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Effect of nitrogen and weed-control practices on performance of irrigated direct-seeded rice (*Oryza sativa*)

KAYAM SINGH AND H.P. TRIPATHI*

Department of Agronomy, N.D. University of Agriculture and Technology, Kumarganj, Faizabad, Uttar Pradesh 224 229

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ABSTRACT

A field experiment was conducted during rainy (*kharif*) season of 2002 and 2003 at Faizabad in silty loam soil to study the effect of nitrogen and weed-control measures on weed growth and yield of direct-seeded rice (*Oryza sativa* L.). There was significant increase in grain and straw yields as well as yield attributes, viz. panicles/m^2 and test weight, with every increase in dose of N up to 120 kg/ha. The weed-control treatments significantly decreased the weed population, dry weight of weeds and weed index and increased the weed-control efficiency, panicles/m^2, grain yield and straw yield compared with the unweeded check. Application of anilofos @ 0.4 kg/ha + one hand-weeding at 30 days after sowing remained on a par with that of weed-free treatment for all the parameters, recording grain yield of 5.13 t/ha and weed-control efficiency of 85.27%. Weed infestation reduced the grain yield by 64.42 and 64.41% and removed N up to 63.94 and 53.27 kg/ha under unweeded check during the first and second year, respectively. There was response up to 120 kg N/ha in the well-managed weed-control plots.

Key word : Direct-seeded rice, Integrated weed management, N removal, Weed dynamics, Yield

Direct-seeded rice (*Oryza sativa* L.) is becoming popular as it is a cheaper alternative to transplanting. But crop-weed competition in the system is more severe, reducing the yield by 20-95% (Gogoi, 1995). Manual weeding is expensive, laborious and time consuming as well as difficult in early stage of crop growth. Use of pre-emergence herbicides has been found effective in early stage, but the second flush of weeds at 25-30 days after sowing (DAS) becomes problematic. Hence integrated weed-management practice is the only effective alternative. Moderate N rates (33-56 kg/ha) increase the crop yield independent of weed density, but higher doses increase the risk of yield loss due to increased weed competition (Cavero *et al.*, 1997). Therefore the present study was undertaken to find out an effective method of weed control at varied fertility levels in direct-seeded rice under irrigated conditions.

MATERIALS AND METHODS

The field experiment was conducted at Agronomy Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad during wet season of 2002 and 2003. The soil was silty loam, of low fertility status, having average organic C 0.45 per cent, available N 211 kg/ha, P 15 kg/ha and K 262 kg/ha, with pH 8. The experiment was laid out in split-plot design with four replications. The treatments comprised five N levels (0, 40, 80 120 and 160 kg N/ha) in main plots, and six weed-control measures (weed-free, hand-weeding at 20 and 40 DAS, hand-weeding at 30 DAS, anilofos @ 0.4 kg/ha at 10 DAS and anilofos @ 0.4 kg/ha at 10 DAS + 1 hand-weeding at 30 DAS) in subplots. Half the N as per treatment and full dose of P (26 kg/ha) and K (50 kg/ha) were applied at sowing in furrows at 4 cm below the seed and the remaining half dose of N was top-dressed in two equal splits at 30 DAS and at panicle-initiation stage. 'NDR 359' was sown on 7 July and harvested in the first fortnight of November during both the years. The total rainfall received during crop season was 691 and 823 mm in the first and second years respectively. The weed density (species-wise) and dry weight were recorded in each plot from randomly selected places (0.25 m^2) at 60 and 90 DAS. The data on weed density were transformed with the formula $\sqrt{X+1}$. The weed-control efficiency and weed index were calculated by the standard formulae.

***Corresponding author** (Email: hpt@india.com)

RESULTS AND DISCUSSION

Weed flora

During both the years the bulk of the weed flora consisted of *Echinochloa crus-galli* (L.) Beavu., *Echinochloa colonum* (L.) Link, *Eleusine indica* L., *Digitaria sanguinalis* (L.) Scop. and *Cynodon dactylon* among the grassy weeds; and *Eclipta alba* (L.) Hoesk, *Commelina benghalensis* L., *Amaranthus viridis* (L.), *Trianthema portulacastrum* (L.). *Celosia argenita*, *Casularia axilaris* L. among the broad-leaf weeds. Among sedges, *Cyperus rotundus*, *Cyperus iria* (L.) and *Fimbristylis miliacea* were present. Analysis of spectrum of weed flora revealed that grasses are more problematic, constituting 60%, followed by sedges (25%) and broad-leaf weeds (15%) among the weed population. Application of anilofos @ 0.4 kg/ha resulted in almost complete control of the grassy weeds and up to some extent of the sedges, but showed very little control of broad-leaf weeds during both the years. The results are in agreement with those of Vaishya and Singh (1988).

