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POTENTIAL APPLICATION OF A CROP EXTRACT FOR WEED SUPPRESSION AS AN ALTERNATIVE FOR CHEMICAL WEED CONTROL IN RICE

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ABSTRACT

An experiment was conducted to assess the feasibility of using a crop extract (bio-herbicide) as an alternative for chemical weed control in rice. The sorghum water extract, used in this experiment, was prepared by soaking sorghum leaves in distilled water in a ratio of 1:5 for 36 h. It was then filtered to collect the extract. After seed bed preparation, seedlings of IR-6 rice were transplanted into the field using a randomized complete block design with four replications. The data showed that hand weeding treatment recorded the maximum fresh and dry weed biomass. Application of half dose of weedicide ryzelan + half dose of sorghum water extract (sorgaab) produced the maximum number of tillers, panicles and normal kernels. The use of sorghum water extract, alone and in combination with commercial herbicide, produced lower fresh and dry weed biomass than the weedy check and hand weeding treatments. Similarly, the maximum number of spikelets, 1000-grain weight and paddy yield were also obtained in sorghum water extract treatment. Based on the results, it is concluded that the crop extract can be safely used as a bio-herbicide for controlling weeds and obtaining higher yield of rice.

Key words: Rice, weeds, crop water extract, weedicide, hand weeding

INTRODUCTION

Rice (*Oryza sativa* L.) is a main source of nourishment for over half the world's population. Calories from rice are particularly important in Asia, especially among the poor, where it accounts for 50-80% of daily caloric intake. In Asia, about 57% of rice is grown on irrigated land, 25% on rain-fed lowland, 10% on the uplands, 6% in deepwater, and 2% in tidal wet lands.

The annual production of rice in Pakistan is 55 million tons, of which Khyber Pakhtunkhwa (KPK) province contributes 0.128 million tons. The total annual rice cultivated area in the country is 2.5 millions hectares and in KPK 61.7 thousand hectares with an average yield of 2212 kg ha^{-1} (Ministry of Agriculture Pakistan, 2008).

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Rice is grown under diverse climatic and edaphic conditions in Pakistan, from the temperate zones of Swat at high altitudes in mountain valleys to warmer areas of Sindh and Punjab. However, the yield obtained on farmers' fields is low in most parts of the country, including Dera Ismail Khan district, on account of water shortage, high costs of inputs, non-availability of skilled labour during peak planting season, sub-optimal plant population, weeds and pest infestation, high dependence of knowledge on nearby growers and low price of rice in the local market (Baloch *et al*., 2004).

In South East Asia, weeds cause yield losses of 10-46% and occasionally up to 100% in rice. Hand weeding is the most common method of weed control in rice in Pakistan. However it is labour intensive and expensive. The use of mechanical weed control is limited to transplanted rice. Herbicides may provide very good control of weeds in rice. However, they are expensive, and there are continuing concerns about their extensive use and environmental safety.

In this scenario, biological weed suppression appears to be the only viable alternative to reduce weed density to safe limits. In this method, leaf water extracts of allelopathic plants, such as sunflower, sorghum, tobacco, millet, soybean, rice and oat are used. These plants release toxins or allelochemicals to inhibit the growth of certain weeds during the crop cycle and thereby increase yields (Ata and Jamil, 2001; Anon, 2002; Labrada, 2008).

Khanh *et al*. (2007) reported that the synthetic herbicides may eliminate weeds, but their excessive use could adversely affect humans and environment. Thus, controlling weeds by biological methods can alleviate the heavy dependence on synthetic agrochemicals and result in more sustainable agriculture.

Irshad and Cheema *et al*. (2005) reported that sorghum water extract is a good alternative for chemical weed control in rice, and reduced the biomass of barnyard grass by up to 41% compared to an untreated control.

Earlier research work (Jensen *et al*., 2008; Tanveer *et al*., 2008; Tesio *et al*., 2008) has provided a broad understanding for initiation of the present studies on application of bio-herbicides activities for chemical weed control in rice. The objective of the current research was to investigate the effect of sorghum water extract as an alternative for chemical weed control in rice.

MATERIALS AND METHODS

The experiment was conducted at the Agricultural Research Institute, Dera Ismail Khan (31º49˙ N, 70°55˙ E), Pakistan. Soil at the experimental site was silty clay, pH = 8 and organic matter content 0.68%. Electrical conductivity in soil was 400 Ec x 10^{-6}

(dS/m). Table 1 shows the climatic situation during the crop growth season. The experiment was laid out in a randomized complete block design with four replications. The net plot size was 1.8 m x 5 m, with rows 20 cm apart.

The recommended dose of Ryzelan ® (Penoxulam @ 30 mL a.i.ha^{-1}) was applied 15 days after transplanting. This herbicide was introduced by Dow Agro Sciences (USA) for controlling broadleaf and annual grasses in rice.

