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Sorghum Allelopathy for Weed Control in Cotton (*Gossypium arboreum* L.)

ZAHID ATTA CHEEMA, MOHAMMAD ASIM AND ABDUL KHALIQ
Department of Agronomy, University of Agriculture, Faisalabad–38040, Pakistan

ABSTRACT

A field trial was conducted to see the feasibility of sorghum allelopathy for weed control in Desi cotton, at agronomic research area, University of Agriculture, Faisalabad. Sorghum water extract (sorgaab) sprays (1-3) and sorghum mulches (3.5, 7.0, 10.5 t ha^{-1}) were tested and compared with directed post emergence application of Paraquat @ 0.48 kg ai ha^{-1} and hand weeding (two). Sorgaab (Sorghum water extract) (active ingredient) sprays and sorghum mulch treatments suppressed the total weed density by 13-54% and 23-62% respectively. While 52-70% and 54-64% suppression was recorded in hand weeding and herbicidal treatment respectively. The weed biomass was suppressed in sorgaab, sorghum mulch and in herbicidal treatments by 40, 56 and 87% respectively. The seed cotton yield increased by 69% (over control) in two sorgaab foliar sprays and 59% in sorghum mulching. Plots treated with herbicide produced comparatively more yield (156%) and two hand weedings resulted in maximum increase (217.4%) in yield of seed cotton.

Key Words: Sorghum; Allelopathy; Weed control; Cotton

INTRODUCTION

Weed infestation in cotton crop is one of the main causes of low yield per hectare against the potential yield. Weeds reduce cotton yield by 16-53% (Ramzan *et al*., 1989). Existing weed control methods in cotton are either expensive or hazardous. Chemical herbicides may cause pollution. While hand weeding is labour intensive and costly.

Allelopathy provides a relatively cheaper and environmental friendly weed control alternative (Purvis *et al*., 1985; Cheema & Ahmad, 1988). Sorghum allelopathic properties have been successfully used in suppressing weed growth and improving yield of crops such as wheat, maize and soybean with less cost (Ahmad, 1998; Khaliq *et al*., 1999). Similarly, Cheema *et al*. (1997) reported that two foliar sprays of sorgaab (SWE) inhibited weed dry weight by 15-53% and improved wheat yield by 14%. Sorghum allelo-chemicals are species specific and concentration dependent in their effect (Cheema & Ahmad, 1992).

Considering the economic importance of cotton in the economy of Pakistan, the costs of weeds in terms of yield reduction, expenditure on their control and successful utilization of sorghum allelopathic properties in some crops, it was contemplated in the present study to investigate the feasibility of using sorghum allelopathy as weed control approach for cotton in Faisalabad conditions.

MATERIALS AND METHODS

A field experiment was conducted at Agronomic Research Area, Department of Agronomy, University of Agriculture, Faisalabad to investigate the response of Desi-cotton and its weeds to sorghum allelopathy. The experiment was laid out in RCBD with four replications. A new Desi Cotton variety FDH-170 was sown on 2nd June 1998 with a single row hand drill on well prepared seed bed. Chopped sorghum was soaked in ordinary water (1:10 w:v) for 24 hours then filtered to collect sorgaab (SWE). Chopped sorghum as mulch @ 3.5, 7.0 and 10.50 t ha^{-1} was spread in the rows with hand hoe. Sorgaab was sprayed with knapsack hand sprayer fitted with t jet nozzle at 20, 20+40, 20+40+60 days after sowing (DAS). Paraquat @ 0.48 kg a.i. (active ingredient) ha^{-1} was applied as directed post emergence at 20 DAS. The volume of spray was (470 L ha^{-1}) measured by calibration. Hand weeding was done manually with hand hoe (Khurpa).

