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Effect of Fertilizer Doses on Nitrate-Nitrogen Leaching

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ABSTRACT

Use of fertilizer and other agricultural chemicals appears unavoidable in present day agriculture and unfortunately their use in multiplying to meet the needs of expanding population. Leaching of fertilizers in the forms of nitrate has been observed that indicates the wastage of the costly fertilizer as well as possible deterioration of groundwater. An experiment was conducted in the research area of Department of Irrigation and Drainage University of Agriculture, Faisalabad, to observe the leaching behaviour of Nitrates in surface irrigated fields. Two doses of fertilizer were selected keeping all other parameters constant. Porous cups installed at depths of 25, 45, 65 and 85 cm are used to take soil water samples. The results showed that keeping all other parameters constants *i.e.* irrigation depths, tillage practices, the nitrate-nitrogen leaching was affected by the rate of fertilizer. The nitrate-nitrogen leaching was about 15% more after fourth irrigation at 85 cm depth as fertilizer rate increased from 125 to 185 kg ha^{-1}. The tail end of the fields had 8% more nitrate compared with stream ends which showed the movement of nitrates with water.

Key Words: Nitrate leaching; N fertilizer; Irrigation

INTRODUCTION

The agricultural chemicals are used in injudiciously without considering their toxic side effects, both of the major groups of agricultural chemicals *i.e.* fertilizers and biocides are poisonous for animals and human beings. The nutrients applied for increasing crop production are subjected to various losses and transformations in the soil. Nitrogen, being the most deficient and crucial plant nutrient, is applied in large amount in the form of chemical fertilizer to meet the demand of high yielding crop varieties. A considerable part of the applied nitrogenous fertilizers is lost through volatilization, denitrification and leaching in the form of nitrates which becomes a source of environmental pollution (Gill, 1978). Nitrogen loss through leaching is due to movement of NO_3-N with water. The phenomenon of fertilizer leaching has two major disadvantages. On one hand leaching results in loss of fertilizer which is a costly input and most of our valuable resources are utilized for its manufacturing. On the other hand, leached materials may pollute the ground water which is mostly used for drinking without treatment. Ground water pollution is of increasing concern in Pakistan because 50 to 60% of our drinking water comes from well water (Sial *et al.*, 1993).

The estimation of nitrogen input and removal by crop production system is one of the first consideration when evaluating management practices to minimize nitrate leaching and contamination of groundwater as characterized by Schepers and Fox (1989). Different crop management practices including irrigation, tillage, fertilizer form, rate of application, soil type can directly/indirectly affect crop nitrogen availability. Nitrate leaching and the concentration of nitrates in coastal plain aquifer of Israel were studied by Ronen and Magaritz (1991). They studied two cases of groundwater contamination from agricultural related sources reveal that the average nitrate concentration increased at a rate of 0.13 mg L^{-1} $year^{-1}$ from 1973 to 1981. Nitrate sources include fertilizers, manures, sewage, animal excreta and solid waste.

MATERIALS AND METHODS

The experiment was carried on research area of Irrigation and Drainage, University of Agriculture, Faisalabad. An area of 0.22 acre was selected and divided into two plots P_1 & P_2. Two fertilizer treatments (i.e. 125 and 185 kg ha^{-1} urea for P_1 and P_2). Wheat variety LU-26 was sown to study the behaviour of nitrate-nitrogen movement in the soil profile. Nitrate-nitrogen concentrations after first, second, third and fourth irrigations were also collected from the experiment.

Irrigation was applied during the growth period as and when needed and its depth applied was measured using cut-throat flume. The depth applied was calculated according to the following equation.

$$qt = 28\ ad \qquad \text{(Hansen } et\ al.\text{, 1989)}$$

Where,

q = discharge (lps)
t = time (h)
a = area (ha)
d = water depth (cm)

Irrigation water analysis for NO_3-N and NH_4 content using Eutrophication meter HC-100 (Make central

Table I. Depth of irrigation applied

Treatment	Irrigation No.	Irrigation Time (min)	Depth Applied (cm)
P_1	1	50	9
	2	22	6
	3	40	6
	4	50	7
P_2	1	45	8
	2	18	5
	3	35	5
	4	42	6

Kagaku Co., Ltd., Japan) was conducted to determine the amount of NO_3-nitrogen and ammonia contents in irrigation water.

Solution sampler (porous cup technique) were used for obtaining soil water samples from different soil depths to estimate leaching pattern of nitrate nitrogen. Porous cups were manufactured locally from sand mixed clay and hardened at high temperature. They were sealed from top using rubber corks with a sealant called Fine Fix. Each rubber cork had two small holes in which china glass tubes were fitted air tightly. One glass tube was kept shorter to provide passage, while the other tube extended to the bottom to allow water suction from the cup. These tubes were joined with plastic pipes of sufficient length depending upon the depth at which cups were to be buried.

