Pakistan Journal of Biological Sciences, 2 (2): 396-398, 1999 Research Articl

Nitrate Leaching Following Nitrogen Fertilization and Irrigation

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Abstract

Experiment was conducted on Bhalwal sandy clay loam (Ustollic Haplargid) to evaluate the effects of irrigation depth the leaching of NO_3-N below the root zone. Two irrigation depths and 4 nitrogen (N) levels were tested. Compare control, grain yield of maize significantly increased with N levels of 50 and 100 kg ha^{-1}. Increasing N to 150 kg^{-1} did increase grain yield significantly. Irrigation depths did not affect the grain yield significantly. The N uptake by crop increa with increasing levels of N, but effect on fertilizer use efficiency was not consistent. The concentration of NO_3-N was hi after harvesting the crop, especially at lower depths of the soil profile. This indicated some leaching of NO_3-N to lo depths and even beyond the root zone.

Introduction

Nitrogen leaching as nitrate has been the main emphasis of many field, laboratory, and green-house experiments (Bauder and Schneiker, 1979) because of its importance from the viewpoint of agroeconomics, environmental pollution and energy conservation (Mahmood *et al.*, 1996; Isherwood, 1997). Muhammed *et al.* (1990) suggested that all fertilizers, regardless of form applied are ultimately changed to mobile NO_3 by natural processes. Carvallo and Cassel (1973) and Cassel *et al.* (1974) reported mass water flow as the primary mechanism for moving NO_3-N downward which depends upon the volume of water passing through the soil profile, the amount of NO_3-N in soil and soil texture (Ritter and Manger, 1985; Hergert, 1986). The extent of potential leaching loss is primarily a function of how much fertilizer N is added and how much N is removed in the harvested product (Bergstron and Brink, 1986; Muhammed *et al.*, 1990). Rate of applied N should not be higher than necessary to obtain maximum yield with low level of N in the drainage water (Linville and Smith, 1971; Fried *et al.*, 1976). Higher fertilizer use efficiency therefore, is required to achieve maximum production with minimal unwanted environmental effects (Yaseen *et al.*, 1994).

The objective of this study was to evaluate the effect of over irrigation on NO_3 movement in soil and to provide irrigation and fertilizer management guide lines.

Materials and Methods

This study was conducted at the University of Agriculture, Faisalabad. The soil was well drained, sandy clay loam and belonged to the Bhalwal soil series (Ustollic Haplargid). The experiment was conducted according to the split plot design with irrigation depths in main plots and the nitrogen levels in subplots.

Two irrigation depths of 7.5 and 12.5 cm were applied. Graded N applications were 0, 50, 100 and 150 kg ha^{-1}. The treatments were replicated thrice. Basal doses of P_2O_5 as single super phosphate (SSP) and K_2O as potassium sulphate were applied at sowing time @ 75 and 50 kg ha^{-1}, respectively.

Soil samples were taken before sowing and after harves the crop from 0-30, 30-60, 60-90, 90-120, 120-150 depths for analysis including NO_3-N. Each sample composite from three sampling sites of each subplot. C was harvested from a net subplot size of 4.5 m X 14.0 Maize seed of IZ bulk @ 40 kg ha^{-1}, was soaked in Furadan solution for four hours and planted. The row-to- distance was 75 cm and after thinning the plant to p distance was 25 cm. Nitrogen as calcium ammonium nit (CAN) was applied in two splits, one half at sowing and other one half with the second irrigation. Diazinon was u for controlling the pests. A total of 70 and 110 cm of w was applied in addition to 4.3 cm rain. At maturity, m was harvested and grain weight was recorded. Soil anal was done according to Black (1965). Plant N determined by the Kjeldahl method. Nitrogen uptake fertilizers use efficiency (FUE) were calculated.

Results and Discussion

Maize grain yield increased with increasing the rates nitrogen (N) application (Table 2). Effect of 2 higher ra (100 and 150 kg N ha^{-1}) was not statistically differ Muhammed et al. (1990 and 1992) reported similar effe of N on maize yields. The two irrigation depths did affect the grain yield significantly. This confirms v Hergert (1986) and Muhammed *et al.* (1992), who fo irrigation levels did not affect the grain yield of maize. interactive effect of irrigation depths and N levels on g yield was also non-significant.

Uptake of N by maize crop increased significantly v increasing rates of N (Table 2), all treatment effects diffe significantly from each other. Again the effect of irrigat depths on N uptake was not significant. The signific increase in N uptake at 150 kg over 100 kg N ha^{-1} was to significant increase in N content of maize stover but in grain.

Higher fertilizer-use efficiency (FUE) of N fertilizers important not only to cut down the fertilizer applicat but also for minimal pollution hazard. The FUE v higher with 100 kg N ha^{-1} than with 50 kg N ha

Table 1: Physical and chemical characteristics of field soil.

