Enhanced Efficiency Liquid N Applications for Corn

Investigators:
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Objectives and Relevance:

Corn production in Missouri has averaged approximately 2.9 million acres since 2004 with a value of $1.2 billion in total production (NASS, 2009). High yield corn production systems have integrated fungicide applications to maximize photosynthetic efficiency of the plant to meet the growing food, fuel, and fiber demands. Plant growth stimulation with the strobilurin fungicides has been related to a reduction in the incidence of disease as well as increased nitrate uptake and assimilation in small grains (Köhle et al., 2002). Research has shown that pyraclostrobin (Headline®) was important in stimulating nitric oxide, a key messenger in plants (Conrath et al., 2004). Increased nitrate uptake and assimilation following an application of a strobilurin fungicide would justify additional nitrogen fertilizer at the time of application to corn. Identifying fertilizer sources that synergistically increase yield with a fungicide treatment would provide opportunities to manage disease, reduce application costs, and provide additional fertilizer when crop demand is greatest.

Chlorophyll meters have been used to diagnose N deficiency and provide recommendations for N rates and yield responses (Scharf et al., 2006). Relative chlorophyll meter readings were the best predictor of yield response to N applications and required a high N reference, but absolute chlorophyll meter values were good predictors of grain yield from V10-R1. Farmers planning a fungicide application could utilize a chlorophyll meter as a decision aid to determine if an enhanced efficiency liquid N fertilizer should be combined with the fungicide.

In 2008, 2009, and 2010, N loss limited grain production in several production fields in upstate Missouri. Research in 2004 and 2005 evaluated rescue N applications for corn (Nelson et al., 2011). Late applications were beneficial for restoring yield; however, liquid N applications reduced yield when broadcast applied at 150 lbs N/acre from 2 to 4 ft tall corn. Over the past two years, commercially available liquid fertilizers were evaluated for corn grain yield response when applied at VT in the presence and absence of Headline (Nelson et al., 2009). Products were identified that consistently increased corn grain yield. Nitamin (30-0-0), slowly available N from triazone and methylene urea, at 1 gallon/acre increased yields 28 bu/acre at four of the six site years. When Nitamin was combined with pyraclostrobin at 6 oz/a, there were inconsistent yield responses. Other research evaluated rates of Nitamin up to 4 gallon/acre with and without Headline in 2008 and 2009 (Figure 1) (Nelson and Meinhardt, 2009). Combinations with Headline at 6 oz/acre were similar to this research; however, a reduced rate of Headline (3 oz/acre) with Nitamin at 1 gal/acre synergistically increased yield 26 bu/acre particularly when Headline was added to the spray mixture first followed by Nitamin. A rate response to Nitamin alone increased yield 2 bu/lb of applied N. Research is needed to confirm the effect of reduced rates of Nitamin and Headline as well as the efficiency of this N source for late applications in corn. If grain yield response and recommended rates could be related to SPAD leaf readings at the time of application, this would be a great tool to help farmers and custom applicators make informed decisions on what products to recommend at a VT application timing.

The objectives of this research were to:

1. Validate the effect of mixing order of an enhanced efficiency liquid N rates with a preventative fungicide, and
2. Provide foliar liquid fertilizer recommendations based on SPAD readings at VT.

<u>Procedures:</u>

Field research was established at the Greenley Research Center near Novelty and Hundley-Whaley Center near Albany. Corn followed soybean and conventional tillage was used at both sites. Plots were 10 by 50 ft and arranged in a randomized complete block design with six replications at each site. This study was arranged as a three-factor factorial including soil applied ammonium nitrate at three rates (75, 150, and 300 lbs N/a), three enhanced efficiency liquid N rates (Nitamin at 0, 1, and 3 gal/acre), and four pyraclostrobin (Headline) treatments (non-treated control, Headline applied at 3 oz/acre plus nonionic surfactant added first or following the addition of Nitamin, and Headline at 6 oz/a added first followed by nonionic surfactant and Nitamin). Foliar treatments were applied on 12 July and 13 July at Novelty and Albany, respectively, when corn was at the VT stage of development (Ritchie et al., 1993). Foliar fertilizer and fungicide treatments were applied with a CO_2 propelled hand boom at 3 gal/acre. Field and management information is reported in Table 1. Supplemental irrigation was scheduled using the Woodruff chart to ensure optimal growing conditions.

