



Effect of organic weed management practices on weed control and yield of soybean-gram cropping system under irrigated condition

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ABSTRACT

The significantly lower weed density and biomass, at 40 days after seeding (DAS) was recorded in weed free plots followed by soil solarization with 25 μ polythene mulch during summer + one hand weeding at 25 DAS in soybean and gram during both the years. Among the weed management practices, combination of stale seedbed + reduced spacing + mulching with wheat straw (2 t/ha) + one HW at 25 DAS recorded higher soybean equivalent yield. Higher net returns and benefit: cost ratio was observed in soybean + sun hemp incorporation after 35-40 DAS in *Kharif* and gram + safflower (2:1) intercropping in *Rabi* season, followed by stale seedbed + reduced spacing + mulching with wheat straw (2 t/ha) + one HW at 25 DAS. Application of two hand weeding (20-25 and 45-50 DAS) recorded higher values of yield attributes.

INTRODUCTION

Soybean (*Glycine max* L.) is a leguminous crop and belongs to family leguminosae with sub family papilionaceae. Soybean is a “Golden bean” of 21th century mainly due to its high protein (40-42%) and oil (20%) contents. Being a rainy season crop, it faces severe weed competition during early stages of crop growth, resulting in loss of about 40-60% of the potential yield, depending on the weed intensity, nature, environmental condition and duration of weed competition (Mishra *et al.* 2002). Gram (*Cicer arietinum*) is one of the most important pulse crop of Maharashtra during *Rabi*. Kumar *et al.* (2014) reported that presence of weeds throughout the crop season reduced the seed yield of gram up to 68%. Weeds are widely reported as a key constraint in organic agriculture. Higher infestation of weeds in crops tends to decrease crop yields by increasing competition for water, sunlight and nutrients while serving as host plants for pests and diseases. The indiscriminate use of herbicides has resulted in loss of biodiversity, environmental and health problems, and development of resistance. In organic farming, cultural and mechanical methods are necessary to break the weed cycle. Soybean-gram is important cropping sequence adopted in Maharashtra in irrigated situation. The research work carried out on organic weed management in soybean-gram cropping sequence is very limited. Hence, the present investigation was conducted to evaluate the non-chemical weed management options in soybean-gram cropping sequence.

MATERIALS AND METHODS

Field experiments were conducted at Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (Maharashtra) during 2017-18 and 2018-19. Geographically, Parbhani is situated at 19°16' North latitude and 76°47' East longitude and at an altitude of 409 meters above sea level in Marathwada division encompassed by 17°35' to 20°40' North and 74°49' to 78°15' East geographical boundaries. The soil of the experimental plot was clayey in texture (52.32 and 53.60% clay), low in organic carbon (0.50 and 0.56%) and available nitrogen (222.48 and 231.18 kg/ha), medium in available phosphorus (17.52 and 18.32 kg/ha), high in available potassium (545.50 and 549.18 kg/ha) and slightly alkaline in reaction (pH-8.00 and 8.10) during both the year respectively.

The experiment was laid out in a randomized block design with three replications. The weed management treatments were: two hand weedings (HW) at 20-25 and 45-50 DAS, one hoeing 20-25 DAS + one HW at 45-50 DAS, soybean + sunhemp incorporation after 35-40 DAS in *Kharif* season and gram + safflower (2:1) in *Rabi* season, stale seed bed + reduced spacing + mulching with wheat straw (2 t/ha) + one HW at 25 DAS, soil mulch at the time of sowing + one hand pulling at 25 DAS, incorporation of neem cake 1.5 t/ha 15 days before sowing + one HW at 25 DAS, soil solarization with 25 μ polythene mulch during summer + one HW at 25 DAS, mulching with straw, weed free and weedy check. In

soybean, sunhemp was sown in between the two rows and it was incorporated at 30 to 35 days after seeding through wooden plough, before start of flowering. The sunhemp was sown simultaneously with tractor drawn seed drill at 20 kg/ha. The wheat straw applied manually through broadcasting in soybean at 5.0 t/ha available at the rate ₹ 1 per kg. Gram + safflower were sown in 2:1 ratio at 30 cm to reduce weed flora in field due to high population density. The observations on weed density and weed biomass were taken randomly from 1.0 m² quadrat from net plot area from each treatment.

