

# EVALUATION OF NITROGEN APPLICATION METHODS AND RATES WITH NUTRISPHERE-N ON CORN IN SOUTHEASTERN COASTAL PLAINS

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## ABSTRACT

Application method of Nitrogen (N) and Nutrisphere-N may influence corn (*Zea mays* L.) growth and yields under dryland conditions. The objective of this study was to determine the effect of two N application methods (all at planting and split application with 35 kg N ha<sup>-1</sup> applied at planting and remaining N at V6 stage) and five N rates (0, 45, 90, 135 and 180 kg N ha<sup>-1</sup>) with and without Nutrisphere-N polymer on dryland corn near Blackville, SC from 2010 to 2012. Compared to control, Nutrisphere-N polymer improved corn grain yield by 33.3 and 29.5% at 90 and 135 kg N ha<sup>-1</sup> applied at planting and 12.1, 12.9, 22.0 and 31.2% at 45, 90, 135 and 180 kg N ha<sup>-1</sup> applied in split applications, respectively. Chlorophyll improved in corn leaves by 19.3% at 8 weeks after planting with application of 45 kg N ha<sup>-1</sup> and Nutrisphere-N at planting. Split N application with Nutrisphere-N slightly improved chlorophyll in corn leaves. Nutrisphere-N increased plant LAI at 8 weeks after planting by 10.2% at 135 kg N ha<sup>-1</sup> in split applications and LAI at 16 weeks after planting by 50.4, 56.2, 59.4 and 70.7% at 45, 90, 135 and 180 kg N ha<sup>-1</sup> with split applications, respectively. Plant NDVI at 16 weeks after planting corn improved with Nutrisphere-N by 9.3, 11.5, 13.0 and 9.2% with N applied at planting and 16.0, 12.9, 10.2 and 14.3% with split N applications at 45, 90, 135 and 180 kg ha<sup>-1</sup>, respectively. Nutrisphere-N increased grain N by 4.5% at 135 kg N ha<sup>-1</sup> applied to corn at planting and 5.2% at 90 kg N ha<sup>-1</sup> applied in split applications. Generally, N applications with Nutrisphere-N positively improved growth parameters and yields of corn.

**Keywords:** Corn, Nutrisphere-N, Normalized Difference Vegetation Index (NDVI), Leaf Area Index (LAI), Polymer

## 1. INTRODUCTION

More fertilizers are required to support World population, but may contribute to environmental pollution unless important issues are sufficiently addressed (Ni *et al.*, 2011). Cahill *et al.* (2010) pointed out that due to increasing fertilizer prices growers are looking for ways to decrease N input in crop production. Due to increasing awareness of natural resources sustainability, there are efforts to develop environmentally friendly N application methods to improve sustainability of crop production (Shaviv, 2005). This can be accomplished by synchronizing plant demands with supplying sufficient N.

Nitrification and ammonia volatility may lead to contamination of N in the soil surface and underground water (Hubbard *et al.*, 2004) and these are very important aspects in improving crop N uptake and use efficiency in crops (Franzen *et al.*, 2011). Hubbard *et al.* (2004) mentioned that NO<sub>3</sub>-N and NO<sub>2</sub>-N movement into groundwater is a problem in the southeastern Coastal Plain due to warm temperatures and relatively high rainfall. Optimum irrigation and N fertilization can help to reduce nitrate leaching and improve N uptake and crop yield (Martinez-Alcantara *et al.*, 2012).

Some concepts in improving N management include splitting N application, nitrification and urease inhibitors and using slow release fertilizers (Shaviv, 2005), which can

decrease volatilization and improve yields (Cahill *et al.*, 2010). Ni *et al.* (2009) indicated that slow-release urea coated fertilizer can help to reduce environmental pollution. In their study, ethylcellulose and poly (acrylic acid-co-acrylamide) were utilized as coating products, which helped to reduce N loss and improve water use efficiency. Another product, urea coated with Nutrisphere-N has both nitrification and urea volatilization inhibiting properties (Franzen *et al.*, 2011).

