INCREASING ROOT MASS AND YIELD IN CORN THROUGH THE USE OF FERTILIZER ADDITIVES

R.W. Heiniger
Crop Science Department
North Carolina State University
Raleigh, North Carolina 27695
Ron_Heiniger@ncsu.edu
(252) 793-4428 ext. 154
(252) 793-5142

INTRODUCTION

Two new fertilizer additives recently released by Specialty Fertilizer Products, Inc. (Lenexa, KS) have the potential to increase N and P concentrations in the root zone, reduce leaching of these nutrients, reduce volatilization losses of N, and decrease P fixation in the soil resulting in a better match between the availability of N and P and crop nutrient demand when compared with conventional fertilizers . Avail™ and Nutrisphere™ are both long chain branched polymers with large negative charge (1800 meq 100 g^{-1}). This charge makes the molecule stable at high ionic concentrations allowing it to hold other molecules in suspension. When Avail™ is added to either a liquid or solid phosphate fertilizer and applied to the soil the negative charged polymer interacts with positive cations like Ca^{++} and Mg^{++} preventing them from interacting with and fixing the phosphate molecule. Likewise, when added to a fertilizer like UAN the Nutrisphere™ coating binds to positively charged cations such as nickel with the result that these cations are no longer be available to form urease which is the catalyst for converting N into NO_3-N.

While comparative research on corn done at Kansas State University (Gordon, unpublished data), University of Illinois (Ebelhar, unpublished data) and other institutions (Randall, unpublished data) indicates that Avail™ and/or Nutrisphere™ improved crop yield on a wide variety of soil types other studies have not found improvements in yield or nutrient use efficiency (Mississippi and Arkansas, unpublished data; Cahill et al., 2010) Clearly, more information is needed to determine if either Avail™ or Nutrisphere™ are effective in increasing plant growth, yield and fertilizer use efficiency in highly productive cropping systems.

The objectives of this research are to 1) examine the impact of the fertilize additives Avail™ and Nutrisphere™ on yield in high population corn systems, 2) determine if Avail™ improves root growth in corn, and 3) determine if Nutrisphere™ influences tissue N concentration, plant biomass, or N uptake

MATERIALS AND METHODS

Planting dates and hybrids for each test are shown in Table 1. A common row spacing of 0.76 m and standard seed rate of 81 510 seeds ha^{-1} were used. At all locations and across years the plots consisted of four rows of corn that were 3.08 m wide and 12.3 m long. The center two

rows of each four row plot were harvested in September using a Gleaner K2 combine with a Harvestmaster™ system (Juniper Systems, Inc., UT) that recorded plot weight, moisture, and test weight. All data were analyzed using PROC Mixed (SAS Institute, 2002-05) with replicated blocks considered as random factors. Mean separations of interest were done using contrast statements.

Table 1. Soil and crop management information for starter materials research trials conducted from 2007 through 2010.

Location	Soil Series	Planting Date	Hybrid	Seed Rate	Row Width
Pamlico 07	Wasda L. muck	Mar 28, 2007	DKC69-71	35 000	30”
Currituck 07	Pasquo. Silt L.	Apr. 3, 2007	Pioneer 31G98	33 000	30”
Perquimans 07	Roanoke F. Sand	Apr. 22, 2007	Terral TV21BR40	32 700	36”
Guilford 07	Dragston S. Loam	Apr. 20, 2007	Pioneer 31G98	33 000	30”
Davidson 07	Kirksey C Loam	May 1, 2007	Pioneer 31G98	33 000	30”
Pasquotank 08	Bladen S. Loam	Apr. 17, 2008	Pioneer 33M53/57	33 000	30”
Beaufort 08	Cape Fear S. Loam	Apr. 25, 2008	Pioneer 33M53/57	33 000	30”
Davidson 08	Kirksey C. Loam	May 2, 2008	Syngenta NK68-B8	33 000	30”
Forsythe 08	Hiwassie C. Loam	May 2, 2008	DKC61-69	33 000	30”
Guilford 08	Dragston S. Loam	May 3, 2008	DKC61-69	33 000	30”
Bertie 08	Goldsboro Sandy L.	Apr. 15, 2008	DKC61-69	33 000	36”
Pamlico 08	Yonges L. Fine Sand	Apr. 11, 2008	Pioneer 31G96	33 000	30”
Pamlico 09	Yonges L. Fine Sand	Apr. 8, 2009	Pioneer 31P44	33 000	30”
Hyde 09	Ponzer muck	Apr. 9, 2009	Pioneer 33M57	33 000	30”
Beaufort 09	Roanoke F. Sandy L.	Apr. 21, 2009	Pioneer 31P42	33 000	30”
Columbus 10	Norfolk L. Sand	Apr. 8, 2010	DeKalb DKC69-40	33 000	30”
Robeson 10	Goldsboro Sandy L.	Apr. 8, 2010	DeKalb DKC69-40	33 000	30”

