	28.01	26.12	28.92	16.59
F_2	27.91	27.69	32.23	32.48	38.47	36.47	32.13	27.01	36.17	16.17
F_3	34.13	34.02	33.71	35.38	40.09	38.31	35.58	33.92	39.18	17.30
LSD (P=0.05)	4.07									
Pooled										
F_1	30.05	25.98	34.33	31.63	32.52	33.79	30.55	28.84	31.26	20.10
F_2	27.83	28.68	34.35	34.34	39.86	37.93	34.53	29.14	37.40	19.72
F_3	35.14	35.37	35.37	37.45	41.64	39.67	37.17	35.06	39.55	20.70
LSD (P=0.05)	2.85									

Table 4. Nutrient uptake (kg/ha) by weed and crop as influenced by weed management and fertilizer levels

Treatment	2008-09				2009-10			
	N	P	K	S	N	P	K	S
Weeds								
Weed management								
W_1	4.70	0.86	5.57	2.22	7.47	1.42	8.98	3.62
W_2	5.67	1.05	6.67	2.70	8.56	1.61	10.16	4.07
W_3	2.70	0.50	3.18	1.26	4.33	0.79	5.28	2.11
W_4	3.14	0.57	3.71	1.47	4.53	0.82	5.38	2.17
W_5	1.98	0.37	2.32	0.94	3.76	0.69	4.42	1.74
W_6	2.69	0.50	3.16	1.29	4.13	0.77	4.94	1.92
W_7	7.04	1.32	8.52	3.39	10.29	1.90	12.56	5.06
W_8	6.00	1.13	7.19	2.99	9.22	1.77	11.28	4.59
W_9	2.85	0.54	3.44	1.39	4.21	0.80	5.12	2.07
W_{10}	9.69	1.77	11.26	4.62	13.89	2.55	16.57	6.72
LSD (P=0.05)	1.14	0.23	1.40	0.56	1.61	0.32	1.94	0.76
Fertilizer levels								
F_1	3.94	0.73	4.71	1.90	6.13	1.14	7.38	2.98
F_2	4.66	0.86	5.55	2.22	7.27	1.35	8.76	3.47
F_3	5.34	0.99	6.25	2.57	7.71	1.45	9.27	3.76
LSD (P=0.05)	0.62	0.13	0.77	0.31	0.88	0.18	1.06	0.41
Crop								
Weed management								
W_1	62.16	16.16	72.67	32.58	53.50	14.10	63.47	28.75
W_2	60.20	16.14	70.93	32.13	51.98	13.64	61.26	27.80
W_3	85.90	22.35	100.24	44.95	71.35	18.62	85.55	38.56
W_4	84.10	22.13	99.04	44.70	70.84	18.97	83.87	37.92
W_5	101.18	27.24	118.73	52.39	88.73	22.10	101.97	45.97
W_6	99.50	26.60	114.87	51.89	84.09	21.45	99.02	43.90
W_7	81.36	21.03	96.42	43.81	65.39	18.05	79.63	35.66
W_8	66.72	17.76	78.53	36.78	54.64	14.87	65.02	29.73
W_9	91.17	23.44	105.94	47.97	76.70	20.91	92.07	41.47
W_{10}	32.17	8.29	36.97	17.06	19.52	5.21	23.18	10.52
LSD (P=0.05)	11.70	3.11	11.18	5.80	10.11	3.31	11.91	5.51
Fertilizer levels								
F_1	63.26	16.57	74.07	32.66	50.81	13.02	60.15	26.99
F_2	76.88	20.18	90.15	40.35	64.17	16.95	75.94	34.13
F_3	89.19	23.60	104.07	48.27	76.05	20.40	90.42	40.95
LSD (P=0.05)	6.41	1.70	6.12	3.17	5.54	1.81	6.53	3.02

availability of these nutrients in soil solution, resulting in higher absorption of nutrients. Similarly, the higher levels of fertilizer application (125% RDF) exerted its superiority in recording the higher uptake of NPK and S by onion bulb crop as well as weeds during both years of experimentation.

Interaction effect

Significantly increased in onion bulb yield was observed with increasing levels of fertilizers applied to onion bulb crop coupled with weed management treatment of pre emergence application of pendimethalin at 1.0 kg/ha supplemented with one hand weeding at 40 DAT. On pooled basis, the treatment combination of W_5F_3 recorded higher onion bulb yield over rest of the treatment combinations except treatment combinations of W_6F_3, W_9F_3 and W_5F_2.

Post-harvest life

At 30, 60 and 90 days after harvest, the highest weight losses were observed with treatment W_5 but it did not differ statistically with treatments W_6, W_9, W_3 and W_4 at different stages of storage. The lowest weight loss was recorded with unwedded control (W_{10}) at all the storage stages during both the years (Table 5). Black mould development was found non significant due to weed management. Fertilizer levels did not altered post harvest life of onion bulb. In case of sprouting, there was no sprouting of onion bulb during storage period of both the years of investigation.

Table 5. Post-harvest losses of onion bulb as influenced by weed management and fertilizer levels

Treatment	Weight losses during storage (%)					
	2008-09			2009-10		
	30 DAH	60 DAH	90 DAH	30 DAH	60 DAH	90 DAH
Weed management						
W_1	11.46 (3.97)	13.87 (5.76)	14.71 (6.46)	13.40 (5.39)	16.33 (7.96)	20.48 (12.36)
W_2	11.54 (4.04)	13.95 (5.83)	14.78 (6.53)	13.48 (5.45)	16.44 (8.08)	20.64 (12.49)
W_3	12.66 (4.83)	14.91 (6.64)	15.70 (7.34)	14.48 (6.27)	18.10 (9.70)	21.81 (14.10)
W_4	12.28 (4.64)	14.62 (6.45)	15.43 (7.15)	14.16 (6.08)	17.54 (9.31)	21.98 (13.72)
W_5	12.99 (5.08)	15.25 (6.94)	16.02 (7.64)	14.82 (6.57)	18.59 (10.21)	22.50 (14.64)
W_6	12.70 (4.87)	15.00 (6.72)	15.79 (7.42)	14.57 (6.35)	18.19 (9.81)	21.67 (14.22)
W_7	10.59 (3.53)	13.27 (5.35)	14.16 (6.05)	12.79 (4.99)	15.13 (7.14)	19.74 (11.53)
W_8	11.33 (3.91)	13.79 (5.72)	14.64 (6.42)	13.28 (5.31)	16.19 (7.86)	20.29 (12.22)
W_9	12.53 (4.78)	14.84 (6.61)	15.64 (7.31)	14.39 (6.24)	17.93 (9.63)	22.17 (14.02)
W_{10}	10.77 (3.51)	13.27 (5.29)	14.14 (5.99)	12.76 (4.90)	15.29 (7.00)	19.70 (11.41)
LSD (P=0.05)	1.41	1.14	1.08	1.20	2.03	1.66
Fertilizer levels						
F_1	11.59 (4.10)	13.98 (5.88)	14.82 (6.58)	13.51 (5.51)	16.51 (8.20)	20.46 (12.60)
F_2	11.73 (4.23)	14.16 (6.04)	14.99 (6.74)	13.71 (5.68)	16.75 (8.51)	21.33 (12.92)
F_3	12.34 (4.62)	14.69 (6.47)	15.49 (7.17)	14.23 (6.08)	17.67 (9.31)	21.50 (13.70)
LSD (P=0.05)	NS	NS	NS	NS	NS	NS

Data in parentheses refer to actual per cent bulb weight losses, DAH - Days after harvestz
Black mould development (%) was not affected due to various treatments
In case of sprouting (%), there was no sprouting of onion bulb during storage period

Economicas

From the economics point of view, the highest net profit of ₹ 2,69,422/ha was obtained from treatment W_5 (pendimethalin 1 kg/ha + one hand weeding at 40 DAT) with CBR value of 7.85 followed by treatments W_6 (₹ 263410/ha) and W_9 (₹ 2,51,910/ha) with CBR values of 7.83 and 6.87, respectively.

Different levels of fertilizer produced significant effect on economics of onion and the maximum net return of ₹ 2,51,317/ha with B:C ratio of 7.31 were registered with treatment F_3 (125 % RDF). The 75 % RDF (F_1) treatment shows lowest monitory return and BCR (Table 1).

On the basis of interaction, maximum net realization and B: C ratio was recorded with W_5F_3 followed by W_6F_3, W_9F_3 and W_5F_2. Whereas, minimum net realization and B: C ratio was recorded with $W_{10}F_2$. It is inferred that the application of pendimethalin at 1.0 kg/ha followed by one hand weeding at 40 DAT and fertilized crop with 100:50:50 kg NPK/ha (100% RDF) treatment combination found most appropriate and profitable not only to secured the net return per unit cost of onion production but also save 25% of fertilizer.

The result of the study undertaken to find out the effective weed and fertilizer management strategies in onion bulb crop revealed that pre-emergence application of either pendimethalin at 1.0 kg/ha or oxyfluorfen at 0.24 kg/ha supplement with one hand weeding at 40 days after transplanting prove efficient weed management strategies. Further, application of fertilizer at 125:62.5:62.5 kg NPK/ha gave higher and profitable onion bulb yield.

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Movement of pendimethalin in saturated and unsaturated conditions in clay loam and sandy loam soils

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ABSTRACT

Movement studies were carried out using packed soil columns to know the distribution pattern of pendimethalin in clay loam and sandy loam under saturated and unsaturated conditions. Pendimethalin was applied at 20 mg/kg of soil and the soil columns were kept for movement studies at time intervals of 1, 3, 5, 7, 15, 22 and 37 days. The soils used in the study were clay loam and sandy loam. Pendimethalin remained primarily in the top soil layers. Under saturated conditions movement of pendimethalin was more in sandy loam as compared to clay loam. Under unsaturated conditions, pendimethalin showed more mobility in clay loam. The increase in herbicide movement was observed with increase in days. The factors that influence movement are the herbicide solubility, soil structure and texture and the amount of water passing through the soil profile influenced movement of herbicide. Pendimethalin moved up to 20-25 and 5-20 cm under unsaturated and saturated conditions at 37 days after application, respectively. In clay loam soil, under saturated and unsaturated conditions, pendimethalin moved up to 15-20 cm at 37 days after application.

Key words: Herbicide, Movement, Pendimethalin, Soil conditions

Movement of herbicide with water through soil profile also needs attention as herbicide leaching through soils may move to the root zone of sensitive non target crop resulting in crop injury besdes reducesing herbicide efficacy. The movement of herbicides in soil is an important process that determines their fate in both soil and aquatic environments. Herbicide leaching through soil may (a) move to the root zone of sensitive non target crop resulting in crop injury (b) move below the root zone thus reducing herbicidal efficacy and (c) may result in herbicidal transport to the ground water causing contamination (Jorden and Harvey 1980, Obrigawitch *et al.* 1981).The factors that influence movement are the herbicide solubility, soil structure and texture and the amount of water passing through the soil profile (Raj *et al*. 2003). Studies on the herbicide mobility can be done in soil columns (Weber and Whitacre 1982), and in the laboratory by using soil leaching column (Dovidson and Santetman 1968, Weber *et al.* 1986), soil thick layer trays (Gerber *et al.* 1970 Wu and Scentelman 1975) and soil thin layer chromatography plates (Helling and Turner 1968).

Pendimethalin [N-(1-ethylpropyl)–3,4-dimethyl-2,6-dinitrobenzenamine] is a selective herbicide, used as pre-emergence application for control of most of the annual grasses and broad-leaved weeds in most of the vegetables in Andhra Pradesh. But the information on movement of this herbicide is meager. Hence, present study was conducted in laboratory to understand the mobility of pendimethalin in clay loam and sandy loam soils under saturated and unsaturated conditions.

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MATERIALS AND METHODS

Samples of clay loam and sandy loam soils (0.25 mm sieved) were used for movement study of pendimethalin. The study was conducted by taking soil columns as described by Harris (1996). An acrylic plastic tube of 5.5 cm internal diameter was used and sliced into 1 cm and 2 cm height rings. These rings were joined leak proof with the help of tape to get total height of 30 cm. These columns were filled with 4.50 kg soil up to 28 cm against the total height of 30 cm. The height of 2 cm served as water reservoir for addition of water. The column was closed at bottom with muslin cloth. Then herbicide was applied to top 1 cm. Then column was placed in a tray of water for saturation. Saturation from bottom will avoid air trapping pores thereby, forming pockets that may obstruct water movement.

The columns were packed by taking 100 g of soil sample increments and by gentle tapping of the material. These were kept in tray for saturation, after saturation the excess water was allowed to drain off by keeping them overnight at room temperature. Unsaturated conditions were maintained by keeping the soil moisture content at its field capacity (36% for clay loam and 28% sandy loam soils). After saturating the column with water, herbicide was applied in top 1 cm of the soil column. Herbicide solution was prepared by dissolving the herbicide in methanol to give a concentration of 20 ppm for the entire weight of soil sample in the column. The columns were flooded with 1 cm water throughout the period of 1, 3, 5, 7, 15, 22 and 37 days. At each interval, column was removed and placed on smooth surface and with the sharp blade, the column was separated by removing the cello tape from the ring joints. After cutting the tape, the ring was gently sided from the column along with the soil taking care that the soil in lower ring did not get disturbed or lost. Then each ring was placed in moisture box, weighed again and dried for determination of moisture content. Before weighing, 25 g of sample from each segment was used for extraction of herbicide. Methanol was used as an extractant. Extraction was performed by shaking the soil with methanol for half an hour. 25 ml of methanol was used in each extraction and then filtered. The filtrate was made up to 50 ml with methanol. Pendimethalin concentrations in the extractant were determined using UV–Visible Spectrophotometer (GS 5701) at 420 nm.

RESULTS AND DISCUSSION

The pH of sandy loam and clay loam soil was 7.71 and 7.82, respectively. The pendimethalin moved up to 5–10 cm and the amount of pendimethalin extracted at this depth was 0.72 mg in sandy loam soil after 24 h of leachingin saturated conditions. At three days after leaching pendimethalin moved up to 10–15 cm and the amount extracted at this depth was 0.65 mg. At 5th, 7th and 15th day after leaching, pendimethalin moved up to 15-20 cm and the amount extracted was 0.66, 0.66 and 0.96 mg, respectively. The herbicide moved up to to 20-25 cm by 22nd day and the extracted amount of pendimethalin was 0.85 mg. At 37th day after leaching, 0.62 mg of pendimethalin was extracted at a depth of 20-25 cm. No pendimethalin was extracted at a depth of 25–30 cm at 37th day (Table 1).

In a clay loam after 24 hrs and 3 days of leaching under saturated conditions, pendimethalin moved up to 5–10 cm and the amount extracted was 0.58 and 0.68 mg respectively. At 5th, 7th, 15th and 22nd day after leaching, pendimethalin moved up to 10 -15 cm, and the amount extracted was 0.66, 0.64, 0.96 and 1.46 mg, respectively. At 37th day after leaching, herbicide moved up to 15-20 cm in soil column and the extracted amount was 0.92mg. There was no movement of pendimethalin at 20-25 cm and 25–30 cm of depth through out the study. Hence, it was inferred that distribution of leaching was higher in upper layers and decreased uniformly with depth (Table 2).

Table 1. Amount of pendimethalin extracted (mg) at different depths and different days of leaching in sandy loam under saturated conditions

Depth (cm)	Days						
	1	3	5	7	15	22	37
0-5	2.03	2.20	2.26	2.51	3.16	3.64	4.01
5-10	0.72	0.96	1.24	1.27	2.66	2.85	3.37
10-15	-	0.65	0.85	0.94	1.40	1.55	2.14
15-20	-	-	0.66	0.66	0.96	1.20	1.63
20-25	-	-	-	-	-	0.85	0.62
25-30	-	-	-	-	-	-	-

Table 2. Amount of pendimethalin extracted (mg) at different depths and different days of leaching in clay loam under saturated conditions

Depth (cm)	Days						
	1	3	5	7	15	22	37
0-5	1.85	2.16	2.26	2.58	2.98	3.28	3.68
5-10	0.58	0.68	0.84	1.36	1.88	2.24	2.44
10-15	-	-	0.66	0.64	0.96	1.46	1.68
15-20	-	-	-	-	-	-	0.92
20-25	-	-	-	-	-	-	-
25-30	-	-	-	-	-	-	-

Under unsaturated conditions, the leaching of pendimethalin in sandy loam after 24 hrs and 3 days of leaching was up to 5–10 cm, and the amount of pendimethalin extracted was 0.54 and 0.68 mg, respectively. Pendimethalin moved up to 10–15 cm and the amount extracted was 0.58 mg at 5th day after leaching. At 7th, 15th, 22nd and 37th day after leaching, pendimethalin moved up to 15–20 cm and the amount extracted was 0.82, 0.86, 0.89 and 0.91 mg, respectively. There was no movement of pendimethalin at a depth of 20-25 cm and 25-30 cm (Table 3).

Under unsaturated conditions the leaching of pendimethalin in a clay loam, at 24 h and 3 days after leaching pendimethalin was moved up to 5–10 cm and the amount of pendimethalin extracted was 0.63 and 1.46 mg respectively. At 5th, 7th and 15th day after leaching, pendimethalin was moved up to 10–15 cm and the amount

Table 3. Amount of pendimethalin extracted (mg) at different depths and different days of leaching in Sandy loam under unsaturated conditions

Depth (cm)	Days						
	1	3	5	7	15	22	37
0-5	1.46	1.80	2.05	2.19	2.64	3.12	3.45
5-10	0.54	0.68	1.06	1.28	1.36	1.96	2.41
10-15	-	-	0.58	0.86	0.92	1.13	1.28
15-20	-	-	-	0.82	0.86	0.89	0.91
20-25	-	-	-	-	-	-	-
25-30	-	-	-	-	-	-	-

Table 4. Amount of pendimethalin extracted (mg) at different depths and different days of leaching in clay loam under unsaturated conditions

Depth (cm)	Days						
	1	3	5	7	15	22	37
0-5	2.08	2.48	2.88	3.04	3.28	3.64	3.88
5-10	0.63	1.46	1.56	1.66	1.85	2.15	2.65
10-15	-	-	0.77	0.97	1.57	1.65	1.97
15-20	-	-	-	-	-	0.92	1.58
20-25	-	-	-	-	-	-	-
25-30	-	-	-	-	-	-	-

extracted was 0.77, 0.97 and 1.57, respectively. At 22nd and 37th day after leaching, pendimethalin moved up to 15-20 cm, and the amount of pendimethalin extracted was 0.92 mg and 1.58 mg, respectively (Table 4). There was no movement of pendimethalin below 20 cm depth. It was observed that amount of pendimethalin extracted in Clay loam under unsaturated conditions was more where compared to saturated conditions.

It was evident that herbicide movement depends on soil properties and water content. In saturated conditions in sandy loam at 37 days after application, pendimethalin moved up to 20-25 cm while it moved only up to 15-20 cm in unsaturated conditions. In clay loam, under saturated conditions, pendimethalin moved up to 15-20 cm and under unsaturated conditions, it moved up to 15-20 cm at 37 days after application. Similar findings were also reported by Raj *et al.* (2003) and Devi *et al.* (2000). In contrast to the results under saturated conditions, the movement of herbicide under unsaturated conditions was more in case of clay loam. It was also reported that water movement and herbicide movement was greater in fine textured soil than in coarse textured soils under nsaturated flow conditions (Goetz *et al.* 1986, Madhuri 2003). Negative correlation of movement of pendimethalin with depth (r=-0.981) and a positive and significant correlation

Table 5. Correlation and regression coefficient for movement of pendimethalin under saturated and unsaturated conditions in clay loam and sandy loam soils

Treatment	ClaylLoam		Sandy loam	
	Saturated	Unsaturated	Saturated	Unsaturated
Correlation coefficient				
Time (days)	0.880	0.852	0.932	0.976
Depth (cm)	-0.982	-0.978	-0.991	-0.981
Regression coefficient				
Time (days)	0.775	0.726	0.869	0.953
Depth (cm)	0.964	0.957	0.991	0.963

(r=0.880) with time (days) was observed under saturated condition in clay loam soil. Similarly under unsaturated conditions, negative correlation of movement of pendimethalin with depth (r=-0.978) and a positive and significant correlation (r=0.851) with time (days) was observed (Table 5).

In sandy loam soil under saturated conditions, negative correlation of movement of pendimethalin with depth (r=-0.995) and a positive and significant correlation (r=0.932) with time (days) was observed. Similarly under unsaturated conditions, negative correlation of movement of pendimethalin with depth (r=-0.984) and a positive and significant correlation (r=0.976) with time (days) was observed (Table 5).

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Effect of chemical and mechanical weed management on yield of French bean–sorghum cropping system

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ABSTRACT

A field experiment was conducted during *2003-04* and *2004-05* to develop an effective weed management practice to study the effect of weed management practice in French bean cropping system under subtropical agro-ecosystems of western Uttar Pradesh. Pre-planting and pre-emergence application of fluchloralin 1.0 kg/ha and pendimethalin 1.0 kg/ha reduced the population of *Anagallis arvensis*, *Melilotus alba*, *Melilotus indica* and *Phalaris minor* significantly than weedy check and other herbicide treatments and resulted significant increase in growth and yield attributes, *viz.* plant height, no. of branches, dry matter accumulation, no. of pods/plant and seeds/pod, seed and straw yield of french bean. Maximum yield was recorded in fluchloralin 1.00 kg/ha and pendimethalin 1.00 kg/ha treatments with a corresponding value of 1.11 and 1.11 t/ha of French bean and 37.1 and 36.2 t/ha of fodder sorghum during both the years of experimentation. Application of fluchloralin 1.0 kg/ha and pendimethalin 1.0 kg/ha increased the net return of French bean significantly over weedy check, besides at B: C. ratio of 1.18 and 1.12 during two cropping seasons.

