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The effect of Agrotain-Plus® on strip-till corn with regards to N, P, K, Mg, Ca, S, Fe, Mn, B, Cu, and Zn levels

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ABSTRACT

The effect of Agrotain-Plus® on strip-till corn was studied to determine its effectiveness in preventing nitrogen loss. Twelve replications were created in this experiment. Six of the replications contained the Agrotain-Plus® and the other six replications lacked the fertilizer additive. Three separate tissue samples of the corn leaves were taken throughout the growing season. Because of lack of rain fall, nitrogen was not a limiting factor. Instead, the tissue samples were used to analyze the relationships between the added fertilizer additive vs. the UAN fertilizer and the levels of the following nutrients contained in the corn leaf: nitrogen, phosphorus, potassium, magnesium, calcium, sulfur, iron, manganese, boron, copper, and zinc. It was found that the amounts of each of the nutrients changed significantly over time. This experiment did not show significant evidence that the added Agrotain-Plus® had a positive correlation with the amount of the other micronutrients or macronutrients located in the corn leaves. Micronutrients calcium, sulfur, manganese and copper significantly changed over time when comparing the effect of Agrotain-Plus® with the effect of UAN fertilizer alone.

Keywords: *nitrogen fertilizer, Agrotain-Plus®, micronutrients, macronutrients, strip-till corn*

INTRODUCTION

Nitrogen loss from the soil is detrimental in corn (*Zea mays* L.), in that it affects the yield, the money spent on nitrogen fertilizer, and the chance of environmental pollution. Current nitrogen prices, as well as concerns over environmental stewardship, are forcing producers to make smarter choices in the fertilizer products used as well as when and how the materials are applied, to optimize their nitrogen use efficiency (Weber 2010).

Loss of nitrogen can occur in four major ways: volatilization, denitrification, leaching, and immobilization. Volatilization occurs when the nitrogen in the form of urea that is produced from the surface applied fertilizers is converted to N_2 gas. This can result in an average of 5% of the added nitrogen volalitilized (Weber 2010). Denitrification is a process where certain soil bacteria that thrive in saturated (anaerobic) soil conditions can convert NO_3-N to oxygen and nitrogen gas (Weber 2010). Denitrification occurs when the bacteria converted NO_3-N is converted into a gas and escapes into the atmosphere (Schwab and Murdock 2005). It occurs when the soil is poorly drained (waterlogged) or soil temperature is higher than 60ºF(Weber 2010). Leaching happens when there is a downward movement of nitrogen caused by the percolation of water. Timing is very important when it comes to the chance of nitrogen loss through leaching. In strip-tillage systems shortened intervals between crops also facilitates the capture of nitrogen before it becomes subject to leaching (Mitchell 2009). If nitrogen in the soil becomes unavailable to the growth of corn, then immobilization will occur. This nitrogen is instead used up by microorganisms that feed on corn stalk that would be in supply on strip-till corn acreage.

A fertilizer additive which could be of value to battle the loss of nitrogen and improve N use efficiency includes the urease inhibitor NBPT ((n-butyl) thiophosphoric triamide). It is marketed under the trade name Agrotain® and Agrotain-Plus®, a product for use in N solutions that combines the urease inhibitor NBPT with DCD (dicyandiamide) a nitrification inhibitor (Weber 2010). The makers of Agrotain-Plus® market that this product will help prevent the crop from losing nitrogen through the following ways: volatilization, denitrification, and leaching. The creators of this commercial product say that Agrotain-Plus® prevents volatilization by blocking the enzyme, urease, to prevent loss into the air of the urea component in UAN. Agrotain-Plus® will protect nitrogen from losses due to denitrification because it works with nature to keep the nitrogen in the ammonium form for a longer period of time, without harming bacteria. The producers say that this fertilizer additive will also control leaching with positively-charged ammonium molecules that will hold on to soil particles for a longer period of time.

It has also been found that applied nitrogen fertilization levels significantly differentiated the uptake of nitrogen, phosphorous, potassium, magnesium, calcium, and sodium by maize plants (Szulc 2009). The purpose of this experiment was to look at the effect of the liquid nitrogen fertilizer with the Agrotain-Plus® and compare it with the effect of the UAN alone. Because of uncontrolled conditions, corn yield could not be studied.

