International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 4, No. 3, p. 27-34, 2014

INNSPUB

RESEARCH PAPER OPEN ACCESS

Weed management through combined application of allelopathic crop water leachates and reduced doses of herbicide in cotton (*Gossypium hirsutum* L.)

Mazhar Iqbal[1], Nasrullah Khan Aadal[1], Tamoor Hussain[1], Muhammad Azeem Tariq[1], Muhammad Tariq[1]

Barani Agricultural Research Institute, Chakwal, Pakistan

Article published on March 18, 2014

Key words: Weed management, Allelopathic crop water leachates, Horse Persulane, lower rate herbicide, cotton

Abstract

A field experiment was carried out at Cotton Research Sub Station, Piplan, Mianwali to determine appropriate combination of sorghum and brassica water extracts with reduced doses of paraquat (Gramoxon 20 SL), and pendimethalin (Stomp 330 E) for weed management in cotton. Combination of sorghum and brassica water leachates each at 20 L ha^{-1} and pendimethalin @ 0.417 kg a. i. ha^{-1} (1/3 dose) as pre-emergence reduced weed density of horse persulane was statistically alike to the brand dose of pendimethalin at 15, 40 and 60 DAS. The diminution in weed dry weight was also equal at 40 DAS while less at 60 DAS. The weed control with 1/3 dose of paraquat in combination with sorghum and brassica water leachates was equal to the full dose paraquat as directed post-emergence recorded at 60 DAS. The maximum seed cotton yield (2150 kg ha^{-1}) was attained with Allelopathic crop water leachates combined with lower rates pendimethalin, while its brand dose @ 1.25 kg a. i. ha^{-1} produced lesser seed cotton yield (1850 kg a. i. ha^{-1}). Economic and marginal analysis demonstrated that the treatment T_6 was the most economical with highest net benefits of Rs.144297/- and marginal rate of return 3299.28% while T_5 and T_7 are uneconomical due to higher cost that vary and less net benefits .It can be concluded that combination of sorghum and brassica water leachates with 1/3 dose of pendimethalin as pre-emergence for controlling horse persulane in cotton is reasonable and therefore the herbicide dose can be reduced by 67%.

* **Corresponding Author:** Tamoor Hussain ✉ tamoorhussain792@gmail.com

Introduction

Cotton is the main fiber crop of Pakistan and play very significant role in the economy of the country. Share of cotton in value addition in agriculture accounts for 7% and GDP is 1.5% based on area of cotton Pakistan ranks 5th in the world while production wise at 3rd position (Anonymous, 2012). The average yield of cotton in Pakistan is much lower than potential yield. The gap in crop yield between research farmers, progressive farmers and common farmers is primarily due to the lack in the adoption of modern management practices and specially plant protection. While in plant protection weed control is the most neglected component which results in yield losses up to 20-40% in different crops (Rehman *et al.*, 2013). Chemical weed control in cotton crop is an efficient and effective method, widely practiced in all crops. Although herbicides are effective tool for weed control yet certain limitation confronts their use. Specific knowledge is needed for their use, which is lacking in Pakistan, due to lack of awareness and limited trained manpower. Some time selection of wrong herbicide lead to create resistance in weeds and remain uncontrolled, moreover herbicides may pollute soil and water (Rehman *et al.*, 2013). So it is needed to find new environmental friendly techniques and methods for controlling weeds. One possible option may be reduction of herbicide usage. Another possibility is to develop natural products, bio-herbicides and utilizing of allelopathic crop water leachates as foliar spray or combined application of these leachates with lower doses of the recommended herbicides. They are effective, economical, viable and environmental friendly (Khalid *et al.*, 2002, Khanh *et al.*, 2005). There are two fundamental approaches to use natural products for weed management. The first is to use them as allelochemicals in crops or cover crops to manage weeds, insects, pests and pathogens. The other strategy is to use them directly as a herbicide in the form of crop water leachates (Duke *et al.*, 2002). Use of sorgaab (sorghum water leachate) as natural weed inhibitor in maize has been suggested by Ahmad *et al.*, (2000) stated that sorgaab reduces total weed density by 34 – 57% and horse persulane density by 24 – 40% and reduction in total dry weight 13 – 34% and also increased maize yield by 13 – 37%. Similarly Cheema *et al.*, (2002) reported that sorgaab @ 12 L ha^{-1} + pendimethalin @ 0.5 kg a.i. ha^{-1}, S-Metolachlor @ 1.0 kg a.i. ha^{-1} improved the seed cotton yield by 70.0% over control. Three sprays of sorgaab @ 12 L ha^{-1} at 15, 30 and 45 DAS improved seed cotton yield by 45.5% over control and proved economical than other treatments. Likewise Cheema *et al.*, (2003) evaluated the effect of sorgaab (25 and 50 times concentrated) and results revealed that sorgaab @ 6 L ha^{-1} or 12 L ha^{-1} combined with phenoxyprop-p-ethyl @ 375g a.i. ha^{-1} reduced weed dry weight by 87% and two sprays of sorgaab (25 times concentrated) @ 12 L ha^{-1} at 30-40 DAS was proved economical. Similarly, Singh *et al.,* (2003) reported that weeds cause enormous losses along with interfering in agroeco-systems, because of environmental and health hazards. Worldwide efforts are being made to reduce the usage of synthetic herbicides for weed control. So allelopathy is alternative environment friendly method of weeds control in all crops by the release of allelochemicals. The crops possessing allelopathic potential should be included in crop rotation, or use them as cover crop, smother crop, green manures, or intercropped for sustainable weed management. By the usage of new genetic techniques, bioefficacy of allelochemicals can be enhanced and allelopathic crops can be used for weed control economically. The objectives of this study was to evaluate the performance of pre-emergence and early post-emergence herbicides alone and its lower rates in combination with allelopathic crop (Sorghum and Brassica) water leachates on cotton weed under field conditions.

