USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Characterizing the Fate of Nitrogen Fertilizer to Improve Nitrogen Use Efficiency in Irrigated Potato Production

Keywords: Nitrate leaching, pollution, controlled release fertilizer, irrigation, potatoes

Duration: March 1999 through February 2000

Federal funds: $24,990

Non-Federal (matching) funds pledged: $31,302

Principal Investigators: Carl J. Rosen, Satish Gupta, Michael Russelle

Congressional District: 7th

Statement of critical regional or State water problems

In Minnesota, the potato crop is grown on more than 12,000 ha of glacial outwash soils that are generally infertile and have low water capacity and rapid drainage. To maximize potato yield, producers commonly apply nitrogen (N) fertilizer rates as high as 300 kg N/ha (Bruening and Montgomery, 1995). Water requirements are often met through sprinkler irrigation. These practices, in combination with the shallow root system of potatoes, have led to significant amounts of nitrate (NO_3^-) leaching to shallow groundwaters in the area. Nitrate leaching can be exacerbated by unpredictable summer rainfalls, particularly those following an irrigation event. Meyette (1984) showed that N concentrations in the groundwater have been steadily increasing since the 1960's under intensively farmed sandy outwash soils of central Minnesota. In many of the wells studied by Meyette (1984), nitrate concentrations were above the 10 mg/L limit for drinking water. Nitrate testing results during 1997-98 from public wells in important potato growing counties were as follows: Otter Tail (2088 samples) 9% over the 10 mg/L standard; Wadena (497) 22%, Hubbard (346) 10%; and Benton (191) 19% (Gallus and Montgomery, 1998).

Since the early 1980's, irrigated potato production has been expanding on irrigated sandy outwash soils. Citizens living in the regions where irrigated potatoes are being grown are becoming increasingly concerned about the elevated nitrate levels in their drinking water (see Sparling and Moir support letters). Potato growers are also aware of the potential impact potato production can have on the environment and thus are very much interested in alternative management practices that might eliminate or minimize groundwater contamination (see Area II Potato Growers support letter). Past research has focused mainly on such variables as irrigation management and nitrogen fertilizer rates and management. However, because of the high N and water requirements of the potato crop, coupled with the use of highly soluble N fertilizers, controlling NO_3^- leaching is

difficult. A potentially attractive alternative to reduce N leaching is to use controlled release fertilizers (CRF). These fertilizers release N at a slow enough rate to minimize NO3- leaching to groundwater while meeting the crop N requirements. The other advantage of slow release N fertilizers is that they are often applied in a single application thus reducing the cost of application. While CRF have been used for many years, the release rate of traditional products such as sulfur-coated urea have been unpredictable (Trenkel, 1997). Recently, there have been several new slow release N fertilizer products on the market. These newer products are coated with polymers that synchronize N release with crop N demands. The proposed study will investigate polyolefin-coated (POC) controlled-release N fertilizers as a tool to minimize NO3- pollution of groundwater and at the same time improve the N use efficiency (NUE) of irrigated potatoes grown in the water quality sensitive regions of central Minnesota.

Statement of results or benefits

The major focus of this study is to characterize the risk of nitrate leaching in potato production under POC CFR N fertilizers as compared to the current fertilization practices in the glacial outwash soils of central Minnesota. Preliminary results obtained in 1996 and 1997 indicated that POC N fertilizers increased potato tuber yield by about 10% compared to conventional soluble N fertilizers. The concentration of nitrate in effluent collected at a depth of 120 cm was lower in plots receiving POC N fertilizers than those fertilized with conventional urea N. Although the cost of POC N fertilizers is currently about five times that of conventional urea, greater acceptance and use of the fertilizers on the high cash value potato crop should enable their production and distribution at an acceptable value/cost ratio. Improved yield and quality, reduced pollution, less frequent application and lower N rates associated with these CRF should more than offset their higher cost compared to conventional N fertilizers. Quantitative results from the study should lead to development of N fertilizer programs based on more efficient N fertilizers. Additionally, since principal aquifers supplying drinking water for urban areas in central Minnesota typically underlie potato producing areas, the urban population will also benefit from reduced health risks associated with the presence of elevated nitrate levels in the drinking water.

Nature and objectives of the research

Polyolefin coated N fertilizers are CRF designed to release N at a rate that, like crop growth, depends on soil temperature. These fertilizers are available in different release categories to match different crop N needs and growth duration. In this study, the POC urea (40-0-0) fertilizers, Meister-70 and Meister-50, will be compared with regular quick-release urea. 15N-labeled Meister-70 and 15N-labeled urea will be used to pinpoint the distribution of applied N in the plant-soil-water system from these sources. We will use the 15N tracer technique to determine both the fate and the behavior of applied N in the environment.

The overall objectives of this research are to:

1) Evaluate the efficacy of urea-based POC N fertilizers to reduce NO-3-N leaching while improving tuber yield and quality in a glacial outwash soil under irrigated potato production in central Minnesota.

2) Determine the fate and total recovery of N from POC urea in comparison to conventional urea fertilizers using the 15N-enrichment method.