RESULTS AND DISCUSSION

Weed flora

The predominant weed flora found in soybean crop were *Cynodon dactylon*, *Brachiaria eruciformis*, *Commelina benghalensis*, *Cyperus rotundus*, *Phyllanthus niruri*, *Parthenium hysterophorus* and *Euphorbia geniculata*. The predominant weed flora found in gram crop were *Cynodon dactylon*, *Cyperus rotundus*, *Phyllanthus*

niruri, *Convolvulus arvensis* and *Amaranthus viridis* during both the years of the study. Weed density at 40 days after seeding of soybean and gram given in **Table 1** and **2**, respectively.

Effect on weeds

During both the years at 40 DAS, significantly the lower biomass of monocot, dicot and total weeds was recorded under weed free treatment followed by soil solarization for 30 days with 25 μ polythene mulch during summer + one HW at 25 DAS and stale seed bed + reduced spacing + mulching with wheat straw (2 t/ha) + one HW at 25 DAS in both soybean and gram (**Table 3** and **4**). Significantly higher biomass of monocot, dicot and total weeds was recorded in weedy check.

Yield

During first year, stale seed bed + reduced spacing + mulching with wheat straw (2 t/ha) + one HW (25 DAS) recorded significantly more seed yield (2.54 t/ha) was on par with weed free (2.42 t/ha) and two hand weeding's at 20-25 and 45-50 DAS (2.37

Table 1. Effect of different treatments on weed density (no./m²) in soybean at 40 days after seeding

Treatment	Monocot			Dicot			Total weed		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Two hand weeding (HW) at 20-25 and 45-50 DAS	12.00	15.00	13.5	5.00	7.13	6.07	17.00	22.13	19.57
One hoeing (20-25 DAS) + one HW (45-50 DAS)	14.47	17.40	15.9	5.40	7.60	6.50	19.87	25.00	22.43
Soybean + sunhemp incorporation after 35-40 DAS	8.60	11.53	10.07	4.60	6.67	5.63	13.20	18.20	15.70
Stale seed bed + reduced spacing + mulching with wheat straw (2 t/ha) + one HW (25 DAS)	7.57	10.50	9.03	3.93	5.60	4.77	11.50	16.10	13.80
Soil mulch at the time of sowing + one hand pulling at 25 DAS	15.67	19.00	17.33	6.67	8.83	7.75	22.33	27.83	25.08
Incorporation of neem cake 1.5 t/ha (15 days before sowing) + one HW (25 DAS)	12.13	15.47	13.80	5.13	7.20	6.17	17.27	22.67	19.97
Soil solarization with 25 μ polythene mulch during summer + one HW (25 DAS)	6.47	9.47	7.97	3.00	4.73	3.87	9.47	14.20	11.83
Mulching with straw	29.87	33.20	31.53	16.00	18.67	17.33	45.87	51.87	48.87
Weed free	1.33	2.40	1.87	1.30	3.30	2.30	2.63	5.70	4.17
Weedy check	31.20	35.20	33.20	18.00	20.73	19.37	49.20	55.93	52.57
LSD (p=0.05)	2.74	2.90	2.92	2.97	3.17	3.14	4.64	4.97	4.94

Table 2. Effect of different treatments on weed density (no./m²) in gram at 40 days after seeding

