Volume XIV, Number 6, July 5, 2000

AMMONIA VOLATILIZATION

Recently I have been asked some questions about what nitrogen source is the best for cranberries particularly with regard to volatilization. Of course, most of the nitrogen in the environment is volatile—as nitrogen gas (N_2) that is essentially inert. Cranberries require nitrogen in the ammonium form NH_4^+, as opposed to nitrate NO_3^-. The current economic situation requires growers to think about the efficiency of every aspect of cranberry growing. Is volatilization of nitrogen as ammonia something you should worry about?

Ammonium (NH_4^+) and ammonia (NH_3) are readily interchangeable. Simply adding or removing a hydrogen ion makes the difference. Ammonium is not volatile, while ammonia is volatile. If we were to take pure ammonium and dissolve it into water an equilibrium between the two ionic states would result. At a pH of about 9.5 equal amounts of ammonium and ammonia would be present. As the pH of the solution is decreased the amount of ammonium increases. This makes sense, as the hydrogen ion concentration increases [indicated as a lower pH] more hydrogen ions are available to create ammonium. As the pH rises fewer hydrogen ions are available and ammonia is the result.

Most ammonia loss is from organic fertilizers such as animal manures. This loss is readily detected as "dairy air". However, when manure is incorporated the loss of ammonia is greatly reduced. When manure is incorporated the ammonium (NH_4^+) ions can attach to soil exchange sites thus slowing or stopping the reactions leading to ammonia (NH_3). Virtually all of the nitrogen applied to cranberry beds is manufactured and is frequently in a blend with other nutrients (i.e. 6-24-24). Common forms are urea, ammonium sulfate, diammonium phosphate, and monoammonium phosphate. The last three fertilizers provide the nitrogen in the form of ammonium, but urea initially breaks down to ammonia.

Lets consider for a moment how the information presented above relates to cranberry production. First, cranberry beds should have an acidic environment. Thus, hydrogen ions are available and the equilibrium between ammonia and ammonium should push towards ammonium.

$$NH_3 \xrightarrow{H^+} NH_4^+$$

Another factor that is necessary for creation of volatile ammonia is the presence of carbonate ions (CO_3^-). Ammonium ions react with the carbonate ions creating ammonium carbonate, an unstable combination. As the ammonium carbonate decomposes

three products result: ammonia, water and carbon dioxide and the ammonia and carbon dioxide are volatile. The best cranberry sites and water sources have low carbonate content (hardness).

Cranberry production areas typically have water and soils that are low in carbonates. Without carbonates the formation of ammonia is limited. This is another reason to choose sites with appropriate soil and water conditions for cranberry production.

Ammonium sulfate and urea are more prone to volatilization that mono- or diammonium phosphate. However, given conditions in cranberry beds significant volatilization should not occur with any N source.

Cranberry beds are all irrigated. After a fertilizer is applied the sprinklers are typically run within 24 hours. The irrigation will solubilize the fertilizer and will wash it into the top layers of soil where it can bind to the soil matrix. This also reduces volatility.

In review, these are the conditions that favor ammonia volatilization.

- Application to soils with low cation exchange capacity
- No incorporation of fertilizer
- High rates of N fertilizer (>100 lbs N/a)
- Moist soil surface, low humidity, windy and no incorporation
- Air temperatures above 75°F
- Presence of carbonates in soil or water
- Choice of fertilizer materials

In my opinion, ammonia volatility is not an issue for cranberry growers. It is almost hard to conceive of any situation where significant volatilization would occur. Any of the ammonium based nitrogen fertilizers are suitable for cranberry production. The decision of which to buy should be based primarily on price per unit of N, the presence of other necessary nutrients, and the ease of storage and application.

Teryl Roper, UW-Madison Extension Horticulturist

ANSWERS TO COMMON NUTRITION QUESTIONS

Micronutrients

A. *Should I consider applying micronutrients such as zinc, manganese, copper and boron?* As the class name suggests, these elements are required in very small amounts. You should add them if a tissue test suggests they are low or dropping. I have not seen tissue test reports showing deficiencies in any of these elements. The one exception may be boron during flowering to fruit set.

B. *Have there been any studies showing the benefits of applying the above micronutrients?* There is very little field research with micronutrients. It is difficult to do and unless replicated many times the effects are usually too small to find with the natural variability of cranberries. There have been some laboratory studies to determine the critical tissue value for these elements. These values are reflected in our current tissue test recommendations. We have also looked at toxicity of these elements and while they may become toxic, the concentrations that affect vegetative growth are 100 fold higher than what we have found in routine tissue tests.

C. *About how much of these elements are needed for optimum crop production?* I'm not sure that is the correct question. Much of these elements are retained in the perennial portions of the vines and little is harvested with the crop. Further, our soils typically contain adequate amounts

of these elements. The question isn't how many pounds per acre, but how many ounces per acre. Further, if your tissue tests show sufficient levels of micronutrients adding micronutrients probably is not necessary (with the possible exception of B).

pH Management

D. *When is the best time to apply sulfur for pH management?* Small doses of no more than 100 lbs/a are best. These can be effective once the soils have dried and warmed in the spring. Fall applications of sulfur would be less effective (depending on the length of fall and the temperatures after harvest) because the reactions that release H^+ ions are microbe mediated and thus are temperature dependent. Early spring applications would not have an effect until the soils warm.

