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Optimisation of nutrient application for yield maximisation of rice under submerged soil condition in Patna district of Bihar

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Abstract : A field study was conducted to establish optimum levels of nutrients for rice crop under different water regimes (0,4,8 and 12 cm stagnation depth). Application of 80 kg N ha^{-1} in combination with 8 cm water regime produced highest number of effective tillers (240 m^{-2}). The interaction between submerged depth, nitrogen and potassium was observed to be significant and positive. Highest rice yield of 7.5 t ha^{-1} was obtained with 80 kg N and 60 kg K_2O ha^{-1} in 8 cm water submergence.

Additional key words: *Water, nitrogen and potassium dynamics, rice yield*

Introduction

Field survey in the canal commands of Bihar indicated that most of the farmers practise field-to-field irrigation method during *kharif* season. Rainfall during *kharif* season (June to September) is 950 mm whereas, crop water requirement of rice is 850 mm only. The excess rainfall causes varying depths of water stagnation in the rice fields and resultant movement of topsoil and nutrients from one field to another. It was observed that in Right Parallel Channel 5 distributary command area of Patna main canal, more than 80% of the farmers do not apply even nitrogenous fertilizers apprehending the loss of nutrients alongwith the flowing water and deposition in lowland. In general, N losses as gases and movement below 0.5 m soil depth ranged from 11-58% of applied N (De Dutta *et al.* 1990). However, rice productivity becomes very low without application of chemical fertilizers to the soil (Enzmann 1984). To bridge the knowledge gap, a study was carried out to establish optimum doses of fertilizers for varying stagnation depths.

Materials and Methods

Experiment was laid out with rice variety *Sita* involving 0, 4, 8 and 12 cm of water stagnation depth in main plots and four levels of nitrogenous fertilizers *viz.*0, 40, 80 and 120 kg N ha^{-1} in sub-plots in a split plot design. The experimental soil (silt loam to silty clay loam) had pH 7.2, EC 0.24 dS m^{-1}, organic carbon 0.61%, available N 269 kg ha^{-1}, P_2O_5 28.2 kg ha^{-1} and K_2O 365 kg ha^{-1}. Lateral seepage from adjoining plots was prevented by placing LDPE films upto 1m depth in trenches around the plots and backfilled with soil. Further to see the effect of nitrogen and potassium interaction on yield of rice, the experiment was also conducted during 2002-03 with same nitrogen levels in the main plot and 0,30,60 and 90 kg ha^{-1} potassium as sub- plot treatments, replicated thrice, at uniform 8 cm water regime. Grain yield of rice was recorded after harvesting and statistically analysed. Nutrient analysis of soil samples was done using standard procedure (Page *et al.* 1982). Average values of nitrate concentration of soil solution from different seasons of rice soils are presented in graphical form. Optimum dose of nitrogen and economic dose of nitrogen were computed using following equations:

$Y = a + bx + cx^2$ ....(1) where

Y=Expected yield, a=intercept, b&c=Coefficients, x=input (nitrogen)

$x_e = 1/2c(Pn/Pk-b)$................ (2) where

x_e=Economic optimum dose of nitrogen, Pn=Price of nutrient (Rs kg^{-1})

Pk=Price of rice (Rs kg^{-1}), b= Coefficient b, c= Coefficient c

Table 1. Rainfall (mm) received during the project period (1999-2004)

Year	1999-00	2000-01	2001-02	2002-03	2003-04
			Monthly Rainfall(mm)		
January	0	0.0(0)	8.7(1)	7.8(2)	12.5(2)
February	0	4.0(1)	0	0	59.7(5)
March	0	3.2(0)	0	0	0
April	0	23.0(3)	15.9(2)	5.2(1)	13.5(1)
May	91.0(7)	77.0(5)	73.6(4)	177.8(9)	0
June	190.6(5)	381.0(16)	378.6(10)	79.6(6)	175.8(6)
July	348.8(15)	241.4(11)	158.2(10)	388.1(10)	358.8(14)
August	264.8(12)	271.0(8)	187.1(7)	379.6(10)	280.8(17)
September	121.2(9)	89.0(7)	276.4(11)	85.3(7)	202.7(16)
October	145.6(10)	0.0(0)	112.8(4)	90.2(4)	125.6(7)
November	24.0(1)	0.0(0)	0	0	0
December	0	0.0(0)	0	0	0
Total	1186.0(60)	1089.6(51)	1211.6(49)	1213.6(49)	1229.4(68)

