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PURPLE NUTSEDGE (*CYPERUS ROTUNDUS* L.) MANAGEMENT IN COTTON WITH COMBINED APPLICATION OF SORGAAB AND S-METOLACHLOR

JAVAID IQBAL AND ZAHID A. CHEEMA*

College of Agriculture, Dera Ghazi Khan and
Weed Science and Allelopathy Lab., Department of Agronomy,
University of Agriculture, Faisalabad 38040, Pakistan.

Abstract

Allelopathy can be employed effectively for weed management in different ways; one such aspect may be its utilization for reducing the use of synthetic herbicides. Considering its importance as a natural weed control approach, a study comprising two doses of sorgaab (*Sorghum bicolor* L. water extract) 12 and 15 L ha^{-1} combined with lower doses i.e. ½ and $1/3^{rd}$ (1075, 717 g a.i. ha^{-1}) of synthetic herbicide (S. metolachlor) as pre-emergence spray against purple nutsedge was undertaken in cotton (*Gossypium hirsutum* L.) under irrigated conditions in central Punjab, Pakistan. Label dose of S. metolachlor (2.15 kg a.i. ha^{-1}) and untreated treatment were maintained as control. The results of two years field trials revealed that 62-92% purple nutsedge control was achieved from sorgaab application in combination with reduced doses of herbicide. Similarly purple nutsedge dry weight was reduced by 75-88% than untreated control indicating that sorgaab with lower S. metolachlor doses was quite effective in suppressing purple nutsedge.

Introduction

Allelopathy is a natural phenomenon and may be employed as an alternative weed control technique. It is environmentally safe, can conserve the available resources and also may mitigate the problems raised by synthetic chemicals (Rizvi & Rizvi, 1992; Duke *et al*., 2001). Sorghum (*Sorghum bicolor* L.) is the one of most promising allelopathic crops (Alsaadawi, 2007) and contains a number of allelochemicals of which fourteen have been reported by Mahmood (2003). These chemicals are highly water soluble, can be released through root exudation, leaching from plants by rain, or decomposition of residues (Rice, 1984). The effects of these allelochemicals depend upon species; concentration (Cheema & Ahmad, 1992), their movement, fate and persistence in soil (Inderjit, 2001). These are also selective like synthetic herbicides (Weston, 1996).

Allelopathic crops may be used in different ways to suppress weeds such as surface mulch (Cheema *et al*., 2000), incorporation into the soil (Ahmad *et al*., 1995; Sati *et al*., 2004), aqueous extracts (Cheema *et al*., 2002; Iqbal & Cheema, 2007a; Javaid & Anjum, 2006), rotation (Narwal, 2000), smothering (Narwal & Sarmah, 1996; Singh *et al*. 2003) or mix cropping or intercropping (Kondap *et al*., 1990; Hatcher & Melander, 2003; Iqbal & Cheema, 2007b). In Sorgaab (sorghum cv. JS-263 water extract) seven allelochemicals (gallic acid, protocateuic acid, syringic acid, vanillic acid, p-hydroxybenzoic acid, p-coumaric acid, and benzoic acid were identified (unpublished data). Parveen (2000) found caffeic, ferulic, chlorogenic, syringic and vanillic acid from sorghum plant (leaf and stem) water extracts through thin layer chromatographic technique. Dhurrin (Nielsen *et al*., 2008) and *p*-hydroxybenzaldehyde (Haskins & Gorz, 1985) are other important allelochemicals reported in sorghum plant.

