INTEGRATED MANAGEMENT OF NITROGEN AND IRRIGATION FOR MAIZE

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A field experiment was conducted on the Bhalwal series (Ustollic Haplargid) with four irrigation levels (0.75, 1.00, 1.25 and 1.50 ET) and four nitrogen rates (0, 50, 100 and 150 kg N ha^{-1} as CAN). Maize grain yield and N uptake was affected significantly by N rates, being maximum with the application of 150 kg N ha^{-1}. The irrigation depths did not affect these parameters. Though, N recovery was affected non-significantly by both the N rates and irrigation depths yet it increased with decreasing N rates. Comparison of NO_3-N in soil before sowing, during crop growth and after harvesting maize showed that soil NO_3-N increased with increasing dose of N. The amount of NO_3-N in soil during crop growth and after harvesting, especially at greater depths, was significantly higher than that before sowing which reflected leaching of NO_3-N.

INTRODUCTION

Nitrogen, being deficient in our soils, has to be applied in relatively large amounts for obtaining optimum crop yield. The applied nitrogen is subjected to various transformations and losses in the soil such as denitrification, volatilization and leaching (Legg and Meisenger, 1982; Hamid and Ahmad, 1988).

To overcome the deficiency and for efficient utilization of applied fertilizer nitrogen, these losses are to be minimized by applying appropriate source and rate of nitrogen. The time of peak concentration of N and root activity has to be synchronized in the soil profile. This involves a close relationship between water supply and the nutrient availability from the soil to crop plants (Singh *et al.,* 1984). Irrigation level should be adjusted in such a way that NO_3-N may not leach beyond the rooting zone (Getmanets and Avramenko, 1976). Irrigation also modifies the biological transformations of nitrogen. Therefore, the present study has been undertaken to determine the degree to which nitrates are leached from soils by different levels of irrigation.

MATERIALS AND METHODS

A field experiment was conducted on the Bhalwal series (Ustollic Haplargid). The experiment was conducted in split plot design with four irrigation levels (0.75, 1.00, 1.25 and 1.50 ET) in main plots and four nitrogen levels (control, 50, 100 and 150 kgha^{-1}, in subplots. The reference crop evapotranspiration (ET) was calculated according to the method of Hargreaves and Samani (1985). The ET was multiplied by crop coefficient (kc) to arrive at ET crop. This was divided by field application efficiency of 0.7 for working out the irrigation water requirement (Ali, 1986). Each level of the two factors was replicated thrice. Seed (40 kg ha^{-1}) of maize variety 'IZ Bulk" was soaked overnight in water and sown on August 11, 1989. The row to row distance was 75 cm and that from plant to plant was 25 cm after thinning. Before sowing the maize crop, representative composite soil samples were taken from 0-30, 30-60, 60-90, 90-120 and 120-150 cm depths (Table 1) to compare the NO_3-N concentration with two later soil samplings.

At sowing, all the P_2O_5 as single superphosphate and K_2O as potassium sulphate were applied @ 75 and 50 kg ha^{-1}, respectively. Graded doses of nitrogen as calcium ammonium nitrate (CAN) were applied in two splits, one half at sowing and the other half with second irrigation. Overall, a total of 44.6, 56.2, 67.7 and 79.4 cm of irrigation water excluding 5.4 cm rain was applied in eight irrigations.

The soil samples were air dried, ground to pass through a 2 mm sieve and mixed thoroughly for NO_3-N analysis by hydrazine reduction method (Kamphake *et al.*, 1967). The crop was harvested on November 13, 1989 and data on grain and straw yields were recorded. Total nitrogen in grain and straw was determined by Kjeldhal's method (Jackson, 1962) to work out nitrogen uptake and nitrogen recovery by the formulae:

$$\text{N uptake (kg ha}^{-1}\text{)} = \frac{\text{Nitrogen (\%) in plant}}{100} \times \text{Yield (kg ha}^{-1}\text{)}$$

$$\text{N recovery (\%)} = \frac{\text{N uptake (treatment) - N uptake (control)}}{\text{N applied}} \times 100$$

where N uptake is in kg ha^{-1}.

RESULTS AND DISCUSSION

Grain yield and nitrogen uptake (Table 2) were affected significantly by nitrogen application but the effect of irrigation depth was non-significant. Similar results were obtained by Hergert (1986). Although, the application of 150 kg N ha^{-1} produced maximum grain yield yet it was statistically similar to that obtained with 100 kg N ha^{-1}. The yield in control and that with the application of 50 kg N ha^{-1} differed significantly from each other but produced lower grain yield than that with 100 kg N ha^{-1}. These results agree with those of Sugimoto *et al.* (1977) who also obtained higher grain yield of maize with 100 than that with 50 kg N ha^{-1}

Nitrogen uptake increased significantly with increasing rates of nitrogen (Table 2), maximum being with the application of 150 kg N ha^{-1} and minimum that with N control.