Materials and Methods

Experimental site

The experiment was carried out at Cotton Research Sub Station, Piplan, Mianwali to find out suitable combination of sorghum and brassica water extracts with reduced doses of paraquat (Gramoxon 20 SL), and pendimethalin (Stomp 330 E) for weed management in cotton. The experiment was laid out in randomized complete block design (RCBD) with four replications having a plot size of 7m x 3m. Cotton

variety MNH-786 was cultivated on well prepared seedbed with plant to plant and row to row distance of 30 cm and 75cm respectively on May, 07, 2009. Insects were controlled by using recommended insecticides.

Treatments

The present experiment consists of following treatments.

T_1= control (weedy check).

T_2 = Pendimethalin (Stomp 330 E) at 1.25 kg a. i. ha^{-1} (full dose) (pre- emergence)

T_3 = Paraquat (Gramoxon 20SL) 200 g a. i.ha^{-1} (full dose) (40 DAS) directed shielded

T_4 = Pendimethalin at 0.417 kg a. i. ha^{-1} (1/3 dose) (pre-emergence)

T_5 = Paraquat 67 g a. i. ha^{-1} (1/3 dose) (40 DAS) directed shielded

T_6 = sorghum + brassica were each at 18 L ha^{-1} + pendimethalin at 0.417 kg a. i. ha^{-1} (1/3 dose) (pre-emergence)

T_7 = sorghum + brassica were each at 18 L ha^{-1} + paraquat 67 g a. i. ha^{-1} (1/3 dose) (40 DAS) directed shielded

Procedure

Crop herbage (sorghum and brassica) was harvested at maturity, dried for few days under shade and then chopped in to 2 cm pieces with the help of fodder cutter. This chopped crop herbage was soaked in a ratio 1:10 (w/v) for 24 hours in the distilled water in a tub. After that water extracts were collected by passing through sieves. The filtrate which collected was boiled at 100˚C for reducing the volume by 20 times (Cheema and Khaliq, 2000). The concentrated extracts were stored at room temperature and then used. Volume of spray (330 L ha^{-1}) was determined by calibration, different water extracts were mixed in tank with each other and with reduced rates of pendimethalin @ 0.417 kg a. i. ha^{-1} and paraquat at 67 g a. i. ha^{-1}. Full branded doses of herbicides (1.25 kg a. i. ha^{-1}, 200 g a. i. ha^{-1} respectively) were maintained as standard. The treatments were applied one day after sowing using 330 L ha^{-1} water as a carrier with knapsack hand sprayer fitted with flat fan nozzle. A weedy check was also included in the experiment for comparison.