Treatment	Monocot			Dicot			Total weed		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Two hand weeding (HW) at 20-25 and 45-50 DAS	10.67	12.80	11.73	4.43	6.40	5.42	15.10	19.20	17.15
One hoeing (20-25 DAS) + one HW (45-50 DAS)	13.87	16.95	15.41	6.58	9.50	8.04	20.45	26.45	23.45
Gram + safflower (2:1)	16.53	18.67	17.60	9.10	11.17	10.13	25.63	29.83	27.73
Stale seed bed + reduced spacing + mulching with wheat straw (2 t/ha) + one HW (25 DAS)	7.23	9.45	8.34	3.00	4.13	3.57	10.23	13.58	11.91
Soil mulch at the time of sowing + one hand pulling at 25 DAS	15.33	17.20	16.27	7.90	9.77	8.83	23.23	26.97	25.10
Incorporation of neem cake 1.5 t/ha 15 days before sowing + one HW at 25 DAS	10.87	13.27	12.07	4.60	6.50	5.55	15.47	19.77	17.62
Soil solarization with 25 μ polythene mulch during summer + one hand weeding at 25 DAS	6.13	8.40	7.27	3.18	4.30	3.74	9.32	12.70	11.01
Mulching with straw	30.53	33.73	32.13	17.50	20.50	19.00	48.03	54.23	51.13
Weed free	1.87	3.87	2.87	1.50	2.75	2.13	3.37	6.62	4.99
Weedy check	31.20	34.40	32.80	19.20	22.10	20.65	50.40	56.50	53.45
LSD (p=0.05)	2.87	2.99	3.00	1.86	1.97	2.00	3.47	4.00	3.89

t/ha). Lower seed yield (1.15 t/ha) was noticed with weedy check. Similar trend was noticed during second year and in pooled results. (Table 5).

In gram all the weed control treatments were found to be significantly superior over the weedy check during both the year. Gram + safflower (2:1) intercropping recorded significantly more seed yield which was at par with stale seed bed + reduced spacing + mulching with wheat straw (2 t/ha) + one HW (25 DAS), weed free, soil solarization with 25 μ polythene mulch during summer + one HW (25 DAS) and incorporation of neem cake 1.5 tonne/ ha 15 days before sowing + one HW (25 DAS) and significantly superior over rest of the treatments.

In pooled data, more seed yield was recorded by gram + safflower (2:1) treatment (2.62 t/ha) which on par with, stale seed bed + reduced spacing + mulching with wheat straw (2 t/ha) + one HW (25 DAS), weed free, soil solarization with 25 μ

polythene mulch during summer + one HW (25 DAS) and incorporation of neem cake 1.5 t/ha 15 days before sowing + one HW (25 DAS) and two hand weeding at 20-25 and 45-50 DAS. (Table 6). It might be attributed to lesser competition offered by weeds for light, water and nutrients which resulted in more uptake of nutrients and produced more photosynthates. Lower yield was noticed with weedy check. This is due to more weed competition with crop for light, water and nutrients produced less photosynthates. Similar results reported by Rathod *et al.* (2017), Pedde *et al.* (2013), Singh and Jain (2017).

Yield attributes

Significantly more number of pods/plant, weight of pods/plant, weight of seeds/plant, number of seeds/pod and test weight of soybean were recorded with two hand weeding at 20-25 and 45-50 DAS, which was at par with soil solarization with 25 μ

Table 3. Effect of different treatments on weed biomass (g/m²) in soybean at 40 days after seeding

