IMPACT OF FIELD SLOPES ON NITRATE-NITROGEN DISTRIBUTION

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This study was conducted to compare the effect of different field slopes (0.0, 0.1, 0.2 and 0.3 percents) on nitrate-nitrogen (NOrN) distribution in surface irrigated fields. To achieve this, advance time of irrigation water, average nitrates in the soil layers at different border sections, irrigation distribution and application efficiencics were determined. The results showed a significant effeet of slopes on the distribution of nitrate-nitrogen and irrigation water. Zero graded fields gave more uniform distribution of NOrN and irrigation water than the other slopes. Nevertheless, fields having gradient of 0.1 % also gave results similar to zero graded fields. Increased slopes caused accumulation of NOrN and irrigation water towards downstream side of plots.

INTRODUCTION

Surface irrigation often follows fertilizer application in Pakistan Agriculture. The excess of applied water percolates beyond root zone, reduces irrigation application efficiency and also results in leaching of fertilizer. Being highly soluble in water, the nitrate-nitrogen fraction available in nitrogenous fertilizers is more likely to leach with deep percolating water. A sizable fraction of nitrogen, sometimes upto 50% is lost through leaching (Gill, 1978; Allison, 1966; Vander, 1944; Viswanath, 1978; Riner, 1985; Sial, 1992 a and Sial, 1992b). Leached nitrogen is not only loss of an expensive input but it ma, also contaminate the ground water and impair its drinking quality.

In view of the demerits associated with fertilizer leaching, its minimization is imperative. Apart from numerous factors that may possibly interact with the leaching process, field slope and consequently water distribution along the field play vital roles during the downward movement of fertilizers. Several studies have been conducted on nitrate-nitrogen leaching and irrigation efficiencies in separate experiments. Almost no effort has been made to study the relationship among nitrate nitrogen leaching, water application and distribution efficiencies under varying topographic grades of the field. This study was, accordingly designed to investigate distribution pattern of nitrate nitrogen (NOrN) at various soil depths under different field grades (0.0 I, 0.1, 0.2, 0.3, percents), water distribution and application cfficiencies for the same plot size and stream discharge.

METHODOLOGY

This study was conducted at the Post Graduate Agricultural Research Station (PARS), University of Agriculture Faisalabad, Pakistan. The soil of the experimental field was sandy loam. A field of 45x92m was selected. The area was divided into twelve plots each 45x7.25m size to test four slope treatments (0.0, 0.1, 0.2 and 0.3 percents) with three replications in a randomized block design. The desired grades of plots were obtained using tractor scraper. A dumpy level was used to check !cveling precision. Fertilizer at the rate of 150 kg N/ha and I 10 kg p/ha was applied in all the plots. Considering field slope and soil type, stream discharge for applying irrigation water was obtained as described by Micheal, (1978). A cutthroat flame was used to measure discharge and apply the required depth of irrigation to each plot. Data were collected for nitrate nitrogen (NOrN) distribution, rate of water advance, depth of standing water, application and water distribution efficiencies.

For analysis of nitrate-nitrogen concentration, soil samples were taken from head (0-2m), middle (22-24m) and tail (43-45m) of each plot at 0-30 and 30-60 cm depths before and after the fertilizer application. Hydrazine Reduction method was used to determine nitrate-nitrogen concentration from the soil samples as described by winkleman *et al.* 1985. For moisture content, soil samples were collected upto 60 cm depth in 15 cm increments. Data regarding irrigation advance rate were collected using the procedure of Walker *et al.* (1984). To ascertain irrigation distribution, water depths were recorded at 0, 9, 18, 27, 36 and 45 meters from the stream end. Using the advance of irrigation water and infiltration rate, total infiltration at each measuring point was calculated. By adding depths of standing and infiltrated water, total depth of irrigation water was calculated. Evaporation losses during irrigation application to each plot were neglected. Application and distribution efficiencies were also calculated using the procedure given by Hansen (1980).

RESULTS AND DISCUSSION

Nitrate-Nitrogen Behaviour

The average concentrations of nitrate-nitrogen obtained before fertilizer application are given in Table I. The results indicate that before fertilizer application, little nitrate-nitrogen was available at both the soil depths for all the plots. In fact the experimental field had not been under cultivation for the last many years and no fertilizer was ever applied.

The effect of slopes on nitrate-nitrogen distribution after fertilizer application is presented in Table 2. The table shows that nitrate-nitrogen concentration tends to decrease with increase in the soil depth. The concentration of No_3 -N decreased by 70% in lower layer compared with the top layer. In 0.0% slope plot, nitrate-nitrogen distribution was almost uniform through the field especially in 0-30 cm soil depth. In the first section (0-2 m) of the border, nitrate was 5.30 mg/I of water which decreased with distance and in the last section (43-45 m), it was 5.07 mg/I. Contrary to this, in all other slopes, nitrate-nitrogen, concentration increased towards downstream side. The analysis of variance of the data revealed that the difference of nitrate-nitrogen at the head and tail ends of the plots with various slopes were statistically significant at 95% level. The increase in nitrate-nitrogen concentration at downstream sides were to the tune of 260, 93 and 48.3 percents for 0.3, 0.2 and 0.1 percent slopes respectively. Results clearly indicates that nitrate-nitrogen moved with water and its mobility was very much dependent on the field slope. The uneven distribution of fertilizer, between the two ends of fields with different slopes, is quite high and therefore demands a judicious planning of irrigation systems. No doubt slopes are provided to increase irrigation efficiencies, however, a large slope may disturb the fertilizer balance in the field. This suggests that uniform distribution of fertilizer should also be considered as a important parameter in designing irrigation systems.

