Ammonium Bicarbonate Toxicity

root injury occurred from within few hours to several weeks in solution culture tests with citrus, avocado, and soybeans

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The ammonium source of nitrogen is often considered less desirable than other nitrogen sources for some plants. Nitrate is believed—by many people—to be superior to ammonium nitrogen for citrus, especially under acid soil conditions.

Workers in Florida showed recently that poor growth in citrus with ammonium nitrogen could largely be overcome by raising the pH—relative acidity-alkalinity—of the nutrient medium to about 6.

It was reasoned that if ammonium nitrogen were less toxic at pH 6 than at pH 4 it might be even less toxic if bicarbonate were present and if the pH were above 7. The hypothesis involved the fixation of the bicarbonate into organic acids which in turn would be combined with the ammonia to form amino acids and thus provide a means of rendering ammonia nontoxic. The treatment, however, proved to be almost lethal to the plants.

Root Injury

Avocado roots were severely injured in solution culture by ammonium bicarbonate within 72 hours and by urea with bicarbonate in about seven days. They were visibly injured by ammonium sulfate in the presence of calcium carbonate, also in solution culture, in about two weeks. Actually avocado roots were injured somewhat by bicarbonate in the presence of nitrate. Such injury occurred in about three weeks.

Roots of citrus and soybean seedlings were injured much in the same manner as were avocado roots, but the injury did not occur quite so rapidly, nor was there injury with a combination of bicarbonate and nitrate.

Bicarbonate concentrations of 5 m.e. —milliequivalents—per liter or less produced relatively little toxicity while those 10 and above produced considerable toxicity. Likewise the lower ammonium concentration, the less the toxicity.

Dry Weights of Roots of Soybeans

Treatment	Wt. in grams
ammonium-N pH 4	1.5
ammonium-N pH 6	1.7
ammonium-N pH 7	3.5
ammonium-N-bicarbonate pH 8.5	1.1
nitrate N—pH 4	4.0
nitrate N—pH 6	3.9
nitrate N—pH 7	3.5
nitrate N—bicarbonate pH 8.5	4.0

Control plants in which nitrate or ammonium nitrogen was maintained and in which changes were made often enough to keep microbial activity at a minimum indicated that the combination of ammonia and bicarbonate was necessary to produce the toxicity. Neither alone caused it.

A number of plants were grown in nutrient solutions with ammonium hydroxide to determine if the ammonium bicarbonate effect could be the result of the hydroxyl ion. Results were inconclusive.

Since a large portion of the nitrogen fertilizer used in California is ammonic, it is of considerable importance to ascertain if these effects obtain in the field, particularly on alkaline or calcareous soils where bicarbonates are always present. Preliminary results with soil tests indicate that there could be some problem, especially since a toxic effect can be pronounced in avocado within hours.

When ammonium nitrogen is applied to neutral, alkaline, or calcareous soils, nitrifying bacteria convert it to nitrate nitrogen. This process is rapid and essentially complete in a few days. It is a safety mechanism that could prevent ammonium bicarbonate toxicity. If soil has been fumigated or sterilized, however, nitrification may be very slow and ammonia application to soils containing bicarbonates may be injurious for some crops.

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age may be closely associated with a failure to achieve physiological hardening or readiness before being placed in storage. If this be true, some of the fall-stored Mt. Shasta stock, in contrast to the Oakdale stock, would have been in a poor physiological condition—perhaps even close to death—when delivered to the planting site the following spring.

Since the weather varies from one year to the next, there is a good chance that the physiological condition of the seedling at a specified date will not be the same each year. Although stock lifted on October 15 did not store well—as measured by lateral root growth—while stock lifted on November 1 did, October 15 and November 1 are not necessarily critical dates. Weather conditions might be such that stock lifted on October 15 would be physiologically hardened and would store well. Similarly the seed collection zone might be correlated with survival and lateral root elongation one year but not the next. Certainly critical dates can be expected to differ at each of the widely separated forest nurseries in the state.

The physiological condition of a seedling can not be determined by inspection. Stock lifted on October 1 appears the same after storage as stock lifted in November or December; the needles are as green and the roots as turgid and as firm. However, some rapid method of measuring the physiological activity—perhaps gas exchange or reserve food measurements—may provide the answer.

Although these studies indicate that early fall lifting and storage may produce seedlings that are certain to die, they also indicate that seedling stock lifted and stored later in the year has a good chance of survival.

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