FERTILIZER - A BIG WATER POLLUTANT

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Leaching of chemical fertilizers out of the crop rootzone is a two way problem. On the one hand, leaching results in loss of fertilizer and on the other, it may pollute the groundwater. In view of resource-use-efficiency and a need to maintain drinking quality of subsurface water, investigation into the fertilizer leaching was conducted. The results revealed noticeable leaching upto 90 cm, whereas traces of fertilizer were also observed at 150 cm soil depth. As watertable depth for about 30% of 41 million acre area of Indus Basin is within 150 cm from ground surface, thus, a sizeable part of subsurface water reservoir is under a direct threat of fertilizer pollution. This study further indicated that fertilizer-tillage-irrigation matrix can be managed to reduce this hazard.

INTRODUCTION

Use of agricultural chemicals including fertilizers, herbicides and pesticides has been accelerated at an alarming rate in the recent past. Agriculture based upon chemicals is being practised with an utter disregard to their side effects on animal and human lives. These days use of fertilizers is recognized as a potential source of environmental pollution, specifically with respect to water quality. Nitrate-nitrogen (NO_3-N) pollution is one area that is currently receiving considerable attention. A major portion of NO_3-N pollution comes from the use of agricultural fertilizers. Downward loss of NO_3-N out of crop rootzone depends upon the amount of water passing through the soil profile and the amount of NO_3-N present in it.

The phenomenon of fertilizer leaching has two major disadvantages. Firstly, leaching results in loss of fertilizer. Secondly the leached material can possibly pollute the subsurface water which is generally used for drinking without treatment. However, the extent of agricultural contribution of NO_3-N to both surface- and subsurface water is yet to be established.

According to Pakistan National Conservation Strategy (1988), 40% of urban and 60% of rural children deaths in the country are caused by water borne diseases. Groundwater pollution is, therefore, of increasing concern as about 70% of drinking water comes from subsurface sources. At the same time, an increased demand for food supplies necessitates fertilizer application. Thus measures are required to keep the fertilizer in rootzone of crops and minimize its deeper movement. Heavy dose of fertilizer, overirrigation, unleveled field, improper tillage and irrigation method play vital role in augmenting fertilizer leaching out of the rootzone. A proper management of soil-water-fertilizer matrix can save water and minimize leaching loss of fertilizer. Remedial measures like split applications of fertilizer, light irrigations, tillage and other land management practices should be properly examined and carefully selected. A study was accordingly planned with the following specific objectives:

1. To ascertain the effect of surface irrigation on fertilizer leaching.
2. To investigate the effects of different tillage practices on nitrate-nitrogen leaching.
3. To assess the contribution of fertilizer to subsurface water pollution.

Table 1. Nitrate-nitrogen contents for various tillage treatments (before irrigation)

Tillage treatment	Depths (cm)				
	0-30	30-60	60-90	90-120	120-150
	(kg ha^{-1}/30 cm layer)				
a. Narrow tine cultivator	21.20	7.06	4.26	2.26	1.06
b. Sweep cultivator	16.26	9.33	3.60	1.46	1.46
c. Disk harrow	15.33	4.52	4.00	1.33	0.93
d. M.B. plow	13.73	5.20	2.40	0.80	0.00
e. Chisel plow	15.60	5.46	1.06	0.67	0.40

FIELD AND LABORATORY PROCEDURE

Five tillage treatments namely tine cultivator, cultivator with sweep shovels (sweep cultivator), disk harrow, M.B. plow and chisel plow were selected for comparing their effects on nitrate leaching. Fifteen plots, each measuring 57 x 10 m in size, were used for making three replications of each treatment. All the plots were ploughed once with their designated implements. At the time of wheat planting, 125 kg ha^{-1} of diammonium phosphate (DAP) were applied after seedbed preparation with two sweep cultivations to all the plots. The first batch of soil samples, for determining NO_3-N contents in the soil layers, was taken two weeks after DAP application at 0-30 cm, 30-60 cm, 60-90 cm, 90-120 cm and 120-150 cm depths. The second batch of soil samples for assessing NO_3-N contents in the soil profile was taken one month after the application of urea (125 kg ha^{-1}) and a surface irrigation of 10 cm. The samples were analysed for NO_3-N contents using disulphonic acid method (Black, 1965). The data on NO_3-N contents were analyzed statistically.

RESULTS AND DISCUSSION

Nitrate-nitrogen contents present at different soil depths (0-30 cm, 30-60 cm, 60-90 cm, 90-120 cm and 120-150 cm) two weeks after application of diammonium phosphate (DAP) are given in Table 1. The data show higher contents of NO_3-N in the top soil layers. This was obvious as neither irrigation was applied nor any precipitation occurred during this time interval to transport the fertilizer downward. Mean NO_3-N contents in various soil layers after the application of urea with first irrigation are given in Table 2.

