AGR-245

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Nitrogen for Kentucky Turfgrasses

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Nitrogen (N) fertilizer is required by turfgrass in larger quantities than any other mineral nutrient because the plant demand for N is high and the supply of N from the natural environment is normally low. In instances where N is not applied according to the University of Kentucky recommendations, applied N can increase the risk of surface and ground water contamination. The fate of N applied to Kentucky turfgrass and detailed descriptions of the N transformations can be found in AGR-248. The objective of this document is to describe the function of N in turfgrass, explain how soil and tissue tests can be used to manage N applications, and to describe the various N fertilizer sources available for application to turfgrass.

Function of Nitrogen in Turfgrasses

Numerous biochemical compounds inside turfgrass cells contain N including amino acids, proteins, chlorophyll, and hormones. Because N is a component of numerous compounds, N deficiency results in a rapid reduction in growth, stand thinning, and will eventually result in yellowing of leaf tissue. Turfgrasses subject to intense traffic stress, such as those grown for sport turf, sod production, and golf courses may exhibit slow recovery in the absence of N fertilization. On the contrary, when N is over applied, turfgrass root growth and stress tolerance are reduced, and thatch levels may become problematic.

Tissue Testing for Nitrogen

Using tissue testing to manage N applications to turfgrass can be problematic for several reasons. First, N concentrations in healthy turfgrass tissue can vary dramatically from season to season and most laboratories do not have sufficient data to separate these differences. For example, in Kentucky, warm-season turfgrasses emerge from dormancy in the spring, grow during the summer, and enter dormancy in the fall. Healthy turfgrass may have 3% N in the spring, 2.5% N in the summer, and 3% N in the fall. Therefore, if the 'healthy N concentration' were 3%, than a tissue test in the summer would result in a recommendation to apply N when none was needed. The inverse of this seasonal effect is true for cool-season grasses, such as tall fescue and bentgrass. Second, N is mobile in turfgrass tissue, which results in N being translocated from older leaves to newer leaves. This movement of N results in N deficiency occurring first in older leaves. However, older leaves are rarely sampled because the mower removes tissue from the upper turf canopy rather than the lower leaves. Therefore, a true N deficiency in turfgrass may be easily overlooked by tissue testing. The last reason tissue tests are of little value is that tissue test calibrations have not been determined on Kentucky turfgrasses. In order to provide a meaningful recommendation, the concentration of N in the turfgrass must be correlated and calibrated to a response from the application of N. The correlation and calibration process is confounded by numerous N transformations that occur in the soil and, despite this difficulty, research in this area continues.

If tissue tests are collected from the same turfgrass, at the same time of year for several years, then historical values may be a useful diagnostic tool. However, please be aware that a sudden change in tissue N may be the symptom rather than the cause of the observed problem.

Soil Nitrogen

The soil N cycle in turfgrass systems is described in detail in AGR-248.

Soil Testing for Nitrogen

A soil test cannot be used to manage N applications to turfgrasses. However, some newer soil N tests are showing promising results in row-crop agriculture. These tests measure CO_2 flux and report values as "CO_2 burst" in parts per million, which provides an estimation of microbial activity. An additional test may provide an estimation of labile amino N extracted from soil organic matter. Soils with appreciable organic matter have been documented to provide N through mineralization and reduce the total N fertilizer required. Thus, establishing a soil test that can provide an estimation of the supply of mineralized N would be valuable. While these tests may eventually prove to be useful, they have not been correlated or calibrated to turfgrass response in Kentucky. In the absence of calibration data, it is not possible to interpret the reported value for turfgrasses. Therefore, using these tests to manage N applications to Kentucky turfgrasses is not recommended.

Applying Nitrogen

Information regarding rates and timing of N applications can be found in AGR-212. In general, apply no more than 1 pound of N per 1,000 ft^2 per application from granular soluble N sources and no more than 2 pounds of N per 1,000 ft^2 when the N source is 100% slow-release. The higher application rate for slow-release N sources is necessary because at lower rates, the amount of N released on a day-to-day basis may be insufficient to meet turfgrass demands. On highly manicured turfgrass, soluble N may be sprayed on the turfgrass foliage. As a foliar spray, the rate of soluble N may vary greatly depending upon the desired result. Nitrogen rates of 0.1 pounds of N per 1,000 ft^2 are usually necessary to induce a turfgrass response, whereas rates exceeding 1 pound of N per 1,000 ft^2 increase the risk of foliar burn.