Weed density (total and individual) was recorded at 25, 45 and 65 DAS per unit area (50 cm × 50 cm) from randomly selected two sites in each treatment. Weeds were harvested at ground level after 45 and 65 DAS to record fresh and dry weights. The weeds were dried in an oven at 70°C for 48 hours. Data on various cotton plant growth parameters as plant height, leaf area, number of bolls per plant were recorded from randomly selected plants in each treatment. Seed cotton yield was recorded from net plots in kg and then converted to kg ha^{-1}. The data were analyzed by using analysis of variance techniques and least significant difference test

was applied to compare the treatment means (Steel & effects of sorghum on this weed were also reported by Torrie, 198 establish ecc

RESULTS

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Table I. All

Treatment					
T_1-Sorgaab(1/1					
T_2-Sorgaab (1/1					
T_3-Sorgaab (1/1					
	(47.0)	(11.11)	(40.0)	(59.7)	(46.3)
T_4-Sorghum mulch	6.0b	1.50cd	2.75b	3.75bc	13.75bc
@ 3.50 t ha^{-1}	(29.4)	(33.3)	(45.0)	(53.1)	(42.1)
T_5-Sorghum mulch	5.25bc	1.0e	1.50c	1.25c	9.0ef
@ 7.00 t ha^{-1}	(38.2)	(55.6)	(70.0)	(84.4)	(62.11)
T_6-Sorghum mulch	4.75cd	2.00ab	1.25c	6.0ab	14.0bc
@ 10.50 t ha^{-1}	(44.1)	(11.11)	(75.0)	(25.0)	(41.1)
T_7-Hand weeding (two) at	4.0de	1.0e	0.75c	1.50c	7.25f
20+40 DAS	(52.9)	(55.6)	(85.0)	(81.3)	(69.5)
T_8-Gramoxone (paraquat)	4.50de	1.25de	2.75c	1.50c	10.0e
0.48 kg ai/ha	(47.0)	(44.4)	(45.0)	(81.3)	(57.9)
T_9 control	8.50a	2.25a	5.0a	8.0a	23.75a
L.S.D. (0.05)					

DAS=Days af parenthesis sh

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Sorghum mulch @ 7.0 t ha^{-1} and two hand weedings reduced the density of field bind weed by 56% over control. These were followed by sorgaab one spray and herbicidal treatment that suppressed the population of field bind weed by 44% over control. The suppressive

Table II. Allelopathic effects of sorghum on weed dry weight (0.5m^{-2})

Treatment	Horse purslane	Field bind weed	Bermuda grass	Purple nutsedge	Total weed dry weight (g)
T_1-Sorgaab(1/10) one spray at 20 DAS	26.20b [1]	0.03e	4.53b	0.16d	30.87b
	(28.4)[2]	(96.6)	(25.1)	(79.8)	(32.6)
T_2-Sorgaab (1/10) two sprays at 20+40 DAS	25.29b	0.06de	3.59c	0.54bc	29.46c
	(30.9)	(93.3)	(40.7)	(31.2)	(35.2)
T_3-Sorgaab (1/10) three sprays at 20+40+60 DAS	22.08c	0.37b	4.45b	0.70ab	27.44cd
	(39.7)	(58.4)	(26.5)	(11.4)	(40.1)
T_4-Sorghum mulch	17.15d	0.17c	5.72a	0.66ab	23.70e
@ 3.50 t ha^{-1}	(53.2)	(80.9)	(5.5)	(16.5)	(48.2)
T_5-Sorghum mulch	22.08c	0.07d	2.20d	0.31cd	24.67de
@ 7.00 t ha^{-1}	(39.7)	(92.1)	(63.6)	(60.76)	(46.1)
T_6-Sorghum mulch	18.36d	0.03e	1.23e	0.50bc	20.13f
@ 10.50 t ha^{-1}	(49.8)	(96.63)	(79.7)	(35.4)	(56.0)
T_7-Hand weeding (two) at	0.62e	0.05de	0.49f	0.60ab	1.76h
20+40 DAS	(98.3)	(94.4)	(91.9)	(24.1)	(96.2)
T_8-Gramoxone (paraquat)	1.76e	0.14c	3.48e	0.62ab	6.06g
0.48 kg ai/ha	(95.2)	(84.3)	(42.5)	(21.5)	(86.8)
T_9 control	36.61a	0.89a	6.05a	0.79a	45.79a
	(-)	(-)	(-)	(-)	(-)
L.S.D. (0.05)	2.40	0.03	0.45	0.23	3.28

DAS = Days after sowing; [1]Any two means not sharing a letter in common differ significantly at 5% level of probability; [2]Figures given in parenthesis show per cent reduction over control

