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RESEARCH ARTICLE

Non-chemical weed management in sweet corn-fennel cropping system

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ABSTRACT

The area and demand of organic agriculture is increasing in Gujarat state and other states in India. The management of weeds is the most serious constraint in organic crop production systems. The integration of various non-chemical weed management practices provides effective weed control for realizing higher crop production. Hence a study was conducted to identify the effective non-chemical approaches for weed management in sweet corn-fennel cropping system. A field experiment was conducted during *Kharif* 2023 and *Rabi* 2023-24 on loamy sand soil at the farm of AICRP-Weed Management, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat. The non-chemical weed management treatments that were effective in manaing weeds include: soil solarization followed by (*fb*) hand weeding (HW) + straw mulch 5 t/ha at 20 DAS + HW at 40 DAS in sweet corn; and hand weeding + straw mulch 5 t/ha at 20 DAS + HW at 50 and 75 DAS in fennel. These were at par with soil solarization *fb* plastic mulch at sowing *fb* HW at 40 DAS in sweet corn and plastic mulch at sowing *fb* HW at 50 and 75 DAS in fennel. The effective treatments recorded lower weed density and biomass, higher growth and yield attributes, higher sweet corn equivalent green cob, gross returns and benefit cost ratio as compared to other treatments.

Keywords: Cropping system, Fennel, Non-chemical approach, Sweet corn, Weed management

INTRODUCTION

Sweet corn (*Zea mays* L. var. saccharata Sturt) is popular among producers and grown in large area. Sweet corn with enhanced sugar content, is gaining popularity in commercial establishments like hotels, malls and stores. Sweet corn is being used in soups, sweets, jams and has many more uses. Similarly, among seed spices, fennel (*Foeniculum vulgare* Mill.) is one of the major seed spices belonging to the family Apiaceae. In both the crops, weed control is challenging constraint as weeds compete for essential resources such as nutrients, water, sunlight, and space and critically contribute to low crop yields. The intensity of weeds and damage due to weeds is related to the type of weeds, species and density of weeds in a crop. A reduction of 50% fennel yield (Gohil *et al.* 2015) and 40-42% green cob yield of sweet corn (Sunitha *et al*. 2010) were reported due to uncontrolled weeds.

Various methods are employed to manage the weeds during growing season of both the crops (Sunitha *et al*. 2010, Patel *et al*. 2019). Chemical method of weed control is cheaper as well as feasible for timely control of weeds (Meena and Mehta 2009, Dobariya *et al*. 2014) but it is not acceptable in organic farming system hence, alternative methods are used to manage the weeds The options for organic weed management include mechanical weeding, cover cropping, crop rotation, modified sowing and planting methods, organic residue mulching, green manuring, reduced or zero tillage, soil solarization, hand weeding, intercropping etc.

Application of straw mulch showed favourable effect on growth parameters and yield of crop as compared to no mulch which might be explained by early emergence, quick establishment of crop and higher interception of light (Patel *et al*. 2019). Moreover, soil under mulch remains loose, friable and well-aerated therefore, roots have access to adequate oxygen and enhance the microbial activity in the soil. Soil solarization is a non-chemical disinfestation practice that involves covering the ground with a transparent polyethylene cover to maintain soil moisture and trap solar energy which reduces weed growth, increases soil temperature and leading to enhancement of crop yield and improve quality of the produce (Setyowati *et al*. 2017). Hoeing is the most efficient method for weed control in all crops, sowing methods and growth conditions and mechanical weeding can provide effective weed management even when other methods are not possible. Stale seedbed is based on the principle of flushing out germinating weed seeds before sowing of the crop.

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This study was conducted to identify the effective non-chemical approach for weed management in sweet corn-fennel cropping system.