Nitrogen Sources

Nitrogen sources are commonly categorized by the rate at which they release the N: soluble or slow-release (Table 1). Soluble N sources may also be referred to as readily available or quick release N and are defined as any

N sources that contains water soluble N in either ammoniacal, nitrate, or urea form. Slow-release N may also be referred to as controlled-release N and is defined as any N source that delays the release of N into water soluble form relative to a reference soluble product (such as urea). A third, more ambiguous category, has been deemed 'Enhanced-Efficiency'. Enhanced efficiency N sources are any N source that results in an increase in plant uptake and reduces the potential for environmental risk when compared to a reference material. Thus, essentially all slow-release N sources are also enhanced efficiency N sources, but only a few soluble N sources may be categorized as enhanced efficiency, as we will discuss.

Which type of N should you choose? Acceptable turfgrass quality can be achieved for extended periods with either soluble or slow-release N sources. In general, slow-release N sources may require fewer applications than soluble N sources, but this is not always the case. The value of slow-release N sources is primarily environmental. Slow-release N sources greatly reduce the risk of off-site movement of N when compared with soluble N sources. However, this does not imply that soluble N sources result in environmental contamination. If applied according to UK recommendations, both soluble and slow-release N sources pose very little environmental risk, but both N sources must be applied appropriately based upon their release characteristics.

Soluble N Sources

Urea

Urea has a guaranteed analysis of 46-0-0 and may be the most common N source applied to turfgrass. Urea may be applied in granular or liquid forms, and is the least expensive N source based upon pounds of N and based upon cost per day of acceptable turf. Upon contact with water, urea immediately solubilizes into the soil solution. Once in the soil solution, urea must be converted to ammonium, which is mediated by the enzyme urease. Many factors may influence this enzymatic reaction. Soil moisture, temperature, and pH each influence the conversion of urea to ammonium and for this reason, urea is best utilized when moisture and temperature are adequate for plant growth.

Ammonium Sulfate

Ammonium sulfate is the ammonium salt of sulfuric acid and contains 21% N. Ammonium sulfate is a popular N source for turfgrasses especially on high pH soils. Ammonium sulfate normally results in a decrease in soil pH and is the most acidifying N source available (Table 2). Its ability to reduce pH is approximately one third that of elemental sulfur. Thus, in situations where high soil pH is limiting turf quality, switching N sources to ammonium sulfate is a cost effective option to reducing pH, but will require time and regular applications. Be aware, soil pH changes are slow and temporary. Ammonium sulfate often results in a noticeable increase in growth and greening compared with urea. This is likely a result of N from ammonium sulfate being immediately plant available in the form of ammonium whereas N from urea must undergo conversion to ammonium prior to being plant available. Ammonium sulfate should be watered in immediately to reduce the probability of leaf burn. Leaf burn is a result of the ammonium sulfate salt remaining on the leaf surface, which lowers the water potential outside the leaf and pulls water out of the plant.

Table 1. Nutrient content of common soluble and slow-release N sources

N Source	Guaranteed Analysis	Other Elements
Quick-Release		
Ammonium Nitrate	34-0-0	
Ammonium Sulfate	21-0-0	24% S
Diammonium phosphate (DAP)	18-46-0	
Monoammonium phosphate (MAP)	10-50-0	
Calcium Nitrate	15-0-0	20% Ca
Potassium Nitrate	13-0-44	
Sodium Nitrate	16-0-0	
Urea	46-0-0	
Slow-Release		
Sulfur-coated Urea	Variable	5-20% S
Polymer-coated Urea	Variable	
Ureaformaldehyde	38-0-0	
Methylene Urea	40-0-0	
Isobutylidene diurea (IBDU)	31-0-0	
Biosolids	Variable	Various

Adapted from Carrow et al. 200.

Table 2. Acidifying effect of N sources based upon 1 pound of N

N Source	Calcium Carbonate Equivalent*
Ammonium Sulfate	5.4
Monoammonium phosphate (MAP)	5.1
Diammonium phosphate (DAP)	3.6
Sulfur-coated Urea (40%N)	3.2
Polymer-coated Urea (44%N)	1.8
Urea	1.8
Ammonium Nitrate	1.8
Ureaform	1.8
Isobutylidene diurea (IBDU)	1.8
Biosolids	1.7
Calcium Nitrate	-1.3
Sodium Nitrate	-1.8
Potassium Nitrate	-2.0

Negative numbers indicate a decrease in acidity (increase in pH).
Adapted from Meister 1999; Pierre 1933; and Tisdale et al. 1985.

Ammonium Nitrate

Ammonium nitrate was a common N source for many years but its use has been reduced because it has been the oxidizing agent in various explosives. Transporting ammonium nitrate on interstate highways is limited and, thus, ammonium nitrate is virtually unattainable for turfgrass use. It has a guaranteed analysis of 34-0-0 with both the ammoniacal and nitrate forms of N being immediately plant available. Ammonium nitrate must immediately be watered in to avoid leaf burn.

