WATER AND CHEMICAL MOVEMENT ON IRRIGATED POTATOES

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INTRODUCTION

The predominant potato variety grown in Washington and Oregon, Russet Burbank, is very susceptible to yield and quality reduction from even the slightest water or nutrient stress. The relatively low cost of fertilizer and water compared to the high economic risk of reduced yield and quality often results in excess applications of both these inputs. Two separate studies in Franklin County have shown over 40% of the wells tested to be above the EPA drinking water standard of 10 ppm nitrate. Potato production is not the only source of this nitrate, but must be considered as one of the contributors. Can intensive, informed management of nutrients and water prevent or reduce the movement of agricultural chemicals beyond the root zone of potatoes? To answer that question we must look at the factors that control water and chemical movement.

FACTORS THAT CONTROL WATER AND CHEMICAL MOVEMENT

Soil type, cultural practices, and crop characteristics are major factors in determining whether leaching of agricultural chemicals will occur.

Soil Type

Many of the potatoes grown in Washington and Oregon are produced on sandy soils. These soils have low organic matter content and low water holding capacity, thus providing little storage for water and water soluble chemicals such as nitrate nitrogen and some pesticides. Despite these constraints, high yields of high quality tubers are produced on sandy soils with adequate irrigation and fertilization. Less coarse textured soils provide more storage for water, but are more likely to provide preferential flow paths for solute movement.

Cultural Practices

Production practices can reduce the amount of water, nutrients, and pesticides that can be stored in the soil. Potatoes have a relatively shallow root zone and the volume of soil in which water and nutrients can be stored is further reduced by hilling. When chemigation is practiced, potato hills often shed a significant portion of water, fertilizer, or pesticide into the furrow.

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This effect is greatest for narrow, steep hills. If the furrow is deepened with a dammer-diker, applied water, fertilizer, or pesticide enter the soil near the bottom of the root zone and may quickly move beyond the root zone. When this happens leaching will occur with any excess water that is applied.

Cultural practices such as low flat hills, or no hills, that increase the soil volume around the crop roots and improve the placement of water and nutrients decrease the potential for agricultural chemicals leaching beyond the root zone. The increased soil volume also buffers changes in soil temperature.

The relatively small volume of soil around the potato roots, the solubility of fertilizers such as nitrate nitrogen, and the low water holding capacity of many soils on which potatoes are grown make it difficult to store nutrients and water in the root zone. This leaves little room for error if water and nutrients are to be available when they are needed by the plant but not leached beyond the plant root zone by excess application. Scheduling water and nutrient applications based on plant need and placing the inputs in an increased soil volume decrease the potential for ground water quality degradation.

Crop Characteristics

Potato cultivars can be loosely classified as determinate (e.g., HiLite and Frontier) or indeterminate (e.g., Russet Burbank and Century Russet) in growth habit. The more determinate varieties generally produce a smaller canopy and frequently fail to close the row. Because of the determinate charactertistic these varieties tend to be less sensitive to stress than less determinate varieties, thus providing a greater margin of error for scheduling water and nutrient applications. However, the smaller canopy of these varieties also tends to shed more chemigated inputs into the furrow. Because the yield and quality of less determinate varieties are severely affected by stress there is strong incentive to apply water and nutrient inputs at levels greater than those required to produce the crop. Excess applications of either cost the producer and the environment.

RESEARCH

Two studies are currently underway to develop guidelines for managing water and chemicals on potatoes. The first is looking at the relationships of yield, quality, and leaching of nitrate nitrogen for a wide range of water and nitrogen conditions. This study is being conducted with two determinate (Frontier and HiLite) and two indeterminate (Russet Burbank and Century Russet) cultivars. Preliminary yield and quality results from this study are discussed by Mary Hattendorf in another paper at this conference. Soil nitrate values from the first year of this study are being analyzed.

A second study is looking at the effects of application method and soil moisture on the movement of metribuzin. A baseline study was also conducted beneath three center-pivot irrigated potato fields in Franklin County in late 1989 and early 1990.

Soil samples taken every two weeks during the growing season and once each month during the off-season were analyzed for ammonium and nitrate nitrogen. Samples were taken to a depth of 1.8 m (6 ft) in 0.30 m (1 ft) increments.

Nitrate Under Potatoes

Four cultivars are being grown under several nitrogen and water management regimes. URAN was applied preplant through the irrigation system to bring the available nitrogen to 134 kg N/ha (120 lb N/A) on all treatments. At lay-by, June 6, granular nitrogen (ammonium nitrate) was side-dressed at three levels under best water management. Liquid nitrogen (URAN) was applied by line source for both best water management and for line-source water.

