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Distribution of Nitrate-Nitrogen in the Soil Profile Under Different Irrigation Methods

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ABSTRACT

The study was carried out to investigate the distribution of nitrate-nitrogen under different methods of irrigation. The soil of the area was sandy loam and cotton crop was grown. In case of border and furrow irrigation, more nitrates were found to migrate to deeper layers for heavy irrigation. Large quantity of water was found in 0-30 cm soil layer as compared to 60-90 cm layer. While in case of raingun sprinkler and trickle irrigation, the distribution of nitrate was just reverse of the border and furrow irrigation. The NO_3 –N leaching was less in light irrigation by raingun sprinkler and trickle irrigation. From the comparison, it was concluded that over irrigation not only removed nitrates from root zone but also other soluble salts, some of which are beneficial for crops.

Key Words: Nitrate-nitrogen; Irrigation methods; Distribution

INTRODUCTION

Irrigation is the artificial application of water, which aims at the maintenance of soil moisture required for optimum plant growth. As the world becomes increasingly dependent on the production of irrigated lands, irrigation agriculture is facing serious challenges that threaten its sustainability (Van Schilfgaard, 1990). It is prudent to make efficient use of water and bring more area under irrigation, through available water resources. This can be achieved by introducing advanced and sophisticated methods of irrigation like trickle, sprinkler and improved water management practices. The application of advanced methods of irrigation depend on the leaching of the nutrients through the soil profile especially in the root zone of the crops.

Hedge (1987) carried out field experiments on sandy clay loam soil. Frequent irrigation at 0.2 and 0.4 bar soil water potential resulted in higher dry matter and root yield, lower NO_3-N content in the root and higher N uptake and water use efficiency than with irrigation at 0.6 bar. Nitrogen fertilizer significantly increased dry matter, root yield, NO_3-N uptake and water use efficiency. Ockerby *et al.* (1993) applied four irrigation efficiencies and six nitrogen fertilizer rates to cotton. He concluded that the rate of N fertilizer for maximum yield varied with plant, available water and soil type. Abu-Award *et al.* (1986) conducted field experiments to study the effects of N and water application rates on the movement of NO_3-N under sprinkler irrigation in a field of sandy loam soil planted to a sweet corn. He found that with increasing rates of urea and water, there was an increase in nitrate concentration and downward movement in the soil.

MATERIALS AND METHODS

The experiment was conducted at the research area of Directorate of Crop Production and Water Management, Postgraduate Agricultural Research Station (PARS), University of Agriculture, Faisalabad. The total area 0.72 ha was divided into four portions for border, furrow, raingun sprinkler and trickle irrigation system. The soil of the area was sandy loam and cotton crop was grown there. A basal doze of 55 kg phosphorous and 55 kg nitrogen ha^{-1} was applied at the time of sowing and remaining 55 kg of nitrogen was applied with first irrigation. The investigation was undertaken to ascertain the NO_3-N status in 0-120 cm soil profile. The soil samples were collected before and after each irrigation with the help of sampling tube to find the distribution of NO_3-N at 0-30, 30-60, 60-90 and 90-120 cm depths. Devarda's alloy method developed by Keeney and Nelson (1982) was used to calculate NO_3-N concentration at various depths.

RESULTS AND DISCUSSION

Data regarding nitrate-nitrogen concentration in soil profile of 0-120 cm depth as influenced by border strip irrigation method is given in Table I.

Table I. Mean NO_3-N concentration (ppm) for border irrigation system

Irrigation No.	Water applied (cm)	Depth (cm)			
		30	60	90	120
1	13.88	5.47	5.72	6.00	4.39
2	13.64	5.31	5.50	5.84	4.40
3	13.33	5.05	5.32	5.79	4.08
4	13.25	4.89	5.23	5.57	3.93
5	13.20	4.10	4.59	4.98	2.96

Lower concentration was found at 0-30 cm depth, which was increased exponentially with depth and it was maximum at 60-90 cm. But 90-120 cm depth showed NO_3-N concentration similar to that as found in 0-30 cm depth.

