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Influence of weed management practices on weeds, yield, quality and economics of fennel

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Abstract

A field experiment on influence of weed management practices on weed indices, yield, quality and economics of fennel was conducted at Seed Spices Research Station during *rabi* season of 2012-13, 2013-14 and 2014-15. The soil was loamy sand, neutral in soil reaction (8.2 pH), with low in organic carbon (0.28 %), medium in available phosphorus (28 kg ha^{-1}) and potash (240 kg ha^{-1}). The treatments consisted best combinations of physical and chemical methods of weed control *viz.,* Hand weeding, inter-culturing and herbicides like pendimethalin, oxadiargyl and oxyfluorfen as pre and post emergence application along with unweeded control (weedy check) replicated thrice and laid out in RBD. Growth and yield attributing characters as well as seed yield were affected significantly by different weed control methods, except quality character on pooled basis. Crop kept weed free up to 45 DAS recorded higher plant height (166.5 cm), number of branches per plant (6.1) and umbels per plant (15.3), number of umbellate per umbel (34.4), test weight(5.2 g) and seed yield(1661 kg ha^{-1}) of fennel whereas, these characters were found significantly minimum under unweeded control. Similarly, weed free up to 45 DAS recorded significantly lower dry weight of weeds (133 kg ha^{-1}) and maximum dry weight of weed was recorded with un-weeded control (1090 kg ha^{-1}). Pre emergence application of Pendimethalin @ 1.0 kg ha^{-1} + Inter-culturing followed by H.W. at 30 DAS recorded higher BCR (2.38) value.

Key words : Fennel, oxadiargyl, oxyfluorfen, pendimethalin, weed management

Introduction

Fennel is export oriented low volume but high value cash crop of arid and semi arid regions of country. It is long duration cold weather seed spice crop and grown during *kharif* and *rabi* season in Gujarat state. It is mainly cultivated for its seed, which have pleasant fragrance and aromatic taste act as a stimulant and carminative. Fennel (*Foeniculum vulgare* Mill.) generally takes longer time for germination and also has slow initial growth which often leads to heavy infestation of weeds. If not controlled timely, these weeds adversely affect the growth and cause huge losses in yields. The losses in yield could be as high as 91.4 % as reported by Mali and Suwalka (1987). Therefore, weed management is one of the most crucial factors in realizing optimum yields. Manual weeding is the common practice in fennel to keep the weeds under check.However, timely unavailability of labourers and higher costs involved are the major constraints in effective weed management in fennel. Suitable alternatives involving use of herbicide is the need of the hour for effective and efficient control of weeds in fennel to ensure optimum yields and reduce the dependence on manual labour. Studies have shown that herbicide application effectively controls the weeds and can increase the seed yield of fennel by 43.2 to 86.9% (Voevodin and Borisenko, 1981). Therefore, use of herbicide as pre or post emergence with cultural practices for weed management has emerged as a best alternative to sustain the productivity in fennel with minimum soil and air pollution.

Material and methods

A field experiment was conducted during *rabi* season of 2012-13, 2013-14 and 2014-15 at Seed Spice Research Station, S. D. Agricultural University, Jagudan. The soil was loamy sand in texture, neutral in soil reaction, with low in organic carbon, medium in available phosphorus and potash. The treatments consisted best combinations of physical and chemical methods as well as alone viz., T_1 : Two H.W.+ I.C. at 20 and 40 DAS,T_2 : Pendimethalin @ 1.0 kg ha^{-1} as PE followed by H.W. + I.C. at 30 DAS, T_3 : Oxadiargyl @ 100 g ha^{-1} as PE followed by H.W. + I.C. at 30 DAS, T_4 : Oxadiargyl @ 100 g ha^{-1} as PoE at 20 DAS, T_5 : Pendimethalin @ 1.0 kg ha^{-1} as PE + Oxadiargyl @ 100 g ha^{-1} as PoE at 20 DAS, T_6 : Oxyfluorfen @ 100 g ha^{-1} as PE followed by H.W. + I.C. at 30 DAS, T_7 : Oxyfluorfen @ 100 g ha^{-1} as PoE at 20 DAS, T_8 : Pendimethalin @ 1.0 kg ha^{-1} as PE + Oxyfluorfen @ 100 g ha^{-1} as PoE at 20 DAS, T_9: Weed free up to 45 DAS and T_{10}: Unweeded control replicated thrice and laid out in

