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Urea as a Source of Fertilizer Nitrogen for Crops in Kentucky

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Kentucky farmers are finding proportionately more nitrogen being marketed each year in the chemical form of urea. This trend has resulted from a greatly expanded production capacity for urea by basic nitrogen producers. Judging from present projections, this increase in the production of urea is likely to continue. Although urea nitrogen has been marketed in Kentucky for several years, there are still many questions asked by farmers about its agronomic characteristics.

Product Description

Urea nitrogen is manufactured by reacting ammonia with carbon dioxide. It is commonly prilled or granulated into a solid, free-flowing material containing 45-46 percent total nitrogen. As such, it is a highly concentrated nitrogen material suitable for direct application to crops or for blending mixed fertilizers. From the standpoint of manufacturing, transportation, and direct application, urea has the advantage over other solid nitrogen materials of being cheaper to manufacture and having a higher content of total nitrogen.

Use of Urea for Making Other Fertilizers

Solid Mixed Fertilizers

Because of its good physical characteristics, granulated rather than prilled urea is commonly used as a major supplemental nitrogen source in blending mixed fertilizers. Urea is now widely used by solid fertilizer blenders in Kentucky in blending fertilizers for use on all nitrogen-requiring crops.

Nitrogen Solutions

Urea is used in the manufacture of nitrogen solutions. When mixed with ammonium nitrate, non-pressure, aqueous solutions of nitrogen can be prepared which are of higher nitrogen content than aqueous solutions of either urea or ammonium nitrate alone. Nitrogen content of nitrogen solutions is usually 28-32 percent total N. Half the nitrogen is from urea and half is from ammonium nitrate. Weight per gallon generally ranges from 10-11 pounds, depending on the nitrogen content. These solutions are widely used in Kentucky for direct application of supplemental nitrogen, particularly on corn. Blenders of fluid mixed fertilizers also use nitrogen solutions as a material in formulating various grades.

Agronomic Evaluation of Urea

To predict what may happen from use of urea, an understanding of how it reacts when applied to soils is needed. The following sections summarize research findings on what happens when urea is used as a fertilizer under the soil and climatic conditions of Kentucky.

Reaction with Soil

In its chemical form, urea is unreactive with soil and is readily soluble in water. When it is added to soil, naturally occurring reactions in the soil cause urea to break down to the ammonium form of nitrogen. Soil pH immediately surrounding the particle of decomposing urea is rapidly increased to the range of pH 7 - pH 10 as this reaction takes place. This is the soil reaction which is critical to the efficiency of urea nitrogen applied to soil, because in the high-pH zone surrounding the decomposing particle of urea, a high concentration of ammonia (NH_3) develops. Under some soil conditions, part of this ammonia nitrogen may be volatilized from the soil. Much research has been conducted during the past several years to determine how much nitrogen loss can take place and to identify what conditions are related to such losses. The amount of loss has been found to range from none to severe, depending largely on soil properties, temperature, moisture level and application methods. Some soil conditions which have been found to increase nitrogen losses from urea reaction in soil are: high soil pH (above 6.5); low soil cation exchange capacity; surface application; high level of soil organic matter; warm soil temperatures; application to moist soil with fast-drying conditions at soil surface. When using urea under conditions which are associated with nitrogen losses from urea, the most effective method of lowering such risk is to incorporate urea into the soil while applying or immediately after applying it.

Urea Is Acid-Forming

Although the immediate reaction of urea in soil is to raise the pH surrounding the urea particles, the long-term effect from use of urea on soil is to lower soil pH. This increased acidification results from soil microbes oxidizing the ammonium nitrogen produced from the breakdown of urea to nitrate nitrogen. This effect can be important, particularly on soils which are already acid to moderately acid (pH 5-6), when a large amount of nitrogen is applied. In such instances, soil pH during the plant growing season may drop low enough to increase the concentration of manganese (Mn) or aluminum (Al) around plant roots to toxic levels, or to result in a lower solubility of soil phosphorus (P) and molybdenum (Mo). This can lower yields of some crops. It should be emphasized that other acid forming nitrogen fertilizers such as ammonium nitrate, nitrogen solutions, and anhydrous ammonia can also bring about these same reactions.

Crop Response to Urea

Urea has been evaluated as a nitrogen source in Kentucky for burley tobacco, corn, wheat and barley, and grass pastures. Results will be discussed by crop.

Burley Tobacco

Research in Kentucky has shown that urea is as effective for producing burley tobacco as the non-acid forming sodium nitrate when soil pH is maintained at the recommended level. Results from a field test on Maury silt loam soil are shown in Table 1.

The only real difference in yield occurred when no lime was used. In that case, soil pH dropped to 4.7 during the growing season where urea was used, but hardly changed where the all-nitrate N source was used. When the soil was limed to offset the acid-forming potential of urea, there was no significant difference between N sources. These data also show that leaf content of manganese (Mn) was greatly increased when urea was used without liming the initially acid (PH 5.4) soil. Leaf content of molybdenum (already deficient) correspondingly dropped to even lower levels. But with use of lime on this initially acid soil, urea performed agronomically as well as the nitrate source of N.

Table 1. Effect of rate of lime application and N source on yield, pH, and Mn and Mo concentration of burley tobacco leaves, average of two years.

