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Calcium's Role In Plant Nutrition

Research shows soluble calcium fertilizer plays vital role in production of high-quality crops.

Summary: *Calcium availability is essential in the biochemistry of plants and, as we are learning, in the nitrogen fertilizer efficiency of surface-applied urea. We should not confuse the role of important soil amendments such as lime or gypsum with the need of soluble calcium by high-value crops. Both are extremely important in soil fertility and plant nutrition and complement each other.*

Calcium fertilization of many crops is frequently confused with lime or gypsum soil amendments. Many believe application of these minerals to soils sufficiently supplies the calcium requirement of crops. Unfortunately, the role of calcium in plant nutrition is often eclipsed by interest in macronutrients or specific micronutrients. Many times, calcium fertilization has been overlooked and is only considered when deficiency disorders influence the economic threshold of produce quality and value. However, we know that calcium 1) is a multifunctional nutrient in the physiology of crop plants and 2) in the soluble form influences availability and uptake. Nitrogen-use efficiency of urea-containing fertilizers is also increased with soluble calcium sources such as calcium nitrate.

Classical visual symptoms in calcium deficient plants include 1) death of growing points, 2) abnormally dark green foliage, 3) premature shedding of blossoms and buds, and 4) weakened stems.

Our focus in this article will primarily address the importance of calcium in cell wall structure and crop production.

Calcium's function

Cell wall strength and thickness are increased by calcium addition. Calcium is a critical part of the cell wall that produces strong structural rigidity by forming cross-links within the pectin polysaccharide matrix. With rapid plant growth, the structural integrity of stems that hold flowers and fruit, as well as the quality of the fruit produced, is strongly coupled to calcium availability.

Solubility helps

Many fruit and tuber crops such as apple and potato have a very narrow window for calcium uptake. Ninety percent of the calcium taken up by potato tubers or apple fruit occurs within a four- to six-week period after bloom for apple or during budding for potato. Uptake can be enhanced by applying calcium in the soluble form (i.e., calcium nitrate or calcium chloride, either of which is immediately available for uptake). With many rapidly growing crops, insoluble sources will not provide adequate calcium fertility.

Disease reduction

Many fungi and bacteria invade and infect plant tissue by producing enzymes that dissolve the middle lamella. Enzymes responsible for dissolving the middle lamella include polyglacturonases and pectolytic enzymes such as pectate transeliminase.

Increasing tissue calcium content astonishingly lowers polyglacturonase and petolytic enzyme activity from

Table 1. Bean tissue calcium content effect on bacterial pathogen infection.

Ca content (%)	Polyglacturonase activity	Pectate transeliminase	*Erwinia* severity *
0.68	62	7.2	4
1.60	48	4.5	4
3.40	21	0	0

* 4 = complete decay of plants in 6 days.
0 = no symptoms
The medullary tissue of the tuber contains at least 200 ppm Ca.

Table 2. Bean tissue calcium content effect on bacterial pathogen infection.

Percent K	Percent Ca	Percent Mg	*Botrytis* infection rating *
1.44	1.06	0.32	4
2.38	0.54	0.41	7
3.42	0.22	0.47	13
4.89	0.18	0.42	15

* 0-5 = slight; 6-10 = moderate; 11-15 = severe

Erwinia carotovora. For example, *Erwinia* bacteria infect many vegetable crops and are also responsible for storage rot in potato tubers. Increasing bean tissue calcium content from l.6 to 3.4 percent greatly reduced *Erwinia cartovora* infection (Table 1). Plants containing 1.6 percent calcium were completely destroyed within six days. Plants containing 3.4 percent calcium were healthy and possessed no symptoms of infection.

Fungal pathogenic infection is also reduced with increased calcium uptake by plants. A steady supply of available calcium delivered during fertigation by calcium nitrate reduces *Fusarium oxysporum* activity, the fungal pathogen that causes wilt and crown rot in tomatoes. Research indicates that tomato plants receiving low rates of calcium fertilization were severely infected with *Fusarium oxysporum*, compared to healthy plants receiving higher calcium rates. Calcium fertilization also reduces Pythium blight and root rot of turf grass and citrus.

How effective is calcium fertilization in comparison to other nutrients? Research indicates that calcium uptake in plant tissue is superior to potassium in reducing the infection of the fungal pathogen *Botrytis* in lettuce (Table 2). Increasing potassium concentration in lettuce from 1.44 to 4.89 percent did not deter *Botrytis* infection. However, decreasing tissue calcium concentration by half from 1.06 to 0.54 percent increased infection from a slight to moderate rating. A further decrease in calcium by one-half in the tissue (0.54 to 0.22%) resulted in severe *Botrytis* infection. Lesson to be learned: enhanced cell wall structural integrity supplied by calcium fertilization is important for plant health.

Increasing N efficiency

Surface application of urea with soluble calcium fertilizer solutions reduces ammonia volatilization. The soluble calcium fertilizer source, either calcium nitrate or calcium chloride, for example, precipitates the carbonate component from the solutions as calcium carbonate. As a result, the concentrated fertilizer solution pH is decreased. Subsequently, less ammonia is lost. Water soluble calcium fertilizer sources are key in this reaction. Calcium sources such as lime, gypsum and soil exchangeable calcium cannot reduce ammonia volatilization loss.