Weed population in the first year was higher than in the second year (Table 3), probably due to longer gap between rains during the early growth period in first year, which provided congenial atmosphere for weed growth. Nitrogen application increased the weed population significantly with increase in the dose up to 160 kg/ha, though the differenes between two successive levels were not significant (Table 3). Amongst weed-control measures, anilofos @ 0.4 kg/ha + 1 hand-weeding at 30 DAS significantly lowered the population of total weeds compared with hand-weeding once and anilofos @ 0.4 kg/ha.

Weed-control efficiency

The dry weight of weeds increased significantly with increase in the dose of nitrogen up to 160 kg/ha, though the differences between two successive levels were not significant. The maximum dry weight of weeds was recorded with 160 kg N/ha (61.61 and 44.55 g/m^2), which was more than double that recorded with the control (30.44 and 22.54 g/m^2).

Different weed-control treatments showed different values of weed-control efficiency, ranging from 36.29 to 100% in 2002 and from 46.29 to 100% in 2003. Among these treatments, anilofos @ 0.4 kg/ha supplemented with 1 hand-weeding at 30 DAS gave maximum weed-control efficiency (87.61 and 82.92%), followed by hand-weeding twice (78.63 and 84.27%) and anilofos @ 0.4 kg/ha at 10 DAS alone (73.37 and 79.38%); whereas the minimum weed-control efficiency was recorded by 1 hand-weeding (36.29 and 46.90%). This was mainly due to decrease in the dry weight of weeds with better management practices, which increased the weed-control efficiency. Bayan and Kandasamy (2002) also reported better weed-control efficiency with integrated method as compared to chemical and mechanical methods.

N removal by weeds

Nitrogen removal by weeds increased significantly at each level with increase in the dose up to 160 kg N/ha during both the years. On an average, maximum removal of N by weeds, i.e. 30.20 kg N/ha, was recorded with 160 kg N/ha, which was 25.96, 19.57, 9.68 and 3.69 kg N/ha higher than those with 0, 40, 80 and 120 kg N/ha respectively. The increase in N removal by weeds was mainly due to increase in the number and dry weight of weeds with increase in the dose of N. Shad and De-Datta (1988) also reported similar results.

Anilofos @ 0.4 kg/ha supplemented with 1 hand weeding at 30 DAS recorded significantly minimum removal of N by weeds (5.74 kg/ha and 4.98 kg/ha) compared with highest N removal of 63.94 and 53.27 kg/ha from unweeded check. The next best treatment was hand-weeding twice, which recorded significantly lower N removal by weeds than anilofos @ 0.4 kg/ha at 10 DAS and hand-weeding at 30 DAS. Hand-weeding at 30 DAS proved the least effective among the weed-control treatments during both the years.

N removal by crop

Nitrogen removal by the crop significantly increased with every increase in the dose of N up to 120 N/ha during 2002 and 160 kg/ha during 2003. On an average, highest N removal of 160 kg/ha was recorded with 160 kg N/ha, which showed an increase of 351.15, 130.26, 39.91 and 9.61 per cent over that of 0, 40, 80 and 120 kg N/ha respectively (Table 1). The increase in N removal was mainly due to increase in the grain and straw yields.

The best weed-management practices, viz. weed-free treatment, hand-weeding twice at 20 and 40 DAS and anilofos @ 0.4 kg/ha + 1 hand-weeding at 30 DAS gave maximum N removal by the crop, being 3 times more than that of the unweeded check and 1.5 times more than that of 1 hand-weeding at 30 DAS. The better N removal by the crop was associated with its better growth and development, resulting in higher yield. The interaction effects of weed-control measures and nitrogen levels on N removal by the weeds or by the crop were not significant.