Data collection

Total weed densities and fresh and dry weight of weeds was recorded from randomly selected two quadrates (50 cm x 50 cm) from each research plot. Weeds were cut from ground surface and their fresh weight was recorded and then dried in an oven at 80°C for 72 hours and their dry weight was recorded. The parameters recorded were cotton germination (1 x 2 m^2), plant height (cm), number of monopodial branches per plant, number of sympodial branches per plant, number of bolls per plant, boll weight (g) and seed cotton yield (kg/ha).

Statistical analysis

The data collected was subjected to Fisher's analysis of variance technique and treatment means were evaluated using least significance difference (LSD) test at 0.05% according to (Steel and Torrie, 1984). Economic analysis and marginal rate of return were measured by following the method given by (Byerlee, 1988).

Results and discussion

Horse persulane density

Horse persulane (*Trianthema Portulacastrum* L) was the main weed at experimental site, Its density was low at 15 DAS increased up to 40 DAS and declined at 60 DAS (Table 4.1) probably its own vigorous plants killed the week ones. Pendimethalin (Stomp 330E) at 1.25 kg a. i. ha^{-1} (full dose) as pre-emergence spray suppressed horse persulane density by 33.33, 50.00 and 69.35% at 15, 40 and 60 DAS respectively. T_4 Pendimethalin 1/3 dose of the label dose suppressed horse persulane density by 38.88, 44.77 and 38.70% respectively at 15, 40 and 60 DAS. While in case of T_6 where sorghum and brassica water leachates were combined with 1/3 dose of the pendimethalin of label dose, horse persulane density was reduced by 33.33, 73.88 and 50.00% respectively at 15, 40 and 60 DAS. The effect of sorghum and brassica water leachates were combined with reduced dose of paraquat (1/3 dose of the of label dose) on horse persulane density at 60 DAS was less than their effect in case of lower

rate of pendimethalin. This (Table 1) show that weed mortality with pendimethalin alone at label dose (Stomp 330E) or its reduced dose and combination with Allelopathic crop water leachates was inconsistent hence no inference can be made. These results are in contrary to the earlier findings of Cheema *et al.*, (2000) who studied that pendimethalin dose can be reduced 67% in combination with sorgaab. Weed mortality with paraquat directed post - emergence spray treatments (T_3, T_5, and T7) was very less i.e. 24.19%, 33.87%, and 11.29% respectively. Perhaps the weed plants were at complex stage and hence little mortality occurred.

Table 1: The effect of combined application of allelopathic crop water leachates (Sorghum + Brassica) and reduced herbicide rates on horse persulane density (0.25 m^2)

No	Treatments[1]	15 DAS *	40 DAS	Decrease/increase over control (%)	60 DAS	Decrease/increase over control (%)
1	T1	9.00a	33.50a		15.50a	
2	T2	6.00b	16.75b	-50	4.75e	-69.35
3	T3				11.75bc	-24.19
4	T4	5.50b	18.50b	-44.77	9.50c	-38.7
5	T5				10.25c	-33.87
6	T6	6.00b	8.75c	-73.88	7.75d	-50
7	T7				13.75ab	-11.29
	LDS value	1.72	2.65		2.45	

*DAS: Days after sowing, Any two means not sharing a letter in common differ significantly at 5% level of probability. ^{ns} non significant, 1: T_1= control (weedy check), T_2 = Pendimethalin (Stomp 330 E) at 1.25 kg a. i. ha^{-1} (full dose) (pre-emergence), T_3 = Paraquat (Gramoxon 20SL) 200 g a. i.ha^{-1} (full dose) (40 DAS) directed shielded, T_4 = Pendimethalin at 0.417 kg a. i. ha^{-1} (1/3 dose) (pre-emergence), T_5 = Paraquat 67 g a. i. ha^{-1} (1/3 dose) (40 DAS) directed shielded, T_6 = sorghum + brassica were each at 20 L ha^{-1} + pendimethalin at 0.417 kg a. i. ha^{-1} (1/3 dose) (pre-emergence), T_7 = sorghum + brassica were each at 20 L ha^{-1} + paraquat 67 g a. i. ha^{-1} (1/3 dose) (40 DAS) directed shielded.

Horse persulane fresh weight (g)

Table-2 predicted that during the present experiment the fresh weight of horse persulane statistically remained unchanged in all the treatments.

