EVALUATION OF COMBINED APPLICATION OF ALLELOPATHIC CROP LEACHATES AND POST-EMERGENCE HERBICIDE FOR CONTROL OF WEEDS IN RICE (*ORYZA SATIVA* L.) CROP.

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ABSTRACT: *A field study was conducted at Agronomic Research Area, University of Agriculture, Faisalabad, during summer season in the year 2007 to explore the possibility of reducing herbicide doses in combination with water leachates of allelopathic crops in rice. The herbicide used in the study was Bispyribac-sodium (Nominee (10SC), an early post-emergence at the label rate (full dose) @ 24.7g a.i. ha^{-1}. Its half rate (12.35g a.i. ha^{-1}), ¼ rate (6.17g a.i. ha^{-1}) alone and along with concentrated water extracts of three allelopathic crops viz. sorghum, sunflower and rice each @ 20 L ha^{-1}. The experiment was laid out in randomized complete block design (RCBD) with four replications and with a net plot size of 6x22.5m^{-2}. The herbicide and water leachates were tank mixed and applied as an early post-emergence spray 12 days after transplanting (DAT) of rice. A weedy check was maintained as control treatment. The density of all the weeds was significantly suppressed by the allelopathic crop leachates treatment in the range of 20-30% except Dactyloctenum aegyptium L. The herbicidal treatments were most effective in inhibiting the total weed density 30-50% over control. The reduction in fresh weight and dry weight of all the weeds with herbicides was maximum (41%) while most of the allelopathic crops leachates treatments significantly reduced total weeds dry weight 15%.*

Key words: allelopathic crops, Sorghum (*Sorghum bicolor* L.), rice (*Oryza sativa* L.), herbicide (Bispyribac-sodium), Rice (*Oryza sativa* L.), Punjab, Pakistan.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the leading cereal crops of Pakistan and plays a pivotal role in the country's economy. It is the second largest agricultural export commodity of Pakistan, after cotton. It is grown on 10% of the total cropped area of Pakistan (Govt. of Pakistan [1]. It is grown on 2365.3 (000) ha and its production is 4823.3 (000) tons (Bureau of Statistics of Pakistan [2]. Currently 42% of its production potential is being harvested [3], which indicates tremendous scope for enhancing rice production [4]. In addition to meeting the food requirement of a considerable portion of a population it also serves as an important source of foreign exchange. Average paddy yield in the country is much lower than the yield obtained at the research stations.

In addition to other factors as plants population, irrigation water availability, crop nutrition, insect diseases, soil type and fertility, weed infestation is a main element in limiting yield in Pakistan [5]. Uncontrolled weeds in rice reduce its yield by 25- 57% [6]. Major weeds of rice crop in Pakistan include following species as barn yard grass, purple nutsedge, flate sedge, water clover, umbrella sedge, jungle rice, knot grass, bermuda grass etc. According to Ashraf and Yousaf [7], total rice production in Pakistan can be enhanced by 28% through efficient weed control.

Weed infestation in rice crop is one of the main causes of low yield per hectare against the potential yield in Pakistan Yousaf [5]. Uncontrolled weeds in rice reduce its yield by 25- 57% Singh *et al* [6]. According to Ashraf and Yousaf [7], total rice production in Pakistan can be enhanced by 28% through efficient weed control. Farmers use traditional methods as crop rotation, puddling to facilitate standing water before transplanting and hand weeding, for weed control in rice. Recently they have started the use of herbicides in rice. However, their usage is very low as compared to advanced countries of the world. Although herbicides are effective in controlling weeds but may pollute the soil and water environment. Existing weed control methods in rice are either expensive or hazardous. Continuous use of same herbicide for a long period of time may cause resistance in weeds.

Allelopathy being a natural phenomenon is environment friendly and can be manipulated for weed management. It provides a relatively cheaper weed control alternative. The production of allelochemicals inhibits the growth of weeds. The production and release of allelochemicals from leaves, flowers, seeds, stems and roots of living and decomposing plant materials can influence weed density and growth [8,9,10].

