INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2002/04–4–549–552
http://www.ijab.org

Evaluation of Concentrated Sorgaab Alone and in Combination with Reduced Rates of three Pre-Emergence Herbicides for Weed Control in Cotton (*Gossypium hirsutum* L.)

ZAHID ATA CHEEMA, ABDUL KHALIQ AND MUHAMMAD TARIQ
Department of Agronomy, University of Agriculture, Faisalabad–38040, Pakistan

ABSTRACT

Concentrated sorgaab alone and in combination with reduced doses of three pre-emergence herbicides was evaluated in a field trial for weed control in cotton (*Gossypium hirsutum* L.) during *Kharif* 2000. Results revealed that concentrated sorgaab @ 12 L ha^{-1} + Pendimethalin @ 0.5 kg a.i. ha^{-1} at sowing reduced the *Trianthema portulacastrum* density by 72% and biomass by 76%. Three sprays of concentrated sorgaab @ 12 L ha^{-1} at 15, 30 and 45 days after sowing (DAS) decreased the total weed density by 47% and dry weight by 29% over control. The yield of cotton was significantly enhanced (72.2%) with the application of concentrated sorgaab @ 12 L ha^{-1} + Pendimethalin @ 0.5 kg. S-metolachlor @ 1.0 kg a.i. ha^{-1} improved the seed cotton yield by 70.0% over control. Three sprays of concentrated sorgaab at 15, 30 and 45 DAS increased seed cotton yield by 45.5% over control. Economic and marginal analyses revealed that three sprays of concentrated sorgaab (15, 30 and 45 DAS) was more economical as compared to other treatments due to higher marginal rate of return and relatively lower application cost.

Key Words: *Gossypium hirsutum* L.; Weed control; Allelopathy; Yield; Economics

INTRODUCTION

Allelopathy is intensively under investigation as an alternative weed control technique in different crops in Pakistan. Crop plants like sorghum, sunflower and rice are strongly Allelochemicals are highly water soluble which inhibit germination and growth of different weeds. Ahmad *et al*. (2000) reported that foliar spraying of sorghum water extract (sorgaab) reduced the total weed density by 34-57% and total weed biomass by 13-54% and increased the yield of maize by 33-37%. Spraying of sorgaab and sorghum mulch incorporation in cotton suppressed total weed biomass by 13-54% and 23-62% and total weed biomass by 40% and 56% respectively (Cheema *et al.*, 2000).

Weed infestation is one of the main reasons for lowering cotton yield. Uncontrolled weeds reduced the yield of cotton crop by 16-53% (Ramzan *et al.*, 1989). Weeds in cotton crop are controlled by hand weeding or chemical herbicides. Hand weeding is expensive while the potential for undesirable environmental contamination from chemical herbicides is high. The herbicide use could be reduced by combining the allelopathic water extracts with lower doses of herbicides (Einhelling, 1996). The study was initiated with the objectives to search for environmentally safe and economically viable weed control strategies. For this purpose performance of concentrated sorgaab alone and in combination with lower doses of some per-emergence herbicides for weed control in cotton was investigated under Faisalabad conditions.

MATERIALS AND METHODS

A field study was conducted at agronomic research area, University of Agriculture, Faisalabad during Kharif 2000. The experiment was laid out in randomized complete block design (RCBD) with four replications and with net plot size of 8 X 2.4 m. Cotton cv. FH-900 was was sown on sandy loam soil with single row hand drill using seed rate of 20 kg ha^{-1}. Sorgaab (sorghum water extract) was prepared by following the procedure devised by following the procedure devised by Cheema (1998) and was concentrated to 25 times by boiling at 100°C. Treatments used in experiment were, one spray of concentrated sorgaab @12 L ha^{-1} at sowing, one spray of concentrated sorgaab @ 12 L ha^{-1} at 15 DAS, two sprays of concentrated sorgaab @ 12 L ha^{-1} at 15 and 30 DAS, three sprays of concentrated @ 12 L ha^{-1} at 15, 30 and 45 DAS, one spray of concentrated sorgaab @ 12 L ha^{-1} + pendimethalin @ 0.5 kg a.i. ha^{-1} at sowing, one spray of concentrated sorgaab @ 12 L ha^{-1} + S^{-} metolachlor @ 1.0 kg a.i. ha^{-1} at sowing and one spray of concentrated sorgaab @ 12 L ha^{-1} + trifluralin @ 0.5 kg a.i. ha^{-1} at sowing. The volume of spray was 300 L ha^{-1}. A knap sack hand sprayer fitted with flat fan nozzle was used for spraying.