Current methods to determine optimum N rates for corn need to evaluate factors influencing N uptake (Kyveryga *et al.*, 2013) and quantify supplied and immobilized nutrients in the soil, especially for the site specific nutrient management (Anthony *et al.*, 2012). Cahill *et al.* (2010) pointed out that growers need to evaluate location and climate to decide about using alternative products. Therefore, objective of this study was to evaluate the effect of N application methods and rates with Nutrisphere-N polymer on dryland corn in Southeastern Coastal Plains.

## 2. MATERIALS AND METHODS

### 2.1. Site Preparation and Management

This study was conducted on Dothan loamy sand (fine loamy, kaolinitic, thermic Plinthic Kandiudult) at Clemson University, Edisto Research and Education Center (REC) near Blackville, SC (33° 21' N, 81° 19' W) under dryland conditions from 2010 to 2012. These are deep, well drained soils with slow permeability and soil pH was 6.2. Wheat cover crop was planted in November/December of 2009, 2010 and 2011 and was killed in early March of the following year. Corn cv. 'Pioneer 31G71' was planted following wheat cover crop at 69,200 seeds ha<sup>-1</sup> in strip-till using a Univerferth Ripper-Stripper (Unverferth Mtg. Co., Inc., Falida, OH) implement and John Deere 1700 MaxEmerge XP Vaccum planters (John Deere Co., Moline, IL) on 25, 18 and 14 March in 2010, 2011 and 2012, respectively. The plot size was 6.1 m long by 3.9 m wide with four corn rows and 0.96 m row spacing.

Nitrogen treatments consisted of two N application methods (all at once at planting and as a split application with 35 kg N ha<sup>-1</sup> applied at planting and the rest as a side-dress application at V6 corn stage) and five nitrogen rates (0, 45, 90, 135 and 180 kg N ha<sup>-1</sup>).

Liquid fertilizer 25-S (liquid formulation of 25% N and 3.5% S) was applied on both sides of corn rows to

selected plots using a Reddick fertilizer applicator (Reddick Equipment Co., Inc., Williamson, NC) following corn planting. Corn in selected plots was side-dressed with different nitrogen rates at V6 stage using a Reddick fertilizer applicator on 14 May 2010 and 9 May in 2011 and 2012. Weed control was based on the South Carolina Extension recommendations.

### 2.2. Plant Measurements

Plant measurements were conducted in the center of each plot. Chlorophyll was measured in corn leaves using Minolta SPAD-502 chlorophyll meter (Minolta Camera Co. Ltd., Japan). Normalized Difference Vegetation Index (NDVI) was measured using handheld GreenSeeker™ (NTech Industries, Inc. Ukiah, CA) instrument and the Leaf Area Index (LAI) LAI-2000 (Li-Cor, Lincoln, NE) meter was used to measure plant index.

Corn was harvested using either Almaco (Nevada, Iowa) or Kinkaid 8XP (Kinkaid Equip. Mtg, Haven, Kansas) small grain plot combine on 27, 8 and 4 August in 2010, 2011 and 2012, respectively. Grain Samples from all harvested plots were evaluated for weight and moisture content using a Burrows Model 750 Digital Moisture Computer (Seedburo Equip. Co., Chicago, IL). Corn grain yields were corrected to 155 g kg<sup>-1</sup> moisture content. Additionally, weather data (air temperature and precipitation) were recorded during soybean vegetation using a weather station located near the experimental site.

### 2.3. Statistical Analysis

The study design was a Randomized Complete Block with four replications. Data were analyzed using the general linear models in SAS (2011) and means with standard error bars were shown for N rates by N application method.

## 3. RESULTS

### 3.1. Weather Conditions

Monthly average temperature, precipitation and average from the 30-year average are shown in **Table 1**. The average monthly air temperature was generally similar to 30-year average, except for March 2012, April 2011, May 2010 and 2012, June 2010 and 2011, July 2011 and August 2012 when temperature was 3.5, 1.3, 1.8, 1.3, 2.3, 2.3, 1.3 and 1.1°C higher and March 2012 and June 2012 when temperature was 2.8 and 1.4°C lower than 30-year average, respectively.