In the former case, a number of crop plants with allelopathic potential can be used as cover, smother and green manure crops for managing weeds by making desired manipulation in the cultural practices and cropping patterns [11,12]. These can be soil incorporated, rotated or intercropped with main crops to manage the target weeds. Allelochemicals in plants can be directly used for weed management [13]. It can be utilized in various ways as inclusion of allelopathic crops in rotation systems, allelopathic water extracts as foliar sprays, allelopathic crop residues used on surface much or soil incorporated.

The allelopathic crops water extracts used as foliar sprays inhibit weed density and dry weight in the range of 21-45% and 14-40% [14] respectively. Allelopathic substances in combination with lower doses of herbicides may be a leading step in recent era. However, there is still need to investigate the suitable combinations of allelopathic crops water extracts with reduced doses of herbicides to minimize the reliance on synthetic chemicals and conserve the environment. In rice no such research has been reported up–till now. Therefore, it would be quite appropriate to initiate research in rice crop.

The general objectives of this research were to evaluate the efficacy of aqueous extracts of allelopathic crops like sorghum, sunflower and rice, on rice crop and to find possible effects by combining these water extracts along with lower doses of rice herbicides on rice weeds under field conditions and also to evaluate the performance of a new early post-emergence herbicide alone also.

MATERIALS AND METHODS

LOCATION

A field experiment was conducted at Agronomic Research Area, University of Agriculture Faisalabad to investigate the response of rice and its weeds to three allelopathic crop leachates. The experiment was laid out in RCBD with four replications having a plot size of 6m × 2.25m. A fine variety of rice, Basmati-385 was transplanted at 26th of July 2007, as a test crop having 22.5 cm spaced rows. Allelopathic crop water extracts with lower rates of Nominee (10SC) were used for weed control in rice. All treatments were sprayed in respective plots with the help of knap sack hand sprayer fitted with flat fan nozzle 12 days after transplanting (DAT).

TREATMENTS

The treatments were used are as under.

T_1 = Control (weedy check)

T_2 = Bispyribac-sodium (Nominee10SC) at 24.7 g a.i. ha^{-1} (full dose)

T3 = Bispyribac-sodium (Nominee10SC) at 12.35 g a.i. ha^{-1} (1/2 dose)

T4 = Bispyribac-sodium (Nominee10SC) at 6.17 g a.i. ha^{-1} (1/4 dose)

T5 = Sorghum+Sunflower+Rice Water Leachates at each 20 L ha^{-1}

T6 = Sorghum+Sunflower+Rice Water Leachates at each 20 L ha^{-1} +Bispyribac-sodium (Nominee10SC) at 12.35 g a.i. ha^{-1} (1/2 dose)

T7 = Sorghum+Sunflower+Rice Water Leachates at each 20 L ha^{-1} +Bispyribac-sodium (Nominee10SC) at 6.17 g a.i. ha^{-1} (1/4 dose)

INPUTS

All treatments were applied 10-15 days after transplanting (DAT). All the phosphatic fertilizer was applied before transplanting while nitrogen was applied in two equal splits, at transplanting and second after 30 days after transplanting (DAT). Crop water extracts were prepared through procedure described by Cheema and A. Khaliq [15].

PROCEDURE

Respective allelopathic crops were harvested at maturity, dried for few days under shade and then chopped into 2 cm pieces with the help of electric fodder cutter. This chopped material was soaked in the water 1:10 (w/v) ratio for 24 hours. Water extracts were collected by passing through sieves. The filtrates were boiled at 100°C for reducing the volume by 20 times. The concentrated crop water extracts were stored at room temperature [16].