Urea Ammonium Nitrate

Urea ammonium nitrate (UAN) is manufactured by blending a solution of urea with a solution of ammonium nitrate. The final guaranteed analysis varies between 28% and 32% depending on the location and temperature at which the solution was manufactured. UAN is comprised of 50% urea-N, 25% ammonium-N, and 25% nitrate-N. UAN should be applied at 0.05 to 0.1 lbs. of N per 1,000 sq. ft. with lower rates used on greens. UAN may remain on the foliage, but this method increases the burn potential. If leaf burn is unacceptable, UAN should be applied at low rates in 80 gallons of water per acre and immediately rinsed off the foliage into the soil.

Monoammonium and Diammonium Phosphates

Both monoammonium (MAP) and diammonium phosphate (DAP) are manufactured by reacting ammonia with phosphoric acid. MAP and DAP have guaranteed analyses of 11-48-0 and 18-46-0, respectively. MAP is a good choice for high pH soils because the soil pH immediately adjacent to the fertilizer particle may be reduced to 3.5, which can result in more of the N and P being available for plant uptake.

DAP is the most used fertilizer in the world and is a good choice for acidic soils because the application of DAP results in a pH of 8.5 immediately around the fertilizer granule. When DAP is applied to high pH calcareous soils, the P may be bound by calcium to form dicalcium phosphate and the N can easily volatilize because ammonium is highly soluble and easily converted to ammonia gas. Over time, the soil pH will return to the initial soil pH due to the conversion of ammonium to nitrate (nitrification). However, in the time required to reduce the soil pH back to its initial level, much of the P will have been converted to non-available forms and N will have been lost to volatilization. When soil pH exceeds 6.5, volatilization of N from DAP can exceed 30% of applied N and can be 5 times greater than that of MAP and 2 times greater than that of urea and ammonium sulfate. Thus, DAP should not be used on high pH calcareous soils.

Calcium Nitrate

Calcium nitrate has a guaranteed analysis of 15-0-0 and contains 20% calcium. The application of calcium nitrate may lead to an increase of soil pH (Table 2). Similar to urea and ammonium nitrate, calcium nitrate absorbs water readily and thus, has a short storage life. Blended fertilizers containing calcium nitrate that have been sprayed with pesticides should be applied as soon as possible to prevent the fertilizer from hardening.

Potassium Nitrate

Potassium nitrate may be referred to as "pot-nit" and has a guaranteed analysis of 13-0-44. It has the added benefit of containing K as well as N. The application of potassium nitrate results in an increase in soil pH and thus can be a good option where a low soil pH is limiting turfgrass quality. On native Kentucky soils, the application of K is normally unnecessary because Kentucky soils are naturally high in K (AGR-249). Your soil test results will determine if K is warranted.

Slow-Release N Sources

Sulfur-coated Urea

Sulfur-coated ureas may be manufactured in several ways, but each has a urea substrate and a component of sulfur in the coating. Some manufactures use a polymer on the urea whereas other use a polymer on the outside of the sulfur. Regardless, SCU is perhaps the most common slow-release N source in turfgrass management. SCU is released almost entirely by catastrophic eruption, which describes the process in which the sulfur shell breaks open as a result of internal pressure. University research has shown that the newer SCUs have a portion of prills that release without erupting. Regardless, the turfgrass response to SCU is comparable with other synthetic N sources. SCUs are the least expensive slow-release N source based upon price per pound of N and price per day of response.

Table 3. Relative burn potential from N sources based upon pounds of N

N Source	%
Sodium Nitrate	100
Potassium Nitrate	88
Ammonium Sulfate	53
Ammonium Nitrate	49
Monoammonium phosphate (MAP)	40
Urea	26
Diammonium phosphate (DAP)	26
Natural Organics	11

Natural organics are 10 times less likely to burn than sodium nitrate.
Adapted from Rader et al. 1943.

Polymer-coated Urea

Polymer-coated ureas (PCUs) are manufactured in a variety of ways, but the finished products all contain a urea substrate coated with a polymer or resin. The guaranteed analysis of PCUs vary between 38% and 44% N. The manner in which N releases from PCUs is called osmotic diffusion. This simply means that water from outside the fertilizer prill enters the urea substrate by crossing through the semi-permeable polymer shell. After the urea inside the shell has dissolved, the water/urea solution moves out of the polymer shell by diffusion. This process is almost entirely mediated by temperature and the thickness and/or density of the polymer shell. Because temperature is the only environmental variable influencing the release of N from PCUs, PCUs have been documented to provide a more predictable and consistent N release than other slow-release N sources. University research has shown that the initial release of N from PCUs can be slow and insufficient to meet turfgrass demands. This initial delay is a result of the time required for the fertilizer to absorb water and dissolve the urea. However after this initial delay, the turfgrass response to PCUs is comparable to other N sources.