**Table 1.** Monthly average air temperature and precipitation during soybean growth near Blackville, SC from 2010 to 2012

Year	Month						Average/Total
	Mar.	Apr.	May	June	July	Aug.	
<b>Temperature (°C)</b>							
2010	11.3	18.2	23.7	27.5	27.6	16.9	20.9
2011	13.4	19.1	22.3	27.4	28.0	18.0	21.4
2012	17.6	18.5	23.2	23.8	27.7	18.8	21.6
30-year avg.	14.1	17.8	21.8	25.2	26.8	17.8	20.6
<b>Precipitation (mm)</b>							
2010	64.0	25.0	88.0	187.0	103.0	162.0	629.0
2011	123.0	57.0	59.0	58.0	140.0	182.0	619.0
2012	119.0	44.0	173.0	80.0	97.0	309.0	822.0
30-year avg.	105.0	80.0	87.0	129.0	130.0	122.0	653.0

Precipitation was 169 mm greater during corn growing season in 2012 and 24 and 34 mm lower in 2010 and 2011 than 30-year average, respectively (**Table 1**). Insufficient precipitation was recorded in March and July 2010, April in all 3 years, May 2011, June 2011 and 2012 and July in 2010 and 2012. Higher than 30-year precipitation was recorded in March 2011 and 2012, May 2012, June 2010, July 2012 and August for all 3 years.

### 3.2. Chlorophyll, Plant Leaf Area Index (LAI) and Normalized Difference Vegetation Index (NDVI)

Nitrogen application with Nutrisphere-N improved chlorophyll in plant leaves by 19.3% at 45 kg N ha<sup>-1</sup> applied at planting compared to untreated N application at 8 weeks after corn planting (**Fig. 1**). Chlorophyll content was similar for treatments with higher N rates applied at planting with and without polymer. Nitrogen applied to corn in split applications slightly improved chlorophyll content, especially at higher N application rates (**Fig. 2**).

Plant LAI was either similar or greater from N treatments with Nutrisphere-N applications at 8 and 16 weeks after corn planting (**Fig. 3-6**). Addition of Nutrisphere-N to 135 kg N ha<sup>-1</sup> in split applications improved plant LAI by 10.2% at 8 weeks after planting. Similar or slightly higher LAI values were observed with Nutrisphere-N polymer for other N application rates. Measurements at 16 weeks after planting indicated 50.4, 56.2, 59.4 and 70.7% greater LAI with Nutrisphere-N polymer application than

without polymer at 45 kg, 90 kg, 135 kg and 180 kg N ha<sup>-1</sup> applied to corn in split applications, respectively. Plant LAI at 8 and 16 weeks after planting corn was similar for treatments with N applied at planting with and without Nutrisphere-N.

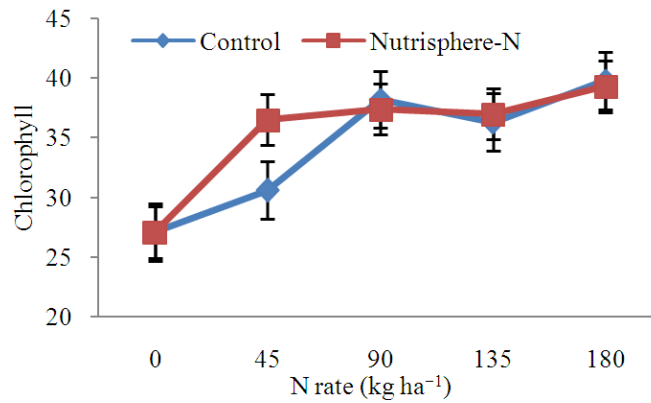
Plant NDVI at 16 weeks after planting was 9.3, 11.5, 13.0 and 9.2% greater with Nutrisphere-N polymer for N applied at planting and 16.0, 12.9, 10.2 and 14.3% greater with polymer over untreated N at 45 kg, 90 kg, 135 kg and 180 kg N ha<sup>-1</sup> in split applications, respectively (**Fig. 7 and 8**).