Table III. Allelopathic effects of sorghum on the growth and yield of cotton

Treatment	Plant height (cm)	Leaf area per plant (cm^2)	No. of bolls per plant	Seed cotton yield per plot kg ha^{-1}	% age increase over control
T_1-Sorgaab(1/10) one spray at 20 DAS	71.35c	2396bc	14.55c	189.35e	17.7
T_2-Sorgaab (1/10) two sprays at 20+40 DAS	92.2ab	2826b	16.48b	255.75d	59.0
T_3-Sorgaab (1/10) three sprays at 20+40+60 DAS	71.9c	2532bc	9.0d	197.93e	23.0
T_4-Sorghum mulch @ 3.50 t ha^{-1}	88.75b	2785b	16.45b	272.18d	69.2
T_5-Sorghum mulch @ 7.00 t ha^{-1}	94.25ab	2441bc	14.80c	246.57d	53.3
T_6-Sorghum mulch @ 10.50 t ha^{-1}	92.80ab	2644b	(18.10)a	352.84c	119.3
T_7-Hand weeding (two) at 20+40 DAS	94.28ab	3979a	19.80a	510.68a	217.4
T_8-Gramoxone (paraquat) 0.48 kg ai/ha	97.25a	2417bc	17.35ab	413.36b	156.9
T_9 control	68.95c	2038c	8.95d	160.89f	(-)
	(-)	(-)	(-)		
L.S.D. (0.05)	7.76	503.20	1.54	26.71	

DAS = Days after sowing; [1]Any two means not sharing a letter in common different significantly at 5% level of probability.

96%, while sorgaab sprays (1-3) inhibited total weed dry weight by 32-40%. The suppression of weed dry weight with sorghum was reported by Cheema and Ahmad (1992).

Dry weight of horse purslane was significantly suppressed in all the treatments (Table II). Maximum

Table IV. Economic analysis

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	Remarks
Seed cotton yield	189	256	198	272	247	353	511	413	161	kg ha^{-1}
10% less to bring at farmers level	18.9	25.6	19.8	27.2	24.7	35.3	51.1	41.3	16.1	kg ha^{-1}
Adjusted value	170.1	230.4	178.2	244.8	222.3	317.7	459.9	371.7	144.9	kg ha^{-1}
Gross income	1871.10	2534.40	1960.20	2292.80	2445.30	3494.70	5058.90	4088.70	1593.90	@ 1100/100 kgs
Cost of hand weeding	-	-	-	-	-	-	1600	-	-	10 men/day/ha @ Rs80/man
Cost of herbicide	-	-	-	-	-	-	-	1032	-	Gramoxone (paraquat) @ Rs 430 Rs/L
Cost of sorgaab	30	60	90	-	-	-	-	-	-	Rs 10/40 kg sorghum + sorgaab preparation
Cost of spraying	80	160	240	-	-	-	-	-	-	Rs. 80/man 1 man/day/ha
Sprayer rent	50	100	150	-	-	-	-	-	-	Rs 50/spray
Cost of mulching	-	-	-	875	1750	2625	-	-	-	Rs. 10/40 kg
Cost of mulchi application	-	-	-	320	320	32	-	-	-	4 men/h Rs. 80/man
Cost that vary	160	320	480	1195	2070	2945	1600	1032	-	Rs.
Net benefit	1711.1	2214.4	1480.2	1497.8	375.3	549.7	3458.9	3056.7	1593.90	Rs/ha

T_1-Sorgaab(1/10) one spray at 20 DAS; T_2-Sorgaab (1/10) two sprays at 20+40 DAS; T_3-Sorgaab (1/10) three sprays at 20+40+60 DAS; T_4-Sorghum mulch @ 3.50 t ha^{-1}; T_5-Sorghum mulch @ 7.00 t ha^{-1}; T_6-Sorghum mulch @ 10.50 t ha^{-1}; T_7-Hand weeding (two) at 20+40 DAS; T_8-Gramoxone (paraquat) 0.48 kg ai/ha; T_9 control

suppression (98%) in dry weight was recorded in two hand weedings and it was *at par* with herbicidal application. Sorghum mulch treatments suppressed the dry weight in the range of 40-53% against control. While sorgaab sprays suppressed ranging from 28-40%. These results are in line with the findings of Ahmad (1998) who indicated suppression of horse purslane with sorghum allelo-chemicals. Maximum reduction in dry weight of field bind weed was found in sorghum mulch @ 10.5 t ha^{-1} and was *at par* with sorgaab one or two sprays, two hand weedings and herbicidal treatment. The effect of sorghum allelochemicals on field bind weed was also given by Cheema and Ahmad (1992) and Ahmad *et al*. (1994).