Corn injury from 0 (no visual crop injury) to 100% (complete crop death) was evaluated 7 and 14 days after treatment (DAT) based on the combined visual effects of foliar treatments on necrosis, chlorosis, and stunting. The severity of common rust (*Puccinia sorghi*), northern corn leaf blight (*Exserohilum turcicum*), and grey leaf spot (*Cercospora zeae-maydis*) was rated on a scale of 0 (no disease) to 100% (complete infestation) 0, 28, and 42 DAT. A Minolta chlorophyll meter (SPAD-502, Konica Minolta, Hong Kong) was used determine absolute ear leaf greenness differences among treatments at the time of application and 28 DAT in order to help determine if an enhanced efficiency liquid N fertilizer would be beneficial in the presence or absence of a fungicide treatment, and determine if an enhanced efficiency fertilizer rate could be recommended based on leaf greenness. The center two rows were harvested for yield and converted to 15% moisture prior to analysis. All data were subjected to ANOVA and means separated using Fisher's protected LSD at $P = 0.05$ or 0.1. Data were combined over factors and locations when appropriate as indicated by the analysis of variance (data not presented).

<u>Results:</u>

Corn plant population at harvest was approximately 27,000/acre at both locations (data not presented). Rainfall at both locations was extensive in 2010. Ammonium nitrate was soil applied approximately 1 month after planting to increase efficiency of this factor (Table 1). However, conditions throughout the season were favorable for extensive N loss. The severity of disease was less than 1% at VT. Chlorophyll meter readings indicated differences among soil applied N rates as expected at the time of the foliar VT applications (Table 2, Figure 1). The Albany site was greener than Novelty indicating less N loss at Albany (Table 2). We expected the 300 lb N/acre rate would be in the low response range to additional N (Scharf et al., 2006), and N would not have been limiting. Based upon previous research from V10 to R1 (Scharf et al., 2006), absolute chlorophyll meter readings at VT indicated that an addition of 130 to 180 lbs N/acre, 100 to 130 lbs N/acre, and 45 to 90 lbs N/acre was recommended for the soil applied rates of 75 lbs N/acre, 150 lbs N/acre, and 300 lbs N/acre, respectively. The Nitamin rates evaluated in this research were applied at 3.1 and 9.3 lbs N/acre for the 1 and 3 gal/acre rates, respectively.

Absolute chlorophyll meter readings at VT generally remain similar or decrease slightly over time in the absence of additional N (Scharf et al., 2006). Chlorophyll meter values 28 DAT indicated an increase in greenness with Nitamin at 3 gal/acre compared to the readings 0 DAT in some instances, while limited differences between the 0 and 28 DAT readings were observed when Nitamin was applied at 0 or 1 gal/acre (Figure 1). Based on the chlorophyll meter values, we expected yield differences for the 3 gal/acre rate of Nitamin; however, this was not the case (Figure 2).

The low rates of soil applied N (75 and 150 lbs N/acre) were not responsive to Nitamin at 1 or 3 gal/acre in 2010. It appears that corn with chlorophyll meter readings less than 45 (Figure 1) should not use a 1 to 3 gal/acre rate of Nitamin or fungicide treatment because N was yield limiting and an insufficient level of N was supplied to the crop. This could explain why some fungicide and foliar fertilizer research was non-responsive under some conditions. Nitamin at 1 gal/acre increased grain yield 11 bu/acre following the 300 lb/acre soil applied N treatment when data were averaged over Headline treatments. Further analysis of soil applied N at 300 lbs/acre indicated Headline at 6 oz/acre plus Nitamin at 1 gal/acre increased yield 21 bu/acre compared to Headline at 3 oz/acre plus Nitamin at 1 gal/acre (Figure 3). This research indicated no significant effect of mixing order on corn response when Nitamin was applied at 1 gal/acre and Headline at 3 oz/acre. In previous research (Nelson et al., 2009), there was a lower overall severity of disease and grain yield potential was higher when a synergistic increase in grain yield was observed with Headline at 3 oz/acre plus Nitamin at 1 gal/acre, which indicated a possible physiological response to this combination.