MATERIALS AND METHODS

Field experiment was carried out during *Kharif* - 2023 and *Rabi* 2023-24 on loamy sand soil at the farm of AICRP-Weed Management, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat. The experiment was laid out in randomized complete block design with three replications and eight treatments. The treatments in sweet corn, during *Kharif* season, include: soil solarization followed by (*fb*) hand weeding (HW) + straw mulch 5 t/ha at 20 days after seeding (DAS) + HW at 40 DAS, soil solarization *fb* plastic mulch at sowing *fb* HW at 40 DAS, stale seed bed preparation *fb* plastic mulch at sowing *fb* HW at 40 DAS, stale seed bed preparation *fb* hand weeding + straw mulch 5 t/ha at 20 DAS *fb* hand weeding at 40 DAS, sunnhemp between rows as smothering crop and used as mulch at 30 DAS with tillage *fb* HW at 40 DAS, inter cultivation (IC) + HW + straw mulch 5 t/ha at 20 DAS *fb* HW at 40 DAS, IC + HW twice at 20 and 40 DAS and weedy check. The treatments in fennel, during *Rabi* season, include: hand weeding + straw mulch 5 t/ha at 20 DAS + HW at 50 and 75 DAS; Plastic mulch at sowing *fb* HW at 50 and 75 DAS; Stale seed bed preparation *fb* plastic mulch at sowing *fb* HW at 75 DAS; Stale seed bed preparation *fb* hand weeding + straw mulch 5 t/ha at 20 DAS *fb* hand weeding at 50 and 75 DAS; Sunnhemp between rows as smothering crop and used as mulch at 30 DAS with tillage *fb* HW at 50 and 75 DAS; IC + HW + straw mulch 5 t/ha at 20 DAS *fb* HW at 50 and 75 DAS; IC + HW at 20, 40 and 60 DAS *fb* earthing-up at 75 DAS and weedy check tested in *rabi* fennel. The recommended seed rate of 16 kg/ha of sweet corn cv. "madhuram" was sown keeping the distance of 45 cm row spacing by manually in previously open furrows with the help of Kudali during *Kharif* season on 28.06.2023. Whereas, fennel cv. "*Gujarat Fennel 12*" was sown keeping the seed rate of 4.0 kg/ha with the spacing of 45 cm during *Rabi* season on 21.11.2023. All other recommended package of practices were adopted to raise the crop. Weed parameters recorded using randomly placed 0.25 m^2 quadrat from net plot area of each treatment and converted into one m^2 area. At 75 DAS, hand weeding was done in respective treatment after recording the weed density in fennel. Data on various observations *viz.*, in sweet corn plant height, green cob yield, green fodder yield while in fennel plant stand, plant height, number of umbels, seed yield and stalk yield recorded during the experimental period was statistically analysed as per the standard procedure and weed data were transformed by square root transformation ($\sqrt{x+1}$) and transformed data were subjected to ANOVA analysis (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

In the experimental field of sweet corn, the major monocot weeds were: *Dactyloctenium aegyptium, Digitaria sanguinalis, Eleusine indica, Commelina benghalensis and Setaria glauca*. *Oldenlandia umbellata, Digera arvensis, Phyllanthus niruri* and *Mollugo nudicaulis* were the dominant dicot weeds in the field. In *rabi* fennel *Dactyloctenium aegyptium, Setaria glauca, Eleusine indica* and *Digitaria sanguinalis* were monocot weeds and *Digera arvensis, Phyllanthus niruri, Chenopodium album* and *Oldenlandia umbellata* were dominant dicot weeds.

Effect on weeds in sweet corn

The weed density and dry biomass at 30 DAS was lower under soil solarization *fb* hand weeding + straw mulch 5 t/ha at 20 DAS + HW at 40 DAS, stale seed bed preparation *fb* hand weeding + straw mulch 5 t/ha at 20 DAS *fb* hand weeding at 40 DAS and IC + HW + straw mulch 5 t/ha at 20 DAS *fb* HW at 40 DAS (**Table 1**). While at 60 DAS and at harvest, significantly lower weed density and dry biomass were noticed under soil solarization *fb* plastic mulch at sowing *fb* HW at 40 DAS, soil solarization *fb* hand weeding + straw mulch 5 t/ha at 20 DAS + HW at 40 DAS and stale seed bed preparation *fb* plastic mulch at sowing *fb* HW at 40 DAS. Effectiveness of soil solarization might be due to ensnared sunlight energy elevates the soil temperature to kill the germinating and germinated weeds as well as the seeds near the soil surface (Arora and Tomar 2012, Kumar *et al*. 2022).

Effect on sweet corn

Sweet corn plant stands at 15 DAS (no./m row length) showed non-significant difference amongst different weed management treatments**.** At 60 DAS, significantly higher plant height was measured under soil solarization *fb* hand weeding + straw mulch 5 t/ha at 20 DAS + HW at 40 DAS but it was at par with soil solarization *fb* plastic mulch at sowing *fb* HW at 40 DAS at 30 DAS. Sweet corn green cob yield under the weed management practices was significant influenced. The soil solarization *fb* hand weeding + straw mulch 5 t/ha at 20 DAS + HW at 40 DAS recorded significantly higher green cob yield and green fodder yield and it was at par with soil

solarization *fb* plastic mulch at sowing *fb* HW at 40 DAS at 30 DAS confirming findings of Choudhary *et al*. (2021). Among all the treatments, weedy check registered significantly the lowest green cob yield and green fodder yield (**Table 3**). All the weed management treatments recorded significantly higher green fodder yield as compared to weedy check.

