Nitrogen (N) form affects medium pH and root-disease incidence.

In this alert, we will discuss the chemical properties of N and how we can use it to manage medium-pH and prevent root diseases.

Plants take up nitrogen at a larger quantity than any other mineral element. For this reason, nitrogen has a large effect on plant quality and medium-pH.

**Nitrogen Forms in Fertilizers**

Nitrogen in fertilizers can come in the form of ammonium (NH$_4^+$), nitrate (NO$_3^-$), urea (CH$_4$N$_2$O) or other organic sources. Fertilizers typically have more than one source ((Fig 1).

Nitrate and ammonium are stabilized in fertilizer salts by combining them with an element of the opposite charge.

Nitrate has a negative charge and is bound to elements with positive charges such as calcium, magnesium, and potassium.

Ammonium has a positive charge and is combined with molecules with negative charges such as phosphates, sulfates, and nitrates.

Urea is an organic molecule. Other organic-N sources come in the form of organic matter (e.g. fish emulsion, manure, etc).

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**Fig. 1.** Example of fertilizer label with three nitrogen sources.

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This fertilizer will have an acid reaction. It has 70% of the total nitrogen from NH$_4^+$ and urea. Fertilizers with 20% or more of the total N in the form of NH$_4^+$ will have an acidic reaction. The higher this number, the more acid the reaction.

Calculation: (3.83% ammoniacal nitrogen + 10.10% urea nitrogen) /20% total N = 0.6965 *100% = 69.65% of N in the form of NH$_4^+$ and urea.
Plants take up nitrate, ammonium, and urea

Plants take-up N in the form of ammonium or nitrate.

Plants readily use ammonium after uptake. For this reason, plants respond (“green up”) very quickly to ammoniacal nitrogen applications, which is also why too much ammonium can cause phytotoxicity (Fig 2).

Plants absorb nitrate and store it in the cells. Plants need to convert nitrate to ammoniacal nitrogen before using it.

Plants can take up urea, but they cannot directly take up N from organic matter (e.g. fish emulsion).

Organic matter has to go through a series of processes before plants can absorb them. Microbes break down organic matter and then transform organic-N into ammoniacal nitrogen. Other microbes then transform ammoniacal nitrogen to nitrate nitrogen. These reactions depend on the presence of microbes and environmental conditions. Therefore, nutrient availability from organic sources is slower and less predictable compared with inorganic sources.

**Take-Home Message #1:** Plants take up N mostly as ammonium and nitrate only. N in organic matter is not readily available for plant uptake.

Nitrogen forms affect medium-pH

Ammoniacal nitrogen (NH$_4^+$-N) lowers pH-medium via interactions with plants and microbes. When roots take up NH$_4^+$ they instantaneously extrude H$^+$ protons (acid). Microbes in the media convert NH$_4^+$-N to NO$_3^-$N and H$^+$ protons are a by-product of the reaction. The higher the concentration of H$^+$ protons, the more acid the solution in the medium. These reactions happen more frequently and faster at temperatures at which plants and microbes are active.

Nitrate nitrogen (NO$_3^-$N) reacts with the plants only and results in pH neutral or basic reaction in the medium.

Fertilizers with 20% or more of the total nitrogen in the form of ammonium and urea will result in a net acidic reaction. See figure 1 for an example on how to calculate this number.

Growers must match fertilizers to water alkalinity and crop requirements. Growers can use the acid and basic reaction of fertilizers to adjust medium pH in the container.

Ammonium at high concentrations can affect uptake of elements with positive charges such as calcium, potassium, and magnesium.

**Take-Home Message #2:** Ammonium-N reduces medium-pH. Nitrate-N has a pH neutral or basic reaction in the medium.

Root diseases affected by N form

Nitrate suppresses Fusarium wilt on asters, basil, chrysanthemum, cyclamen, dianthus, and gladiolus. Whereas, Fusarium wilt on mums and cyclamens can be higher when using ammoniacal nitrogen.

Ammonium suppresses Black root rot on several crops including pansy and vinca. Nitrate nitrogen applications can increase Black root rot on Pansy.

Pythium root rot increases with increasing N levels, regardless of the source.