Treatment	Monocot			Dicot			Total weed		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Two hand weeding (HW) at 20-25 and 45-50 DAS	6.61	8.61	7.61	3.20	5.10	4.15	9.81	13.71	11.76
One hoeing (20-25 DAS) + one HW (45-50 DAS)	8.07	11.15	9.61	3.46	7.13	5.29	11.53	18.27	14.90
Soybean + sunhemp incorporation after 35-40 DAS	4.93	7.48	6.21	2.95	4.85	3.90	7.88	12.33	10.11
Stale seed bed + reduced spacing + mulching with wheat straw (2 t/ha) + one HW (25 DAS)	4.12	7.00	5.56	2.51	4.45	3.48	6.63	11.45	9.04
Soil mulch at the time of sowing + one hand pulling at 25 DAS	9.03	13.00	11.02	5.03	8.16	6.60	14.07	21.16	17.61
Incorporation of neem cake 1.5 tonne/ ha (15 days before sowing) + one HW (25 DAS)	6.80	8.72	7.76	3.29	5.37	4.33	10.09	14.08	12.09
Soil solarization with 25 μ polythene mulch during summer + one HW (25 DAS)	3.61	5.52	4.57	2.00	3.60	2.80	5.61	9.12	7.37
Mulching with straw	16.67	22.91	19.79	12.20	15.53	13.87	28.87	38.44	33.66
Weed free	0.74	2.40	1.57	0.83	1.80	1.32	1.57	4.20	2.89
Weedy check	17.42	23.23	20.33	13.27	16.27	14.77	30.68	39.50	35.09
LSD (p=0.05)	1.54	2.27	2.22	2.12	2.26	2.30	2.95	3.88	3.81

Table 4. Effect of different treatments on mean weed biomass (g/m²) in gram at 40 days after seeding

Treatment	Monocot			Dicot			Total weed		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Two hand weeding (HW) at 20-25 and 45-50 DAS	5.95	9.00	7.48	3.37	4.42	3.90	9.32	13.42	11.37
One hoeing (20-25 DAS) + one HW (45-50 DAS)	8.74	12.38	10.56	5.84	6.94	6.39	14.58	19.32	16.95
Gram + safflower (2:1)	10.71	14.80	12.76	9.02	10.38	9.70	19.73	25.18	22.46
Stale seed bed + reduced spacing + mulching with wheat straw (2 t/ha) + one HW (25 DAS)	4.03	7.70	5.87	2.82	3.90	3.36	6.85	11.60	9.23
Soil mulch at the time of sowing + one hand pulling at 25 DAS	9.22	13.38	11.30	7.04	8.72	7.88	16.26	22.09	19.18
Incorporation of neem cake 1.5 t/ha 15 days before sowing + one hand weeding at 25 DAS	6.06	9.13	7.60	3.45	4.68	4.07	9.51	13.81	11.66
Soil solarization with 25 μ polythene mulch during summer + one hand weeding at 25 DAS	3.42	6.42	4.92	2.38	3.56	2.97	5.80	9.98	7.89
Mulching with straw	17.04	21.18	19.11	12.70	15.23	13.97	29.74	36.42	33.08
Weed free	1.95	3.20	2.58	1.30	2.30	1.80	3.25	5.50	4.38
Weedy check	17.42	22.08	19.75	12.93	15.73	14.33	30.35	37.82	34.08
LSD (p=0.05)	1.47	1.76	1.76	1.54	1.69	1.70	2.26	2.33	2.52

polythene mulch during summer + one hand weeding at 25 DAS treatment and significantly superior over rest of the treatments. It might be due to lowering crop-weed competition during critical crop growth period at pod development stage. Similar findings were also reported by Patel *et al.* (2018), Rathod *et al.* (2017), Yadav and Shaikh (2009), Rai *et al.* (2016) Sharma *et al.* (2016), Purena *et al.* (2015). (Table 5).

Significantly more number of pods/plant, weight of pods/plant, weight of seeds/plant, number of seeds/plant, number of seed/pod and test weight of gram were recorded with weed free which was at par with the soil solarization with 25 μ polythene mulch during summer + one HW (25 DAS), incorporation of neem cake 1.5 t/ha 15 days before sowing + one HW (25 DAS) and two hand weeding at 20-25 and 45-50 DAS. It might be due to the complete elimination of weeds at critical period of crop-weed competition resulting better plant growth and higher yield

attributing parameters. These findings are in accordance with those of Ratnam *et al.* (2011) and Gore *et al.* (2018) (Table 6).

