ENHANCED EFFICIENCY NITROGEN FERTILIZERS RELEASE IN AN ILLINOIS SOIL; Soil Column study

L.A. Doyle and J.D. Hernandez
Southern Illinois University, Department of Plant Soils and Agricultural Systems
Carbondale, Illinois 62901

Abstract

The release rates of ammonium and nitrate from applications of enhanced efficiency nitrogen fertilizers to soil is not well understood. A better knowledge of the soil processes involved with N release could allow for greater acceptance of these fertilizers. The objective of this study was to compare traditional quick release fertilizers with enhanced efficiency nitrogen fertilizers to examine their release rates. The fertilizers chosen were urea and a polymer-coated urea, which were applied to soil cores. Weekly extractions using 0.03 M potassium chloride were formed over a 10 week period to achieve release curves of the ammonium and nitrate fertilizers. Results show that there were differences between the PCU and urea fertilizers, with the PCU fertilizer exhibiting reduced levels of nitrate release throughout the study compared to the urea. It can be concluded from the study that the PCU fertilizer showed promise as a possible method of reducing N leaching and providing a more efficient fertilizer by releasing N slowly, allowing for improved nutrient absorption by plants.

Introduction

The use of nitrogen fertilizers in agriculture has often resulted in pollution of soil waterways and groundwater resources. Rising costs of N, however, have led to increased research into more efficient forms of N fertilizers, and made their use more economical. In the past, low prices associated with traditional quick release N fertilizers made them popular with farmers, but as a downside they had a poor environmental track record. Their low prices also allowed them to be applied in excessive amounts resulting in increased soil water pollution. A major source of water contamination has been shown to be nitrate from N fertilizers (Goolsby, et al 1999). These excess applications not only affected their local area of application but also had a much broader impact; particularly that associated with the “dead zone” in the Mississippi delta being one such example.

The use of enhanced N fertilizers may have the possibility to significantly reduce the negative effects incurred from N fertilization. Many, if not most, of the enhanced N fertilizers currently in use, however, have not yielded enough of a predictable breakdown under field conditions to economically justify their use. One reason for this is that there is much yet to be learned about the breakdown process of enhanced N fertilizers in the soil. Factors such as compound release rate and the compounds biochemical transformation and degradation processes, all factors which are determined by the particular soils distinctive properties, must still be more fully comprehended for enhanced N fertilizers to achieve optimal management and fertilizer design, and, therefore, broad acceptance.

Increasing nitrogen use efficiency (NUE) is one method that can be used to address environmental concerns associated with N fertilization. Past research has shown that enhanced N fertilizers have the ability to improve NUE while at the same time extending N availability throughout the growing season. One of its main downsides is, as mentioned above, its lack of predictability. To improve NUE of enhanced N fertilizers it is important to understand the processes that lead to its degradation in soil. Soil humidity, temperature, soil chemistry, and soil ecology all have an effect on the efficiency of N-release (Koivunen, 2004). In addition, both biotic and abiotic factors can work together to bring about degradation and hydrolysis of enhanced N fertilizers in the microenvironment. However, much less is known about abiotic processes, which involve the physical/chemical relationships in the soil-plant system.

The rising prices, as mentioned above, compounded with environmental concerns have produced an environment more conducive to the acceptance of enhanced efficiency nitrogen fertilizers. As we enter an era of high natural gas prices and stricter environmental regulations new fertilizers must be created that can better answer both these conditions. The objective of this study was to compare the nitrogen release rates between a quick release N fertilizer (Urea) and an enhanced efficiency N fertilizer

Materials and Methods

The soil used in the study was the Stoy series. It tends to be strongly acidic and is a fairly common soil series in southern Illinois. The soil was also analyzed for native NH4-N and NO3-N to determine the residual N status. Two fertilizers were used: solid polymer coated urea (PCU) - an enhanced efficiency fertilizer and commercial urea (quick release); a control without N application was also included. The collection of the soil cores was accomplished through the use of a hydraulically powered push type core sampler; built for the purposes of pulling samples from the soil into a PVC-column-lysimeter (CL). The soil cores weighed approximately 1500 g. The equivalent of 1000 mg N kg^{-1} for each fertilizer source was applied to each column except for the control (equivalent of approximately 1500 mg nitrogen per column). Afterwards, the columns were placed in upright holders and a schedule of sequential N extractions was implemented.