The lower concentration of NO_3-N in 0-30 cm depth compared with 60-90 cm depth was perhaps due to utilization of nitrates by crop roots. Irrigation level consistently affected the NO_3-N concentration. Table II indicates the results of NO_3-N concentration in size profile as affected by soil depth under furrow irrigation method.

Table II. Mean NO_3-N concentration (ppm) for furrow irrigation system

Irrigation No.	Water applied (cm)	Depth (cm)			
		30	60	90	120
1	11.74	5.43	5.60	5.97	3.92
2	11.57	5.16	5.50	5.75	3.26
3	11.50	4.92	5.13	5.63	3.18
4	11.46	4.43	5.08	5.42	2.92
5	11.38	4.03	4.52	4.85	2.14

The distribution of NO_3-N concentration under furrow irrigation method was not different from those obtained under border irrigation method. The NO_3-N content increased with increasing soil depth being maximum at 60-90 cm depth. The nitrate being highly soluble is mobile in the soil and moves with leaching water. So, it is readily washed from surface soil (root zone of the crop) into the deeper horizons. The data on NO_3-N concentration in various soil depths under raingun sprinkler have been presented in Table III.

Table III. Mean NO_3-N concentration (ppm) for raingun sprinkler irrigation system

Irrigation No.	Water applied (cm)	Depth (cm)			
		30	60	90	120
1	8.20	8.38	4.86	4.34	3.84
2	9.80	5.08	4.32	3.76	2.40
3	10.16	4.31	3.72	3.35	2.92
4	10.65	3.82	3.25	3.06	2.79
5	11.08	3.25	3.13	2.96	2.28

The results indicate that NO_3-N content found at 0-30 cm depth was higher than its contents recorded at no depths. Minimum concentration was noted at 90-120 cm depths. The data of NO_3-N distribution in soil profile under trickle irrigation method have been presented in Table IV.

Table IV. Mean NO_3-N concentration (ppm) for Trickle irrigation system

Irrigation No.	Water applied (cm)	Depth (cm)			
		30	**60**	**90**	**120**
1	9.05	5.46	4.93	3.45	2.84
2	8.95	5.15	4.03	3.83	2.86
3	8.87	4.64	3.72	3.48	2.38
4	8.80	4.06	3.78	3.36	2.30
5	8.74	3.44	3.30	2.98	2.22

The results of Table IV are in line with those obtained by raingun sprinkler irrigation system. Later irrigation levels also affected the NO_3-N movement. Lower concentration of nitrates in 0-30 cm soil layer as compared to 60-90 cm layer might be due to utilization of NO_3-N by the roots of crop which is almost restricted to this much depth, or may be attributed to less moisture content present in this layer.

Comparison of NO_3-N concentration (ppm) in soil at various depths under four irrigation methods. In case of border and furrow irrigation, NO_3 concentration observed to be located up to 90 cm depth. More NO_3 migrated to deeper layers of soil for later irrigation. Large volume of water in case of border and furrow irrigation methods, disburse extra NO_3-N leaching and enhance nitrate leaching. With the passage of time, irrigation levels also affected the NO_3-N concentration in soil. Lower concentration of nitrates in 0-30 cm soil layer as compared to 60-90 cm layers, might be due to utilization of NO_3-N by the roots of crops which is almost restricted to this much depth. While in case of raingun sprinkler irrigation system, the result was just reverse of above case i.e. higher concentration of nitrate-nitrogen occurred in 0-30 cm soil depth which decreased afterwards. So, nitrate moved slowly and thus remains for more time within the reach of roots. So, it can be concluded that NO_3-N leaching was less by using light irrigation by trickle and sprinkler irrigation.

Hence, more quantity was available in the upper layer of soil as compared to border and furrow irrigation in which more amount NO_3-N leached down. Irrigation by conventional methods provided extra quantity of water which acts as a carrier for nitrates. On the other hand, light irrigation with same fertilizer rates by pressurized system better hold the nutrients within the upper soil layer. This comparison showed that over irrigation not only removed nitrates from root zone but other soluble salts as well. Some of these slats are beneficial for crops. Leaching of these minerals, not only is adverse for crop growth but the leached nutrients may reach the ground water reservoir and render it unfit for drinking purpose.

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