Rescue N applications of liquid UAN that were broadcast applied at 150 lbs N/acre caused extensive injury to corn reduced yield and should not be recommended (Nelson et al., 2011). However, crop injury due to Nitamin at 1 or 3 gal/acre was 1% or less 7 and 14 DAT (data not presented). Therefore, crop response differences in 2010 were probably related to the higher severity of disease observed during this year and N fertility. Soil and foliar applied N affected the severity of foliar disease. The severity of grey leaf spot and northern corn leaf blight increased as soil applied N increased at Novelty, but no differences were observed at Albany (Table 3). An interaction between soil applied N rates and Nitamin rates at Albany and Novelty indicated a slight increase in the severity of common rust at Novelty as the soil and foliar N rates increased. However, the severity of common rust was greater at low soil applied N rates and a high rate (3 gal/a) of Nitamin. Similarly, the severity of grey leaf spot and northern corn leaf blight increased as the Nitamin rate increased at Novelty and Albany (Table 4). These differences were probably due to improved growth and increased greenness with Nitamin at 3 gal/acre (Figure 1).

Headline at 6 oz/acre reduced the severity of grey leaf spot at Novelty, while no differences among fungicide treatments were observed for grey leaf spot at Albany or northern corn leaf blight at Novelty or Albany (Table 5). An interaction between Headline treatments, Nitamin rates, and locations was observed for the severity of common rust (Table 6). In general, the severity of common rust was greater as the Nitamin rate increased. Headline at 6 oz/acre reduced the severity of common rust at the 3 gal/acre rate of Nitamin compared to the non-treated control.

In summary, Nitamin at 1 gal/acre increased grain yields 11 bu/acre when chlorophyll meter readings at VT were greater than 45. Headline at 6 oz/acre plus Nitamin at 1 gal/acre increased grain yields 21 bu/acre compared to Headline at 3 oz/acre plus Nitamin, but this treatment was similar to Nitamin applied alone. Decisions to apply Nitamin alone, Headline alone, or a combination of Headline and Nitamin may need to be based on the yield potential of the corn crop using an absolute chlorophyll meter reading near VT which can help identify sites that are non-responsive and aid in better understanding sites that are responsive to foliar fertilizer and/or fungicide applications. In 2010, the severity of disease was affected by N fertility and was affected by the rate of a foliar fertilizer especially in a year with a high risk of foliar disease. This research will be repeated in 2011.

Timetable:

Feb., 2011: Assemble products for treatments
April, 2011: Plant research trial and apply response treatments at both locations
July, 2011: Apply foliar fertilizer and fungicide treatments, SPAD readings, rate severity of disease.
Sept.-Dec., 2011: Harvest experiments, analyze results, and submit final report.

References:

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Table 1. Field and management information at Novelty and Albany in 2010.

Management information	Novelty	Albany
Previous crop	Soybean	Soybean
Hybrid or cultivar	DK 63-42 VT3	DK 63-42 VT3
Planting date	13 Apr.	26 Apr.
Seeding rate (seeds/acre)	32,000	29,500
Harvest date	30 Sept.	19 Oct.
Maintenance fertilizer	13 Apr., MAP 32-160-300 (N-P-K)	15 Apr., 18-46-80 (N-P-K)
Ammonium nitrate	7 May, Between-row at 75, 150, or 300 lbs N/acre	26 May, Between-row at 75, 150, or 300 lbs N/acre
Weed management		
Burndown	NA	NA
Preemergence	15 Apr., Atrazine (2 qt/acre) + Outlook (21 oz/acre)	27 Apr., Lumax (3.2 qt/acre)
Postemergence	22 June, Roundup PowerMAX (30 oz/acre) + DAS (17 lbs/100 gal)	
Insect management	NA	NA
Disease management	Pyraclostrobin +/- Nitamin	Pyraclostrobin +/- Nitamin
Date & Time	12 July, 1700 to 2100 h	13 July, 1100 to 1600 h
Relative humidity (%)	74	60
Wind speed (MPH, direction)	1-3, E	3-4, S
Height (inches)	72-96	84-108
Leaf moisture	Dry	Dry

†Abbreviations: DAS, diammonium sulfate; MAP, monoammonium phosphate; NA, None applied.

Table 2. Chlorophyll meter readings at Novelty and Albany, and severity of disease for preplant N rates at VT. Data were combined over foliar fertilizer and fungicide treatments.

	Chlorophyll meter		Severity of disease†		
Preplant N rates	Novelty	Albany	Grey leaf spot	Common rust	Northern corn leaf blight
lbs N/acre	--- SPAD units ---		----------------------------- % -----------------------------		
75	32.5	36.6	< 1	0	< 1
150	37.3	44.2	< 1	0	< 1
300	43.2	50.3	< 1	0	< 1
LSD (P = 0.01)	1.4		NS	NS	NS

†Common rust (*Puccinia sorghi*); grey leaf spot (*Cercospora zeae-maydis*); northern corn leaf blight (*Exserohilum turcicum*).

