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Weed-population dynamics and fennel (*Foeniculum vulgare*) growth as influenced by integrated weed management

G.R. CHAUDHARY

All-India Co-ordinated Research Project on Spices, S.K.N. College of Agriculture, Jobner 303329 (Rajasthan)

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ABSTRACT

A field trial was conducted during winter (*rabi*) season of 1991-92 to 1993-94 at S.K.N. College of Agriculture, Jobner under semi-arid condition of Rajasthan. All the weed-control treatments except metolachlor @ 0.5 and 1.0 kg/ha significantly reduced the population of *Chenopodium murale* L. compared with unweeded control. *Heliotropium ellipticum* Ledebour was tolerant to oxyfluorfen @ 0.15 kg/ha, pre-emergence application of oxyfluorfen @ 0.15 kg/ha, pendimethalin @ 1.0 and 1.5 kg/ha, pre-plant incorporation of fluchloralin @ 1.0 and 1.5 kg/ha, pre-plant incorporation of fluchloralin @ 0.75 and 1.25 kg/ha, hand-weeding once (25 DAS) and twice (25 and 50 DAS, weed-free treatment and lower doses of herbicides supplemented with hand-weeding once (50 DAS) significantly reduced the total mean density (except at harvest with fluchloralin @ 0.15 kg/ha) and loss in seed yield (except oxyfluorfen @ 0.15 kg/ha and fluchloralin @ 0.75 kg/ha). All the weed control measures significantly increased the plant height and crop biomass (except metolachlor @ 0.5 and 1.0 kg/ha) over unweeded control. Lower doses of herbicides except metolachlor supplemented with hand-weeding once, pendimethalin @ 1.5 kg/ha, hand-weeding once and twice and weed-free treatment significantly increased the harvest index compared with unweeded control. Maximum benefit : cost ratio of 3.35 was obtained under weed-free condition, followed by pendimethalin @ 1.0 kg/ha supplemented with hand-weeding once (2.75). Among the herbicidal treatments, metolachlor @ 0.5 and 1.0 kg/ha was least effective in reducing the weed density and loss in seed yield.

Key words : Fennel, Weed dynamics, Integrated weed management

Fennel (*Foeniculum vulgare* Mill.) is an important spice crop in India, having 15% of the country's total sown area and production in Rajasthan. Slow growth at initial stages and long duration of the crop favours recurrent flushes of weeds, which compete with fennel for essentials of growth and cause heavy reduction in its seed yield. Frequent irrigation in loamy sand soils also promotes weed growth, causing intense competition. Applications of herbicides in fennel controls the weeds

effectively giving increase in seed yield up to 43.2 to 86.9% (Voevodin and Borisenko, 1981). Though frequent hoeing controls the weeds, it can also damage the crop. Therefore the present study was undertaken to find out the effective integrated weed-control measure in fennel.

MATERIALS AND METHODS

Field trials were carried out during winter (*rabi*) season of 1991-92 to 1993-94 at S.K.N. College of Agriculture, Jobner, under semi-arid conditions of Rajasthan. The soil had pH 8.0 and was low in available nitrogen and medium in available phosphorus and potassium status. The treatments details are given in Tables 1 and 2. The treatments were evaluated in randomized block design with three replications. The weed-free plots were maintained weed free by manual weeding equivalent to hand-weeding thrice. Fennel variety 'UF CM-1' was sown on 18, 29 and 22 October during 1991-92,1992-93 and 1993-94, respectively, and harvested on 15, 18 and 20 April in the respective years. A uniform dose of 30 kg N and 40 kg P_2O_5/ha was drilled at the time of sowing and 80 kg N/ha was top-dressed in two equal splits at 45 days after sowing (DAS) and at flower initiation. Weed population at 25, 50 and 75 DAS and at harvest, plant height, crop biomass at harvest and seed yield were recorded. Weed-control efficiency, weed index and harvest index were worked out.

RESULTS AND DISCUSSION

Weed flora

The experimental field was infested with major weeds, viz. *Chenopodium murale* L. and *Heliotropium ellipticum* Ledebour and minor weeds like *Chenopodium album* L., *Melilotus indica* (L.) All., and some of off season weeds like *Amaranthus viridis* L. and *Tribulus terrestris* L.

