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Effect of water deficit and nitrogen levels on yield, n-uptake and nutrient balance in rice (*Oryza sativa* L.)

S. K. Prasad*, A.K. Singh and S. N. Das
Department of Agronomy, Rajendra Agricultural University, Bihar, Pusa, SAMASTIPUR (BIHAR) INDIA

ABSTRACT
A field experiment was conducted at Pangabri plot of Pusa Farm, Rajendra Agricultural University Bihar, Pusa during two consecutive Kharif season of year 2000 and 2001 to study the effect of water deficit and nitrogen levels on growth, yield and nutrient balance in rice (*Oryza sativa* L.). Moisture regimes 'So' i.e. 5±2 cm irrigation after 3 days disappearance of ponded water produced maximum grain yield and nitrogen uptake than that obtained with lower moisture regimes i.e., 'S_1', 'S_2' and 'S_3'. 120 kg N/ha (N_3) of nitrogen level registered statistically higher grain yield and N-uptake in comparison to lower nitrogen levels N_0, N_1, and N_2. Higher positive nitrogen balance was recorded with S_3N_3 treatment combination. All treatment combination showed positive balance of P. However, K-balance with all treatments under investigation were negative.

Key words : Water deficit, N-uptake and Balance sheet.

INTRODUCTION

Rice is a semi-aquatic plant and is cultivated in diverse agro-eco-systems like up, medium and low land and also cultivated well in rainfed condition. In all the agro-eco-system water plays an important role to express the yield potential of rice variety. Thus an adequate quantity of water supply is considered essential for exploiting the potential yield. Hence, appropriate scheduling of irrigation are vital for optimising the grain yield of rice. Gajbhiye *et al*. (1990) suggested that knowledge of optimum level of soil moisture for plant establishment and growth is important for scheduling irrigation under water deficit situation. Nitrogen (N) is also the key nutrient element limiting the yield of rice. Due to natural losses of nitrogen through various channel it become essential to apply adequate level of nitrogen for achieving optimum yield.

Therefore, the present investigation was undertaken to find out the effect of water deficit and nitrogen levels on growth, yield and nutrient balance in rice under North Bihar condition.

MATERIALS AND METHODS

Present field experiment was under taken during Ph.D. Programme at South Pangahri plot of Pusa farm, Rajendra Agricultural University, Bihar, Pusa situated at 25^o 59'N and 85^{o}48"E at an elevation of 52.92 metre above the mean sea level. The physico-chemical analysis of experimental plot revealed that the soil was sandy loam in texture and low in available NPK status i.e. 206.3, 12.3 and 113.8 kg NPK/ha; respectively.

The experiment was conducted during two consecutive Kharif season of year 2000 and 2001. The experiment was laid out in a randomized block design having three replications. The treatment consisted of 4 nitrogen levels No- 0 kg N/ha, N_1- 40 kg N/ha, N_2- 80 kg N/ha and N_3-120 kg N/ha and 4 moisture regimes. 'So'- 5 ± 2 cm irrigation after 3 days disappearance of Ponded water; 'S_1'-Irrigation with held during 10-60 days after transplanting (DAT); 'S_2'-irrigation with held during 10-60 and 61-75 DAT only and 'S_3'- Rainfed (control). Irrigation of rice crop was provided according to the treatments and had 7, cm irrigation water during each irrigation. Phosphorus and potassium @ 40 and 20 kg/ha, respectively was uniformly applied. The source of nitrogen, phosphorus and potassium were Urea, SSP and MoP, respectively. The crop received one fourth of nitrogen and full dose of phosphorus, potassium and zinc sulphate (25 kg/ha) as a basal and remaining half and one-fourth of nitrogen was applied at the time coinciding tillering and panicle initiation period, respectively. The test variety was "Rajshree" a medium long cultivar. The uptake of NPK was calculated by multiplying NPK contents in grain and straw with their respective grain yield and dry matter. Balance sheet was tabulated by considering the amount of nutrient added and nutrient removed by the crop during period of experimentation.

RESULTS AND DISCUSSION

Grain and straw yield:

Grain and straw yield significantly increased with different moisture regimes and nitrogen levels. The maximum grain (32.09 and 36.68 q/ha) and straw (51.92 and 62.12 q/ha) yield was recorded with 'So' moisture regime and minimum with 'S_3' (rainfed) during the year 2000 and 2001, respectively (Table 1). However, during first year straw yield at 'S_1' moisture regime was statistically at par with 'So' moisture regime. The percentage increase in grain yield of 'So' over 'S_3' (rainfed) was 32.71 and 30.62 during year 2000 and 2001, respectively. This was might be due to favourable moisture condition with 'So' moisture regime which consequently improved the growth and yield attributing characters and ultimately increased the grain yield. Similar results have been reported by Patjoshi and Lenka (1998).