Purple nutsedge (*Cyperus rotundus*) and horse purslane (*Trianthema portulacastrum*) were the predominant weeds present at the experimental site. Total and individual weed density was recorded four times i.e. 14, 29, 44 and 59 DAS from randomly selected two quadrates

0.5 m^2 from each plot. Weed biomass was taken twice at 38 DAS and 68 DAS and for determining individual fresh weight weeds were harvested at ground level from two quadrates (0.5 $m^{2)}$ from each plot. The weeds were dried in an oven at 70°C for 48 hours to record dry weight. Data on various growth parameters of cotton crop as plant height, leaf area index and number of bolls per plant were recorded from randomly selected five plants in each plot. Seed cotton was picked manually from net plot and then converted into kg ha^{-1}. The data collected were analyzed statistically using Fisher's analysis of variance technique and least significant difference test was applied to compare the treatment means (Steel & Torrie, 1984). Economic and marginal analysis was performed by following he procedure devised by Byerlee (1988).

RESULTS AND DISCUSSION

Reduction in total weed density was greatest (52%) in case of concentrated sorgaab @ 12 L ha^{-1} with S-metolachlor @ 1.0 kg a.i. ha^{-1} and was followed by three sprays of concentrated sorgaab @ 12 L ha^{-1} at 15, 30, and 45 DAS with 47.2% reduction in total weed density (Table I). Similar findings were also reported by Bhatti *et al.* (2000) and Ahmad *et al.* (2000) In case of individual weed species, maximum reduction in density (52.3%) of *Cyperus rotundus* was observed, where concentrated sorgaab @ 12 L ha^{-1} +S-metolachlor @ 1.0 kg a.i. ha^{-1} was applied, which was statistically on par with three sprays of concentrated sorgaab (15, 30 and 45 DAS) where reduction in density was 47% (Table I). The inhibition of *Cyperus rotundus* density was reported by Cheema *et al.* (2000) and Bhatti *et al.* (2000). Application of concentrated sorgaab @ 12 L ha^{-1} + pendimethalin @ 0.5 kg a.i. ha^{-1} reduced the density of *Trianthema portulacastrum* by 72.0% over control and was followed by one spray of concentrated sorgaab @ 12 L ha^{-1} + S-metolachlor @ 1.0 kg a.i ha^{-1} reducing the density by 52%. This was statistically on par with three sprays of concentrated sorgaab (at 15, 30, 45 DAS) with 46% reduction in *Trianthema portulacastrum* density over control. This is significant reduction in *Trianthema portulacastrum* density which shows effectiveness of allelochemicals against this weed. These results support the work of Cheema (1998) and Kim *et al.* (1993) who stated that suppression in weeds was probably due to presence of allelochemicals in sorghum water extract.

The total weed dry weight was reduced by 50% in combined spray of concentrated sorgaab @ 12 L ha^{-1} and pendimethalin @ 0.5 kg a.i. ha^{-1} (Table-II) and was followed by concentrated sorgaab @ 12 L ha^{-1} + S-metolachlor and three sprays of concentrated sorgaab (15, 30 and 45 DAS) which reduced the total weed dry weight by 30.0 and 29.0% respectively. These findings support the work done by Khaliq *et al.* (1999) and Bahatti *et al.* (2000) who reported that total dry weight was less in sorghum water application. Dry weight of *Cyperus rotundus* was significantly suppressed in most of the treatments (Table II). Maximum suppression (49.4%) of *Cyperus rotundus* dry