Avail™ Research:

Plant and yield responses to Avail™ were tested at eight locations in North Carolina across three years: Pamlico07, Currituck07, Davidson07, Perquimens07, Guilford07, Beaufort08, Pasquotank08, and Hyde09 (Table 1). At all of these sites a split plot experimental design was used with main treatments consisting of a no-starter check, a blended liquid fertilizer (depending on the site either 10-27-0, 17-17-0, or 12-12-4), and the same liquid fertilizer with Avail™ added at 0.005 L L^{-1}. Subplots consisted of different rates of application applied in a 2 X 2 band. At Pamlico07, Currituck07, and Guilford07 rates of 46.8, 93.5, 187.0, and 374 L ha^{-1} were applied. At Davidson07 the main treatments were applied at 93.5 and 187.0 L ha^{-1}, while at Perquimans07, Pasquotank08, Beaufort08, and Hyde09 the main plot treatments were applied at only one rate of 187.0 L ha^{-1}. At all locations 30% UAN was applied at layby at rates adjusted within each treatment to provide a total of 202 kg of N ha^{-1}.

Root and stalk measurements were taken at five locations, Pamlico07, Currituck07, Beaufort08, Pasquotank08, and Hyde09 prior to R1. Five consecutive plants from the outside row of each plot were excavated by digging a 30 cm deep trench on each side of the plant and carefully removing the root ball from the soil. At the same time stalk diameter was measured at the

internode below the ear leaf. The root ball was then separated from the plant by clipping above the highest brace root. Roots were washed to remove soil and the depth and the width at the widest point was measured. The root ball was then dried and weighed.

Nutrisphere™ or Combined Research:

Plant and yield responses to Nutrisphere™ were tested at eight locations: Pamlico07, Curricutck07, Guilford08, Forsythe08, Pamlico08, Bertie08, Pamlico09 and Beaufor09. At all sites with the exception of Guilford08 and Forsythe08 the experimental design was a split plot with four replications. The two main plot treatments were 30% UAN and 30% UAN with Nutrisphere^{TM} added at the recommended rate of 0.005 L L^{-1}. Subplots consisted of four rates of application that differed slightly across years. In 2007 the N fertilizer materials were applied in a broadcast application shortly following planting. In 2008 the N fertilizer materials were applied at layby and in 2009 N materials were applied both at planting (21 April) and at layby (27 May). From the at planting application of N on all but the highest N rate treatment whole plant tissue samples were collected at growth stages V5 (27 May at Beaufort09 and 21 May at Pamlico09) and whole plant tissue samples, above ground biomass and N uptake were measured at R1 (27 June at Beaufort09 and 26 June at Pamlico09). In addition, stalk samples were collected at harvest by clipping a 15 cm portion of stalk from just above the soil surface. Tissue and stalk samples consisted of five consecutive plants collected from a random sampling of the outside rows of each plot. Samples were chopped and dried and at R1 biomass was measured before they were sent to the North Carolina Department of Agriculture and Consumer Services (NCDA&CS) laboratory in Raleigh, NC where they were analyzed using standard procedures for testing total % Kjehdal N. At each site with the exceptions of Pamlico09 and Beaufort09, starter fertilizer was applied to all the plots at planting in a 2 x 2 band at a rate of 90.4 L ha^{-1}.