### 3.3. Ear-leaf N, Grain Yield and Grain N Content

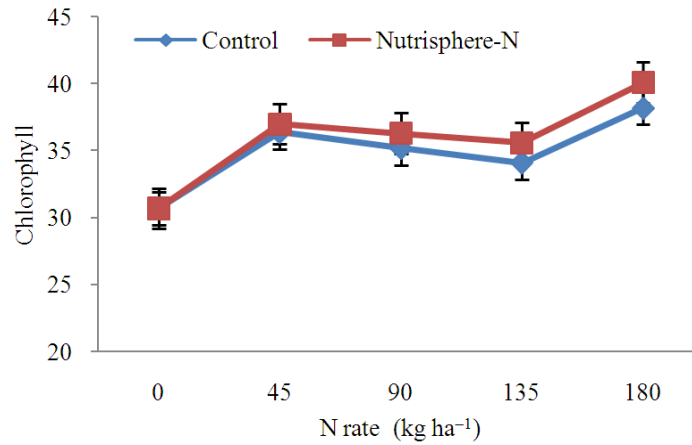
Corn ear-leaf N concentration at R1 stage was either similar or slightly higher for N treatments with Nutrisphere-N polymer (**Fig. 9 and 10**).

Generally, greater corn yields were obtained from N treatments with Nutrisphere-N application than without polymer (**Fig. 11 and 12**). With all N applied at planting, corn grain yield increased by 33.3 and 29.5% with application of Nutrisphere-N polymer at 90 kg and 135 kg N ha<sup>-1</sup> compared to untreated N. For split N applications, Nutrisphere-N polymer improved corn yields by 12.1, 12.9, 22.0 and 31.2% over untreated N.

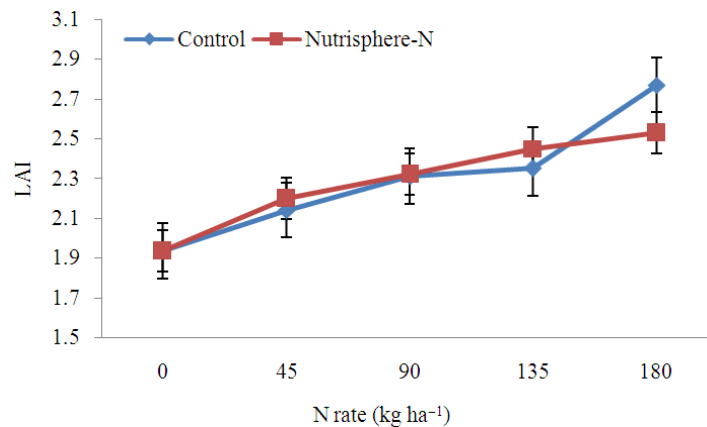
Grain N concentration was 4.5% greater at 135 kg N ha<sup>-1</sup> and Nutrisphere-N polymer applied at planting and 5.2% greater at 90 kg N ha<sup>-1</sup> applied with polymer to corn in split applications (**Fig. 13 and 14**). Grain N concentrations were similar for treatments with and without Nutrisphere-N for other N application rates.



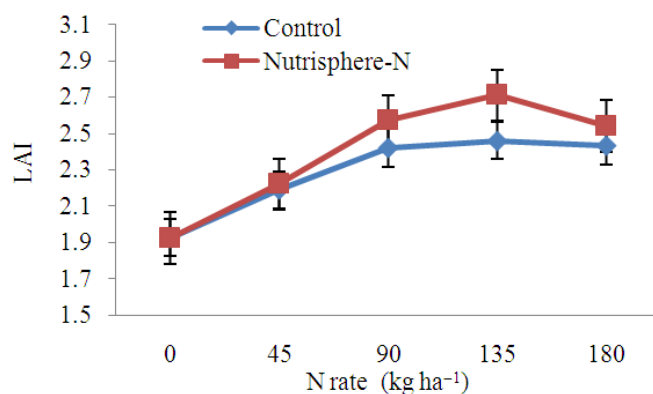
**Fig. 1.** Influence of N application rate at planting with Nutrisphere-N on chlorophyll content in corn leaves at 8 weeks after planting corn. Vertical bars indicate standard error