Table I. Effect of concentrated sorgaab alone and in combination with pre-emergence herbicides on weed density (0.5 m^2) at 59 DAS

Treatments	*C. rotundus*	*T. portulacastrum*	Total
T_1 Control (weedy Check)	95.1 a^{2} (-)[3]	5.0 a (-)	100.1 a (-)
T_2=conc., sorgaab @ 12Lha $^{-1}$ sowing	71.3 c (25.0)	4.2b (6.0)	75.5c (24.6)
T_3 =conc. sorgaab @ 12Lha^{-1} 15 DAS^{-1}	74.1 c (22.0)	4.0 b (20.0)	78.1 c (22.0)
T4 =conc. sorgaab @ 12Lha^{-1} 15+30 DAS	69.9 c (26.5)	4.0 c (20.0)	73.9 c (26.2)
T_5 =conc., sorgaab @ 12Lha^{-1} 15+30+45 DAS	50.3 d (47.1)	2.6 c (48.0)	52.9 d (13.0)
T_6 =conc., sorgaab @ 12Lha^{-1} + pendimethalin (Stomp 330 EC) @ 0.5 kg a.i.ha^{-1} at sowing	85.1 b (10.5)	1.4 d (72.0)	86.5 b (13.0)
T_7 = conc., sorgaab @ 12Lha^{-1} + S-metolachlor (Dual Gold 960 EC) @ 1.0 kg a.i. ha^{-1} at sowing	45.4 d (52.3)	2.4 c (52.0)	47.8 d (52.0)
T_8 = conc., sorgaab @ 12Lha^{-1} + trifluralin (Treflan 4EC) @ 0.5 kg a.i.ha^{-1} at sowing	75.3 c (20.8)	2.7 c (46.0)	47.0 c (22.0)
LDS	***5.8***	***0.4***	***4.1***

Table II. Effect of concentrated sorgaab alone and in combination with pre-emergence herbicides on weed density (g/0.5 m^2) at 68 DAS

Treatments	*C. rotundus*	*T. portulacastrum*	Total
T_1 Control (weedy Check)	16.4 a^{2} (-)[3]	30.8 a (-)	47.2 a (-)
T_2=conc., sorgaab @ 12 Lha^{-1} sowing	16.1 c (1.8)	33.6a (+9.0)	49.7a (+5.3)
T_3 =conc. sorgaab @ 12 Lha^{-1} 15 DAS^{-1}	15.5 ab (5.5)	33.2 a (+7.8)	48.7 a (+3.2)
T4 =conc. sorgaab @ 12 Lha^{-1} 15+30 DAS	14.2 b (13.4)	28.3 bc (-8.1)	42.5 b (-10.0)
T_5 =conc., sorgaab @ 12 Lha^{-1} 15+30+45 DAS	9.6 c (41.5)	23.9 d (-22.6)	33.5 c (-29.0)
T_6 =conc., sorgaab @ 12 Lha^{-1} + pendimethalin (Stomp 330 EC) @ 0.5 kg a.i.ha^{-1} at sowing	16.2 a (1.2)	7.5 e (-76.0)	23.7 d (-50.0)
T_7 = conc., sorgaab @ 12 Lha^{-1} + S-metolachlor (Dual Gold 960 EC) @ 1.0 kg a.i. ha^{-1} at sowing	8.3 c (49.4)	24.8 cd (-19.5)	33.1c (-30.0)
T_8 = conc., sorgaab @ 12 Lha^{-1} + trifluralin (Treflan 4EC) @ 0.5 kg a.i.ha^{-1} at sowing	14.0 b (14.6)	25.7 cd (-16.5)	39.7 b (-15.0)
LDS	1.8	3.5	9.5

[1]Days after sowing; [2.] Any two means not sharing a letter in common differ significantly at 5% level of probability. [3]. Figures given in parenthesis show % decrease over control

Table III. Effect of concentrated sorgaab alone and in combination with pre emergence herbicides on growth and yield of cotton

