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Studies on the sensitivity of Azolla species to rice herbicides

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Abstract: Laboratory and green house experiments were conducted during 2002 to find out the sensitivity of different Azolla species to rice herbicides. From the screening experiment in the laboratory, three herbicides *viz.* anilofos 0.4 kg ha^{-1}, butachlor 1.25 kg ha^{-1} and clomazone 0.3 kg ha^{-1} and four species of Azolla *viz., A. microphylla, A. filiculoides,* TNAU hybrid and Rong Ping hybrid at 500 kg ha^{-1} were chosen and compared independently and in different combinations in the pot culture experiment. Rice var. CO 47 was raised under green house conditions and the experiment was carried out under FRBD with 3 replications. The growth, yield and yield parameters were recorded after imposing the treatments. The results revealed that combination of clomazone 0.3 kg ha^{-1} and *A. microphylla* performed significantly superior with respect to plant growth, yield attributes and yield. Among the herbicides tried, clomazone application at 03 kg ha^{-1} showed an increase in plant growth characters, yield attributes and yield. Between the individual Azolla species, *A. microphylla* recorded the highest grain yield and was on par with *A. filiculoides.*

Key words : Clomazone, Azolla species, Growth, Yield parameters, Yield.

Introduction

Worldwide, India stands first in rice area with 43 million hectare and second in rice production (199 million tonnes), after China (Anon, 2001) contributing 31.0 per cent of global rice production (Brar and Walia, 2001). Demand for rice is increasing and an additional 300 million tonnes per year has to be produced by 2025 (Swaminathan, 1998). Approaches to achieve this demand include expanding the rice area (horizontal expansion) increasing the yield (vertical expansion), shrinking the yield gap and reducing yield losses. Weed infestation is one of the major constraints responsible for low yields of rice in India. Several studies conducted in India and abroad indicate that weed incidence in low land situation accounts for a yield loss of 11-12 per cent in transplanted rice (Ghosh and Moorthy, 1998). Reliance on herbicides for weed control is expected to continue because there is no other attractive superior technology available (Singh and Bhan, 1998).

Azolla is a free floating aquatic fern that assimilates nitrogen in symbiotic association with the cyanobacterial symbiont, *Anabaena Azolla.* Biological nitrogen fixation (BNF) through *Azolla-Anabaena* complex could contribute 40-60 kg N ha^{-1} in one crop of rice and is considered to be a potential biological system for increasing rice yield at comparatively low cost in lowland rice cultivation. The important factor in using *Azolla* as biofertilizer for rice crop, is its quick decomposition in soil and better availability of nitrogen. Britto and Seethalakshmi (2002) reported that increased concentration of 2,4-D decreased the biomass and chlorophyll content of two *Azolla* species *viz. A. microphylla* and *A. filculoites.*

The integration of Azolla and herbicides in rice cultivation was found to be superior over other treatments, which registered the synergistic interaction or improved weed reduction or yield increment when used in combination (Kathiresan *et al.* 2002). Hence the present investigation was undertaken to study the sensitivity of Azolla species to rice herbicides.

Materials and Methods

A laboratory study was carried out for fixing the treatment combination for pot culture experiment, by using five herbicides (anilofos, butachlor, clomazone, 2,4-D and metsulfuran methyl) at recommended (x) and double the recommended (2x) dose compared with control and with four species of Azolla grown under water (50 ml water + 0.5 g *Azolla*) and soil

Table 1. Effect of herbicides and Azolla speices on biomass (g) grown under water and soil medium