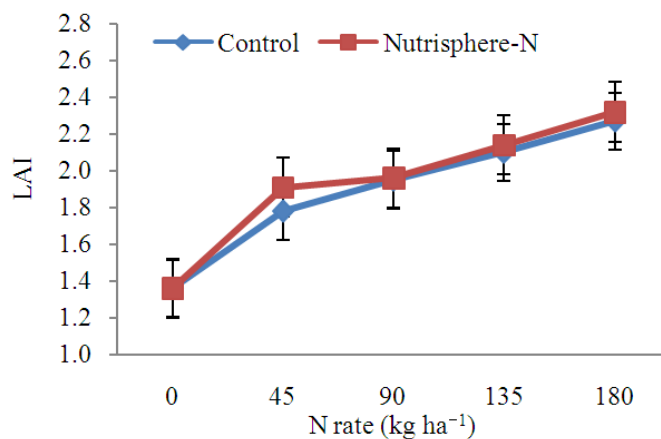
**Fig. 2.** Influence of split N application rate with Nutrisphere-N on chlorophyll content in corn leaves at 8 weeks after planting corn. Vertical bars indicate standard error



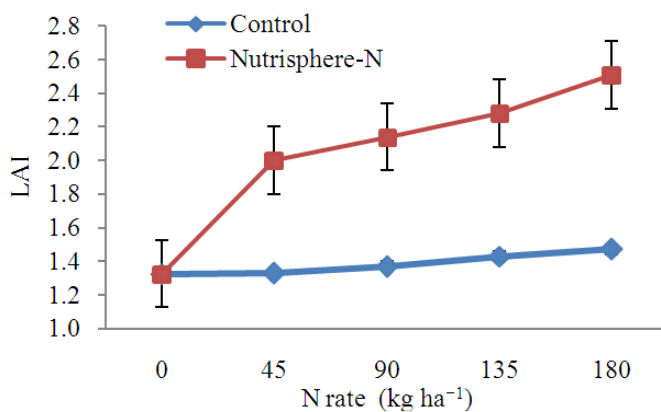
**Fig. 3.** Influence of N application rate at planting with Nutrisphere-N on corn Leaf Area Index (LAI) at 8 weeks after planting corn. Vertical bars indicate standard error



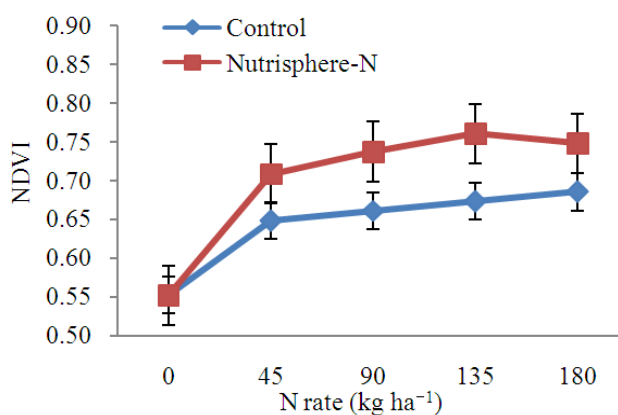
**Fig. 4.** Influence of split N application rate at planting with Nutrisphere-N on corn Leaf Area Index (LAI) at 8 weeks after planting corn. Vertical bars indicate standard error



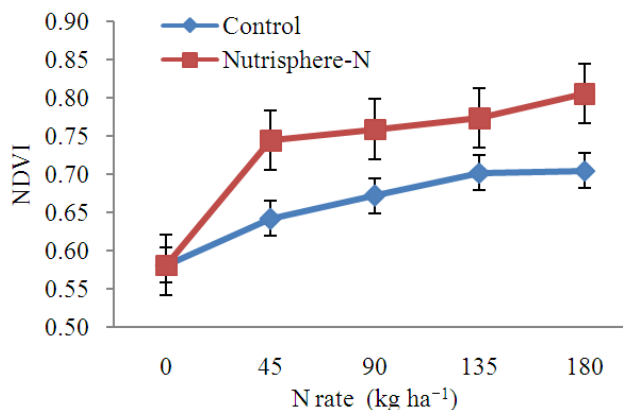
**Fig. 5.** Influence of N application rate at planting with Nutrisphere-N on corn Leaf Area Index (LAI) at 16 weeks after planting corn. Vertical bars indicate standard error