Table 3. Severity of grey leaf spot and Northern corn leaf blight 42 d after treatment as affected by preplant N and location, and severity of common rust as affected by preplant N, location, and Nitamin rate.

					Common rust					
	Grey leaf spot		Northern corn leaf blight		Novelty			Albany		
Preplant N	Novelty	Albany	Novelty	Albany	0 gal/a	1 gal/a	3 gal/a	0 gal/a	1 gal/a	3 gal/a
(lbs N/acre)										
75	3	1	0	1	1	1	1	2	3	7
150	5	1	1	1	1	1	2	2	2	4
300	7	1	1	1	2	2	2	2	2	2
LSD (P = 0.1)	----- 1 -----		---------- 1 ----------		------------------------ 1 ------------------------					

Table 4. Severity of grey leaf spot and northern corn leaf blight 42 d after treatment as affected by Nitamin application rate. Data were averaged over location, fungicide treatment, and soil applied N rates.

Nitamin rate	Grey leaf spot	Northern corn leaf blight
(gal/acre)	--------------------------- Severity of disease (%)	----------------------------
0	2.7	0.6
1	2.6	0.8
3	3.3	1.1
LSD (P = 0.1)	0.3	0.2

Table 5. Effect of pyraclostrobin (Headline) treatment and location on the severity of grey leaf spot and northern corn leaf blight.

	Grey leaf spot		Northern corn leaf blight	
Fungicide treatment	Novelty	Albany	Novelty	Albany
	------------- Severity of disease (%) -------------			
Non-treated	6	1	1	1
Headline at 3 oz/acre + NIS fb Nitamin	5	1	1	1
Nitamin fb Headline at 3 oz/a + NIS	5	1	1	1
Headline at 6 oz/acre + NIS fb Nitamin	4	1	1	1
LSD (P = 0.1)	----- 1 -----		--------- NS --------	

†Mixing order for fungicide treatments.
‡Abbreviations: fb, followed by; NIS, non-ionic surfactant.

Table 6. Severity of common rust at Novelty and Albany as affected by Nitamin rate and pyraclostrobin (Headline) treatment.

	Novelty			Albany		
Fungicide treatment	0 gal/acre	1 gal/acre	3 gal/acre	0 gal/acre	1 gal/acre	3 gal/acre
	------------------- % -------------------					
Non-treated	2	2	2	3	3	7
Headline at 3 oz/acre + NIS fb Nitamin	1	1	2	2	2	4
Nitamin fb Headline at 3 oz/a + NIS	1	1	2	2	2	4
Headline at 6 oz/acre + NIS fb Nitamin	1	1	2	2	2	3
LSD (P = 0.1)	------------------- 1 -------------------					

†Mixing order for fungicide treatments.
‡Abbreviations: fb, followed by; NIS, non-ionic surfactant.

