Localized compaction and doming to increase N-use efficiency and reduce leaching

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Abstract
Nitrate-nitrogen leaching from agricultural lands results in inefficient use of nitrogen-fertilizer as well as degradation of groundwater or surface water if leachate returns to the surface through artificial drainage or baseflow. Subsurface barriers placed above a fertilizer band have been shown to reduce anion leaching. Laboratory data suggest that compacted soil works well as a subsurface water-flow barrier (Kiuchi et al., 1992; Kiuchi et al., 1994). A field-scale implement has been designed and constructed to inject nitrate-nitrogen fertilizer below the soil surface and create a thin compacted strip of soil above the fertilizer band covered by a small dome of soil. Data from a field study indicate that nitrate-nitrogen placed beneath such a domed, compacted strip is less susceptible to leaching than nitrate-nitrogen placed below the soil surface without such a cover. In 1993, nitrate-nitrogen remaining in the upper soil profile (32 inches deep) after three months of the growing season was 56% of the total amount applied compared with 37% remaining where there was only the typical knife injection band. Grain weight and plant weight at black layer development were not significantly different between the two application methods. Overall grain yields at harvest were different, the conventional knife application technique yielding slightly more than the localized compaction and doming application technique.

Disciplines
Agriculture | Hydrology | Soil Science

Comments

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Localized Compaction and Domning To Increase N-Use Efficiency and Reduce Leaching

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Summary

Nitrate-nitrogen leaching from agricultural lands results in inefficient use of nitrogen-fertilizer as well as degradation of groundwater or surface water if leachate returns to the surface through artificial drainage or baseflow. Subsurface barriers placed above a fertilizer band have been shown to reduce anion leaching. Laboratory data suggest that compacted soil works well as a subsurface water-flow barrier (Kiuchi et al., 1992; Kiuchi et al., 1994). A field-scale implement has been designed and constructed to inject nitrate-nitrogen fertilizer below the soil surface and create a thin compacted strip of soil above the fertilizer band covered by a small dome of soil. Data from a field study indicate that nitrate-nitrogen placed beneath such a domed, compacted strip is less susceptible to leaching than nitrate-nitrogen placed below the soil surface without such a cover. In 1993, nitrate-nitrogen remaining in the upper soil profile (32 inches deep) after three months of the growing season was 56% of the total amount applied compared with 37% remaining where there was only the typical knife injection band. Grain weight and plant weight at black layer development were not significantly different between the two application methods. Overall grain yields at harvest were different, the conventional knife application technique yielding slightly more than the localized compaction and doming application technique.

Project Description

Leaching of nitrate-nitrogen is considered an environmental problem throughout much of the Midwestern states. Nitrate-nitrogen that leaches into groundwater threatens rural domestic water supplies with contamination. Farming techniques that reduce the amount of nitrogen lost to leaching are needed. An improved fertilizer-banding device has been designed and tested to apply fertilizer nitrate-nitrogen to row crops, and to physically alter soil properties near the fertilizer band so that nitrate-nitrogen movement can be reduced as discussed by Horton et al. (1992).
A plot area consisting of four blocks, each with three plots, was selected at the Agronomy and Agricultural Engineering Research Center, near Ames, Iowa. Two methods of applying nitrate-nitrogen fertilizer were employed as two of the treatments: 1) the localized, compacted dome (LCD) following the knife injection; and 2) knife injection alone. Treatment 3 involved check plots where no nitrogen was used. Nitrate-nitrogen fertilizer, mixed with bromide (an anionic tracer) was applied as a side dress application between the rows at a rate of 115 lbs/ac. The bromide served as an additional tracer, which, in contrast to the nitrate, is not naturally present and is not readily absorbed by corn plants.