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RBD. The seeds were sown manually at about 4-5 cm depth in furrows at 45 cm row spacing and covered properly with the soil, using seed rate at 5 kg ha^{-1}. All standard packages of practices were followed throughout the cropping season. Pre and post emergence herbicides were applied immediately after sowing and at 30 DAS with the help of a Knapsack sprayer fitted with flat fan nozzle with a spray volume of 600 l ha^{-1}, respectively. In manual weed control treatments, crop was inter cultured in band and within line, weeds were uprooted and removed at 20 and 40 DAS as per treatments. In weed free up to 45 DAS, the weeds were removed manually after every seven days for ensuring complete weed free condition. All the weed count data were recorded at 20, 40 and 60 DAS, whereas dry weight of weeds was recorded at harvest. The weed control efficiency was calculated by using the formula given by Mani *et al.*, 1973. Observations were recorded on growth parameters; yields attributes and yield at harvest. Economics of the investigation was also calculated and compared statistically. The statistical analysis of data was done as per standard procedure suggested by Panse and Sukhatme (1985).

Results and discussion

Growth, yield and quality attributing characters

Growth and yield attributing characters were affected significantly by different weed control methods, except quality character on pooled basis (Table 1). Crop kept weed free up to 45 DAS recorded significantly higher plant

Table 1. Growth, yield and quality attributes of fennel as influenced by different weed control treatments (Pooled data)

Treatments	Plant height (cm)	No. Of branches $plant^{-1}$	No. Of umbels $plant^{-1}$	No. Of umbellate $umbel^{-1}$	No. of seeds $umbellate^{-1}$	Test weight (g)	Volatile oil (%)
T_1 : Hand weeding and IC at 20 and 40 DAS	164.2	5.8	14.9	33.2	37.4	5.1	1.5
T_2 : Pendimethalin @ 1.0 kg /ha as PE + I.C.followed by H.W. at 30 DAS	155.9	5.8	14.7	32.9	35.0	5.1	1.5
T_3 : Oxadiargyl @ 100 g/ha as PE+ I.C. followed by H.W. at 30 DAS	154.4	6.0	14.8	33.0	35.8	5.1	1.5
T_4 : Oxadiargyl @ 100 g/ha as PoE at 20 DAS	127.0	4.0	11.1	20.9	21.7	4.7	1.5
T_5: Pendimethalin @ 1.0 kg /ha as PE + Oxadiargyl @ 100 g/ha as PoE at 20 DAS	154.8	5.8	14.7	32.1	35.1	5.0	1.5
T_6 : Oxyfluorfen @ 100 g /ha as PE + I.C.followed by H.W. at 30 DAS	142.1	5.1	11.1	17.4	22.7	4.6	1.5
T_7 : Oxyfluorfen @ 100 g/ha as PoE at 20 DAS	117.6	3.5	10.3	15.4	21.7	4.5	1.5
T_8 : Pendimethalin @ 1.0 kg /ha as PE + Oxyfluorfen @ 100 g/ha as PoE at 20 DAS	143.3	4.0	12.6	29.4	31.9	4.9	1.5
T_9 : Weed free up to 45 DAS	166.5	6.1	15.3	34.4	37.0	5.2	1.5
T_{10} :Unweeded control	93.5	3.4	7.4	10.1	18.4	3.8	1.4
S. Em. ±	4.47	0.21	0.41	0.98	1.00	0.10	0.02
C.D. at 5 %	12.6	0.6	1.2	2.8	2.9	0.3	NS
Y x T	NS	NS	NS	NS	NS	NS	NS
S. Em. ±	-	-	-	-	-	-	-
C.D. at 5 %	-	-	-	-	-	-	-
C.V. %	9.46	12.6	9.87	11.36	10.21	6.33	4.10

height, number of branches per plant and umbels plant^{-1}, number of umballates umbel^{-1} as well as test weight and was remained at par with Hand weeding + IC at 20 and 40 DAS (T_1), Pendimethalin @ 1.0 kg ha^{-1} as PE + I.C.followed by H.W. at 30 DAS (T_2), Oxadiargyl @ 100 g ha^{-1} as PE + I.C.followed by H.W. at 30 DAS (T_3) and Pendimethalin @ 1.0 kg ha^{-1} as PE + Oxadiargyl @ 100 g ha^{-1} as PoE at 20 DAS (T_5), except in case of test weight where it was also at par with Pendimethalin @ 1.0 kg ha^{-1} as PE + Oxyfluorfen @ 100 g ha^{-1} as PoE at 20 DAS (T_8).All these characters were found minimum under unweeded control treatment (T10). These results match the findings of Gohil *et al.*, (2014) and Meena and Mehta (2009).