Treatment details		Water medium				Soil medium			
		Control	Normal dose	Higher dose	Mean	Control	Normal dose	Higher dose	Mean
Herbicide									
H_1 Anilofos	a_1	0.230	0.450	0.540	0.407	0.645	0.630	0.605	0.627
	a_2	0.690	0.840	0.695	0.742	0.670	0.665	0.760	0.698
	a_3	0.500	0.430	0.580	0.503	0.630	0.635	0.585	0.617
	a_4	0.505	0.635	0.840	0.660	0.795	0.580	0.765	0.713
	Mean	0.481	0.589	0.664		0.685	0.627	0.679	
H_2 Butachlor	a_1	0.235	0.535	0.475	0.415	0.740	0.970	0.480	0.730
	a_2	0.740	0.825	0.655	0.740	0.725	0.785	0.515	0.675
	a_3	0.595	0.495	0.535	0.542	0.740	0.765	0.705	0.737
	a_4	0.830	0.585	0.770	0.728	0.690	0.740	0.535	0.655
	Mean	0.600	0.610	0.609		0.724	0.815	0.559	
H_3 Clomazone	a_1	0.330	0.460	0.565	0.452	0.500	0.480	0.675	0.552
	a_2	1.045	0.580	0.685	0.770	0.830	0.625	0.580	0.678
	a_3	0.650	0.425	0.485	0.520	0.950	0.670	0.640	0.753
	a_4	0.590	0.870	0.680	0.713	0.670	0.565	0.830	0.688
	Mean	0.654	0.584	0.604		0.737	0.585	0.681	
H_4 2,4-D	a_1	0.180	0.370	0.495	0.348	0.880	0.630	0.695	0.735
	a_2	0.785	0.565	0.705	0.685	0.780	0.735	0.695	0.737
	a_3	0.535	0.570	0.785	0.630	0.325	0.590	0.615	0.510
	a_4	0.625	0.545	0.810	0.660	0.780	0.525	0.875	0.727
	Mean	0.531	0.512	0.699		0.691	0.620	0.720	
H_5 Metasul-furan methyl	a_1	0.335	0.500	0.570	0.468	0.275	0.775	0.995	0.682
	a_2	0.645	0.660	0.775	0.693	0.270	0.975	0.525	0.590
	a_3	0.435	0.505	0.480	0.473	0.485	0.630	0.540	0.557
	a_4	0.545	0.640	0.880	0.688	0.675	0.690	0.735	0.700
	Mean	0.490	0.576	0.676		0.426	0.767	0.699	

	Water SEd	Water CD (0.05)	Soil SEd	Soil CD (0.05)
H	0.006	0.012	0.015	0.029
a	0.005	0.010	0.013	0.026
d	0.005	0.009	0.011	0.023
Ha	0.012	0.014	0.029	0.058
ad	0.009	0.018	0.023	0.045
Hd	0.010	0.020	0.025	0.051
Had	0.020	0.041	0.051	0.101

a_1 - A. microphylla, a_2 - A. filculoides, a_3 - TNAU hybrid, a_4 - Rong Ping hybrid

(20 g soil + 50 ml water + 0.5 g *Azolla*) medium in petri plates with two replications. From the screening study, three herbicides (anilofos, butachlor, clomazone) with four species of *Azolla* were screened for pot culture experiment. Pot culture experiment was conducted during February 2002 at Department of Soil Science and Agricultural Chemistry, TNAU, Coimbatore with CO-47 cultiva of rice in FRBD with three replications. Th treatments include the three selected herbicide at recommended and double the recommende doses and four Azolla species at 500 kg ha alone and in combination constituting twent treatments. Common recommended fertilizer dos

