Biuret in Urea Fertilizers

By R.L. Mikkelsen

In the past, urea manufacturing processes sometimes resulted in fertilizers with elevated biuret concentrations. In high concentrations, biuret interferes with internal N metabolism and hinders protein formation in plants. Biuret is degraded by many soil microorganisms, but the rate is relatively slow. Modern urea manufacturing typically results in biuret concentrations less than 1.0 to 1.3%, which does not pose problems for most uses. There are some plant species that appear to be especially sensitive to biuret, so "low-biuret" urea should be used for foliar application in these situations.

Urea has become the leading form of N fertilizer worldwide. Urea, a naturally occurring compound, can also be made by reacting carbon dioxide with ammonia at high temperature and pressure. Its high N content (46% N) makes urea economical to produce, transport, and deliver to the farm.

Two concerns are sometimes expressed by growers using urea as a N source for crop nutrition. First, when urea remains on the soil surface, a portion of the applied N may be lost through NH_3 volatilization…thereby diminishing its fertilizer value. When urea is first applied to soil, it generally reacts quickly with soil enzymes (urease) to convert to NH_4^+ then to NH_3 (**Figure 1**) which may be lost as a gas. Considerable effort has been made to understand this NH_3 loss pathway, resulting in urea coatings (such as controlled-release fertilizers), additives (such as urease inhibitors), and management practices that can substantially reduce these losses.

Reaction 1:

$CO(NH_2)_2 + H^+ + 2H_2O \rightarrow 2NH_4^+ + HCO_3^-$ (urea hydrolysis)

urea — urease

Reaction 2:

$NH_4^+ \rightarrow NH_3 + H^+$ (ammonia volatilization)

Figure 1. Typical breakdown of urea by soil enzymes to form ammonium (NH_4^+) and ammonia (NH_3).

A second concern related to urea fertilization is potential biuret toxicity for growing crops. When molten urea is heated near or above its melting point (132 °C or 270 °F) during manufacturing, several different compounds can be formed…including biuret (**Figure 2**). Biuret can be toxic to plants at elevated concentrations, whether applied to soil or foliage. Although modern urea manufacturing methods now consistently result in low biuret concentrations, questions still arise regarding potential hazards associated with biuret.

Biuret in Soils

Many years ago, researchers found that plant growth was reduced or completely eliminated following high applications of biuret to soils, and this growth suppression often persisted for a period of many weeks. Although the ability to degrade biuret is widespread among soil microorganisms, microbial growth is only half as fast with biuret as a N source as it is with urea. The presence of biuret also decreases the rate of nitrification in soil.

Foliar application effectively supplies nutrients for many orchard crops.

Seedling Damage

When urea with elevated biuret is placed adjacent to seeds, toxicity may result to the geminating plant. Some of this damage is due to the NH_3 evolved from the urea during normal hydrolysis, but biuret may make the harsh condition more severe. The extent of biuret damage to seedlings depends on the crop, the biuret concentration, and the fertilizer placement. Neither urea nor urea which contains biuret should be placed directly with a seed during planting. If the fertilizer is separated from

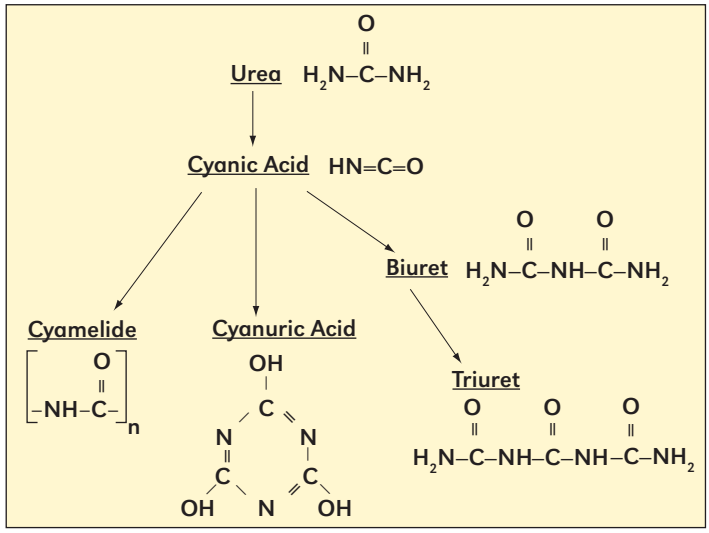

Figure 2. Possible reaction products formed from urea during exposure to high temperature.

