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EFFECT OF UREA WITH NUTRISPHERE-N POLYMER IN FALL AND SPRING NITROGEN APPLICATIONS FOR CORN

[1]Pawel Wiatrak and [2]Walter B. Gordon

[1]School of Agricultural,
Forest and Environmental Sciences, Clemson University, Edisto REC, Blackville, USA
[2]Department of Agronomy, Kansas State University, Manhattan, Kansas, USA

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ABSTRACT

Polymer coated urea may be a viable option to improve Nitrogen (N) uptake and corn (*Zea mays* L.) grain yields, especially in areas with relatively high soil N loss. The objective of this study was to evaluate the effect of two urea application timings (fall and spring) and three N rates (90, 180 and 270 kg N ha^{-1}) with and without Nutrisphere-N polymer on irrigated corn near Scandia, KS from 2006 to 2008. Compared to uncoated N, urea coated with Nutrisphere-N improved grain yields by 18.3% with applications of 180 kg N ha^{-1} in the fall. Application of urea with Nutrisphere-N in the spring produced similar grain yields for treatments with and without Nutrisphere-N. Corn ear-leaf content was highest with urea applied at 90 kg N ha^{-1} in the fall and urea coated with Nutrisphere-N at 180 and 240 kg N ha^{-1} in the fall and spring. Grain N content was highest from urea coated with Nutrisphere-N application at 270 kg N ha^{-1} in the fall and spring. Compared to untreated urea, Nutrisphere-N improved grain N removal by 29.6% at 180 kg N ha^{-1} applied in the fall. Spring urea application with Nutrisphere-N produced similar grain N removal compared to urea without Nutrisphere-N. Generally, adding Nutrisphere-N to urea fertilizer may help improve N content in leaves and grain and increase grain yields of corn, especially with the fall N applications having higher potential of soil N loss.

Keywords: Corn, Polymer, Nutrisphere-N, Urea

1. INTRODUCTION

Fertilizer usage is high to support crop production for a growing world population (Ni *et al*., 2011). Hubbard *et al*. (2004) noted that high nitrate-N concentrations in soil and groundwater may lead to health problems in humans and animals. The need for greater crop productivity and higher yield effects on production costs per unit of yield coupled with maximizing return on capital invested in N fertilizer as well as environmental concerns are driving crop producers to evaluate practices, which improve N use efficiency (Shaviv, 2005). Shaviv (2005) also emphasized the importance of synchronizing plant N demand and supply. Spargo *et al*. (2011) noted that sustainable crop production should include optimal utilization of mineralizable N from soil organic matter as well as carry-over N from previous crops.

Fertilizer recommendations depend on evaluation of supplied and immobilized nutrients in the soil, which are especially important for site-specific management of nutrients (Anthony *et al*., 2012). Key factors in improving N use efficiency and uptake are nitrification and ammonia volatilization (Mortvedt *et al*., 1999). Hubbard *et al*. (2004) reported that leaching of NO_3-N and NO_2-N to groundwater is a problem in the southeastern Coastal Plain of the United States (US) due to relatively high rainfall.

Optimized irrigation and N fertilization practices can help to minimize NO_3-N leaching below the root zone, improve N uptake and increase crop yield (Martinez-Alcantara *et al*., 2012). Additional options to improve N efficiency include splitting N applications, nitrification and urease inhibitors and using slow release fertilizers (Shaviv, 2005). Cahill *et al*. (2010) added that alternative

Corresponding Author: Pawel Wiatrak, School of Agricultural, Forest and Environmental Sciences, Clemson University, Edisto REC, Blackville, USA

N fertilizers may help to decrease volatilization, improve N use efficiency and increase crop yields. Slow-release fertilizers with good water-retention properties would be environmentally friendly due to reduction of nutrient loss and improved efficiency (Ni *et al*., 2009).

Kyveryga *et al*. (2013) noted that current N recommendations for corn do not fully quantify factors, which affect yield response to N. Urea coated with various materials, including a dicarboxylic co-polymer (Nutrisphere-N®), may be a good N management option, because of nitrification and urea volatilization inhibiting properties (Gordon, 2008). However, growers need to evaluate the use of alternative N fertilizer under different climatic conditions and locations (Cahill *et al*., 2010). Therefore, the objective of this study was to evaluate the effect of two urea application timings (fall and spring) and three N rates (90, 180 and 270 kg N ha^{-1}) with Nutrisphere-N polymer on irrigated corn in the Great Plains region of the US.