*Corresponding author: E-mail: cheemaza@yahoo.com

Pakistan is, by and large, a mono-crop economy as cotton contributes nearly 7.5% of value added in agriculture and about 1.6% to GDP and a significant source of foreign exchange earnings (Anon., 2008). In the recent years, for controlling cotton pests the use of synthetic pesticides has made it much expensive crop. Among the pests, weeds inflict heavy losses in cotton yield (13-41 %). The indirect adverse effects of weeds on cotton crop due to enhanced disease and insect pest problems are significantly higher than any other crop grown in the country. Purple nutsedge (*Cyperus rotundus* L.) is considered one of the worst weeds of the world, widely distributed through out the tropics and subtropics in 52 different crops and in 92 countries (Rao, 2000) and is very common throughout South East Asia (Merita & Moody, 1999; Rajput *et al*., 2008). In Pakistan it is among the most common weeds found throughout the Indus valley during summer season in major field crops such as cotton, sugarcane and maize. Purple nutsedge is highly competitive and causes seed cotton yield reduction by 62-85% as compared with no purple nutsedge control treatments (Bryson *et al*., 2003). It can harbor cotton pests and diseases, reduce irrigation efficiency (Rao, 2000). Usual weed control methods; manual or mechanical, kill only the top growth with little effect on tubers. Very few selective herbicides for purple nutsedge are available. Further more, chemical weed control involves safety risks and may enhance environmental pollution. The continuous use of herbicides may cause weed shift problem and weed resistance to herbicides (Zhang, 2003). Dinitroanaline herbicides as pendimethalin and trifluralin are available in Pakistan and are being used by cotton growers for controlling *Trianthema portulacastrum*. This group of herbicides is ineffective against *Cyperus rotundus* while S-metolachlor (Dual Gold 960 EC) is suggested to be effective in controlling all major weeds of cotton (Tanveer *et al*., 2003) including purple nutsedge (Cheema *et al.*, 2005b; Jarwar & Baloch, 2005). Sorghum allelochemicals have been reported to have phytotoxic effect on purple nutsedge (Mahmood & Cheema, 2003).

The organic chemical compounds having herbicidal properties may be combined with allelopathic water extracts at lower doses (Cheema *et al*., 2005a; Iqbal & Cheema, 2007a). This, on one side, may improve the efficacy of allelopathic extracts and may provide the opportunities of reducing the herbicidal doses on other. Hence the cost of weed control could be lowered, promoting sustainable environmental safety (Hussain *et al.*, 2007).

Therefore, it was contemplated in the present studies to evaluate the possibility of using allelopathic sorgaab in combination with lower (one half and one third of label dose) S.metolachlor doses for getting effective purple nutsedge control in cotton.

Materials and Methods

A two-year (2003-2004) field investigation for controlling purple nutsedge in cotton was undertaken at Research farm, Department of Agronomy, University of Agriculture, Faisalabad, Punjab, Pakistan under irrigated conditions. The soil belongs to the Lyallpur soil series (Aridisol-fine-silty, mixed, hyperthermic Ustalfic, Haplargid in USDA classification and Haplic Yermosols in the FAO classification scheme). Sorgaab was prepared by following the procedure devised by Cheema & Khaliq (2000). Experiment was laid out in Randomized Complete Block Design with 4 replications in plots measuring 7m×3m. Sorgaab @ 12 and 15 L ha^{-1} was sprayed as pre-emergence alone or tank mixed with one half and one third lower doses of S.metolachlor as pre-emergence spray. S. metolachlor @ 2.15 kg a.i. ha^{-1} (label dose) pre-emergence was used as standard treatment and untreated treatment as control. The seedbed was prepared by giving two cultivations and planking the field once. Trial was conducted in a field where previous history showed heavy infestation of purple nutsedge. Cotton cultivar FH901 was sown by single row hand drill in 75 cm spaced rows on moist seedbed. Fertilizer was applied at 115kg N, 57kg P_2O_5 ha^{-1} in the form of urea and triple super phosphate, respectively. Sorgaab and S.metolachlor (Dual Gold 960 EC) were applied in the respective plots with volume of spray 300 Lha^{-1}, using a Knapsack hand sprayer fitted with T-Jet nozzle. All Agronomic operations except those under study were kept normal and uniform for all the treatments. Data on purple nutsedge density and biomass were recorded at 15, 45 and 75 days after sowing (DAS) from two randomly selected quadrates (50×50 cm) from each experimental plot and then averaged. Purple nutsedge dry weight was recorded after drying in an oven at 80°C for 48 h. Data on cotton leaf area index at 60, 90, 120 DAS, cotton plant height, number of bolls per plant, boll weight, and seed cotton yield were recorded for each plot. Data collected was analyzed by Fisher's analysis of variance technique. Least significance difference (LSD) test was applied at 0.05 probability level to compare treatment means (Steel & Torrie, 1984).

