Water or nitrogen placement and leaching from furrow irrigation

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Past nitrate leaching concerns from permeable furrow-irrigated soils were more for nutrient utilization inefficiency than groundwater contamination. Systematic variation occurs in infiltration, saturated flow, equipotentials, and solute movement with furrow irrigation (2, 3). Saturated flow near furrows can leach water and NO_3-N beyond the root zone (Figure 1). Sprinkler and furrow irrigation comparisons confirmed NO_3-N leaching losses with furrow irrigation even without over-irrigation (8).

Logistic and agronomic considerations influence positioning of irrigation furrows, seed, fertilizers and water, as well as irrigation scheduling and duration. To maximize efficiency and minimize leaching, Taylor (10) spaced furrows so that lateral joining of wetting fronts preceded or coincided with penetration to wet soil below roots. Gunnelon et al. (4) showed that joint nutrient and water application from a point source strongly favored downward nutrient movement. Hummadi et al. (6) showed that with furrow irrigation some NO_3-N from preplant broadcast ammonium phosphate and side-dressed urea banded in shoulders of beds, migrated upward into raised double-row lettuce beds by season's end. The same principle is used to manage salts (1, 5, 11).

We explored practices to reduce NO_3-N leaching from furrow-irrigated corn. Band placement was as recommended by Kemper et al. (7). Split-root studies have shown vigorous rooting into soil as dry as -18 bars (9). We hypothesized that banding on the season-long dry side of a raised ridge would allow adequate rooting and crop N extraction and reduce leaching.

Approach

Corn was grown in 76-cm rows (70,000 plants ha^{-1}) for 2 yr on Portneuf silt loam (Durixerollic Calciorthid) near Kimberly, ID. The 1st half of a split urea application was either broadcast before mid-May planting or banded at planting 5 cm to the side and 2.5 cm below the 5 cm-deep seed, on the side of seed away from the normally irrigated furrow (Figure 1). In late June, all plots were side-dressed 7.6-cm deep in a band 12.7 cm to the dry side of established corn. Total N applied each year to satisfy soil test recommendations was 90 kg ha^{-1} in 1988 and 180 kg ha^{-1} in 1989. Every other furrow was irrigated each irrigation. In half of the plots the same furrow was irrigated all season. In the rest the irrigated furrow was shifted from one side of the corn to the other (rotated) each irrigation. Soil in the plant row was sampled for NO_3-N 7-10 days after each irrigation and in Fall and Spring. Growth, yield, and N uptake were monitored.

Results

Generally, by mid-season deep profile NO_3-N (Figure 2) was less without furrow rotation for either banded or broadcast fertilizer. Apparently, furrow rotation promoted fertilizer-to-water contact, increasing leaching. With rotated furrow irrigation, season-long upper profile NO_3-N concentrations were higher with banding than broadcasting. Rotated irrigation evidently carried banded and/or sidedressed N toward rows and up into ridges where it was sampled. Rotation may also have promoted more mineralization. Without furrow rotation, early season upper profile NO_3-N was greater for banding, but greater by late-season for broadcasting. Water infiltrating from non-rotated furrows by season's end likely carried broadcast N to the sampling zone in rows and up into ridges, whereas N sidedressed on the dry side moved either very little or toward the dry furrow, away from the sampling zone. Post-season NO_3-N (Figure 3) was higher with furrow rotation above approximately 1.5 m depth than without furrow rotation. Treatments did not affect corn silage or grain yield, or their N uptake (Tables 1 and 2). Therefore, differences in profile NO_3-N primarily reflect differences in NO_3 movement, transformations, and/or mineralization rather than treatment uptake differences.

Conclusions

Banding N and limiting wetting of ridges and the upper profile reduced NO_3 leaching loss. Higher upper-profile NO_3-N levels at season's end using furrow rotation probably resulted from more N mineralized where higher water contents existed in more of the profile. Dry-side banding produced equal yields and plant N uptake. More post-harvest leaching was evident where furrows were rotated.

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Table 1. Grain and silage yield (t ha^{-1}) at 15.5 and 65% H_2O, respectively.

Treatment	Grain 1988	Grain 1989	Grain Mean	Silage 1988	Silage 1989	Silage Mean
Banded rotated	7.33	6.10	6.71	20.08	21.56	20.82
Broadcast rotated	7.91	5.96	6.94	21.27	20.77	21.02
Banded non- rotated	7.55	5.80	6.67	19.52	21.00	20.26
Broadcast non- rotated	7.60	5.47	6.53	20.11	19.61	19.86

Grain and Silage Yield (t ha^{-1}). No value in any column differs at P≤5% from any other value in that column

Table 2. Grain and silage N uptake (kg ha^{-1}).