Parameter	Unit	0-30	30-60	60-90	90-120	120-150
Clay	%	28.4	28.4	28.9	29.6	28.6
Silt	%	22.7	21.1	21.7	22.7	26.8
Sand	%	48.9	50.5	49.4	47.7	44.6
Textural class			Sandy clay loam (USDA)			
pHs		7.80	7.80	7.90	7.85	7.85
SP		34.60	34.10	35.20	36.40	35.80
ECe	dSm 1	0.62	0.65	0.71	0.56	0.55
Organic matter	%	0.58	0.42	0.36	0.33	0.30
NO_3 N	mg kg^{-1}	8.90	5.30	3.90	2.70	3.10

Table 2: Maize grain yield, N uptake and fertilizer use efficiency as affected by irrigation depth and N rate.

N rate (kg ha^{-1})	Grain Yield	N uptake	FUE
	----------- kg ha^{-1}	---------	(%)
0	3312	61.06	-
50	3860	77.54	33.1
100	4664	102.76	41.8
150	4834	116.02	36.8
LSD (0..05)	530	11.70	NS
Irrigation			
7.5 cm	4089	85.55	39.5
12.5 cm	4246	93.13	34.9
LSD (0.05)	NS	NS	NS
Irrigation x nitrogen	NS	NS	NS

NS = Non significance

owever, with further increase in N to 150 kg, the FUE ecreased, it was still higher than the 50 kg N ha^{-1}. None the differences was significant. Muhammed *et al.* (1990) served similar effect of N rate on FUE. Application of 100 N ha^{-1} was found to be the optimum or most efficient rate for maximum maize grain yield in this experiment. This statement is also corroborated by the grain yield with 100 and 150 kg N ha^{-1}. As might be expected the overall FUE was not significantly higher with lower depth of irrigation than with greater depth. This indicates that leaching losses were not more with 12.5 cm irrigation depth than that with 7.5 cm level.

However, if we apply the concept of Aslyng (1984) or Fried *et al.* (1976) for N balance (assuming all N losses other than leaching to be equal), it will lead to slightly higher leaching losses of N with greater depth of irrigation. The concentration of NO_3-N in soil before sowing and after harvesting the maize crop is given in Tables 3 and 4, respectively. These values are averages of 3 replications and are given at different depths of the soil profile. The comparison of these Tables shows higher concentration of NO_3-N in the soil, especially at lower depths of the soil profile after harvesting maize, which may indicate leaching loss of NO_3-N. The concentration of NO_3-N at different depths of the soil profile with 7.5 and 12.5 cm irrigation depths was almost the same (Table 4), indicating no differential effect of irrigation depth on leaching of NO_3-N.

ble 3: Nitrate nitrogen concentration in soil before showing maize.

gation depth	N (kg ha -1)	0-30	30-60	60-90	90-120	120-150	Mean
		------------	------------	(mg kg^{-1})	------------	------------	
5 cm	0	10.2	5.7	5.4	3.9	2.7	5.6
	50	7.6	5.5	4.2	2.6	2.6	4.5
	100	8.5	7.0	3.9	2.0	2.9	4.9
	150	7.4	5.4	2.6	2.4	3.3	4.2
	Mean	8.4	5.9	4.0	2.7	2.9	
5 cm	0	9.2	3.5	3.3	2.2	2.3	4.1
	50	12.2	6.1	4.6	2.6	5.5	6.2
	100	7.5	3.9	2.7	2.3	2.4	3.8
	150	8.2	5.5	4.1	3.7	3.1	4.9
	Mean	9.3	4.8	3.7	2.7	3.3	
mean		8.9a	5.3b	3.9c	2.7c	3.1c	

ha^{-1})	0	50	100	150
N conc.	4.8	5.4	4.4	4.6

on depth	7.5 cm	12.5 cm
N conc.	4.8	4.8

followed by the same letter (s) are not significantly different at $p = 0.05$ by Duncan's multiple range test.

Table 4: Nitrate nitrogen concentration in soil after harvesting maize

Irrigation depth	N (kg ha 1)	0-30	30-60	60-90	90-120	120-150
		(mg kg⁻¹)				
7.5 cm	0	8.8	7.3	12.3	6.1	7.8
	50	5.9	10.9	7.9	6.8	10.9
	100	10.5	9.2	8.4	12.6	12.0
	150	11.5	8.7	9.8	12.2	9.3
	Mean	9.2	9.0	9.6	9.4	10.0
12.5 cm	0	13.5	10.7	3.2	3.1	5.5
	50	10.9	7.7	8.5	10.2	10.3
	100	6.5	12.5	7.0	11.0	16.1
	150	13.3	12.2	9.7	11.5	11.1
	Mean	11.0	10.8	7.1	8.9	10.8
Depth mean		10.1	9.9	8.4	9.2	10.4

N (kg ha ¹)	0	50	100	150
Mean n conc.	7.8	9.0	10.6	11.0

Irrigation depth	7.5 cm	12.5 cm
Mean N conc.	9.4	9.7

Results are non significantly by Duncan's multiple range test.

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