



Integrated weed management in fennel production system and its residual effect on succeeding summer greengram

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ABSTRACT

A field trial was conducted during two consecutive *Rabi* season of 2016-17 and 2017-18 on loamy sand soil at AICRP-Weed Management, B.A. College of Agriculture, Anand Agricultural University, Anand (Gujarat) to study the effect of integrated weed management in fennel production system and its residual effect on succeeding summer greengram. Significantly, lowest and highest weeds density at harvest was recorded with farm yard manure (FYM) 20 t/ha and vermicompost 8.0 t/ha, respectively. However, highest fennel seed yield (2.09 t/ha) was recorded with vermicompost 8.0 t/ha application. Significantly higher plant height, number of umbels/plant and seed yield was recorded with paddy straw mulch 10 t/ha *fb* hand weeding (HW) at 30 and 60 days after transplanting (DATP) and it was at par with paddy straw mulch 5 t/ha *fb* HW at 30 and 60 DATP and twice inter cultivation (IC) + HW at 30 and 60 DATP *fb* earthing-up at 75 DATP. Higher fennel equivalent yield (2.43 t/ha) and gross return (₹ 243000/ha) was recorded with application of vermicompost 8.0 t/ha, while highest net return (₹ 138220/ha) and benefit cost ratio (2.56) was recorded with application of FYM. Paddy straw mulch 10 t/ha *fb* HW at 30 and 60 DATP recorded higher fennel equivalent yield (3.24 t/ha), gross returns (₹ 219816/ha), net returns (₹ 241976/ha) and benefit cost ratio (3.11). Application of FYM and vermicompost was found equally effective while mulching treatments recorded higher seed yield of succeeding greengram.

INTRODUCTION

Fennel (*Foeniculum vulgare* Mill.) belongs to the family Apiaceae (Umbelliferae) is one of popular seed spice in India. Fennel is traditionally used for medicinal and culinary purposes. Fennel is grown throughout India. However, major production states of fennel seed are Rajasthan, Andhra Pradesh, Telangana, Punjab, Madhya Pradesh, Uttar Pradesh, Gujarat, Karnataka, and Haryana (Meena and Mehta 2009). Vermicompost and FYM play an important role in the supply of macro and micronutrients. Mulches are commonly used in cultivation of vegetables and other spices (Massucati and Kopke 2014) and medicinal crops and are acceptable in organic farming as well as in any other crop production that requires reduced use of pesticides. Applying mulches after planting the main crop or before the weeds start to germinate, certainly bring about many benefits to cultivated crops.

Fennel generally takes much time for germination and also has slow initial growth which often leads to heavy crop weed competition (Gohil *et*

al. 2015). If weeds are not controlled in weedy check, reduced the seed yield to the tune of 50 per cent (Gohil *et al.* 2015).

Further, application of herbicides in fennel effectively controls the weeds and reduced the loss of seed yield (Chaudhary, 2000). To keep the fennel field weed free, about 3–4 hand weeding are required (Parthasarathy *et al.* 2008). However, hand weeding is highly labor intensive, time-consuming and expensive. Therefore, the present study was conducted to evaluate the combined effect of organic manures and integration of herbicides with mulch on weeds and yield of fennel.

MATERIALS AND METHODS

The present field experiment was conducted at AICRP-Weed Management, B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat) during two consecutive *Rabi* season of the year 2016-17 and 2017-18 on loamy sand soil. The soil of the experimental field was low in available nitrogen and medium in available phosphorus and

high in potassium with pH 8.0. The experiment was laid out in a split plot design and replicated thrice. Ten treatments were there. They are: two organic manures, farm yard manure (FYM) 20 t/ha and vermicompost 8.0 t/ha, were allotted to main plot while five weed management practices, paddy straw mulch 5 t/ha *fb* HW at 30 and 60 DATP, paddy straw mulch 10 t/ha *fb* HW at 30 and 60 DATP, IC+HW at 30 and 60 DATP *fb* earthing-up at 75 DATP, pendimethalin 0.75 kg/ha pre-transplant *fb* IC+HW at 40 DATP and weedy check, were assigned to sub-plots. The fennel cv. 'GF 12' was transplanted in the experimental field on 15 and 16 September 2017 and 2018, respectively keeping the distance of 90 x 60 cm. All recommended packages of practices were followed throughout the growing season to raise the crop during both the years of experimentation. FYM and vermicompost were applied as per treatment directly in the furrow before transplanting of fennel for proper decomposition while as well as pendimethalin was also applied pre-transplanting with the help of a knap-sack sprayer fitted with flat-fan nozzle with a spray volume of 600 l/ha. Later paddy straw mulch was spread after transplanting as per the treatment. Interculturing (IC) and hand weeding (HW) were carried out as per the treatments. The observations on weed density and biomass were taken at 30 and 60 days after transplanting (DATP) from four randomly selected spots by using 0.25 m² iron quadrat from net plot area. Weed control efficiency (WCE) was calculated using standard formula suggested by Maity and Mukherjee (2011). The seed and stalk yield were recorded from the net plot area and converted in to hectare. Data on various observations during the experiment period was statistically analyzed as per the standard procedure developed by Cochran and Cox (1957).