Horse persulane dry weight (g)

The reduction in dry weight of horse persulane in T_2 and T_6 *viz.* pendimethaline label dose (Stomp 330E) and its reduced dose (1/3 dose) combined with allelopathic crop water leachates i.e. sorghum and brassica each at 20 L ha^{-1} up to 40 DAS was equal but at 60 DAS reduction in dry weight with full dose of pendimethalin (T_2) was more (57.10%) than T_6 (pendimethalin 1/3 dose +water leachates). Allelopathic crop water leachates (T_7) combined with 1/3 dose of paraquat suppressed the weed dry weight by 85% equal to the label dose of paraquat (86.89%) recorded at 60 DAS (Table-2). The present study shows that allelopathic crop water leachates can be used to reduce the rate of herbicides. The combination of paraquat and allelopathic crop water leachates used as directed post emergence spray was feasible in reducing the dose of paraquat by 67%, however in case of pendimethalin at lower rates and the allelopathic crop water leachates combination was effective up to 40 DAS but its effect was less at 60 DAS which is difficult to explain. These results to some extent support previous findings of (Cheema *et al.*, 2003a) who suggested that 67% reduction in pendimethalin dose in combination with allelopathic crop water leachates. While the findings regarding paraquat and allelopathic crop water leachates are encouraging and in line with the work of (Cheema *et al.*, 2003b) who recommended that allelopathic crop water leachates in combination with lower herbicides rate can be used for weed control in cotton.

Table 2: The effect of combined application of allelopathic crop water leachates (Sorghum + Brassica) and reduced herbicide rates on weed fresh and dry weight (g) (0.25m²)

No.	Treatments	Weed fresh weight (g)	Dry weight (g)			
			40 DAS *	Decrease/increase over control (%) (40 DAS)	60 DAS	Decrease/increase over control (%) (60 DAS)
1	T1	385.37^{ns}	87.00		301.25	
2	T2	331.75	69.00	-20.69	129.25	-57.10
3	T3				39.50	-86.89
4	T4	365.52	81.75	-6.03	197.15	-34.56
5	T5				150.50	-50.04
6	T6	371.75	71.25	-18.10	175.00	-41.91
7	T7				39.50	-86.89
	LSD	Non significant	6.15		4.75	

*DAS: Days after sowing, Any two means not sharing a letter in common differ significantly at 5% level of probability. ^{ns} non significant, 1: T_1= control (weedy check), T_2 = Pendimethalin (Stomp 330 E) at 1.25 kg a. i. ha^{-1} (full dose) (pre-emergence), T_3 = Paraquat (Gramoxon 20SL) 200 g a. i.ha^{-1} (full dose) (40 DAS) directed shielded, T_4 = Pendimethalin at 0.417 kg a. i. ha^{-1} (1/3 dose) (pre-emergence), T_5 = Paraquat 67 g a. i. ha^{-1} (1/3 dose) (40 DAS) directed shielded, T_6 = sorghum + brassica were each at 20 L ha^{-1} + pendimethalin at 0.417 kg a. i. ha^{-1} (1/3 dose) (pre-emergence), T_7 = sorghum + brassica were each at 20 L ha^{-1} + paraquat 67 g a. i. ha^{-1} (1/3 dose) (40 DAS) directed shielded.

Cotton

Cotton germination (1 x 2 m²)

Germination in cotton is extremely sensitive and influenced by the environment but in this study germination remained unaffected by the treatments and by environment (Table 3). These results are contrary to the findings of (Vasilakoglou *et al*., 2005) who investigated the effect of Allelopathic water extracts on the cotton germination.

Plant height (cm)

The plant height was significant different in all treatments and was higher than control (Table 3). Highest plant was found (111.25.00 cm) in T_7 i.e. sorghum and brassica water leachates at 20 L ha^{-1} +1/3 dose of paraquat while shortest plant height (95.00 cm) were recorded in T_1 more was in control plants competed with crop plants hence resulted in shorter plants while in other treatments taller plants were due to improved weed control. The present results were in corroborated with the findings of (Cheema *et al*., 2000a).

Number of monopodial branches per plant

Data pertaining to number of monopodial branches (Table 3) show that monopodial branching in most of the treatments was significantly affected. In T_6 i.e. sorghum and brassica water leachates each at 20 L ha^{-1} +1/3 dose of pendimethalin the number of monopodial branches plant^{-1} increases which is due to better weed control. The results confirm the study of (Cheema *et al.,* 2000b) and (Cheema et *al*., 2005) who affirmed that monopodial branches enhanced with weed control.