Key words: Cropping system, Economics, Fodder sorghum, French bean, N uptake, Weed management

French bean (*Phaseolus vulgaris* L.) is an important and highly profitable crop in hilly tracts of Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh and parts of Maharashtra as a *Kharif* season crop due to its specific adaption to a cool and long growing season (*Tripathi et al.* 1986*)*. It occupies an important position among various *Kharif* pulses crops grown in temperate hills of India. In north-eastern plains of India, this has been introduced as non–traditional winter season crop. . The initial growth rate of French bean is slow and the inter-spaces are infested with weeds. The losses in general, due to weed depend on composition of weed flora, extent of infestation and the crop canopy, but it has been estimated that losses due to weeds alone can reduce the yield to the tune of 20-60 per cent. To keep the weeds within a desirable limit, various methods which include physical, mechanical, chemical and biological are in use and among these methods, control of weeds through herbicide use is not only efficient method but is easily adopted by farmers. French bean–sorghum is one of the most prevalent cropping systems and sorghum being the important *Rabi* fodder crop in Uttar Pradesh is generally grown in a sequence with French bean.

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MATERIALS AND METHODS

A field experiment was conducted at the Research Farm, Janta Vedic College Baraut, Baghpat during *Rabi 2003-04* and *2004-05*. The soil of the experimental field was sandy loam in texture, slightly alkaline in reaction, low in organic carbon (0.35%) and available nitrogen (235 kg/ha) and was medium in available phosphorus (13.2 kg/ha) and potassium (260.2 kg/ha). French bean variety '*PDR-14*' was sown in 30 cm inter row and 10 cm intra row spacing on 25^{th} of October during both the years of experimentation using 120 kg seed/ha. Recommended doses of 120 kg N, 60 kg P_2O_5 and 50 kg K_20 were uniformly applied to all the treatments. Full dose of P and K and half dose of N were applied as basal at the time of sowing and rest half of the N total as per treatment was applied before second irrigation at 47 DAS. The experiment of 12 treatments comprising of weedy check, hand weeding at 30 DAS, weed free, fluchloralin 0.75 kg/ha, fluchloralin 1.0 kg/ha, fluchloralin 0.75 kg/ha with hand weeding at 30 DAS, pendimethalin 0.75 kg/ha, pendimethalin 1.0 kg/ha, pendimethalin 0.75 kg/ha with hand weeding at 30 DAS, oxyfluorfen 0.15 kg/ha, oxyfluorfen 0.20 kg/ha, oxyfluorfen 0.15 kg/ha with hand weeding at 30 DAS and were arranged in a randomized block design with three replications. Herbicide treatments were applied pre–planting and pre–emergence with the help of knapsack sprayer fitted with flat fan T-jet nozzle at a spray volume of 500 litre. In weed free plots, weeds were removed manually.

RESULTS AND DISCUSSION

Floristic composition

The experimental field was infested with weeds as well as sedges. The dominant weeds in French bean were *Anagallis arvensis*, *Melilotus alba*, *Melilotus indica* and *Phalaris minor.* The Sorghum crop in weedy check plot was *Cynodon dactylon*, *Alternanthera* sp., *Cyperus iria etc*.

Weed biomass

Weeds population was significantly affected in French bean by different weed management practices. During first year, fluchloralin 1.0 kg/ha and pendimethalin 1.0 kg/ha were comparable for weed population and these were significantly superior over weedy check and application of hand weeding at 30 DAS treatments. Dry matter of weeds was minimum (3.84 g/m^2) with fluchloralin 1.0 kg/ha due to higher weed control efficiency (80.48 %) But during second year, dry matter of weed was lowest (3.34 g/m^2) with fluchlorlin kg/ha closely followed by pendimethalin 1.0 kg/ha in ascending order, respectively (Table 1). All these treatments were significantly superior to weedy check due to their higher weed control efficiencies. There was no impact of treatments applied on weed dry matter accumulation in sorghum crop during both years.

Yield

Fluchloralin 1.0 kg/ha produced taller plant closely followed by pendimethalin 1.0 kg/ha as compared to weedy check. The superiority of fluchloralin 1.0 kg/ha and pendimethalin 1.00 kg/ha at 90 DAS in term of shoot height might have accrued to increase (Table 2). These results were akin to Mishra *et al.* (1998). Similarly, dry matter production was the result of growth characters, *viz.* plant height, no. of branches/plant and leaf area index. The highest dry matter and maximum yield was recorded in fluchloralin 1.0 kg/ha (1.11 and 0.97 t/ha) and pendimethalin 1.0 kg/ha (1.11 and 0.96 t/ha) during both the crop seasons. Since no weed was observed in both treatments which may have resulted in increased nutrient, water, space and light supply to the French bean crop due to no crop-weed competition thereby resulting in more photosynthesis and hence better translocation of photosynthates besides larger sink and stronger reproductive in weed control treatments have reported by Dhanapal *et al*. (1989) and Rao *et al.* (1997). Application of weed control measures in preceding French bean crop affected plant height and dry matter yield/plant of succeeding fodder sorghum in both the years. Similarly, different treatments applied in preceding French bean failed to cause significant variation in green fodder yield of fodder sorghum crop in both the years (Table 3). Maximum equivalent yield by system of French bean was recorded with fluchloralin 1.00 kg/ha (3.76 and 4.06 t/ha) and pendimethalin 1.00 kg/ha (3.74 and 3.98 t/ha) than weedy check treatments.

N uptake

The availability of nitrogen, space, light and water to French bean crop due to absence of crop-weed competition, provided a favorable environment for growth and development of the crop. The herbicide fluchloralin 1.00 kg/ha and pendimethalin 1.0 kg/ha significantly affected

Table 1. Effect of various treatments on dry matter of weeds in French bean and sorghum at 60 DAS.

Treatment	Dry matter of weeds (g/m^2) in French bean		WCE (%)	Dry matter of weeds (g/m^2) in sorghum		WCE (%)
	2003-04	2004-05		2003-04	2004-05	
Weedy check	18.48(4.36)	16.58(4.13)	-	17.19(4.20)	20.11(4.54)	-
Hand weeding at 30 DAS	14.24(3.84)	12.21(3.56)	24.6	8.49(3.00)	11.49(3.46)	46.4
Weed free	0.00(0.71)	0.00(0.71)	100.0	4.04(2.13)	4.68(2.27)	76.6
Fluchloralin 0.75 kg/ha	6.98(2.73)	5.92(2.53)	63.2	4.72(2.28)	5.23(2.39)	73.3
Fluchloralin 1.00 kg/ha	3.84(2.08)	3.34(1.88)	80.5	4.29(2.19)	4.73(2.29)	75.8
Fluchloralin 0.75 kg/ha + HW 30 DAS	4.98(2.34)	4.16(2.16)	73.9	4.47(2.23)	4.98(2.34)	74.7
Pendimethalin 0.75 kg/ha	7.62(2.85)	6.13(2.57)	60.8	4.40(2.21)	5.47(2.44)	73.5
Pendimethalin 1.00 kg/ha	4.03(2.13)	3.55(2.01)	78.4	4.11(2.15)	5.04(2.35)	75.5
Pendimethalin 0.75 kg/ha + HW 30 DAS	5.65(2.48)	4.78(2.30)	70.2	4.29(2.19)	5.29(2.41)	74.3
Oxyfluorfen 0.15 kg/ha	8.84(3.06)	7.08(2.75)	54.6	4.63(2.26)	5.53(2.45)	72.7
Oxyfluorfen 0.20 kg/ha	5.89(2.53)	5.14(2.37)	68.5	4.22(2.17)	5.09(2.36)	75.0
Oxyfluorfen 0.15 kg/ha + HW 30 DAS	6.38(2.62)	5.61(2.47)	65.8	4.39(2.21)	5.29(2.41)	74.0
LSD (P=0.05)	0.20	0.31	4.3	NS	NS	NS

Table 2. Growth attributes of French bean at 90 DAS as influenced by various herbicides

Treatment	Plant height (cm)		No. of branches/plant		Dry matter accumulation/plant (g)		Stover yield (t/ha)	
	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05
Weedy check	20.7	19.5	4.19	4.00	7.2	6.9	1.09	1.03
Hand weeding at 30 DAS	23.1	22.2	4.83	4.75	7.4	7.0	1.13	1.12
Weed free	27.5	27.2	6.53	6.44	10.0	10.0	1.60	1.58
Fluchloralin 0.75 kg/ha	24.5	24.4	5.14	5.00	7.6	7.2	1.26	1.22
Fluchloralin 1.00 kg/ha	26.8	26.6	6.11	6.05	10.0	9.9	1.58	1.56
Fluchloralin 0.75 kg/ha + HW 30 DAS	25.0	25.5	5.62	5.89	9.7	9.6	1.50	1.49
Pendimethalin 0.75 kg/ha	24.6	24.7	5.27	5.53	8.3	7.9	1.26	1.23
Pendimethalin 1.00 kg/ha	25.7	26.3	6.05	5.98	10.0	9.9	1.58	1.56
Pendimethalin 0.75 kg/ha + HW 30 DAS	25.0	25.4	5.58	5.78	9.7	9.6	1.50	1.49
Oxyfluorfen 0.15 kg/ha	23.1	24.4	5.47	5.47	7.5	7.1	1.18	1.13
Oxyfluorfen 0.20 kg/ha	24.9	25.2	5.44	5.55	8.5	8.1	1.48	1.46
Oxyfluorfen 0.15 kg/ha + HW 30 DAS	23.2	25.1	5.35	5.47	8.6	8.2	1.29	1.26
LSD (P=0.05)	1.86	1.28	0.54	0.32	0.98	1.05	0.94	0.92

Table 3. Effect of different weed control treatments on yield of French bean, sorghum and French bean equivalent yield of system

Treatment	Yield (t/ha)		Green fodder yield (t/ha)		French bean equivalent yield of system (t/ha)	
	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05
Weedy check	0.64	0.43	26.87	33.62	2.88	3.23
Hand weeding at 30 DAS	0.67	0.49	29.85	35.63	3.16	3.46
Weed free	1.13	0.99	31.95	36.95	3.79	4.07
Fluchloralin 0.75 kg/ha	0.86	0.65	30.25	35.27	3.38	3.59
Fluchloralin 1.00 kg/ha	1.11	0.97	31.76	37.15	3.76	4.06
Fluchloralin 0.75 kg/ha + HW 30 DAS	0.95	0.78	31.03	34.26	3.53	3.63
Pendimethalin 0.75 kg/ha	0.85	0.65	30.36	34.96	3.38	3.56
Pendimethalin 1.00 kg/ha	1.11	0.96	31.54	36.24	3.74	3.98
Pendimethalin 0.75 kg/ha + HW 30 DAS	0.94	0.77	30.65	35.48	3.50	3.72
Oxyfluorfen 0.15 kg/ha	0.69	0.51	29.82	33.55	3.18	3.30
Oxyfluorfen 0.20 kg/ha	0.91	0.72	30.62	34.57	3.46	3.60
Oxyfluorfen 0.15 kg/ha + HW 30 DAS	0.86	0.66	30.05	33.84	3.37	3.48
LSD (P=0.05)	1.08	0.78	NS	NS	1.84	2.17

Table 4. Total N uptake (kg/ha) of French bean, sorghum and system as influenced by various herbicides at harvest

Treatment	Total N uptake of French bean (kg/ha)		Total N uptake of sorghum (kg/ha)		Total N uptake of system (kg/ha)	
	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05
Weedy check	22.6	17.5	70.1	76.6	92.6	94.1
Hand weeding at 30 DAS	27.8	22.5	83.3	87.8	111.1	110.3
Weed free	58.7	52.9	94.9	98.0	153.5	151.0
Fluchloralin 0.75 kg/ha	38.5	31.8	84.3	89.0	122.7	120.8
Fluchloralin 1.00 kg/ha	55.9	49.9	90.4	95.7	146.3	145.6
Fluchloralin 0.75 kg/ha + HW 30 DAS	46.1	40.1	86.7	91.3	132.8	131.3
Pendimethalin 0.75 kg/ha	38.0	31.5	83.9	87.8	121.9	119.3
Pendimethalin 1.00 kg/ha	55.3	49.7	90.1	94.7	145.5	144.4
Pendimethalin 0.75 kg/ha + HW 30 DAS	45.4	39.8	86.6	91.6	132.0	131.3
Oxyfluorfen 0.15 kg/ha	34.3	25.0	82.7	84.8	117.0	109.8
Oxyfluorfen 0.20 kg/ha	43.3	37.0	89.6	90.9	133.0	127.9
Oxyfluorfen 0.15 kg/ha + HW 30 DAS	39.7	32.8	85.7	87.7	125.4	120.5
LSD (P=0.05)	3.3	3.8	NS	NS	10.0	12.1

Table 5. Relative economics of different weed control treatments in French bean

Treatment	2003-04			2004-05		
	Cost of cultivation (x10^3 ₹/ha)	Net returns (x10^3 ₹/ha)	B:C ratio	Cost of cultivation (x10^3 ₹/ha)	Net returns (x10^3 ₹/ha)	B:C ratio
Weedy check	22.09	6.61	0.30	22.09	2.55	0.11
Hand weeding at 30 DAS	23.14	6.96	0.30	23.14	3.97	0.17
Weed free	26.29	24.37	0.93	26.29	23.59	0.90
Fluchloralin 0.75 kg/ha	22.69	15.82	0.70	22.69	11.89	0.52
Fluchloralin 1.00 kg/ha	22.94	27.09	1.18	22.94	25.77	1.12
Fluchloralin 0.75 kg/ha + HW 30 DAS	23.74	18.91	0.80	23.74	16.47	0.69
Pendimethalin 0.75 kg/ha	23.08	15.25	0.66	23.08	11.41	0.49
Pendimethalin 1.00 kg/ha	23.43	26.43	1.13	23.42	25.11	1.07
Pendimethalin 0.75 kg/ha + HW 30 DAS	24.13	18.34	0.76	24.13	15.67	0.65
Oxyfluorfen 0.15 kg/ha	23.14	8.00	0.34	23.14	4.88	0.21
Oxyfluorfen 0.20 kg/ha	23.19	17.84	0.73	23.19	13.63	0.59
Oxyfluorfen 0.15 kg/ha + HW 30 DAS	24.19	14.69	0.61	24.19	10.58	0.44

the maximum total nitrogen uptake (55.95 and 49.95 kg/ha) and (55.3 and 49.7 kg/ha) by seed and stover in French bean crop than weedy check at harvest. Weed control measures had non-significant improvement in nitrogen uptake by succeeding fodder crop during both the years. Maximum N-uptake (kg/ha) by system (kg/ha) was recorded with fluchloralin 1.0 kg/ha (146.3 and 145.6 kg/ha) and pendimethalin 1.0 kg/ha (145.4 and 144.4 kg/ha) as comparable to other weed control treatments during both the years (Table 4).

Economics

The variables like seed, fertilizer and weed management were considered as cash inputs for the demonstrations as well farmers practice. Economic returns as a function of seed yield and sale price varied during different years. More returns during 2003-04 were obtained due to higher sale price and higher seed yield. The maximum gross returns ₹ 50,040 per hectare and 49,860 per hectare and net returns of ₹ 27,095 per hectare and ₹ 26,432 per hectare was recorded with fluchloralin 1.00 kg/ha and pendimethalin 1.00 kg/ha and the highest B.C. ratio of 1.18 and 1.13 was recorded with fluchloralin 1.00 kg/ha and pendimethalin 1.00 kg/ha (Table 5). This show that French bean is more responsive towards the inputs use and under good management and it can give even higher returns.

Thus, the result of two year study clearly indicated that weed management treatments in French bean crop by fluchloralin 1.00 kg/ha and pendimethalin 1.00 kg/ha treatments were recording higher productivity and profitability of French bean

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Effect of plant population and weed management practices on productivity of sweet corn

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ABSTRACT

Experiment was carried out under heavy black clay soil (vertisol) at the Experimental Farm, N.M. College of Agriculture, Navsari Agricultural University, Navsari during two successive seasons of 2007-08 and 2008-09 to study the effect of varying plant population and weed management practices on weed flora and productivity of sweet corn (*Zea mays* L. Saccharata). Weed density and biomass was significantly lower with crop population of 1,11,111 plants/ha. Significantly higher green cob (9.5 t/ha) and green fodder (14.9 t/ha) yield with net return (₹ 75,779/ha) and benefit: cost ratio (5.36) was produced with plant population of 1,11,111 plants/ha and was at par with crop population of 83,333 plant/ha. Significantly lowest weed biomass was recorded in weed free check which recorded highest yield of green cob (10.7 t/ha) and fodder (17.1 t/ha). Application of atrazine 1 kg/ha + hand weeding at 40 days after sowing was remunerative with higher net return (₹ 88,873/ha) and benefit: cost ratio (6.72).

Key words: Atrazine, Hand Weeding, Pendimethalin, Plant population, Sweet corn

Sweet corn is gradually becoming an important vegetable crop in India, as it forms a useful ingredient in the preparation of salad and other food ingredient both at home and in hotels. To augment higher crop yield per unit area, proper plant density and weed management are the most important factors which cause marked effect on the growth and eventually the yield of a crop. Determining sweet corn plant population response is a recurrent area of study but it is very inconsistent across different environment and management practices. A detailed analysis of effect of plant population density on sweet corn does not exist in the pre-reviewed literature. While numerous authors have examined various aspects of population-mediated effects in field corn (Stanger and Lauer 2006), This type of information has little application to sweet corn because of the many different genes that affect all phases of plant growth, the different crop production practices used, and the different traits that are important to yield and marketability (Azanza *et al.* 1996).

Further, weed causes huge losses, and the magnitude of losses largely depends upon the composition of weed flora, period of crop-weed competition and its intensity. The season-long weed competition caused considerable yield losses in maize (Dalley *et al*. 2006). Weeds reduce crop yield by competing for light, water, nutrients and carbon dioxide, interfere with harvesting and increase the cost involved in crop production (Oerke 2005). If weed growth is minimized during critical period of crop-weed competition, the yield can be equivalent to that of weed free yield. Considering the above facts and views, the present experiment is planned to study the effect of plant population and weed management on sweet corn (*Zea mays* L. *saccharata*) production.

MATERIALS AND METHODS

The study was conducted at Instructional Farm, Navsari Agricultural University, Navsari situated between 20º 57' N latitude, 72º 54' E longitude and has an altitude of about 10 m to study effect of crop population and weed management practices on weed flora and sweet corn yield. The soil was clay in texture having 7.4 pH, 0.50% organic carbon, low in available nitrogen (165 kg/ha) and available phosphorus (31.6 kg/ha) and rich in potassium (372 kg/ha). The study involved twenty-four treatment combinations consisting of three plant populations, *viz.* 1,11,111 plants/ha, 83,333 plants/ha and 74,074 plants/ha and eight weed management practices, *viz.* weedy check, weed free check (three hand weeding at 20, 45 and 60 days after sowing), atrazine 1 kg/ha as pre-emergence, atrazine 1 kg/ha as pre-emergence + HW at 40 DAS, pendimethalin

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1 kg/ha as pre-emergence, pendimethalin 1 kg/ha as pre-emergence + HW at 40 DAS, atrazine 0.50 kg/ha + pendimethalin 0.25 kg/ha as pre-emergence by tank mixture and hand weeding at 20 DAS + inter culturing at 40 DAS. The experimental plots were 3.6 m wide and 4.2 m long, laid out according to factorial randomized block design with each treatment replicated three times. Sowing was done manually. '*Madhuri*' sweet corn variety was used. Seeds were treated with Thiram 3 g/kg of seeds and sown evenly. The crop was fertilized with recommended dose of fertilizer (120:40:00 kg $N:P_2O_5:K_2O$ kg/ha). The shallow furrows were opened manually in each plot as per treatments and entire quantity of phosphorous (40 kg P_2O_5/ha) in the form of single super phosphate and 50% dose of nitrogen (60 kg N/ha) in the form of urea were manually applied uniformly before sowing of sweet corn crop in both the years. Remaining 50% nitrogen (60 kg N/ha) in the form of urea was applied at 30 days after sowing when irrigation was applied. The package of recommended practices was adopted to maintain the crop. After sowing, immediately a light irrigation was given to the crop for uniform germination and next day the herbicide was spray according to treatment. All the herbicides were applied as pre emergence using knapsack sprayer fitted with flat fan nozzle using in 500 litre water/ha. Data on weeds population were recorded 20 days after sowing. The observations of weed density and their dry matter were taken randomly from 1.0 m^2 quadrate from net plot area from each treatment. Same were harvested and then oven dried for 48 hours at 70^0C.

To calculate the cost of weed control, the cost of each treatment was determined and then compared with each other according to the prevailing market prices of maize grains. Data on weed density and dry weight was subjected to square root transformation before analysis. Treatment effects in both years were same so pooled analysis of data was made. The data were statistically analyzed using MSTATC software. The purpose of analysis of variance was to determine the significant effect of treatments on weeds and maize. LSD test at 5% probability level was applied when analysis of variance showed significant effect for treatments (Steel and Torrie 1980).