As vertical movements of nitrates is critical. A set of four cups were installed at 25, 45, 65 and 85 cm depth from the surface at six different locations in each plot. Hence 24 porous cups were buried in each plot to get subsurface water samples, carrying applied nitrates. Soil water samples were collected applying negative pressure/suction with 50 ml syringes to the plastic pipes joined with the cups. Initial suction was applied 10–12 hours before each sampling that allowed sufficient time for water to be moved into the cup from the surrounding soils. These water samples were collected and stored in small plastic bottles. Subsurface sampling was done after first, second and third irrigations to the crop.

RESULTS AND DISCUSSION

Present study was conducted for examining the effect of rate of fertilizer application on NO_3-N leaching keeping other parameters constant. Nitrate-nitrogen contents in the soil water sample were determined in the laboratory.

In order to estimate the true effect of treatments it was planned to study residual NO_3-N in the soil profile. The sampling for residual nitrates was done at the time of sowing before application of fertilizer dose.

Table II. Mean residual NO_3-N concentration

Treatment Kg/ha Urea	Depth (cm) 25	45	65	85
	ppm			
125 (P_1)	0.52	1.25	1.45	1.31
185 (P_2)	0.44	1.27	1.45	1.27
Mean	0.48	1.26	1.45	1.29

The mean values (Table II) indicate that NO_3-N content in the soil profile varied through the depth. The maximum concentration of NO_3-N was found at depth 65 cm. Nitrate-nitrogen concentration below this depth decreased considerably up to 85 cm depth. The smaller concentration of NO_3-N in the top 25 cm layer compared with that of 65 cm depth, may be due to utilization of nitrates by the previous crop. The higher concentrations at 65 cm depth might also be due to upward movement of nitrates from the deeper layers of the soil through capillary action resulting in an accumulation of NO_3-N in the layer during dry period. These results agreed with the finding of Krantz *et al.* (1943) who observed nitrate accumulation in the upper layer after a dry period. The present study supports the idea of back transport phenomenon of nitrates during dry period, during the crop season or between two consecutives crops. This phenomenon is a blessing and partly a natural check against movements of nitrates from root zones into deeper soil layers, therefore longer dry periods between crops or the practice of fallowing would help enhance back transport of nitrates and reduce the wastage of costly nutrients and also the likely contamination of groundwater.

The mean values of NO_3-N concentrations in water samples from different soil layers after application

Table III. Average nitrate-nitrogen concentration after first irrigations

Treatment (kg/ha)	Soil depth (cm) 25	45	65	85
	ppm			
125 (P_1)	8.76	5.58	2.54	1.50
185 (P_2)	11.0	7.40	2.62	1.27

of fertilizer (urea) and after first irrigation are given in Table III. The results suggest that the NO_3-N concentration in the soil profile was affected by doses of fertilizer as well as depth of sampling. The maximum concentration of NO_3-N was observed at 25 cm soil depth in both the treatments and the same decreased in the deeper layers. The NO_3-N concentration was 25.5% higher in 185 kg ha^{-1} plots compared with those of 125

Table IV. Average nitrate nitrogen concentration at head and tail end of field after first irrigation

Treatment (kg/ha)	Observation point	Soil depth (cm)			
		25	45	65	85
		ppm			
125 (P_1)	Head	8.53	5.61	2.34	1.02
	Tail	8.63	5.89	2.77	1.11
185 (P_2)	Head	9.78	6.94	2.28	1.33
	Tail	10.51	7.78	2.97	1.09
Average	Head	9.15	6.27	2.31	1.17
	Tail	9.57	6.83	2.87	1.1

kg ha^{-1} plots at 25 cm depth, whereas the same difference was about 32.6% at 45 cm depth. The results obtained agreed with the findings of Overrein (1969) and Barraclough *et al.* (1983), who reported that nitrate-nitrogen leaching increased with increasing fertilizer rate. Apparently a higher dose of applied fertilizer causes more nitrates to leach down into deeper layers even after first irrigation in wheat fields. At this point crop/root activity is restricted to top few centimeters of soil. The nitrates leached beyond 25 cm may not be readily available to the young plants. Therefore, amounts of fertilizer and depth of irrigation need to be carefully selected such that the crop benefits the most. The data values in Table III indicate that the traces of nitrates have moved to 65 and 85 cm soil depths with first irrigation, suggesting movements of nitrates to such depths under normal farming conditions of this region. These observations also argument the fears of groundwater contamination in shallow water table areas with little drainage facilities.

Nitrates are soluble and mobile in soil and move with the leaching water. In this study, the soil water samplers (porous cups) were installed at stream end (head), middle and tail (far end) of the experimental plots. Results show that differences exist among nitrate contents at both ends of plots. The difference in head and tail end readings are given in Table IV. On the average, nitrate concentration was 2% and 9% more at tail compared with stream end in case of 125 kg ha^{-1} and 185 kg ha^{-1} plots respectively.

This supports the idea that in surface irrigation water front dissolves and displaces nitrates towards the tail end of the fields. The variations in the nitrate contents of soil water samples near stream and far ends of fields were constant in all plots. Though the difference of nitrates at the two ends of fields are not of serious magnitude in the present study, however, they may attain a serious level in surface irrigation if field slopes, stream discharges and plot sizes are not properly designed/selected.

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