Methylene Urea and Ureaformaldehyde

Methylene urea and ureaformaldehyde are reacted slow-release N sources that have a guaranteed analysis of 38-0-0 and 40-0-0, respectively. Because they are reaction products, they do not require a coating to maintain their slow-release characteristics. The release of N is microbially mediated, and thus any environmental factor that influences microbial activity will influence the release of N from methylene ureas. The cost of methylene ureas is comparable to other synthetic slow-release N sources based upon price per ton and price per pound of N.

Natural Organics

Natural organics are any N sources that originate from a plant or animal. Examples of natural organic fertilizers are municipal biosolids, bone meal, and feather meal. The N is bound into organic molecules and requires microbial activity to be liberated for turfgrass consumption. Generally, natural organics have low N analyses (<11%) unless blended with synthetic N sources. Turfgrass response to natural organics is normally equal to or better than equivalent amounts of N from urea and some other slow-release N sources. The increased response is likely a result of other nutrients also found in natural organics (phosphorus, magnesium, etc.). Natural organics are commonly the least expensive N source based upon price per ton and are the most expensive based upon price per pound of N. Natural organics that contain phosphorus should be applied based upon pounds of phosphorus to be applied, not based upon the pounds of N. When phosphorus-containing natural organics are applied based upon pounds of N, the amount of P that is also applied may be excessive. See AGR-244 for more information on P.

Liquid Slow-Release

Liquid slow-release N sources may be solutions or suspensions and primarily include methylene ureas. Examples of solutions include Coron and triazones; suspensions include powder-sized methylene urea sold under the brand names Blue Chip and Powder Blue. Suspension products are derived from the same granular methylene urea as describe above. The only difference is the particle size of the suspension is small enough to pass through nozzle screens. While these products contain a portion of slow-release N, the turfgrass response to these products is similar to urea. The actual benefit of liquid slow-release N sources is their documented reduction of foliar burn.

Enhanced-Efficiency Fertilizers

All slow-release N sources are also enhanced-efficiency fertilizers (EEF) because they deliver their N to the plant more efficiently than their soluble N counterpart (i.e. urea, ammonium sulfate, etc.).

Urea may be treated with stabilizing compounds that reduce gaseous losses of N via denitrification and/or volatilization. Stabilized urea is considered an EEF but is not considered a slow-release N source. Stabilized urea contains either a nitrification inhibitor [nitrapyrin or dicyandiamide (DCD)] and/or a urease inhibitor [N-(n-butyl) thiophosphoric triamide (NBPT) or phenyl phosphorodiamidate (PPD)]. Many other urea stabilizing products claim to reduce gaseous N loss, but only nitrapyrin, DCD, NBPT, and PPD have been confirmed in university turfgrass studies.

Stabilized urea is not a slow-release N source and will solubilize into the soil solution at the same rate as urea. When using stabilized urea, it is important to consider the turfgrass response relative to the cost. Stabilized urea is best used when conditions favor gaseous N losses; however, even under these conditions, in many cases stabilized urea will not increase the color, quality, or the longevity of turfgrass response relative to urea, but the cost of stabilized urea is nearly double that of urea. When stabilized urea is ineffective, the conditions were likely not conducive to losses of gaseous N. Examples of conditions conducive to gaseous N loses are soils with pH > 7.0 or saturated soils. Therefore, if you do not have these conditions, stabilized urea may be unnecessary.

Summary

Nitrogen is normally the most beneficial element applied to turfgrass because the plant's demand is high and the supply is low. A greater understanding of the numerous N sources available will enhance your nutrient management program.

References

Carrow, R.N., D.V. Waddington, and P.E. Rieke. 2001. Turfgrass soil fertility and chemical problems: assessment and management. Ann Arbor Press, Chelsea, MI.

Meister, R.T. 1999. Farm Chemicals Handbook. Meister Publ. Co., Willoughby, OH.

Pierre, W.H. 1933. Determination of equivalent acidity and basicity of fertilizers. Industrial & Engineering Chemistry Analytical Edition 5: 229-234.

Rader, L.R., Jr., L.M. White, and C.W. Whittaker. 1943. The salt index - A measure of the effect of fertilizers on the concentration of the soil solution. Soil Sci. 55: 201-218.

Tisdale, S.L., W.L. Nelson, and J.D. Beaton. 1985. Soil Fertility and Fertilizers. 4th ed. Macmillan Publishing Co., New York, NY.

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