Two hand weedings appeared more suppressive in reducing dry weight of bermuda grass (92%) and was significantly different from other weed control treatments (Table II). It is apparent from the results that sorghum mulch treatments were comparatively more suppressive in dry matter reduction than sorgaab foliar sprays. Similar findings were also given by Khaliq *et al*. (1999). Dry weight of purple nutsedge was significantly reduced by all the weed control treatments as compared to control, maximum suppression (80%) was observed in sorgaab single foliar spray against control and was *at par* statistically with sorghum mulch @ 7.0 t ha^{-1}. Cheema and Ahmad (1992) and Khaliq *et al.* (1999) who stated that sorghum allelochemicals have suppressive effect on weeds reported similar effect of sorghum allelopathy on this weed.

Table V. Marginal analysis

Treatment	Doses	Cost that vary RS/ha	Net benefit Rs/ha	Marginal rate of return (%)
T_9-Control	-	0	1593.9	0
T_1-Sorgaab spray at 20 DAS	One	160	1711.1	73.25
T_2-Sorgaab sprays at 20+40 DAS	Two	320	2214.4	314.56
T_3-Sorgaab sprays at 20+40+60 DAS	Three	480	1480.2	D
T_8-Graoxone (Paraquat)	@ 0.48 kg ai/ha	1032	3056.7	118.30
T_4-Sorghum mulch	@3.5 t ha^{-1}	1195	1497.8	D
T_7-Hand weeding	Two	1600	3458.9	70.81
T_5-Sorghum mulch	@ 7.00 t ha^{-1}	2070	375.3	D
T_6 Sorghum mulch	@ 1050 t ha^{-1}	2945	549.70	D

D = Dominaned due to less net benefits than the proceeding treatment; MRR = MRR was calculated by dividing the marginal net benefit (change in net benefits) by the marginal cost (change in cost) and expressed as percentage; Variable cost = The costs (ha^{-1}) of purchased inputs, labor, and machinery that vary between experimental treatments.

The seed cotton yield was significantly increased in all the weed control treatments (Table III) over control. Hand weeding treatment (two) showed maximum increase (217%) and was followed by paraquat directed post emergence @ 0.48 kg ai ha^{-1}. Sorghum mulch @ 10.50 t ha^{-1} appeared also a good treatment with 119% increase in yield. Two foliar sorgaab sprays at 20+40 DAS improved the yield by 59%, while three sorgaab sprays at 20+40+60 DAS increased the yield by 23%. Probably three sprays of sorgaab did not improve number of bolls per plant.

Height of cotton plants (Table III) was significantly

affected by various weed control treatments over control. Taller plants were observed in herbicidal treatment and was followed by hand weeding. Sorghum mulch @ 7.0 t ha^{-1} increased the height of plant by 37% which was not significantly different from sorghum mulch @ 10.50 t ha^{-1} (35%) and sorgaab two sprays (34%). Leaf area was significantly more (95%) in hand weedings (two) as compared to all other treatments. Two foliar sprays increased leaf area by 39%. Maximum number of bolls were recorded in hand weedings and was *at par* with sorghum mulch @ 10.50 t ha^{-1} and herbicide paraquat directed post emergence. Sorgaab (two sprays) was the next better treatment. The impact of sorgaab and sorghum mulch on growth parameters was also reported by Cheema *et al*. (1990), Ahmad *et al*. (1994) and Khaliq *et al*. (1999).

Economic analysis (Table IV) revealed that hand weedings (two) at 20+40 DAS gave the highest net benefits and was followed by paraquat @ 0.48 kg ai ha^{-1}. While marginal analysis (Table V) showed that two foliar sprays of sorgaab were better in terms of maximum (314%) marginal rate of return and was followed by paraquat, directed post emergence. While sorghum mulch was uneconomical due to higher cost.

CONCLUSIONS

The results of this study indicate that sorgaab two foliar sprays at 20+40 DAS could be a useful practice but at existing prices and labour wages two hand weedings and directed post emergence application of paraquat @ 0.48 kg ai ha^{-1} was more economical

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