RESULTS AND DISCUSSION

Weed flora

The predominant weed flora of the weedy plot included : *Echinochloa crusgalli* and *Cynodon dactylon* among monocot, *Cyperus rotundus* among sedges, and *Amaranthus viridis, Digera arvensis, Portulaca oleracea, Alternenthara sessili* and *Trianthema* sp. among dicot weeds during both the years of investigation.

Effect on weeds

Lower weed density was observed under plant population of 1,11,111 plant/ha (Table 1). Similar trend was followed in case of weed biomass at harvest. However, significantly higher weed density and biomass were recorded with plant population of 74,074 plant/ha. This might be due to more space in lower crop population, which leads to luxurious growth of weeds in these treatments resulted in the higher dry matter accumulation by weeds while higher crop population recorded lowest weeds dry weight due to better crop stand in higher crop population.

Among the weed management treatments, weed free check (W_2) did not scrub the density of weeds because weeding was done at 20 DAS, whereas weeds biomass at harvest was significantly lowest with this treatment. However, marked reduction in weed density was observed with pre-emergence application of atrazine 0.5 kg/ha coupled with pendimethalin 0.25 kg/ha (W_4) followed by application of pre-emergence atrazine 1.0 kg/ha (W_3) and proved superior rest of other treatments.

Crop growth attributes

All treatments of crop population differed significantly among each other and independent in their effect on sweet corn plant height and dry matter accumulation and remain in $P_3>P_2>P_1$ order of their significance. Further, crop population of 74,074 plants /ha and 83,333 plants /ha were statistically on par but found significantly superior to crop population of 1,11,111 plants/ha in case of 50% silking. The increase in sweet corn plant dry matter with reducing crop population might be due to increase in sweet corn plant growth, ultimately lead to production of more photosynthates. The probable reasons for higher growth in lower crop plant density might be due to greater light interception, efficient utilization of soil moisture and the nutrients under lower degree of inter-plant competition. These results are in accordance with the findings of Sukanya *et al.* (1999).

At harvest, treatments weed free check, atrazine 1 kg/ha as pre-emergence + HW at 40 DAS, pendimethalin 1 kg/ha as pre-emergence + HW at 40 DAS and H.W. at 20 DAS + inter culturing at 40 DAS were found equally effective in increasing sweet corn plant height, 50% silking, and dry matter accumulation except hand weeding (HW) at 20 DAS + inter culturing at 40 DAS for dry matter accumulation but significantly superior to rest of the weed management practices. Significantly, lowest value of all said parameters was recorded under weedy check treatment. Moreover, application of herbicides coupled with

Table 1. Effect of crop population and weed management practices on weeds and growth and yield of sweet corn

Treatment	Total weed density/m^2 at 20 DAS	Total weed biomass (g/m^2)	Crop plant height (cm)	Days of 50% silking	DMA (g/plant)	Cob		
						Weight (g)	Length (cm)	Girth (cm)
Plant population								
1,11,111 plants/ha	8.12 (78.27)	13.10 (206.66)	153.2	59.7	84.7	103.9	15.1	11.1
83,333 plants/ha	8.61 (86.54)	14.86 (262.73)	164.7	64.0	96.6	119.1	17.6	14.3
74,074 plants/	8.90 (92.14)	15.16 (272.15)	170.6	65.5	101.9	122.2	19.2	16.0
LSD (P=0.05)	0.36	0.61	5.51	2.29	3.75	6.28	0.76	0.55
Weed management practices								
Weedy check	14.51 (210.83)	29.69 (886.54)	132.0	58.5	62.6	104.1	13.4	10.3
Weed free check	9.30 (87.44)	9.09 (83.47)	177.0	66.9	111.6	121.8	19.3	15.6
Atrazine 1 kg/ha	5.73 (32.89)	14.90 (224.18)	159.0	61.0	87.9	112.8	16.3	13.3
Atrazine 1 kg/ha+ hand weeding 40 DAS	6.00 (36.28)	10.27 (106.38)	173.6	65.8	108.3	122.6	19.2	15.2
Pendimethalin 1 kg /ha	6.81 (46.50)	15.25 (234.93)	157.5	60.3	86.0	110.9	15.8	13.1
Pendimethalin 1 kg/ha+ hand weeding 40 DAS	6.66 (44.39)	10.50 (111.08)	171.8	65.7	106.9	118.7	18.9	14.8
Atrazine 0.5 kg/ha + pendimethalin 0.25 kg/ha	5.24 (27.33)	14.65 (216.23)	160.2	61.2	88.6	111.4	16.8	13.4
HW 20 DAS + inter cultivation 40 DAS	14.12 (199.55)	10.63 (114.65)	171.7	65.0	103.5	118.2	18.7	14.7
LSD (P=0.05)	0.60	0.98	8.72	3.65	5.97	10.06	1.22	0.89

Figures in parentheses refer to actual weed population and those outside are $\sqrt{X + 0.5}$ transformed values

one hand weeding proves superior compared to alone application. This might be due to herbicide application coupled with HW provided better weed control throughout the crop life facilitated the crop plants to make optimum use of available underground and above ground resources. These observations are in agreement with those of Sharma (2007) and Prasad *et al.* (2008).

Yield attributes and yield

Crop population of 74,074 plants/ha proved its superiority by producing higher weight, length and girth of cob compared to other treatments. While significantly the lowest value recorded under the higher crop population of 1,11,111 plants/ha. Data further revealed that crop population exerted their significant effect on green cob and fodder yield being maximum (9.5 and 14.9 t/ha, respectively) and minimum (8.5 and 13.1 t/ha, respectively) with crop population of 1, 11,111 plants/ha and 83,333 plants/ha, respectively. Moreover, crop population of 1, 11,111 plants/ha and 83,333 plants/ha were found equally effective and significantly superior to crop population of 74,074 plants/ha in case of green fodder yield. Though the higher values for almost all the yield attributes were observed under lower crop population of 74,074 plants/ha, it could not compensate the yield loss due to lower plant stand compared to higher plant geometry. Besides, this higher crop population utilized the production resources more efficiently towards plant development. Hence higher and medium crop population of 1,11,111 plants/ha and 83,333 plants /ha increased the cob yield by 10.7 and 6.8%, respectively while green fodder yield by 13.6 and 10.6%, respectively over crop population of 74,074 plants/ha. These findings are in agreement with those of Kar *et al.* (2006).

Table 2. Sweet corn yield and economics as influenced by various crop population and weed management treatments (pooled)

Treatment	Yield (t/ha)		Cost of production (x10^3 ₹/ha)	Gross realization (x10^3 ₹/ha)	Net realization (x10^3 ₹/ha)	benefit: cost ratio (BCR)
	Green cob	Green fodder				
Plant population						
1,11,111 plants/ha	9.4	14.9	17.38	93.16	75.78	5.36
83,333 plants /ha	9.1	14.5	16.53	90.06	73.53	5.45
74,074 plants /ha	8.5	13.1	16.08	83.75	67.67	5.21
LSD (P=0.05)	3.36	5.70				
Weed management practices						
Weedy check (W_1)	6.5	9.2	12.68	62.71	50.03	4.94
Weed free check (W_2)	10.7	17.1	18.68	105.83	87.15	5.66
Atrazine 1 kg /ha (W_3)	8.5	12.8	13.54	83.14	69.60	6.14
Atrazine 1 kg /ha+ Hand weeding 40 DAS (W_4)	10.6	16.7	15.54	104.42	88.87	6.72
Pendimethalin 1 kg /ha (W_5)	7.9	12.2	14.13	77.67	63.53	5.50
Pendimethalin 1 kg /ha+ Hand weeding 40 DAS (W_6)	9.9	16.3	16.13	98.93	82.80	6.13
Atrazine 0.5 kg /ha+ pendimethalin 0.25 kg /ha (W_7)	8.3	12.9	13.50	82.09	68.59	6.08
HW 20 DAS + inter-cultivation 40 DAS (W_{8+})	9.8	15.9	15.21	97.13	81.92	6.39
LSD (P=0.05)	5.57	9.11				

Selling rate of produce (₹/t)
Green cob : 8000
Green fodder : 1200
A) Total fixed cost (₹/ha) : 12682

B) Variable cost (₹/ha)

P_1 :4700	W_1 : -	W_4 : 2860	W_7 : 818		
P_2 :3850	W_2 : 6000	W_5 : 1450	W_8 : 2525		
P_3 :3400	W_3 : 860	W_6 : 3450			

Weed free check proved its superiority by producing the thicker cob with higher value of weight and length compared to other treatments but statistically did not differ with treatments atrazine 1 kg/ha as pre-emergence + HW at 40 DAS, pendimethalin 1 kg/ha as pre-emergence + HW at 40 DAS and HW at 20 DAS + inter culturing at 40 DAS except HW at 20 DAS + inter culturing at 40 DAS for cob girth (Table 2). While, weedy check noted significantly the lowest value of all yield attributes. The pronouncing effect of all said growth parameter reflected on green cob and fodder yield and treatments Weed free check and atrazine 1 kg/ha as pre-emergence + HW at 40 DAS were equally effective for green cob (10.6 and 10.6 t/ha, respectively) and fodder (17.1 and 16.7 t/ha, respectively) yield per hectare, respectively but significantly superior to the rest of weed management practices. Significantly the low value of green cob and fodder yield of 6.5 and 9.2 t/ha, respectively was recorded with weedy check treatment.

Economics

Plant population of 1,11,111 plants/ha secured maximum net realization of ₹ 75,779 /ha with benefit: cost ratio (BCR) of 5.36, which was closely followed by treatments 83,333 plants/ha with net return of ₹ 73,527/ha and BCR 5.45. Data further revealed that maximum net return of ₹ 88,873 with BCR of 6.72 was realized in atrazine 1 kg/ha + HW 40 DAS followed by weed free check with net realization of ₹ 87,149 with BCR value of 5.66. The lowest net return of ₹ 50,029 was noted in weedy check with BCR value of 4.94.

The higher profitable green cob yield of *Rabi* sweet corn cv. '*Madhuri*' can be obtained by sowing the crop either at 45 x 20 cm (1,11,111 plant population/ha) or 60 x 20 cm (83,333 plant population/ha) and applying atrazine 1.0 kg/ha as pre-emergence coupled with hand weeding at 40 DAS or keeping the crop weed free throughout the crop life using three hand weeding at 20, 45 and 60 days after sowing.

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Productivity and profitability of rice–wheat sequence under conservation tillage

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ABSTRACT

Field experiment was conducted during 2009-10 and 2010-11 at Agronomical Research Farm of Birsa Agricultural University, Ranchi with four tillage management (zero till rice and zero till wheat; zero till rice and conventional till wheat; conventional till rice and zero till wheat and conventional till rice and conventional till wheat) in main plot and three methods of weed control practices *viz.,*weedy check, recommended herbicides butachlor 1.5 kg/ha pre-emergence + 2,4-D 0.5 kg/ha post-emergence for rice and isoproturon 0.75 kg/ha + 2,4-D 0.5 kg/ha post-emergence for wheat and two hand weeding (20 and 40 DAS for rice and 25 and 50 DAS for wheat) in sub plot to assess the productivity and profitability of rice -wheat (cropping system under conservation tillage. Direct seeded rice–wheat sequence with conventional tillage produced maximum rice equivalent yield 7.44 t/ha (for 3.1 t/ha rice and 3.6 t/ha wheat) and net return (₹ 58,206/ha). Among weed control, rice-wheat either with butachlor 1.5 kg/ha pre-emergence + 2,4-D 0.5 kg/ha post-emergence in rice and isoproturon 0.75 kg/ha + 2,4-D 0.5 kg/ha post-emergence in wheat or, with two hand weeding in both crops produced maximum rice equivalent yield (7.4 t/ha and 7.8 t/ha) and net return (₹ 62,258/ha and ₹ 60,498/ha)

Key words: Conservation tillage, Direct-seeded rice, Economics, Rice-wheat system, Weed control

Rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L. emend. Fiori and Paol) is the dominant cropping system in northern India covering about 10.5 million hactare area which contributes about 32% to the national food basket. Both rice and wheat are the two most important crops and the staple food of millions of Indian people (Sharma *et al*. 2008). In recent years, the rice-wheat has started suffering a production fatigue, in productivity. This production system is labour, water and energy-intensive and is becoming less profitable as these resources are becoming increasingly scarce and costly. Further, puddled rice soil produces more clods on ploughing and requires more fuel, labour and time to bring the soil to a reasonably good tilth for seeding wheat. Sometimes, all efforts to obtain a good tilth lead to soil moisture depletion and the farmers have to give a pre-sowing irrigation and wait for few days for sowing wheat. This situation is more aggravated on late harvesting of rice due to late transplanting or long duration cultivar. This pushes the seeding of succeeding wheat crop beyond November which decreases its productivity by 30-50 kg/ha/day (Chauhan *et al*. 2001). Hence the constraints related to both the crops must be tackled simultaneously to increase the productivity of the system.

Now, farmers are shifting to direct seeding because of its various benefits of similar or even higher yields (Bhusan *et al*. 2007, Farooq *et al*. 2009) and savings in irrigation water (Sharma *et al*. 2002, Singh *et al*. 2002), labour and production costs (Kumar *et al*. 2009), higher net returns and reduction in methane emission as well, which covers 28% of the total rice area in India. Direct seeding of rice aides in quick establishment and early harvest than transplanted rice and consequently facilitate timely wheat seeding (Singh *et al*. 2007) and thus enhances sustainability of both the rice and wheat in rice and wheat cropping system (Singh *et al*. 2005). However, direct seeding is subjected to greater weed competition than transplanted rice because both weed and crop seeds emerge at the same time and compete with each other resulting yield reduction by 50 to 100% (Rao *et al*. 2007). Jain *et al*. 2006 also reported 65 to 90% loss in grain yield of wheat due to weeds. Hence, the present investigation was undertaken to study the impact of combinations of conventional and zero tillage with weed control measures during on productivity and weed dynamics of rice and wheat cropping system

MATERIALS AND METHODS

Field experiments were conducted in a split plot design at Birsa Agricultural University Farm, Ranchi during the rainy and winter season of 2009-10 and 2010-11 to study the impact of combinations of conventional and zero tillage with weed control measures during *Kharif* and *Rabi* season on productivity and weed dynamics of rice and

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wheat cropping system. Treatment consisted of combination of four tillage practices; (i) Zero till rice and zero till wheat (ii) Zero till rice and conventional till wheat (iii) Conventional till rice and zero till wheat (iv) Conventional till rice and conventional till wheat in main plot and three methods of weed control practices (i) Weedy check (ii) Recommended herbicides butachlor 1.5 kg/ha pre-emergence + 2,4-D 0.5 kg/ha post-emergence for rice and isoproturon 0.75 kg/ha + 2,4-D 0.5 kg/ha post-emergence for wheat (iii) Two hand weeding (20 and 40 DAS for rice and 25 and 50 DAS for wheat) in sub plot and replicated 4 times. The soil was sandy loam, acidic in reaction (pH 5.43), low in, available nitrogen (242.2 kg/ha), potassium (123 kg/ha) and medium in organic carbon (0.52) available phosphorus (14.85 kg/ha).

A uniform fertilizer dose of 100- 40- 30 kg N- P_2O_5-K_2O/ha for direct seeded rice and 100- 60- 40 kg N- P_2O_5-K_2O/ha for wheat was applied. Half dose of N and full amount of P and K were applied at the time of seeding and remaining nitrogen was applied in two equal splits at maximum tillering and panicle initiation in direct seeded rice and at crown root initiation and at panicle initiation in wheat. The veriety '*Naveen*' of 120-125 days duration for rice and for wheat '*K-9107*' of 130- 140 days duration were used. The total rainfall received during crop season was 1063.7 and 1177.0 mm in 2009 and 2010, respectively. Observations on weeds were recorded with the help of a quadrate 0.5 x 0.5 m placed randomly at two spots in each plot at 30, 60 and 90 DAS.

The data on weeds were subjected to square root transformation ($\sqrt{x + 0.5}$) to normalize their distribution. Weed control efficiency was calculated using weed dry weight data at 60 DAS which was maximum during weed growth period irrespective of treatments. Economic analysis was done on the basis of prevailing market price of input used and output obtained from each treatment. The data were analysed separately for the year 2009 and 2010 and both the year's data were subjected for pooled analysis to obtain a trend among results over the years.

RESULTS AND DISCUSSION

Yield attributes and yield

Conventionally tilled rice produced 14.6% higher productive tillers, 3.0% higher panicle length, 9.3% higher filled grain, resulting in 25.5% higher grain and 27.9% higher straw yield compared to zero tilled rice (Table 1). Similarly, higher productive tillers/m^2, spike length, filled grains/spike and 1000 grain weight under conventionally tilled wheat over zero tilled wheat resulted 14.7% higher grain (3.52 t/ha) and 17.9% higher straw (4.9 t/ha) yield of wheat (Table 2).

Among weed control method, two hand weeding in rice (20 and 40 DAS) produced 53.3% higher productive tillers, 5.1% higher panicle length, 36.0% higher filled grain/panicle as well as 7.0% higher 1000 grain weight than weedy check resulting 105.6% higher grain and 125.2% higher straw yield and is at par with application of recommended herbicides in rice which also recorded 49% higher productive tillers, 3.4% higher panicle length, 34% higher filled grain/panicle, and 4% higher 1000 grain weight compared to weedy check resulting 104% higher grain and 108.6% higher straw yield. Hand weeding at 25 and 50 DAS in wheat crop recorded higher yield attributing parameters like 31.3% higher productive tillers/m^2, 5.3%

Table 1. Effect of tillage and weed control on yield attributes and grain and straw yield of rice (pooled data)

Treatment		Productive tillers (m^2)	Panicle length (cm)	Filled grains/ panicle	Unfilled grains/ panicle	1000-grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
Tillage								
Rice	Wheat							
Zero	Zero	249	17.9	58	14.5	20.0	2.3	3.1
Zero	Conventional	277	18.2	60	14.9	20.4	2.5	3.4
Conventional	Zero	297	18.5	64	15.9	20.9	2.9	4.1
Conventional	Conventional	305	18.7	65	16.2	21.4	3.1	4.3
LSD (P=0.05)		28	NS	4	0.7	NS	0.3	0.3
Weed management								
Rice	Wheat							
Weedy check	Weedy check	210	17.8	50	12	20.0	1.6	2.1
Butachlor + 2,4-D	Isoproturon + 2,4- D	314	18.4	67	17	20.8	3.3	4.4
Hand weeding	Hand weeding	323	18.7	68	17	21.4	3.3	4.7
LSD (P=0.05)		26	0.9	5	1.0	1.7	0.2	0.2

Table 2. Effect of tillage and weed control on yield attributes and grain and straw yield of wheat (pooled data)

Treatment		Productive tillers (m^{2})	Panicle length (cm)	Filled grains/ panicle	Unfilled grains/ panicle	1000 grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
Tillage								
Rice	Wheat							
Zero	Zero	217	10.4	44	10	42.2	3.0	4.1
Zero	Conventinal	233	10.8	46	10	42.4	3.4	4.8
Conventional	Zero	221	10.5	45	10	42.3	3.1	4.3
Conventional	Conventinal	240	10.8	47	10	42.1	3.6	5.1
LSD (P=0.05)		NS	NS	NS	NS	NS	0.2	0.3
Weed management								
Rice	Wheat							
Weedy check	Weedy check	192	10.3	43.2	9.8	42.2	2.7	3.7
Butachlor + 2,4-D	Isoproturon + 2,4-D	239	10.7	46.3	10.2	42.1	3.5	4.9
Hand weeding	Hand weeding	252	10.9	46.9	10.3	42.4	3.7	5.1
LSD (P=0.05)		16	0.5	2.6	0.6	2.0	0.2	0.3

Table 3. Economics and rice equivalent yield as influence by tillage and weed management in rice–wheat system (pooled data)

Treatment		Gross return ($x10^3$ ₹/ha)	Net return ($x10^3$ ₹/ha)	B:C ratio	Rice equivalent yield (t/ha)
Tillage					
Rice	Wheat				
Zero	Zero	74.32	44.66	1.49	5.9
Zero	Conventional	83.74	50.49	1.51	6.8
Conventional	Zero	83.62	51.86	1.62	6.7
Conventional	Conventional	93.56	58.21	1.64	7.3
LSD (P=0.05)		3.53	3.53	0.10	0.4
Weed management					
Rice	Wheat				
Weedy check	Weedy check	60.31	31.15	1.06	4.8
Butachlor + 2,4-D	Isoproturon + 2,4-D	93.13	62.26	2.02	7.4
Hand weeding	Hand weeding	97.98	60.50	1.61	7.8
LSD (P=0.05)		4.37	3.56	0.1	0.4

higher spike length and 8.6% higher filled grains/panicle, resulting in 35.8% higher grain and 38.6% higher straw yield compared to weedy check and is at par with application of recommended herbicides in wheat producing 24.5% higher productive tillers/m^2, 3.4% higher spike length and 7.2% higher filled grain with enhanced grain (31.4%) and straw yield (31.4%) compared to weedy check.

Rice equivalent yield

Conventionally tilled both rice and wheat produced 25.23, 11.9 and 11.4% higher mean rice equivalent yield compared to zero tilled in both rice and wheat (5.9 t/ha); zero tilled rice-conventional tilled wheat (6.7 t/ha); and conventional tilled rice-zero tilled wheat (6.7 t/ha). The corresponding increase in rice equivalent yield was 23.8, 10.2 and 10.9% in first year while 26.7, 13.4 and 11.9% respectively in second year (Table 3). The results are in conformity with the findings of Pandey *et al*. (2008) who have reported that conventional methods of tillage performed in rice and wheat produced more yields than zero tillage in the system.

