Applying dairy manure to agricultural fields has been shown to increase crop yields, improve the water-holding capacity of the soil, and enhance soil fertility. However, when manures are applied to fields at high rates over a period of several years, nutrients can accumulate, causing eutrophication in drainage waterways; degradation of drinking water; nutrient toxicities in plants; nutrient deficiencies in plants; disruptions in soil microbial populations; and nutritional imbalances for grazing animals. Growers and dairy producers also run the risk of violating state and federal regulations designed to avoid these issues.

In this publication, we will help you understand the reasoning behind laws that limit the application of specific nutrients in dairy manure. We will also provide a few general recommendations on how to avoid overloading fields with nutrients, and how to reclaim a field once you have exceeded these thresholds. The recommendations presented in this paper are suggestions, and do not have any regulatory implications. However, to enjoy the benefits of dairy manure applications instead of the pitfalls, please take note.

## **Phosphorus**

Phosphorus (P) tends to be the nutrient of greatest concern when it comes to animal manure field applications. When dairy manure is

applied based on the nitrogen (N) needs of the crop, P is typically applied at 3 to 6 times the amount of P that the crop can use.

"Eutrophication" can occur if P enters waterways through soil erosion and runoff.
Eutrophication—excessive aquatic plant growth and decay from increased P and N concentrations—can cause dissolved oxygen concentrations to decrease so much that aquatic plants and animals suffocate. In order to avoid eutrophication, the Total Maximum Daily Load (TMDL) for total P in the southern Idaho waterways is only 0.075 parts per million (ppm) as established by EPA Region 10.

Phosphorus that accumulates in soil can contribute to eutrophication. Therefore, in

rus does leach into the groundwater in areas that have received manure applications for long periods of time.

Because the calcium in free lime binds strongly to phosphorus, phosphorus leaching will likely be less prevalent in Idaho than other regions of the U.S. due to the high lime content of our soils. Still, if more P is applied than can be chemically bound, leaching can occur. Sandy soils are particularly vulnerable to P leaching. At this time, there seem to be more questions than answers in terms of phosphorus leaching and Idaho soils.

To lower the risk of P leaching into ground-water, the IDPTH for fields with subsurface water drainage (groundwater) is 20 ppm using Olsen soil test P (18-24" soil depth) if the field has a water table less than 5 feet below the soil surface, and 30 ppm with a water table more than 5 feet below the soil surface. For more information on Code 590, go to:

http://efotg.nrcs.usda.gov/references/public/ID/590.pdf.

If your soil test P exceeds the IDPTH, dairy manure can still be applied, but you must not exceed the P uptake of the succeeding crop. In other words, whatever P you apply must be fully used up by the crops.

Fertilizer guides from the University of Idaho and from other universities in the western region of the U.S. can help growers determine how much P will be needed by their crops.

Zinc (Zn) deficiency in plants is another concern with excessive P in the soil. Phosphorus and zinc interact in the root. Excessive concentrations of P in the root hinder Zn from being transported to leaves to support growth. The good

# To prevent accumulations of P in the soil, you should closely monitor:

- 1) the amount of P that you are applying to your soils;
- 2) soil test P concentration; and
- **3**) the P requirements for your crop.

news is that Zn deficiency is less common on manured soils, as the Zn in manure is chelated to organic compounds and readily available to plants. That said, Zn deficiencies could still occur, as Zn deficiencies on manured soils have not been extensively researched or investigated.

If your soil tests exceed the maximum legal levels of P, you may want to consider stopping applications of P until the P level decreases. Some people may worry that their crop yields will suffer if they do not fertilize with P. If your soil is already high in P, this should not be an issue. Most crops will not show an increased yield when Olsen soil test P concentrations exceed 20 ppm.

While P in the soil will decrease naturally over time, one of the most common methods for removing P from soils is crop removal. Crops such as corn grown for silage, alfalfa grown for hay, and triticale, can be useful for lowering P concentrations. "Mitigating High-Phosphorus Soils" (Bulletin 851) contains a wealth of information on lowering P concentrations related to dairy manure applications:

http://info.ag.uidaho.edu/pdf/BUL/BUL0851.pdf.

### **Nitrogen**

Idaho Statute Code 590 allows for manures to be applied based on nitrogen needs on soils with Olsen P concentrations that do not exceed the IDPTH. In this case it is assumed that the crop uses the majority of the N from manure. While this is generally true, the amount of manure N remaining at the end of the season depends on the manure and its application rate relative to crop N requirements. For example, manures that overwinter on fallow soils contain organic N and ammonium compounds that will slowly mineralize to form nitrates, which might be taken up by the following crop, or might move further down into the soil, beyond root systems, and leach into groundwater.