Seed yield and economics

The fennel seed yield (Table 2) was significantly affected by different weed management practices during different years and on pooled basis. During 2012-13, application of Pendimethalin @ 1.0 kg ha^{-1} as PE + Oxadiargyl @ 100 g ha^{-1} as PoE at 20 DAS (T_5) proved better and recorded significantly higher seed yield over rest of the treatments, except application of Pendimethalin @ 1.0 kg ha^{-1} as PE and H.W.+I.C. at 30 DAS (T_2), weed free up to 45 DAS (T_9), Hand weeding followed by IC at 20 and 40 DAS (T_1), Oxadiargyl @ 100 g ha^{-1} as PE + I.C. followed by H.W. at 30 DAS (T_3) and Pendimethalin @ 1.0 kg ha^{-1} as PE + Oxyfluorfen @ 100 g ha^{-1} as PoE at 20 DAS (T_8). During 2013-14, weed free up to 45 DAS recorded higher yield over rest of the treatments except hand weeding followed by IC at 20 and 40 DAS (T_1), Pendimethalin @ 1.0 kg ha^{-1} as PE + I.C. followed by H.W. at 30 DAS and Pendimethalin @ 1.0 kg ha^{-1} as PE + Oxadiargyl @ 100 g ha^{-1} as PoE at 20 DAS in the year 2013-14. Whereas, in the year 2014-15 and on pooled basis, weed free up to 45 DAS (T_9) recorded significantly higher fennel yield and remained at par with the T_2, T_1, T_3 and T_5 and were recorded significantly higher seed yield over rested treatments. Higher yield under weed free crop condition might minimize the competition between crop and weed for resources i.e. light, water, nutrient *etc*. Similar findings were reported by Meena and Mehta (2009), Gohil *et al.*, (2014) and Rajender Kumar *et al.*, (2015) in respect of seed yield of fennel. The lowest yield was accrued with the treatment unweeded control during course of investigation and on pooled basis. Pendimethalin @ 1.0 kg ha^{-1} as PE + I.C. followed by H.W. at 30 DAS (T_2) recorded higher BCR (2.38). Which was closely followed by treatments T_5 (Pendimethalin @ 1.0 kg ha^{-1} as PE + Oxadiargyl @ 100

Table 2. Seed yield of fennel and BCR as influenced by different weed management treatments

Treatments	Fennel seed yield (Kg ha^{-1})				BCR
	2012-13	2013-14	2014-15	Pooled	
T_1 : Hand weeding and IC at 20 and 40 DAS	1647	1624	1594	1621	2.27
T_2 : Pendimethalin @ 1.0 kg /ha as PE + I.C. followed by H.W. at 30 DAS	1698	1602	1610	1637	2.38
T_3 : Oxadiargyl @ 100 g/ha as PE + I.C. followed by H.W. at 30 DAS	1590	1412	1573	1525	2.07
T_4 : Oxadiargyl @ 100 g/ha as PoE at 20 DAS	840	985	886	903	0.95
T_5: Pendimethalin @ 1.0 kg /ha as PE + Oxadiargyl @ 100 g/ha as PoE at 20 DAS	1789	1593	1450	1611	2.32
T_6 : Oxyfluorfen @ 100 g /ha as PE + I.C. followed by H.W. at 30 DAS	724	876	854	818	0.74
T_7 : Oxyfluorfen @ 100 g/ha as PoE at 20 DAS	449	524	504	492	0.13
T_8 : Pendimethalin @ 1.0 kg /ha as PE + Oxyfluorfen @ 100 g/ha as PoE at 20 DAS	1540	1400	1300	1414	2.08
T_9 : Weed free up to 45 DAS	1666	1683	1633	1661	2.19
T_{10} : Unweeded control	197	388	211	265	0.38(-)
S. Em. ±	88	86	80	49	-
C.D. at 5 %	263	256	238	139	
Y x T					-
S. Em. ±	-	-	-	-	-
C.D. at 5 %	NS	NS	NS	NS	-
C.V. %	12.63	12.35	11.95	12.33	-

g ha^{-1} as PoE at 20 DAS), T_1 (I.C and H.W. at 25 and 40 DAS) and T_9 (weed free up to 45 DAS) recorded BCR values of 2.32,2.27 and 2.19, respectively (Table 2). The results are in conformity with Thakral, K.K. (1981) on fennel crop.