RESULTS AND DISCUSSION

Weed flora

In general, dominance of dicot weed (62.6 %) was observed during the experimental period. Major weeds observed in the experimental field were, *Eleusine indica* (20.6 %), *Dactyloctenium aegyptium* (23.3 %), *Commelina benghalensis* (4.87 %), *Eragrostic major* (5.09 %) among monocot weeds, *Oldenlandia umbellate* (13.9 %), *Phyllanthus niruri* (14.2 %), *Boerhavia diffusa* (4.65 %) and *Digera arvensis* (2.21 %) in dicot weeds.

Effect on weeds

The weed density recorded in two organic manure treatments was non-significant at 30 and 60 DATP while it was significant at harvest. Weed management practices have showed significant effect on weed density at 30 and 60 DATP (**Table 1**). Among weed management practices, application of pendimethalin 0.75 kg/ha pre-transplant *fb* IC + HW at 40 DATP recorded significantly lower weed density and it was at par with paddy straw mulch either 5 or 10 t/ha *fb* HW at 30 and 60 DATP. The highest weed density was in weedy check at 30 DATP. Application of pendimethalin 0.75 kg/ha pre-transplant *fb* IC + HW at 40 DATP provide 100 per cent control of weeds at 60 DATP with no weed biomass at 60 DATP. The paddy straw mulch, either 5 or 10 t/ha, *fb* HW at 30 and 60 DATP as well as application of pendimethalin 0.75 kg/ha pre-transplant *fb* IC + HW at 40 DATP have recorded significantly lower weed biomass. Lower weed density and biomass in fennel with pendimethalin *fb* HW at 45 DAS was also observed by Gohil *et al.* (2014) and Kumar *et al.* (2015). The highest weed control efficiency of 69.1 and 100 per cent at 30 and 60 DATP, respectively was

Table 1. Effect of organic manures and weed management treatments on weed density, biomass and WCE in fennel

Treatment	Weed density (no./m ²)			Weed biomass (g/m ²)			Weed control efficiency (%)		
	30 DATP	60 DATP	At harvest	30 DATP	60 DATP	At harvest	30 DATP	60 DATP	At harvest
<i>Organic manures</i>									
Farm yard manure 20 t/ha	12.9(195)	11.4(183)	6.81(62.5)	9.44(104)	8.74(121)	13.2(251)	-	-	-
Vermicompost 8.0 t/ha	12.7(190)	11.2(196)	7.32(72.4)	10.1(115)	8.71(119)	13.6(313)	-	-	-
LSD (p=0.05)	NS	NS	0.495	0.397	NS	NS	-	-	-
<i>Weed management</i>									
Paddy straw mulch 5 t/ha <i>fb</i> HW at 30, 60 DATP	11.6(137)	10.8(127)	4.65(34.4)	9.20(91.0)	7.67(58.9)	7.22(90.5)	54.7	86.3	89.0
Paddy straw mulch 10 t/ha <i>fb</i> HW at 30, 60 DATP	9.01(81.3)	7.44(59.5)	4.02(24.7)	8.02(67.1)	6.14(37.2)	6.68(76.5)	66.6	91.4	90.7
IC + HW at 30 and 60 DATP <i>fb</i> earthing-up at 75 DATP	15.6(245)	16.5(317)	5.49(49.6)	10.5(125)	8.13(69.5)	7.68(104)	37.8	83.9	87.3
Pendimethalin 0.75 kg/ha pre-transplant <i>fb</i> IC + HW at 40 DATP	6.65(47.4)	1.00(0.00)	9.63(95.9)	7.83(62.1)	1.00(0.00)	17.6(319)	69.1	100	61.2
Weedy check	21.0(452)	20.8(443)	11.5(133)	13.2(201)	20.7(431)	27.8(822)	-	-	-
LSD (p=0.05)	7.45	12.7	NS	NS	5.07	NS	-	-	-
Interaction M x W	NS	NS	NS	Sig.	NS	NS	-	-	-