At Guilford08, Forsythe08, Columbus10, and Robeson10 the Nutrisphere™ polymer test was combined with a test of starter fertilizer with and without Avail™ using a randomized complete block design with four replications. At Guilford08 and Forsythe08 ten treatments were applied: A) 12-12-4 applied as a starter in a 2 x 2 band with 30% UAN broadcast applied at 143 kg N ha^{-1}, B) 12-12-4 in a 2 x 2 band with 30% UAN broadcast applied at 179 kg N ha^{-1}, C) 12-12-4 in a 2 x 2 band with 30% UAN plus Nutrisphere broadcast applied at 143 kg N ha^{-1}, D) 12-12-4 in a 2 x 2 band with 30% UAN plus Nutrisphere broadcast at 179 kg N ha^{-1}, E) 12-12-4 in a 2 x 2 band with Avail plus 30% UAN broadcast applied at 143 kg N ha^{-1} , F) 12-12-4 in a 2 x 2 band with Avail with 30% UAN broadcast applied at 179 kg N ha^{-1}, G) 12-12-4 with Avail in a 2 x 2 band with 30% UAN plus Nutrisphere broadcast applied at 143 kg N ha^{-1}, H) 12-12-4 with Avail in a 2 x 2 band with 30% UAN plus Nutrisphere broadcast applied at 179 kg N ha^{-1}, I) no starter fertilizer with 30% UAN broadcast applied at 179 kg N ha^{-1}, and J) no fertilizer applied. The starter fertilizer with or without Avail™ was applied a rate of 187 L ha^{-1}. At Columbus10 and Robeson10 five treatments were used: A) 11-37-0 applied as a starter in a 2 x 2 band with 30% UAN broadcast applied at 179 kg N ha^{-1}, B) 11-37-0 in a 2 x 2 band with Avail with 30% UAN broadcast applied at 179 kg N ha^{-1}, C) 11-37-0 in a 2 x 2 band with 30% UAN plus Nutrisphere broadcast at 179 kg N ha^{-1}, D) 11-37-0 with Avail in a 2 x 2 band with 30% UAN plus Nutrisphere

broadcast applied at 179 kg N ha^{-1}, E) no starter fertilizer with 30% UAN broadcast applied at 179 kg N ha^{-1}.

RESULTS AND DISCUSSION

IMPACT OF AVAIL™ ON PLANT GROWTH

When the data were combined across locations there were significant location by starter interactions for root ball mass, root ball depth, and stalk diameter. In most cases these significant differences were between one or more of the starter materials and the no-starter treatment (data not shown). Comparisons between the same starter material with and without Avail™ found significant differences in root mass at both locations in 2007 and differences in stalk diameter at Pamlico07, Beaufort08 and Pasquotank08 (Table 2). There were no significant differences in root ball depth or width between the same starter material with and without Avail™. In 2009, no differences were found between the 10-27-0 with or without Avail in any of the plant or root properties measured.

Table 2. Measured root and stalk properties from starter treatments with (Yes) and without (No) Avail. Letters in the same row within each root or stalk property indicate significant differences at p = 0.05.

Location - Year	Root Properties						Stalk Properties	
	Depth (in)		Width (in)		Mass (oz)		Diameter (in)	
	No	Yes	No	Yes	No	Yes	No	Yes
Pamlico – 07	5.3	6.0	5.8	6.1	7.5a	8.7b	0.95a	1.0b
Currituck – 07	3.6	3.7	5.0	5.0	9.0a	11.2b	0.93	0.95
Beaufort – 08	2.6	2.6	4.0	4.3	2.6	2.8	0.74a	0.78b
Pasquotank - 08	3.7	3.8	5.8	5.6	4.7	3.8	0.79a	0.83b
Hyde – 09	6.9	7.1	5.2	5.4	3.1	3.2	0.95	0.95

IMPACT OF AVAIL™ ON YIELD

When the data were combined across locations there were significant location and fertilizer source main effects on yield. In four of eight site years starter fertilizer significantly increased grain yield when compared to the untreated check resulting in a significant yield advantage to the use of starter fertilizer with or without Avail™. Table 3 shows the impact of starter materials with or without Avail™ on corn yield across the eight site-years tested. In six of the eight years the use of Avail™ resulted in numerically higher yield. However, only at Guilford07 was this increase significant. When these results were combined across site years Avail™ significantly increased yield when compared to the use of the blended fertilizer alone.