Increasing nitrogen levels significantly increase the grain and straw yield. Maximum grain (34.82 and 39.96 q/ha) and straw (54.61 and 65.81 q/ha) yield was noticed

* Author for corrospondence.

with “N_3 nitrogen level i.e., 120 kg N/ha and minimum with ‘No’ i.e. 0 kg N/ha during year 2000 and 2001, respectively (Table 1). The maximum grain and straw yield with increasing nitrogen levels might be due to better N-uptake leading to greater dry matter production and its translocation to the sink site. The percentage increase of grain yield with “N_3” over “No” was 77.74 and 78.15 during year 2000 and 2001, respectively. This finding is in agreement with the finding of Shivay *et al*. (2001).

Table 1: Effect of water deficit and nitrogen levels on grain and straw yield of rice (q/ha)

Treatments	Grain yield (q/ha)		Straw yield (q/ha)	
	2000	2001	2000	2001
Moisture regimes				
S_0	32.09	36.68	51.92	62.12
S_1	30.07	33.81	49.95	57.58
S_2	27.88	30.53	47.11	52.63
S_3(Rainfed)	24.18	28.08	41.22	48.53
S.Em(±)	0.42	0.96	0.99	1.10
C.D.at 5%	1.21	2.79	2.88	3.18
Nitrogen levels (kg/ha)				
N_o	19.59	22.43	33.74	40.75
N_1	27.17	30.66	45.64	53.50
N_2	32.64	36.06	54.21	60.80
N_3	34.82	39.96	56.61	65.81
S.Em(±)	0.42	0.96	0.99	1.10
C.D.at 5%	1.21	2.79	2.88	3.18

N-uptake:

Moisture regimes and nitrogen levels significantly improved the N-uptake. Maximum N-uptake (36.99 and 42.66 kg/ha) by grain was obtained with ‘S_0’ moisture regime during year 2000 ;and 2001, respectively in comparison to lower moisture regimes. N-uptake by straw was maximum with ‘So’ moisture regime but it was statistically at par with “S_1” moisture regime during both the year of investigation. Total N-uptake was significantly maximum (65.50 kg/ha) with ‘So’ moisture regime during first year but it was at par with “S_1” moisture regime at second year of investigation. The lowest total N-uptake was recorded with ‘S_3’ i.e., rainfed (Table 2). This variation might be due to the influence of differential utilization of water in various moisture regimes. This finding corroborated well with the report of Bharambe *et al*. (1989). N-uptake by grain, straw and total N was significantly increased with nitrogen levels. Higher level of nitrogen (N₃ nitrogen level) showed maximum grain (43.43,

Table 2: Effect of water deficit and nitrogen levels on nitrogen uptake (kg/ha) on rice.

Treatments	N-uptake by grain (kg/ha)		N-uptake by straw (kg/ha)		Total N-uptake (kg/ha)	
	2000	2001	2000	2001	2000	2001
Moisture regimes						
S_0	36.99	2.26	28.51	34.15	65.50	76.41
S_1	35.35	39.72	28.49	32.85	63.84	72.58
S_2	33.53	36.6	27.82	31.04	61.35	67.72
S_3	29.70	34.51	25.21	29.62	54.91	64.13
S.Em(±)	0.52	0.63	0.48	0.52	0.90	1.17
C.D.at 5%	1.52	1.83	1.38	1.52	2.61	3.40
Nitrogen levels (kg/ha)						
N_o	19.29	22.08	16.76	20.23	36.05	42.31
N_1	32.69	36.87	25.66	30.08	58.36	66.95
N_2	40.16	44.35	32.43	36.48	72.59	80.83
N_3	43.43	49.87	35.18	40.88	78.60	90.75
S.Em(±)	0.52	0.63	0.48	0.52	0.90	1.17
C.D.at 5%	1.52	1.83	1.38	1.52	2.61	3.40

Table 3(a): Effect of water deficit and nitrogen levels on NPK-balance sheet in rice (2000).

Treatments	N (kg/ha)			P (kg/ha)			K (kg/ha)		
	Added	Removal	Balance (kg/ha)	Added	Removal	Balance (kg/ha)	Added	Removal	Balance (kg/ha)
S_0N_0	00.00	46.73	-46.73	17.60	8.20	9.40	16.60	46.19	-29.59
S_0N_1	40.00	72.17	-32.17	17.60	13.69	3.91	16.60	72.13	-55.53
S_0N_2	80.00	89.37	-9.34	17.60	16.8	30.77	16.60	81.98	-65.38
S_0N_3	120.00	97.42	+22.58	17.60	19.14	-1.54	16.60	90.32	-73.72
S_1N_0	00.00	43.65	-43.65	17.60	7.20	10.40	16.60	41.75	-25.15
S_1N_1	40.00	68.82	-28.82	17.60	12.24	5.36	16.60	66.94	-50.34
S_1N_2	80.00	85.08	-5.08	17.60	15.57	2.03	16.60	78.61	-62.01
S_1N_3	120.00	92.79	+27.21	17.60	17.62	-0.02	16.60	83.48	-66.88
S_2N_0	00.00	41.46	-41.46	17.60	6.39	11.21	16.60	38.68	-22.08
S_2N_1	40.00	64.43	-24.43	17.60	11.71	5.89	16.60	61.60	-45.00
S_2N_2	80.00	76.53	+3.47	17.60	13.43	4.17	16.60	70.44	-53.84
S_2N_3	120.00	88.48	+31.52	17.60	15.58	2.02	16.60	79.14	-62.54
S_3N_0	00.00	37.42	-37.42	17.60	6.21	11.39	16.60	36.08	-19.48
S_3N_1	40.00	62.39	-22.39	17.60	10.37	7.23	16.60	58.71	-42.11
S_3N_2	80.00	72.40	+7.60	17.60	13.02	4.58	16.60	69.81	-53.21
S_3N_3	120.00	84.34	+35.66	17.60	14.69	2.91	16.60	75.11	-58.51