Soybean equivalent yield and economics

During both the years, significantly higher soybean equivalent yield of system was recorded by stale seedbed + reduced spacing (30 cm) + mulching with wheat straw (2 t/ha) + one HW at 25 DAS which was at par with soybean + sunhemp incorporation after 35-40 DAS in *Kharif*, and gram + safflower (2:1) in *Rabi* season. Lower soybean equivalent yield was observed with weedy check (Table 7). Suppression of weeds and higher yield in gram + safflower (2:1) intercropping was due to reduced spacing and higher plant density. Lower soybean equivalent yield was observed with weedy check. Das and Yaduraju (2008) reported similar findings in respect of soybean equivalent yield.

Table 5. Effect of different treatments on mean seed yield and yield attributes of soybean

Treatment	Yield (t/ha)			Weight of pods/plant (g)		Weight of seeds/plant(g)		No. of seeds/plant	
	2017-18	2018-19	Pooled	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
	Two hand weeding (HW) at 20-25 and 45-50 DAS	2.37	2.56	2.47	17.99	20.20	12.80	13.15	90.06
One hoeing (20-25 DAS) + one HW (45-50 DAS)	1.97	2.13	2.05	15.73	17.06	9.77	11.03	68.73	79.89
Soybean + Sunhemp incorporation after 35-40 DAS	2.20	2.41	2.30	14.52	16.47	8.69	9.57	61.13	69.30
Stale seed bed + reduced spacing + mulching with wheat straw (2 t/ha) + one HW (25 DAS)	2.54	2.77	2.66	14.32	16.23	8.53	9.33	59.33	67.58
Soil mulch at the time of sowing + one hand pulling at 25 DAS	1.36	1.52	1.44	14.80	16.92	8.74	10.59	63.23	76.71
Incorporation of neem cake 1.5 t/ha 15 days before sowing + one hand weeding at 25 DAS	2.15	2.33	2.24	15.83	17.74	9.88	12.14	69.51	87.88
Soil solarization with 25 μ polythene mulch during summer + one hand weeding at 25 DAS	2.18	2.37	2.27	17.13	19.05	12.45	12.62	87.62	91.36
Mulching with straw	1.25	1.38	1.32	10.57	11.96	7.62	8.32	52.95	60.22
Weed free	2.42	2.65	2.54	19.48	21.38	14.04	14.48	98.81	104.88
Weedy check	1.15	1.29	1.22	10.31	11.40	7.50	8.10	52.78	58.67
LSD (p=0.05)	0.29	0.35	0.33	2.49	2.77	1.60	2.08	11.29	15.03

Table 6. Effect of different treatments on mean seed yield and yield attributes of gram

Treatment	Yield (t/ha)			Weight of pods/plant (g)		Weight of seeds/plant (g)		No. of seeds/plant	
	2017-18	2018-19	Pooled	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
	Two hand weeding (HW) at 20-25 and 45-50 DAS	2.39	2.27	2.33	17.57	15.54	11.90	11.61	56.41
One hoeing (20-25 DAS) + one HW (45-50 DAS)	2.27	2.13	2.20	15.75	14.42	10.58	9.87	50.16	43.27
Gram + safflower (2:1)	2.77	2.47	2.62	10.35	9.69	6.88	6.43	32.60	30.77
Stale seed bed + reduced spacing + mulching with wheat straw (2 t/ha) + one HW (25 DAS)	2.58	2.39	2.49	10.97	9.95	7.28	6.63	34.50	31.61
Soil mulch at the time of sowing + one hand pulling at 25 DAS	2.11	2.09	2.10	14.36	13.42	9.70	9.62	45.97	42.93
Incorporation of neem cake 1.5 t/ha 15 days before sowing + one hand weeding at 25 DAS	2.47	2.41	2.44	17.90	19.72	12.12	12.22	57.43	54.13
Soil solarization with 25 μ polythene mulch during summer + one hand weeding at 25 DAS	2.48	2.43	2.45	18.07	21.32	12.43	12.30	58.89	58.30
Mulching with straw	1.75	1.21	1.48	13.41	9.22	7.94	6.14	37.62	25.93
Weed free	2.50	2.41	2.45	20.31	18.16	13.49	12.20	63.94	51.02
Weedy check	1.55	1.12	1.33	12.28	8.84	6.82	5.74	32.32	23.87
LSD (p=0.05)	0.30	0.29	0.32	3.32	3.35	2.49	1.99	10.09	9.25