Treatments	Plant height (cm)	LAI	Number of bolls per plant	Seed cotton yield (kg ha^{-1})
T_1 Control (weedy Check)	100.2d[2]	1.2 f	18.9 e	1299.1 e
T_2=conc., sorgaab @ 12Lha $^{-1}$ sowing	101.6 d	1.8 e	20.9 d	1317.2 e (1.4)
T_3 =conc. sorgaab @ 12Lha^{-1} 15 DAS[1]	115.8 bc	1.9 d	21.9 d	14.66.7 d
T4 =conc. sorgaab @ 12Lha^{-1} 15+30 DAS	115.5 c	1.8 de	21.5 d	1540.4 d (18.6)
T_5 =conc., sorgaab @ 12Lha^{-1} 15+30+45 DAS	116.7 bc	2.3 c	24.1 c	2006.8 b (54.5)
T_6 =conc., sorgaab @ 12Lha^{-1} + pendimethalin (Stomp 330 EC) @ 0.5 kg a.i.ha^{-1} at sowing	124.0 a	2.8 a	29.8 a	2236.4 a (72.2)
T_7 = conc., sorgaab @ 12Lha^{-1} + S-metolachlor (Dual Gold 960 EC) @ 1.0 kg a.i. ha^{-1} at sowing	124.2 a	2.5 b	29.5 a	22.7.8 a (70.0)
T_8 = conc., sorgaab @ 12Lha^{-1} + trifluralin (Treflan 4EC) @ 0.5 kg a.i.ha^{-1} at sowing	119.9 ab	2.3 c	27.0 b	1831.2 c (41.0)
LDS	4.4	0.1	1.5	108.5

[1]Days after sowing; [2]Any two means not sharing a letter in common differ significantly at 5% level of probability. 3. Figures given in parenthesis show % decrease over control

weight was obtained in plots having spray of concentrated sorgaab @ 12 L ha^{-1} with S-metolachlor @ 1.0 kg a.i. ha^{-1} and was statistically on par with three sprays of concentrated sorgaab @ 12 L ha^{-1} the reduction of dry weight of *Cyperus rotundus* was 41.5% over control (Table II). Similar findings were reported by Cheema (1998) and Ahmad *et al.* (2000). Application of concentrated sorgaab @ 12 L ha^{-1} + pendimethalin @ 0.5 kg a.i. ha $^{-1}$ resulted in maximum suppression (76.0%) of Trianthema portulacastrum dry weight over control (Table II). Among the concentrated sorgaab sprays, three sprays of concentrated sorgaab @ 12 L ha^{-1} gave a considerable (22.6%) reduction in the dry weight of *Trianthema portulacastrum*. These results are in line with the findings of Cheema *et al.* (2000) and Ahmad *et al.* (2000), who reported that suppression in dry weight was due to presence of allelochemicals in sorghum herbage.

Plant height of cotton was significantly affected by all the treatments expect T_2 (concentrated sorgaab spray at sowing). Tallest plants (124.2 cm) were recorded where

Table IV: Economic analysis

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	Remarks
Seed cotton yield	1299.13	1317.18	1466.18	1540.36	2006.76	2236.41	220.7.24	1831.24	kg ha^{-1}
10 % Less	1169.22	1185.47	1320.23	1386.32	1806.08	2012.77	1987.02	1648.12	kg ha^{-1}
Gross income	26307.45	26673.08	29705.18	31192.20	40636.80	45287.32	44707.95	37082.70	@ Rs.22.5/Kg
Cost of herbicides Per ha						682	572	475	Stomp @ Rs.450/L Dual Gold @ Rs. 550/L
Cost of conc. sorgaab	-	30	30	60	90	30	30	30	Rs.10/40 kg sorghum + conc. sorgaab
Cost of spraying	-	80	80	160	240	80	80	80	Rs.80/manha^{-1}
Sprayer rent	-	50	50	100	150	50	50	50	Rs.50/Spray
Cost that vary	-	160	160	320	480	842	732	635	Rs.ha^{-1}
Net benefits	26307.45	26513.08	29545.18	30872.2	40156.8	44445.32	43975.95	36450.7	