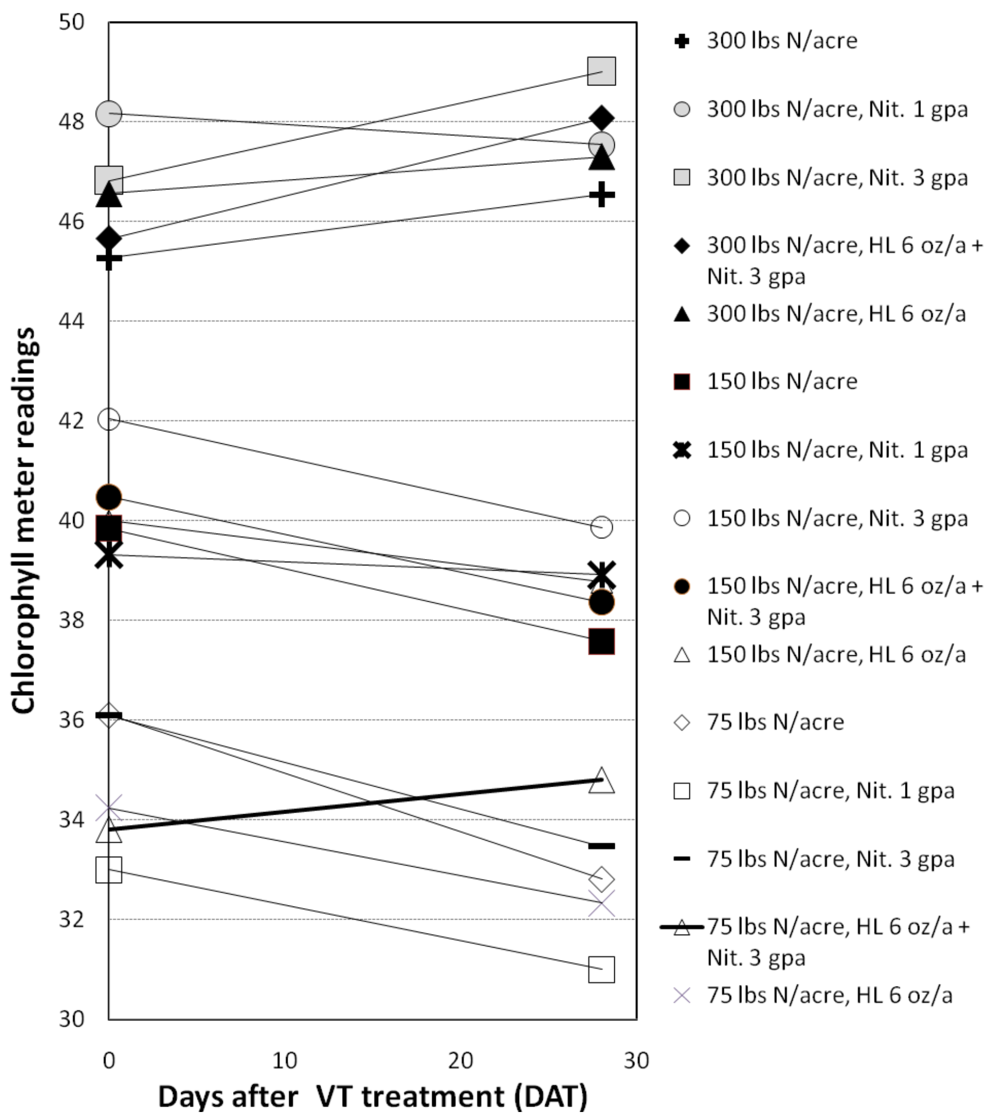

Figure 1. Chlorophyll meter readings at the time of application (VT) and 28 days after treatment (DAT) for selected soil applied N treatments (75, 150, or 300 lbs N/acre), Nitamin (Nit.) rates (0, 1 or 3 gallons per acre = gpa), and pyraclostrobin (Headline = HL) at 6 oz/acre. Data were combined over Novelty and Albany locations.

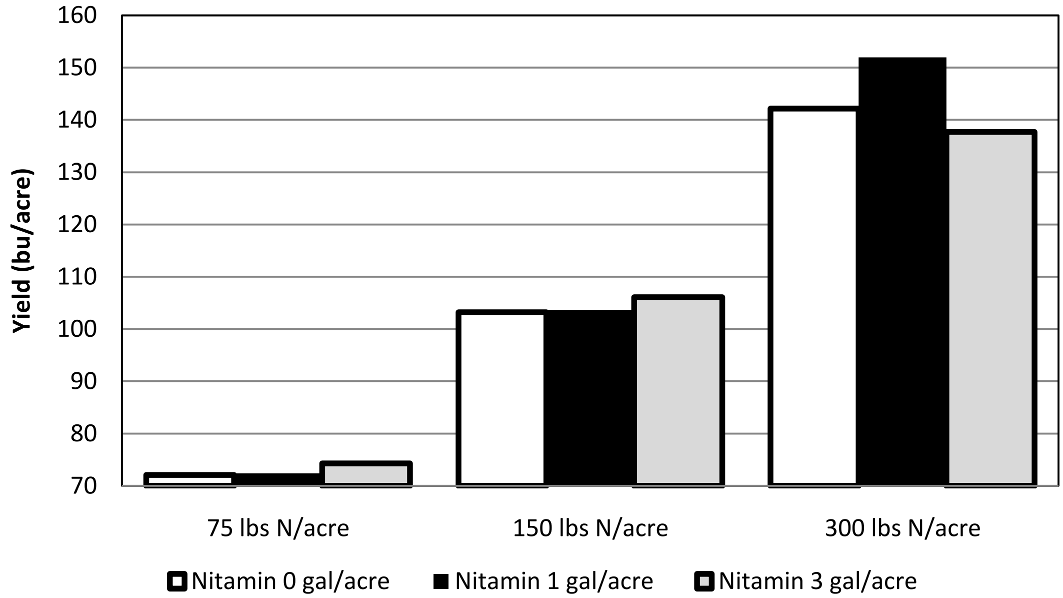

Figure 2. Corn grain yield as affected by soil applied N (75, 150, and 300 lbs N/acre) and foliar Nitamin rate (0, 1, and 3 gal/acre) at VT. LSD (P = 0.05) was 10 bu/acre. Data were combined over locations and pyraclostrobin treatments.