Number of sympodial branches per plant

Number of sympodial branches per plant is the main yield component in cotton that directly contributes to the seed cotton yield. Table-3 predicted that number of sympodial branching was maximum (28.80, 27.95 plant^{-1}) in two treatments T_6 and T_7 i.e. sorghum and brassica water leachates each at 20 L ha^{-1} +1/3 doses of pendimethalin and paraquat at 0.417 kg a. i. ha^{-1} and 67 g a. i. ha^{-1} respectively both were statistically at par. T_3 was followed by $T_4$and T_5 due to less weed control. T_2 also gave same weed control but sympodial branching remained less it would be difficult to explain the reason of difference in sympodial branching. Possibly in selection of plants or error could be the cause of differential results in terms of sympodial branching. The number of sympodial branching was enhanced due to relatively better weed control in respective treatments. These results are in accordance with the previous findings of

(Cheema *et al.,* 2002) who explained that sympodial branching was increased with weed suppression.

Number of bolls per plant

Bolls per plant (Table 3) were affected by most of the treatments, while the treatment T_6 i.e. sorghum and brassica water leachates each at 20 L ha^{-1} + pendimethaline at 0.471kg a. i. (1/3 dose) and T_7 i.e. sorghum and brassica water leachates each at 18 L ha^{-1} + paraquat 67 g a. i. ha^{-1} (1/3 dose) recorded maximum bolls per plant (32.75, 30.15 $plant^{-1}$). Increase in number of bolls was possibly due to better inhibition of weeds which facilitated nutrient availability for cotton. Cheema *et al.,* (2000b) also narrated the similar results that sorghum mulch and herbicidal treatments significantly influenced the number of bolls per plant due to better weed control.

Boll weight (g)

Data pertaining to Boll weight was presented in (Table 3) reveals that all the treatments statistically affected the boll weight as compared to control. The heaviest boll weight was measured in T_7 i.e. sorghum and brassica water leachates each at 20 L ha^{-1} + paraquat 67 g a. i. ha^{-1} (1/3 dose) (4.52g) followed by T_3 i.e. paraquat at 200 g a. i. ha^{-1} (full dose) (4.28 g). These results correlated with the investigations of (Cheema *et al.*, 2000b) who observed that boll weight was affected by sorgaab, sorghum mulch and herbicidal treatments.

Seed cotton yield (kg ha^{-1})

Yield is a complex character and controlled by various yield components influencing crop growth. The results related to seed cotton yield (Table 3) show statistically significant influence of all the treatments. The raise in seed cotton yield over control varied from 40.19% to 104.76%. The treatment (T_6) combination of sorghum and brassica water leachates each at 20 L ha^{-1} and 1/3 dose of pendimethalin as pre-emergence conferred maximum improvement in seed cotton yield (kg ha^{-1}) (104.76%). While herbicide pendimethalin label dose sprayed as pre-emergence i.e. 1.25 kg a. i. ha^{-1} increased seed cotton yield only by 76.19% although weed control in both of was equal at 40 DAS and less in T_6 at 60 DAS. The possible cause for superior seed cotton yield in T_6 may due to more number of bolls per plant. The effects of allelopathic crop water leachates on seed cotton yield were confirmed by (Cheema *et al.,* 2002) while (T_7) combination of allelopathic crop water leachates and 1/3 dose of paraquat cannot boost up seed cotton yield also by the reticence of weed in cotton crop. The results from different treatment combination vary greatly which indicate complex nature of allelopathic phenomenon and interaction of different factors as various allelopathic conditions, herbicidal doses, edaphic and moisture content and weed intensity.

Table 3. The effect of combined application of allelopathic crop water leachates and reduced herbicide rates on yield parameters and yield in cotton.

No.	Treatments[1]	Cotton germination	Plant height (cm)	Monopodial branches/plant	Sympodial branches/plant	Number of bolls/ Plant	Boll weight (g)	SEED COTTON YIELD (Kg ha^{-1})	Seed yield decrease/increase over control (%) (Kg ha^{-1})	(GOT %)
1	T1	14.50	95.00d	3.45b	16.80d	20.75e	3.20e	1050f		35.10a
2	T2	9.75	105.60abc	3.37b	21.20c	28.90c	4.15bc	1850c	76.19	37.15a
3	T3	11.50	108.75ab	4.75a	25.65b	29.75bc	5.15ab	2075b	97.62	36.25a
4	T4	11.75	105.00bc	3.33b	20.15c	24.95d	4.10cd	1675d	59.52	35.20a
5	T5	11.50	102.10c	3.30b	20.75c	24.15d	3.75de	1675d	59.52	35.20a
6	T6	10.75	107.50ab	4.95a	28.80a	32.75a	4.15bc	2150a	104.76	38.75a
7	T7	10.75	111.25a	4.50a	27.95a	30.15ab	5.12a	1472e	40.19	37.50a
	LSD	Non significant	5.15	0.71	2.15	2.9	0.95	34.25		5.1

