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Effect of pre-emergence herbicides on weed growth and physiological traits of transplanted rice

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ABSTRACT

Weed management practices in rice consisted of weedy check, hand weeding at 30 and 60 DAT, butachlorat 1.5 kg/ha and anilofos at 0.5 kg/ha. The experiment was part of a long term trial in rice – wheat cropping system conducted in a split plot design with three replications. Data on weed dry weight, crop growth and yield parameters were recorded at different growth stages. Herbicides were effective in reducing the growth of several weeds and improving the physiological status of the crop. Hand weeding twice recorded lowest weed dry weight at both 60 and 90 DAT during both the years (7.44 and 13.64g/m^2, respectively). Butachlor and anilofos treatments recorded lower weed dry weight at 60 and 90 DAT as compared to weedy plot. Physiological parameters such as chlorophyll content and photosynthetic rate of the crop were higher in the herbicide treatments.

Key words: Herbicides, Physiological traits, Weed growth

Rice-wheat cropping system (RWS) is one of the widely practised cropping systems in India occupying an area of about 12.33 mha. About 10 mha of this land is in the Indo-Gangetic plains and represents about 75% of the total area under rice cultivation (Prasad and Nagarajan 2004). In spite of a huge cultivated land and large food value, the productivity of rice in the country is quite low (2.8 t/ ha) as against world average (3.9 t/ha). Proliferation of weeds is one such limiting factors that may show manifold negative effects (Singh *et al.* 2013). A poor weed control can affect the crop yield, weed flora and their intensity (Peer *et al.* 2013). Rice growers use different pre- and post-emergence herbicides to manage weeds. There is very little information on the effects of herbicides on these parameters. Therefore, the present investigation was carried out to evaluate the effects of herbicides applied in rice on some physiological attributes as well as their effect on weed and crop yield.

MATERIALS AND METHODS

The field study was conducted during the rainy seasons of 2009 and 2010 at the N. E. Borlaug Crop Research Centre, G B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India. Geographically, the site lies in Tarai plains about 30 km southwards of foothills of Shivalik range of the Himalayas at 29° N latitude, 79° 29'E longitude and at an altitude of 243 meter above the mean sea level. The experimental plot had a sandy loam textured soil. Experiment was laid out in split plot design with four treatments as main plot treatments in rice-while wheat treatments constituted the sub-plot treatments. Treatments in rice crop consisted of weedy check, hand weeding twice at 30 and 60 DAT, butachlor at 1.5 kg kg/ha and anilofos at 0.5 kg/ha. The herbicides were applied three days after transplanting. The rice variety used was '*Narendra 359*'.

The weed flora was recorded at 30, 60 and 90 days after transplanting (DAT) and their dry weights were recorded subsequently. The leaf area of rice was measured by using a portable leaf area meter (LiCOR LI-3000A) at 30, 45 and 60 DAT and was expressed as cm^2/plant and the leaf area index was calculated by the method of Palanisamy and Gomez, (1974). Plant height, tiller numbers and crop dry matter (g/plant) were recorded at different growth stages (30, 45, 60, 75, 90 DAT). Specific leaf weight and relative leaf area growth rate were calculated from 30 to 60 DAT. Leaf area index, leaf area (cm^2/ plant), leaf area ratio were calculated at 30, 45 and 60 DAT. Net photosynthetic rate (P_n) of rice leaves was measured 24 hrs after herbicide spraying from each plot by Infra Red Gas Analyzer (IRGA) (TPS-2, PP system, USA). Chlorophyll estimation was done according to Hiscox and Israelstam, (1979). Biological yield and grain yield of rice from each plot were recorded at harvest. The means were tested at $P > 0.05$ by using split plot design. The data on main plots are presented in the tables and discussed.

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RESULTS AND DISCUSSION

Crop establishment considerably varied during different years. In the first week after transplanting in 2009, the experimental field received maximum 77.6 mm of rainfall while in 2010, it was 396mm. Average weed density, four weeks after transplanting was higher in 2010 than 2009. The high weed density observed during 2010 was the result of excess rainfall. The temperature ranged normal until harvest during both the years.

Weed flora and dry weight

The weed density was recorded at different growth stages, *viz.* 30, 60 and 90 DAT. The weed flora consisted of grasses, sedges and broad-leaf weeds. Major grasses included *Echinochloa crusgalli, Echinochloa colona, Leptochloa chinensis* and *Paspalum distichum* while the broad-leaf weeds were *Caesulia axillaris, Alternanthera sessilis* and *Ammenia* spp. Among the sedges, *Cyperus iria* and *Cyperus difformis* were the dominant species. Hand weeding treatment recorded distinctly lower weed dry weight at all the growth stages. Both the herbicide treatments (butachlor and anilofos) recorded significantly lower weed dry weight at 30 and 60 DAT as compared to weedy plot (Table 1).

