Carter, D.L., D.T. Westermann, R.E. Sojka, B.D. Meek, J.L. Wright, M.J. Brown, and G.A. Lehrsch. Controlling nitrate leaching and erosion on irrigated land. IN Proc. Clean Water--Clean Environment--21st Century, Team Agriculture--Working to Protect Water Resources. Vol. II: Nutrients, pp. 27-30. March 5-8, 1995, Kansas City, MO. USDA and ASAE St. Joseph, MI.

Controlling Nitrate Leaching and Erosion on Irrigated Land

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Summary

New integrated agronomic cropping systems that nearly eliminate irrigation-induced erosion, significantly reduce nitrate leaching potential, increase crop utilization of nitrogen from legume sources and fertilizer, improve irrigation uniformity, decrease production costs, and increase net profits have resulted from several years of research at Kimberly, Idaho. These systems include growing corn or cereal without tillage following alfalfa to efficiently utilize nitrogen from the legume and reduce irrigation-induced erosion. Where no corn was grown following alfalfa, nitrate-N accumulated up to 550 lbs/ac in the upper 5 feet of soil compared to only 50 lbs/ac where corn was grown. Where beans were grown for two seasons following alfalfa, nitrate-N leaching was 50 lbs/ac more than where corn and then winter wheat were grown. Banding nitrogen fertilizer on the opposite side of the corn row from the irrigation furrow used all season reduced nitrate leaching as compared to where a furrow was irrigated on the same side of the row as the fertilizer band. Nitrate moves below the root zone during wet winters by deep drainage and pass through flow. Polyacrylamide (PAM) concentrations of 10 ppm or less applied into the irrigation water can almost eliminate furrow erosion, and it increases infiltration. Applying cheese whey alone and in combination with straw at whey rates of 12 gallons and straw rates of 4 lbs/100 ft of row before beginning irrigations reduced sediment loss by more than 95%.

Project Description

Problem: Irrigation-induced erosion reduces the crop-producing potential of our valuable irrigated lands. Crop production potential was decreased an average of 25% by the irrigation-induced erosion that occurred over 80 years on a large acreage in Idaho. Similar yield potential decreases are being identified in other irrigated areas, indicating the seriousness of the problem. Additionally, off-site negative impacts of the sediment are serious. Reservoirs constructed for water storage are being filled with sediment, as are stream channels in some areas. Fish-spawning gravels are being covered by sediment. Wear of pumps is greatly enhanced by the presence of sediment in the water.

Nitrate leaching beyond the plant root zone can lead to nitrate contamination of groundwater. Furthermore, that leaching represents a lost resource and an economic loss to producers, because the nitrogen leached below the plant root zone is no longer available to growing crop plants. The more nitrogen that can be maintained in the root zone by reducing leaching, the smaller and less costly will be the needed nitrogen fertilizer. One important and overlooked nitrogen source in the root zone is that derived from nodules and roots of killed legumes. This source can provide up to

350 to 400 lbs/ac during the two years following the killing of alfalfa, and 70 to 80% of it is mineralized to nitrate the first growing season.

Objectives: The objectives of the ARS research at Kimberly, Idaho, is to develop improved tillage, fertilization, irrigation, and cropping sequence practices, along with the application of amendments to reduce both irrigation-induced erosion and nitrate leaching, and further to integrate these developments into the most effective, lowest cost, and most producer acceptable practices possible.

Methods: Conservation tillage, including no-till, combined with changes in cropping sequences that would permit the fewest tillage operations over the crop rotation cycle and include fibrous-rooting, high nitrogen-requiring crops the two seasons following the killing of alfalfa, were extensively field evaluated. Nitrogen uptake by crops following alfalfa and nitrate leaching under different traditional and conservation practices was compared. The efficiency of nitrogen fertilizer in relation to timing and placement was evaluated. Non-growing season leaching of nitrogen from the root zone was evaluated. The availability of nitrogen from killing alfalfa at different time periods before sweet corn was planted was extensively field tested. The effectiveness of polyacrylamides at concentrations of 10 ppm or less in the irrigation water, applied at varying times periods during an irrigation to control irrigation, was extensively evaluated. The application of cheese whey, straw, and their combination to irrigation furrows before irrigation began was field evaluated as irrigation-induced erosion control practices.