*DAS: Days after sowing, Any two means not sharing a letter in common differ significantly at 5% level of probability. [ns] non significant, 1: T_1= control (weedy check), T_2 = Pendimethalin (Stomp 330 E) at 1.25 kg a. i. ha^{-1} (full dose) (pre-emergence), T_3 = Paraquat (Gramoxon 20SL) 200 g a. i.ha^{-1} (full dose) (40 DAS) directed shielded, T_4 = Pendimethalin at 0.417 kg a. i. ha^{-1} (1/3 dose) (pre-emergence), T_5 = Paraquat 67 g a. i. ha^{-1} (1/3 dose) (40 DAS) directed shielded, T_6 = sorghum + brassica were each at 20 L ha^{-1} + pendimethalin at 0.417 kg a. i. ha^{-1} (1/3 dose) (pre-emergence), T_7 = sorghum + brassica were each at 20 L ha^{-1} + paraquat 67 g a. i. ha^{-1} (1/3 dose) (40 DAS) directed shielded.

Ginning out turn (GOT %)

Ginning out turn (GOT %) in cotton is mainly due to the genetic makeup of the variety, however up to certain limits variations in the environment may influence it. In current research work the ginning out turn (GOT %) was remained unaffected statistically by any of the treatments (Table 3). The present inference was concurred with the study of (Cheema *et al.*, 2000a, b) who stated no affect of different treatments practices for control of weed on GOT% and this behavior of cultivar is due to its inheritance potential of seed.

Economic and marginal analysis

The efficacy of any production system is eventually assessed on the basis of its economics. Economic analysis is the essential concern to find out that which treatment gives highest net return, while marginal analysis indicates relative contribution of additional expenditure. Economic and marginal analysis show that treatment (T_6) combination of allelopathic crop water leachates i.e. sorghum and brassica at 20L ha^{-1} and 1/3 dose of pendimethalin pre-emergence was most economical (Table 4a) with highest net benefit Rs 144297/- and marginal rate of return (3299.88%) just by spending Rs. 828 ha^{-1}. Other treatments like T_2, T_3, and T_4 also economical (Table 4b). While the treatments as T_5 and T_7 were uneconomical due to higher costs that vary and comparatively less net benefits.

Table 4a. Economic analysis.

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	Remarks
Seed cotton yield	1050	1850	2010	1675	1675	2150	1472	Kg ha^{-1}
Adjusted seed cotton yield	945	1665	1809	1508	1508	1935	1325	To bring at farmer level (10%)
Income	70875	124875	135675	113100	113100	145125	99375	Rs:3000 per 40 kg
Cost of herbicide	0	175	220	58	74	58	74	Pendimethalin and Paraquat cost
Cost of extracts	0	0	0	0	0	440	440	Rs: 110 per 20 L
Spray application	0	330	330	330	330	330	330	Rs.330/man/day/ha^{-1}
Cost that vary	0	505	550	388	404	828	844	Rs.ha^{-1}
Net benefit	70875	124370	135125	112712	112696	144297	98531	Rs ha^{-1}

Table 4b. Marginal analyses.

TREATMENTS[1]	COST THAT VARY (Rs)	NET BENEFITS (Rs)	MARGINAL COST	MARGINAL NET BENEFITS	MARGINAL RETURN RATE %
T1	0	70875	0	0	0
T4	388	112712	388	41837	10782.73
T5	404	112696	16	0	D
T2	505	124370	101	11674	11558.42
T3	550	135125	45	10755	23900.00
T6	828	144297	278	9172	3299.28
T7	844	98531	16	0	D