Table 1. Weed dry weight at different growth stages in rice under different weed management practices in a rice- wheat cropping system (pooled data of two years)

Treatment	Weed dry weight (g/m²)		
	30 DAT	60 DAT	90 DAT
Weedy check	21.47	44.86	36.07
Hand weeding (30, 60 DAT)	20.34	7.44	13.64
Butachlor (1.5 kg/ha)	16.53	32.25	29.15
Anilofos (0.5 kg/ha)	20.85	23.28	31.24
LSD (P=0.05)	3.92	9.43	9.25

Leaf area, leaf area index and leaf area ratio of rice crop

Leaf area differed significantly among all rice treatments and gradually increased up to 60 DAT. At 30 and 45 DAT, significantly higher leaf area and leaf area index was observed in anilofos treated plot while butachlor and hand weeding recorded statistically similar leaf area. At 60 DAT, higher leaf area and leaf area index was recorded in hand weeding and both the herbicides recorded statistically similar leaf area and leaf area index (Table 2). Leaf area ratio of rice (LAR) was higher at 45 DAT among all the growth stages and decreased at 60 DAT (Table 2). At all the growth stages, hand weeding recorded significantly lower LAR.

Plant height and tiller number

Plant height increased from 30 DAT up to harvest but there was no significant difference in plant height among the treatments (Table 3). Tiller number gradually increased from 30 to 60 DAT and declined thereafter. At 60 and 75 DAT, number of tillers was similar in all the treatments but productive tillers (at 90 DAT) were significantly higher in hand weeding and was at par with butachlor (Table 4).

Table 3. Plant height at different growth stages under different weed management practices in rice-wheat cropping system (pooled data of 2 years)

Treatment	Plant height (cm) at different days after transplanting				
	30	45	60	75	90
Weedy check	62.67	74.51	91.79	102.7	103.3
Hand weeding (30, 60 DAT)	63.61	77.44	93.57	103.3	104.8
Butachlor (1.5 kg/ha)	63.31	76.34	92.87	103.5	104.1
Anilofos (0.5 kg/ha)	62.27	74.62	93.33	103.5	103.9
LSD (P=0.05)	NS	NS	NS	NS	NS

Table 4. Tiller number at different growth stages under different weed management practices in a rice crop (pooled data of 2 years)

Treatment	Tiller number (per plant) at different days after transplanting				
	30	45	60	75	90*
Weedy check	9.17	10.78	12.39	12.96	7.69
Hand weeding (30, 60 DAT)	9.22	11.10	12.64	13.47	9.24
Butachlor (1.5 kg/ha)	9.20	11.19	12.93	12.93	8.79
Anilofos (0.5 kg/ha)	9.74	13.38	12.25	12.82	8.20
LSD (P=0.05)	NS	1.07	NS	NS	0.66

*Productive tillers

Table 2. Leaf area index, leaf area and leaf area ratio of rice under different weed management practices in a rice-wheat cropping system (pooled data of 2 years)

Treatment	Leaf area index			Leaf area (cm²/plant)			Leaf area ratio		
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT
Weedy check	1.31	3.47	5.96	393.3	1045.4	1803.8	13.25	23.50	13.65
Hand weeding (30, 60 DAT)	1.37	3.78	6.59	411.1	1134.8	1989.4	10.56	20.50	12.75
Butachlor (1.5 kg/ha)	1.38	3.65	6.37	412.8	1101.3	1914.1	13.68	23.11	13.15
Anilofos (0.5 kg/ha)	1.42	3.99	6.40	426.8	1194.5	1929.4	13.71	23.60	14.11
LSD (P=0.05)	0.01	0.02	0.05	3.9	16.4	15.8	0.18	0.17	0.20

Table 5. Crop dry weight (g/plant) at different growth stages under different method of weed management (pooled data of two years)

Treatment	Days after transplanting												
	30		45		60			75			90		
	Leaf	Culm	Leaf	Culm	Leaf	Culm	Ear	Leaf	Culm	Ear	Leaf	Culm	Ear
Weedy check	2.85	4.00	3.49	5.38	9.83	11.58	4.12	9.70	19.10	5.30	7.28	22.28	23.81
Hand weeding (30, 60 DAT)	3.76	4.59	4.92	6.13	11.90	14.93	4.51	10.22	22.36	5.46	8.76	26.46	31.09
Butachlor (1.5 kg/ha)	3.10	3.97	3.92	5.46	11.42	13.52	3.79	11.48	20.51	6.50	9.04	24.80	29.44
Anilofos (0.5 kg/ha)	3.10	4.08	4.02	5.79	9.85	13.50	3.61	10.78	19.44	4.81	9.23	26.17	25.60
LSD (P=0.05)	0.41	0.18	0.15	0.42	0.59	1.02	0.34	1.66	2.12	0.88	0.79	2.51	1.43