Two hand weeding at 20 and 40 days after sowing in rice and at 25 and 50 days after sowing in wheat crop being similar to application of butachlor 1 kg/ha pre-emergence + 2,4-D 0.5 kg/ha post-emergence in rice crop and isoproturon 0.5 kg/ha post-emergence + 2,4-D 0.5 kg/ha in wheat crop produced 62.70% higher mean rice equivalent yield compared to weedy check. Similarly, chemical weeding in both the crops had 54.79% higher rice equivalent yield than weedy check. This is in conformity with the results of Jha *et al.* (2011).

Economics

Conventionally tilled both rice and wheat recorded 25.9, 11.8 and 11.9% higher mean gross return; 30.3, 15.3 and 12.2% higher mean net return than zero-zero, zero-conventional and conventional **-** zero tillage performed in rice and wheat, respectively. However, conventional **-** zero tillage and conventional-conventional recorded similar B: C ratio indicating marginal reduction in grain yield (11.4%) compensated with reduced cost of tillage operation under zero tillage performed in wheat crop. Higher economic returns due to conventional tillage in rice and wheat have also been reported by Pandey *et al*. (2008).

Two hand weedings performed both in rice (20 and 40 DAS) and wheat (25 and 50 DAS) being similar to application of butachlor 1 kg/ha pre-emergence + 2,4-D 0.5 kg/ha post-emergence in rice crop and isoproturon 0.5 kg/ha post-emergence + 2,4-D 0.5 kg/ha in wheat crop recorded 62.5% higher gross return, 94.2% higher net return as well as 51.9% higher B:C ratio compared to weedy check in rice and wheat crops. Similarly, chemical weeding to both the crops had 99.8% higher net return and 90.6% higher net benefit cost ratio. This is in conformity of the results of Pandey *et al*. (2005), Mishra *et al*. (2009) and Singh *et al*. (2010).

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Effect of stale seedbed method and weed management on growth and yield of irrigated direct-seeded rice

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ABSTRACT

A field experiment was conducted at Agricultural Research Farm of Banaras Hindu University, Varanasi to study the effect of methods of rice establishment and weed management practices in irrigated direct seeded rice. Treatment comprised of three crop establishment methods, *viz.* dry seeding after land preparation using stale seed bed method by shallow ploughing or by glyphosate 1 kg/ha, puddled wet seeded in main plot and five weed control measures in subplot, *viz.* weedy, hand weeding at 15 and 30 DAS, pendimethalin 1 kg/ha pre emergence followed by 2,4-D EE 500 g/ha at 30 DAS, butachlor 1 kg/ha pre-emergence followed by 2,4-D 500 g/ha, fenoxaprop-p-ethyl with safener 56 g/ha 15 DAS followed by ethoxy sulfuron 18 g/ha at 20 DAS in a split plot design replicated thrice. Crop establishment methods did not influence rice growth and yield components, and yield. Irrespective of method of establishment, hand weeding twice was found to be superior in managing weeds in DSR than all sequentially applied herbicide treatments.

Key words: Chemical control, DSR, Irrigated, Stale seedbed, Weed management

Rice in the Indo Gangetic plains is raised by two principal rice methods of establishment, *viz.* transplanting and direct seeding. Due to certain constraints associated with transplanted rice like water (Bhuiyan *et al.* 1995) and labour shortage, deterioration of soil physical properties and environmental pollution (Balasubramanian and Hill 2002), emphasis is now being given on direct-seeded-rice cultivation which provides opportunities for system intensification and diversification (Mazid *et al.* 2002). A major impediment in the successful cultivation of direct-seeded rice (DSR) in tropical countries is heavy infestation of weeds which often range from 50-91% (Paradkar *et al.* 1997) due to simultaneous emergence of weeds and crop and less availability of efficient selective herbicides for control of weeds during initial stages of crop weed competition. Further, nature of weed flora infesting direct-seeded rice also changes over years and it increased infestation of weedy rice in DSR of South Asian countries.

Stale or false seedbed technique is preventive method of weed management.This technique involves the soil preparation of a seedbed to promote germination of weeds, a number of days or weeks before the actual sowing or planting of the crop, thus depleting the seed bank in the surface layer of soil and reducing subsequent emergence of weeds (Rao *et al.* 2007). Following emergence, weeds are killed either by a non selective herbicide or by shallow tillage prior to the sowing of rice. Stale seedbed can also be implemented by submergence of rice field after 7 and 14 days of weed emergence (Sindhu *et al.* 2010). Singh *et al.* (2009) reported 53% lower weed density in dry–DSR after stale seedbed than without this practice. The initial seedbed preparation is then followed by destruction of the emerging weed seedlings with minimal soil disturbance (Mohler 2001). The control of emerging weed seedlings is mostly done with herbicides (Oliver *et al.* 1993). The present study was undertaken with main objective to find out the feasibility of using the option of stale seedbed during direct-seeding method of rice establishment and subsequent management of weeds by herbicides.

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MATERIALS AND METHODS

A field experiment was conducted during wet season of 2009 and 2010 at Agricultural Research Farm, Institute of Agricultural Sciences, Varanasi, Uttar Pradesh The soil of the experimental field was sandy clay loam in texture having pH 7.5, organic carbon 0.40%, available nitrogen 284 kg/ha, available phosphorus 16.9 kg/ha, available potassium 140 kg/ha. Treatment comprised of three crop establishment methods, *viz.* dry-seeded after using stale seedbed method by shallow ploughing (ii) by glyphosate 1 kg/ha (iii) rice wet seeded after puddling in main plot and five weed control measures in sub plot, *viz.* weedy, hand weeding (15 and 30 DAS), pendimethalin 1 kg/ha pre-emergence followed by 2,4-D 500 g/ha at 30 DAS, butachlor 1 kg/ha pre-emergence followed by 2,4-D 500 g/ha, fenoxaprop-p-ethyl with safener 56 g/ha 15 DAS+ ethoxysulfuron 18 g/ha at 20 DAS in a split plot design, replicated thrice. In stale seedbed treatment to facilitate weed emergence, water was applied in first week of June 2009 and 2010, and the first flush of weeds was controlled by application of glyphosate 1 kg/ha or by shallow tillage as per the treatment. Rice cultivar '*BPT-5204*' was sown by the help of zero till ferti-cum seed drill on 20 and 19th June 2009 and 2010, respectively. In two main plots, *i.e.* stale seed bed method by shallow ploughing or by glyphosate 1 kg/ha, rice seeds were drill seeded and overnight water soaked rice seeds were sown using drum seeder in puddled wet seeded treatment. A uniform dose of 120 kg N, 60 kg P_2O_5 and 60 kg K_2O were applied in the form of urea, diamonium phosphate and muriate of potash in each experimental plot. One third of nitrogen and full dose of phosphorus and potassium were applied as basal dose and remaining amount of nitrogen was applied in two equal splits at tillering and panicle initiation stages. Herbicides were applied as pre- and post-emergence as per the treatment with the help of under arm lever operated knapsack sprayer, fitted with flat fan nozzle with water as a carrier at 200 liter/ha.

Weed density and weed biomass were recorded at 60 days after sowing. Observations on weed density and weed biomass were recorded randomly from three places in each plot using 0.25/m^2 quadrate. The data recorded on weeds were subjected to square root transformation $(\times+0.5)^{1/2}$ homogeneity of variance. Biometrical observations on growth attributes, yield attributes and yields were also recorded. At 60 day stage of crop growth, dry matter accumulation was recorded on the basis of per meter row length whereas number of tillers and leaf area was recorded using 0.25/m^2 quadrate. Ten random plant samples were taken from each quadrate and the average leaf area/pant was determined by Systronics Leaf Area Meter 211. Leaf area was then converted to per m^2 using number of tillers/m^2. Weed competition index (%) was calculated by formula given by Gill and Vijaykumar (1966) and B: C ratio was calculated using formula, gross return/ total cost of cultivation.

RESULTS AND DISCUSSION

The major weed flora infesting crop field were: *Cynodon dactylon* (9.25%), *Echinochloa colona* (24.5%), *Echinochloa crusgalli* (14.2%), *Leptochloa chinensis* among grasses; *Commelina benghalensis* (4.54%), *Physalis minima, Phyllanthus fraternus* (13.9%), *Euphorbia hirta, Trianthema monogyna Chorchorus olitorius* (6.8%), *Eclipta alba* (2.1%) among broad-leaved weeds; *Cyperus iria* (13.2%), *Cyperus difformis* and *Fimbristylis miliaceae* among sedges.

Weed growth

The results revealed that the narrow-leaved weeds other than sedges were more in numbers as compared to broad-leaved weeds during both the years (Table 1 and 2). Crop establishment method did not show significant variations in weed density except in total weed density in second year. The wet-seeded rice recorded lesser weed density in comparison to dry-seeded rice using stale seed-bed with glyphosate 1 kg/ha and shallow tillage during both the years. Amongst herbicidal management, fenoxaprop–p-ethyl 56 g/ha followed by ethoxysulfuron 18g/ha significantly reduced total weed density in comparison to butachlor 1 kg/ha followed by 2,4-D 0.5 kg/ha and it was at par with pendimethalin 1 kg/ha followed by 2,4-D 0.5 kg/ha. Similar finding were also observed in case of total weed biomass during second year. In the first year, the fenoxaprop-p-ethyl 56 g/ha followed by ethoxysulfuron 18 g/ha was significantly superior to all the herbicidal treatment. It was also observed that fenoxaprop -p-ethyl followed by ethoxysulfuron significantly reduced population and biomass of *Echinochloa colona* compared to other herbicidal treatment during both the years except weed density during second year of experimentation. Butachlor 1 kg/ha followed by 2,4-D 0.5 kg/ha was not effective in reducing weed population and biomass in comparison to other herbicidal treatment.

Crop growth

Growth attributes, *viz.* dry matter, numbers of tillers/ m^2 and leaf area index recorded at 60 DAS (Table 3) revealed that during first year, variations in these attributes due to crop establishment methods was non significant, however, in the second year, number of tillers/m^2 and leaf area index varied significantly, stale seedbed method by glyphosate 1 kg/ha recorded more number of tillers and higher leaf area index in comparison to shallow tillage. All the herbicidal treatments resulted in statistically similar variations in growth attributes. Hand weeding twice had significantly better performance of all the growth attributing characters in comparison to rest of the treatment. Weedy recorded the minimum value of growth attributes during both the years of experimentation.

Table 1. Effect of rice establishment method and weed management treatments on weed density at 60 DAS

Treatment	Broad-leaved weed		Sedges		*E. colonum*		*E. crusgalli*		Other narrow-leaved weed		Total	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Rice establishment												
Dry-seeded after stale bed using shallow tillage	5.4 (52.2)	8.4 (92.8)	2.5 (11.7)	7.5 (74.9)	11.7 (249.6)	17.2 (368.3)	3.3 (20.5)	8.9 (99.2)	7.7 (83.5)	7.8 (79.7)	14.8 (334.1)	23.8 (714.9)
Dry-seeded after stale bed using glyphosate	4.1 (30.1)	8.7 (98.1)	2.6 (14.1)	6.6 (54.1)	15.3 (340.3)	18.61 (435.5)	2.1 (10.4)	8.5 (93.1)	8.7 (98.4)	7.5 (70.1)	17.1 (389.6)	24.3 (750.9)
Wet seeded rice	6.7 (70.1)	8.8 (97.9)	6.0 (53.1)	6.8 (61.1)	12.4 (218.9)	16.1 (332.5)	3.5 (26.1)	8.8 (100.0)	8.0 (85.9)	7.7 (76.0)	17.0 (367.7)	22.8 (667.5)
LSD (P=0.05)	NS	NS	2.4	NS	NS	1.49	NS	NS	NS	NS	NS	1.7
Weed management												
Butachlor + 2,4–D	2.1 (9.8)	9.2 (87.1)	3.8 (25.3)	7.1 (52.0)	20.3 (476.0)	20.9 (447.1)	3.6 (28.0)	9.5 (91.1)	14.5 (213.3)	8.4 (73.8)	21.8 (539.1)	27.3 (751.1)
Pendimethalin+ 2,4–D	4.0 (19.6)	9.6 (94.2)	4.6 (41.3)	7.6 (58.7)	17.2 (335.6)	19.9 (404.4)	3.5 (20.4)	9.8 (97.3)	8.4 (73.8)	8.9 (80.9)	19.6 (416.9)	27.0 (735.6)
Fenoxaprop-p-ethyl + ethoxysulfuron	9.8 (108.9)	9.3 (89.3)	4.8 (28.3)	7.7 (61.3)	7.4 (98.7)	19.3 (379.6)	1.7 (6.7)	9.7 (95.6)	6.4 (42.7)	7.8 (61.3)	14.8 (238.7)	26.0 (687.1)
HW at 15 and 30 DAS	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.71
Weedy	10.2 (115.1)	14.4 (210.7)	4.7 (36.0)	11.9 (144.9)	20.1 (437.8)	25.6 (662.7)	5.3 (40.0)	14.2 (203.1)	10.7 (116.4)	12.6 (160.4)	24.5 (624.4)	37.1 (1381.8)
LSD (P=0.05)	2.80	1.34	NS	1.17	6.41	1.66	NS	1.21	1.58	1.41	5.75	1.23

Original figures in parentheses were subjected to square root transformation before statistical analysis

Table 2. Effect of rice establishment method and weed management treatments on weed biomass at 60 DAS

Treatment	Broad-leaved		Sedges		*E. colonum*		*E. crusgalli*		Total	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Rice establishment										
Dry-seeded after stale bed using shallow tillage	3.9 (27.7)	7.2 (66.6)	1.7 (4.9)	6.1 (48.0)	9.0 (143.5)	9.6 (117.9)	6.4 (21.2)	8.3 (86.4)	13.4 (197.3)	15.9 (318.9)
Dry-seeded after stale bed using glyphosate	4.0 (31.1)	7.1 (64.9)	1.7 (6.1)	5.3 (34.5)	11.5 (198.4)	9.0 (104.2)	4.0 (16.5)	7.9 (78.8)	13.9 (263.8)	15.0 (282.4)
Wet seeded rice	5.7 (49.1)	7.1 (63.4)	3.4 (19.0)	5.6 (40.0)	10.3 (155.7)	8.2 (86.2)	5.8 (18.9)	7.74 (75.0)	15.7 (324.7)	14.5 (264.4)
LSD (P=0.05)	NS	NS	NS	0.32	NS	NS	NS	NS	NS	NS
Weed management										
Butachlor + 2,4–D	1.6 (8.7)	7.7 (62.3)	2.5 (11.7)	6.4 (44.0)	17.6 (320.4)	11.9 (147.4)	6.1 (23.3)	9.3 (87.6)	20.0 (416.1)	18.4 (341.4)
Pendimethalin + 2,4 –D	4.7 (29.5)	9.0 (82.0)	2.3 (8.6)	6.0 (39.2)	11.7 (176.6)	9.5 (91.7)	8.2 (34.4)	9.3 (89.8)	17.6 (360.0)	17.3 (302.7)
Fenoxaprop-p-ethyl + ethoxysulfuron	8.2 (82.3)	8.1 (68.1)	3.3 (16.8)	6.6 (45.2)	4.9 (42.6)	8.6 (77.5)	1.6 (2.2)	9.5 (93.02)	11.6 (141.5)	16.8 (283.8)
HW at 15 and 30 DAS	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Weedy	7.5 (59.4)	10.4 (112.5)	2.6 (12.8)	8.6 (75.8)	16.4 (289.8)	13.9 (197.1)	10.7 (34.0)	11.2 (129.9)	28.0 (396.0)	22.6 (515.3)
LSD (P=0.05)	2.89	1.66	NS	1.32	4.89	1.26	5.73	1.55	5.17	1.27

Original figures in parentheses were subjected to square root transformation before statistical analysis

Yield attributes and yield

The results revealed that number of grains/panicle and grain yield did not vary significantly due to rice establishment methods during both the years (Table 3), however, variation in yield attributing characters, *viz.* number of panicles/m^2 and 1000 grain weight was significant in second and first year, respectively. Glyphosate 1 kg/ha recorded significantly more numbers of panicles/m^2 in

Table 3. Effect of establishment method and weed management on growth, yield and weed competition index in direct-seeded rice

Treatment	No. of tillers/m^2 at 60 DAS		Leaf area index at 60 DAS		No. of panicles/m^2		No. of grains /panicle		1000-grain weight (g)		Grain yield (x10^3 ₹/ha)		Weed competition index (%)		B: C ratio	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Rice establishment																
Dry-seeded after stale bed using shallow tillage	148.1	75.8	1.6	1.0	357	276	111.7	94.7	12.5	9.6	2.66	2.61	25.8	39.8	1.97	2.65
Dry-seeded after stale bed using glyphosate	154.8	82.8	1.9	1.2	401	329	114.6	88.3	12.7	10.8	2.74	2.63	26.6	41.5	1.95	2.44
Wet seeded rice	112.7	82.8	1.4	1.2	352	313	100.3	86.3	10.3	9.73	2.29	2.63	33.6	33.9	2.01	2.35
LSD(P=0.05)	NS	4.17	NS	0.11	NS	22.7	NS	NS	1.48	NS	NS	NS	NS	NS	-	-
Weed management																
Butachlor + 2,4–D	88.9	67.2	1.0	0.7	292	234	102.4	78.1	10.4	8.49	2.25	2.69	37.1	36.8	2.16	1.99
Pendimethalin + 2,4–D	170.7	64.7	2.1	0.7	356	236	108.1	77.7	11..2	9.78	2.72	2.37	24.2	43.8	2.52	1.75
Fenoxaprop-p-ethyl + ethoxysulfuron	145.8	60.0	1.8	0.7	410	295	117.0	88.3	12.2	9.34	2.91	2.63	19.1	37.9	2.90	1.92
HW at 15 & 30 DAS	207.3	179.7	2.4	3.45	577	564	118.3	134.1	13.4	13.8	3.60	4.28	0.0	0.0	3.32	3.40
Weedy	80.0	30.4	0.9	0.8	216	121	98.6	70.6	11.5	8.33	1.32	1.12	62.9	73.5	1.48	0.82
LSD(P=0.05)	71.3	13.4	0.9	1.2	159	38.7	NS	9.7	1.8	1.0	0.4	365	10.6	8.27	-	-

Table 4. Interaction between establishment methods and weed management on grain yield (t/ha) of direct-seeded rice in 2009

Weed management	Establishment method: Dry-seeded using stale seedbed with Shallow tillage	Glyphosate 1 kg/ha	Wet-seeded rice
Butachlor + 2,4–D	2.09	2501	2.16
Pendimethalin + 2,4–D	2.96	3280	1.91
Fenoxaprop-p-ethyl + ethoxysulfuron	3.59	3340	2.27
HW at 15 and 30 DAS	3.36	3493	3.47
Weedy	1.28	1081	1.61
LSD(P=0.05)			
Weed management treatment at the same crop establishment			0.76
Crop establishment at same or different weed management			0.81

comparison to shallow tillage whereas in case of 1000 grain weight it was statistically similar to shallow tillage. Fenoxaprop-p-ethyl 56 g/ha followed by ethoxysulfuron 18g/ha recorded higher values of yield attributes in comparison to weedy and it was as at par with butachlor 1 kg/ha and pendimethalin 1 kg/ha followed by 2,4-D 0.5 kg/ha. Rice grain yield with fenoxaprop-p-ethyl 56 g/ha *fb* ethoxysulfuron 18 g/ha was significantly higher than weedy check and it was at par with all the other herbicidal treatment in second year. In first year, it was significantly superior to butachlor 1 kg/ha *fb* 2,4-D 0.5 kg/ha and statistically similar to pendimethalin 1 kg/ha *fb* 2,4-D 0.5 kg/ha. Weed competition index was higher in the first year with butachlor 1 kg/ha and in second year the differences in weed competition index were not significantly different among herbicide treatments. Among herbicide sequential application of fenaxaprop-p-ethyl 56 g/ha *fb* ethoxysulfuron 18 g/ha had higher benefit: cost ratio than other herbicidal treatment in first year whereas in second year butachlor 1 kg/ha followed by 2,4-D 0.5 kg/ha had higher benefit: cost ratio. Hand weeding twice recorded the highest benefit: cost ratio during both the years.

Interaction effect

Interaction effect between crop establishment method and weed management in first year revealed that stale seedbed by shallow tillage in combination with fenoxaprop-p-ethyl 56 g/ha *fb* ethoxysulfuron 18 g/ha had the highest grain yield and it was significantly superior to all the crop establishment method under butachlor 1 kg/ha *fb* 2,4-D 0.5 kg/ha and weedy treatments (Table 4). The same treatment was significantly at par with combination of crop establishment method under hand weeding twice.

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Integrated weed management in gladiolus

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ABSTRACT

A field experiment was carried out during *Rabi* season from 2007-2010 at Chatha, Jammu to find out relative efficiency of weed management practices in gladiolus (*Tagets erecta* L.). Result revealed significant enhancement in spike yield with 2 hand weedings at 20 and 40 days after transplanting (6.05 t/ha) and pendimethalin 2 kg/ha + 1 hand weeding (5.79 t/ha), both of which were superior to weedy check (3.25 t/ha). The highest weed control efficiency (78.2%) was also achieved with 2 hand weedings, followed by pendimethalin + hand weding 76.9%). Application of pendimethalin along with hand weeding proved to be economical.