49.87) straw (35.18, 40.88) and total N-uptake (78.60, 90.75 kg/ha) than the respective lower levels of nitrogen during year 2001 & 2001, respectively. This was might be due to higher amount of biomass production with higher nitrogen levels. Similar results were reported by Balasubramanian (2002).

Balance sheet of nutrients:

Balance sheet of soil available nutrient (NPK) was calculated by considering only the amount of nutrient added and nutrient removed (uptake) by the rice crop. Balance sheet of all the major nutrient have been presented in Table 3(a,b).

N-Balance:

The data of N-balance was found to be positive only with higher levels of nitrogen i.e., treatment receiving 80 and 120 kg N/ha during both year of investigation. The

Table 3(b): Effect of water deficit and nitrogen levels on NPK-balance sheet in rice (2001).

Treatments	N (kg/ha)			P (kg/ha)			K (kg/ha)		
	Added	Removal	Balance (kg/ha)	Added	Removal	Balance (kg/ha)	Added	Removal	Balance (kg/ha)
S_0N_0	00.00	38.71	-38.71	17.60	6.79	10.81	16.60	36.83	-20.23
S_0N_1	40.00	61.53	-21.53	17.60	11.64	5.96	16.60	60.03	-43.43
S_0N_2	80.00	77.89	+2.11	17.60	15.33	2.27	16.60	71.66	-55.06
S_0N_3	120.00	83.90	+36.10	17.60	16.45	1.15	16.60	76.22	-59.82
S_1N_0	00.00	38.26	-38.26	17.60	6.31	11.29	16.60	36.42	-19.82
S_1N_1	40.00	60.53	-20.53	17.60	10.76	6.84	16.60	58.25	-41.65
S_1N_2	80.0	75.00	+5.00	17.60	13.72	3.88	16.60	68.60	-52.00
S_1N_3	120.00	81.68	+38.42	17.42	15.49	2.11	16.60	72.26	-55.66
S_2N_0	00.00	6.22	-36.22	17.42	5.59	12.01	16.60	33.45	-16.85
S_2N_1	40.00	57.29	-17.29	17.42	10.40	7.20	16.60	54.61	-38.01
S_2N_2	80.00	73.14	+6.86	17.42	12.85	4.75	16.60	66.13	-49.53
S_2N_3	120.00	78.78	+41.22	17.42	13.88	3.72	16.60	70.19	-53.59
S_3N_0	00.00	31.04	-31.04	17.42	5.66	11.94	16.60	28.75	-12.15
S_3N_1	40.00	54.10	-14.10	17.42	9.03	8.57	16.60	49.33	-32.73
S_3N_2	80.00	64.36	+15.64	17.42	12.10	5.50	16.60	62.34	-45.74
S_3N_3	120.00	70.17	+49.53	17.42	12.16	5.44	16.60	63.95	-47.35

maximum positive (+) N-balance was recorded with 120 kg N/ha with corresponding higher water deficit condition during both years of investigation while, negative (-) N-balance with 0, 40 kg N/ha was noted with corresponding lower water deficit condition. The positive (+) N-balance of 80 and 120 kg N/ha with corresponding higher water deficit may be due to more addition of nutrient and lower removal of nitrogen due to paucity of water. The negative (-) N-balance at lower levels of nitrogen i.e. 0 and 40 kg N/ha with lower water deficit condition might be attributed to lower addition of nitrogen and higher removal of nitrogen with adequate moisture condition. Ram *et al*. (1997) also reported similar result.

P-balance:

P-balance was recorded positive during both the year of investigation. The maximum P-balance was recorded with S_3N_0 (11.94 and 11.39 kg/ha) and minimum with S_0N_3 (1.15 and –1.54 kg/ha) during the year 2000 and 2001, respectively. The minimum P-balance in SoN_3 may be due to application of higher levels of nitrogen which increased the P-uptake resulting in less P-balance. Similar result have been recorded by Minhas and Sood (1994).

K-balance:

K-balance was recorded to be negative during both the years of investigation. This might be due to higher K removal by crop than that the quantity added and might also be due to its luxury consumption from soil reserves.

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