D= Dominated, Marginal rate of return (%) = Change in net profits/Change in cost ×100, Cost that vary = The cost that is incurred on variable inputs in the production of a particular commodity. [1]T_1= control (weedy check), T_2 = Pendimethalin (Stomp 330 E) at 1.25 kg a. i. ha^{-1} (full dose) (pre-emergence), T_3 = Paraquat (Gramoxon 20SL) 200 g a. i.ha^{-1} (full dose) (40 DAS) directed shielded, T_4 = Pendimethalin at 0.417 kg a. i. ha^{-1} (1/3 dose) (pre-emergence), T_5 = Paraquat 67 g a. i. ha^{-1} (1/3 dose) (40 DAS) directed shielded, T_6 = sorghum + brassica were each at 20 L ha^{-1} + pendimethalin at 0.417 kg a. i. ha^{-1} (1/3 dose) (pre-emergence), T_7 = sorghum + brassica were each at 20 L ha^{-1} + paraquat 67 g a. i. ha^{-1} (1/3 dose) (40 DAS) directed shielded.

Conclusion

The findings of the present research recommended the use of allelopathic crop water leachates (Sorghum+Brassica) mixed with each other and 1/3 dose of pendimethalin for economical weed control in cotton with comparatively improved environmental safety.

References

Ahmad S, Rehman A, Cheema ZA, Tanveer A and Khaliq A. 1995. Evaluation of some crops residue for their allelopathic effect on germination and growth of cotton and cotton weeds. In: proceedings of all Pakistan Weed Sciences Conference, Faisalabad Pakistan, p. 63-76.

Anonymous. 2012. Economic Survey of Pakistan Ministry of Food, Agriculture and Livestock, Federal Bureau of Statistics, Islamabad

Byerlee, D. 1988. From Agronomic data to farmers recommendation, A economics training manual CIMMYT. Mexico, p. 31-33.

Cheema ZA, Ali B and Khaliq A. 2005. Determining suitable combination of sorgaab and pendimethalin for weed control in cotton (*Gossypium hirsutum*) International Journal of Agriculture and Biology **7,** 889-891.

Cheema, ZA, Asim M and Khaliq A. 2000a. Sorghum allelopathy for weeds control in cotton (*Gossypium arborium* L.). International Journal of Agriculture and Biology **2,** 37-41.

Cheema ZA, Asim M and Khaliq A. 2000b. Sorghum allelopathy for weed control in cotton (*Gossypium arboretum* L.). International Journal of Agriculture and Biology **1,** 37-41.

Cheema ZA, Khaliq A and Tariq M. 2002. Evaluation of concentrated sorgaab alone in combination with reduced rates of three pre-emergence herbicides for weed control in cotton (*Gossypium hirsutum* L.) International Journal of Agriculture and Biology **7,** 549-552.

Cheema ZA, Khaliq A and Farooq R. 2003a. Effect of concentrated sorgaab alone and in combination with herbicides and a surfactant in wheat. Journal of Animal and Plant Sciences **13,** 10-13.

Cheema ZA, Khaliq A and Hussain AR. 2003b. Reducing herbicides rate in combination with allelopathic sorgaab for weed control in cotton. International Journal of Agriculture and Biology **5,** 1560-1565.

Duke SO, Rimando AM, Baerson SR, Scheffler BE, Ota E and Belz RG. 2002. Strategies for the use of natural products for weed management. Journal of Pesticide Sciences **27,** 298-306.

Khanh TD, Chung MI, Xuan TD and Tawata S. 2005. The exploitation of crop allelopathy in sustainable agricultural production. Journal of Agronomy and Crop Sciences **191,** 172-184.

Khalid S, Ahmad T and Shad RA. 2002. Use of allelopathy in agriculture. Asian Journal Plant Sciences **1,** 292-294.

Rehman M, Ishaque M, Abbas G and Khokhar MB. 2013. Evaluation of combined application of allelopathic crop leachates and post emergence herbicide for control of weeds in rice (*Oryza sativa* L.) Crop Sciences International (Lahore), 915-920.

Singh HP, Batish DR, Kaur S, Setia N and Kohil RK. 2003. Effect of 2-benzoxazolinone on the germination, early growth and morphogenic response of mung bean. Journal of Agriculture and Biology **147,** 267-274.

Steel RGD and Torrie JH. 1984. Principles and Procedures of Statistics. McGraw Hill Book Company Inc, New York, USA, 232-251.

Vasilakoglou I, Dhima K and Elefthrohorinos DI. 2005. Allelopathic potential of Bermuda grass and Johnson grass and their interference with cotton and corn. Journal of Agronomy **97,** 303-313.