Yield

The successive increase in N application significantly increased the grain and straw yields up to 120 kg N/ha in both the years (Table 1). Application of N even at 40 kg/ha gave 66.18 and 71.63% increase in grain yield over control during 2002 and 2003, respectively. This increase was

Table 1. Yield attributes, yield and N uptake of direct-seeded rice as influenced by nitrogen level and weed control measure

Treatment	Panicles/m²		Test weight (g)		Grain yield (t/ha)		Straw yield (t/ha)		N removal by crop (kg/ha)	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Nitrogen (kg/ha)										
0	113	107	21.67	21.62	1.93	1.91	2.62	2.81	35.10	35.83
40	286	289	22.76	22.80	3.21	3.27	4.48	4.79	66.48	69.71
80	321	324	22.96	23.08	4.63	5.03	6.93	7.12	110.8	117.25
120	363	367	23.06	23.23	5.58	5.64	8.28	8.33	143.67	148.27
160	396	401	23.07	23.14	5.83	5.89	8.86	9.10	157.35	162.66
SEm±	8	9	0.30	0.18	0.19	0.18	0.25	0.23	4.55	4.12
CD (P=0.05)	26	29	0.98	0.60	0.63	0.57	0.81	0.77	14.85	13.45
Weed-control measures										
Unweeded check	175	166	20.08	20.32	1.92	1.94	3.02	3.05	44.18	45.98
Weed-free treatment	411	418	23.53	23.73	5.39	5.46	7.77	8.06	137.91	142.14
Hand-weeding at 20 and 40 DAS	391	395	23.20	23.37	5.24	5.27	7.60	7.83	126.59	131.81
Hand-weeding at 30 DAS	237	240	22.98	22.94	3.94	4.00	5.55	5.55	89.51	93.06
Anilofos @ 0.4 kg/ha at 10 DAS	284	290	23.14	23.13	4.19	4.25	5.87	6.06	94.23	99.08
Anilofos @ 0.4 kg/ha + 1 hand-weeding at 30 DAS	274	278	23.28	23.18	5.09	5.17	7.60	7.94	123.77	128.40
SEm±	7	8	0.25	0.26	0.15	0.14	0.25	0.23	4.05	3.85
CD (P=0.05)	22	23	0.70	0.73	0.44	0.40	0.70	0.66	11.52	10.93

Table 2. Effect of weed-control measure on grain yield (t/ha) of direct-seeded rice under various levels (mean data of 2002 and 2003)

Weed-control measure	Nitrogen levels (kg/ha)					Mean
	0	40	60	120	160	
Unweeded check	1.39	1.79	2.09	2.14	2.26	1.93
Weed-free treatment	2.32	4.15	6.24	7.11	7.32	5.42
Hand-weeding at 20 and 40 DAS	2.21	3.85	6.14	6.88	7.20	5.26
Hand-weeding at 30 DAS	1.69	2.90	4.51	5.32	5.44	3.97
Anilofos @ 0.4 kg/ha at 10 DAS	1.78	3.09	4.95	5.51	5.78	4.22
Anilofos @ 0.4 kg/ha + 1 hand-weeding at 30 DAS	2.14	3.66	5.97	6.69	7.19	5.13
Mean	1.92	3.24	4.83	5.61	5.86	
	N	*W*	*N*×*W*			
SEm±	0.13	0.11	0.26			
CD (P=0.05)	0.40	0.32	0.76			

mainly due to significant increase in panicles/m² and test weight, which have positive correlation with grain yield. Lawal and Lawal (2002) also reported similar results.

All the weed-control measures markedly improved the grain and straw yields over the unweeded check during both the years (Table 1). Weed-free treatment, hand-weeding twice and anilofos @ 0.4 kg/ha + hand-weeding at 30 DAS, being at par, resulted in maximum grain yield, which was significantly higher than that of the rest of the weed-control measures. Hand-weeding once at 30 DAS and anilofos @ 0.4 kg/ha alone, though proved least effective among the weed-control measures, were both significantly superior to the unweeded control. Anilofos @ 0.4 kg/ha supplemented with 1 hand-weeding registered increase of 164.84, 28.93 and 21.13% during the first year, and 165.68, 29.16 and 21.59% during the second year in grain yield over the unweeded check, hand-weeding once and anilofos @ 0.4 kg/ha alone respectively. Tomar *et al.* (2002) also reported better results of herbicide supplemented with 1 hand-weeding in rice compared with the application of herbicide alone. The unchecked weeds under weedy plots reduced the grain yield by 64.41 and 64.40% compared with the grain yield of weed-free treatment and by 62.36 and 62.36% compared with that of anilofos @ 0.4 kg/ha supplemented with 1 hand-weeding at 30 DAS. The highest yield under these treatments was mainly due to better control of weeds, leading to greater availability of nutrients, which ultimately improved the growth and yield attributes as well as grain and straw yields.