Abbreviations and notes for this article: N = nitrogen; NH_4^+ = ammonium; NH_3 = ammonia

the seed by a small volume of soil, toxicity problems are greatly diminished. Amending the urea with a small amount of urease inhibitor will also reduce these adverse affects.

Soil Application of Biuret

Many studies have been done to determine the maximum biuret concentration tolerated by crops. The specific crop sensitivity depends on many factors such as the plant species, soil properties, the method and timing of fertilizer application, and both the concentration and total amount of biuret applied.

The soil properties on which the biuret-exposed crop is grown are important in determining potential toxicity. Biuret is not retained in soil and is easily leached. Plants are generally less sensitive to biuret when it is applied to soils containing appreciable amounts of clay or organic matter, or of low pH.

The specific toxic agent associated with biuret in the root zone is not known. It has been considered that cyanuric acid or nitrite may accumulate in the soil following biuret application and contribute to plant toxicity. Although these compounds can be injurious to plants, biuret by itself is also harmful.

Many crops can tolerate large amounts of biuret applied with urea if it is not in direct contact with the seed. A general guideline for safe use of urea applied to soil would permit a maximum 2% biuret in urea. Many crops are not adversely affected until biuret concentrations greatly exceed this level, which is greater than the 1.0% biuret commonly found in most urea currently produced in North America. There are a few plant species (such as citrus and pineapple) that do not tolerate elevated levels of biuret.

Citrus leaves damaged by biuret and urea application.

Foliar Application of Biuret

During the 1950s, foliar biuret damage was first noted following urea sprays on sensitive avocado, citrus, and pineapple. Since that time, considerable effort has been devoted to determining the safe threshold concentration of biuret in foliar sprays of urea. As with soil application, some plant species are more tolerant of biuret than others, but the allowable concentration of biuret in urea intended for foliar sprays is much lower than for soil application. Urea and biuret move readily into the leaves of many plants, making the potential for adverse effects greater with foliar fertilization.

Foliar application of urea can be extremely beneficial in some circumstances for plants. Several cereal, vegetable, and perennial crops respond favorably to foliar applications of urea with increased growth, yield, and quality. These benefits can include boosting grain N concentrations, reducing N losses through leaching and denitrification, and supplying N when root uptake is limited. However, foliar-applied nutrients may be directly absorbed by plants (without the buffering effects of the soil), so careful attention must be paid to this practice to do it properly.

Following foliar application of urea containing 0.5% biuret to potatoes, visual symptoms of yellow leaves, upward leaf rolling, and necrotic leaf margins have been noted. Application of urea and biuret on oranges resulted in damaged leaves, where the apical portion of the leaf was the most sensitive to biuret (**see photo**). These yellow leaves never regained their normal color, although the new flush of growth appeared normal. Because biuret is not rapidly metabolized by plants, repeated spray applications of urea and biuret may have a cumulative effect, especially with perennial crops.

Effects of Biuret on Plant Metabolism

Plants are not able to rapidly metabolize biuret. In one experiment, biuret still remained in the leaves of orange trees eight months after foliar application. Soil-applied biuret similarly accumulates in plants for long periods of time. The exact mechanism of biuret damage to plants is still uncertain, but the harmful effects of high concentrations have been well documented.

When present in elevated concentrations, biuret interferes with normal protein synthesis and internal N metabolism in the plant. Lower N concentrations are typically found in biuret-damaged leaves than in healthy urea-treated leaves. Biuret also disrupts normal activity of many important plant enzymes…increasing some enzymes and decreasing others…compared with healthy leaves.

Although biuret in urea can be damaging to plants when present in high concentrations, modern manufacturing processes have greatly reduced the severity of this problem. Early urea fertilizer manufacturing facilities often produced urea containing more than 5% biuret. Foliar application of urea solutions containing 1% biuret is acceptable for many common agronomic crops. However, for foliar fertilization of some sensitive crops, urea with especially low concentrations of biuret (less than 0.3 % biuret) may be required. If the sensitivity of a specific crop to biuret in foliar sprays is not known, it is advisable to start with low-biuret urea until the sensitivity has been determined.

The modern N fertilizer industry produces urea that is remarkably safe, consistent, and effective for enhancing plant growth. Urea has many properties that make it the most commonly used N fertilizer in the world. Biuret toxicity problems are generally rare, but special attention should be made for fertilization of especially sensitive crops. BC

For more information and a list of scientific references, visit this URL: www.ipni.net/biuret

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