Rate of lime Tons/A	**N[1]/ source**	**Leaf Characteristics**			
		Yield lbs/A	**Manganese PPM**	**Molybdenum PPM**	**Soil pH[2]/**
0	Sodium Nitrate	2612	170	0.22	5.3
0	Urea	2358	673	0.14	4.7
5.0	Sodium Nitrate	2765	116	0.50	5.8
5.0	Urea	2647	101	0.41	5.7
.5	Sodium Nitrate	2772	108	0.60	6.3
7.5	Urea	2750	107	0.58	6.0

[1]*Both N sources applied at 225 lbs N/A preplant.*

[2]*Soil pH (water) measured at midseason of each year. Soil pH before liming was 5.4.*

Wheat and Barley
Urea has also been compared with ammonium nitrate as a source for spring topdressed N on wheat and barley in field tests conducted by U.K. Results (Table 2) of a 3-year study on "Arthur" wheat and a 2-year study on "Barsoy" barley show no differences between the two sources from an early to mid-March topdressing.

Table 2. Effect of spring topdressed ammonium nitrate and urea on yield of wheat and barley.

lbs N/A[1]	Wheat (bu/A[2])		Barley (bu/A[3])	
	Ammonium Nitrate	Urea	Ammonium Nitrate	Urea
0	**52**		**57**	
30	57	55	59	60
60	61	65	67	68
90	64	63	72	76

[1] Topdressed in early to mid-March
[2] Av. 3 years data
[3] Av. 2 years data

Corn
UK has conducted several field experiments comparing urea with ammonium nitrate (AN) for both conventionally grown corn and no-till corn, either all applied at planting or as a delayed application 5-7 weeks after planting. Results have been variable, but in general the following trends are evident:

(1) Conventionally grown corn
a.When N is broadcast just before planting and incorporated into the soil, there is little difference between sources observed.
b.When N is broadcast at planting and not incorporated into soil, there is a trend for AN to be slightly more effective on poorly drained soils, but little difference on well-drained soils.
c.When N is topdressed over corn 5-7 weeks after planting and not incorporated, there is little difference between sources.

(2) No-till corn (sod, stalkland, or small grain stubble)
a.Variable results have been obtained when all N was topdressed at planting, but collectively the data would indicate that there is a risk for urea to be slightly less effective than AN, particularly at low to moderate rates of N.
b.When all N is topdressed over corn 5-7 weeks after planting, the risk increases for urea to be less effective than AN, although results have been variable.

(3) Risk
Due to the large number of factors which determine the amount of nitrogen which will be lost, the results between experiments is quite variable. Apparently, under most conditions in Kentucky, the loss of nitrogen from surface applied urea will be less than 5% as compared with AN. Although uncommon, these losses can be much larger. The highest losses found were about 25%.

(4) Rate of N
Results of field experiments show the risk that urea will result in lower corn yields than AN is greatest when there is nitrogen stress (low to moderate rates of applied N) on the crop. In experiments there was little difference between sources when 150 lbs N/A was used.

Grass Pastures

Results from several experiments comparing urea with ammonium nitrate (AN) show that use of urea topdressed onto grass fields is not likely to be as effective as AN. These studies show that yields of forage and total content of N are usually lower from urea than AN. The degree of agronomic loss measured in Kentucky is in the range of 10-30 percent. In other words, each pound of urea N topdressed will likely yield 70-90 percent of that from a pound of topdressed ammonium nitrate N. Studies conducted in central Kentucky have shown such losses for March, June and August topdressings. A study conducted at Princeton, however, has shown little difference between urea and AN topdressed onto fescue at 50 lbs N/A in early spring (March-early April). But topdressings from mid-April to early October resulted in urea being only 80-90 percent as effective as AN.

Is Urea a Slow-Release Form of N?

Because of the fact that urea must be converted to ammonium and nitrate nitrogen for its use by plants, some people describe urea as being a "slow-release" form of N. Field performance data show this is not the case. The conversion of urea-N to ammonium-N and on to nitrate-N is rapid, and under Kentucky's soil, climatic, and cropping conditions is not considered to represent a "slow release" of N either for application to fallow land ahead of the intended crop, for application at or after time of planting, or for application onto grass sods.

Summary

Field studies conducted in Kentucky indicate that urea can be a good source of N for most N-requiring crops. The greatest risk of inefficiency of urea is from topdressing it onto grass fields and no-tillage corn. By keeping in mind the principles of urea reaction when applied to soil, it can satisfactorily be used in many crop production systems. The following statements point up the thoughts to keep in mind when using urea:

- It is acid forming and, when used in large amounts, results in an appreciable drop in soil pH during the growing season. By keeping soil adequately limed, urea can be as effective as non-acid forming N sources.
- Its initial reaction when applied as fertilizer results in high concentrations of ammonia N immediately around each particle. Therefore, care should be taken not to place it close to seeds or young seedlings to reduce likelihood of ammonia toxicity.
- Incorporation of urea into soil lowers risk of N loss from urea under conditions where N loss might be expected.
- Urea is a highly concentrated nitrogen material (45-46% N) and generally more economical per unit of N than other solid forms. When purchasing nitrogen, make your decision on cost per pound of N, not cost per pound of material.