Table 6. Specific leaf weight, relative leaf area growth rate, photosynthetic rate and total chlorophyll of rice under different weed management practices in a rice-wheat cropping system (pooled data of 2 years)

Treatment	Specific leaf weight			Relative leaf area growth rate		Photosynthetic rate	Total chlorophyll (mg/g fr. Wt)
	30 DAT	45 DAT	60 DAT	30-45	45-60		
Weedy check	6.85	3.52	5.89	0.0281	0.0158	12.25	1.116
Hand weeding (30, 60 DAT)	9.48	4.67	6.21	0.0292	0.0163	16.04	1.367
Butachlor (1.5 kg/ha)	6.92	3.86	6.16	0.0280	0.0164	15.71	1.269
Anilofos (0.5 kg/ha)	6.72	3.53	5.27	0.0297	0.0140	14.71	1.228
LSD (P=0.05)	0.48	0.03	0.11	0.0003	0.00015	1.48	0.105

Crop dry weight (g/plant)

Crop dry weight was separated into leaf, culm and ear dry weight at different growth stages. Dry matter accumulation was found to be higher in between 30 to 60 DAT (Table 5). Crop dry weight was significantly higher in hand weeding at all the growth stages and lower in unweeded control.

Specific leaf weight, relative leaf area growth rate, net photosynthetic rate and total chlorophyll

Specific leaf weight of the rice was distinctly higher at 30 and 45 DAT in hand weeding. At 60 DAT, SLW was significantly higher and comparable in hand weeding and butachlor treatments (Table 6). Significant difference was recorded in P_n rate and chlorophyll content among the treatments (Table 6). Hand weeding and both the herbicide treatments recorded higher P_n rate over unweeded control. Hand weeding, being at par with butachlor, recorded significantly higher total chlorophyll content followed by anilofos. Distinctly lower chlorophyll content was recorded in unweeded control.

Biological yield and grain yield

Biological yield was significantly higher in butachlor and was comparable with anilofos and hand weeding. All the treatments recorded significantly higher biological yield and grain yield over weedy check. Hand weeding recorded significantly higher grain yield which was at par with butachlor and anilofos (Table 7).

Table 7. Biological and grain yield of rice under different weed management practices in a rice wheat cropping system (pooled data of 2 years)

Treatment	Biological yield (t/ha)	Grain yield (t/ha)
Weedy check	11.72	3.58
Hand weeding (30, 60 DAT)	13.62	4.27
Butachlor (1.5 kg/ha)	13.72	4.02
Anilofos (0.5 kg/ha)	13.30	3.91
LSD (P=0.05)	0.62	0.62

Leaf area was found to be positively correlated with total chlorophyll, biological yield and grain yield (Table 8). At the same time, it was noted that the positive correlation between the leaf area and leaf area index was highly significant. Similarly, leaf area index was positively correlated with total chlorophyll, biological yield and grain yield. A positive correlation was also established between leaf dry weight and leaf area index. Positive correlation of total chlorophyll was also found with grain yield.

Evaluating such attributes at different stages of a crops' life span gives us an idea about the initial stand establishment as well as of final crop yield. The present study therefore considered how different herbicide applications affected different aspects of growth and development of rice crop. Interestingly, they were found to be as effective as hand weeding in lessening the weed number. Leaf area and the associated indices are among the important growth parameters to study being suggestive of higher

Table 8. Correlation coefficient of total chlorophyll and photosynthetic rate with biological and grain yield

Characters	Leaf area index	Total chlorophyll	Biological yield	Grain yield
Leaf Area	0.998**	0.416ns	0.750ns	0.517ns
Leaf area index	-	0.503ns	0.517ns	0.537ns
Leaf dry weight	0.709ns	-	-	-
Total chlorophyll			0.870ns	0.999**

**on values = highly significant, *on values = significant correlation, ns = non-significant

photosynthetic efficiency of crop and eventually a greater yield (Channappagoudar *et al*. 2013a). A higher leaf area index (leaf area per unit ground area) implies a greater photon flux density (PFD) captured by canopy leading to higher chlorophyll content and photosynthetic production (Manzoor and Goutam 2014). Higher dry matter accumulation under weed management practices is also indicative of the better utilization of resources (Channappagoudar *et al*. 2013b).

The weed management practices in the present study decreased crop weed competition with enhanced availability of nutrients and there by increased the LAR, particularly at later growth stages of crop, which subsequently resulted in higher yield (Varshney *et al*. 2012). Data on grain yield and biological yield revealed that the herbicide treated plots were similar to that obtained from hand weeding.

This study conclusively revealed that the recommended dose of pre-emergence herbicides in rice have been found as effective as hand weeding in controlling the weeds without any phytotoxic effect on crop.

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