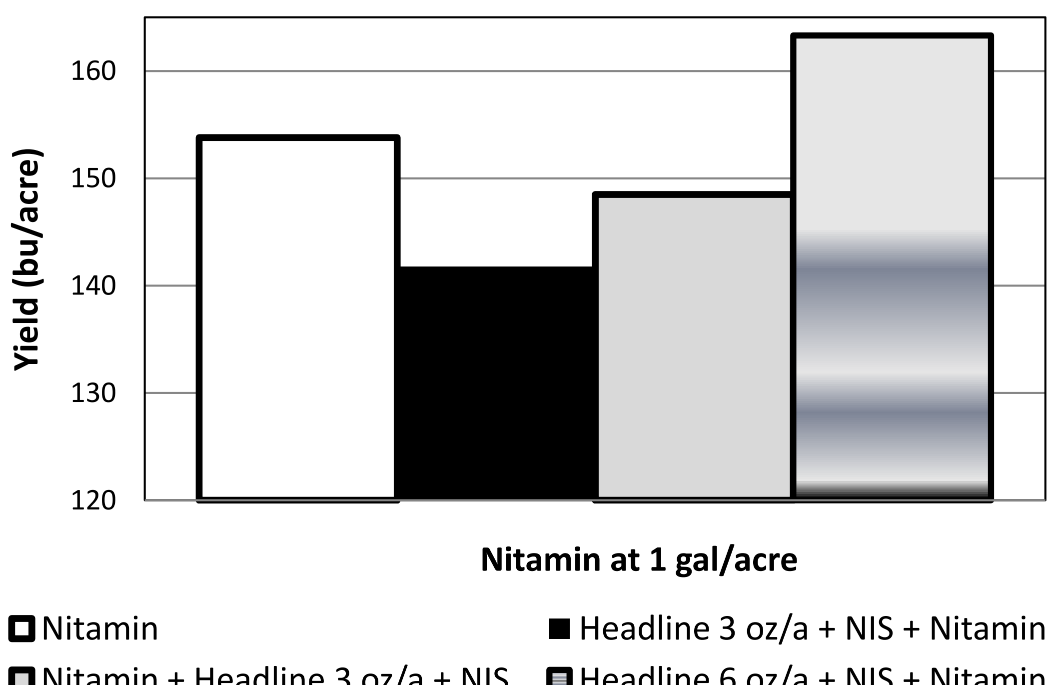

Figure 3. Corn grain yield as affected by Nitamin at 1 gal/acre applied alone and with pyraclostrobin (Headline) fungicide rates. LSD (P = 0.1) was 15 bu/acre. The order listed in the legend was the spray mixing order.

Budget:

CATEGORIES	Year 2011	Total*
A. Salaries Technical assistance or graduate research assistant (50%)	$14,382	$28,205
B. Fringe Benefits Fringe for graduate student	$1,995	$3,985
TOTAL SALARIES AND FRINGE BENEFITS	$16,377	$32,190
C. Travel Travel to field site To present research findings at National Meetings	 $500 $800	 $1000 $800
TOTAL TRAVEL COSTS	$1300	$1800
D. Equipment	$0	$0
TOTAL EQUIPMENT use and maintenance COSTS	$1200	$2400
E. Other Direct Costs Soil analysis Field supplies Publication cost Off-site PI	 $200 $500 $1,000 $5,000	 $400 $1000 $1000 $10,000
TOTAL OTHER DIRECT COSTS	$6,700	$12,400
TOTAL REQUEST	**$25,577**	**$48,790**

*Included the 2010 (Year 1) budget.

Budget narrative:
Salaries and fringe benefit funds are requested for partial support of a research technical support and/or graduate research assistant.

Presentations, publications, and documentation will help defray cost of publication and documentation of results and conclusions as well as assist travel and board for presentation of results.

Equipment use and maintenance will help defray machinery use and maintenance costs associated with field research.

Other Direct Costs: Covers cost of analysis, sample containers, fertilizer, seed, plot preparation, planting, weed control harvesting, flags, and other field supplies and operations.