Results and Discussions

Density and dry weight of *Cyperus rotundus*: The population of *Cyperus rotundus* was significantly inhibited by all the treatments as compared to control (Table 1). Sorgaab at 12 or 15 L ha^{-1} sprayed as pre-emergence suppressed the population of purple nutsedge by 31 to 56% and 35 to 52% at 15, 45 and 75 DAS respectively. This suppression is due to the allelopathic activity of sorgaab against purple nutsedge. Almost similar effects were recorded on dry weight of this noxious weed (Table 2). These finding are in line with work of Cheema *et al*., (2004) who suggested 67% reduction in dry weight of purple nutsedge with sorgaab. The higher rate of sorgaab has shown no effect which is contradictory to the earlier findings of Iqbal & Cheema, (2007a) who stated that higher rate of allelochemicals was more inhibitory. The effects of sorgaab @ 12 and 15 L ha^{-1} in combination with one half and one third doses of S.metolachlor @ 1075 and 717 g a.i. ha^{-1} were more pronounced and statistically equal to the label rate of S.metolachlor @ 2.15 kg a.i. ha^{-1} during both years of study indicating the possible reduction in herbicide dose by 50-67%. This supports the objectives of initiating present studies and in line with work of Cheema *et al*., (2003) who found 58-71 % inhibition with sorgaab combined with reduced rates of S.metolachlor as compared to control.

Cotton growth: Leaf area index (LAI) of cotton at 60, 90 and 120 DAS (Table 3) was significantly affected as compared to control. LAI at 60 DAS gave similar results among the treatments with label rate of S.metolachlor, ½ and 1/3rd dose of S.metolachlor combined with Sorgaab @ 12 and 15 L ha^{-1}. At 90 DAS maximum LAI was achieved by label rate of S.metolachlor which was statistically at par with ½ dose of herbicide combined with Sorgaab 12 L ha^{-1} followed by 1/3rd dose of herbicide combined with Sorgaab 15 L ha^{-1}. At 120 DAS in the year 2004 same trend was found as at 60 DAS but in the year 2003 1/3rd dose of herbicide combined with 15 L ha^{-1} showed less LAI than label rate and ½ dose of herbicide combined with Sorgaab 15 L ha^{-1}. Sorgaab alone @ 12 and 15 L ha^{-1} showed statistically similar effects but different as compared with control. The decrease in LAI (Fig. 1) after 90 DAS during the year 2004 was due to the less rainfall received during the crop season (23.91mm) as compared to the year 2003 (52.56mm) and there was shortage of at least two irrigations during August and September 2004. Pettigrew, (2004) also reported that moisture deficit affected cotton growth, yield and yield parameters. Increase in LAI of cotton crop was due to the better

Table 1. Effect of sorgaab in combination with reduced S-metolachlor rates on purple nutsedge.

No.	Treatments: Extract/Herbicide (PRE)	Rate	Purple nutsedge control (%) 15 DAS 2003	15 DAS 2004	45 DAS *	75 DAS 2003	75 DAS 2004	Purple nutsedge dry weight reduction (%) 45 DAS *	75 DAS 2003	75 DAS 2004
1.	S-metolachlor	2.15 kg a.i. ha^{-1}	70	72	82	91	79	86	90	83
2.	Sorgaab	12 L ha^{-1}	53	31	41	52	36	34	43	42
3.	Sorgaab	15 L ha^{-1}	44	33	39	51	38	45	47	42
4.	Sorgaab + S-metolachlor	12 L + 1075 g a.i ha^{-1}	69	72	77	92	72	77	88	81
5.	Sorgaab + S-metolachlor	15 L + 717 g a.i ha^{-1}	62	67	73	85	67	75	80	76
6.	Untreated		0	0	0	0	0	0	0	0
LSD $p<0.05$			28	13	16	14	12	6	14	9

DAS= Days after sowing
PRE= Pre-emergence
*= Mean of the two years, as year effect was non-significant

Table 2. Effect of sorgaab in combination with reduced S-metolachlor rates on leaf area index and leaf area duration.

No.	Treatment: Extract/herbicide (PRE)	Rate	Leaf area index 60 DAS *	90 DAS *	120 DAS *	Leaf area duration (days) 60-90 DAS *	90-120 DAS *
1.	S.metolachlor	2.15 kg a.i. ha^{-1}	2.19 a†	4.38 a	4.32 a	98.57 a	229.00 a
2.	Sorgaab	12 L ha^{-1}	1.36 b	3.27 c	3.39 c	69.54 c	169.43 c
3.	Sorgaab	15 L ha^{-1}	1.37 b	3.17 c	3.33c	68.14 c	165.63 c
4.	Sorgaab + S.metolachlor	12 L +1075 g a.i ha^{-1}	2.15 a	4.28 a	4.23 a	96.36 ab	224.00 a
5.	Sorgaab + S.metolachlor	15 L + 717 g a.i ha^{-1}	2.18 a	4.04 b	4.00b	93.24 b	213.83 b
6.	Untreated	-	1.23 b	2.70 d	2.55 d	58.90 d	137.61 d
LSD $p<0.05$			0.185	0.202	0.191	4.98	8.064