Weed-population dynamics

All the weed-control measures except metolachlor @ 0.5 and 1.0 kg/ha significantly reduced the population of *Chenopodium murale* compared with that of unweeded control. *Heliotropium ellipticum* was tolerant to oxyfluorfen @ 0.15 kg/ha. All the weed-control measures significantly reduced the total mean weed density compared with unweeded control except at 25 DAS with hand-weeding once and twice (where the first hand-weeding was done 25 DAS), oxyfluorfen @ 0.75 kg/ha and fluchloralin @ 0.75 kg/ha and at all the stages of observation with metolachlor @ 0.5 and 1.0 kg/ha (Table 1). Weed-free treatment recorded the lowest total mean weed density at all the stages of observation. The lower doses of herbicides supplemented with hand-weeding once (50 DAS) were as effective as weed-free treatment in reducing the total mean weed density at harvest (except metolachlor). Among herbicidal treatments, pre-emergence application of pendimethalin @ 1.5 kg/ha also remaind on a par with that of weed-free treatment in reducing the total weed density. The weed density decreased with the advancement of crop growth owing to increased competition among the weed species and between weeds and crop plants, leading in elimination of some weed plants or species. Maximum weed-control efficiency was obtained with weed-free treatment at 25, 50 and 75 days after sowing and with pre-emergence

Table 1. Effect of integrated weed management on mean weed density, dry weight of weeds and weed-control efficiency

Treatment	Mean weed density 0.25 m² at 50 DAS			Total mean weed density (0.25 m²)			W D W (q/ha)	Weed-control efficiency (%)			
	C.m	*H.e*	Others	25 DAS	50 DAS	H	H	25 DAS	50 DAS	75 DAS	H
Unweeded control	4.9 (24.0)	1.0 (0.7)	1.9 (3.0)	5.6 (35.3)	5.3 (27.7)	3.6 15.0	17.43	–	–	–	–
Oxyfluorfen 0.15 kg/ha-PE	2.6 (6.3)	1.8 (2.7)	0.9 (0.3)	4.9 (15.7)	3.1 (9.3)	2.7 (7.3)	7.60	28.6	41.5	39.6	28.9
0xyfluorfen 0.30 kg/ha-PE	3.1 (9.3)	1.1 (0.7)	0.7 (0.0)	3.2 (9.7)	3.2 (10.0)	2.6 (6.7)	6.09	42.9	34.0	29.2	31.6
Oxyfluorfen 0.15 kg/ha+HW	2.5 (6.0)	1.8 (2.7)	0.9 (0.3)	3.5 (12.7)	3.0 (9.0)	2.1 (4.3)	3.20	37.5	43.4	68.8	44.7
Fluchloralin 0.75 kg/ha-PPI	2.8 (9.3)	0.9 (0.3)	1.3 (1.3)	4.3 (21.0)	3.3 (11.0)	2.8 (7.7)	7.22	23.2	37.7	37.5	26.3
Fluchloralin 1.25 kg/ha-PPI	2.7 (8.7)	0.7 (0.0)	1.2 (1.0)	3.2 (12.3)	2.8 (9.7)	2.5 (6.0)	5.70	42.9	47.2	41.7	34.2
Fluchloralin 0.75 kg/ha+HW	2.9 (8.0)	1.0 (0.7)	1.3 (1.3)	3s.9 (15.3)	3.2 (10.0)	2.1 (4.3)	3.51	30.4	39.6	68.8	44.7
Metolachlor 0.5 kg/ha-PE	3.0 (8.7)	1.2 (1.0)	1.2 (1.0)	4.3 (17.7)	3.3 (10.7)	2.9 (8.3)	10.81	23.2	37.7	20.8	23.7
Metolachlor 1.0 kg/ha-PE	4.0 (18.7)	0.7 (0.0)	0.9 (0.3)	4.2 (17.7)	4.1 (19.0)	3.4 (11.3)	9.19	25.0	22.6	12,5	10.5
Metolachlor 0.5 kg/ha+HW	3.6 (14.0)	0.9 (0.3)	1.2 (1.0)	5.3 (28.0)	3.8 (15.3)	2.6 (6.7)	3.88	5.4	28.3	66.7	31.6

(Table 1. Continued)