Table 2. Effect of herbicides and Azolla species on plant growth characters

Treatment	Plant height (cm)											
	Active tillering stage						Flowering stage					
	a_1	a_2	a_3	a_4	a_5	Mean	a_1	a_2	a_3	a_4	a_5	Mean
H_1	49.50	53.50	53.20	51.40	51.20	51.76	74.20	82.40	82.10	80.00	80.20	79.78
H_2	48.90	52.60	52.20	51.40	50.33	51.08	73.40	81.60	81.00	80.40	79.80	79.24
H_3	50.10	57.03	56.20	55.00	54.10	54.48	76.00	85.20	84.80	83.90	83.20	82.62
H_4	45.80	48.20	48.06	47.30	47.00	47.27	68.40	72.80	72.50	71.00	70.10	70.96
Mean	48.57	52.83	52.41	51.27	50.65		73.00	80.50	80.10	78.82	78.32	
		H		a		Ha		H		a		Ha
SEd		0.29		0.33		0.66		0.21		0.24		0.48
CD (0.05)		0.60		0.67		1.35		0.43		0.49		0.97
	Number of tillers						Number of productive tillers					
H_1	4.66	6.80	6.66	5.66	5.90	5.94	4.66	5.66	6.00	6.00	6.33	5.73
H_2	4.70	6.20	6.20	5.80	6.00	5.78	4.66	5.66.	5.66	5.66	4.66	5.26
H_3	5.50	7.50	7.40	7.00	7.10	6.90	4.66	8.00	8.00	7.33	5.66	6.73
H_4	4.20	4.90	4.70	4.60	4.50	4.58	3.00	4.66	4.33	4.00	3.00	3.80
Mean	4.76	6.35	6.24	5.76	5.87		4.25	6.00	6.00	5.75	4.91	
		H		a		Ha		H		a		Ha
SEd		0.16		0.18		0.36		0.55		0.62		1.24
CD (0.05)		0.32		0.36		0.73		1.12		1.26		2.52

H_1 - Anilofos 0.4 kg ha^{-1} H_2 - Butachlor 1.25 kg ha^{-1} H_3 - Clomazone 0.3 kg ha^{-1} H_4 - Control

a_1 - Control a_2 - *A. microphylla* a_3 - *A. filculoides* a_4 - TNAU hybrid a_5 - Rong Ping hybrid

was applied (120:38: 38 kg ha^{-1}) to all the treatments.

The experimental soil was moderately alklaine in reaction (pH 8.0) and low in soluble salt content (EC < 0.45 dSm^{-1}). The available nitrogen status was low with medium available P and K. To assess the sensitivity of *Azolla* species to rice herbicides, plant growth parameters, yield attributes and yield were recorded.

Results and Discussion

Sensitivity of Azolla to herbicides

Significant effect of herbicides on Azolla species on biomass (g) grown under water and soil medium were found out through screening study. Among the herbicides butachlor and clomazone performed well and were on par with each other followed by anilofs, 2,4-D and metsulfuran methyl (Table 1). Hence, three herbicides *viz.* anilofos, butachlor and clomazone were selected for pot culture study. Among the *Azolla* species all the four species performed well and are tolerant to

Table 3. Effect of herbicides and *Azolla* speices on yield and yield attributes

Treatment	Panicle length (cm)						100 grain weight (g)					
	a_1	a_2	a_3	a_4	a_5	Mean	a_1	a_2	a_3	a_4	a_5	Mean
H_1	20.60	22.66	22.40	21.33	21.13	21.62	1.44	1.54	1.52	1.48	1.45	1.48
H_2	20.36	22.16	21.73	21.40	20.46	21.22	1.47	1.50	1.49	1.44	1.44	1.47
H_3	20.43	25.26	23.23	23.23	22.86	23.00	1.44	1.64	1.59	1.56	1.52	1.55
H_4	17.16	18.46	18.50	18.36	18.23	18.14	0.92	1.41	1.39	1.36	1.33	1.28
Mean	19.64	22.14	21.46	21.08	20.67		1.32	1.52	1.50	1.46	1.43	
	H		a		Ha		H		a		Ha	
SEd	0.37		0.42		0.84		0.02		0.02		0.05	
CD (0.05)	0.76		0.85		1.71		0.04		0.05		0.10	
	Straw yield (g/pot)						Grain yield (g/pot)					
H_1	96.66	120.00	113.33	108.33	105.00	108.66	40.00	53.33	51.66	50.00	50.00	49.00
H_2	95.00	111.66	111.66	103.33	103.33	105.00	40.00	51.66	50.00	50.00	48.33	48.00
H_3	100.00	145.00	128.33	125.00	125.00	124.66	41.66	55.00	55.00	53.33	53.33	51.66
H_4	93.33	91.66	90.00	81.66	80.00	87.33	23.30	38.33	38.33	36.66	28.33	32.99
Mean	96.25	117.08	110.83	104.58	103.33		36.24	49.58	48.75	47.50	45.00	
	H		a		Ha		H		a		Ha	
SEd	4.49		5.02		10.05		2.99		3.35		6.70	
CD (0.05)	9.09		10.17		20.34		6.06		6.78		13.56	