Advance Time of Irrigation Water

Time taken by irrigation water to move from border inlet to the far end was measured at different points (Table 3). The results showed that total advance time of irrigation water decreased as slopes increased and the difference were statistically significant. The

Table. 1 Average nitrate-nitrogen concentration before fertilizer application

Distance from stream (m)	Soil depth (cm) 0-30				30-60			
	Field Slope (%)							
	0.0	0.1	0.2	0.3	0.0	0.1	0.2	0.3
0-2	0.39	0.40	0.30	0.62	0.11	0.19	0.14	0.33
22-24	0.66	0.39	0.67	0.19	0.23	0.24	0.09	0.18
43-45	0.43	0.49	0.38	0.38	0.16	0.12	0.21	0.29

Table. 2 Average nitrate-nitrogen concentration after fertilizer application.

Distance from stream (m)	Soil depth (cm) 0-30				30-60			
	Field Slope (%)							
	0.0	0.1	0.2	0.3	0.0	0.1	0.2	0.3
0-2	5.30	4.74	4.46	2.96	2.75	2.07	1.37	1.65
22-24	5.15	5.39	7.21	7.06	2.12	2.89	2.86	2.46
43-45	5.07	7.03	8.61	10.65	1.53	2.75	3.82	3.95
Total	15.52	17.16	20.28	23.67	6.40	7.71	8.05	8..06

Table. 3 Mean time of advance of irrigation water.

Distance from stream (m)	Field Slope (%)			
	0.0	0.1	0.2	0.3
9	2.27	2.16	2.00	1.82
18	2.31	2.05	1.89	1.71
27	2.33	1.93	1.75	1.57
36	2.24	1.83	1.63	1.40
45	2.20	1.77	1.46	1.28
Total time taken (min)	11.35	9.74	8.71	7.78

results revealed that 14.2, 23,0 and 37.5 percent less time was required by the water to reach tail ends in 0.1, 0.2 and 0.3 percent slopes compared with zero graded field. It was also observed that for zero graded fields almost constant advance time was observed for all sections in the field while for the rest of slopes advance rate decreased as water moved towards tail end. As slopes increases, the advance phase of irrigation is completed in shorter time interval.. This amounts to lesser infiltration opportunity time and consequently decreased fertilizer leaching in the stream side sections of the plots. In other words water soluble fractions of fertilizer are more likely to be carried to downstream sides as the field slopes increase.

Mean Distribution of Irrigation Water at Head and Tail Ends

Depth of standing irrigation water was non-uniform in the plots with different slopes (Table 4), however the difference in water depths of zero graded field was nominal.. In 0.1% slope plots 5.0 cm and 8.05 cm depths of standing irrigation water were observed at head and tail points of the border.. Similarly for 0.2 and 0.3% slopes 3.85 cm and 2.95 cm water depths were found at head points while 9.20 and 10.25 cm found at tail points. It was noted that minimum variation in total depth of

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0-2	0.39	0.40	0.30	0.62	0.11	0.19	0.14	0.33
22-24	0.66	0.39	0.67	0.19	0.23	0.24	0.09	0.18
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22-24	5.15	5.39	7.21	7.06	2.12	2.89	2.86	2.46
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Table. 4 Mean distribution of total depth of standing Irrigation water

Distance from stream (m)	Field Slope (%)			
	0.0	0.1	0.2	0.3
0	7.20	5.00	3.85	2.95
9	7.00	5.65	5.30	4.70
18	6.93	6.51	6.43	6.23
27	6.72	7.22	7.35	7.70
36	6.46	7.60	8.20	9.10
45	6.24	8.05	9.20	10.50

standing irrigation water between head and tail points was observed in 0.1 % graded border which is only 61 % and this difference increased as slope increased. Maximum variation of standing irrigation water between head and tail points was observed in 0.3% slope which was 256 %. All this suggests that water accumulation increases at the tail side of plots with increasing slopes. This helps understanding the additional concentration of nitrates at tail sides of the plots with more slopes. Water application cfficiencies of 82, 73, 67 and 62 percent were calculated in 0.0, 0.1, 0.2 and 0.3 percent slope fields respectively. It clearly indicates that zero graded fields showed highest application efficiency of 82%. It was also observed that as slopes increased from 0.0% to 0.3% application efficiency decreased by 24% which agrees with the results of Cheema (1982). Highest water distribution efficiency of 95.75% was observed in zero graded border and lowest water distrihution efficiency of 67% was found in 0.3% grade. In 0.1 % and 0.2% graded fields 85.75% and 77% distribution efficiency were respectively estimated.

Nitrate-nitrogen distribution, advance time of irrigation, depth of standing water, application and distribution efficiencies measured in the present investigation to asses the effects of field slopes. All suggest the desirability of zero graded fields compared with the other slopes. However, for sandy soils and/or light water applications where slopes become unavoidable, the demerits of sloped fields be kept in view for planning irrigation systems.

CONCLUSION

1. Zero graded fields help uniform fertilizer distribution in the soil profile through out the field.
2. Advance time of irrigation water decreased as slopes increased. This suggests that in higher slopes water reached early at tail end and started accumulating there. The more water accumulation at tail end may adversely effect the crops.
3. Uniform water distribution was observed in zero gradient fields while difference in water distribution at tail and head of the plots was the highest in maximum slope.
4. Highest water application and distribution efficiencies were observed in zero percent slope.

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