Key words: Gladiolus, Hand weeding, Herbicides, Integrated weed management

Gladiolus is an important cut flower crop commercially grown in many tropical, sub-tropical and temperate parts of the world. It is ideal both for garden display and floral arrangements for table and interior decoration as well as making high quality bouquet. It contributes largely to the floriculture industry by virtue of its yield potential, colour variation and long life. In India, gladiolus has established itself as a commercial proposition. In the modern agriculture, the weed control is becoming essential for higher yield of gladiolus. Employing labour increases cost of cultivation and affects successful commercial flower production. Integrated weed management is effective, economic and eco-friendly approach in improving and sustaining the agricultural productivity (Foy 1993). An attempt was made to find out an effective weed management practice in gladiolus under irrigated subtropical conditions of Jammu & Kashmir.

MATERIALS AND METHODS

An experiment was carried out during *Rabi* season of 2007-08, 2008-09 and 2009-10 at the research farm of Sher–e–Kashmir University of Agriculture Science and Technology-Jammu, Chatha. Soil of the experimental site was sandy clay loam, having pH 7.76, low in available N, P and medium in K. Planting of gladiolus was done by dibbling at a spacing of 40 x 40 cm. Application of N, P and K was made 500, 300 and 200 kg/ha through urea, diammonium phosphate, murate of potash, respectively. Thirteen treatments comprising of hand weeding alone and along with pre-emergence application of pendimethalin 2 kg/ha, atrazine 1.5 kg/ha, glyphosate 2 kg/ha), local thatch grass mulching in the inter-row, directed burner flamings in inter-rows, besides weed-free and weedy check were laid out in randomized block design. Data on dry weed weight at 60 days after sowing and weed population were collected. Fresh spike yield was recorded at different pickings.

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RESULTS AND DISCUSSION

Two hand weedings at 20 and 40 DAS registered minimum weed population (4.66/m^2) and weed dry weight (2.58 g/m^2), closely followed by pre-emergence application of pendimethalin 2 kg/ha + 1 HW and two directed burner flamings in inter-rows (Table 1). Reduction in weed population and weed dry weight in these treatments can be attributed to relatively better management practices which shifted the competition in favour of gladiolus. There was significant enhancement in weed control efficiency (78.2%) and spike yield (6.05 t/ha) with 2 hand weedings, followed by application of pendimethalin +1 HW (76.9% and 5.79 t/ha), both of which were significantly superior to weedy check (3.25 t/ha). The crop plants in the former treatments experienced good vegetative growth right from the early stages up to the end of cropping period because of less competition of weeds for nutrients, water, space and sunlight.

There was considerable loss in yield due to persistence of weeds. Maximum yield loss *i.e.* weed index value was in weedy check treatment (53.4%) in comparison to weed-free plots. Application of pendimethalin + 1 HW proved to be economical weed management practice. Similar findings were obtained by Singh and Bijimol (1999) and Patil and Shalini (2006).

Table 1. Effect of integrated weed management on growth, yield and weed dynamics of gladiolus

Treatment	Weed population (no/m^2)			Weed dry matter (g/m^2)			Fresh spike yield (t/ha)			Weed index (%)	Weed control efficiency (%)
	2007-08	2008-09	2009-10	2007-08	2008-09	2009-10	2007-08	2008-09	2009-10		
One hand weeding (20DAS)	6.7 (43.5)	7.8 (60.1)	7.2 (51.1)	3.5 (11.6)	3.4 (10.9)	4.2 (17.0)	4.72	4.81	4.91	30.9	68.3
Two hand weedings (20, 40 DAS)	4.7 (21.2)	4.3 (17.9)	4.9 (23.3)	2.4 (5.1)	2.1 (3.6)	3.1 (8.7)	5.91	6.07	6.14	13.3	78.2
Local thatch grass mulching in the inter-row spaces	8.6 (73.3)	9.2 (84.0)	9.1 (81.9)	4.2 (16.8)	4.2 (17.3)	4.2 (16.7)	4.02	4.29	4.34	39.4	64.1
One hand weeding + local thatch grass mulching	7.9 (62.7)	7.8 (60.0)	7.2 (51.4)	4.0 (15.7)	4.0 (15.6)	3.9 (14.2)	4.36	4.41	4.57	36.1	65.9
Two directed burner flamings in inter-rows	5.4 (27.6)	5.3 (27.3)	5.1 (25.0)	3.4 (10.7)	3.1 (8.7)	2.9 (7.8)	5.37	5.66	5.88	19.1	73.2
Atrazine 1.5 kg/ha pre-mergence	8.2 (65.6)	7.9 (62.0)	7.1 (49.5)	4.3 (17.9)	4.0 (15.6)	3.9 (14.5)	4.06	4.38	4.40	38.5	65.2
Pendimethaline 2 kg/ha pre-emergence	9.0 (80.4)	9.1 (81.9)	9.0 (81.6)	4.7 (21.7)	4.6 (20.5)	4.5 (19.7)	3.90	4.14	4.25	41.1	60.7
Glyphsoate 2.0 kg/ha post-emergence directed application	9.2 (82.9)	9.0 (81.2)	8.8 (78.0)	4.6 (20.7)	3.9 (14.5)	4.7 (21.6)	4.06	4.22	4.37	39.4	62.4
Atrazine 1.5 kg/ha pre-emergence + 1HW	6.9 (47.7)	6.2 (37.8)	6.0 (35.1)	3.2 (9.76)	3.4 (10.7)	3.2 (9.3)	4.97	5.17	5.26	26.2	72.0
Pendimethaline 2 kg/ha pre-emergence + 1 HW	5.6 (30.5)	5.1 (25.2)	4.9 (23.8)	2.5 (5.6)	2.9 (7.7)	2.6 (6.1)	5.62	5.80	5.95	16.9	76.8
Glyphsoate 2.0 kg/ha post-emergence directed application + 1 HW	6.3 (39.5)	5.6 (30.8)	5.3 (27.3)	2.9 (7.7)	2.8 (7.0)	3.8 (13.6)	5.11	5.35	5.41	24.0	72.8
Weed free	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	6.68	7.00	7.22	0.0	100.0
Weedy check	12.7 (162.3)	12.5 (156.7)	11.9 (156.7)	12.0 (143. 0)	11.9 (141.8)	11.5 (132.6)	3.53	3.24	2.97	53.3	0.0
LSD (P=0.05)	0.59	0.23	0.23	0.38	0.63	0.37	0.595	0.43	0.428	-	-

Original values are given in parentheses; DAS=Days after sowing; HW= Hand weeding

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Short communication

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Efficacy of bispyribac-sodium on weed flora and yield of drilled rice

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Rice (*Oryza sativa* L.) being a major food crop of Madhya Pradesh is cultivated on 1.68 million ha with production of 1.56 million tones (Anonymous 2009). Direct seeding of rice has more benefits as compared to traditional transplanting like easier planting, timely sowing, less drudgery, early crop maturity by 7-10 days, less water requirement, better soil physical condition for next crop and low production cost and more profit. Weeds are one of the limiting factors in direct- seeded rice which reduced the yield up to 50-97% in rainfed uplands (Kurchania *et al.* 1992, Singh *et al.* 1996).

Pre-emergence herbicides like pretilachlor, butachlor, anilophos, and post- emergence herbicides like 2,4-D, and Almix are used frequently to control grassy and broad-leaved weeds in drilled rice. These herbicides are effective against weeds but most of them are specific and applicable for narrow range of weed species. Continuous application of these herbicides may also results in weed flora shift and development of herbicidal resistance in weeds. This situation warrants for initiating research efforts to develop and evaluate new and alternate herbicides which have wider applicability and weed control spectrum. Bispyribac-sodium is effective against many annual and perennial grasses, sedges, and broad leaved weeds in rice. The meager information is available in this regard for Kymore plateau and Satpura Hills Zone of M.P. Keeping all these facts in view, the present investigation was undertaken.

A field experiment was carried out during *Kharif* season of 2010 at Jawaharlal Nehru Kirshi Vishwa Vidyalaya, Jabalpur (M.P.) to test the efficacy of bispyribac-sodium against weeds. The soil of the experimental field was clayey in texture, neutral in reaction (pH 7.1), medium in organic carbon (0.64%) and available N (372 kg/ha), and available P (17.45 kg P_2O_5/ha) and high in available K (297 kg K_2O/ha). Rice variety '*IR 64*' was grown in the experimental field with recommended package of practices during *Kharif* 2010. Total 10 treatments were laid-out on well prepared seed bed in a randomized block design with three replications. Treatments were; bispyribac-Na 10 g/ha, bispyribac-Na 20 g/ha, bispyribac-Na 30 g/ha, bispyribac-Na 40 g/ha, bispyribac-Na 80 g/ha, bispyribac-Na 20 g/ha + 2,4-D 500 g/ha, cyhalofop -butyl 75 g/ha, butachlor 1500 g/ha, hand weeding twice (20 and 40 DAS), weedy check. All the herbicides were applied at 15 days after sowing (DAS) except butachlor which was applied at 1 DAS whereas hand weeding was done at 20 and 40 DAS. Fertilizers were applied uniformly to all the plots through urea, single super phosphate and muriate of potash at the rate of 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha, respectively.

The herbicides were applied by knapsack sprayer fitted with flat-fan nozzle using 500 litres water/ha. Weed density of major weeds *viz.*, *Echinochloa colona*, *Cyperus iria*, *Dinebra retroflexa*, *Eclipta alba* and *Phylanthus niruri* and other associated weeds were recorded at 40 DAS and at harvest by quadrate count method. The quadrate of 0.25 square metres (0.5 x 0.5 m) was randomly placed at three places in each plot and then the species wise and total weed count was recorded. The data thus obtained, were transformed and expressed in number per square metre. The percentage composition of weed flora was estimated from weedy check plot. The weed biomass from different plots under all the treatment was recorded only at before application, 40 DAS and harvest. The associated weeds were collected randomly with 0.25 m^2 quadrat from three places in each plot. The weeds were first sun dried and thereafter kept in paper bags and dried in oven at 60^0C for 48 hours and dry weight was recorded till constant weight was achieved. Lateron, the data on weed biomass was transformed and expressed in g per square metre. The data obtained on various observations were tabulated and subjected to their analysis by using analysis of variance (ANOVA and the treatment was tested by F test. The data on weed count and weed biomass were subjected to square root transformation, *i.e.*$\sqrt{x+0.5}$, before carrying out analysis of variance and comparisons were made on transformed values.

Grassy weeds were more prominent followed by broad-leaved as they constituted (65%) and (24.18%) mean relative density, respectively at 60 DAS, but sedges

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attained only (10.67%) mean relative density. However, *Echinochloa colona* among the grassy weeds and *Eclipta alba* among the broad-leaved weeds were more dominant in rainfed direct- seeded rice. Almost similar weed flora associated with rice was reported by Yadav *et al*. (2009).

Herbicidal treatments significantly influenced the population and dry matter production of weeds. Among the herbicidal treatments, the lowest weed density (2.74/m^2) was observed under bispyribac-sodium 80 g/ha at 15 DAS followed by bispyribac-sodium 40 g/ha (3.94/m^2). The minimum weed dry weight (0.71/m^2) was recorded in weed free treatment and proved significantly superior over all weed control treatments. The maximum weed dry weight (7.93 g/m^2) was noted in weedy check. Among the herbicides treatments, the lowest weed dry weight (0.95 g/m^2) was observed under bispyribac-sodium 80 g/ha (Table 1). These results are in conformity with the findings of Yadav *et al.* (2009).

Weed index is a measure of reduction in the seed yield due to competition stress offered by weeds as against weed free treatment. Weed control treatments caused significant variation on weed index of direct-seeded rice. The maximum weed index (66.4%) was recorded in weedy check. Among the herbicidal treatments bispyribac-sodium 80 g/ha recorded minimum weed index (5.2%). This clearly indicated that weeds were controlled effectively under bispyribac-sodium 80 g/ha.

Weed control methods caused significant variation on grain yield of direct-seeded rice. The maximum grains yield (4.85 t/ha) recorded in hand weeding (at 20 and 40 DAS) and lowest (1.62 t/ha) under weedy check. The yield loss due to uncontrolled growth of weeds as compared to hand weeding was 67.5%. Among the herbicidal treatments bispyribac-Na 80 g/ha recorded maximum grain yield (4.59 t/ha) which was at par with other lower doses of bispyribac-Na except 10 g/ha, but was significantly higher as compared to cyhalofop-butyl and butachlor. Cyhalofop-butyl and butachlor produced 11.3% and 9.3% less grain yield compared to bispyribac-Na 20 g/ha. The crop under weed free plots attained lush growth due to elimination of weeds from inter and intra-row spaces besides better aeration due to manipulation of surface soil and thus, more space, water, light and nutrients were available for the better growth and development, which resulted into superior yield attributes and consequently the highest yield. Yadav *et al.* (2009), also reported hand weeding as an effective method of weed control for achieving the maximum yield of direct seeded rice. Weed control methods caused significant variation on straw yield of direct-seeded rice. The maximum straw yield (6.53 t/ha) recorded in two hand weeding (at 20 and 40 DAS) and lowest straw yield (3.05 t/ha) found in weedy check plot.

Cost of cultivation varied under different weed control treatments. The minimum cost of cultivation (₹ 17028/ha) was registered under control plot. However, it was maximum (₹ 25428/ha) under hand weeding twice (at 20 and 40 DAS). The cost of cultivation under different herbicide treatments varied from ₹ 17800 to ₹ 22000. The cost of cultivation of weed free treatment receiving two hand weeding was the highest due to maximum variable cost, which was not affordable by the poor farmers and at the same time availability of laboures during peak period is also questionable.

Table 1. Weed density and dry weight and yield of rice as influenced by different weed control treatments

Treatment	Weed density (no./m^2)	Weed dry matter (g/m^2)	Weed index	Grain yield (t/ha)	Straw yield (t/ha)	Cost of cultivation (x10^3 ₹/ha)	B:C ratio
Bispyribac-Na 10 g/ha	8.77 (76.3)	4.58 (20.5)	30.8	3.35	4.85	17.87	2.04
Bispyribac-Na 20 g/ha	6.20 (38.0)	3.52 (11.9)	7.3	4.49	6.08	18.47	2.63
Bispyribac-Na 30 g/ha	4.67 (21.3)	2.97 (8.3)	7.0	4.51	6.13	19.07	2.56
Bispyribac-Na 40 g/ha	3.94 (15.0)	2.29 (4.7)	5.9	4.56	6.15	19.67	2.51
Bispyribac-Na 80 g/ha	2.74 (7.0)	0.95 (0.4)	5.3	4.59	6.23	22.07	2.25
Bispyribac-Na 20 g/ha + 2,4-D 500 g/ha	4.82 (22.8)	2.92 (8.0)	8.2	4.45	6.43	18.87	2.56
Cyhalofop-butyl 75 g/ha	7.45 (55.0)	4.05 (15.9)	17.6	3.99	5.83	18.28	2.38
Butachlor 1500 g/ha	8.69 (75.0)	5.29 (27.4)	17.4	4.00	5.93	18.02	2.42
Hand weeding	0.71 (0.0)	0.71 (0.0)	0.0	4.85	6.53	25.43	2.06
Control	15.02 (225.0)	7.93 (62.4)	66.5	1.62	3.05	17.03	1.06
LSD (P=0.05)	0.70	0.36	-	0.18	0.39	-	-

Value in parantheses are original. Data transformed to square root transformation

All the treatments received post-emergence application of bispyribac-sodium 10 to 80 g/ha, cyhalofop-butyl (75 g/ha) and butachlor (1500 g/ha) needed less variable cost over hand weeding. Thus, use of herbicides for control of weeds seems to be cheaper. Application of bispyribac-sodium 20 g/ha was more remunerative (2.63) than rest of the treatments including weed free treatment (2.06). Similar findings have also been reported by Subramanium *et al.* (2006) and Yadav *et al.* (2009).

SUMMARY

A field experiment was conducted during *Kharif* seasons of 2010 at JNKVV, Jabalpur to study the efficacy of bispyribac-sodium and other herbicides against weeds in drilled rice. The field was infested with grassy weeds *viz., Echinochloa colona, Dinebra retroflexa, Cyperus iria, Eclipta alba* and *Phyllanthus niruri*. The efficacy of bispyribac-sodium as post- emergence was significantly superior when applied at 80 g/ha over other herbicides. However, the application of bispyribac-sodium 20 g/ha was more remunerative. Among the herbicidal treatments bispyribac-Na 80 g/ha recorded maximum grain yield (4.59 t/ha) which was at par with other doses of bispyribac-Na except 10 g/ha and significantly higher as compared to cyhalofop-butyl and butachlor.

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Weed dynamics, yield and economics of pigeonpea influenced by growth promoters and mulching

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Pigeonpea or red gram having the total duration of 100-105 days and very slow in growth habit up to 50 to 65 DAS, facilitates the weeds to grow luxuriantly leads to even more than 75% yield loss and also complete crop failure under uncontrolled condition (Channappa goudar and Biradar, 2007). Conventionally, weeds are controlled by many means like chemical, manual, mechanical and biological. Chemical measures have ill effects to soil, succeeding crops and soil micro organisms. In this context, the idea of suppressing weed growth by plant growth would be highly possible. Similarly, unlike the other pulse crops, which act as cover crops namely blackgram and greengram, the red gram is slow growing during its early growing period up to 50-65 days apart from its erect stature, which induces the weed growth resulting in poor growth and development of crop and finally yield. Mulching is one of the possible ways to control weeds without using herbicides. Mulching reduced the population and dry weight of broad-leaved weeds significantly as compared to grass weeds (Radwan and Hussin 2001). Mulching has suppressing effect on weeds ands also conserves moisture (Tiwari *et al.* 1991).

Like mulching, applying growth promoters one way or other controls the weeds without herbicides by its indirect effect as it helps in rapid crop canopy coverage which in turn control weeds by shade effect. Hence, foliar spray of growth promoters was also included in addition to mulching to study their effect on weeds, yield and yield attributes and economics in red-gram.

A field experiment was conducted at Agricultural College and Research Institute, Madurai, Tamil Nadu during *Rabi* 2009-2010 to study the combined effect of foliar spray of growth promoters and mulching on weeds and their influence on yield and yield attributes and economics of red gram cv. '*APK1*'. The soil of the experimental field was well drained clay loam with organic carbon content of 0.46 per cent and low, medium and high N, P_2O_5 and K_2O respectively. The experiment consisted of two main plot treatments, *viz*. M_1- Organic mulch with blackgram residue 6 t/ha and M_2–no mulch. The foliar spray of growth promoters and micro nutrient mixture were assigned to sub plot, they were S_1 -foliar spray of micro nutrient mixture, S_2 – NAA 40 ppm, S_3 - salicylic acid 100 ppm, S_4 –Brassinolide 0.1 ppm, S_5 –triacontanol 500 ppm and S_6 -no spray.

Organic mulch namely black gram residues were cut into small pieces and applied at the rate of six t/ha on 15 days after germination in between the crop rows after thinning. The foliar spray of all the nutrients and growth promoters were done on 15, 30, 45 and 60 DAS. Micro nutrient mixture contains various nutrients at different concentration ($FeSO_4$ -0.5%**,** $MgSO_4$ -0.5% and $ZnSO_4$ -0.5%).

Weed density of predominant individual weeds of grasses, sedges and broad leaved weeds in each plot was recorded by using quadrate (0.5 x 0.5 m) in four places at random on 40 and 60 DAS of the crop and expressed as no/m^2 . Observations on yield attributes such as number of flowers per plant, number of pods per plant, pod length, number of grains per pod and 100 grain weight and yield were recorded. All the data were statistically analyzed in split plot design and discussed in the results. In addition, economics covering cost of cultivation, gross return, net return and B:C ratio of the above experiment were worked.

The main plot treatment of mulching significantly reduced the density of grasses, sedges and broad leaved weeds (BLW) to 12.83, 14.54 and 16.30 no./m^2 at 40 DAS and 15.27, 17.03 and 17.64 no./m^2 at 60 DAS, respectively (Table 1 and 2). It might be attributed to hindrance of crop residue on the resources like light and aeration which are more essential for germination of weed seeds besides killing of weed seeds by increased soil temperature caused by high concentration of CO_2 under mulching than no mulching. Ahmed *et al*. (2007) reported that wheat straw mulch spreading had significant effect on weed suppression in wheat. The density of weeds was found to be more under no mulch irrespective of morphology charac-

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teristics of weeds following availability of all the resources in no mulch at 40 and 60 DAS (Table 1 and 2). Tamana Bakhtl *et al.* (2009) also reported maximum weed density of 40.33/m^2 in the weedy check, while the minimum weed density was recorded with mulching with news papers in pea.

Under sub plot treatments, foliar spray of NAA at 40 PPM registered lesser weed density of grasses, sedges and BLW (23.51, 24.35 and 27.00 no./m^2 at 40 DAS and 25.89, 27.38 and 27.89 no/m^2 at 60 DAS, respectively over rest of the treatments (Table 1 and 2). Rapid canopy coverage of plants which have been given with foliar spray of growth promoter NAA at 40 PPM could have suppressed the weed growth through shade effect during the critical crop weed competition period particularly at early stage of crop growth. NAA at 40 ppm gave much impact in influencing the growth of red gram. Kadam *et al.* (2008) reported that NAA at 30 ppm concentrate was found to be more effective in increasing the number of branches, total dry weight and chlorophyll content in black gram. The foliar spray of micronutrient mixture was found to be the next best treatment in reducing the weed density at 40 and 60 DAS in redgram (Table 1 and 2). The enhanced growth of plant next to NAA could have suppressed the weed density by providing shade effect. Gupta and Vyas (1994) observed that dry weight of soybean plant was increased due to application of zinc, iron and molybdenum.