For more information on this topic go to: https://www.youtube.com/watch?v=nd0EPVb04vU&t=948s

**Take-Home Message #3:** Nitrogen form can affect disease severity. The effect is specific to N-form, host, and pathogen.
Summary
✓ Fertilizers contain nitrogen in the form of ammonium, nitrate, urea or other organic forms.
✓ Plants take-up nitrogen in the form of nitrate, ammonium, and urea.
✓ Plants cannot directly take-up N bound to organic sources. Microbes break down organic-N sources into ammonium and nitrate.
✓ 20% or more of the total nitrogen in the form of ammonium and urea will result in an acidic reaction. The exact reaction in the container will depend on water alkalinity and plant genetics.
✓ Root diseases can increase or decrease with different N-forms. If your crop has a high incidence of a root disease, try switching to a different N-source or lower N-rate.

Nitrogen Form in Fertilizers

<table>
<thead>
<tr>
<th>Nitrogen Form in Fertilizers</th>
<th>Plant absorption</th>
<th>Effect on medium-pH</th>
<th>Effect on root disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium (NH₄⁺)</td>
<td>Direct uptake and use.</td>
<td>Acid</td>
<td>↓ Black root rot, ↑ Fusarium wilt</td>
</tr>
<tr>
<td>Nitrate (NO₃⁻)</td>
<td>Direct uptake, stored in cells. Plants transform it to NH₄⁺ before use.</td>
<td>Neutral or basic</td>
<td>↑ Black root rot, ↓ Fusarium wilt</td>
</tr>
<tr>
<td>Urea (CH₄N₂O)</td>
<td>Direct uptake or microbes transform to NH₄⁺ before plants absorb it.</td>
<td>Acid</td>
<td>N/A</td>
</tr>
<tr>
<td>Other organic sources</td>
<td>No direct uptake or use. Microbes transform to NH₄⁺ before plant can taken it up and used it.</td>
<td>Acid</td>
<td>N/A</td>
</tr>
</tbody>
</table>

TAKE-HOME MESSAGE: Know your nitrogen forms and read fertilizer labels.

Rosa E. Raudales is an assistant professor at the University of Connecticut (rosa.raudales@uconn.edu) with a M.S. in Plant Pathology and a Ph.D. in Horticulture. Juan Carlos Cabrera is a Ph.D. student in Plant Science at the University of Connecticut.

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www.e-gro.org

CONTRIBUTORS

Dr. Nora Catlin
Floriculture Specialist
Cornell Cooperative Extension
Suffolk County
nora.catlin@cornell.edu

Dr. Chris Currey
Assistant Professor of Floriculture
Iowa State University
currey@iastate.edu

Dr. Ryan Dickson
Extension Specialist for Greenhouse Management & Technologies
University of New Hampshire
ryan.dickson@unh.edu

Thomas Ford
Commercial Horticulture Educator
Penn State Extension
tgf2@psu.edu

Dan Gilrein
Entomology Specialist
Cornell Cooperative Extension
Suffolk County
dog1@cornell.edu

Dr. Joyce Latimer
Floriculture Extension & Research
Virginia Tech
jlatimer@vt.edu

Heidi Lindberg
Floriculture Extension Educator
Michigan State University
wolleage@anr.msu.edu

Dr. Roberto Lopez
Floriculture Extension & Research
Michigan State University
rglopez@msu.edu

Dr. Neil Mattson
Greenhouse Research & Extension
Cornell University
neil.mattson@cornell.edu

Dr. W. Garrett Owen
Floriculture Outreach Specialist
Michigan State University
wgowen@msu.edu

Dr. Rosa E. Raudales
Greenhouse Extension Specialist
University of Connecticut
rosa.raudales@uconn.edu

Dr. Beth Scheckelhoff
Extension Educator - Greenhouse Systems
The Ohio State University
scheckelhoff.11@osu.edu

Lee Stivers
Extension Educator - Horticulture
Penn State Extension
Washington County
ljs32@psu.edu

Dr. Paul Thomas
Floriculture Extension & Research
University of Georgia
pathomas@uga.edu

Dr. Ariana Torres-Bravo
Horticulture/Ag. Economics
Purdue University
torres2@purdue.edu

Dr. Brian Whipker
Floriculture Extension & Research
NC State University
bwhipker@ncsu.edu

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