Treatment	Grain 1988	Grain 1989	Grain Mean	Silage 1988	Silage 1989	Silage Mean
Banded rotated	113.6	102.3	108.0	162.8	143.9	153.3
Broadcast rotated	119.3	92.8	106.0	158.2	135.2	146.7
Banded non- rotated	115.9	91.2	103.6	149.6	134.8	142.2
Broadcast non- rotated	114.6	87.1	100.9	150.4	120.4	135.4

Grain and Silage N Uptake (kg ha^{-1}). No value in any column differs at P≤5% from any other value in that column

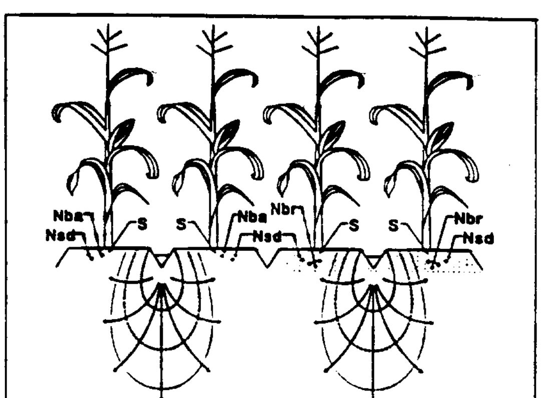

Figure 1. Schematic of plant, seed (S), water, banded N (Nba), sidedressed N (Nsd), and broadcast N (Nbr) relative to furrow and bed. Equipotential and flow lines are presented conceptually.

