Corn Fertility Management and Nitrate Leaching to Groundwater in Sandy Soils

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BACKGROUND / NEED

High permeability and shallow depth to groundwater in the Central Sands region of Wisconsin make groundwater highly susceptible to contamination. Nitrate is the most common groundwater contaminant. Nitrogen based fertilizers and animal wastes used in agriculture are the largest source of nitrate contamination of groundwater. Portage County, located in the Central Sands region, is intensively farmed. It also supports 17,000 dairy cows which produce 254,000 tons of manure each year. To support these cows 43,000 acres of field corn and 33,000 acres of alfalfa are raised each year for dairy feed. Rising fertilizer costs, concern over groundwater protection, and a move toward sustainable agricultural practices has renewed interest in utilizing manure to its maximum potential. Very little research on groundwater impacts from the use of manure as a nitrogen source has been conducted. This project will develop data to assist farmers in determining optimum manure use rates for corn production following alfalfa on sandy soils.

OBJECTIVES

To demonstrate the response of field corn following alfalfa in sandy soils to: three rates of manure application, one application rate plus a commercial fertilizer sidedress, and a control. To determine the impact of each treatment and control on nitrate levels in groundwater below each treated plot. To determine costs and cost savings from decreased fertilizer use and compare to yield data. To recommend an optimum rate of manure application to maximize production and minimize groundwater contamination. To document the groundwater quality variability on a small area of farmland and determine the number of monitoring wells needed to statistically evaluate groundwater quality from individual fields or plots.

METHODS

Five treatments were used on 15 plots in 1989 including 20 pounds starter fertilizer/plot, manure inputs of 0, 7.7, 15 and 23 tons/acre, and sidedress nitrogen of 65 pounds/acre were used on 4 of 5 sets of plots to supplement alfalfa and manure credits. Five follow-up treatments were used on the same 15 plots the second year. Second year treatments included 20 pounds of starter fertilizer, 0, 11, and 22 tons/acre manure, and 45 pounds/acre as sidedress and a control plot. All treatments were run in triplicate. In 1989 4 treatments that were not supposed to receive sidedress nitrogen received 66 pounds/acre sidedress nitrogen by mistake. Three new treatments on 9 plots were established with first year corn in 1990. These plots all had 20 pounds/acre starter fertilizer applied. One set received 11 tons/acre manure, one 45 tons/acre sidedress, and the third did not receive supplemental nitrogen. One hundred-fifty wells were installed upgradient and downgradient of the 24 plots to evaluate groundwater impacts. Crop yields were measured from each plot.

RESULTS

1989 Plots: Nitrate concentrations in groundwater upgradient of the plots was consistently less than 0.2 mg/l. Over-application of nitrogen combined with the dry growing season in 1989 resulted in only moderate yields and no

significant difference in yields between treatments. Over-fertilization resulted in high nitrate concentrations reaching groundwater from all but one treatment in 1989 and in all plots in 1990 as carry-over nitrogen continued to leach. In 1990 carry-over nitrogen plus 20 pounds/acre starter fertilizer resulted in 94 and 112 pounds/acre yields. Other second-year plots receiving supplemental nitrogen of 11 and 22 tons/acre manure or 45 pounds/acre sidedress nitrogen resulted in yields of 118, 130 and 141 pounds/acre respectively, indicating that starter plus carry-over fertilizer produce good yields, and if supplemented with additional nitrogen gave excellent yields during an exceptionally good growing season. Late summer and early spring groundwater nitrate values for all treatments did however approach or slightly exceed 20 mg/l with some levels exceeding 40 mg/l. Carry-over nitrogen from 1989, plus 20 pounds of starter/plots provided sufficient nitrogen for 95 to 111 bushels/acre yields compared to 119 to 141 bushels/acre when additional manure or side dress plus nitrogen was used. The 111 bushels/acre would normally be considered a very good yield and occurred from plots that had 23 tons/acre manure in 1989 indicating carry-over of both manure and alfalfa nitrogen for use in 1990. In 1989 lower yield efficiency resulted in lower yields per unit of N applied and did not make it economical to apply N sidedress. In 1990, which was an excellent growing year, the opposite was true. There was a greater yield efficiency thus greater yields and return for the N applied.

1990 Plots: The control plots established in 1990, receiving 20 pounds/acre nitrogen resulted in some groundwater samples exceeding 10 mg/l nitrate, indicating that leaching of nitrogen released from alfalfa can impact groundwater in sandy soil areas. Additional nitrogen applied from either manure at 11 tons/acre or fertilizer at 45 pounds/acre resulted in additional yields of 30 to 40 bushels/acre in 1990. Some residual soil nitrogen from 1990 treatments resulted in groundwater nitrate levels primarily less than 10 mg/l in 1991.

CONCLUSIONS

The credit from alfalfa alone as calculated using Extension guidelines will in most cases supply sufficient nitrogen for yields in excess of 100 bushels/acre of corn. More carry-over of available nitrogen appeared to occur in these soils than predicted for sandy soils in Wisconsin. Alfalfa credits can provide the majority of nitrogen needs of corn the first year of a rotation, however maximum yields appear to require additional nitrogen inputs from manure or sidedress. These additional inputs could, however, easily result in excess nitrogen and leaching during average to poor growing seasons. In an excellent growing year supplemental nitrogen can increase yields significantly from those produced from alfalfa credits alone. Reasonable yield goals and appropriate nitrogen inputs used to meet these goals need to be established for areas with sandy soils.

IMPLICATIONS / RECOMMENDATIONS

Spring testing for residual nitrate and ammonium-N is recommended to estimate carry-over nitrogen amounts and take appropriate credit to reduce fertilizer impacts. The use of 7 to 11 tons/acre of manure shortly before planting combined with reduced use of starter fertilizer should result in good yields without excessive leaching to groundwater.