Table 3. Yield results from eight locations across two years comparing treatments with no starter, starter (10-27-0, 12-12-4, or 17-17-0) without Avail, and the same starter treatment with Avail. Different letters within each row indicate locations or overall average where the use of Avail resulted in a significant yield increase compared to the use of the same starter material without Avail at p=0.05.

			Corn Yield (t ha^{-1})		
Location - Year	Blended Fertilizer	Soil P Level	No Starter	Starter only	Same Starter with Avail
Pamilico 07	10-27-0	Med	11.6a	12.1ab	12.8b
Currituck 07	10-27-0	Med	12.0a	12.6a	12.6a
Davidson07	17-17-0	Med	7.8a	9.1b	8.2ab
Guilford07	12-12-4	Low	9.0a	8.9a	10.4b
Perquimans07	12-12-4	Low	8.2a	9.1ab	10.1b
Pasquotank08	10-27-0	High	10.4a	9.6a	10.1a
Beaufort08	10-27-0	High	8.1a	7.7a	8.0a
Hyde09	10-27-0	High	14.0a	14.2a	14.0a
Average			9.9a	10.5b	11.0c

IMPACT OF NUTRISPHERE™ ON YIELD

Because of differences in N rate and application timing results were combined within years with the exception of the locations Guilford08 and Forsythe08 which were analyzed as a unit due to the fact that they included starter fertilizer treatments with and without Avail™. In both 2007 and 2008 the combined analysis found a location by rate interaction ($p = 0.0022$ and 0.0059 in 2007 and 2008, respectively) and a significant rate effect ($p < 0.0001$ and 0.0055, respectively). In 2008 when N was applied at layby there was a significant source effect ($p = 0.0067$). The addition of Nutrisphere™ resulted in a significant yield increase of 0.74 t ha^{-1} compared with 30% UAN alone (Table 4). While the source by rate interaction was not significant in either 2007 or 2008 contrast statements indicated that there were differences in corn yield between 30% UAN and 30% UAN plus Nutrisphere™ at one or more N rates. In 2009 there were strong location by rate ($p < 0.0001$) and application timing by source ($p = 0.0124$) interactions. When Nutrisphere™ was added to 30% UAN and applied at planting there was a significant yield increase of 0.37 t ha^{-1} and contrast statements found a significant yield increase when Nutrisphere™ was applied with 30% UAN at a rate of 101 kg N ha^{-1} (Table 4). In 2009 no significant yield differences between 30% UAN and 30% UAN plus Nutrisphere™ were found when the applications were made at layby.

When Forsythe08 and Guilford08 were combined statistical analysis found a strong treatment effect ($p = 0.0011$). Contrast statements were used to examine differences between 30% UAN and 30% UAN with Nutrisphere™. There was a significant yield increase ($p = 0.0152$) of 0.93 t ha^{-1} resulting from the use of Nutrisphere™ whenever starter fertilizer (either 12-12-4 or 12-12-4 with Avail™) was applied (Figure 1). However, when Columbus10 and Robeson10 were combined there were no significant yield differences between the use of Avail™ or starter without Avail™ nor the use of Nutrisphere™ and 30% UAN without Nutrisphere™.

Table 4. Corn yield response to different rates of 30% UAN applied with and without Nutrisphere™ at either planting or layby.

		Nitrogen Rate Code†					
Timing/Year	Nitrogen Treatment	0	1	2	3	4	Average
		---------- t ha^{-1} ----------					
Plant 07	30% UAN	8.65	11.02a‡	11.06a	11.88a	12.06a	10.93A§
	UAN + Nutrisphere™	8.65	10.58a	11.86b	12.55a	12.86b	11.30A
	N Rate Averages	8.65a¶	10.80b	11.46c	12.21d	12.46d	
Layby 08	30% UAN	5.54a	6.28a	6.12a	6.89a	7.19a	6.40A
	UAN + Nutrisphere™	6.40a	6.79a	7.22b	8.08b	7.23a	7.14B
	N Rate Averages	5.97a	6.54ab	6.67bd	7.48c	7.21cd	
Plant 09	30% UAN	7.41	11.02a	11.68a	13.24a	13.18a	11.30A
	UAN + Nutrisphere™	7.41	11.71b	12.15a	13.61a	13.50a	11.67B
	N Rate Averages	7.41a	11.37b	11.91c	13.42d	13.34d	
Layby 09	30% UAN	7.11	11.37a	12.51a	13.39a	13.44a	11.09A
	UAN + Nutrisphere™	7.11	11.51a	12.32a	13.62a	13.87a	11.14A
	N Rate Averages	7.11a	11.44b	12.42c	13.50d	13.65d	