Side-dress nitrogen. Ammonium nitrate was applied at rates of 123, 246, and 370 kg N/ha (110, 220, and 330 lb N/A). The material was placed 10 cm (4 in) below the soil surface into each side of the potato hill with two shanks mounted 51 cm (20 in) apart. Following application of the fertilizer the potatoes were hilled. Total applied nitrogen for the season was 134, 257, 380, and 504 kg N/ha (120, 230, 340, and 450 lb N/A).

Chemigated nitrogen. URAN was applied through the sprinkler irrigation system weekly for 11 weeks (June 8 to August 17). The rate of application for the line-source ranged from 0 to 35 kg N/ha (0 to 30 lb N/A) giving a rate of 17 kg N/ha (15 lb N/A) at the midpoint of the line-source. Total applied nitrogen for the season ranged from 134 to 519 kg N/ha (120 to 463 lb N/A).

Sampling. Soil samples were collected from each treatment block on May 28 to establish a base level of nitrogen for comparison of the treatments. Samples were taken in six 30 cm (1 ft) increments and analyzed for ammonium and nitrate nitrogen. Samples at the same depths were again collected July 25 and at harvest for each plot. Water samples were collected for all irrigations during which nitrogen was applied with the water.

Metribuzin Movement

Metribuzin was applied with a conventional ground spray rig and through chemigation at two soil water contents. The "dry" treatments were obtained by covering those plots with a tarp during the irrigation previous to the application of the metribuzin. Water contents for the surface 1 cm of soil for the "wet" treatment was 4.8% by weight. For the "dry" treatment no water was found in the surface 1 cm using standard gravimetric methods. Metribuzin was applied to the conventional treatments with a ground rig at a rate of 0.56 kg/ha a.i. (0.5 lb/A a.i.) in a carrier volume of 280 L/ha (30 gal/A). For the chemigated treatments metribuzin was applied at 0.56 kg/ha a.i. (0.5 lb/A a.i.) in an irrigation application of 1.3 cm (0.5 in), the equivalent of a carrier volume of 119, 340 L/ha (12,770 gal/A).

Potassium bromide (KBr) and F D & C #1 blue dye were applied with the metribuzin in the chemigated treatments as soil water tracers. The KBr was applied at a rate of 20 mg/m^2. The blue dye was applied in solution as 0.25% by weight. Soil samples were collected for analysis by excavating transverse to the potato hills with a backhoe. The vertical faces of the trench were carefully shaved with a clean trowel. Samples were taken horizontally at depths of 0-2, 2-10, 10-18, 18-33, 33-48, and 48-63 cm (0-0.75, 0.75-4, 4-7, 7-13, 13-19, and 19-25 in) using core samplers. Samples were taken one hour, one day, 15 days, and 90 days following the application of the metribuzin. For the samples taken 90 days after application an additional depth increment, 63-78 cm (25-31 in) was added. All sampling equipment was cleaned with acetone between each sample.

SUMMARY

Several points emerge from the preliminary results from these studies. Under commercial, center-pivot irrigated potato fields in Franklin County, 330 kg/ha (300 lb/A) of nitrate nitrogen remained in the soil profile in late September. These values declined to 225 kg/ha (200 lb/A) by mid February. The values observed in September increased from 250 kg/ha (225 lb/A) in early August. Since two of the fields were harvested in late July-early August it must be inferred that this increase is attributable to degradation of the plant residue returning nitrogen to the soil. This observation is supported by data from the nitrate study being conducted. In that study extensive sampling indicated increased soil nitrogen between late July and harvest for all four varieties. Nitrogen returned to the soil late in the growing season is likely to be leached beyond the rooting depth of the following crop by winter precipitation or early season irrigations. A fall cover crop that takes up nitrogen and releases it to meet the requirement of the following crop would greatly reduce the potential for nitrate leaching.

Blue dye used in the metribuzin study show quite vividly that a significant portion of applied water (and any chemical in the water) are shed by the plant canopy and the sides of the potato hill into the furrow. This concentrates applications in a soil volume that contains few potato roots. Observations on the four cultivars grown in the nitrate management studied suggest that while rooting patterns of cultivars vary considerably under the hill, few roots reach the furrow. The fact that water and chemical inputs are not concentrated in the soil volume containing the plant roots suggests that alternate hilling practices could improve production efficiency and decrease the potential for leaching of nitrates and pesticides.