Effect on weeds in fennel

The lower weed density and dry biomass was noticed under soil solarization *fb* hand weeding + straw mulch 5 t/ha at 20 DAS + HW at 50 and 75 DAS, soil solarization *fb* plastic mulch at sowing *fb* HW at 50 and 75 DAS, stale seed bed preparation *fb* plastic mulch at sowing *fb* HW at 75 DAS and stale seed bed preparation *fb* hand weeding + straw mulch 5 t/ha at 20 DAS *fb* hand weeding at 50 and 75 DAS as compared to others at all the growth stages in fennel (**Table 2**). Decrease in the density and dry biomass of weeds by 93% due to soil solarization in fennel at harvest was noticed by Campiglia *et al*. (2000). Similarly, stale seedbed technique also reduced the density and dry biomass of weeds as early germinated weed flush prior to sowing of crop were destroyed from the respective plots.

Table 1. Density and dry biomass of weeds as influenced by different treatments in sweet corn of sweet corn-fennel cropping system

Treatment	Weed density (no./m^2)			Weed dry biomass (g/m^2)		
	At 30 DAS	At 60 DAS	At harvest	At 30 DAS	At 60 DAS	At harvest
Soil solarization *fb* hand weeding + straw mulch 5 t/ha at 20 DAS + HW at 40 DAS	1.00 (0.00)	4.20 (17.0)	4.49 (19.3)	1.00 (0.00)	2.74 (6.55)	5.70 (31.9)
Soil solarization *fb* plastic mulch at sowing *fb* HW at 40 DAS	3.40 (10.7)	3.58 (12.0)	4.01 (15.3)	1.99 (2.96)	2.66 (6.06)	5.31 (27.4)
Stale seed bed preparation *fb* plastic mulch at sowing *fb* HW at 40 DAS	3.85 (14.0)	3.95 (14.7)	4.24 (17.3)	2.44 (4.95)	2.89 (7.38)	5.46 (28.9)
Stale seed bed preparation *fb* hand weeding + straw mulch 5 t/ha at 20 DAS *fb* hand weeding at 40 DAS	1.00 (0.00)	8.44 (70.7)	6.74 (45.3)	1.00 (0.00)	4.49 (19.2)	8.23 (67.2)
Sunnhemp between rows as smothering crop and used as mulch at 30 DAS with tillage *fb* HW at 40 DAS	6.57 (42.7)	12.6 (157)	8.29 (69.3)	3.68 (12.6)	7.24 (52.1)	10.5 (109)
IC + HW + straw mulch 5 t/ha at 20 DAS *fb* HW at 40 DAS	1.00 (0.00)	10.7 (115)	6.29 (38.7)	1.00 (0.00)	3.99 (15.6)	7.84 (62.1)
IC + HW at 20 and 40 DAS	5.12 (25.3)	11.2 (125)	10.1 (101)	1.71 (1.93)	5.12 (25.2)	10.9 (118)
Weedy check	20.7 (429)	17.6 (313)	11.4 (129)	7.80 (60.2)	16.5 (274)	23.4 (551)
LSD (p=0.05)	0.99	1.94	1.59	0.49	1.94	1.98

Data subjected to $(\sqrt{x+1})$ transformation. Figures in parentheses are means of original values. DAS – days after seeding; *fb* - followed by; HW – hand weeding; IC - intercultivation

Table 2. Density and dry biomass of weed as influenced by different treatments in fennel under sweet corn-fennel cropping system