2. MATERIALS AND METHODS

2.1. Site Preparation and Management

This experiment was conducted on Crete silt loam soil (Fine, smectitic, mesic Pachic Udertic Argiustolls) at North Central Kansas Experiment Field, Kansas State University, located near Scandia, KS under irrigated conditions from 2006 to 2008. The soil pH was 7.0, organic matter content was 2.8%, Bray-1 P was 28 ppm and exchangeable potassium (K) was 240 ppm.

Corn cv. 'DeKalb DKC60-19' was planted following previous corn crop at 76,570 seeds ha^{-1} in no-till on 20, 22 and 19 April in 2006, 2007 and 2008, respectively. Nitrogen treatments consisted of uncoated urea and urea coated with Nutrisphere-N (2.1 l 1000 kg^{-1}) applied in the fall/winter January 2006 and November in 2007 and 2008, respectively) and in the spring (following planting) and three N rates (90, 180 and 270 kg N ha^{-1}).

Weed control was based on the Kansas State University Extension recommendations.

2.2. Plant Measurements

Plant measurements were conducted in the center of each plot. Corn ear-leaf samples for N content were collected at R1 stage. Corn was harvested using small grain plot combine on 20 October 2006, 10 October 2007 and 18 October 2008. Grain samples from all harvested plots were evaluated for moisture content. Corn grain yields were corrected to 155 g kg^{-1} moisture content. Additionally, grain samples were evaluated for N content. The N removal (recovery) was calculated based on grain N content and yields.

2.3. Statistical Analysis

The study design was a randomized complete block with four replications. Data were analyzed using the general linear models (SAS, 2011) and means for grain yields and N removal were shown by N application timings.

3. RESULTS

3.1. Corn Ear-Leaf and Grain N Content

Corn ear-leaf was highest for treatments with urea at 90 kg N ha^{-1} and urea with Nutrisphere-N applied at 180 and 270 kg N ha^{-1} (**Table 1**). Compared to uncoated N, urea coated with Nutrisphere-N improved corn ear-leaf content by 16.2% and 14.4% at 180 kg and 270 kg N ha^{-1} for the fall applied N and 24.8%, 11.8% and 11.9% with applications of 90 kg, 180 kg and 270 kg N ha^{-1} for spring applied N, respectively. Averaged across N rates, urea coated with Nutrisphere-N increased ear-leaf N content by 8.7% with fall application and 16.2% with spring application of N.

Highest grain N was recorded with application of urea coated with Nutrisphere-N at 270 kg N ha^{-1} in the fall and spring (**Table 1**). Grain N improved with Nutrisphere-N application by 4.1%, 9.5% and 7.5% for fall applications and 6.6%, 8.7% and 6.0% over untreated control at 90 kg, 180 kg and 270 kg N ha^{-1} applied in the spring, respectively. Grain N improved on average by at least 7% with fall and spring N applications using urea coated with Nutrisphere-N compared to uncoated urea.

Table 1. Influence of urea with and without Nutrisphere-N applied in the fall and spring on ear-leaf and grain N of corn

Treatment	N rate ($kg\ ha^{-1}$)	Ear-leaf N %	Grain N %
Control	0	1.67	1.12
Fall applied N			
Urea	90	2.95	1.22
Urea	180	2.53	1.26
Urea	270	2.63	1.34
Urea with Nutrisphere-N	90	2.82	1.27
Urea with Nutrisphere-N	180	2.94	1.38
Urea with Nutrisphere-N	270	3.01	1.44
Spring applied N			
Urea	90	2.30	1.21
Urea	180	2.62	1.27
Urea	270	2.68	1.33
Urea with Nutrisphere-N	90	2.87	1.29
Urea with Nutrisphere-N	180	2.93	1.38
Urea with Nutrisphere-N	270	3.00	1.41
LSD (0.05)		0.09	0.05