( ) number of rainy days

Rainfall received during the project period (1999-2004) has been represented (Table1). Average excess rainfall received (against crop water requirement) during months of June-September was 122 mm. However, the excess water was drained in order to maintain the desirable water level in the experimental plots.

Results and Discussion

Results obtained in four seasons of rice indicated that difference in water regimes had a significant effect on number of effective tillers m^{-2} area. Among nitrogen levels, 80 kg ha^{-1} produced highest number of effective tillers (Fig.1) might be due to optimum water regime which in turn influenced the nitrogen availability to rice plants in the root zone. A considerable amount of nitrate is being leached to root zone under higher levels of water regimes and is being further influenced by the increase in added nitrogen. The average grain yield of 5.0 t ha^{-1} was observed at 8 cm water regime with 80 kg nitrogen (Table 2).

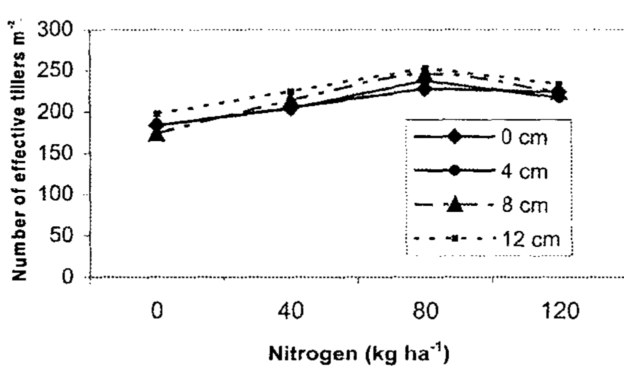

Fig.1. Effect of nitrogen and moisture on number of effective tillers in rice

The nitrate concentration at deeper depths was relatively less compared to the upper layer. The effect was more pronounced with the treatment combination of 12 cm water and 120 kg ha^{-1}. Nitrate concentration after application of the nitrogen increased steadily at different stages of the rice crop at all the water depths. However, the concentration decreased at harvest which could be attributed to NO_3^- movement with water in different quantities to the root zone and uptake of the crop during critical stages of growth (Fig. 2). There was an increase in the yield with increasing levels of nitrogen and potassium. Highest grain yield (7.53 t ha^{-1}) was obtained with 80 kg nitrogen and 60 kg potassium (Table 4). Different workers also observed that nitrogen and potassium

Table 2. Effect of water regimes and nitrogen levels on grain yield (q ha^{-1})

Treatments	1999-2000	2000-2001	2001-2002	Mean
Water level (cm)				
0	44.6	40.6	41.9	42.35
4	44.5	49.7	43.8	46.00
8	47.2	60.5	49.5	52.39
12	44.8	52.3	45.2	47.58
CD (5%)	0.74	NS	2.80	—
Nitrogen level (kg ha^{-1})				
0	43.8	36.8	34.7	38.4
40	44.4	46.5	44.7	45.2
80	47.5	59.6	49.8	52.3
120	45.3	60.9	52.4	52.9
CD (5%)	0.94	5.83	3.10	—

interaction enhances the yields of rice crop (Balasubramaniyan *et al.* 1991; Prasad *et al.* 2001; Tunga and Nayak 2000). Potassium concentration increased with increase in potassium levels, Nitrate–N was 11.5 ppm under