Treatment	Mean weed density 0.25 m^2 at 50 DAS			Total mean weed density (0.25 m^2)			W D W (q ha)	Weed-control efficiency (%)			
	C.m	*H.e*	Others	25 DAS	50 DAS	H	H	25 DAS	50 DAS	75 DAS	H
Pendimethalin 1.0 kg/ha-PE	2.3 (4.7)	0.9 (0.3)	1.1 (0.7)	2.9 (8.3)	2.4 (5.7)	2.6 (6.7)	4.97	48.2	54.7	43.8	31.6
Pendimethalin 1.5 kg/ha-PE	2.0 (3.7)	0.7 (0.0)	1.1 (0.7)	2.0 (3.3)	2.1 (4.3)	2.1 (4.7)	3.71	64.3	60.4	52.1	44.7
Pedimethalin 1.0 kg/ha+HW	1.9 (3.3)	0.7 (0.0)	1.1 (0.7)	2.9 (8.0)	2.1 (4.0)	1.0 (0.7)	2.02	48.2	60.4	62.5	73.7
H W once	1.9 (3.0)	0.9 (0.3)	1.3 (0.7)	5.0 (28.3)	2.1 (4.0)	2.3 (5.0)	8.64	10.7	60.4	75.0	39.5
H W twice	1.4 (2.3)	0.7 (0.0)	0.9 (0.3)	5.7 (36.7)	1.4 (2.7)	1,4 (1.7)	3.36	-1.8	73.6	62.5	63.2
Weed free	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	1.3 (1.3)	0.84	87.5	86.8	85.4	65.8
CD (P = 0.05)	1.7	0.6	NS	2.2	1.6	1.0	2.18	–	–	–	–

Actual weed counts are in parentheses transformed to $\sqrt{x+0.5}$

DAS=Days after sowing W.D.W. = weed dry weight; HW = hand-weeding; PE = pre-emergence; PPI = pre-plant incorporation; H = at harvest; C.m. = *Chenopodium murale*; *H.e* = *Heliotropium ellipticum*

Table 2. Effect of integrated weed management on fennel growth, harvest index, benefit : cost ratio (mean data of 3 years), seed yield and weed- competition index

Treatment	Plant height	Crop bio-mass	H.I. (%)	Seed yield (q/ha)				Weed competition index ratio				B : C ratio (mean)
				1991-92	1992-93	1993-94	Mean	1991-92	1992-93	1993-94	Mean	
Unweeded control	98.9	8.74	18.7	1.36	1.30	2.19	1.62	86.6	82.0	83.4	84.1	–0.11
Oxyfluorfen 0.15 kg/ha-PE	112.2	15.51	22.2	4.07	2.78	2.50	3.12	59.9	61.5	81.1	69.4	0.38
Oxyfluorfen 0.30 kg/ha-PE	120.0	18.12	24.3	5.65	3.01	3.30	3.99	44.3	58.3	75.0	60.8	0.54
Oxyfluorfen 0.15 kg/ha+HW	118.3	25.21	31.2	7.50	4.26	10.70	7.49	26.1	41.0	18.9	26.5	2.13
Fluchloralin 0.75 kg/ha-PPI	114.0	17.16	19.2	3.83	2.45	3.16	3.15	62.3	88.1	76.1	69.1	0.51
Fluchloralin 1.25 kg/ha-PPI	118.5	16.71	28.9	7.84	4.17	2.29	4.77	22.8	42.2	82.7	53.2	1.11
Fluchloralin 0.5 kg/ha-PE	114.4	20.18	37.2	7.75	5.32	8.22	7.12	23.6	26.3	37.7	30.1	2.16
Metolachlor 0.5 kg/ha-PE	101.4	9.10	26.7	2.62	1.76	2.01	2.13	47.2	75.6	84.8	79.1	0.20
Metolachlor 1.0 kg/ha-PE	109.0	8.70	24.0	3.18	1.90	0.80	1.96	68.7	73.7	96.3	80.8	0.38
Metolachlor 0.5 kg/ha+HW	113.8	19.96	28.5	6.33	3.66	5.76	5.25	37.6	49.3	56.4	48.5	1.33

(Table 2 : Continued)