The sequential extractions were performed at 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 weeks. Potassium chloride 0.03 M was used as the extracting solution in the amount of 200 ml, and was applied in each CL as indicated in the extraction schedule. Fifteen minutes after the extracting solution was applied to the CL, and leachate collected, the CL was attached to a vacuum pump (2 psi) to extract any remaining non-capillary extracting solution. The CL incubation-leachate was then treated with one drop of hydrochloric acid 5N, and stored under freezing conditions. Afterwards the extracts were analyzed for nitrate (NO3-) and ammonium (NH4+) content by using discrete flow analyzer equipment, LaChat (Wendt, K. 1999). The soils were field kept under constant temperature of 24^{o} C. The experimental design was totally randomized with 3 replications. All the data was subjected to analysis of variance using the General Linear Model (GLM) procedure of SAS (SAS Inst., 2003), and differences among treatment means were separated using Least Significant Differences Test (alpha=0.05).

Results

The ammonium release curves (Figure 1) from the urea and PCU fertilizers were very similar. All of the weeks exhibited differences between treatments except for weeks 4 ($p>F < 0.1396$), 6 ($p>F < 0.1304$), and week 10 ($p>F < 0.1575$). Much more variation could be seen with nirate levels (Figure 2) between the urea and PCU treatments. Significant differences were observed between both fertilizers concerning nitrate release except for in weeks 6 ($p>F < 0.1091$), 7 ($p>F < 0.1245$), and 8 ($p>F < 0.1255$). However, we can appreciate a tendency of the data where PCU and Urea showed differences. Ammonium-N accumulation showed a similar release rate at any week when comparing Urea and PCU (Figures 3 & 4). Also, it can be seen that the PCU fertilizer released less total cumulate % of nitrate than the urea at any week in the experiment, suggesting that the release of the nitrate has a slower rate than the urea fertilizer.

Conclusion

The release of nitrogen in the forms of NH4-N and NO3-N from urea (a quick release nitrogen fertilizer) was different than PCU (an enhanced nitrogen fertilizer) in most of the weekly comparisons. The lower rates of nitrate release compounded with the more even distribution of N for PCU indicates that PCU fertilizers have the ability to reduce environmental pollution through reduced leaching, and also provide for improved plant growth due to a more steady "diet" of N.

Looking at the cumulative graphs, it appears that the study could be expanded to cover a longer span of time due to the still active release of nitrate-N in both treatments of urea and PCU.

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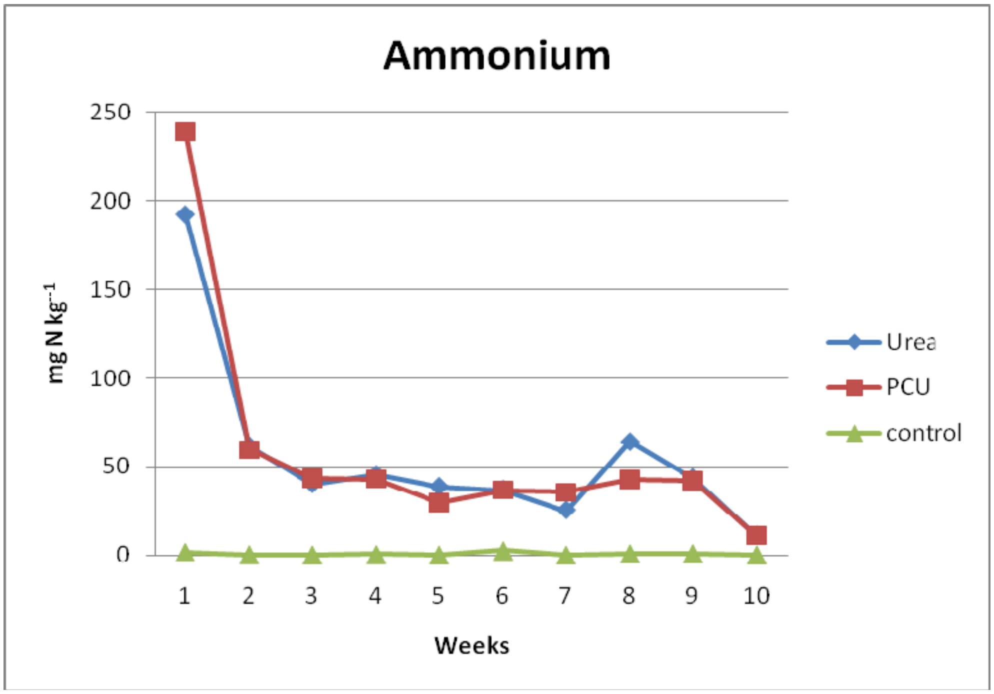