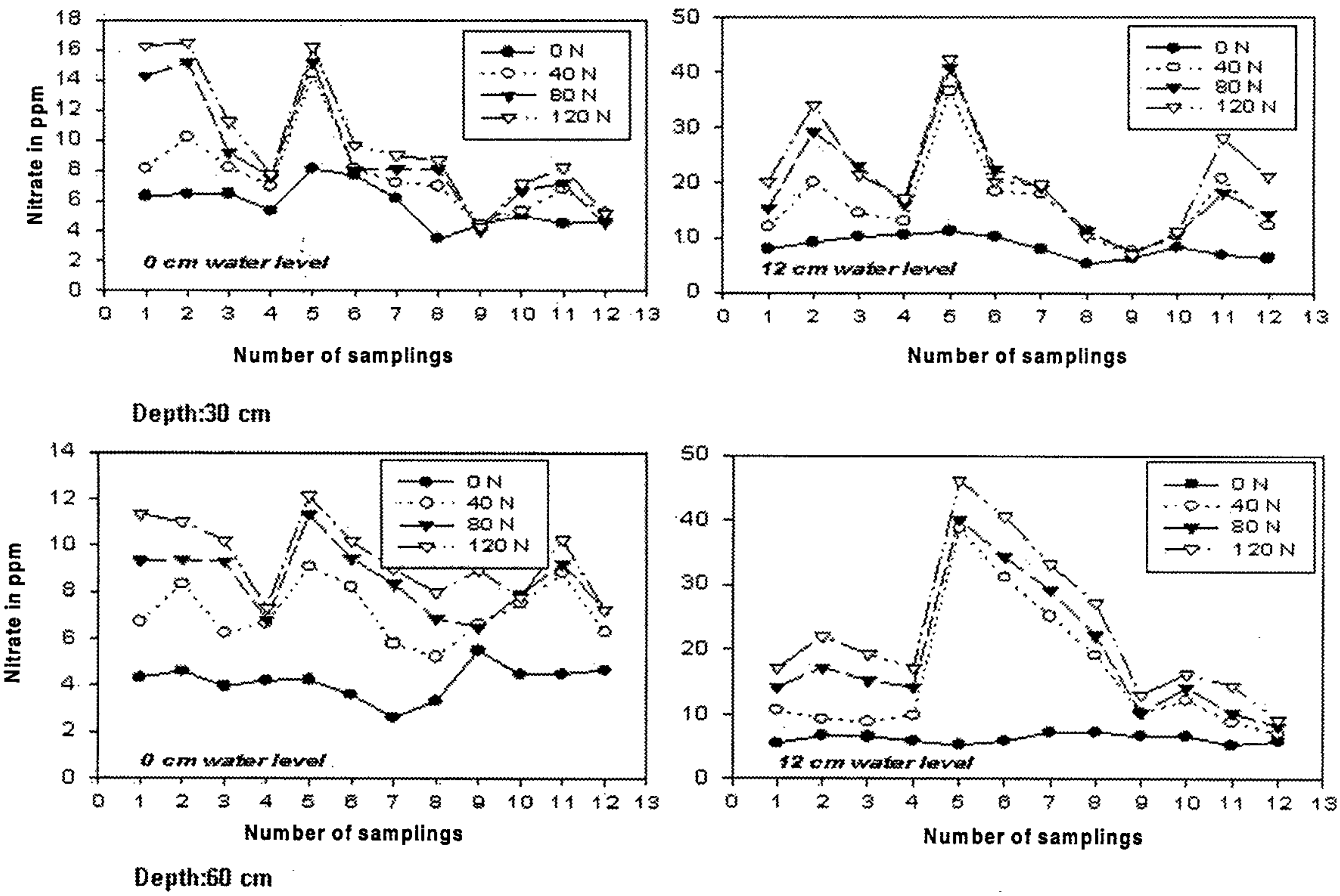

Fig.2. Nitrate concentration in soil solution at 30 and 60 cm depth

Table 3. Effect of different levels of N and K on pH, EC, NO_3^- N and potassium

Treatment	pH (1:2)	EC (dS m^{-1})	Potassium (ppm)	Nitrate nitrogen (ppm)
N0K0	8.01	0.21	1.9	10.7
N0K30	8.11	0.43	2.2	10.7
N0K60	8.19	0.47	3.0	10.9
N0K90	8.32	0.53	3.1	11.6
N40K0	7.48	0.51	1.9	10.9
N40K30	8.02	0.51	2.2	11.0
N40K60	8.40	0.53	2.6	11.1
N40K90	8.49	0.65	2.6	11.3
N80K0	6.99	0.24	2.8	10.6
N80K30	8.09	0.25	3.4	11.0
N80K60	8.12	0.56	3.8	11.1
N80K90	8.16	0.97	4.0	11.5
N120K0	7.37	0.44	2.4	10.6
N120K30	7.80	0.47	2.4	10.9
N120K60	8.11	0.53	3.6	11.1
N120K90	8.50	0.55	4.2	11.4

highest N level. Potassium movement was observed along with nitrate to root zone and that ranged from 1.9-4.2 ppm (Table 3).

The economic dose of nitrogen was obtained as 100.5 kg ha^{-1} and economic yield was estimated as 53.26 q ha^{-1}. As nitrogen dose was increased up to 107 kg ha^{-1}, yield also increased. The maximum yield was 53.33q ha^{-1}. Yield started declining with further increase in nitrogen dose (Fig.3).Regression equation and its coefficients with standard error are given below:

Regression equation	**R^2 value**
$Y=31.48+(0.4095*N)+(-0.00192*N^2)$	0.997
Co-efficient: a=31.484; b=0.4095; c=-0.00192; Standard error = 0.0042	

Table 4. Effect of Nitrogen and potassium levels on effective tillers and grain yield in rice (2002-2003)

Potassium (kg ha^{-1})	Nitrogen (kg ha^{-1}) (a) Effective tillers (m^2)					Nitrogen (kg ha^{-1}) (b) Grain yield (t ha^{-1})				
	0	40	80	120	Mean	0	40	80	120	Mean
0	196	212	235	245	222	4.61	5.97	7.29	6.52	6.10
30	191	217	232	247	222	4.92	6.80	7.37	7.07	6.54
60	199	224	256	273	238	4.20	6.40	7.53	6.30	6.11
90	198	226	243	274	235	5.25	5.84	6.59	7.05	6.18
Mean	196	220	242	260	—	4.75	6.25	7.19	6.73	—
CD (5%)		Nitrogen: 25.05;Potassium: 12.40,Nitrogen X Potassium: 32.88				Nitrogen: 0.79;Potassium: 0.56, Nitrogen X Potassium: 1.24				

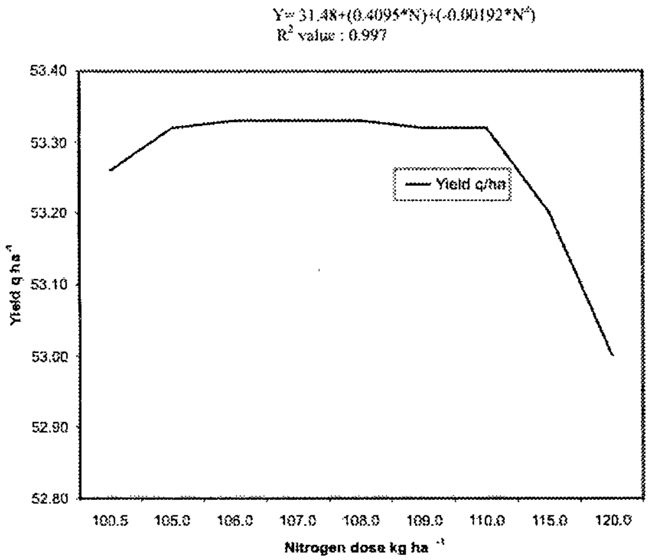

Fig. 3. Grain yield and nitrogen dose relationship

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