H_1 - Anilofos 0.4 kg ha^{-1} H_2 - Butachlor 1.25 kg ha^{-1} H_3 - Clomazone 0.3 kg ha^{-1} H_4 - Control
a_1 - Control a_2 - *A. microphylla* a_3 - *A. filculoides* a_4 - TNAU hybrid a_5 - Rong Ping hybrid

herbicides without any ill effects on its growth. So all the species of *Azolla* were chosen for pot culture experiment. The results of screening study showed that in higher dose of herbicides on the four *Azolla* species were able to survive but the growth was good only in recommended dose. Hence, recommended doses were selected fo pot culture experiment

The results o growth and yield para meters due to the effec of combination o herbicides with *Azoll* are presented in Table 2 and 3.

Effect on plant growt characters

Plant height (cm)

Significant diff rences in plant heigl at different stages wer observed due to variou treatments. At tillerin stage among the herb cides tried, clomazor at 0.3 kg ha^{-1} recorde the highest plant heig (54.5 cm) followed l anilofos at 0.4 kg h (51.7 cm). Regardi the *Azolla* sp. the highe plant height w observed in *A. micr phylla* and was fou to be on par wi *A.filculoites*. The inte action effect was al significant among t treatments. The high plant height was obs ved in (clomazone

A. microphylla) (57.0 cm) and this was on par with (clomazone + *A. filculoites*). The lowest plant height was observed in absolute control (48.6 cm). Similar results were observed in flowering stage.

Number of tillers

On perusal of the data, the number of tillers was in the range of 4.2 to 7.3. The maximum number of tillers were observed in clomazone applied pot (6.9) and among the *Azolla* species, *A. microphylla* recorded the highest number of tillers (6.3). The interaction effect was found to be non-significant. At flowering stage, significant effect due to interaction was observed among herbicides and *Azolla* species. The treatment which received clomazone + *A. microphylla* recorded the highest number of tillers (12.0) and the lowest was found in absolute control (7.0).

The data on productive tillers showed significant effect of treatments. The highest productive tillers were observed (6.7) in clomazone at 0.3 kg ha^{-1} followed by (5.7) anilofos at 0.4 kg ha^{-1}. Among the Azolla species, the highest number of productive tillers were observed in *A. microphylla* (6.0). The interaction effect was non-significant among the herbicides and *Azolla*.

Yield Attributes

The various treatments significantly influenced the yield attributes (Table 3). The highest panicle length and test weight were recorded in clomazone applied pots (23.0 cm, 1.55 g). Among the *Azolla* species, *Azolla microphylla* recorded the highest panicle length and test weight (22.1 cm, 1.52 g). The highest panicle length and test weight was observed in clomazone + *A. microphylla* followed by clomazone + *A. filiculoides*.

Yield

The grain and straw yields ranged from 23.3 to 55.0 g pot^{-1} and from 93 to 145 g pot^{-1} respectively. The lowest yield was observed in absolute control. The maximum grain and straw yield was observed in clomazone + *A. microphylla* (55.0 g). The concomitant use of herbicides + *Azolla* may augment the grain yield by protecting the crop from weeds and probably by increasing the N fixation by *Azolla* species. The results of *Azolla* inoculation improving rice yields are in consonance with the reports of Nazeer and Prasad (1984) and Singh and Singh (1995). Among the herbicides tried, clomazone at 0.3 kg ha^{-1} increased the grain yield.

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