Weed study

The experimental field was infested with monocot weeds, viz. *Asphodelus tenuifolius*, *Digitaria sanguinalis* L. and *Eragrostis major* L. as well dicot weeds viz., *Melilotus indica* L. *Chenopodium album* L. *Amaranthus spinosus* L. *Amaranthus viridis* L. *Spergula arvensis* L. *Boerhavia diffusa* L., *Phyllanthus niruri* L.*Convovulus arvensis* L. *Portulaca oleracea* L.*Tribulus terrestris* L. and *Euphorbia hirta* L. Dry weight of weeds was effectively controlled by different weed control treatments (Table 3). Significantly minimum dry weight of sedges was recorded with treatment T_9 (Weed free up to 45 DAS), which remained at par with T_1 : Hand weeding and IC at 20 and 40 DAS, T_2 : Pendimethalin @ 1.0 kg ha^{-1} as PE + I.C. followed by H.W. at 30 DAS and T_3 : Oxadiargyl @ 100 g ha^{-1} as PE + I.C. followed by H.W. at 30 DAS. Dry weight of monocot was minimum with the treatment T_9 (Weed free up to 45 DAS) and was at par with the treatment T_1, T_2, T_3 and T_6. However, dry weight of dicot and total weeds were the minimum under treatment T_9 and was at par with treatments T_1 : Hand weeding and IC at 20 and 40 DAS, T_2 : Pendimethalin @ 1.0 kg ha^{-1} as PE + I.C. followed by H.W. at 30 DAS and T_3 : Oxadiargyl @ 100 g ha^{-1} as PE + I.C. followed by H.W. at 30 DAS and T_5: Pendimethalin @ 1.0 kg ha^{-1} as PE + Oxadiargyl @ 100 g ha^{-1} as PoE at 20 DAS. However, pendimethalin and oxadiargyl as pre-emergence with H.W. + I.C. at 20 and 40 DAS were significantly superior to reduce dry weight of dicot and total dry weed weight than post emergence application of Oxadiargyl and oxyfluorfen. Whereas, dry weight of sedges, monocot, dicot and total dry weight of weed were

Table 3. Dry weight of weeds (kg ha^{-1}) in fennel crop at harvest and WCE as influenced by different weed management practices

Treatments	Sedges	Monocot	Dicot	Total	WCE (%)
T_1 : Hand weeding and IC at 20 and 40 DAS	21	50	74	145	91
T_2 : Pendimethalin @ 1.0 kg ha^{-1} as PE + I.C. followed by H.W. at 30 DAS	24	54	74	152	90
T_3 : Oxadiargyl @ 100 g ha^{-1} as PE + I.C. followed by H.W. at 30 DAS	25	53	81	159	90
T_4 : Oxadiargyl @ 100 g ha^{-1} as PoE at 20 DAS	95	359	304	758	52
T_5: Pendimethalin @ 1.0 kg ha^{-1} as PE + Oxadiargyl @ 100 g ha^{-1} as PoE at 20 DAS	76	257	75	408	74
T_6 : Oxyfluorfen @ 100 g ha^{-1} as PE + I.C. followed by H.W. at 30 DAS	46	61	469	576	63
T_7 : Oxyfluorfen @ 100 g ha^{-1} as PoE at 20 DAS	91	92	907	1090	30
T_8 : Pendimethalin @ 1.0 kg ha^{-1} as PE + Oxyfluorfen @ 100 g ha^{-1} as PoE at 20 DAS	67	89	389	545	65
T_9 : Weed free up to 45 DAS	21	45	67	133	92
T_{10} : Unweeded control	97	423	1046	1566	0
S. Em. ±	2.4	6.0	13.5	17.0	-
C.D. at 5 %	7.0	17.0	38.5	48.0	-
Y x T	NS	S	S	S	-
S. Em. ±					
C.D. at 5 %	-	29.0	67.0	84.0	-
C.V. %	12.59	12.15	11.70	9.31	-

recorded maximum in unweeded control treatment. The maximum weed control efficiency (92%) was recorded with the treatment T_9, which was closely followed by the treatment T_1, T_2 and T_3 (Table 3). Thus, herbicides followed by inter culturing with hand weeding found better for effective management of dicot and monocot weeds at all stages. Meena and Mehta (2009) in fennel observed that lowest weed biomass and the higher weed control efficiency at maturity were recorded with integration of herbicides with hand weedding and inter culturing.

Under adequate and cheap labour availability keep the *rabi* fennel weed free up to 45 DAS for getting remunarative higher yield. For obtaining the maximum net return and income per rupee investment with higher yield, apply pendimethalin @ 1.0 kg ha^{-1} as pre emergence and inter culturing followed by hand weeding at 30 DAS.

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