†Nitrogen rates for each year were: 2007 0 = 0, 1 = 56, 2 = 91, 3 = 161, and 4= 303 kg N ha^{-1}; 2008 – 0 = 34, 1 = 90, 2 = 202, 3 = 258, and 4 =314 kg N ha^{-1}; 2009 – 0 = 0, 1 = 101, 2 = 146, 3 = 202, and 4 = 258 kg N ha^{-1}.

‡ Different letters within each year and rate code column indicate significant differences at $p < 0.10$.

§ Different letters within each year under the Average column indicate significant differences between 30% UAN and 30% UAN plus Nutrisphere™ at $p < 0.10$.

¶ Different letters within each row showing the N rate averages indicate significant differences at $p < 0.10$.

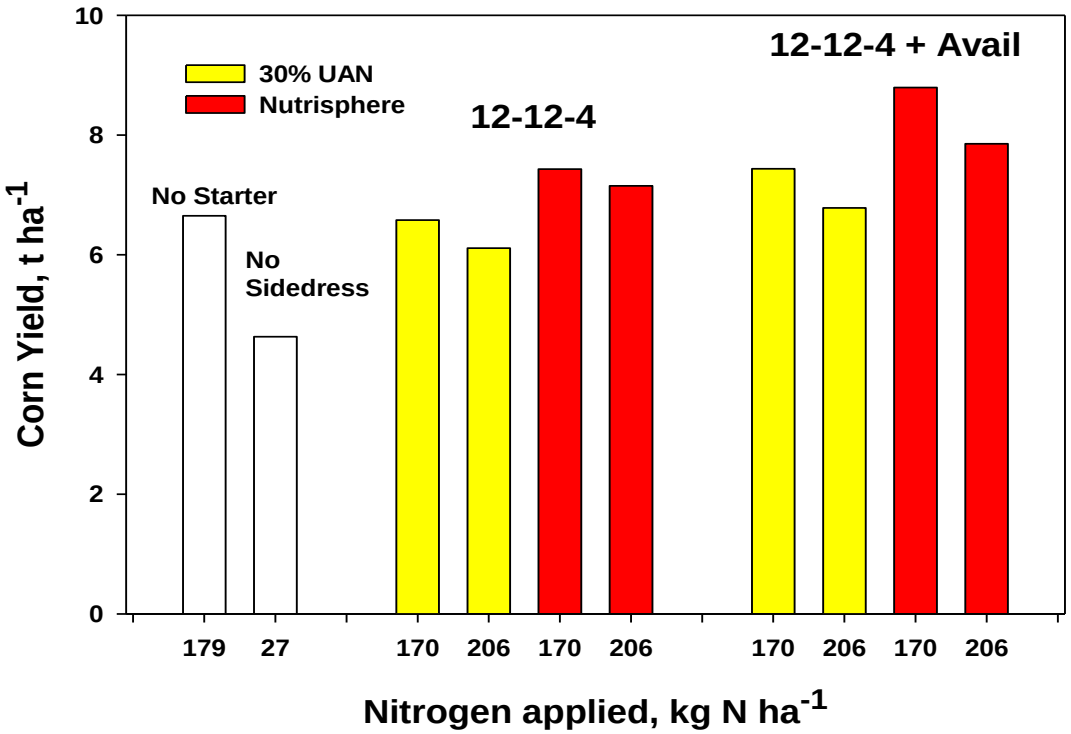

Figure 1. Grain yield measured with various treatments including either no starter, 12-12-4, or 12-12-4 plus Avail™ applied in a 2 x 2 band at planting and a layby application of either 30% UAN or 30% UAN with Nutrisphere™ added. Contrast statements found that when either 12-12-4 or 12-12-4 with Avail™ was used Nutrisphere™ added to 30% UAN significantly increased corn yield compared to the use of 30% UAN alone at p = 0.0152.