Table 7. Soybean equivalent yield and monetary returns as influenced by different weed management treatment

Treatment	Soybean equivalent yield (t/ha)			Gross monetary returns (x10 ³ ₹/ha)			Net monetary returns (x10 ³ ₹/ha)			Benefit: Cost ratio (B:C)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Two hand weeding (HW) at 20-25 and 45-50 DAS	5.36	5.65	5.50	147.8	192.1	170.0	65.4	98.4	81.9	1.80	2.05	1.93
One hoeing (20-25 DAS) + one HW (45-50 DAS)	4.81	5.02	4.92	132.6	170.8	151.7	60.0	89.2	74.6	1.84	2.09	1.97
Soybean + sunhemp incorporation after 35-40 DAS in <i>Kharif</i> and gram + safflower (2:1) in <i>Rabi</i> season	5.66	5.76	5.71	156.3	195.9	176.1	95.3	124.7	110.0	2.60	2.77	2.69
Stale seed bed + reduced spacing + mulching with wheat straw (2 t/ha) + one HW (25 DAS)	5.77	6.02	5.89	159.1	204.7	181.9	80.7	113.4	97.0	2.04	2.24	2.14
Soil mulch at the time of sowing + one hand pulling at 25 DAS	4.00	4.36	4.18	110.3	148.3	129.3	41.7	70.3	56.0	1.60	1.90	1.75
Incorporation of neem cake 1.5 t/ha 15 days before sowing + one hand weeding at 25 DAS	5.24	5.61	5.43	144.7	190.8	167.7	31.1	61.6	46.3	1.24	1.48	1.36
Soil solarization with 25 µ polythene mulch during summer + one hand weeding at 25 DAS	5.28	5.67	5.47	145.7	192.7	169.2	42.1	77.8	59.9	1.42	1.68	1.55
Mulching with straw	3.44	3.03	3.23	94.8	102.9	98.8	35.3	30.3	32.8	1.53	1.42	1.48
Weed free	5.54	5.93	5.74	152.9	201.5	177.2	68.3	104.8	86.6	1.82	2.08	1.95
Weedy check	3.09	2.81	2.95	85.2	95.6	90.4	28.8	28.9	28.8	1.50	1.43	1.47
LSD (p=0.05)	0.54	0.53	0.57	14.9	17.9	19.2	15.6	17.9	19.4	-	-	-

Soybean + sunhemp incorporation after 35-40 DAS in *Kharif* and gram + safflower (2:1) in *Rabi* season recorded significantly higher net returns of system (₹ 95257/ha) which was at par with stale seed bed + reduced spacing + mulching with wheat straw (2 t/ha) + one HW at 25 DAS (₹ 80668/ha) and significantly superior over rest of the treatments. It might be due to higher seed yield and less cost of cultivation in these treatments. Kumar and Das (2008) reported similar findings in respect of system economics. Least net monetary returns were recorded by weedy check treatment (₹ 28769/ha). Similar kind of trend was noticed during second year and in pooled results. The higher B:C ratio (2.60) was observed with soybean + sunhemp incorporation after 35-40 DAS) in *Kharif* and gram + safflower (2:1) in *Rabi* season treatment followed by stale seed bed + reduced spacing + mulching with wheat straw (2 t/ha) + one HW at 25 DAS (2.04).

Conclusion

In organic agriculture, application of stale seed bed + reduced spacing + mulching with wheat straw (2 t/ha) + one HW at 25 DAS recorded higher soybean equivalent yield and profits, followed by soybean + sunhemp incorporation after 35-40 DAS in *Kharif* and gram + safflower (2:1) in *Rabi* season. Soil solarization with 25 µ polythene mulch during summer + one HW (25 DAS) recorded lower weed density and biomass at 40 days after sowing.

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