Analysis of variance of the data after irrigation indicated that the effect of depth of soil on NO_3-N contents tested statistically significant. A comparison of the values of NO_3-N contents before and after irrigation (Fig. 1) suggests that maximum concentration of NO_3-N was present in upper 0-60 cm

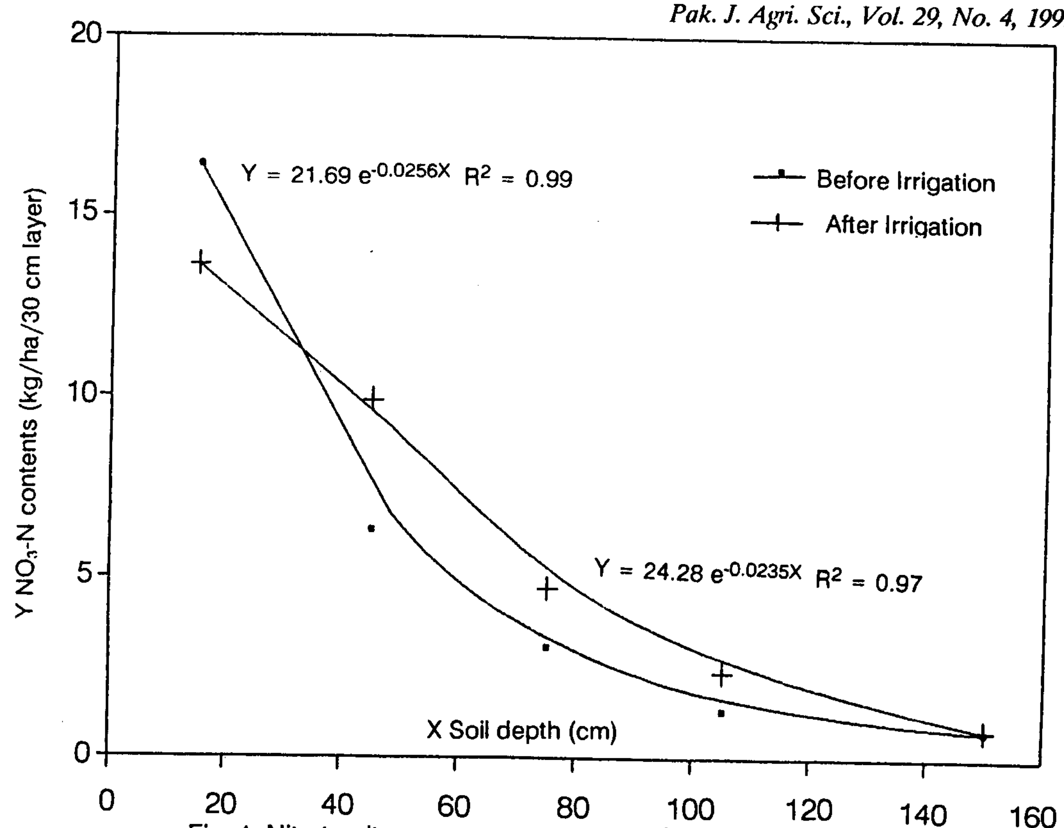

Fig. 1. Nitrate-nitrogen contents averaged over the treatments

layer. A noticeable leaching appears to have occurred upto 90 cm. Traces of nitrates were, however, found upto 150 cm soil depth just with a conventional dose of fertilizer and a single 10 cm irrigation. The exponential nature of curves further indicates that NO_3-N would even leach beyond 150 cm. This downward movement of nitrates would perhaps continue in the irrigations to follow. In case, this trend persists in our agricultural fields year after year, then the day is not too far when underground water reservoir would be badly polluted.

The effect of tillage implements tested statistically non-significant. This was expected as there was little or no good reason for the average nitrates in each treatment to differ. Of greater interest here was the implement-depth interaction. A significant implement-depth interaction suggested that various tillage practices managed nitrates differently at each soil depth. However, sweep and tine cultivators were better compared with other implements. Sweep tilled plots were better than even the tine cultivation in retaining NO_3-N in the top (0-60 cm) soil layer. It is apparent that sweep cultivation can be considered as an appropriate tillage practice among the treatments included in this experiment. In short, the following conclusions were drawn from this study:

1. A normal 10 cm irrigation played a significant role in the downward movement of nitrates.
2. Sweep cultivators and narrow tine were considered relatively appropriate for retaining nitrates in the 0-60 cm soil layer compared with other implements.

Table 2. Nitrate-nitrogen contents of various tillage treatments (after irrigation)

Tillage treatment	Depths (cm)				
	0-30	30-60	60-90	90-120	120-150
	(kg ha^{-1}/30 cm layer)				
a. Narrow tine cultivator	16.66	10.80	5.67	2.93	1.33
b. Sweep cultivator	19.46	15.20	4.80	3.20	0.00
c. Disk harrow	10.13	8.93	6.00	2.67	1.20
d. M.B. plow	9.73	5.73	3.06	2.13	0.66
e. Chisel plow	12.26	8.80	4.00	1.06	0.86

3. A noticeable leaching of nitrates was observed upto 90 cm after irrigation, whereas traces of nitrates upto 150 cm soil depth were observed. The nitrate contents exponentially decreased with the depth of soil. An extrapolation of this trend suggests nitrates would certainly move to far lower soil depths than considered here.

The results of the present study evidenced leaching of nitrogenous fertilizer in the form of NO_3-N upto 150 cm soil depth. As about 30% of 41 million acres surveyed had watertable within 150 cm from ground surface in Pakistan (International Waterlogging and Salinity Research Institute, 1989), apparently a sizeable part of our subsurface water reservoir is under a direct threat of fertilizer pollution. Presently, Pakistan on the average uses 56 kg ha^{-1} of fertilizer as against 779 kg ha^{-1} in Holland (Rahman, 1988). Thus the situation may further worsen as the use of fertilizer increases manifold. Measures need to be taken to reduce the irreversible pollution of subsurface water. Unfortunately most of our anti-pollution programmes are either urban or industry oriented and rural sector is absolutely neglected. Drainage, tillage, irrigation, crop rotation and fertilizer practices need to be managed in order to reduce the threat of fertilizer on subsurface water pollution.

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