Therefore, the study focused on the effect of Agrotain-Plus® on strip-till corn with regards to levels of nitrogen, phosphorus, potassium, magnesium, calcium, sulfur, iron, manganese, boron, copper, and zinc in the corn leaves. In (Schulte 1991) plant growth is restricted when: 1) not enough of one or more elements are present; 2) too much of one or more elements are present, or 3) the levels of one or more elements are adequate but out of balance with other elements. The complete plant analyses showed the levels of the nutrients at three stages of growth. The nutrient composition of a plant changes as the plant matures and with the portion of the plant sampled; therefore, critical levels are defined for a specific plant part at a specified stage of maturity (Schulte 1991). Consequently, these levels were important in analyzing if the Agrotain-Plus® had an effect on the corn plants over time throughout the growing season.

MATERIALS AND METHODS

Field experiments were conducted on a clay loam field with 0% slope in Moundridge, KS. A seed trait specialist and a precision agriculture specialist at MidKansas Coop in Moundridge, KS set aside this test plot to perform this experiment. The test plot that was used was a strip-till field where nitrogen had a high potential of being lost or was conducive

Table 1. Average amounts and standard deviations of micronutrients throughout growing season located in the corn leaf tissue samples that underwent a complete plant analysis. Samples were taken from each of 12 replications from a strip-till corn plot either with UAN fertilizer plus Agrotain-Plus® or UAN fertilizer alone.

Average Values for Growing Season			
Date Sample was taken:	**5/26/2011**	**6/13/2011**	**7/6/2011**
Nutrient w or w/o A+	**% of nutrient in corn plant**	**% of nutrient in corn plant**	**% of nutrient in corn plant**
Nitrogen without	4.61 ± 0.08	3.86 ± 0.13	2.79 ± 0.10
Nitrogen	4.84 ± 0.18	3.79 ± 0.11	2.8 ± 0.13
Phosphorus without	0.37 ± 0.02	0.23 ± 0.02	0.23 ± 0.01
Phosphorus	0.35 ± 0.04	0.24 ± 0.02	0.23 ± 0.01
Potassium without	3.41 ± 0.28	2.43 ± 0.37	1.93 ± 0.14
Potassium	3.14 ± 0.55	2.48 ± 0.34	1.9 ± 0.08
Magnesium without	0.42 ± 0.04	0.45 ± 0.14	0.31 ± 0.03
Magnesium	0.42 ± 0.05	0.47 ± 0.15	0.31 ± 0.02
Calcium without	0.61 ± 0.02	0.8 ± 0.30	0.53 ± 0.02
Calcium	0.68 ± 0.08	0.85 ± 0.31	0.52 ± 0.02
Sulfur without	0.29 ± 0.01	0.28 ± 0.01	0.2 ± 0.01
Sulfur	0.32 ± 0.02	0.28 ± 0.02	0.2 ± 0.01
	ppm of nutrient in corn plant	**ppm of nutrient in corn plant**	**ppm of nutrient in corn plant**
Iron without	569.67 ± 76.17	367.17 ± 109.69	126.83 ± 1.21
Iron	507.67 ± 126.78	383.33 ± 102.21	127.00 ± 4.93
Manganese without	98.17 ± 8.29	114.17 ± 23.69	89.83 ± 5.98
Manganese	110.83 ± 16.65	113.00 ± 24.62	85.33 ± 7.76
Boron without	8.83 ± 0.90	22.83 ± 3.01	15.33 ± 0.75
Boron	9.50 ± 0.50	23.00 ± 3.51	15.50 ± 1.26
Copper without	18.17 ± 1.21	17.67 ± 3.77	10.00 ± 0.82
Copper	21.83 ± 1.86	18.67 ± 4.69	10.83 ± 1.95
Zinc without	46.33 ± 2.69	23.67 ± 1.37	31.00 ± 1.83
Zinc	44.00 ± 4.97	24.17 ± 1.34	30.50 ± 2.87

to nitrogen deficiency through denitrification, leeching, ammonia volatilization, and immobilization. The corn was planted by a twelve row planter with twelve sets of rows.