Data subjected to $(\sqrt{x+1})$ transformation. Figures in parentheses are means of original values.

recorded with pendimethalin 0.75 kg/ha pre-transplant fb IC + HW at 40 DATP, while at harvest it was the highest under paddy straw mulch 10 t/ha fb HW at 30 and 60 DATP. Similar results were reported by Meena and Mehta (2009).

Effect on crop

Plant stand (no./net plot), plant height at 120 DATP, No. of umbels/plant and stalk yield (t/ha) did not differ significantly amongst two organic manure treatments while significant differences occurred due to weed management practices except plant stand which was non-significant (Table 2). Significantly highest plant height of 34.2 cm at 45 DATP was recorded under application of farm yard manure 20 t/ha. The seed yield of fennel was highest (2.09 t/ha) with vermicompost 8.0 t/ha indicating that vermicompost is ideal organic manure for better growth and yield of many crops as it contain higher nutritional value than FYM. Patel *et al.* (2003) also

recorded higher yield attributes when recommended dose of nitrogen (RDN) was applied through inorganic fertilizers in fennel.

Among weed management practices, significantly higher plant height at 45 and 120 DATP, number of umbels/plant and seed yield was recorded under paddy straw mulch 10 t/ha fb HW at 30 and 60 DATP and it was at par with paddy straw mulch 5 t/ha fb HW at 30 and 60 DATP and twice IC + HW at 30 and 60 DATP fb earthing-up at 75 DATP. Ko³ota and Katarzyna (2013) reported that mulches reduce the rate of weed seed germination, as the mulches do not provide necessary conditions for weed seed germination.

Fennel equivalent yield and economics

The fennel equivalent yield (2.43 t/ha) and gross return (₹ 243000/ha) was higher under application of vermicompost 8.0 t/ha, while net

Table 2. Effect of organic manures and weed management treatments on growth of fennel

Treatment	Plant stand	Plant height (cm)		No. of umbels/plant	Seed yield (t/ha)	Stalk yield (t/ha)
	at harvest (no./net plot)	At 45 DATP	At 120 DATP			
<i>Organic manures</i>						
Farm yard manure 20 t/ha	21.3	34.2	149	30.6	1.94	4.78
Vermicompost 8.0 t/ha	21.3	31.1	152	30.4	2.09	4.81
LSD (p=0.05)	NS	2.18	NS	NS	0.139	NS
<i>Weed management</i>						
Paddy straw mulch 5 t/ha fb HW at 30, 60 DATP	22.6	34.4	162	34.8	2.30	6.63
Paddy straw mulch 10 t/ha fb HW at 30, 60 DATP	23.0	36.8	166	40.6	2.88	6.67
IC + HW at 30 and 60 DATP fb earthing-up at 75 DATP	23.1	31.3	155	37.9	2.49	5.34
Pendimethalin 0.75 kg/ha pre-transplant fb IC + HW at 40 DATP	22.3	32.0	155	30.2	1.90	4.29
Weedy check	15.6	28.8	115	9.01	0.490	1.04
LSD (P=0.05)	NS	3.02	30.0	6.24	0.697	0.543
Interaction M x W	NS	NS	NS	NS	NS	NS

Table 3. Economics of organic manures and weed management treatments in fennel-greengram organic cropping system