Among the sub plot treatments, the plants in no spray treatment had no significance in checking the weed density owing to lesser crop canopy in this treatment wherein the density of grasses, sedges and BLW were 37.0, 40.8 and 45.4 no/m^2 at 40 DAS and 39.8, 43.8 and 46.7 no./m^2 at 60 DAS, respectively (Table 1and 2). This in corroboration with Talnikar *et al.* (2008) who reported heavy infestation of weeds in pigeon pea due to slow early growth of crop.

The interaction effect among mulching and foliar spray of growth promoters and micro nutrient mixture was significant on density of sedges at 40 DAS and grasses and sedges at 60 DAS (Table 1 and 2). Mulching in association with NAA at 40 PPM resulted in grater reduction of sedge weed density to 9.03 and 12.87 no./m^2 at 40 and 60 DAS, respectively and grasses to 11.1 no./m^2 at 60 DAS (Table 1 and 2). The less number of emergence of sedges and grasses than BLW in the experimental plot could have

Table 1. Effect of mulching and foliar spray of growth promoters on density of grasses, sedges and BLW weeds (no./m^2) in pigeonpea at 40 DAS

Foliar spray (S)	Grasses			Sedges			BLW		
	M_1- mulch	M_2-no mulch	Mean	M_1- mulch	M_2-no mulch	Mean	M_1- mulch	M_2- no mulch	Mean
S_1-Micro nutrient mixture	1.14 (11.90)	1.65 (42.98)	1.40 (27.44)	1.18 (12.98)	1.67 (44.56)	1.42 (28.77)	1.21 (14.34)	1.69 (47.36)	1.45 (30.85)
S_2-NAA 40 ppm	1.08 (10.03)	1.59 (36.98)	1.34 (23.51)	1.04 (9.03)	1.62 (39.67)	1.33 (24.35)	1.15 (12.13)	1.64 (41.86)	1.40 (27.00)
S_3-Salicylic acid 100 ppm	1.20 (14.02)	1.68 (46.12)	1.44 (30.07)	1.26 (16.23)	1.70 (48.23)	1.48 (32.23)	1.26 (16.32)	1.72 (50.57)	1.49 (33.45)
S_4-Brassinolide 0.1 ppm	1.11 (11.01)	1.64 (41.98)	1.38 (26.50)	1.16 (12.45)	1.672 (45.01)	1.42 (28.73)	1.23 (15.04)	1.70 (48.23)	1.47 (31.64)
S_5-Tricontanol 500 ppm	1.15 (12.10)	1.69 (47.12)	1.42 (29.61)	1.25 (15.89)	1.72 (49.90)	1.48 (32.90)	1.26 (16.34)	1.74 (53.12)	1.50 (34.73)
S_6-No spray	1.30 (17.89)	1.76 (56.12)	1.53 (37.01)	1.36 (20.67)	1.80 (61.01)	1.58 (40.84)	1.41 (23.65)	1.84 (67.14)	1.62 (45.40)
Mean	1.17 (12.83)	1.67 (45.22)		1.21 (14.54)	1.70 (48.06)		1.26 (16.30)	1.72 (51.38)	
	SEd±	LSD (P= 0.05)		SEd±	LSD (P= 0.05)		SEd±	LSD (P= 0.05)	
M	0.01	0.04		0.01	0.05		0.01	0.04	
S	0.01	0.03		0.01	0.03		0.01	0.03	
MxS	0.02	NS		0.02	0.06		0.02	NS	
S×M	0.02	NS		0.02	0.04		0.02	NS	

Data in parentheses are original values. Others are log (x+2) transformed values

Table 2. Effect of mulching and foliar spray of growth promoters on density of weeds BLW weeds (no./m^2) in pigeonpea at 60 DAS

Foliar spray	Grasses			Sedges			BLW		
	M_1- mulch	M_2- no mulch	Mean	M_1- mulch	M_2- no mulch	Mean	M_1- mulch	M_2- no mulch	Mean
S_1-Micronutrient mixture	1.20 (13.87)	1.68 (45.97)	1.44 (29.92)	1.22 (14.78)	1.80 (47.89)	1.46 (31.34)	1.25 (15.67)	1.71 (48.78)	1.48 (32.23)
S_2-NAA 40 ppm	1.12 (11.13)	1.63 (40.65)	1.37 (25.89)	1.17 (12.87)	1.64 (41.89)	1.41 (27.38)	1.18 (13.02)	1.65 (42.76)	1.41 (27.89)
S_3-Salicylic acid 100 ppm	1.25 (15.89)	1.70 (48.45)	1.48 (32.17)	1.32 (18.98)	1.72 (50.87)	1.52 (34.93)	1.30 (17.89)	1.73 (51.78)	1.51 (34.84)
S_4-Brassinolide 0.1 ppm	1.20 (13.98)	1.69 (46.98)	1.45 (30.48)	1.23 (15.01)	1.70 (48.34)	1.47 (31.68)	1.26 (16.01)	1.71 (49.01)	1.48 (32.51)
S_5-Tricontanol 500 ppm	1.25 (15.98)	1.72 (49.98)	1.49 (32.98)	1.27 (16.78)	1.75 (53.98)	1.75 (35.38)	1.32 (18.67)	1.76 (54.98)	1.55 (36.83)
S_6-No spray	1.36 (20.78)	1.78 (58.87)	1.57 (39.83)	1.41 (23.78)	1.82 (63.89)	1.62 (43.84)	1.42 (24.56)	1.85 (68.90)	1.64 (46.73)
Mean	1.23 (15.27)	1.70 (48.48)		1.27 (17.03)	1.72 (51.14)		1.29 (17.64)	1.73 (52.70)	
	SEd±	LSD (P= 0.05)		SEd±	LSD (P= 0.05)		SEd±	LSD (P= 0.05)	
M	0.01	0.04		0.01	0.05		0.01	0.04	
S	0.01	0.03		0.01	0.03		0.01	0.03	
MxS	0.02	0.05		0.02	0.06		0.02	NS	
SxM	0.02	0.04		0.02	0.04		0.02	NS	

Data in parentheses are original values. Others are log (x+2) transformed values

paved the way to suppress those weeds easily under mulching when it combined with shade effect of plants given by NAA at 40 ppm.

The next best combination to check the sedges density (12.45 no./m^2) at 40 DAS was mulching with foliar spray of brassinolide 0.1 ppm (Table 1 and 2). Whereas, at 60 DAS mulching combined with foliar spray of micronutrient mixture ranked second in bringing down the grasses (13.87 no./m^2) and sedges (14.78 no./m^2) density, which in turn comparable with the treatment (Table 1 and 2). The weed density of grasses and sedges was found to be more in the treatment combination of no mulch with no spray irrespective of stages.

Organic mulching recorded higher values of yield attributing characters like number of flowers/plant (41.36%), number of pods/plant (34.13%), test weight (15.45%) number of seeds/pod and seed yield (47.83%) over the control plot with no mulch (Table 3 and 4).

The improvement in the yield attributes under organic mulching might be due to maintenance of higher soil moisture in root zone which resulted in better nutrient uptake, increased growth, LAI and DMA, photosynthesis *etc*. resulting in higher yield attributes.

Organic mulching resulted in a substantial increase in redgram pod yield (1329 kg/ha) which accounts for 47.83% increase over no mulching. This was mainly due to optimum soil moisture content maintained in all stages of crop growth, which enabled higher nutrient uptake, greater dry matter accumulation, higher number of pods/plant, more grains/pod and increased hundred seed weight. Better control of weeds under mulch which could have also favored to increase the yield. Abubakkar *et al.* (2004) also made similar observations in summer green gram.

Among the foliar spray, NAA at 40 ppm influenced the yield attributes, *viz.* number of flowers/plant (50.06%), number of pods/plant (105%), pod length (19.46%) grains/pod and yield (40.11%) over the no spray control (Table 3 and 4).

In the present study also application of NAA was found to stimulate early flowering. The number of pods/plant was increased by the foliar application of NAA at 40 ppm. Similar results were reported by Subramani and Solamalai (2000) in legumes.

Table 3. Effect of mulching and foliar spray of growth promoters on no. yield attributes and grain yield of pigeonpea

Foliar spray	No. of flowers/plant			No of pod/plant			Grain yield (kg/ha)		
	M_1-Mulch	M_2- no mulch	Mean	M_1-Mulch	M_2- no mulch	Mean	M_1-Mulch	M_2- No mulch	Mean
S_1-Micronutrient mixture	184.7	138.9	161.8	215.3	156.9	186.1	1336	985	1160
S_2-NAA 40 ppm	205.7	152.5	179.1	252.3	175.3	213.8	1453	1069	1261
S_3-Salicylic acid 100 ppm	172.0	129.4	150.7	198.5	147.9	173.2	1319	912	1116
S_4-Brassinolide 0.1 ppm	186.3	137.0	161.7	210.4	152.1	181.2	1322	965	1144
S_5-Tricontanol 500 ppm	169.4	125.3	147.4	188.7	146.9	167.8	1302	903	1103
S_6-No spray	158.9	78.8	118.9	110.4	97.3	103.9	1240	560	900
Mean	179.5	127.0		195.9	146.1		1329	899	1114
	Sed±	LSD (P=0.05)		SEd±	LSd (P= 0.05)		SEd±	LSD (P= 0.05)	
M	3.9	16.9		4.6	19.6		29.1	125.3	
S	5.5	11.5		6.4	13.3		38.1	79.5	
MxS	8.1	21.2		9.4	24.5		57.2	152.2	
SxM	7.8	16.3		9.0	18.8		53.9	112.5	

Table 4. Effect of mulching and foliar spray of growth promoters on pod length yield attributes of pigeonpea

Treatment	Pod length (cm)	No. of seeds/ pod	100 grain weight (gram)
Mulching			
M_1-Mulch	5.68	5.21	9.49
M_2 –No mulch	4.70	4.10	8.22
LSD(P= 0.05)	0.57	0.51	0.89
Foliar spray			
S_1-Micronutrient mixture	5.33	4.72	8.87
S_2-NAA 40 ppm	5.40	5.09	9.71
S_3-Salicylic acid 100 ppm	5.27	4.61	8.72
S_4-Brassinolide 0.1 ppm	5.34	4.72	8.87
S_5-Tricontanol 500 ppm	5.29	4.66	8.87
S_6-No spray	4.52	4.14	8.07
LSD (P= 0.05)	0.38	0.34	0.62

The pod length was also increased by the application of NAA at 40 ppm (Table 4). The increased pod length may be attributed to increase in the number of cell as well as elongation of cells which is the characteristic action of auxin. Similar result was reported by Sharma (1999).

The gross return, net monetary returns and benefit cost ratio were higher under mulching with the combination of foliar application of NAA at 40 ppm. This combination registered ₹ 87,176/ha , ₹ 63969/ha and 2.76 as gross return, net profit and benefit cost ratio, respectively (Table 5). The next best combination in registering the higher net profit (₹ 56068/ ha) and benefit cost ratio (2.41) was mulch with brassinolide 0.1 ppm which was followed by mulch with salicylic acid 100 ppm (Table 5). The treatment combination, no mulch with no spray registered lowest net return (₹ 17,022) and BC ratio (1.03) with lowest cost of cultivation.

Table 5. Effect of mulching and foliar spray of growth promoters on economics of pigeonpea

Treatment	Cost of cultivation ($x10^3$ ₹/ha)	Gross returns ($x10^3$ ₹/ha)	Net returns ($x10^3$ ₹/ha)	B:C ratio
M_1S_1	25.46	81.06	55.59	2.18
M_1S_2	23.20	87.17	63.96	2.76
M_1S_3	23.14	79.14	55.99	2.42
M_1S_4	23.26	79.33	56.06	2.41
M_1S_5	23.18	78.12	54.93	2.37
M_1S_6	22.66	74.40	51.73	2.28
M_2S_1	24.06	59.10	35.03	1.46
M_2S_2	21.80	64.12	42.31	1.94
M_2S_3	21.74	54.72	32.97	1.52
M_2S_4	21.86	57.90	36.03	1.65
M_2S_5	21.78	54.18	32.39	1.49
M_2S_6	16.57	33.60	17.02	1.03

SUMMARY

The experiment was laid out in split plot design and replicated thrice at Agricultural College and Research Institute, Madurai during *Rabi* 2009-2010. The main plot treatment consisted of mulching with crop residue and no mulch as control. Foliar spray of micronutrient mixture,

NAA at 40 ppm, salicylic acid at 100 ppm, brassinolide at 0.1 ppm, triacontanol at 500 ppm and no spray were assigned to sub plot. Among the main plot treatments, mulching with crop residue effectively controlled the weed density of grasses, sedges and broad leaved weeds which increased the yield attributes. The eonomic parameters, *viz*. gross return, net return, and benefit cost ratio were higher in mulching. The subplot treatment foliar spray of NAA at 40 ppm reduced the weed density significantly, which also enhanced the yield and yield attributes despite recording more economic returns. When both the main and subplot treatments combined together, they gave better control of sedges at 40 and 60 DAS and grasses at 60 DAS due to shade effect of robust stature of plants. This treatment combination resulted in substantial increase in yield and yield attributes and also more economic returns.

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Short communication

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H_2O_2 induced seed viability assessment of Asian spider flower

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Key words: *Cleome viscosa*, Hydrogen peroxide, Seed viability, Tetrazolium, Weed

A reserve of viable, ungerminated seeds borne in a soil in a given habitat is called as 'seed bank'. Weed seed bank is the reserve of weed seeds present either on soil surface or scattered within the soil profile. It consists of both recently shed and older seeds that have persisted in the soil for several years. Most of the soil seed bank consists of buried seed, however some seeds lie on soil surface or in litter or humus. Such self-sown weeds appear simultaneously along with crops and result in strong crop weed competition causing reduction in grain/seed yield. It is essential to assess such seed reserves to judge their potential to cause harm to subsequent crop. Asian spider weed (*Cleome viscosa*) is a problematic weed of woodlands, grasslands, fallow lands, roadsides and waste lands. They grow on wide range of soils like sandy soils, calcareous and rocky soils and also found in dry and humid conditions. Knowledge of weed seed banks and their persistence is essential for long term weed management strategies.

Viability testing has been used to assess the viability of a wide variety of dormant weed seeds embedded in seed banks including many on agricultural weeds, restoration and conservation ecology and natural ecosystems, particularly those with frequent fires.Several methods have been used to estimate viability, germination test (counting the seedlings emerging from soil filled flats) (Forcella and Lindstrom 1988) and examination of imbibed seeds for signs of decay (Froud-Williams *et al*. 1984) as the indicators of seed viability of weed seed banks. Each test has advantages and disadvantages. *In situ* germination of soil borne seeds does not require separation of seeds from the soil, but it may require up to 2 years to induce germination of deeply dormant seeds (Roberts and Feast 1973). Typically, conditions are manipulated to encourage germination, but some seeds may still remain dormant and some seeds may die during the study. Tetrazolium testing provides a quicker way to obtain seed viability, saving time and labour. Reports on *Cleome viscosa* weed seed viability testing are scanty. Hence, the present investigation was carried out to know the viability of *Cleome viscosa*.

Cleome viscosa seeds were collected from farmlands College and laboratory studies were conducted in the Department of Seed Science and Technology, Agricultural College and Research Institute, Madurai.

Twenty five seeds were soaked in water for 18 h in four replicates. The seeds were bisected longitudinal lateral and curved embryos extracted. Ten well formed embryos were incubated in darkness in 5 ml of 0.2% 2, 3, 5 tri-phenyl-tetrazolium chloride solution for 4 h then observed for staining pattern. This served as control.

Another batch of twenty five seeds was soaked in water for 18 h in four replicates and ten embryos were extracted (as detailed above) and soaked in 1% H_2O_2 followed by incubation in darkness for 15, 30 and 60 M followed by Tz staining for 4 h and observed for staining pattern.

All embryos were visually observed under the microscope (40x) for staining. The embryos soaked in 0.2% Tz solution remained unstained even after 4 h of incubation period (prolonged soaking after 20 h also did not stain the embryos). Whereas the embryos soaked in 1% H_2O_2 followed by 0.2% Tz solution showed stained embryos. The intensity of staining increased with increased soaking durations in 1% H_2O_2. The embryos soaked in 30 M showed prominent staining compared to 15 and 60 M. Being deeply dormant, untreated embryos did not stain. This was in agreement with Fontaine *et al.* (1994), who reported that exogenous application of H_2O_2 accelerates seed germination. H_2O_2 stimulates the respiration of deeply dormant embryos by acting as an electron acceptor in respiratory electron transport or by oxidizing endogenous inhibitors present in seeds leading to metabolism initiation (Henrotte Devillez 1976). Chien and Lin (1994) in cereals reported that during early phase of germination (imbibition phase), H_2O_2 may activate mitochondrial O_2 respiration and oxidative pentose pathway leading to the production of thioredoxin reduction by NADPH which mobilizes

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the storage proteins present in seeds, resulting in promotion of seed germination. Fontaine *et al.* (1994) also proposed that H_2O_2 is helpful in cracking the hard seeds, allowing them to interact with water, thereby inducing the seed germination by stimulating metabolic reactions. Ogawa and Iwabuchi (2001) reported that endogenously generated H_2O_2 functions as a promoter of seed germination by oxidizing germination inhibitors present in seed. It could be concluded that mere soaking of *Cleome* embryos in Tz solution can not lead to staining misleading the observer about the viability status of the deeply dormant embryos. Hence, *Cleome viscosa* embryos must be activated by soaking in 1% H_2O_2 for 30 M followed by 4 h Tz staining for quick estimation of seed viability.

SUMMARY

Experiment carried out to assess the viability of Asian spider flower seeds revealed that presoaking embryos of *Cleome viscosa* in 1% H_2O_2 for 30 M followed by 0.2% tetrazolium (Tz) staining for 4 h showed pronounced improvement in staining compared to embryos not subjected to H_2O_2 that remained unstained.

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Short communication

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Dry-seeded rice productivity in relation to sowing time, variety and weed control

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In Punjab in India, rice is raised by puddled transplanting which causes high losses of water through puddling, surface evaporation and percolation. An alternate method of rice planting which reduces water and labour needs to be explored. Direct dry-seeded rice (DSR) is one of the options. The success of DSR, however, lies in effective weed control. The weed flora in DSR consists of aerobic and anaerobic grasses, broad-leaved and sedges, which emerge in several flushes during the crop growth period.The risk of crop yield loss due to competition from weeds is higher in DSR than for transplanted rice. Sowing time has significant influence on weed species composition and intensity. A short duration (125 days) and early maturing rice variety '*PR 115*' gave highest yield in DSR, followed by medium (140 days) variety '*PR 111*' at Ludhiana, Punjab (Gill *et al.* 2006).

A field experiment was conducted at the Research Farm, Department of Agronomy, Punjab Agricultural University Ludhiana during *Kharif* 2008. The soil was sandy loam, pH 7.1, low in organic C (0.32%) and available N (252.7 kg N/ha), medium in available P (12.9 kg P/ha) and available K (246.1 kg K/ha). The experiment comprised of 24 treatment combinations, *viz.* six sowing dates (dry seeding on 0 (5 June), 7, 14, 21, 28 days after nursery sowing (DANS) and transplanting 28 days after nursery sowing) assigned to main plots, and four combinations of two rice varieties, '*PR 115*' (short duration, 125 days) and '*PAU 201*' (mid-duration of 144 days), and two weed control treatments (pendimethalin 0.75 kg/ha pre-emergence, followed by bispyribac-sodium 0.030 kg/ha as post-emergence 25 days after seeding/transplanting) and 3 hand hoeings at 20, 40, 60 days after seeding/transplanting) to sub-plots, replicated three times in a split-plot design. The rice was seeded in moist soil with hand drill in 20 cm spaced rows using 30 kg seed/ha. The soil was kept moist throughout and irrigation was stopped two weeks before crop harvest. Data on population and dry matter accumulation by different weed species was recorded at 60 days placing 50 cm square quadrant at two spots in a plot. Ten crop plants were randomly selected at harvest and panicle length and grains per panicle were recorded.

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Weed flora in the experimental field consisted mainly of grasses (*Digitaria sanguinalis*, *Echinochloa* spp, *Eleusine aegyptiacum*, *Leptochloa chinensis* and *Eragrostis* spp), broad-leaved (*Ammania baccifera* and *Caesulia axillaries*) and sedges (*Cyperus rotundus*, *Cyperus iria* and *Cyperus compressus*). Population of *Echinochloa* sp, *L. chinensis* and *D. sanguinalis* did not vary among sowing dates except *Eragrostis* sp. which was higher under rice seeded on 28 DANS than all the other dry seeding dates and transplanting. *Ammania baccifera* and *C. axillaris* infestation was significantly higher in rice seeded directly on 21 and 28 DANS as compared to all the other dry seeding dates and transplanting. Dry-seeding rice on 7, 14 and 28 DANS recorded significantly higher *C. compressus* intensity as compared to other sowing dates. Higher pressure of broad-leaved weeds in rice seeded directly on 21 DANS reduced the *C. compressus* intensity. Rice seeded directly on 0 DANS recorded the lowest total weed density similar to transplanted treatment. The delay in dry seeding increased total weed population as compared to early seeding dates.