Treatment	Plant height	Crop bio-mass	H.I. (%)	Seed yield (q/ha)				Weed competition index ratio				B : C ratio (mean)
				1991-92	1992-93	1993-94	Mean	1991-92	1992-93	1993-94	Mean	
Pendimethalin 1.0 kg/ha-PE	118.7	19.79	26.2	6.33	3.43	5.10	4.59	37.6	52.5	61.4	51.4	1.29
Pendimethalin 1.5 kg/ha-PE	119.1	19.45	33.9	7.44	4.07	7.05	6.19	26.7	43,6	46.7	39.3	1.70
Pendimethalin 1.0 kg/ha+HW	116.0	27.39	31.7	9.39	6.57	10.07	8.67	7.6	9.0	23.7	14.9	2.75
H W once	115.8	19.69	32.3	6.02	3.43	7.99	5.81	40.7	52.5	39.5	43.0	1.90
H W twice	117.7	25.93	30.3	8.86	5.65	8.49	7.67	12.1	21.7	35.7	24.7	2.51
Weed free	124.6	29.57	34.7	10.15	7.22	13.20	10.19	–	–	–	–	3.35
CD (P = 0.05)	8.0	5.50	11.5	1.30	1.01	1.32	2.30	–	–	–	–	–

Particulars	Year		
	1991-92	1992-93	1993-94
General cost of cultivation (Rs/ha)	3,400	3,603	3,603
Labour charges (Rs/man day)	22	22	2,222
Seed sold (Rs/q)	1,800	2,000	2,000
H W once (Rs/ha)	330	330	330
H W twice (Rs/ha)	660	660	660
Weed free (Rs/ha)	990	990	990

Herbicide cost	Cost (Rs/litre)
Oxyfluorfen	4,633
Fluchloralin	531
Metolachlor	800
Pendimethalin	533
Spraying charges (Rs/ha)	66

H.I. = harvest index

application of pendimethalin @ 1.0 kg/ha supplemented with hand-weeding once at harvest (Table 1). These results are in conformity with those of Damato *et al.* (1986). Among herbicidal treatments, metolachlor @ 0.5 and 1.0 kg/ha gave minimum weed-control efficiency at all the stages of observation.

Crop growth

All the weed-control measures except metolachlor @ 0.5 kg/ha significantly increased the mean plant height over unweeded control. Maximum mean plant height of 124.6 cm was recorded under weed-free condition. All weed-control measures except metolachlor @ 0.5 and 1.0 kg/ha significantly increased the mean crop biomass over unweeded control. The maximum mean crop biomass of 29.57 q/ha recorded at harvest stage in season-long weed-free plots was at par with that of hand-weeding twice, oxyfluorfen @ 0.15 kg/ha and pendimethalin @ 1.0 kg/ha both supplemented with hand-weeding once but significantly higher over rest of the treatments (Table 2). Lower doses of herbicides (except metolachlor) supplemented with hand-weeding once, pendimethalin @ 1.5 kg/ha, hand-weeding once and twice and weed-free treatment significantly increased the harvest index compared with unweeded control. This increase in harvest index may be attributed to the production of more photosynthates due to better weed-control efficiency of these treatments.

Weed-competition index

The season-long weed infestation reduced the seed yield by 86.6, 82.0, 83.4 and 84.1% during 1991-92, 1992-93, 1993-94 and on mean data basis respectively compared with the weed free treatment (Table 2). Hand-weeding twice and other doses of herbicides (except metolachlor) supplemented with hand-weeding once were as effective as weed-free treatment in minimizing the crop-weed competition. Damato *et al.* (1986) reported similar effect of integrated weed management in fennel. The season-long weed-free plots gave a net profit of Rs 3.35 on investment compared with the net loss of Re 0.11/Re investment from unweeded control plots. The lower doses of herbicides supplemented with hand-weeding once were more remunerative compared with their higher doses, because hand-weeding (50 DAS) effectively controlled the second flush of weeds, though the herbicides might have been degraded at least to their half-life level in the soil by this time (Kewat and Pandey,1998), resulting in sub-lethal effects on late-germinating weeds and leading to their poor control. Thus it can be concluded that pre-emergence application of pendimethalin @ 1.0 kg/ha supplemented with hand-weeding once (50 DAS) was as effective as weed-free treatment in respect of weed-control efficiency and seed yield.

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