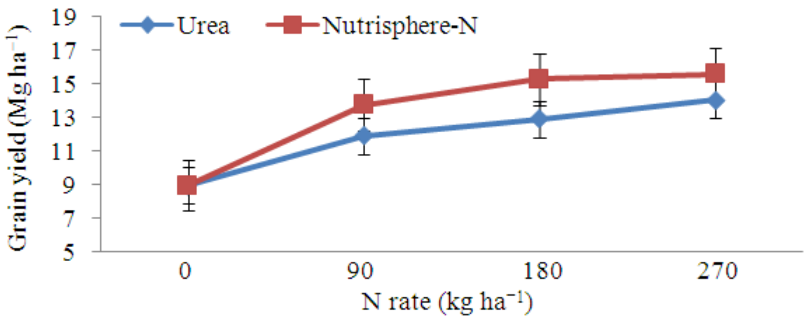

Fig. 1. Influence of N application rate in the form of urea with Nutrisphere-N applied in the fall on grain yields of irrigated corn. Vertical bars indicate standard error of four replicates

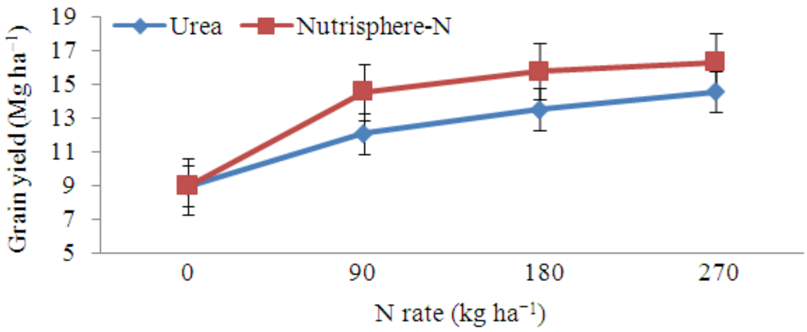

Fig. 2. Influence of N application rate in the form of urea with Nutrisphere-N applied in the spring on grain yields of irrigated corn. Vertical bars indicate standard error of four replicates

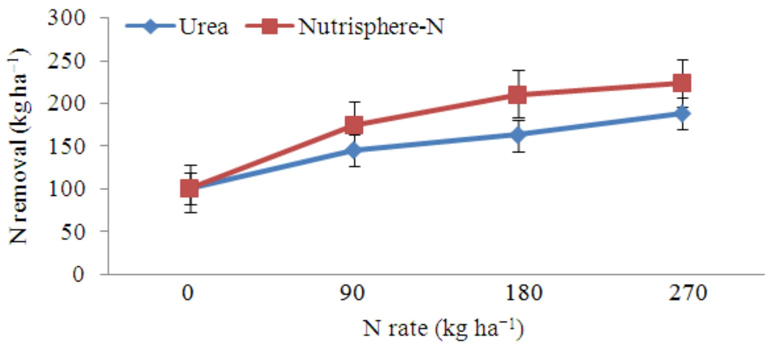

Fig. 3. Influence of N application rate in the form of urea with Nutrisphere-N applied in the fall on grain N removal in irrigated corn. Vertical bars indicate standard error of four replicates

3.2. Grain Yields

Urea coated with Nutrisphere-N improved corn grain yields by 18.3% at 180 kg N ha^{-1} applied in the fall over uncoated urea (**Fig. 1**). With spring N applications, grain yields were similar for treatments with and without Nutrisphere-N (**Fig. 2**). Treating urea with Nutrisphere-N, increased corn yields on average by 15% with fall N application and 16.3% with N applied in the spring.

3.3. Grain N Removal

Grain N removal was greater with higher grain yields and N content. Urea coated with Nutrisphere-N improved grain N removal by 29.6% over uncoated urea at 180 kg N ha^{-1} applied in the fall (**Fig. 3**).