Liquid nitrogen was put on the corn at the time of planting and a 32-0-0 fertilizer was used. UAN-32 or 32-0-0 is a clear, solution of ammonium nitrate and urea. UAN-32 contains three forms of nitrogen which deliver phased release crop feeding. It is composed of 25% nitrate, 25% ammonium and 50% urea. All 12 replications received the standard UAN-32 liquid fertilizer.

The planting was completed in 12 replications. The first 12 rows contained only the UAN fertilizer. The next 12 rows included the UAN fertilizer plus the Agrotain-Plus®. In other words, every other 12 rows was skipped so that the other sets of 12 rows would receive the additional nitrogen fertilizer additive, Agrotain-Plus®. The creators of this commercial product claimed that it could reduce the amount of nitrogen loss because it would keep the nitrogen in an ammonium form for a longer period of time; which would prevent some of the nitrogen loss through ammonia volatilization. It also claimed that it would maximize economic yield and would lower nitrogen costs by giving farmers a lengthened opportunity of time to apply nitrogen to the fields. The makers of Agrotain-Plus® also claim to reduce the amount of nitrogen that can become immobilized. One 15 pound bag of dry Agrotain-Plus® was used for half of the 14 acres of strip-till corn acreage.

Throughout the growing season, the amount of precipitation was recorded. Three tissue samples of the corn were taken at each significant growth stage. The first sample was taken on 5/16/2011 when the corn plant was at its emergence to 4 leaf stage. At that time 20 samples of the entire corn plant were taken in each replication. The next tissue sample was taken on 6/13/2011 and this was when the corn plant was at the 6 leaf to 10 leaf stage. At that time the youngest mature leaf was picked from 20 different corn plants in each replication. The final tissue sample was acquired on 7/6/2011. This sample was taken when the corn was tasseling to silking. For this sample, the leaf at or below the ear was used for the sampling. Again, 20 samples were taken from each replication.

All tissue samples were placed in separate paper bags and then were mailed to NutriSolutions from Winfield AgriSolutions at the Servi-Tech Laboratories located in Dodge City. The Servi-Tech lab sent back the results that were labeled as complete plant analysis, which analyzed the corn plant leaves in terms of its N, P, K, Mg, Ca, S, Fe, Mn, B, Cu, and Zn levels.

The statistical analysis that was used for this experiment was a repeated measures Analysis of Variance. This ANOVA examined if there was significance in the following categories: if the amount of each macronutrient and micronutrient in the corn leaves changed over time, if the Agrotain-Plus® had a significant effect on the amount of each macronutrient and micronutrient in the corn leaves, and if there was a significant difference in the macronutrient and micronutrient levels in the corn leaves between the plants that received UAN alone and the plants that received the UAN plus the additive, Agrotain-Plus® over time.

RESULTS

The data indicated what should be the optimum levels at that particular point in the growing season of the micronutrients and macronutrients. The data also indicated if the corn plant was lacking in certain micronutrient and macronutrient levels. Due to uncontrolled conditions there was a lack of rainfall. The corn received only 3.76 inches of rain during the entire growing season, which was not sufficient for healthy growth. Because of this, yield could not be studied in the experiment. The data from the complete plant tissue analysis samples was analyzed to discover relationships caused by the effect of the treatment on the nutrient levels.
The averages and standard deviations of the three tissue samples that were taken are listed in *Table 1*.

Table 2. Significant p Values associated with relationships between the three complete plant analyses taken in 2011 in Moundrige, KS on a strip-till corn plot throughout the growing season. Treatment includes UAN with Agrotain-Plus® vs. UAN alone. * denotes significance.