Figure 1. Ammonium nitrogen release of urea and polymer coated fertilizers and control over time in a Stoy soil (Illinois)

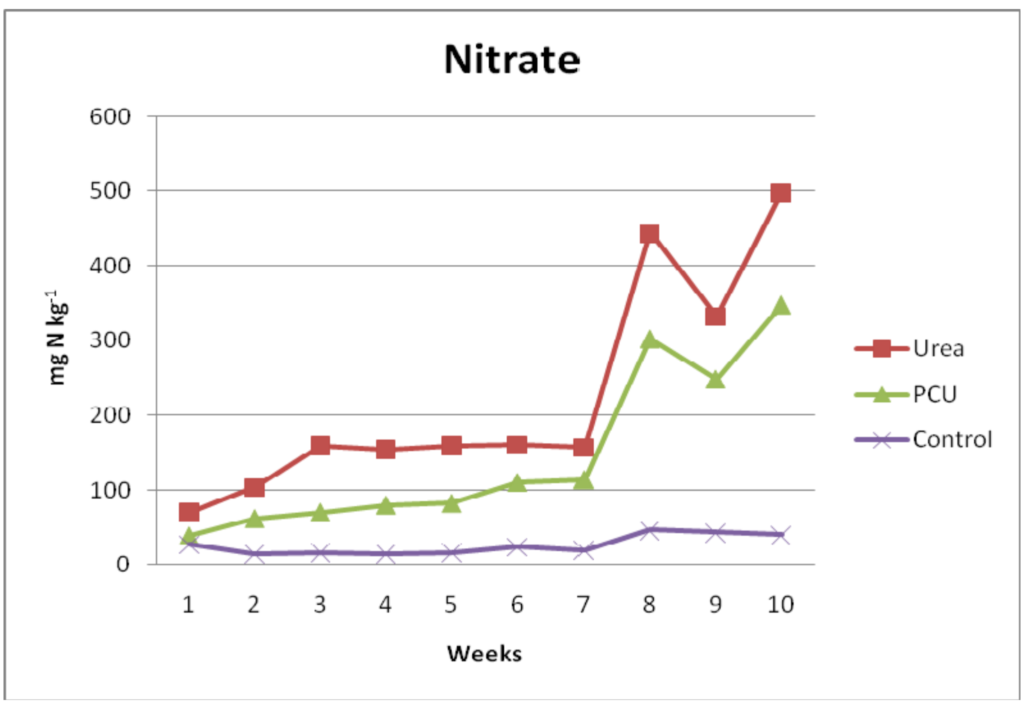

Figure 2. Nitrate nitrogen release of urea and polymer coated fertilizers and control over time in a Stoy soil (Illinois)