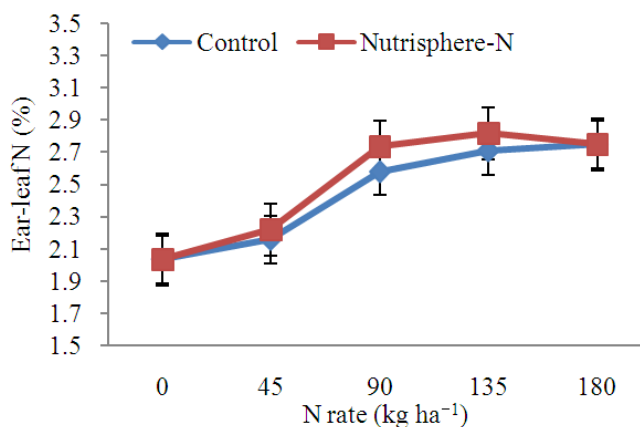
**Fig. 6.** Influence of split N application rate at planting with Nutrisphere-N on corn Leaf Area Index (LAI) at 16 weeks after planting corn. Vertical bars indicate standard error



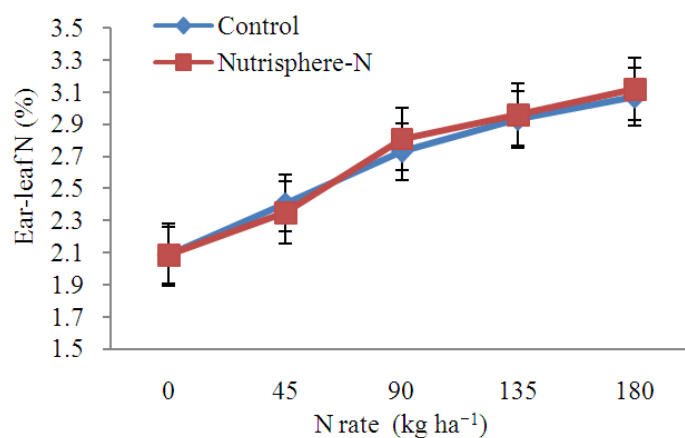
**Fig. 7.** Influence of N application rate at planting with Nutrisphere-N on corn Normalized Difference Vegetation Index (NDVI) at 16 weeks after planting corn. Vertical bars indicate standard error



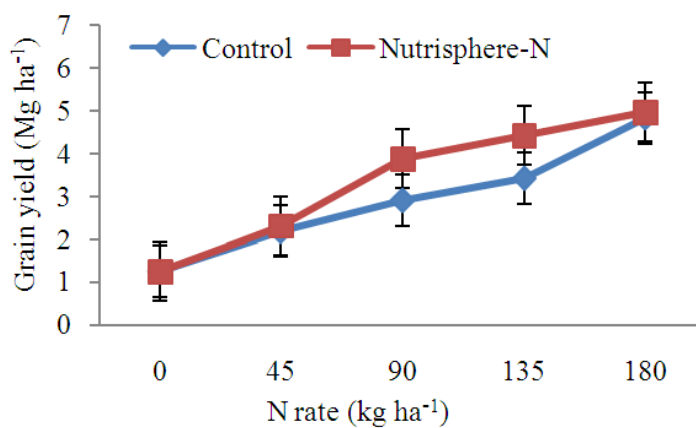
**Fig. 8.** Influence of split N application rate at planting with Nutrisphere-N on corn Normalized Difference Vegetation Index (NDVI) at 16 weeks after planting corn. Vertical bars indicate standard error



