Prevention of Ground and Surface Water Contamination by New Agricultural Management Systems

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Summary

New agricultural management systems must be agronomically and environmentally sound. This is a challenge where large amounts of animal manures are produced by localized livestock operations. In the Southern Plains, this mainly involves beef, poultry, and swine, where manure application for up to 35 years has increased soil nitrogen (N) and phosphorus (P) and, in some cases, surface and groundwater contamination. Effective remedial strategies must be targeted to source areas; thus, an indexing approach was developed and successfully ranked site vulnerability to P loss. Fixed soil ammonium (NH\textsubscript{4}-N) may become available to plants in the root zone by uptake of NH\textsubscript{4}-N and potassium, which blocks the release of fixed soil N. For illitic soils with high fixed NH\textsubscript{4}-N, methods to account for amounts made available to crops are needed for more accurate determination of supplemental N needs.

Project Description

Increasing awareness of water quality contamination associated with agriculture in the Southern Plains has created a need for new production systems that reduce potential movement of N and P to surface and groundwaters. The focus of this project is on four areas requiring attention in the Southern Plains: 1) animal manure management; 2) use of cover crops; 3) targeting management strategies; and 4) soil-fixed N availability.

Results

**Animal manure management:** There has been a dramatic increase in livestock production (as beef, poultry, and swine) in the Southern Plains over the last 10 years. As large amounts of manure produced often exceed local crop N and P requirements, information is needed on the fate of manure in soil in order to develop new management systems that are both agronomically and environmentally sound. Thus, we investigated the effect of poultry litter management on N and P loss in runoff, by broadcasting 5 tons of litter per acre to 3, 170 ft\textsuperscript{2} plots under Bermudagrass. Litter was applied to the upper half of one and the total area of the other two plots, one of which was tilled to 3 inches and the other remained as no-till. A fourth untreated plot served as a control. Relative to the control, litter application increased soluble and particulate P transport in runoff from tilled and no-till treatments, although the half-area treatment was similar to the control (Fig. 1). Litter application increased the nitrate -N concentration of subsurface flow at a depth of 2 feet. In all cases, < 2% of litter N and P was lost in surface and subsurface flow.
Figure 1. Poultry litter application (5 tons/ac) increased interflow nitrate-N and runoff P.

**Use of cover crops:** The use of cover crops as an integral component of sustainable agriculture is gaining renewed interest. Thus, we investigated the effect of various cover crops on the transport of soil, N, and P in runoff from several Southern Plains watersheds. Cover crops can reduce soil, N, and P forms (60-90%), although the portion that is bioavailable may increase (20-40%) as a result of leaching of P from the cover crop or residue and preferential transport of finer-sized sediment. Particulate bioavailable P is estimated by iron oxide strip extraction of runoff and represents sediment-bound P that is potentially available for algal uptake. Overall, cover crops improved surface water quality by reducing erosion and nutrient loss.

**Targeting management strategies:** An indexing procedure was developed to identify site vulnerability to P loss in runoff by accounting for transport (runoff and erosion) and source factors (soil P, fertilizer management) influencing P loss. The index ranked the vulnerability for P loss from 20 grassed and cropped watersheds in the Southern Plains in close agreement with losses measured over the last 15 years. The index can identify P sources within a watershed that will require more intensive management in developing sustainable agricultural systems.

**Soil fixed N availability:** Little information exists about the extent to which fixed ammonium in soils is released under conditions imposed during analyses that are bases of N availability indexes and under conditions of very low soil solution concentrations of ammonium and potassium. This information is needed because fixed ammonium constitutes a significant portion of the total N in many soils. In this study, 5 to 45% of the total N in 10 surface soils and 10 to 85% in their associated subsoils was fixed, representing from 45 to 1,763 ppm fixed ammonium-N. These agriculturally important U.S. soils, including Alfisols, Aridisols, Inceptisols, and Mollisols, were...
subjected to analytical procedures designed to provide chemical (i.e., autoclave-distillable N) and biological (i.e., aerobic and anaerobic N mineralization) indexes of available N. Results indicated that only small fractions (generally < 0.1) of the fixed ammonium were released using the indexes. Subsequent extractions of 168-day aerobic incubated samples with sodium tetraphenylboron, which precipitates soluble ammonium and potassium in the soil solution, resulted in most of the fixed ammonium being released in 7 days. Therefore, much of the fixed ammonium in soils is available in the absence of an ammonium/potassium blocking effect. Consequently, the degree to which plants can extract soil-fixed ammonium will depend on the extent to which they lower ammonium and potassium concentrations in the vicinity of the roots and, thereby, remove the blocking effect. For soils containing high contents of fixed ammonium, additional information is now needed to establish the extent to which fixed ammonium is made available to crops so that appropriate accounting can be given to this source when calculating supplemental N needs.

**Technology Transfer**

The principal investigators are working with SCS personnel in Southern Plains states (Arkansas, Oklahoma, and Texas) to develop guidelines for animal manure disposal, and at a national level to develop an indexing procedure to identify soils and management practices that are sensitive to N and P loss to surface and groundwater. Dr. Sharpley was ARS representative on an interagency committee (SCS, ES, and ARS), which reviewed and revised Oklahoma SCS, Waste Utilization Standard and Specifications (SCS Technical Practice Code 633) governing recommendations for land applications of manure and sludge on agricultural land in an environmentally acceptable manner while maintaining crop productivity. The new recommendations incorporate information from his research on poultry litter management and principles of the P index. As a result, Oklahoma’s recommendations regarding manure management address water quality issues on a site-specific basis, thereby allowing farmers more overall flexibility to utilize manure. These recommendations have a stronger theoretical basis than those of many other states. Dr. Sharpley is now cooperating with Arkansas SCS in their revision of manure management recommendations.

Dr. Sharpley, an instructor for the SCS National Training Program for Agrichemicals and Water Quality, has incorporated information from this project into the training program. All principal investigators have given presentations on developing farm nutrient plans for both crop production and water quality to state agricultural extension agents and SCS district conservationists. Technical presentations have also been made at numerous national and international conferences on sustainable agriculture and water quality.
Public Affairs Activities


