



# Production Agriculture's Most Often Unexploited Opportunity

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## Being Smart about Nitrogen Applications Goes Beyond the Basics

**A**gricultural experts have long touted the need and benefits of added nitrogen for commercial production of many crops. Most have suggested that growers need only “get enough of the cheapest form” applied for the growing crop (and add a little extra because some of the nitrogen is lost). Growing concerns over off-site environmental problems have served to influence some of these “experts”. However, we have yet to see any evidence of changes to recommendations that can genuinely influence the crop quality, yield, and season length. All of these potentially profitable benefits can be achieved by merely providing the crop with the proper form, rate, placement, and timing of nitrogen inputs, which automatically reduce the negative environmental impacts.


## Changing Nitrogen Management Practices

What if by simply changing nitrogen management practices, growers could save input dollars and increase the volume and quality of the crops they grow? It may sound too good to be true; however, simple plant physiology suggests these benefits can be accrued by growers virtually every year, with every crop they grow, by disciplined use of nitrogen inputs. If the recommending agronomist is lazy and looks at input nitrogen simply as a uniform supply for the formation of amino acids, other equally important facts of plant physiology that have influence over nitrogen use efficiency are missed. For the grower, following such over simplified guidance is a missed opportunity to earn greater profits associated with a more detailed review of plant processes related to nitrogen use.

## Nitrogen Forms and Risks

Let's start with nitrogen availability and uptake. In general, nitrogen can be found in and readily taken up from soils in different forms by the plant root. Nitrates are negatively charged and don't bind as strongly to soil particles, so they flow readily. If there is too much water, plant available nitrates can be lost; either being lost through anaerobic denitrification or flowing below the root zone and becoming inaccessible to the growing plant. However, if soil moisture is low to adequate, plant roots can readily absorb nitrates along with the water they transpire and draw in other mineral nutrients and support growth. Ammonia dissolves readily in soil water transforming into the positively charged ammonium ion. This positively charged ion “sticks” better to soil, so it is better retained after application. However, plant cells can tolerate only low concentrations of this form of nitrogen (e.g. most grass-like crops less than 1% by weight). Once taken up, ammonium must be detoxified via conjugation with plant sugars, a process which converts ammonium into amino acids, and eventually proteins and other useful compounds, inside plant cells. The low concentration tolerance does limit the amount of ammonium uptake to the amount of readily available sugars for detoxification, so larger plants can absorb more ammonium per unit time than smaller plants. Because young plants are more sensitive to ammonium toxicity, growers must pay attention to the timing, rate, and placement of the less expensive ammonia and ammonium form fertilizers to avoid causing plant stress. Amino acids can also be taken up by plant roots directly; however, their use as fertilizers is a bit more complex. Free amino acids can be found at very low concentrations in soil





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water as a byproduct of natural cycling of roots, soil organisms, and microbial activities. Amino acids are very much more abundant during the breakdown of various organic fertilizers, including seed meals, meat by-products, etc. This can pose a chemical risk, because rapid decomposition results in rapid ammonium release, and a biological risk as well, because pathogens and pests compete with neutral and beneficial soil life for the same material. Because so many different life forms are eager to consume organic fertilizers once they get wet, timing, rate, and placement are also important to avoid both chemical and biological stress to growing plant roots.

### **Why Nitrogen Form is a Significant Factor in Determining Plant Growth**

Understanding the different plant responses to nitrate and ammonium reveals why nitrogen form is a significant factor in determining plant growth and nitrogen use efficiency. As stated earlier, ammonium nitrogen is converted without exogenous energy into amino acid. In comparison, nitrates need to be “reduced” (remove the oxygen and replace with hydrogen in the molecule). In plants, this process is executed by nitrate reductase. When nitrate levels in cells begin to rise, the production and activity of this enzyme is triggered requiring the plant to expend energy. In general, the higher the cellular nitrate content, the greater the generation of this enzyme and energy expenditure. Both building and powering these enzymes uses plant energy, which would otherwise be invested into expanding harvestable yield. Recent publications have gone a step further showing that nitrogen causes genes to be expressed differently in the cell, based on the form. When nitrates are “sensed” in the root environment, genes that generate the hormone, cytokinin, are ‘turned on’. Cytokinins are expressed in the root and transported to the above-ground portion of the plant where they induce cell division. This cell division is apparent during the vegetative growth stage, when increasing plant cells (and size) is important. So, nitrates in the root zone during vegetative stages are a valuable input. In most soils, especially early in the season, cool temperatures delay the soil nitrification processes and limit

the supply of nitrates. This natural limitation demands that an adequate supply of nitrate-nitrogen be applied by growers to exploit this plant function. Publications dating back as far as the 1980s have touted the benefits of ammonia nutrition in corn production as the “late” supply of nitrogen. Until recently, underlying plant processes were not fully understood. Ammonium forms of nitrogen both eliminate the energy loss associated with powering the nitrate reductase process, as well as induce the production of auxin. Auxins are powerful hormones that cause plant cells to grow larger, as well as suppress cell division. Auxins also induce root elongation, which aids in soil nutrient acquisition, and focuses plant energy into filling the grain. If nitrates cause cytokinin production during the reproductive stages of development, the flow of plant sugars is diverted from reproductive grain fill to attempts to grow new green tissue-like “suckers”. While these do not always reduce yield, they are always a sign of delayed maturity.

### **A Systems Approach to Improved Nitrogen Use Efficiency**

Clearly, feeding plants the right form of nitrogen at the right time is required to obtain maximum yields. However, as important as proper nitrogen nutrition is to optimum plant development, it does not happen in a vacuum. All other plant processes need to function properly for the plant to develop on time. When a plant needs to grow and function, plant processes are delayed until the proteins needed for such tasks are formed, even for nitrogen metabolization. Often these proteins require other metal ions, like iron, manganese, copper, or zinc, to be built and function properly. When these essential micronutrients are limited, plant processes are delayed until these metals accumulate. If soil or root conditions are compromised, these micronutrients are difficult or impossible to access. Therefore, timely foliar applications of micronutrients that can be taken up readily aid in enhancing plant maturity. If your system includes timely foliar applications with the right material, in the right place, and in the right form, the system is very likely to enhance yield quality, as well as speed the crop to maturity. Isn't that what the Maximum Farming System is all about? ▲