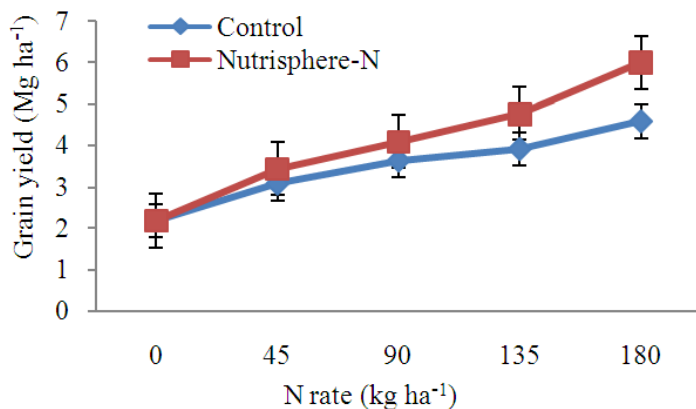
**Fig. 9.** Influence of N application rate at planting with Nutrisphere-N on N concentration in corn leaves at R1 stage. Vertical bars indicate standard error



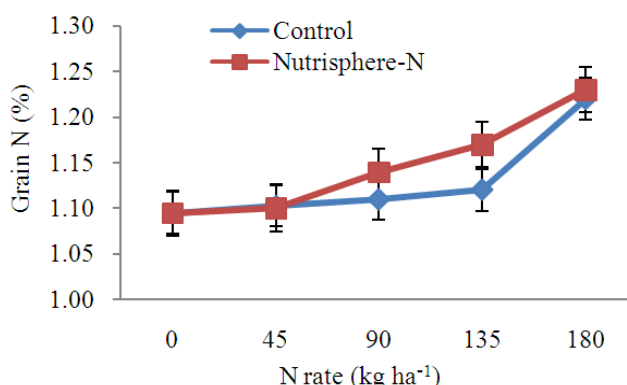
**Fig. 10.** Influence of split N application rate at planting with Nutrisphere-N on N concentration in corn leaves at R1 stage. Vertical bars indicate standard error



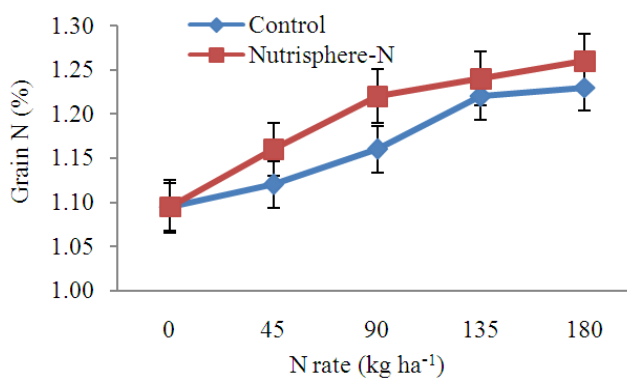
**Fig. 11.** Influence of N application rate at planting with Nutrisphere-N on corn grain yields. Vertical bars indicate standard error



**Fig. 12.** Influence of split N application rate at planting with Nutrisphere-N on corn grain yields. Vertical bars indicate standard error



**Fig. 13.** Influence of N application rate at planting with Nutrisphere-N on N concentration in corn grain. Vertical bars indicate standard error



**Fig. 14.** Influence of split N application rate at planting with Nutrisphere-N on N concentration in corn grain. Vertical bars indicate standard error

#### 4. DISCUSSION

Previous research was not conclusive. Slow-release N products did not always significantly improve crop yields (Stagnari and Pisante, 2012). Man *et al.* (2011) did not observe a significant difference in plant dry matter and grain yields of winter wheat (*Triticum aestivum* L.) between coated urea and uncoated urea. Franzen *et al.* (2011) noted that spring wheat and rice did not produce higher yields with Nutrisphere-N compared to urea.

However, Cahill *et al.* (2010) indicated that Nutrisphere-N improved yields of corn stover. Alternative products were not consistent in increasing corn or wheat grain yields compared to conventional fertilizer, but Nutrisphere-N increased yield of wheat straw in three out of four site years (Cahill *et al.*, 2010). Madani *et al.* (2012) reported that biomass and straw yield of drought-stressed wheat improved with increased N application rates.