Results

No-till corn and cereal can be grown successfully following alfalfa on furrow irrigated lands, almost eliminating erosion, improving irrigation uniformity, reducing nitrogen fertilizer needs, and reducing nitrate leaching. Field research to refine no-till cropping following alfalfa showed that the alfalfa could be killed any time up to about 3 weeks before seeding corn, and nitrogen from the decomposing alfalfa roots and nodules adequately supplied nitrogen needs for the corn. Based upon the nitrogen concentration in the corn, no corn crop grown exhibited nitrogen deficiency. Where no crop was grown for comparison, the upper 5 feet of the soil profile contained up to 550 lbs of nitrate-N/ac on September 24, compared to 50 lbs/ac where corn had been grown. This nitrate-N represents a significant nitrate leaching potential. Another field study where traditional tillage dry edible beans were grown for two successive seasons compared to no-till corn followed by a no-till winter wheat showed about 50 lbs more nitrate-N/ac leaching below the root zone under the beans than under the corn-wheat.

When no-till cereal was grown following alfalfa, the nitrogen uptake requirements to satisfy the wheat sometimes exceeded the soil available nitrogen supply. Also, because wheat is harvested much earlier than corn, nitrate-N accumulates in the soil after wheat harvest.

Banding nitrogen fertilizer on the opposite side of the corn row from the irrigation furrow used all season reduced the nitrate-N leaching as compared with leaching when the furrow on the same side of the corn row as the fertilizer band was used for some irrigations. These results demonstrate the important relationship between fertilization and irrigation practices when attempting to control nitrate leaching.

When soil testing to determine nitrogen fertilizer needs for irrigated spring wheat, the amount of available nitrogen in both the first and second foot of soil should be measured. If only that nitrogen in the first foot is considered, fertilizer recommendations will likely be excessive to wheat needs and lead to nitrate leaching. The $^{15}NO_3$-N recovery from that applied ranged from about 50 to 70% for both soil depths for two locations about 150 miles apart, on different soils.

The nitrate-N content in irrigated silt loam soils in southern Idaho decreases over wet winters. From September 1992 through March 1993, with about 10 inches of precipitation, about 90 pounds of nitrate-N disappeared from the upper 3 feet of the soil profile, but this was not detected by increases in nitrate-N concentrations in the soil solution samples at greater depths. During the drier 1993-94 winter season, with only 2.5 inches of precipitation, the nitrate-N increased in the upper 3 feet of soil profile and remained about constant below that depth. Deep drainage and by-pass flow appeared to be major mechanisms for nitrate-N losses during wetter winters because nitrate concentration changes were not detected in samples extracted by sampling tubes. Fall irrigation practices, winter-time precipitation, surface evaporation, and deep drainage all influenced the gain or loss of nitrate-N in soil profiles.

In addition to no-till corn and cereal following alfalfa, no-till cereal following corn, no-till corn following corn, and no-till corn following cereal can be successfully grown on furrow irrigated land. Additionally, a large number of reduced tillage crops, as compared to traditional tillage crops, can be grown successfully with significantly less irrigation-induced erosion and sediment loss. New conservation tillage cropping sequences reduce sediment loss 80 to 100%, require about one-fourth the number of tillage operations over the rotation cycle, produce the same crop yield and quality, and provide a greater net income, ranging from $50 to $100/ac greater net income each year.

Polyacrylamide (PAM) concentrations of 10 ppm in the furrow stream during the advance stage only, reduced erosion by more than 95% for the entire irrigation. Lower concentrations during the entire irrigation, or short intermittent application of 5 to 10 ppm every four hours were also highly effective. The cost of using PAM to control irrigation induced erosion will likely range $4 to $8/ac each irrigation. This cost will be gained back by benefits in infiltration and improved yields. Combining the use of PAM and conservation tillage for irrigation-induced erosion control has great resource conservation and economic potential for irrigated agriculture.

Applying cheese whey alone or in combination with straw to irrigation furrows before the irrigations begin can almost eliminate irrigation induced erosion for the entire irrigation season. Straw applied at a rate of 4 pounds followed by spraying whey at a rate of 12 gal/100 ft of row reduced sediment loss by about 98%.

Technology Transfer

Results from these extensive research endeavors are intended for use primarily by farmers, but are useful to everyone in the agricultural and environmental communities. The application of these results will improve the quality of both surface and subsurface drainage water, conserve natural soil resources, and help farmers produce crops more efficiently. The technology developed by these research efforts is being transferred by publishing results in scientific and popular publications and by giving numerous oral presentations. Results have been used toward developing a National Irrigation Land and Water Improvement Initiative. Data from the PAM research have helped achieve labelling in several states for PAM as an amendment added through the irrigation water. A cooperative research and development agreement (CRADA) with Cytec Industries was established in December 1993 to determine optimal PAM application strategies.

Public Affairs Activities

Reprints of papers listed under References are available upon request, and additional information can be obtained by contacting the authors. Researchers will be participating in many meetings and conferences and reporting results from various segments of the research program at Kimberly. Researchers are available to provide consultation and to present oral reports as their schedules permit.

References

The following references report on various aspects of the research discussed.

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