The sorghum water extract for testing (sorgaab) was prepared by soaking sorghum leaves in distilled water in a ratio of 1:5 for 36 h. It was then filtered to collect the extract.

Weed control treatments in the rice plots included the following:

T_1: Weedy check (untreated control)
T_2: Ryzelan (full recommended dose 30 mL ha^{-1})
T_3: Sorghum water extracts (full recommended dose 15 L ha^{-1})
T_4: Ryzelan (15 mL ha^{-1}) + sorghum extract (7.5 L ha^{-1})
T_5: Hand weeding (50 DAT)

After proper seed bed preparation, seedlings of rice cv. IR-6 were transplanted in the middle of June. Fertilizers were applied @ 120:90:60 NPK kg/ha. Half the nitrogen with the full dose of potash and phosphorus were applied at seed bed preparation, and the remaining half dose of nitrogen was applied in two equal portions 25 and 45 days after transplantation (DAT). Data were recorded for the number of tillers (m^{-2}), number of panicles (m^{-2}), number of spikelets ($panicle^{-1}$), normal kernel (%), 1000-grain weight (g), and paddy yield (t ha^{-1}). The data obtained were analyzed statistically using the analysis of variance technique. The significant means were separated using the least significant difference test (Steel and Torrie, 1980).

Table-1. Meteorological data recorded at the Agricultural Research Institute, Dera Ismail Khan, during 2009.

Month	Temperature (^{0}C)		Relative Humidity		Rainfall (mm)
	Max:	Min:	0800 Hrs.	1400 Hrs.	
May	42	24	69	35	29
June	42	27	60	34	10
July	20	27	66	37	--
August	39	27	67	38	5
September	34	22	64	37	21
October	32	17	63	40	11

RESULTS AND DISCUSSION

Fresh and dry weed biomass (g)

Data on fresh weed biomass are presented in Table-2, which showed that fresh weed biomass was not significantly affected by weed management practices. However, among treatments, there was a visible difference where T_5 had the maximum (132.7 g) fresh weed biomass of common sedges including purple nutsedge (*Cyperus rotundus* L.), umbrella sedge (*Cyperus iria* L.), small-flowered umbrella plant (*Cyperus difformis* L.), and grasses viz. bermuda grass [*Cynodon dactylon* (L.) Pers.], jungle rice [*Echinochloa colona* (L.) Link.] and barnyard grass [*Echinochloa crus-galli* (L.) Beauv] as compared to T_4 (81.68 g). This might be the interactive effect of both ryzelan and sorghum water extract. The results are similar to those of Cheema *et al.* (2002), who applied sorghum water extract and recorded minimum fresh weed biomass. Similarly, Parvis and Jessop (1985) found sorghum water extract successfully inhibited the growth of wheat weeds.

Data on dry weed biomass are shown in Table-2. The data showed non-significant difference among weed management practices. Treatment T_5 recorded the maximum (36.92 g) dry weed biomass while T_3 showed minimum dry weed biomass. The results are similar to those of Cheema *et al.* (2002), who found that dry weed biomass was successfully reduced in plots which received a sorghum water extract.
Khaliq *et al.* (2002) also recorded that a combination of a herbicide and sorghum water extract, in their case, Metolachlor + sorgaab, and pendimethalin + sorgaab, reduced weed dry weight by 78 and 75%, respectively. Anwar *et al.* (2004) also reported that the use of sorghum water extract not only reduced weed number and weed weight but also improved fresh and dry weight of crop.

Table-2. Effect of weed management practices on fresh and dry weed biomass in rice.

Treatment		Fresh weed biomass (g)	Dry weed biomass (g)
T_1	Weedy check	113.4^{NS}	27.32^{NS}
T_2	Ryzelan (30 mL ha^{-1})	86.29	22.93
T_3	Sorghum water extract (15 L ha^{-1})	97.90	21.89
T_4	Ryzelan (15 mL ha^{-1}) + Sorghum water extract (7.5 L ha^{-1})	81.68	24.09
T_5	Hand weeding (50 days after transplanting)	132.7	36.92

NS = Non-significant

Number of tillers (m^{-2})

Data revealed that weed management practices had significant effect on number of tillers (Table-3). It is obvious from the data that the maximum number of tillers (358.5) was recorded in T_4 followed by T_5 (329.0). However, the results were not statistically different in both the treatments. The minimum number of tillers (284.3) was recorded in the weedy check due to higher weed density. The higher number of tillers in T_4 and T_5 was probably due to the increased availability of nutrients for the rice plants from reduced competition between crop plants and the weed flora.

The higher number of tillers in T_4 indicated that the use of herbicide plus a reduced concentration of bio-herbicide could increase the number of tillers in rice. These findings agree with Cheema *et al.* (2003), who obtained increased number of tillers when herbicide was applied in combination with natural allelopathic water extract (sorgaab).