The LCD implement consists of a specialized knife shank to inject the nitrate-nitrogen fertilizer below the soil surface. The knife has a triangular shoe to smear the soil at the bottom of the furrow and prevent the fertilizer from traveling through macropores such as worm holes or naturally occurring cracks. Following the knife shank, a compacting disk presses soil into the knife furrow to close the slit, and leaves a slanted surface to direct water away from the fertilizer band. Finally, a disk pushes soil into a dome over the furrow and leaves another furrow several inches to one side of the fertilizer band. As a result, water is encouraged to infiltrate at a safe distance from the fertilizer band, instead of directly through the knife slit.

Soil samples were collected 38 days (August) and again 83 days (September) after chemical application in July 1993. The ability of the two application systems to prevent leaching was determined by the percent of nitrate-nitrogen remaining in the upper root zone (32 inches deep) at the end of the growing season. Corn plant samples were collected at the development of the black layer (physiological maturity), and grain yields were computed at harvest.

**Results**

The ability to retard leaching using localized subsurface compaction and doming over the line-source of nitrate-nitrogen fertilizer was assessed by determining the presence of the applied chemicals in the root zone. Figure 1 shows the distribution of the nitrate-nitrogen 38 days (August) and 83 days (September) after application. In the 38 days between application and the first sampling date, 16.9 inches of rain had fallen, and there was ample opportunity for nitrate-nitrogen leaching. Chemical analyses of soil samples show that both nitrate-nitrogen and bromide (data not shown) levels were higher near the soil surface in soil profiles treated with the LCD application technique than in profiles with the conventional knife application technique. The differences shown for the 0-8 inch layer were statistically significant. At deeper depths, profiles of the compacted strip had lower levels of the chemicals than the knife profiles. Thus, after one month, the knife treatment allowed more fertilizer movement than the LCD treatment.

**Distribution of nitrate in the soil profiles:** By the September sampling, an additional 12.1 inches of rain had fallen. The LCD profiles still had higher nitrate-nitrogen and bromide concentrations near the surface than the conventional knife profiles, as well as lower concentrations at deeper depths. These data suggest that nitrate-nitrogen can be held near the soil surface for longer periods of time if localized compaction strips are employed.
The total quantities of nitrate-nitrogen and bromide within the upper root zone (32 inches deep) are shown in Fig. 2. The data collected in August show that the nitrate-nitrogen and bromide levels were slightly higher for the localized compaction treatment than for the knife treatment. The nitrate-nitrogen difference was statistically significant at the 0.10 level, but the bromide difference was not. The September data showed that the nitrate-nitrogen and bromide retentions were significantly greater at the 0.05 level for the LCD treatment compared with the knife treatment. This again suggests that nitrate-nitrogen can be maintained in the root zone where it can be used by plants.

*Figure 1.* Distribution of nitrate in the soil profiles.

*Figure 2.* Nitrate-nitrogen and bromide remaining in the root zone.
**Crop response to localized compaction and doming:** Crop yield data for 1993 were disappointing in that the heavy rainfall amounts reduced yields to about one-half of the levels typically obtained. However, grain weights and plant weights measured at black layer development were not significantly different between the LCD and knife application techniques. Corn yields, as measured at harvest, were statistically greater for the knife technique than the LCD technique (69 bu/ac and 61 bu/ac, respectively). The delayed planting and fertilizing dates may have played a significant role in this result.

**Technology Transfer**

Use of localized compaction and doming as an improved method for fertilizer banding can be shown to reduce nitrate-nitrogen movement in the root zone. This technique could potentially be used by producers and custom applicators wherever fertilizers are being applied by subsurface injection. However, at this stage, more information is needed on the factors affecting reduced leaching and on the crop production aspects. If LCD application reduces plant availability and/or increases denitrification, nitrogen-use efficiency could be decreased. This information is being obtained in additional field testing, and it would be premature to recommend the LCD for widespread use without this additional testing. The possible potential of this application technology is being presented to the agricultural industry, both chemical dealers and producers, through conferences and field days. When the assessment of this technology is more complete, and if it is appropriate, a concerted effort will be made to work with the chemical application equipment industry to bring the concept to commercial reality.

**References**