Crop water extracts at 20 L ha^{-1} each and in combination with half dose of Nominee 10SC at 12.35 g a.i ha^{-1}, 1/4 dose i.e. 6.17 g a.i. ha^{-1} and full dose of Nominee 10SC at 24.7 g a.i. ha^{-1} and also separately for comparison with other treatments. All treatments were sprayed after 10-15days after transplanting by knapsack hand sprayer fitted with flat fan nozzle after calibrations using 320 liters of water per hectare. Full dose of Nominee 10SC (24.70 g a.i. ha^{-1}) was used as standard. A weedy check was also maintained for comparison.

PARAMETERS

Individual and total weed densities and fresh and dry weight of weeds was recorded from randomly selected two quadrates (50 cm x 50 cm) from each experimental 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. To calculate average plant height and grains per panicle, 10 productive tillers were selected at random from each plot. From each experimental plot 1000 grains were counted manually and their weight was recorded on electric balance. Grain yield per plot was recorded and converted into t ha^{-1}.

STATISTICAL ANALYSIS

The data collected was subjected to Fisher's analysis of variance technique and treatment means were compared using least significance difference (LSD) test at 0.05% Steel & Torrie [17]. Economic analysis and marginal rate of return were determined by following the procedure evolved by Byerlee [18].

RESULTS AND DISCUSSION

Weed flora recorded was consisted of mainly the weed species as *Echinochloa crus-galli* L., *Cyperus iria* L., *Conyza stricta* L. and *Dactyloctenum aegyptium* L. The density of all the weeds was significantly suppressed by the allelopathic crop leachates treatment in the range of 20-30% except *Dactyloctenum aegyptium* L. The herbicidal treatments were most effective in inhibiting the total weed density 30-50% over control.

The reduction in fresh weight and dry weight of all the weeds with herbicides was maximum (41%) while most of the allelopathic crops leachates treatments significantly reduced total weeds dry weight up to 15%. These results confirm the previous work of Iqbal [19] who reported reduction in weed dry weight with sorgaab. The effects of all treatments on total weeds density, total weeds fresh weight and total weeds dry weight is shown in the (Table I). There was no effect of any treatments on density, fresh weight and dry weight of *Dactyloctenum aegyptium* L.

4.16 Plant height (cm)

The results of Table II, reveal that all treatments had suppressive effect on plant height while T_5 (Sorghum, Sunflower and Rice water leachates) @ 20 L ha^{-1} relatively less suppressant. While where full dose of Nominee 10SC was applied, was more suppressive. These results are contrary to Cheema [20] and Ahmad *et al* [21] that there is an inhibitory effect of allelopathic crops water extracts on plant height.

4.17 Number of unfertile tillers/m^2

Table II, reveals that full dose of Nominee 10SC (T_2) produces minimum number of unfertile tillers. While unfertile tillers (8%) were relative more observed in T_5 (Sorghum + Sunflower + Rice water leachates). In treatment (T_6) where combination of allelopathic crops water extracts with half dose of Nominee 10SC was applied the number of unfertile tillers was statistical equal to full dose of herbicide (T_2). These results suggest that herbicide in combination with allelopathic crop water leachates provided less number of unfertile tillers. These results correlate with the findings of Rola [22] who observed decrease in the number of unfertile tillers in treated plots as compared to control.

4.18 Number of fertile Tillers/m^2

The results of Table II reveal that there is increase in the number of fertile tillers in all the treatments over control (T_1). The maximum increase in number of fertile tillers where full dose of Nominee 10SC (T_2) was applied. Allelopathic crops water leachates combined with 1/2 dose of Nominee 10SC (T_6) increased number of fertile tillers statistically at par to the full dose of Nominee 10SC (T_2). Water extracts spraying showed negligible increase in fertile tillers. These results reveal that herbicide in combination with allelopathic crop water leachates produce fertile tillers almost equal to the herbicide used in full dose. This is supported that by Cheema *et al* [23] who stated that maximum number of fertile tillers was obtained where two foliar sprays of allelopathic crops with reduced doses of herbicides were applied.