DAS= Days after sowing
PRE= Pre-emergence
†=Means not sharing a letter in common differ significantly at $p<0.05$
*= Mean of the two years as year effect was non-significant

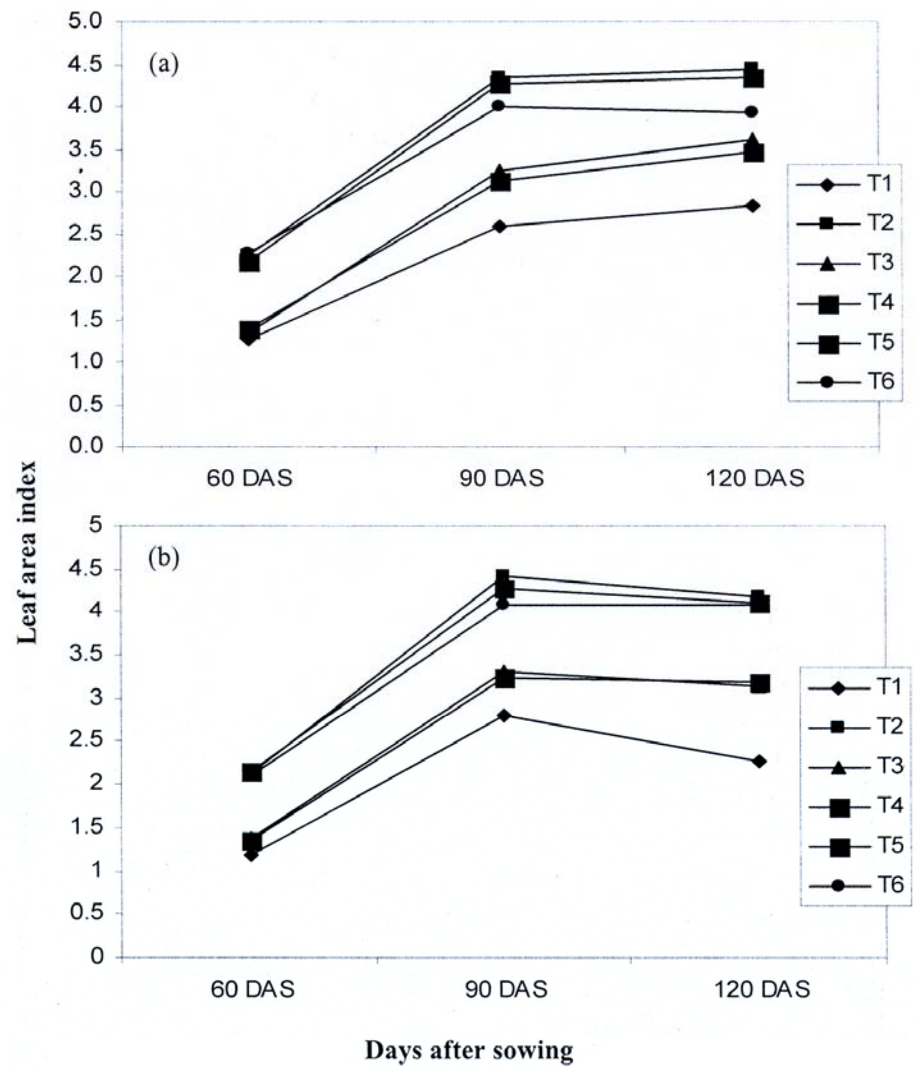

Fig. 1. Leaf area indices at 60, 90 and 120 DAS (a) 2003 (b) 2004

weed control that promoted the cotton plant to utilize the resources in a better way and solar radiation without any interference (Irshad & Cheema 2004). Crop growth rate was less after 90 DAS because of shifting of resources to reproductive growth than vegetative growth. Data on cotton plant height at maturity revealed that all the treatments significantly enhanced the plant height as compared with control (Table 4). Three treatments i.e. label rate of herbicide, ½ dose of herbicide combined with sorgaab 12 L ha^{-1} and $1/3^{rd}$ dose of herbicide combined with sorgaab 15 L ha^{-1} showed statistically similar effects. Boquet *et al.*, (2004) reported that increases in lint yield were associated with increases in plant height.