A recent field experiment with urea calcium ammonium nitrate ("UCAN" 21-0-0-4Ca with a calcium/urea ratio of 0.4), UAN, and UAN + Agrotain® (urease inhibitor) was conducted at Kansas State University to determine nitrogen fertilizer efficiency of each source. The test crop was corn. Results as shown in Figure 1 indicate that within each fertilizer rate, UCAN produced the highest yields and the highest nitrogen fertilizer efficiency. A three-fold increase in yield per pound of nitrogen applied was observed for UCAN-21 in comparison to surface-applied UAN or UAN plus Agrotain® at the 50- and 100-lb/A rates of N. UAN and UAN plus

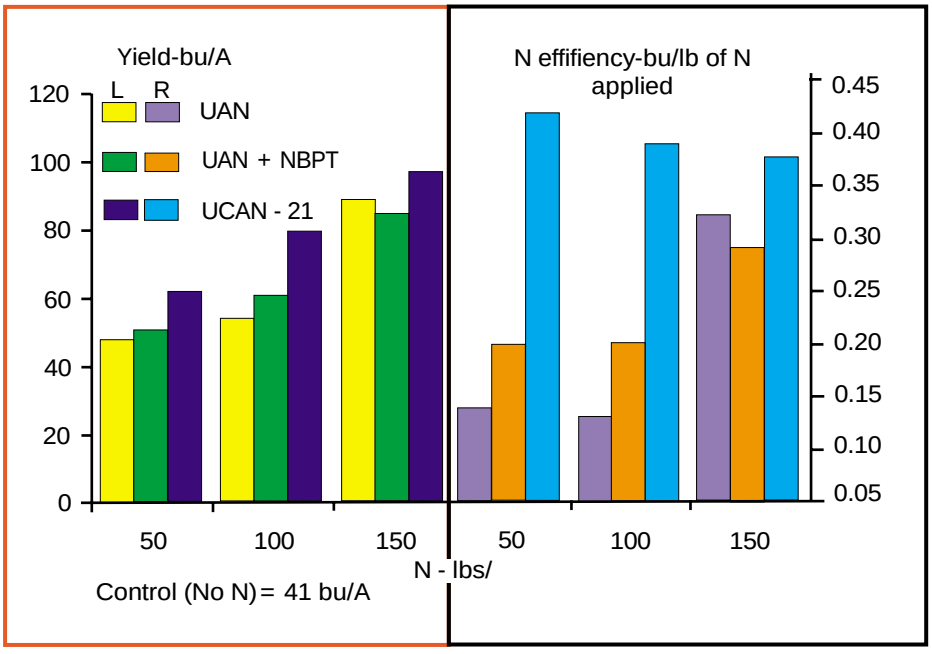

Figure 1. Corn grain yield and N fertilizer efficiency by N source and rate.

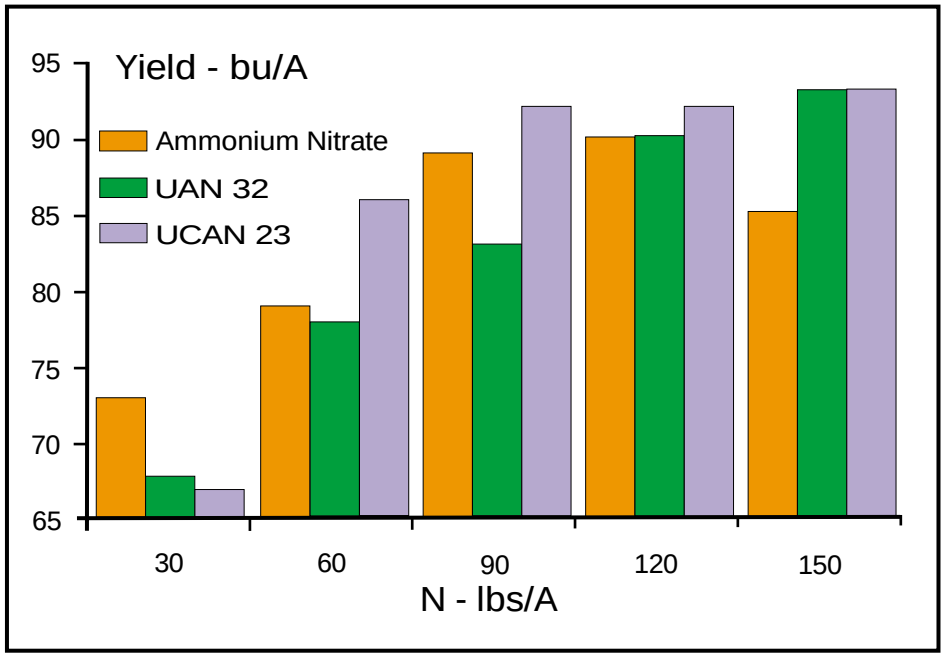

Figure 2. Wheat grain yield by N fertilizer source and rate.

Agrotain® approached the nitrogen fertilizer efficiency of UCAN–21 only when nitrogen was applied in excess (150 lbs/A).

To test further this hypothesis, a no-till study was conducted on wheat at the University of Tennessee (Figure 2). Fertilizer sources were ammonium nitrate, UAN-32, and UCAN-23 (23-0-0-4Ca) applied at incrementally increasing rates of 30 lbs/A of N. It is interesting to note that UCAN-23 performed as well as and often superior to ammonium nitrate, the preferred nitrogen source for no-till cultivation. UCAN-23 achieved optimal economic yield at 60 lbs/A of N. Ammonium nitrate and UAN required 90 to 120 lbs/A of N, respectively, to produce similar yields. Minimally, nitrogen application rate could be reduced by 30 lbs/A of N with UCAN-23 and produce the same economic yield as other sources. Also, from an environmental point of view, judicious nitrogen management, coupled with yield optimization, is the goal of the fertilizer industry. Mixing two fertilizers to reduce nitrogen loss is very appealing. Calcium, therefore, plays a vital role in urea/nitrogen fertilizer efficiency.

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