Number of panicles (m^{-2})

The number of panicles was significantly affected by weed management practices (Table-3). The highest number of panicles was obtained in T_4 (360.8) whereas the weedy check produced the lowest number of panicles (257.3). The higher number of panicles in T_4 (half dose of ryzelan with half dose of sorghum water extract) suggested that the combination of ryzelan plus sorghum water extract was as effective as the application of the herbicide alone.

Number of spikelets ($panicle^{-1}$)

Data on the number of spikelets are presented in Table-3, and revealed that weed management practices had a significant impact on number of spikelets. The maximum number of spikelets (157.8) was recorded in T_3 (sorghum water extract), which was not statistically different from T_2 (full dose of ryzelan). This demonstrates that sorghum water extract is a good alternative for chemical weed control in rice. The minimum number of spikelets (135.1) was obtained in the weedy check.

The higher number of spikelets recorded in the sorghum water extract treatment demonstrated that the use of this bio-herbicide is potentially a good alternative for chemical weed control and can result in increased number of spikelets in rice. The weedy check treatment gave the minimum number of spikelets probably due to higher weed population. The results are similar to those of Irshad and Cheema *et al*. (2005), who also reported that sorghum water extract significantly reduced barnyard grass as compared to weedy check, and led to maximum number of spikelets.

Normal kernel (%)

The data pertaining to normal kernels are given in Table-3, and shows a higher percentage of normal kernels in T_4, but not statistically different from T_1 and T_2. The lowest normal kernel percentage was recorded in T_5.

Table-3. Effect of weed management practices on plant characteristics of rice.

Treatment	Tillers /m²	Panicles /m²	Spikelets /panicle	Normal kernels (%)	1000-grain weight (g)	Paddy yield (t/ha)
T_1 Weedy check	284.3 c	257.3 d	135.1 b	75.00 a	25.61 b	5.988^{NS}
T_2 Ryzelan (30 mL/ha)	309.5 bc	298.8 c	154.0 a	74.75 a	24.64 b	6.637
T_3 Sorghum water extract (15 L/ha)	318.8 bc	317.5 bc	157.8 a	73.50 ab	27.60 a	6.738
T_4 Ryzelan (15 mL/ha) + Sorghum water extract (7.5 L/ha)	358.5 a	360.8 a	148.2 ab	75.50 a	25.38 b	6.238
T_5 Hand weeding (50 days after transplanting)	329.0 ab	330.0 b	141.9 ab	70.25 b	23.94 b	6.262
$LSD_{0.05}$	34.77	28.39	18.77	4.428	1.760	---

Means followed by different letter(s) in a column are significant at 5% level of probability. NS = Non-significant.

The higher normal kernels recorded in T_4 indicated that the application of bio-herbicide along with commercial herbicide is a useful proposition for increasing normal kernels in rice. The use of sorghum water extract alone gave comparatively fewer normal kernels, that is, the use of sorghum water extract alone had a reduced positive effect on kernel production.

1000-grain weight (g)

Data on 1000-grain weight of paddy as affected by different weed control treatments are presented in Table 3. Grain weight is the key to higher yield. Analysis of the data revealed that weed control treatments had significant effect on grain weight. All weed control treatments significantly increased grain weight; however, T_3 recorded the maximum (27.60g) grain weight. Minimum grain weight (23.94 g) was obtained from hand weeding. The weedy check (25.61 g), full dose of ryzelan (24.64 g) and half dose of ryzelan plus half dose of sorghum water extract (25.38g) were not statistically different.

The higher grain weight recorded from the sorghum water extract might be due to presence of essential nutrients which significantly increased spike density and resulted in higher grain weight. Xuan *et al.* (2004) reported that many plant water extracts successfully enhanced the 1000- grain weight of rice. Similar results were obtained by Salisbury and Ross (1978), who found that sorghum extract increased grain weight of maize by suppressing the vegetative growth.

Paddy yield (t/ha)

Data recorded on paddy yield are presented in Table 3. The use of different weed control treatments had no significant effect on paddy yield. Among treatments, weedy check recorded the minimum (5.988 t/ha) paddy yield while the maximum (6.738 t/ha) was produced in the sorghum extract treatment. These results agree with Cheema *et al.* (1997), who showed that increasing the concentration of sorghum extract from 50% to 100% improved the yield by 14%.

The increased yield might be due to the fact that all yield components were higher in plants treated with herbicide and sorghum water extract. The likely reason for high paddy yield in the different weed control treatment might be the increased availability of nutrients and the reduced competition which stimulated vegetative growth and resulted in better spike population and more grains spike^{-1} and ultimately higher paddy yield.

CONCLUSIONS

This paper suggests that the application of allelopathic crop water extracts not only reduces the reliance on synthetic herbicides but can also reduce their indiscriminate use. The application of sorghum water extract alone or in combination with a 50% reduced dose of ryzelan was found to be the best treatment for suppressing weeds and producing higher paddy yield. Reduced herbicide doses, in combination with allelopathic crop water extracts, also minimize the cost of production thereby increasing the farm income.

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