Table 3. Effect of sorgaab in combination with reduced S-metolachlor rates on cotton growth parameters.

Treatment			Crop growth rate ($gm^{-2}d^{-1}$)		Plant height (cm)	
No.	Extract/herbicide (PRE)	Rate	60-90 DAS	90-120 DAS		
			*	*	2003	2004
1.	S.metolachlor	2.15 kg a.i. ha^{-1}	5.63 a†	3.11	147.85 a	143.35 a
2.	Sorgaab	12 L ha^{-1}	3.68 b	2.71	139.45 b	131.40 b
3.	Sorgaab	15 L ha^{-1}	4.05 b	2.66	138.70 bc	134.70 ab
4.	Sorgaab + S.metolachlor	12 L + 1075 g a.i ha^{-1}	5.94 a	2.69	147.15 a	141.30 a
5.	Sorgaab + S.metolachlor	15 L + 717 g a.i ha^{-1}	4.68 b	2.85	148.25 a	142.60 a
6.	Untreated	-	2.05 c	2.54	131.70 c	125.65 b
LSD $p<0.05$			1.283	1.034	7.016	9.704

DAS= Days after sowing
PRE= Pre-emergence
†=Means not sharing a letter in common differ significantly at $p<0.05$
*= Mean of the two years as year effect was non-significant

Table 4. Effect of sorgaab in combination with reduced S-metolachlor rates on seed cotton yield and its components

Treatment			Sympodial branches ($plant^{-1}$)	Number of bolls ($plant^{-1}$)	Boll weight (g)	Seed index (g)	Ginning out turn (%)	Seed oil contents (%)	Seed cotton yield (kg ha^{-1})
No.	Extract/Herbicide (PRE)	Rate	*	*	*	*	*	*	*
1.	S.metolachlor	2.15 kg a.i. ha^{-1}	25.10 a†	28.68 a	3.92 a	94.33 a	40.03 a	21.04 a	2007 a (33.85)
2.	Sorgaab	12 L ha^{-1}	20.98 b	18.73 b	3.49 b	85.36 b	39.05 abc	19.07 c	1719 b (14.67)
3.	Sorgaab	15 L ha^{-1}	20.73 b	18.45 b	3.53 b	83.79 bc	38.81 bc	19.02 c	1698 b (13.28)
4.	Sorgaab + S.metolachlor	12 L+ 1075 g a.i ha^{-1}	24.08 a	27.50 a	3.98 a	91.29 a	39.96 a	20.46 b	1973 a (31.57)
5.	Sorgaab + S.metolachlor	15 L + 717 g a.i ha^{-1}	23.45 a	27.33 a	3.82 a	91.86 a	39.62 ab	20.48 b	1925 a (28.40)
6.	Untreated	-	19.10 b	15.43 b	3.14 c	80.99 c	38.06 c	18.17 d	1499 c (-)
LSD $p<0.05$)			2.474	3.837	0.199	3.484	1.092	0.368	118.5

PRE= Pre-emergence
†=Means not sharing a letter in common differ significantly at $p<0.05$
*= Mean of the two years as year effect was non-significant; Figure in parenthesis show percent increase over control.

Cotton yield and yield parameters: All the treatments significantly improved the seed cotton yield over control (Table 4). Maximum seed cotton yield was achieved with the application of label rate of S.metolachlor (34%) which was statistically at par with ½ and 1/3rd dose of S.metolachlor combined with Sorgaab 12 L ha^{-1} (32%) and 15 L ha^{-1} (28%) respectively. Sorgaab alone at 12 and 15 L ha^{-1} showed statistically similar results and yield was increased by 15% and 13 % respectively as compared to control treatment. The increase in seed cotton yield was possibly due to the better *Cyperus rotundus* control which reduced the weed crop competition that increased the LAI, number of bolls per plant and boll weight of cotton (Table 4). Boquet *et al*., (2004) reported that increases in lint yield were associated with increases in boll weight and boll number. Cheema *et al*., (2003) also reported the increase in seed cotton yield and concluded that herbicidal dose can be reduced up to 67% when combined with concentrated sorgaab.

Conclusions

Sorgaab (sorghum water extract) in combination with reduced rates of herbicide S. metolachlor by one half to one third was quite effective in suppressing the density and dry weight of purple nutsedge in cotton and was almost on par with the label rate of the herbicide. This would be helpful in reducing the herbicide usage there by promoting environmental safety.

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