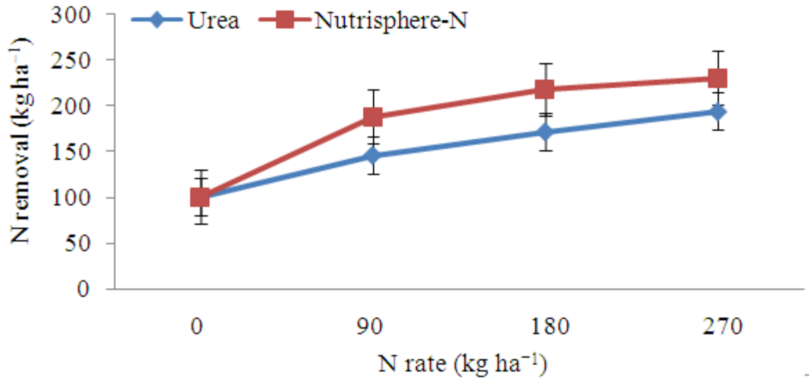

Fig. 4. Influence of N application rate in the form of urea with Nutrisphere-N applied in the spring on grain N removal in irrigated corn. Vertical bars indicate standard error of four replicates

For N applied in the spring, grain removal was similar for treatments with and without Nutrisphere-N (**Fig. 4**). On average grain N recovery improved by more than 20% with Nutrisphere-N treated over untreated urea for fall and spring applied N.

4. DISCUSSION

Previous research with N additives has shown significant amounts of variation. Slow-release N products did not provide advantage over conventional fertilizer in bell pepper (*Capsicum annuum* L.) production (Stagnari and Pisante, 2012) and Nutrisphere-N reportedly did not affect spring wheat and rice yields (Franzen *et al*., 2011).

However, unpublished replicated studies with rice over a six year period showed consistent Nutrisphere-N responses (personal communication, Dr. R. Helms, G&H Associates, Stuttgart, AR). Gordon (2008) reported consistent and highly significant effects of Nutrisphere-N on irrigated corn and dryland grain sorghum responses to N over a 2 year period in Kansas. Mooso *et al*. (2012) reported that Nutrisphere-N significantly increased dryland wheat yields in the Northern Great Plains (Montana) particularly at the lower N rates examined. Murphy and Sanders (2007) cited a number of studies with positive responses to Nutrisphere-N effects on N management. Polymer-coated urea (slow solubility) helped to reduce NO_3-N leaching in potato (*Solanum tuberosum* L.) (Wilson *et al*., 2009). Greater N recovery was reported from coated than regular fertilizer due to better timing in releasing N and matching crop N demand (Wen *et al*., 2001). Drury *et al*. (2012) observed that polymer-coated urea was very effective with high soil moisture and resulted in reduced N_2O emissions. Moreover, slow release products reduced nutrient losses and improved water use efficiency under insufficient rainfall (Ni *et al*., 2011).

This study showed that compared to control, urea coated with Nutrisphere-N applied in the fall improved corn grain yields by 18.3% at 180 kg N ha^{-1}, but spring N application with polymer produced similar yields compared to urea without Nutrisphere-N. Nutrisphere-N improved corn ear-leaf, which was highest at 180 and 270 kg N ha^{-1} applied in the fall and spring and also high with urea applied at 90 kg N ha^{-1} in the fall. Grain N content improved significantly at 240 kg N ha^{-1} applied in the fall and spring. Urea applied with Nutrisphere-N in the fall increased grain N removal by 29.6% over uncoated urea, but spring applications showed similar grain N removal for treatments with and without Nutrisphere-N applications.

5. CONCLUSION

This study investigated the effect of two N application timings (fall and spring) and four N application rates (0, 90, 180 and 270 kg N ha^{-1}) with Nutrisphere-N polymer on earl-leaf N content, grain yield, grain N content and N removal. Compared to untreated N, Nutrisphere-N significantly improved corn ear-leaf content. Highest content was observed from urea with Nutrisphere-N applications at 180 and 270 kg N ha^{-1} applied in the fall and spring and also for urea at 90 kg N ha^{-1} applied in the fall. Corn grain yields improved with urea coated with Nutrisphere-N by 18.3% at 180 N ha^{-1} applied in the fall, but produced yields were similar for urea with and without Nutrisphere-N applied in the spring. Nutrisphere-N increased grain N content, which was highest at 270 kg N ha^{-1} applied in the fall and spring. Grain N removal was 29.6%

greater with application of Nutrisphere-N over uncoated urea at 180 kg N ha^{-1} in the fall. Spring urea application with Nutrisphere-N showed similar N removal compared to untreated urea. Future research may focus on evaluating soil N transformations and availability to crops under different soil moisture conditions during the growing season.

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