This study showed that Nutrisphere-N improved chlorophyll in plant leaves by 19.3% at 8 weeks after corn planting with 45 kg N ha<sup>-1</sup> applied at planting. Split N application slightly improved chlorophyll content. Application of 135 kg N ha<sup>-1</sup> with Nutrisphere-N in split applications improved plant LAI by 10.2% at 8 weeks after planting. Plant LAI at 16 weeks after planting was 50.4, 56.2, 59.4 and 70.7% greater at 45 kg, 90 kg, 135 kg and 180 kg ha<sup>-1</sup> N applied with Nutrisphere-N in split applications, respectively. Plant NDVI at 16 weeks after planting was 9.3, 11.5, 13.0 and 9.2% greater for N applied at planting and 16.0, 12.9, 10.2 and 14.3% higher at 45 kg, 90 kg, 135 kg and 180 kg N ha<sup>-1</sup> applied in split applications with Nutrisphere-N, respectively. Corn grain yield increased by 33.3% and 29.5% at 90 kg and 135 kg N ha<sup>-1</sup> applied at planting with Nutrisphere-N, respectively. Additionally, application of 45 kg, 90 kg, 135 kg and 180 kg N ha<sup>-1</sup> in split applications with Nutrisphere-N increased corn yields



by 12.1, 12.9, 22.0 and 31.2%, respectively. Grain N improved by 4.5% at 135 kg N applied with Nutrisphere-N at planting and 5.2% at 90 kg N ha<sup>-1</sup> applied with Nutriplant-N in split applications.

## 5. CONCLUSION

This study investigated the effect of two N application methods and five N application rates with Nutrisphere-N polymer on growth and yield of corn grown under dryland conditions. Compared to untreated N, application of 45 kg N ha<sup>-1</sup> with Nutrisphere-N polymer at planting improved chlorophyll in plant leaves by 19.3%. Higher N rates produced similar chlorophyll content in plant tissues for treatments with and without polymer. Split N applications with Nutrisphere-N slightly improved chlorophyll content, especially at higher N application rates.

Plant LAI at 8 weeks after planting increased by 10.2% at 135 kg N ha<sup>-1</sup> with Nutrisphere-N polymer applied in split applications over untreated N. Adding Nutrisphere-N polymer generally did not affect plant LAI for other N rates. Plant LAI at 16 weeks after planting was 50.4, 56.2, 59.4 and 70.7% greater with Nutrisphere-N polymer at 45, 90, 135 and 180 kg ha<sup>-1</sup> N with split applications, respectively. Similar LAI was observed for N applied at planting with and without Nutrisphere-N at 8 and 16 weeks after planting corn.

Application of Nutrisphere-N polymer improved plant NDVI by 9.3, 11.5, 13.0 and 9.2% for N treatments applied at planting and 16.0, 12.9, 10.2 and 14.3% for split N applications at 45, 90, 135 and 180 kg N ha<sup>-1</sup> at 16 weeks after planting, respectively. The corn ear-leaf N concentration at R1 stage was similar for treatments with Nutrisphere-N and untreated fertilizer.

Compared to untreated control, addition of Nutrisphere-N polymer improved corn grain yield by 33.3 and 29.5% at 90 kg and 135 kg N ha<sup>-1</sup> applied at planting, respectively. For split N applications, corn grain yields increased by 12.1, 12.9, 22.0 and 31.2% at 45, 90, 135 and 180 kg N ha<sup>-1</sup> with Nutrisphere-N than untreated N. Nutrisphere-N polymer improved grain N concentration by 4.5% at 135 kg N ha<sup>-1</sup> applied at planting and 90 kg N ha<sup>-1</sup> with split application. Smaller differences between N concentrations were observed for other N rates with and without Nutrisphere-N. Future research may evaluate Nutrisphere-N under different soil moisture conditions during corn growing season.

## 6. ACKNOWLEDGEMENT

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