Treatment	Fenne l seed yield (t/ha)	Green-gram seed yield (kg/ha)	Green-gram haulm yield (kg/ha)	Fennel Equivalent yield (t/ha)	Gross returns (x10 ³ `/ha)	Additional cost of treatment (x10 ³ `/ha)	System cost of cultivation (x10 ³ `/ha)	Net returns (x10 ³ `/ha)	B:C ratio
<i>Organic manures</i>									
Farm yard manure 20 t/ha	1.94	568	768	2.27	227.00	31.27	88.78	138.22	2.56
Vermicompost 8.0 t/ha	2.09	577	794	2.43	243.00	50.38	107.89	135.11	2.25
<i>Weed management</i>									
Paddy straw mulch 5 t/ha fb HW at 30, 60 DATP	2.30	617	831	2.66	266.00	40.78	167.71	189.87	2.71
Paddy straw mulch 10 t/ha fb HW at 30, 60 DATP	2.88	613	839	3.24	324.00	46.67	219.82	241.98	3.11
IC + HW at 30 and 60 DATP fb earthing-up at 75 DATP	2.49	575	765	2.83	283.00	45.03	180.46	202.62	2.76
Pendimethalin 0.75 kg/ha pre-transplant fb IC + HW at 40 DATP	1.90	560	775	2.23	223.00	40.30	125.19	147.35	2.28
Weedy check	0.490	498	696	0.78	78.00	31.33	-10.84	11.32	0.88
Price of produce:	Fennel seed = `100/kg		M ₁ = ` 20000 + 1750 = ` 21780, M ₂ = ` 40000 + 890 = ` 40890						
Cost of inputs:	Green gram: seed at ` 55.75, Haulm at ` 2/kg		W ₁ = ` 5000 + 890 + 3560 = ` 21780,						
	Paddy straw mulch ` 1.0/kg		W ₂ = ` 10000 + 1780 + 3560 = ` 15340						
	FYM = ` 1/kg, Vermicompost = ` 5/kg		W ₃ = ` 3200 + 8900 + 1600 = ` 13700						
	Pendimethalin (Stomp 30 EC) = ` 490/lit		W ₄ = ` 1225 + 800 + 1600 + 5340 = ` 8965						
	Herbicide application cost = ` 800/ha/application		BC ratio = Gross return / Cost of cultivation						

Table 4. Residual effect of organic manures and weed management treatments adopted in fennel on growth characteristics of greengram

Treatment	Plant stand at harvest (no./net plot)	Plant height (cm)		Plant biomass at 40 DATP (g/plant)	Seed yield (kg/ha)	Haulm yield (kg/ha)
		At 30 DAS	At 60 DAS			
<i>Organic manures</i>						
Farm yard manure 20 t/ha	10.8	18.8	44.3	10.6	568	768
Vermicompost 8.0 t/ha	11.2	21.9	47.5	10.7	577	794
LSD (p=0.05)	NS	1.33	2.60	NS	NS	NS
<i>Weed management</i>						
Paddy straw mulch 5 t/ha fb HW at 30, 60 DATP	11.2	21.7	47.8	10.8	617	831
Paddy straw mulch 10 t/ha fb HW at 30, 60 DATP	11.0	20.6	46.4	10.9	613	839
IC + HW at 30 and 60 DATP fb earthing-up at 75 DATP	10.9	21.5	46.7	10.8	575	765
Pendimethalin 0.75 kg/ha pre-transplant fb IC + HW at 40 DATP	11.3	19.4	44.6	11.2	560	775
Weedy check	10.4	18.7	44.0	9.49	498	696
LSD (p=0.05)	NS	NS	NS	1.01	54	77
Interaction M x W	NS	NS	NS	NS	NS	NS

returns (₹ 138220/ha) and benefit cost ratio (2.56) were higher under application of farm yard manure (Table 4). The higher net returns and benefit cost ratio under application of FYM might be due to high cost of vermicompost. Among weed management practices, paddy straw mulch 10 t/ha fb HW at 30 and 60 DATP recorded higher fennel equivalent yield (3.24 t/ha), gross returns (₹ 219816/ha), net returns (₹ 241976/ha) and benefit cost ratio (3.11) as compared to rest of the treatment.

Effect on succeeding crop

The organic manures did not differ in their effect on plant stand at harvest, plant biomass at 40 DAS, seed yield and haulm yield. However, plant height measured at 30 and 60 DAS showed significant differences due to organic manure with significantly higher plant height at 30 and 60 DAS under application of farm yard manure 20 t/ha and vermicompost 8.0 t/ha, respectively.

The plant stand at harvest and plant height at both dates did not differ significantly with weed management practices. Significantly higher plant biomass at 40 DAS was recorded with pendimethalin 0.75 kg/ha pre-transplant fb IC + HW at 40 DAS as compared to weedy check. Further, paddy straw mulch 5 t/ha fb HW at 30, 60 DAS recorded significantly higher seed yield than in pendimethalin 0.75 kg/ha pre-transplant fb IC + HW at 40 DAS and weedy check. However, all the weed management treatments were at par with each other and were superior over weedy check with respect to haulm yield. Among all the weed management practices, weedy check recorded significantly the lowest seed and haulm yield of greengram.

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