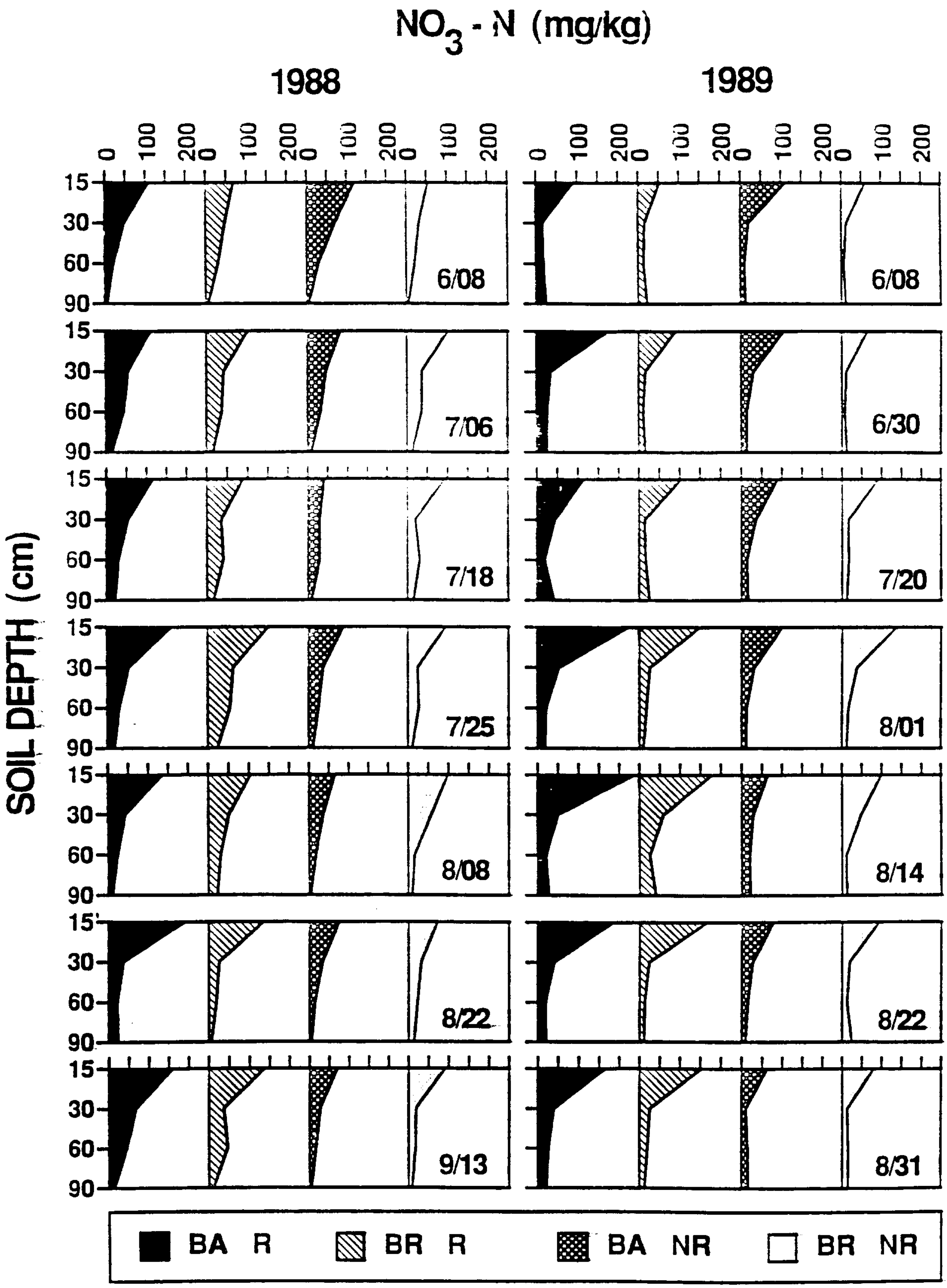

Figure 2. Soil NO_3-N profiles for 4 treatment combinations: Banded (BA), Broadcast (BR), Rotated (R), and Non- rotated (NR).

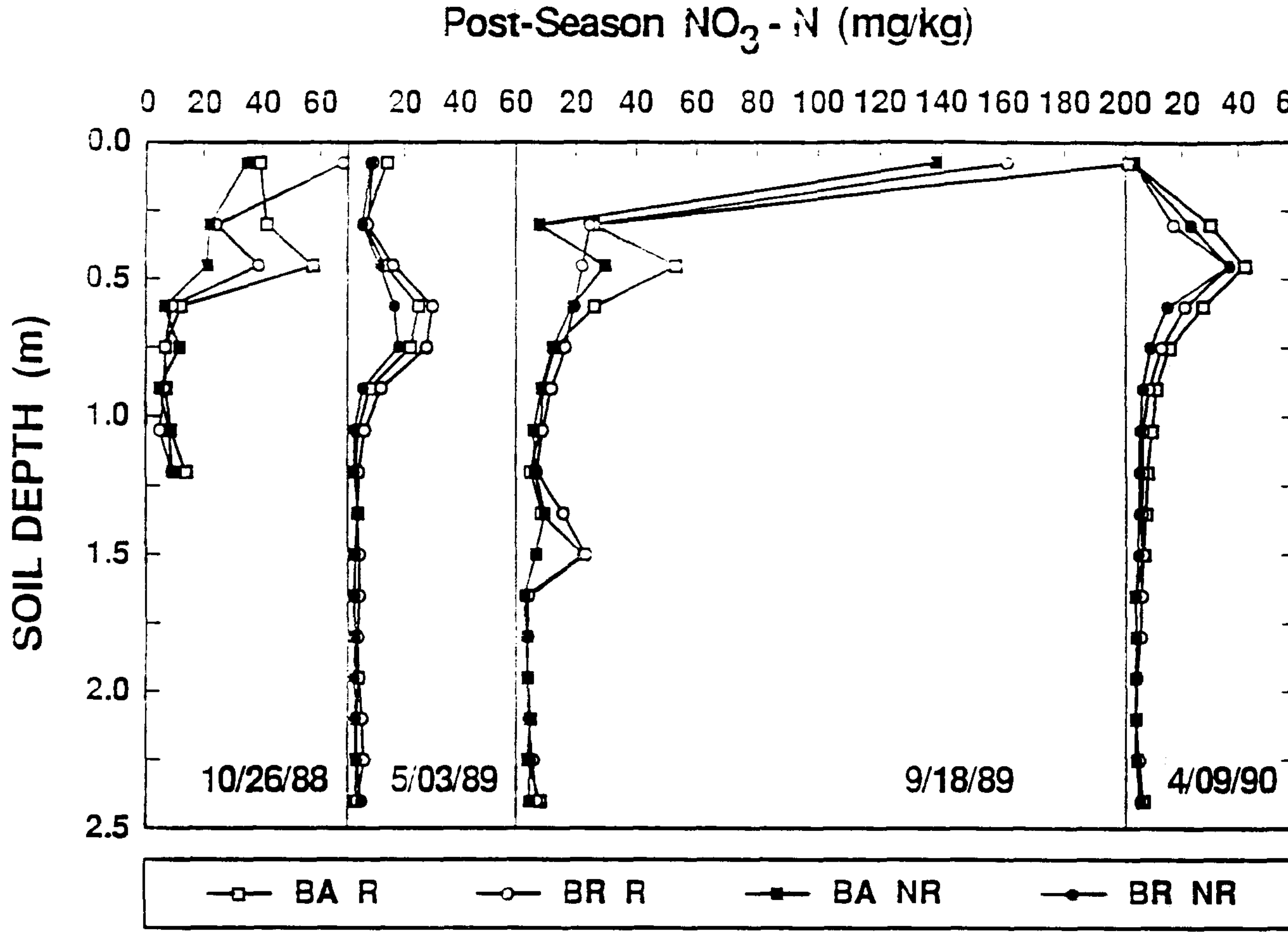

Figure 3.Fall and Spring post-season soil NO_3-N profiles for select treatments for the 1988 and 1989 cropping season.