4.19 Number of spikelets/ panicle

The results of Table II, show that maximum number of spikelets per panicle was obtained by the application of full dose of Nominee 10SC @ 24.7 g a.i. ha^{-1} (T_2) and treatment having combination of allelopathic crops water leachates with half dose of Nominee 10SC (T_6). Other treatments had less effect on increase the number of spikelets per panicle, but gave more number of spikelets per panicle than T_5 where only crops water leachates were applied than T_2 and T_6.

4.20 Number of grains/panicle

Number of grain panicle is an important yield component in rice. The data presented in Table II, indicates significant effect of all the treatments. Maximum number of grains per panicle (229.4) were recoded in plots treated with full dose of Nominee 10SC which was statistically higher than other treatment, while minimum number of grains were found in T_7 (allelopathic crops water extracts of sorghum, sunflower and rice in combination with 1/4th dose of Nominee 10SC) which was statistically at par with T_4. These results corroborate the findings of Cheema [20] and Ahmad *et al* [21] who found that there is increase in number of grains with combination of sorghum residues and fertilizer application.

4.21 1000 grain weight (g)

Data pertaining 1000-grain weight presented in Table 4.21 reveals that all the treatments increased 1000-grain weight significantly over control. Heaviest grains were recorded in plots treated with full dose of Nominee 10SC i.e. (T_2) which was statistically at par with plots treated with sorghum, sunflower and rice water leachates each @ 20 L ha^{-1} with reduced dose of Nominee 10SC @ 12.35 g a.i. ha^{-1} (T_6). These findings are contrary to those of Majid and Sindhu [24] and Akhtar [25], who observed higher leaf area index, crop growth rate and heavier grains with appropriate management of weeds.

4.23 Paddy yield (t ha^{-1})

Paddy yield was significantly increased by all the treatments (Table II). The herbicidal treatment with full dose of Nominee (10SC) was most effective in improving the paddy yield by 34% while other treatments were also effective among each other over control by 8-26% which is contrary to the work reported by Cheema and Khaliq [15].

Economic analysis and marginal rate of return (Table III & IV) showed that there was an overall increase in the net field benefits in different weed control methods over control. Among different treatments the highest monetary gain was obtained from T_2 giving a net increase of (Rs.105155 ha^{-1}) followed the T_6 with a net profit of Rs.98810 ha^{-1}. However marginal analysis revealed that only the herbicide treatments were economical due to higher marginal rate of return while other were dominated to the cost of vary. As this was a preliminary study, so there is need to repeat it with some modification in treatments, however it has given some identification that herbicide dose can be reduced to a considerably extant by using allelopathic crop water leachates as sorghum, sunflower and rice with lower dose of the herbicide Nominee (10SC).

CONCULSIONS

It can be concluded from the results that allelopathic crop leachates @ 20 L ha^{-1} are less effective for weed control in rice if used alone and if applied in combination with reduced doses of herbicide Nominee (10SC) beside that full dose of herbicide is used, which is useful practice with relatively less cost as compared to herbicides. The use of allelopathic crop leachates, being natural weeds inhibitors, would reduce the need of chemical herbicides and provide economic benefits. However, the studies of this nature may be continued.

Table I. Effect of combined application of allelopathic crop water leachates and an early post-emergence herbicide on total weed density, total fresh and dry weight ($g/0.25m^2$) in rice.

Treatments	Weed density (60DAT)	Weeds fresh weight (g) (60DAT)	Weeds dry weight (g) (60DAT)
T_{10}	301.20 a	1354.00 a	236.90 a
T_2	156.60 f (-48.01)	797.30 f (-41.12)	143.20 f (-39.55)
T_3	207.50 d (-31.10)	903.40 d (-33.28)	157.10 d (-33.68)
T_4	239.40 b (-20.51)	984.80 c (-27.26)	174.50 c (-26.34)
T_5	228.60 c (-24.10)	1151.00 b (-14.99)	200.60 b (-15.32)
T_6	189.00 e (-37.25)	861.10 e (-36.40)	152.00 e (-35.83)
T_7	210.90 d (-29.98)	979.10 c (-27.69)	176.90 c (-25.32)
LSD=	**9.101**	**17.91**	**5.073**

° *Means with different letters in a column differed significantly (5% level).* ° DAT: days after transplanting

Table II. Effect of combined application of allelopathic crop water leachates and an early post-emergence herbicide on growth and paddy yield.