Weed population and dry matter did not vary among rice varieties. Among weed control, pendimethalin *fb* bispyribac-sodium gave effective control of *Echinochloa* sp. and *D. sanguinalis* and recorded similar population to that of three hoeings. Poor control of *Eragrostis* sp. and *L. chinensis* by these herbicides significantly increased their population as compared to three hand hoeings which removed different flushes of these weeds. Pendimethalin provided effective control of broad-leaved weeds and proved as effective as three hoeings. Total weed density under herbicides was statistically similar to three hand hoeings due to effective control of majority of weeds by the sequential application of herbicides (Table 1). Hand hoeings twice was highly effective in controlling weeds in dry-seeded rice (Kathiresan and Manoharan 2002, Singh *et al.* 2004), and had higher weed control efficiency than herbicides (Behera and Jena 1998).

Grassy weeds accumulated the lowest dry matter in transplanting treatment which was at par with all the direct sowings except 28 DANS (Table 1). Higher pressure of weeds increased dry matter under late sowings and standing water in transplanted crop did not allow weeds to germinate and accumulate dry matter. Transplanted crop recorded lower weed dry matter as compared to direct sown crop (Singh *et al.* 2003). Rice cv. '*PAU 201*' recorded significantly lower weed dry matter than '*PR 115*'. Weed control treatments did not influence grassy weeds dry matter because herbicides and hand hoeings gave good control of prominent grassy weeds. The dry matter of broad-leaved weeds and sedges did not vary statistically among sowing dates and varieties. However, herbicidal treatment recorded significantly higher dry matter of broad-leaved weeds and sedges as compared to three hoeing. Although pendiemthalin kept population of broad-leaved weeds under check, still they accumulated dry matter sufficiently higher than three hoeings. Higher population of *C. rotundus* increased the dry matter of sedges under chemical as compared to three hoeings.

Transplanted rice crop produced the highest rice grain yield, which was at par with direct seeding on 0 DANS but significantly higher than other direct seeding dates. The rice grain yield in transplanted treatment was 11.9, 22.1, 20.7, 41.8 and 71.3% higher as compared to direct seeding on 0, 7, 14, 21 and 28 DANS, respectively. Rice seeded directly on 0, 7 and 14 DANS yielded at par but significantly higher than that seeded on 21 and 28 DANS. Three hand hoeings produced significantly higher rice grain yield as compared to sequential application of pendimethalin and bispyribac. Lower weed pressure in hand-hoed plots helped the crop produce more number of effective tillers which increased the grain yield than herbicide treated plots.

Table 1. Effect of sowing time, variety and weed control on weed growth and yield performance of rice

Treatment	Total weed count at 60 DAS (no./m^2)	Weed dry matter at 60 DAS (kg/ha)			Effective tiller/m^2	Panicle length (cm)	Grains/ panicle	Grain yield (t/ha)
		Grassy weeds	Broad-leaved weeds	Sedges				
Sowing time								
Direct sowing on 0 DANS	29.6	119 (44)	115 (33)	129 (72)	492	22.0	113.2	5.03
Direct sowing on 7 DANS	56.1	112 (29)	147 (136)	173 (239)	492	22.2	97.4	4.62
Direct sowing on 14 DANS	69.0	124 (62)	114 (35)	138 (103)	529	22.1	99.4	4.67
Direct sowing on 21 DANS	102.4	117 (44)	115 (34)	162 (187)	510	20.3	88.9	3.97
Direct sowing on 28 DANS	96.4	154 (148)	143 (117)	160 (173)	504	20.4	85.8	3.29
Transplanting on 28 DANS	25.4	108 (16)	108 (18)	129 (72)	364	25.2	125.7	5.64
LSD (P=0.05)	30.5	16	NS	NS	82	1.7	14.5	0.59
Variety								
'*PR 115*'	68.1	128 (74)	125 (68)	148 (144)	483	22.4	106.9	4.46
'*PAU 201*'	58.2	116 (40)	122 (57)	153 (152)	481	21.7	96.6	4.61
LSD (P=0.05)	NS	11	NS	NS	NS	0.6	5.7	NS
Weed control								
Pendimethalin 0.75 kg/ha *fb* bispyribac 0.03 kg/ha	66.3	124 (61)	132 (87)	167 (199)	467	22.0	103.1	4.36
Hand hoeing at 20, 40 and 60 DAS	60.0	121 (53)	115 (38)	134 (96)	497	21.1	100.4	4.71
LSD (P=0.05)	NS	NS	11	16	NS	NS	NS	0.21

Data subjected to square root transformation. Figures in parentheses are means of original values. DANS - days after nursery sowing

Interaction revealed that rice seeding directly on 0, 7 and 14 DANS produced similar grain yield under herbicides and three hand hoeings but further delay in rice seeding significantly reduced the grain yield under herbicides as compared to hand hoeing. Higher weed pressure under late sowings put more competition which reduced the grain yield under herbicide treated plot while three hoeings successfully removed the weeds even under late sowings.

SUMMARY

Transplanted crop recorded the lowest total weed population and dry matter and similar to dry seeding on 0 days after nursery sowing. Total weed population and dry matter was lower under early sowing on 0, 7 and 14 DANS as compared to delayed sowings. Sequential application of herbicides effectively controlled *Echinochloa* sp. and *D. sanguinalis* while control of *Eragrostis* sp. and *L. chinensis* was very poor. Transplanted crop recorded the highest rice grain yield, at par with dry seeding on 0 DANS but significantly higher than dry seeding on later dates. Three hand hoeings gave significantly higher grain yield than herbicides. Rice seeding directly on 0, 7 and 14 DANS produced similar grain yield under herbicides and three hand hoeings. Further delay in seeding significantly reduced grain yield under herbicides as compared to hand hoeings.

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Short communication

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Chemical management of broad-leaved weeds in grapes

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Grape (*Vitis vinifera* L.) is one of the most important fruit crops of temperate zone, which has acclimatized to sub tropical and tropical agro climatic conditions prevailing in the Indian sub-continent. In India, grapes are grown under different soil and cultural conditions. Weed flora varies according to the climate and physio-chemical properties of the soil. rrespective of the agro climatic conditions, *Parthenium hysterophorus, Cynodon dactylon Cyperus rotundus* are the common weeds in the Indian vineyards although as many as 378 species of weeds have been reported to infest the cultivated lands in Karnataka (Krishna Sastry *et al.* 1980). The weed flora also differ with the training and irrigation system of the vineyards. The variety of weeds and their intensity is more in vineyards where vines are trained to vertical trellises such as T, V, Y or tatura due to availability of uninterrupted sunlight. Under drip-irrigation system, weeds grow mainly in the wetted area particularly during summer (Patil 2005).

In the past, majority of workers have tried either pre-emergence or post-emergence application of weedicides for the control of weeds in the grape vineyard. No single weedicide either as pre-emergence or post-emergence can offer a long lasting control of weeds in vineyards since grape vines are irrigated and the soil moisture is maintained throughout the year, which helps the weeds to grow almost throughout the year. Keeping all these aspects in mind, the present investigations was undertaken.

A field experiment was conducted on grape (*Vitis vinifera* L. (cv *Thompson Seedless*) at the vineyard of the National Research Centre for Grapes, Pune (latitude 18.31 N, longitude 73.55 E) after October pruning of 2010. The trial was laid out in randomized complete block design, having ten treatments with three replications, to test the effect of various treatments for controlling weeds in the vineyards under tropical conditions of Pune, Maharashtra. The vines selected were spaced at 2.4 m between rows and 1.2 m within rows. The plot size was 4.8 x 4.8 m accommodating eight vines in each treatment. Irrigation and fertilizer requirements were kept as per standard recommendation.

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Herbicides were applied at 3 to 4 leaf stage of weed in vineyard. Hand weeding was also done along with weedicides application. The treatments details are given Table 2.

Weeds were counted by taking a quadrate of 0.5 x 0.5 m placed at random inside the each treated plot. The total number of dicot and monocot weeds present (Table 2) in the quadrate frame was counted at 15 and 30 days after treatment. The weed count per square meter was then worked out. The sum of all weeds was recorded as total weed count per square meter.

For dry weight, above ground portion of the weeds in the quadrant was collected from each plot at 15 days and 30 days after treatment. The weed samples were air-dried and later oven dried to constant weight at 60 ºC and dry weight was recorded. These dry weights were converted to dry weight per square meter.

Grape yield per hector basis was calculated based on bunch weight at the time of crop harvest. Bunch weight calculated from collecting random five bunches from eight vines from each treatment while, the yield of five vines in each treatment was recorded and average yield per hectare was calculated and expressed in tones. All parameters studied showed high degree of variation. Therefore, data was subjected to square-root transformation to make the analysis of variance valid.

The dominant weed flora was *Parthenium hysterophorus, Cyperus rotundus* L., *Euphorbia geniculata* L., *Portulaca oleracea* L., *Commelina benghalensis* L. and *Amaranthus spinosus* L.

Herbicides treatments in grape vineyard significantly reduced the total number of weeds.The results revealed significant effect of different weed control treatments on weed population. Lowest weed density (12.2/m^2) after 15 days of application was observed in glyphosate (42% SL) followed by BCSAA 10717 (2%) + glphosate (42% SC) and BCSAA 10717-2% + glphyosate 4% SC. However, after 30 days after spraying of weedicides, highest weed control was observed with lowest weed density (4.80/m^2)

Table 1. Effect of herbicide on weed density (no./m²) in vineyard at 15 days after treatment application

Treatment	Dosage		Weed count (no./m²)						
	g/ha	Volume (ml)	P.h.	E.g.	A.s.	C.b.	C.r.	Other grasses	Total
T_1 - Untreated control (weed check)	Untreated	–	40(6.4)	26 (5.2)	14 (3.8)	21 (4.7)	97 (9.9)	9 (3.2)	207 (14.4)
T_2 - BCSAA 10171-2% + glyphosate 40-42% SC	32.5+650	1625	12(3.6)	15 (0.4)	11 (3.5)	17 (4.2)	120 (11.0)	10 (3.3)	185(13.6)
T_3 - BCSAA 10171-2% + glyphosate 40-42% SC	37.5+750	1875	7(2.8)	18 (4.4)	13 (3.7)	23 (4.9)	80 (9.0)	19 (4.5)	160(12.7)
T_4 - BCSAA 10171-2% + glyphosate 40-42% SC	42.5+850	2125	33(5.8)	7 (2.8)	22 (4.8)	30 (5.6)	134 (11.6)	21 (4.7)	247(15.8)
T_5 - BCSAA 10171-2% + glyphosate 40-42% SC	85.0+1700	4250	22(4.8)	5 (2.5)	13 (3.7)	10 (3.3)	103 (10.2)	7 (2.8)	160(12.7)
T_6 - BCS AA 10717 SC 500	42.5	85	28(5.4)	15 (0.4)	8 (3.0)	22 (4.8)	87 (9.4)	4 (2.2)	164(12.9)
T_7 - Glyphosate 42 SL	850	2073	55(7.5)	22 (4.8)	13 (3.7)	12 (3.6)	39 (6.3)	8 (3.0)	149(12.3)
T_8 - Glyphosate 41 SL	1025	2500	72(8.5)	38 (6.2)	27 (5.3)	12 (3.6)	67 (8.3)	19 (4.5)	235(15.4)
T_9 - Paraquat 24 SL	600	2500	34(5.9)	18 (4.4)	21 (4.7)	11 (3.5)	89 (9.5)	15(4.0)	188(13.8)
T_{10} - Hand weeding	Hand weeded	-	135(11.7)	13 (3.7)	13 (3.7)	8 (3.0)	94 (9.8)	3(2.0)	266(16.3)
LSD (P=0.05)			6.67	1.95	1.13	1.20	4.16	1.21	0.39

P.h. - *Parthenium hysterophorus,* C.r. -*Cyperus rotundus*, E.g. - *Euphorbia genieculata*, C.b. - *Commelina benghalensis,* A.s. - *Amaranthus spinosus*

Table 2. Effect of herbicides on density in vineyard at 30 days after treatment

Treatment	Dosage		Weed count (no/m²)						
	g/ha	Volume (ml)	P.h.	E.g.	A.s.	C.b.	C.r.	Other grasses	Total
T_1	Untreated	-	40(6.4)	26(5.2)	14(3.9)	21(4.7)	97(9.9)	9(3.2)	207(14.4)
T_2	32.5+650	1625	12(3.6)	15(4.0)	11(3.5)	17(4.2)	120(11.0)	10(3.3)	185(13.6)
T_3	37.5+750	1875	7(2.8)	0 (1.0)	0(1.0)	23(4.9)	80(9.0)	0(1.0)	110(10.5)
T_4	42.5+850	2125	0(1.0)	0(1.0)	0(1.0)	30(5.6)	134(11.6)	0(1.0)	164(12.9)
T_5	85.0+1700	4250	22(4.8)	0(1.0)	0(1.0)	0(1.0)	0(1.0)	0(1.0)	22(4.8)
T_6	42.5	85	28(5.4)	15(4.0)	8(3.0)	22(4.8)	87(9.3)	0(1.0)	160(12.7)
T_7	850	2073	55(7.5)	22(4.8)	13(3.7)	12(3.6)	39(6.3)	0(1.0)	141(11.9)
T_8	1025	2500	72 (8.5)	0(1.0)	27(5.3)	0(1.0)	67(8.3)	0(1.0)	166(12.9)
T_9	600	2500	34(5.9)	0(1.0)	21(4.7)	0(1.0)	89(9.5)	0(1.0)	144(12.0)
T_{10}	Hand weeded	-	135(11.7)	13(3.7)	13(3.7)	8(3.0)	94(9.8)	3(2.0)	266(16.3)
LSD (P=0.05)			7.0	1.6	1.6	1.8	6.1	0.6	0.39

P.h. - *Parthenium hysterophorus,* C.r. - *Cyperus rotundus*, E.g. - *Euphorbia geneculata*, C.b. - *Commelina benghalensis*, A.s. - *Amaranthus spinosus* L.

in BCSAA 10717-2% + glyphosate (42% SC) treated plote than rest of the weedicide (Table 2 and 3). This might be due to the persistence of glyphosate for a long period. Similar results were observed by Gaziev *et al.* (1985) who showed that glyphosate persisted in soil for 3 to 5 months under rainfed conditions and 3 months in irrigated conditions.

After 30 days of spraying, highest weed density was occurred in hand weeding treatment which was in contrast with findings of Rekha *et al.* (2002) and Hussain *et al.* (2008). The studies are in confirmation with the earlier works by Bajwa *et al.* (1990) and Bajwa *et al.* (1992), who reported glyphosate as very effective for controlling both mono and dicot weeds in grapes.

Application of glyphosate with other weedicides treatment in '*Thompson Seedless'* grape vineyard significantly reduced the dry weight in all weeds both at 15 and 30 days as compared to hand weeding and control. BCSAA 10717-2% + glyphosate 42% SC showed its superiority by recording lower dry weight of weeds as compared to other post-emergent herbicides like BCSAA**,** glyphosate and paraquat (Fig. 1). Similar results were obtained by Bajwa *et al.*, (1993b) and Muniyappa and Prathibha *et al.* (1993).

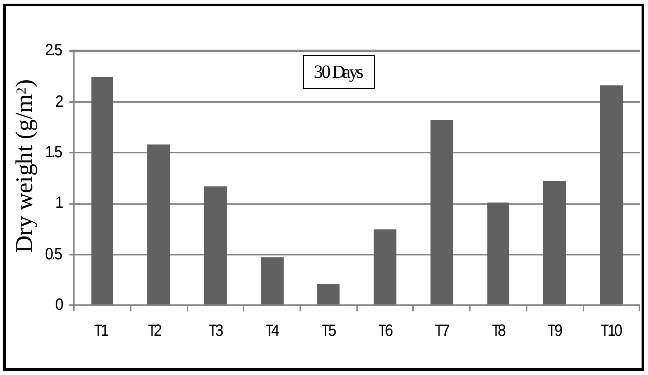

Fig. 1. Effect of weed control treatment on dry weight (g/m^2) of total weeds in vineyard at 30 days after treatment

Table 3. Effect of weed control treatments on bunch weight and yield of grapes

Treatment	Dosage		Bunch weight (g)	Yield (t/ha)
	g/ha	Volume (ml/ha)		
T_1	Untreated	-	233	20.5
T_2	32.5+650	1625	245	26.6
T_3	37.5+750	1875	269	29.0
T_4	42.5+850	2125	270	24.0
T_5	85.0+1700	4250	244	28.2
T_6	42.5	85	280	29.6
T_7	850	2073	260	30.8
T_8	1025	2500	246	15.3
T_9	600	2500	218	32.1
T_{10}	Hand weeded	-	260	23.1
LSD (P=0.05)			8	1.01

The application of BCSAA 10717-500 SC (T_6) showed lowest dry weight (0.847 g/m^2) followed by BCSAA 10717 2% + glyphosate 42% SC (1.238 g/m^2) and then BCSAA 10717 2% + glyphosate 42.5 SC (1.503 g/m^2) after 15 days of application of weedicides. While after 30 days, the application of BCSAA 10717 2% + glyphosate 42% SC showed lowest dry weight followed by BCSAA 10717 2% + glyphosate 42% SC as compared to untreated, hand weeding and other weedicide treatments. These results are in conformity with results of Aulakh (1999).

The data on bunch weight and yield depicted that all the treatments showed significant effects on grape yield (Table 3). Weed control treatments with or without herbicides significantly increased the number of bunches per vine as compared to hand weed check. The bunch weight was higher where BCSAA 10717-500 SC was used for weed control, followed by BCSAA 10717-2% + glyphosate 42% SC. Similar results were observed by Yamadagni and Sharma (1992) who reported that, application of diuron at 2 and 3 kg/ha increased the bunch weight as compared to weed free and weedy check. Least bunch weight was recorded in control (weed check) (T_1).

Maximum yield (32.12 t/ha) was produced in paraquat 24 SL weedicide treatment followed by glyphosate 42 SL treatment. Increase in yield in weedicidal treatments and hand weeding might be due to increase in yield components resulting from weedy check of weeds and shifting of competition of moisture and nutrients in favor of crop. Increase yield by the application of weedicides has been reported by Bajwa *et al. (*1993b) and Bajwa *et al.* (1997)

No phytotoxic signs or symptoms, *viz*. leaf tip/surface injury, wilting, vein clearing, necrosis, epinasty or hyponasty were observed at 1, 3, 5, 7, 10, 15 and 30 days after reatment with tested herbicide. Present study recommended the use of BCSAA 10717 2% + glyphosate 42% SC at the rate of 85.0 + 1700 g/ha or glyphosate 42% SL at the rate of 850 g/ha which seems to be economical and long lasting effects for weed control.

SUMMARY

A field experiment was conducted to study the effect of different herbicides alone or in combination, *viz*. BCSAA 10717-2% + glyphosate (42% SC), BCSAA10717-500 (SC), It is glyphosate (42% SC), glyphosate (41% SC) and paraquat(24 SL) for management of annual and perennial broad-leaved weeds in grapes after October pruning of the year 2010-2011. Herbicide treatments in grape vineyard significantly reduced the total number of weed. Among the tested herbicides, the most effective weed control was recorded with BCSAA 10717 (2%) + glyphosate 42% SC (85.0 + 1700 g/ha) which showed lowest weed density of 22 (4.80) plants/m^2 and lowest dry weight (0.212 g) of weed after 30 days. While paraquat (24 SL) found effective in increasing the yield with decreasing competition between grape vine and weed, The highest yield (32.12 t/ha) was found in area where paraquat 24 SL was used for

weed control. No phytotoxic signs or symptoms, *viz.* leaf tip/surface injury, wilting, vein clearing, necrosis, epinasty and /or hyponasty were observed by weed management treatments.

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Short communication

Weed management in pearlmillet based intercropping system

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Pearlmillet [*Pennisetum glaucum* (L.) Br. *emend Stuntz*.] is an important coarse grain cereal crop of dry land agriculture. It can be grown on light textured soil under low moisture conditions as sole as well as with mothbean and cluster-bean in inter-cropping system in arid and semi-arid region of Rajasthan. Besides other production constraints, weed infestation is considered as one of the most important constraints to limit the yield in the pearlmillet based inter-cropping systems. Being the rainy season cropping system, it may be infested severely with different kind of weeds which may reduce the yield of pearlmillet and inter crops. Several workers like Singh and Yadav (1994), Ram *et al*. (2005) reported weed management in sole pearlmillet but information regarding the control of weeds in pearlmillet based inter-cropping system is scarce, particularly by herbicide. Keeping these points in view, the present study was under taken.

A field experiment was conducted at Agronomy Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner during *Kharif* 2007. The soil was sandy loam in texture, low in organic carbon (0.08%) and available N (86.4 kg/ha), medium in P (21.9 kg/ha) and high in K (234.0 kg/ha) contents with a pH of 8.5. There were 21 treatments consisting of 3 treatments of intercropping (pearlmillet sole, pearlmillet + clusterbean and pearlmillet + mothbean) and 7 treatments of weed control (weedy check, weed free, hand weeding once at 25 DAS, hand weeding twice at 25 and 45 DAS, pendimethalin at 0.75 kg/ha, oxyfluorfen at 0.1 kg/ha and oxyfluorfen at 0.2 kg/ha).The treatments were replicated thrice in factorial randomized block design. Crops were sown on 17 July, 2007 in lines spaced 60 cm in pearlmillet and 30 cm in inter-cropping treatments by 'Kera' method in open furrow. A basal dose of N (20 kg/ha) and P (20 kg/ha) were drilled uniformly before sowing and remaining 20 kg N/ha was top dressed in the rows of pearlmillet only. Weed density and dry weight was recorded by putting a quadrat (0.25 m^2) at random spots at two places in each plot. The total rainfall during the crop season was 121.9 mm.