Results from Repeated Measures ANOVA			
P Values			
Nutrient	**Time**	**Treatment**	**Treatment x Time**
N	<0.0001*	0.2736	0.081
P	<0.0001*	0.6473	0.2826
K	<0.0001*	0.6135	0.5225
Mg	<0.0001*	0.8734	0.9709
Ca	<0.0001*	0.6162	0.0295*
S	<0.0001*	0.1052	0.0339*
Fe	<0.0001*	0.4004	0.6173
Mn	<0.0001*	0.7462	0.0219*
B	<0.0001*	0.6815	0.8247
Cu	<0.0001*	0.206	0.0197*
Zn	<0.0001*	0.4621	0.367

The results from the repeated measures Anova (*Table 2*) showed significance for all micronutrients [p<0.0001] that the amounts of the micronutrients in the corn leaves changed over time.

The results did not show significant evidence to prove that the Agrotain-Plus® had a positive correlation with the amounts of the micronutrients and macronutrients located in the corn leaves. Most of the nutrients including N, P, K, Mg, Fe, B, and Zn, did not show significance when the ANOVA assessed significance of the effect of the Agrotain-Plus® over time. However, the following micronutrients: Cu [p<0.0197], Ca [p<0.0295], S [p<0.0339], and Mn [p<0.0462] confirmed significance in that the amount of the micronutrient changed over time in regards to the addition or no addition of the nitrogen fertilizer additive, Agrotain-Plus.

DISCUSSION

Because of lack of rainfall and extreme drought, yield was not apparent. It was found that as the summer went on without moisture, the tissue analyses showed less of each nutrient. This proved the point that the results indicated that all micronutrients had a significant p value when it accessed the amount and how it changed over time. Because there was no water, the corn dried out completely, making it insufficient to produce a yield. Also when water moves from the roots to the leaves it transports all of the water soluble nutrients from the soil to the leaves. When a plant becomes extremely dry and wilts, this transport of the water soluble nutrients has ceased.

Even though yield could not be studied, Schulte (1991) found that when a nutrient is deficient, addition of that nutrient results in increased crop growth and usually an increase in the concentration of that element. This shows the importance of complete plant analysis when it comes to increasing yield.

The three most important macronutrients are N, P, and K. Nitrogen combines with compounds produced by carbohydrate metabolism to form amino acids and proteins, is an essential component of chlorophyll enzymes, and stimulates root growth and crop development as well as uptake of other nutrients. Because the corn plants were deficient in nitrogen, this caused a decrease in the uptake of the other nutrients. Phosphorus plays a key role in photosynthesis, cell respiration, energy storage and energy transfer, cell division, cell enlargement and is necessary for corn plants to complete normal production cycles. Potassium is what strengthens plant stalks and stems and is involved in protein, starch, and carbohydrate synthesis. Potassium also improves the water regime of the plant and increases its tolerance to drought. By the third and final tissue analysis, all replications showed deficiencies in the N, P, and K contents regardless of whether or not the corn received the fertilizer additive.

Lloyd (1961) showed that the N or P content in the corn leaf at 95% of maximum yield positively correlated with the concentration of the other nutrients because of their significant interaction on yield. Nutrient imbalance may occur when the leaf N or P content extends beyond a certain optimum level in relation to the other one (Lloyd 1961). In Schulte (1991) plant analyses are interpreted on the basis of “critical levels” for each nutrient. Jones (1973) define the critical level as that concentration below which yields decrease or deficiency symptoms appear. Also the significant effect of numerous interactions between micronutrients indicates that the critical level of any particular nutrient varies with leaf levels of other nutrients (Peck 1968). In Viets (1953) it was found that total P and N contents of corn leaves were highly correlated. The results from this experiment did not display positive correlation with the P and N levels and the addition of Agrotain-Plus®. In Martin (1973) the basic principle of the use of plant analysis is that the chemical composition of the plant reflects its nutrient supply in relation to growth. In this study, it was obvious that the deficiencies in the nutrient levels positively correlated with the lack of growth.

In conclusion, this study found that the fertilizer additive, Agrotain-Plus®, did not prove to be useful in increasing the nitrogen content of the corn plant over time as predicted by the producers. This could have been due to the extremely harsh heat and dry weather that the corn crop experienced. All in all, this experiment proved that under severely dry conditions Agrotain-Plus® did not perform as marketed.

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