T_1 Control (weedy Check), T_2=conc., sorgaab @ 12Lha $^{-1}$ sowing, T_3 =conc. sorgaab @ 12Lha^{-1} 15 DAS$^{-1,}$ T4 =conc. sorgaab @ 12Lha^{-1} 15+30 DAS, T_5 =conc., sorgaab @ 12Lha^{-1} 15+30+45 DAS, T_6 =conc., sorgaab @ 12Lha^{-1} + pendimethalin (Stomp 330 EC) @ 0.5 Kg a.i.ha^{-1} at sowing, T_7 = conc., sorgaab @ 12Lha^{-1} + S-metolachlor (Dual Gold 960 EC) @ 1.0Kg a.i. ha^{-1} at sowing, T_8 = conc., sorgaab @ 12Lha^{-1} + trifluralin (Treflan 4EC) @ 0.5 kg a.i.ha^{-1} at sowing

Table V. Marginal analysis

Treatments	Cost that vary (Rs.ha^{-1})	Net benefit (Rs.ha^{-1})	MRR (%)
T_1 Control (weedy Check)	0	26307.45	0
T_2=conc., sorgaab @ 12Lha $^{-1}$ sowing	160	26513.08	128.5
T_3 =conc. sorgaab @ 12Lha^{-1} 15 DAS^{-1}	160	29545.18	2023.58
T4 =conc. sorgaab @ 12Lha^{-1} 15+30 DAS	320	30872.2	829.38
T_5 =conc., sorgaab @ 12Lha^{-1} 15+30+45 DAS	480	40156.8	5802.87
T_6 =conc., sorgaab @ 12Lha^{-1} + pendimethalin (Stomp 330 EC) @ 0.5 Kg a.i.ha^{-1} at sowing	842	44445.32	426.70
T_7 = conc., sorgaab @ 12Lha^{-1} + S-metolachlor (Dual Gold 960 EC) @ 1.0Kg a.i. ha^{-1} at sowing	732	43975.95	1515.53
T_8 = conc., sorgaab @ 12Lha^{-1} + trifluralin (Treflan 4EC) @ 0.5 Kg a.i.ha^{-1} at sowing	635	36447.7	D
LDS			

D= Dominated due to less benefits than preceding treatments; MRR= MRR was calculated as dividing the change in the benefits by change n cost land expr3essed as percentage; Variable cost is the cost of purchased inputs. Labor and machinery ha^{-1} that vary between the experimental treatments; Net Benefit = Gross income – variable cost

concentrated sorgaab @ 12 Lha^{-1} + S-metolachlor @ 1.0 kg a.i. ha^{-1} was applied at sowing (Table III). This was statistically on par with T_7 and T_8. This increase in plant height of cotton was possibly due to suppression of weeds in these plots. Similar findings were obtained by Ahmad *et al.* (2000) who reported that plant height was significantly influenced by application of sorgaab. All the treatments significantly influenced the leaf area index (Table III). Maximum LAI (2.8) was found in plots where concentrated sorgaab @ 12 L ha^{-1} + pendimethalin @ 0.5 kg a.i. ha^{-1} was applied at sowing and was followed by the application of concentrated sorgaab @ 12 L ha^{-1} + S-metolachlor @1.0 kg a.i. ha^{-1} with LAI value of 2.5. Maximum leaf area index was possible due to better suppression of *Trianthema portulacastrum* population and biomass. The results support the work of Khaliq *et al.* (1999) who reported that leaf area index increase was probably due to less crop weed competition. All the treatments significantly improved the number of bolls per plant as compared to control (Table III). Maximum number of bolls per plant (29.9) were recorded in plots where concentrated sorgaab @ 12 L ha^{-1} + S-metolachlor @ 1.0 kg a.i ha^{-1} was applied at sowing and was statistically on par with application of concentrated sorgaab @ 12 L ha^{-1} + pendimethalin @ 0.5 kg a.i ha^{-1} . Increase on number of bolls plant was probably due to inhibition of weeds which facilitated better nutrient availability for cotton plants. These results support the previous find9ngs reported by Cheema *et al*. (2000) who stated that sorgaab, sorghum mulch and herbicides significantly influenced the number of bolls per plant. Seed cotton yield was significantly improved (72%) in case of concentrated sorgaab @ 12 L ha^{-1} + pendimethalin @ 0.5 kg a.i ha^{-1} (Table III) and was statistically on par with application of concentrated sorgaab @ 12 L ha^{-1} + S-metolachlor @ 1.0 kg a.i. ha^{-1} with 70% increase over control. Three sprays of concentrated sorgaab at 15, 30 and 45 DAS increased the seed cotton yield by 54.5% Concentrated sorgaab with combination of reduced rates of pre-emergence herbicides significantly suppressed weed population which increased seed cotton yield. These results are in conformity with those of Cheema *et al.* (2000) who reported that allelochemicals were present in sorghum herbage, which were non toxic to cotton land seed cotton yield was increased.