Treatments	Plant height (cm)	Fertile tillers (m^{-1})	Spikelets/panicle	Grains/panicle	1000 grains weight (g)	Paddy yield (t ha^{-1})
T_1	110.40 a	183.10 e	188.20 f	178.20 e	12.44 d	2.125 c
T_2	102.50 b	230.30 a	236.40 a	229.40 a	13.99 a	2.850 a (34.12)
T_3	103.30 b	205.50 cd	228.50 bc	220.50 b	13.09 b	2.432 b(14.45)
T_4	104.90 b	198.20 d	222.30 de	213.30 cd	12.89 c	2.350 b(10.59)
T_5	106.50 a	193.20 de	218.80 e	217.70 bc	12.76 c	2.300 bc(8.23)
T_6	104.00 b	225.10 ab	231.60 ab	222.60 b	13.21 ab	2.680 a(26.12)
T_7	105.40 b	213.00 bc	225.70 cd	209.80 d	13.11 b	2.400 b(12.94)
LSD	4.847	13.53	5.314	5.838	0.1993	0.2153

° Means with different letters in a column differed significantly (5% level).

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Table III
Economic analysis.

	T1	T2	T3	T4	T5	T6	T7	Remarks
Average paddy yield (t ha^{-1})	2.13	2.85	2.43	2.35	2.30	2.68	2.40	t ha^{-1}
10% less paddy yield	0.21	0.29	0.25	0.24	0.23	0.27	0.24	To bring at farmer level
Adjusted paddy yield (t ha^{1})	1.92	2.56	2.18	2.11	2.07	2.41	2.16	10% reduction
Income from paddy yield (Rs.)	76800	102400	87200	84400	82800	96400	86400	Rs.40000 t^{-1}
Straw yield (t ha^{-1})	5.07	6.78	5.75	5.59	5.47	6.38	5.71	t ha^{-1}
10% less straw yield	0.507	0.678	0.575	0.559	0.547	0.638	0.571	To bring at farmer level
Adjusted Straw yield (t ha^{-1})	4.57	6.11	5.18	5.04	4.93	5.75	5.14	10% reduction
Income from straw yield (Rs.)	2285	3055	2590	2520	2465	2875	25.70	Rs.550 t^{-1}
Gross income (Rs.)	79085	105455	89790	86920	85265	99275	88970	
Herbicide cost (Rs.)	---	150	75	37.5	----	75	37.5	
Cost of sorgaab (Rs.)	---	----	---	----	80	80	80	Rs. Kg. sorghum herbage+boiling
Cost of sunflower W..E. (Rs.)	---	----	---	----	80	80	80	Rs. Kg. sunflower herbage+boiling
Cost of rice W.E. (Rs.)	---	----	----	----	80	80	80	Rs. Kg. rice herbage+boiling
Spray application cost (Rs.)	----	100	100	100	100	100	100	Rs.100/man/day/ha.
Sprayer Rent (Rs.)	----	50	50	50	50	50	50	Rs.50/spray
Total cost that vary (Rs.)	----	300	225	187.50	390	465	427.50	
Net benefits (Rs.)	79085	105155	89565	86732.50	84875	98810	88542.50	

Table IV
Marginal analysis.

Treatments	Total cost that vary	Net benefits	Marginal cost	Marginal net benefit	Marginal rate of reduction (%)
T_1	0	79085	-----	----	----
T_4	187.5	86732.50	187.5	7647.5	4078.66
T_3	225	89565	37.5	2832.5	7553.33
T_2	300	105155	75	15590	20786.66
T_5	390	84875	-----	-----	D
T_7	427.5	88542.50	-----	-----	D
T_6	465	98810	------	-----	D

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