The interaction effect between nitrogen × weed control measure (N×W) on the grain yield was found to

Table 3. Effect of nitrogen and weed-control measures on weed growth and nitrogen removal in direct-seeded rice

Treatment	Total weed population/m²				Dry weight of weeds/m² (g)				N removal by weeds (kg/ha)	
	60 DAS		90 DAS		60 DAS		90 DAS			
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Nitrogen (kg/ha)										
0	1.48 (81.33)	1.42 (15.22)	1.58 (91.33)	1.47 (28.51)	27.50	25.43	30.44	22.54	4.60	3.88
40	1.57 (98.33)	1.49 (29.83)	1.67 (114.15)	1.50 (30.23)	32.83	29.06	38.06	29.82	11.57	9.69
80	1.64 (119.54)	1.57 (36.24)	1.71 (137.94)	1.63 (41.68)	39.83	33.78	46.72	37.67	22.34	18.69
120	1.74 (145.83)	1.70 (49.47)	1.80 (160.22)	1.73 (52.51)	48.61	42.14	53.45	41.30	28.91	24.12
160	1.75 (158.28)	1.72 (51.97)	1.86 (184.86)	1.79 (60.80)	54.61	45.72	61.61	44.55	32.36	28.04
SEm±	0.04	0.05	0.04	0.04	1.00	1.28	1.12	1.33	0.93	0.77
CD (P=0.05)	0.14	0.16	0.14	0.14	3.26	4.19	3.67	4.35	3.03	2.51
Weed-control measures										
Unweeded check	2.53 (351.60)	2.52 (335.51)	2.56 (379.21)	2.55 (354.01)	117.20	105.26	126.47	89.16	63.94	53.27
Weed-free treatment	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	0.0	0.0	0.0	0.0	0.0	0.0
Hand-weeding at 20 and 40 DAS	1.68 (51.62)	1.61 (40.21)	1.86 (77.18)	1.63 (42.45)	17.20	13.62	25.73	17.11	8.40	7.97
Hand-weeding at 30 DAS	2.31 (216.43)	2.18 (167.65)	2.36 (230.62)	2.29 (199.02)	72.13	59.97	76.87	66.82	22.89	20.47
Anilofos @ 0.4 kg/ha at 10 DAS	1.82 (72.93)	1.78 (59.67)	1.95 (93.61)	1.82 (65.07)	26.53	23.18	31.20	21.31	18.75	14.61
Anilofos @ 0.4 kg/ha + 1 hand-weeding at 30 DAS	1.48 (31.40)	1.40 (24.23)	1.61 (45.60)	1.46 (27.84)	11.00	9.34	16.07	16.6	5.74	4.98
SEm±	0.04	0.04	0.04	0.04	1.24	1.30	1.45	1.45	0.80	0.67
CD (P=0.05)	0.12	0.13	0.10	0.12	3.51	3.69	4.11	4.12	2.26	1.89

Figures in parentheses are original values

be similar and significant during both the years. The pooled-analysis of data (Table 2) indicates that an increasing N level increased the grain yield with different magnitude under various weed-control measures. On an average, application of 160 kg N/ha gave an increase of 5.00, 4.99 and 5.05 t/ha over the control under weeds-free treatment, hand-weeding twice and anilofos @ 0.4 kg/ha supplemented with 1 hand-weeding respectively compared with 0.87 t/ha under unweeded control, indicating better nitrogen response under well-managed weedy plots.

The response to N was found to be quadratic in nature. The optimum doses of N for different weed-management practices were worked out from the respective equations, assuming price of rice @ Rs 5,500/t and cost of N @ Rs 11/kg. The optimum doses of N varied around 150±3 kg/ha with all the weed-control measures except unweeded check (113.75), which recorded the lowest response; and 2 hand-weedings at 20 and 40 DAS (159 kg/ha), which gave the highest response.

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