E. *Is there a general rule for calculating the number of pounds of sulfur per acre required to reduce soil pH by 1 point?* There are some general rules, but all of these are mediated by the soil type and carbonate concentration in the soil. The table that follows gives some guidelines.

Initial pH	Sand or loamy sand	Sandy loam or loam
	Lb./acre	Lb./acre
7.0	800	2500
6.5	650	2000
6.0	252	1500
5.5	350	1000
5.0	170	500

F. *How many pounds of sulfur per acre should I apply to maintain my current soil pH?* That depends on how alkaline your water supply is. Eric Hanson had a great discussion of that in the cranberry school proceedings from 1999. If your water does not contain much carbonate it won't take much if any sulfur to manage pH. This question would need to be answered on a bed-by-bed basis.

FOLIAR FEEDING

Do plants do better if "fed" through leaves or through roots? "Several popular fertilizer products available to growers promote leaf feeding as superior to soil application of nutrients," explains Sherry Combs, director of the University of Wisconsin-Madison/Extension Soil and Plant Analysis Laboratory and UW-Extension soil specialist.

"Advertised claims include more efficient nutrient uptake, bigger fruits and vegetables, ability to 'spoon-feed' plants and better use of nutrients by the whole plant," she explains. "In reality, foliar 'feeding' is not superior, but some crops under certain growing conditions do respond better to applying nutrients to leaves," Combs adds.

Soluble liquid fertilizers are used when applying nutrients to leaves. This results in rapid absorption and has the advantage of near-immediate correction of nutrient deficiencies. "However, leaf fertilization is not the best choice when applying large quantities of nutrients because of foliage burn," Combs adds. "Because of the small amount of nutrients applied and remaining on leaves, benefits often are only temporary. Repeated applications may be needed," she says.

Fertilizing leaves of fruit crops and ornamentals can help correct certain deficiency symptoms. "Roses commonly exhibit iron and manganese deficiency—interveinal yellowing—when grown on high pH soils," Combs says. High pH soils lacking in iron and manganese make it difficult for certain plants, such as roses, to get enough micronutrients from the soil to support good growth. "Applying iron or manganese to the leaves of plants supplies these nutrients directly and avoids the problem," Combs adds.

Plants take in nutrients applied to foliage through the leaf stomata, the cell openings of plant leaves. This process occurs most rapidly during the first hour after application.

"For leaf absorption to be most effective, applications should be made when temperatures are cool and humidity is high, such as in the early morning or early evening," Combs says. "Applications during these times are also less likely to cause leaf burn."

"Feeding" leaves should not take the place of traditional soil application of macronutrients such as nitrogen, phosphorus and potassium. "Trying to apply the quantity of macronutrients required by plants can cause severe leaf burn," adds Combs. "In fact, a large portion of the nutrients applied to the leaves of plants falls on the soil surface. These nutrients are then absorbed by plant roots in the same manner as nutrients initially applied to the soil surface."

Sherry Combs, UW-Soil Science

EXCESSIVE RAIN AND NITROGEN LOSS

Excessive rain in many cranberry growing regions creates the possibility of nitrogen loss on cranberries. The actual extent of the losses in specific beds or marshes is difficult to estimate. Several factors influence the amount of nitrogen loss including soil type, amount of water received and length of time between application and excessive rainfall.

Obviously, more water leaches through a sandy bed than a peat bed. Sand based beds have a greater potential for nitrogen loss to leaching than peat based beds. Peat has greater cation exchange capacity which would adsorb ammonium ions tightly and restrict leaching.

Cranberry growers apply nitrogen as ammonium rather than nitrate. Ammonium is far less likely to leach than nitrate. Urea N is leachable as a neutral molecule if heavy rains occur before the urea is converted to ammonium (about 3-5 days). Our preliminary research indicates that ammonium N will not be converted to nitrate N at a soil pH of less than 5.5, so it is unlikely that any ammonium was converted to nitrate and lost in cranberry beds. This is common in corn fields and has been widely discussed in ag publications since the heavy rains.

The actual amount of nitrogen taken up between application and rainfall is difficult to estimate. This depends on the form of nitrogen applied, crop activity, soil temperatures and irrigation or minor rainfall after application. My opinion is that much of the nitrogen could have been taken up if a week or more elapsed between application and excess rainfall.

Making replacement nitrogen fertilizer applications potentially could lead to vine overgrowth if previously applied nitrogen is still in the root zone. Peat based beds should have been able to "hold on" to ammonium if it had been moved into the soil. Be conservative about making "replacement" fertilizer applications unless you see signs of reduced vigor that would warrant application.

Teryl Roper, UW-Extension Horticulturist

It is rather for us to be here dedicated to the great task remaining before us—that from these honored dead we take increased devotion for that cause for which they gave the last full measure of devotion—that we here highly resolve that these dead shall not have died in vain—that this nation, under God, shall have a new birth of freedom— and that government of the people, by the people, for the people, shall not perish from the earth.

Abraham Lincoln