Treatment	Weed density (no./m^2)			Weed dry biomass (g/m^2)		
	At 30 DAS	At 75 DAS	At harvest	At 30 DAS	At 75 DAS	At harvest
Hand weeding + straw mulch 5 t/ha at 20 DAS + HW at 50 and 75 DAS	1.00 (0.00)	3.11 (8.67)	3.41 (10.7)	1.00 (0.00)	2.19 (3.82)	2.58 (5.79)
Plastic mulch at sowing *fb* HW at 50 and 75 DAS	1.00 (0.00)	3.58 (12.0)	4.94 (23.7)	1.00 (0.00)	2.24 (4.04)	3.22 (9.56)
Stale seed bed preparation *fb* plastic mulch at sowing fb HW at 75 DAS	1.00 (0.00)	5.76 (33.3)	3.37 (10.7)	1.00 (0.00)	5.82 (33.0)	2.64 (6.00)
Stale seed bed preparation *fb* hand weeding + straw mulch 5 t/ha at 20 DAS *fb* hand weeding at 50 and 75 DAS	1.00 (0.00)	6.29 (38.7)	3.72 (13.0)	1.00 (0.00)	2.77 (6.94)	2.67 (6.16)
Sunnhemp between rows as smothering crop and used as mulch at 30 DAS with tillage *fb* HW at 50 and 75 DAS	11.5 (133)	5.20 (26.7)	7.10 (50.7)	5.26 (26.7)	3.02 (8.32)	5.71 (31.9)
IC + HW + straw mulch 5 t/ha at 20 DAS *fb* HW at 50 and 75 DAS	4.06 (16.0)	5.30 (28.0)	4.26 (17.3)	1.41 (1.02)	3.15 (9.04)	3.12 (8.81)
IC + HW at 20, 40 and 60 DAS *fb* earthing-up at 75 DAS	6.30 (40.0)	1.00 (0.00)	5.07 (24.7)	1.71 (1.94)	1.00 (0.00)	3.75 (13.4)
Weedy check	21.2 (450)	13.8 (191)	11.6 (136)	9.59 (91.8)	16.3 (265)	17.2 (297)
LSD (p=0.05)	1.66	1.75	1.68	0.75	1.16	1.62

Data subjected to $(\sqrt{x+1})$ transformation. Figures in parentheses are means of original values. DAS – days after seeding; *fb* - followed by; HW – hand weeding; IC - intercultivation

Effect on fennel

The fennel plant stand at 15 DAS (no./m row length) was statistically similar under different weed management treatments**.** Fennel plant height at 75 DAS was significantly higher soil solarization *fb* hand weeding + straw mulch 5 t/ha at 20 DAS + HW at 50 and 75 DAS while at harvest, fennel plant height was highest with stale seed bed preparation *fb* hand weeding + straw mulch 5 t/ha at 20 DAS *fb* hand weeding at 50 and 75 DAS (**Table 4**). Significantly lowest fennel plant height, seed and stalk yield was recorded with weedy check at 75 DAS and at harvest. All the weed management treatments remained at par with each other and recorded significantly higher number umbels/m row length, seed and stalk yield as compared to weed check. Among all the treatments, soil solarization *fb* hand weeding + straw mulch 5 t/ha at 20 DAS + HW at 50 and 75 DAS recorded significantly higher seed and stalk yield and it was at par with stale seed bed preparation *fb* hand weeding + straw mulch 5 t/ha at 20 DAS *fb* hand weeding at 50 and 75 DAS, IC + HW + straw mulch 5 t/ha at 20 DAS *fb* HW at 50 and 75 DAS, stale seed bed preparation *fb* plastic mulch at sowing *fb* HW at 75 DAS and IC + HW at 20, 40 and 60 DAS *fb* earthing-up at 75 DAS. These findings are in agreement with those of Patel *et al*. (2018). Campiglia *et al*. (2000) observed that yield of fennel was improved up to 91% following solarization with clear polyethylene mulch compared with the un-mulched control.

Sweet corn equivalent yield

The highest system productivity reduction of 65.6% was noticed under weedy check in the sweet corn-fennel cropping sequence (**Table 5**).

The least reduction in yield due to weed competition, highest sweet corn equivalent green cob, green fodder yield, gross returns, net returns and benefit cost ratio was observed higher with soil solarization *fb* hand weeding + straw mulch 5 t/ha at 20 DAS + HW at 40 DAS in sweet corn and same

Table 3. Effect of different treatments on growth and yield of sweet corn under sweet corn-fennel cropping system

Treatment	Plant stands at 15 DAS (no./net plot)	Plant height (cm)		Green cob yield (t/ha)	Green fodder yield (t/ha)
		30 DAS	60 DAS		
Soil solarization *fb* hand weeding + straw mulch 5 t/ha at 20 DAS + HW at 40 DAS	166	88.1	199	19.0	20.1
Soil solarization *fb* plastic mulch at sowing *fb* HW at 40 DAS	165	86.6	191	17.4	15.2
Stale seed bed preparation *fb* plastic mulch at sowing *fb* HW at 40 DAS	162	69.4	172	13.1	13.5
Stale seed bed preparation *fb* hand weeding + straw mulch 5 t/ha at 20 DAS *fb* hand weeding at 40 DAS	164	65.8	189	14.6	15.7
Sunnhemp between rows as smothering crop and used as mulch at 30 DAS with tillage *fb* HW at 40 DAS	165	73.4	170	14.4	15.4
IC + HW + straw mulch 5 t/ha at 20 DAS *fb* HW at 40 DAS	165	66.1	187	14.6	15.7
IC + HW at 20 and 40 DAS	165	65.5	172	11.6	12.6
Weedy check	163	59.6	163	7.67	7.63
LSD (p=0.05)	NS	12.6	NS	3.86	3.02