The nitrogen recovery in maize crop (Stover + Grain) ranged from 56 to 71% with applied rates of N (Table 2). Nitrogen recovery was not affected significantly by both the N rates and the irrigation levels. It indicates non-synchronized relationship among the nitrogen rates, irrigation levels and root activity. This could also be confirmed from greater NO_3-N concentration at lower soil depths (Table 3).

In general, nitrate leaching is considered associated with excess rates of water that percolate down the rooting zone of crop. According to Singh *et al.* (1984), NO_3 leaching can be minimized by matching its supply levels to crop needs through its soil-application. Effect of irrigation depth was found statistically at par during crop growth

Table 1. Characteristics of the soil of experimental site

Soil depth (cm)	Sand (%)	Silt (%)	Clay (%)	ECe dS m^{-1}	pHs	Organic matter (%)	CEC C mol (+) kg^{-1}	SP
0-30	48.9	22.7	28.4	0.62	7.80	0.58	8.7	34.6
30-60	50.5	21.1	28.4	0.65	7.80	0.42	10.4	34.1
60-90	49.4	21.7	28.9	0.71	7.90	0.36	9.5	35.2
90-120	47.7	22.7	29.6	0.56	7.85	0.33	9.8	36.4
120-150	44.6	26.8	28.6	0.55	7.85	0.30	8.3	35.8

Table 2. Effect of irrigation depth and nitrogen rate on maize

Nitrogen (kg ha^{-1})	ET values				Mean
	0.75	1.00	1.25	1.50	
		Grain yield (kg ha^{-1})			
Control	1698	1631	1438	1600	1592 c
50	3173	2600	2767	2548	2772 b
100	3730	3548	4148	3692	3780 a
150	4133	4175	4420	4156	4221 a
Mean	3184	2989	3193	2999	
		Nitrogen uptake (kg ha^{-1})			
Control	44.6	42.9	40.8	41.9	42.6 d
50	90.1	78.6	70.0	72.3	77.7 c
100	121.4	112.9	94.4	109.0	109.4 b
150	129.9	125.6	133.2	118.8	126.8 a
Mean	96.5	90.0	84.6	85.5	
		Nitrogen recovery (%)			
Control	-	-	-	-	-
50	90.9	71.5	58.2	60.6	70.8
100	76.4	70.0	53.6	67.0	66.8
150	56.6	55.1	61.5	51.1	56.1
Mean	74.6	65.5	57.8	59.6	

Means in a column followed by the same letter(s) are not significantly different at P = 0.05 by Duncan's Multiple Range test.

Table 3. Comparison of NO_3-N concentration (mg kg^{-1}) in soil before sowing, during crop growth and after harvesting maize crop

Parameter	Stage of soil sampling		
	Before sowing	During crop growth	After harvesting crop
		Effect of irrigation	
ET value			
0.75	6.52 d	9.63 a	8.82 bc
1.00	5.89 d	9.17 ab	8.62 c
1.25	6.52 d	9.45 ab	9.02 abc
1.50	6.07 d	9.18 abc	8.85 bc
		Effect of fertilizer	
N-level (kg ha^{-1})			
0	5.39 g	7.64 d	6.32 f
50	5.95 fg	9.32 bc	8.71 c
100	6.59 ef	9.72 b	9.65 b
150	7.07 de	10.75 a	10.63 a
		Effect of soil depth	
Soil depth (cm)			
0-30	9.98 a	10.25 a	10.21 a
30-60	8.15 f	9.82 ab	9.52 abc
60-90	5.72 g	9.14 ab	8.24 ef
90-120	4.05 h	9.01 cde	8.32 ef
120-150	3.35 h	8.57 def	7.85 f

Means with different letter(s) indicate significant differences among soil sampling times at P = 0.05, LSD:Irrigation = 0.65, Fertilizer = 0.62 and soil depth = 0.73.

at all irrigation levels (Table 3), indicating even distribution of NO_3 by irrigation water at this stage of growth. However, NO_3-N concentration was statistically more during crop growth and after harvesting compared to NO_3-N status of soil before sowing. Similar trend was noted for applied nitrogen. The NO_3-N concentration with applied nitrogen and irrigation levels was higher during crop growth because soil sampling was done just after the application of second half of nitrogen with second irrigation applied according to the respective ET levels. Extent of NO_3 distribution in soil profile (0-150 cm depth) clearly indicated downward decrease in NO_3-N concentration at each soil sampling time (Table 3, Part: Effect of soil depth). However, the comparison among these three sampling times elucidated higher NO_3-N in soil during crop growth and after harvesting than that of before sowing at all the depths except the surface 0-30 cm where it was statistically at par. This depth also contained statistically higher NO_3-N compared to that at deeper soil layers at all the sampling times. This could be due to applied nitrogen. Since roots of maize can go up to 60 cm depth, the NO_3 moving to lower depths will be wastage. So this higher concentration of NO_3-N at greater depths, i.e. beyond the root zone during crop growth and after harvesting shows the leaching of NO_3-N in this experiment.

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