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Weed flora of the experimental field consisted of *Tribulus terrestris* L., *Cenchrus biflorus*, *Corchorus tridense*, *Cyperus* spp., *Euphorabia microphylla*. However, the predominant weeds were *Tribulus terrestris*, *Cenchrus biflorus* and *Corchorus tridense*.

The density and dry weight of total weeds were significantly reduced in both the inter-cropping systems compare to sole cropping of pearlmillet (Table 1). Among the individual weeds, pearlmillet + mothbean inter-cropping system reduced the density of *Tribulus terrestris* and *Cenchrus biflorus* significantly over sole cropping of pearl millet. All the growth parameters, *viz*. plant height, dry matter accumulation, root weight and length and yield attributing characters, *viz*. effective tillers/plant, length of ear and test weight of pearlmillet were non-significant among different inter-cropping treatments hence, seed and stover yield of pearlmillet was also found non-significant among inter-cropping of clusterbean/mothbean and sole pearl millet. The pearlmillet equivalent yield and net return was significantly higher in both the inter-cropping systems compared to sole pearlmillet but yield of inter-cropping of pearlmillet either with mothbean or clusterbean were non-significant (Table 1) among themselves.

All the weed control measures decreased the density and dry weight of individual as well as total weeds significantly over weedy check. Pendimethalin at 0.75 kg/ha significantly reduced the density and dry weight of individual as well as total weeds significantly over oxyfluorfen at 0.1-0.2 kg/ha as pre-emergence. Hand weeding twice at 25 and 45 DAS significantly reduced density and dry weight of individual as well as total weeds compared to all other treatments and was statistically at par with weed free treatment. Hand weeding once at 25 DAS also reduced the density and dry weight of individual and total weeds as compared to oxyfluorfen at 0.1-0.2 kg/ha. Weed control treatments had significant effect on plant stand of pearlmillet (Table 1). Pendimethalin at 0.75 kg/ha and oxyfluorfen at 0.2 kg/ha significantly reduced the plant stand of pearlmillet as compared to weed free treatment at 25 DAS and at harvest. This might be due to some phytotoxic effects of these herbicides on pearlmillet (Yadav *et al.* 2004). All the mechanical treatments had almost similar plant stand as that of weed free treatment.

Application of pendimethalin and oxyfluorfen (0.2 kg/ha) also reduced the plant height of pearlmillet significantly over all other treatments of weed control at 20 DAS (Table 1). It means that pendimethalin and oxyfluorfen (0.2 kg/ha) had some phytotoxic effect on pearlmillet. At 45 DAS and at harvest, significantly lower plant height of pearlmillet was observed in pendimethalin and oxyfluorfen at 1.0-2.0 kg/ha compared to weed free with different reasons. Reduction in plant height in pendimethalin 0.75 kg/ha and oxyfluorfen at 0.2 kg/ha was due to some phytotoxic effect as evident from the observation taken at 20 DAS. Both the treatments reduced the weeds significantly and could be comparable with one hand weeding at 25 DAS, but plant height of pearlmillet reduced in the oxyfluorfen at 0.1 kg/ha treated plots which was due to the poor control of weeds by this treatment. The dry matter of pearlmillet roots significantly influenced by weed control treatments at 20 and 40 DAS. Pendimethalin at 0.75 kg/ha applied as pre-emergence significantly reduced the root length of pearlmillet at 45 DAS compared to all other treatments.

Similarly, dry matter production of pearlmillet was also affected by weed control treatments. At 20 DAS, significantly lower dry matter of pearlmillet was recorded in pendimethalin and oxyfluorfen at 0.2 kg/ha treatments compared to all other weed control treatments. At 45 DAS and at harvest, significantly lower dry matter was also produced by these two treatments compared to weed free and hand weedings, but it was significantly higher than weedy check. This might be due to phytotoxic effect of these treatments on pearlmillet. However, oxyfluorfen at 0.1 kg/ha also recorded significantly lower dry matter of pearlmillet at 45 DAS and at harvest compared to all other weed control treatments. This might be due to poor control of weeds in this treatment.

All the weed control treatments significantly increased the grain and stover yield of pearlmillet over weedy check (Table 2). Weed free treatment recorded the maximum grain and pearlmillet equivalent yield and consequently net return closely followed by hand weeding twice. Significantly higher grain and pearlmillet equivalent yield was obtained in pendimethalin and oxyfluorfen treated plots compared to weedy check but these herbicidal treatments produced significantly lower yield than weed free and two hand weedings, inspite of good weed control. This might be due to some phytotoxic effect on pearlmilet as evident from root study of pearlmillet.

Table 1. Effect of intercropping and weed control treatments on growth attributes of pearlmillet

Treatment	Plant stand ($x10^5$/ha)		Plant height (cm)			Drymatter production (g/plant)			Root weight (g)		Length (cm)
	At 25 DAS	At harvest	20 DAS	45 DAS	At harvest	20 DAS	45 DAS	At harvest	20 DAS	40 DAS	45 DAS
Intercropping											
Pearlmillet sole crop	1.84	1.75	48.77	147.48	152.62	1.23	17.82	27.73	0.40	4.88	29.15
Pearlmillet + cluster bean	1.78	1.73	48.36	147.77	152.17	1.18	16.96	27.41	0.38	5.05	29.08
Pearlmillet + moth bean	1.78	1.74	48.20	146.96	151.85	1.18	16.47	26.61	0.38	4.90	29.12
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Weed control											
Weedy check	1.95	1.86	50.13	139.14	144.11	1.37	12.63	20.01	0.43	4.01	31.97
Weed free	1.97	1.94	51.03	152.88	157.70	1.39	20.84	32.67	0.44	5.30	32.66
Hand weeding once at 25 DAS	1.95	1.90	50.91	150.92	155.46	1.37	18.58	29.93	0.43	5.23	32.43
Hand weeding twice at 25 and 45 DAS	1.89	1.87	50.49	152.18	156.62	1.35	18.49	31.09	0.44	5.21	32.43
Pendimethalin at 0.75 kg/ha (pre-emergence)	1.47	1.43	45.20	146.59	151.55	0.94	16.59	26.77	0.26	5.80	10.50
Oxyfluorfen at 0.1 kg/ha (pre-emergence)	1.82	1.70	48.83	143.07	148.03	1.13	14.56	21.68	0.43	5.10	31.88
Oxyfluorfen at 0.2 kg/ha (pre-emergence)	1.55	1.47	42.49	147.05	152.02	0.84	17.89	28.61	0.30	4.92	31.96
LSD (P=0.05)	0.10	0.11	2.16	4.21	5.03	0.03	1.03	1.75	0.04	0.47	0.32

DAS= Days after sowing

Table 2. Effect of intercropping and different weed control treatments on yields of pearlmillet

Treatment	Grain yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Intercrop equivalent yield (t/ha)	Pearlmillet grain equivalent yield (t/ha)
Intercropping					
Pearlmillet sole crop	2.35	4.94	7.29	-	2.33
Pearlmillet + clusterbean	2.28	4.81	7.09	0.85	3.13
Pearlmillet + mothbean	2.31	4.86	7.17	0.83	3.13
LSD (P=0.05)	NS	NS	NS	-	0.28
Weed control					
Weedy check	1.48	3.87	5.35	0.42	1.90
Weed free	2.76	5.68	8.45	0.63	3.39
Hand weeding once 25 DAS	2.59	5.32	7.92	0.61	3.12
Hand weeding twice at 25 and 45 DAS	2.64	5.40	8.05	0.62	3.26
Pendimethalin at 0.75 kg/ha	2.27	4.64	6.92	0.58	2.99
Oxyfluorfen at 0.1 kg/ha	1.97	4.22	6.19	0.45	2.42
Oxyfluorfen at 0.2 kg/ha	2.45	4.97	7.42	0.51	2.96
LSD (P=0.05)	1.75	3.23	4.03	-	1.98

Table 3. Effect of intercropping and different weed control treatments on N, P uptake and net returns by pearlmillet

Treatment	N uptake (kg/ha)		P uptake (kg/ha)		Net returns ($x10^3$ ₹/ha)
	Grain	Stover	Grain	Stover	
Intercropping					
Pearlmillet sole crop	34.52	23.87	6.49	5.58	16.70
Pearlmillet + clusterbean	35.36	23.58	6.49	5.62	23.13
Pearlmillet + mothbean	35.15	23.87	6.49	5.61	21.14
LSD (P=0.05)	NS	NS	NS	NS	2.39
Weed control					
Weedy check	18.76	16.70	3.82	3.98	12.60
Weed free	44.56	29.21	8.08	6.83	24.43
Hand weeding once 25 DAS	39.56	26.22	7.16	6.22	23.74
Hand weeding twice at 25 and 45 DAS	42.15	27.47	7.66	6.46	23.75
Pendimethalin at 0.75 kg/ha	35.97	22.88	6.48	5.43	20.12
Oxyfluorfen at 0.1 kg/ha	25.67	19.60	5.31	4.61	16.38
Oxyfluorfen at 0.2 kg/ha	38.41	24.33	6.90	5.72	21.22
LSD (P=0.05)	2.63	1.81	0.54	0.48	1.69

Weeding was associated with no or lower dry matter production of weeds under these treatments. Further, in weed free and hand weeding treatments, weeds were removed manually with the help of hand hoe, which makes the soil porous and creates favourable environment for growth in addition to effective control of weeds. The favourable effect of weed control on account of reduced weed crop competition under these treatments led to significant increased in various yield parameters, *viz.* numbers of effective tillers, length of ear and test weight. Further, contribution of weed control measures towards the important yield attributes could be owing to their effect on reducing crop weed competition and increasing the weed control efficiency and hence, better utilization of inputs by crop plants. Ram *et al.* (2005) also reported improvement in yield components due to elimination of severe crop weed competition.

N uptake by crop recorded under all the weed control measures was significantly higher over weedy check (Table 3). The maximum uptake of N and P by crop up to harvest was observed under weed free closely followed by hand weeding twice which effectively controlled and suppressed the weed growth and thereby provided almost weed free environment to the crop to utilize the available nutrients. Thus increase in crop dry matter with a concomitant increase in its nitrogen and phosphorus content seems to be responsible for increased uptake of nitrogen and phosphorus by crop under these treatments. Similar findings were also reported by Sreenivas and Satyanarayan (1996) and Ram *et al.* (2005). Nitrogen and phosphorus uptake by pearlmillet grain and stover were also not affected significantly by intercropping system.

SUMMARY

A field experiment was conducted during *Kharif* season of 2007 to study the weed management in pearlmillet inter-cropping systems. The experiment was laid out in factorial randomized block design and replicated three times. Pre-emergence application of pendimethalin at 0.75kg/ha and oxyfluorfen at 0.2 kg/ha decreased the crop growth and yield attributes, *viz.* plant stand, plant height, dry matter production, root weight and root length compared to two hand weeding due to some phytotoxic effect but superior to one hand weeding and weedy check. Significantly higher seed, stover, biological and pearlmillet equivalent yield were recorded in two hand weeding treatment over all other treatments except weed free. The N and P uptake of pearlmillet and net returns increased significantly under all the weed control treatments as compared to weedy check.

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Short communication

Effect of brown manuring on weed growth, yield and economics of irrigated maize

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Key words: Brown manuring, Economic returns, Weed density, Yield

Maize (*Zea mays* L.) considered as the queen of the cereals, is one of the most important crops next to rice and wheat in global agriculture. Though maize is under cultivation in India, production and productivity are comparatively less over temperate countries. It was due to many factors. However, the factor which causes drastic reduction in growth, development and yield of the maize is weed which accounts for 40% yield loss and even >70% yield loss under uncontrolled weed growth condition in maize. Weeds are controlled by many means. However, in the current scenario of agriculture, evolving ecofreindly approach of weed control is more advisable so as to protect the natural resources such as soil flora and fuana including human being and animals in a holistic manner.

In this context, an advanced weed management strategy which has emerged in India is brown manuring. It aimed at suppressing the weeds without affecting the soil physico and chemical properties and its associated microbes. It can be achieved through raising green manure crops such as *Sesbania* (Daincha), sunhemp *etc*. as inter crop and killing the same by application of post-emergence herbicides. The killed manure is allowed to remain in the field along with main crop without incorporation / in-situ ploughing until its residue decomposes itself in the soil aiming to add organic manure beside weed suppression by its shade effect. Given the post-emergence spray on green manure leaves resulting in loss of chlorophyll in leaves showing brown in colour is referred to as brown manuring (Tanwar *et al.* 2010). Brown manuring also helps in suppressing the weeds upto 50% of total weed population on the account of the shade effect of killed green manure till 45 DAS upto which the critical period of crop weed competition continues in maize. Keeping these points in view, a study was undertaken to find out the effect of brown manuring on weed growth, yield and economics of irrigated maize.

A field experiment was conducted during late *Rabi* season of 2011-2012 at Agricultural College and Research Institute, Madurai. The experiment was laid out in randomized block design with seven treatments and replicated thrice (Table1). The maize hybrid *'CoH (M) 5'* was sown with recommended space of 60 x 25 cm. In between the rows of maize, two rows of *Sesbania* were sown with an intra row spacing of 20 cm in the respective treatments as per treatment schedule. The sowing of maize and daincha was taken up simultaneously.

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Calibrated quantity of herbicides was applied as aquous spray (500 l/ha) with knapsack sprayer. Hoeing was given on 20 and 35 DAS in mechanical weeding by hand hoeing twice. Pre-emergence application of alachlor was given 1.0 kg/ha on 3rd DAS in the respective treatments. In brown manuring treatments plots, *Sesbania* (daincha) and maize were grown together for 35 days and thereafter, *Sesbania* was knocked down with the use of 2,4-D spray 0.5 kg/ha.

Results revealed that density of grasses, sedges, broad-leaved weeds and total weeds was reduced substantially by pre-emergence alachlor 1.0 kg/ha + brown manuring over rest of the treatments at 60 DAS (Table1). This might be due to pre-emergence alachlor application which provided effective control of weeds during the early stage and maintained nearly weed free conditions upto 30 DAS and suppression of weeds thereafter by the shade effect of daincha crop residue and rapidly growing canopy of maize at later stages up to harvest. However, it was equally effective as that of PE alachlor 1.0 kg/ha + daincha as inter crop with in-situ incorporation on 35 DAS. This result corroborated with the findings of Samar Singh *et al.* (2007). Among the treatments, the weed density was statistically higher in unweeded check. It was due to rank weed growth under uncontrolled situations during the entire crop growth period.

With regard to weed control efficiency, it was higher (89.65% at 60 DAS) in PE alachlor 1.0 kg/ha + brown manuring (Table 1). This was closely followed by PE alachlor 1.0 kg/ha + daincha as intercrop with in-situ incorporation on 35 DAS (86.04% of at 60 DAS). This was evident from greater reduction weed density in this treatment. This was in agreement with the findings of Kumar and Mukherjee (2011).

The higher stature of yield attributes, *viz.* cob length (17.09 cm), no. of grains/cob (569.14) and 100 grain weight (23.57 g) were noticed with PE alachlor 1.0 kg/ha + brown manuring. The improvement in the yield attributes in the above said treatment was primarily due to less weed competition during the crop weed competition period as a result of better weed control by pre-emergence alachlor up to 30 DAS and suppression of weeds thereafter by smothering effect of brown manuring till harvest. PE alachlor 1.0 kg/ha + dainaha as intercrop with in-situ incorporation on 35 DAS has also increased the value of yield attributes next to the above promising treatment (Table 1). The yield attributes were greatly affected by rank weed growth recorded in unweeded check.

The highest grain (7.23 t/ha) and stover yield (11.56 t/ha) was recorded with PE alachlor 1.0 kg/ha + brown manuring (Table 1). It was closely followed by PE alachlor 1.0 kg/ha + daincha as intercrop with in-situ incorporation on 35 DAS (6.38 and 10.20 t/ha). These results are in conformity with the findings of Kumar and Mukherjee (2011). Infestation of more weeds noticed in unweeded check resulted in drastic reduction in grain and stover yield as compared to the rest of the treatments.

Maximum productivity of grain and stover yield with PE alahclor 1.0 kg/ha + brown manuring had resulted in the highest net return of ₹ 45,993/ha and benefit cost ratio of 3.061 during the year of the study (Table 1). This might be due to higher economic yield recorded in this treatment. This result was in conformity with the findings of Sunitha *et al.* (2010). PE alachlor 1.0 kg/ha + daincha as intercrop with in-situ incorporation on 35 DAS was the next best practice in increasing the net returns (₹ 37,235/ha) and benefit cost ratio (2.97). Weeds allowed to grow during the crop season in unweeded check deprived the crop for all the available growth resources and resulted in poor performance of maize and reduced the grain and stover yield and finally economic returns. Similar results were also reported by Pandey *et al.* (2002).

Table 1. Effect of brown manuring on weed density, yield and economics of maize

Treatment	Density of weeds at 60 DAS				Weed contrsol efficiency (%)	Yield attributes			Grain yield (t/ha)	Stover yield (t/ha)	Net returns (x10^3 ₹/ha)	B:C ratio
	Grasses	Sedges	Broad-leaved weeds	Total (no./m^2)		Cob length (cm)	No. of grains /cob	100-grain weight (g)				
Mechanical weeding by hand hoe on 20 and 35 DAS	7.50 (0.97)	6.66 (0.93)	5.66 (0.88)	19.82 (1.33)	80.5	14.5	433.1	21.3	5.67	8.51	29.23	2.43
PE alachlor 1.0 kg/ha *fb* mechanical weeding at 35 DAS	7.16 (0.96)	6.16 (0.91)	5.49 (0.87)	18.48 (1.31)	81.5	14.6	434.6	21.3	5.75	8.63	31.64	2.70
Daincha as intercrop with in-situ incorporation on 35 DAS	9.66 (1.06)	8.00 (1.00)	8.00 (1.00)	25.66 (1.44)	74.8	13.1	372.9	20.7	4.56	6.85	21.43	2.16
Brown manuring	9.26 (1.05)	7.66 (0.98)	7.66 (0.98)	24.15 (1.41)	75.8	13.2	375.0	20.8	4.61	6.92	23.33	2.37
PE alachlor 1.0 kg/ha + daincha as intercrop with in-situ incorporation on 35 DAS	5.66 (0.88)	4.33 (0.80)	4.20 (0.79)	14.19 (1.20)	86.0	15.9	489.7	22.4	6.38	10.20	37.23	2.97
PE alachlor 1.0 kg/ha + brown manuring	4.16 (0.78)	3.20 (0.71)	3.16 (0.71)	10.52 (1.09)	89.7	17.1	569.1	23.6	7.23	11.56	45.99	3.61
Unweeded check	32.83 (1.54)	32.16 (1.53)	36.66 (1.58)	101.65 (2.01)	-	11.2	275.1	17.2	3.19	4.80	11.57	1.71
LSD (P=0.05)	0.031	0.058	0.062	0.054	-	0.86	6.46	0.72	0.31	0.31	-	-

Figures in parentheses are log (x+2) transformed values

Sale price of output (₹ 0./t): Maize grain - 8000, maize stover - 500, Input price (₹ /kg): Maize seed - 190, Seed of daincha - 40, Urea - 4.78, SSP-3.22, Mop-4.45; Herbicides (₹ /l): Alachlor - 325, 2, 4-D sodium salt - 300; Labour wage - ₹ 125/man day for A type, ₹ 100/man day for B type

SUMMARY

A field experiment was conducted during *Rabi* season of 2011-12 at Madurai to study the effect of brown manuring on weed dynamics, yield and yield attributes and economics of irrigated maize. The weed management practice of PE alachlor 1.0 kg/ha + brown manuring proved to be effective in registering the lowest weed density of grasses, sedges, broad-leaved weeds and total weeds at 20, 40 and 60 days after sowing (DAS) and was at par with PE alachclor 1.0 kg/ha + daincha as intercrop with in-situ incorporation on 35 DAS except at 20 and 40 DAS. The above said prominent treatment has also registered higher weed control efficiency (84.41, 92.15 and 89.65% at 20, 40 and 60 DAS, respectively). As a result, the above promising treatment has increased the yield attributes such as cob length (17.09 cm), no. of rows/cob (14.76), no. of grains/row (38.56) and 100-grain weight (23.57 g), which in turn reflected in registering higher grain yield of 7,227 kg/ha and stover yield of 11,563 kg/ha. The net returns (₹ 45,993/ha) and benefit cost ratio (3.61) were also more in PE alachlor 1.0 kg/ha + Brown manuring. The weed management practice of PE alachlor 1.0 kg/ha + daincha as intercrop with in-situ incorporation on 35 DAS was found to be the next best treatment in recording the higher grain and stover yield and economic returns. Uncontrolled weed growth throughout the crop growth period in unweeded check reduced the grain and stover yield to the extent of 44.2% and 41.5%, respectively as compared to PE alachlor 1.0 kg/ha + brown manuring.

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