DAS – days after seeding; *fb* - followed by; HW – hand weeding; IC - intercultivation

Table 4. Effect of different treatments on growth and yield of fennel under sweet corn-fennel cropping system

Treatment	Plant stands at 15 DAS (no./m row length)	Plant height (cm)		No. of umbels (no./m row length)	Seed yield (t/ha)
		75 DAS	At harvest		
Hand weeding + straw mulch 5 t/ha at 20 DAS + HW at 50 and 75 DAS	13.8	147.7	190.7	53.7	1.56
Plastic mulch at sowing *fb* HW at 50 and 75 DAS	13.6	129.3	191.3	53.7	1.33
Stale seed bed preparation *fb* plastic mulch at sowing *fb* HW at 75 DAS	13.4	131.7	187.3	51.0	1.48
Stale seed bed preparation *fb* hand weeding + straw mulch 5 t/ha at 20 DAS *fb* hand weeding at 50 and 75 DAS	13.7	143.7	192.7	51.8	1.46
Sunnhemp between rows as smothering crop and used as mulch at 30 DAS with tillage *fb* HW at 50 and 75 DAS	13.2	124.3	178.3	53.7	1.17
IC + HW + straw mulch 5 t/ha at 20 DAS *fb* HW at 50 and 75 DAS	13.4	143.3	181.3	52.0	1.53
IC + HW at 20, 40 and 60 DAS *fb* earthing-up at 75 DAS	13.5	134.3	183.3	52.1	1.46
Weedy check	13.4	96.0	162.3	17.9	0.36
LSD (p=0.05)	NS	13.0	14.0	12.5	0.15

DAS – days after seeding; *fb* - followed by; HW – hand weeding; IC – inter cultivation

Table 5. System productivity of sweet corn-fennel cropping system under organic farming (Sweet corn equivalent)

Treatment		Green cob equivalent yield (t/ha)	Green fodder equivalent yield (t/ha)	Additional cost over control (Rs./ha)	Total cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C
Sweet corn	Fennel							
Soil solarization *fb* hand weeding + straw mulch 5 t/ha at 20 DAS + HW at 40 DAS	Hand weeding + straw mulch 5 t/ha at 20 DAS + HW at 50 and 75 DAS	29.40	22.3	102505	273746	485600	211854	1.77
Soil solarization *fb* plastic mulch at sowing *fb* HW at 40 DAS	Plastic mulch at sowing *fb* HW at 50 and 75 DAS	26.30	17.3	144200	318499	429100	110601	1.35
Stale seed bed preparation *fb* plastic mulch at sowing *fb* HW at 40 DAS	Stale seed bed preparation *fb* plastic mulch at sowing *fb* HW at 75 DAS	23.00	15.6	90370	260721	376200	115479	1.44
Stale seed bed preparation *fb* hand weeding + straw mulch 5 t/ha at 20 DAS *fb* hand weeding at 40 DAS	Stale seed bed preparation *fb* hand weeding + straw mulch 5 t/ha at 20 DAS *fb* hand weeding at 50 and 75 DAS	24.30	17.8	58320	226320	400100	173780	1.77
Sunnhemp between rows as smothering crop and used as mulch at 30 DAS with tillage *fb* HW at 40 DAS	Sunnhemp between rows as smothering crop and used as mulch at 30 DAS with tillage *fb* HW at 50 and 75 DAS	22.20	16.9	52640	220225	366800	146575	1.67
IC + HW + straw mulch 5 t/ha at 20 DAS *fb* HW at 40 DAS	IC + HW + straw mulch 5 t/ha at 20 DAS *fb* HW at 50 and 75 DAS	24.80	17.8	65530	234060	407600	173540	1.74
IC + HW at 20 and 40 DAS	IC + HW at 20, 40 and 60 DAS *fb* earthing-up at 75 DAS	21.30	14.6	49280	216619	348700	132081	1.61
Weedy check	Weedy check	10.10	6.4	0	163724	164300	576	1.00

DAS – days after seeding; *fb* - followed by; HW – hand weeding; IC - intercultivation

components of IWM as in sweet corn except for HW at 50 and 75 DAS in fennel (**Table 5**). Next best IWM strategy was soil solarization *fb* plastic mulch at sowing *fb* HW at 40 DAS in sweet corn and HW at 50 and 75 DAS in fennel.

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