Economic and marginal analyses revealed that maximum net benefits were obtained in T_6 (Table IV) with 426.7% marginal rate of return (Table V) while three sprays of concentrated sorgaab at 15,30 and DAS was the most economical weed control practice in cotton with maximum (5802.9%) marginal rate of return and relatively lower application cost.

The study concluded that three sprays of concentrated sorgaab at 15, 30 and 45 DAS was effective against weeds of cotton and the combination of concentrated sorgaab with reduced (less than half) doses of pre-emergence herbicides i.e. pendimethalin @ 0.5 kg a.i ha^{-1} and S-metolachlor @ 1.0 kg a.i ha^{-1} was quite useful weed control practice in cotton. Studies of this nature with different combination of sorgaab and herbicides may be continued for developing a sound weed control strategy for cotton, having more reliance on allelochemicals than herbicides.

REFERENCES

Ahmad, A., Z.A. Cheema and R. Ahamd, 2000. Evaluation of sorgaab as natural weed inhibitor in maize. *JAPS*, 10 :141–6.

Bhatti, M.Q.L., Z.A. Cheema and T. Mahmood, 2000. Efficacy of sorgaab as natural weed inhibitor in raya. *Pakistan J. Biol. Sci*., 3: 1128–30.

Byerlee, D., 1988. From agronomic data to farmers recommendations. An Economics Training Manual. *CIMMYT*. Mexico. Pp: 31–3.

Cheema, Z.A., 1998. Sorghum allelopathy: Anew weed control technology for enhancing wheat productivity. *JAPS*, 8:19–21.

Cheema, Z.A., H.M.I. Sadiq and A. Khaliq, 2000. Efficacy of sorgaab (Sorghum water extract as a natural weed inhibitor in wheat. *Int. J. Agri. Biol.*, 2: 144–6.

Cheema, Z.A., M. Asim and A. Khaliq, 2000. Sorghum allelopathy for weed control in cotton (*Gossypium arboreum* L.). *Int. J. Agri. Biol.*, 2: 37–41.

Einhelling, F.A., 1996. Interaction involving allelopathy in cropping systems. *Agron. J.*, 88: 886–93.

Khaliq, A., Z.A. Cheema, M.A. Mukahtar and S.M.A. Basra, 1999. Evaluation of sorghum (*Sorghum bicolor*) water extract for weed control in soyabean. *Int. J. Agric. Biol.*, 1: 23–6.

Kim, S.Y., S.K. Datta, R.P. Robles, K.U. Kim, S.C. Lee and D.H. Shin, 1993. Allelopathic effect of sorghum extract and residues on selected crops and weeds. *Korean J. Weed Sci*., 14: 34–41 (*Field Crop Absts*., 48: 6673; 1995).

Ramzan, M., M. Saleem and M.L. Shah, 1989. Kapas Ki jaribootian aur oon Ka tadarak. *Zarat Nama*, Dir. Agric., Govt. of Punjab, Lahore.

Steel, R.G.D. and J.H. Torrie, 1984. *Principles and Procedures of Statistics.* pp: 172–7. McGraw Hill Book Co., Inc. Tokyo.

(Received 10 August 2002; Accepted 13 September 2002)