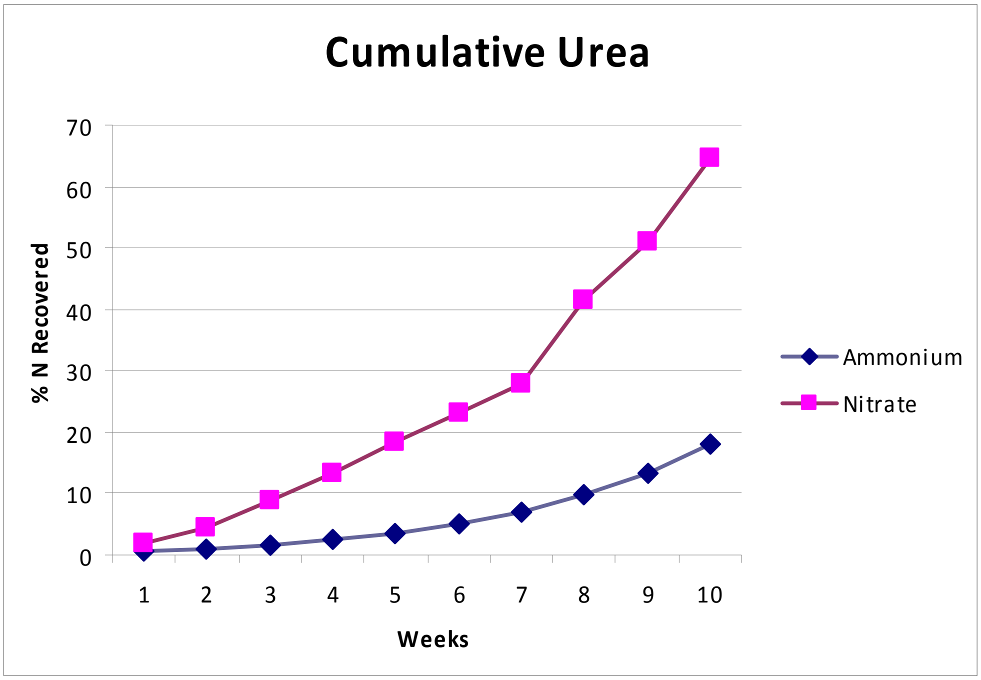

Figure 3. Cumulative amounts of ammonium-nitrate and nitrate-nitrate released from urea over a 10 week period in an Illinois Stoy soil

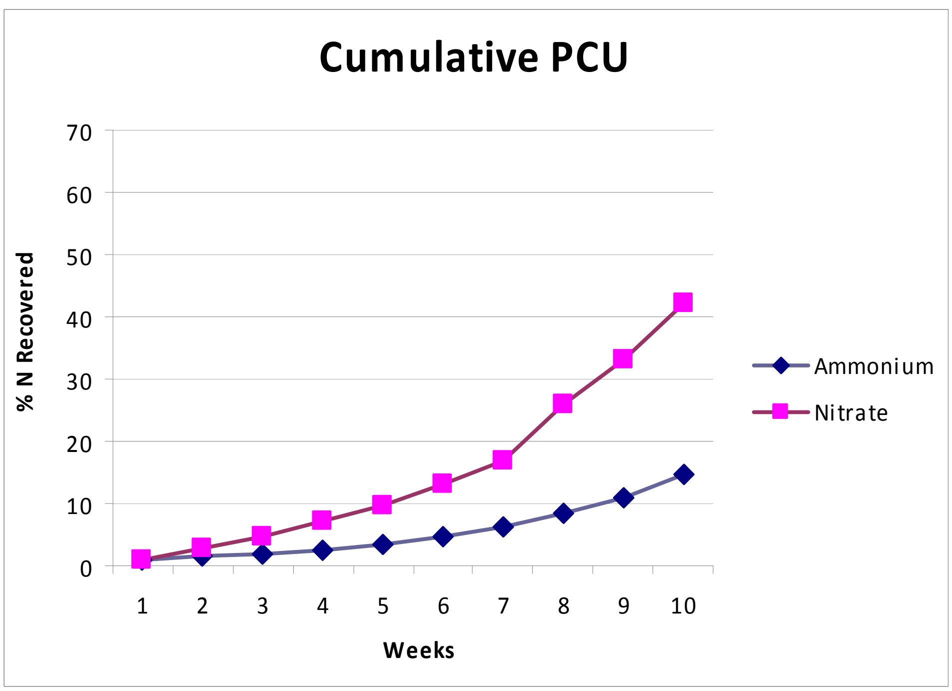

Fig. 4. Figure 4.Cumulative amounts of ammonium-nitrogen and nitrate-nitrogen released from PCU over a 10 week period in an Illionois Stoy soil

Fig. 5. PCU fertilizer (left) and urea fertilizer (right).

Fig. 6. Prototype of leaching columns designed for this study

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Program Chair:

Darryl Warncke
Michigan State University
East Lansing, MI 48824-1325
(517) 355-0270
warncke@msu.edu

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International Plant Nutrition Institute
2301 Research Park Way, Suite 126
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