Nitrate, an inorganic and plant available form of N, is highly mobile and can therefore easily move into shallow groundwater resources when not utilized by plants. The movement of nitrates into drinking water and into waterways can pose serious environmental and health threats. Nitrates can also cause eutrophication in lakes and streams. Nitrates in drinking water from groundwater wells can cause blue baby

While these results are encouraging, repeated applications of dairy wastes could potentially raise Cu concentrations to levels toxic to plants. Once this happens, there is very little a grower can do to reclaim the field. A small number of fields in Idaho that have received frequent applications of lagoon water have shown evidence of Cu toxicity. Because Cu is so tightly bound by the soil, and so little is removed by crops, it is very difficult to quickly lower soil concentrations. If you wait until Cu plant toxicity symptoms occur (including plant death), you will continue to see Cu toxicities on that field for an indefinite period of time.

In terms of regulation, there is an existing EPA 503 "worst case scenario" standard that limits annual loading of Cu from biosolids to 66 lbs Cu/acre, and lifetime loading to 1,339 lbs Cu/acre. Reaching these limits is almost impossible with dairy waste applications, and would devastate most agricultural crops long before the lifetime loading limits were met. New York and Illinois have set lower lifetime loading limits for Cu at 75 and 250 lbs/acre, respectively, to avoid the potential of irreversible toxic accumulations of Cu in the soil.

While more studies are needed to develop an official threshold for Cu in Idaho soils, based on what we know, it would be advisable to cease Cu additions to soils with greater than 50 ppm DTPA-extractable Cu. To determine if you currently have a Cu accumulation problem in your soil, or to identify a developing accumulation, request an analysis for DTPA-extractable Cu

## Copper concentrations can be lowered in dairy waste by:

- 1) reducing the amount of copper sulfate used in foot baths;
- **2**) reducing the overall frequency of foot baths;
- 3) improving hoof trimming and stall surfaces; and
- **4**) disposing of the Cu waste in an alternative location to the lagoon.

every 2 to 3 years from a soil testing laboratory accredited by the Idaho State Department of Agriculture.

Mario de Haro Marti with the University of Idaho is also investigating the use of electrolysis for removing soluble copper from dairy lagoon water.

### Soluble salts

Accumulations of sodium (Na), potassium (K), calcium (Ca), and/or magnesium (Mg) salts do not pose any serious human health or environmental threats (that we know of), and therefore soluble concentrations of salts in soils and waterways are not regulated by federal, state, or local government agencies.

However, salt accumulations can cause toxicities in plants, induce water stress, seal soil surfaces, and lower crop yields. Also, if there is an imbalance in the concentrations of calcium, potassium, and magnesium cations, a deficiency can occur due to cation competition. For example, if there are high concentrations of potassium in the soil, whether from manure, potassium fertilizer, or another source, the plant can take up a disproportionate amount of potassium cations in comparison to calcium and magnesium cations, thus triggering calcium and/or magnesium deficiencies in the plant.

Forage plants, such as alfalfa, will increase their uptake of K as concentrations in the soil increase, thus increasing K concentrations within the plant tissue. This can be of great concern for beef and dairy cattle grazing. Excessive animal intakes of K can cause grass tetany from a lack of magnesium absorption (which can lead to udder edema). Milk fever has also been linked to high forage K tissue concentrations. Potassium concentrations in forages used for grazing should not exceed 2.0% on a dry weight basis.

If you frequently apply manures and/or other salt sources to your fields, we recommend analyzing your soil for electrical conductivity, sodium, potassium, magnesium, and calcium concentrations on a yearly basis. Guidelines for soil analysis, interpretation, and reclamation of salt-affected soil are listed in the publication "Managing Salt-affected Soils for Crop Production" (PNW 601-E), which can be found at: http://extension.oregonstate.edu/catalog/pdf/pnw/pnw601-e.pdf

To reap the benefits of manure applications without the worry of overloading your soils, follow these basic guidelines:

- 1) Know the environmental, regulatory, plant nutrition, human health, and animal consumption limits for P, N, Cu, and soluble salts.
- 2) Stay on top of soil, plant tissue, manure, groundwater, and stream analysis for key nutrients within your cropping system.
- **3**) Know the signs of nutrient overloading.
- **4**) Reclaim overloaded soils earlier rather than later.
- 5) Develop manure application rates that are based on common sense, and not just on regulations.

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