Evaluating Fall N Applications for Corn: 2004 Report

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Objectives:

The objective of this study is to evaluate fall N applications in production cornfields over several weather years. This includes:

a. Tracking how much fall-applied N is lost from production cornfields.
b. Determining how much yield potential is lost.
c. Determining the economics of additional spring N applications.

Accomplishments for 2004:

- Seventeen experiments were established in production cornfields that had received N applications in fall/winter 2003 (Figure 1 and Table 1). Most of these experiments were in west-central Missouri, near the Missouri River, and in the claypan region of northeast Missouri. Fall 2003 applications of NH_3 in Missouri were down from the previous two years, but were still higher than any year before 2001 (Figure 2), and these regions were among the highest in the state. Two experiments were established in Vernon County because it is a higher-risk area for loss of fall-applied N, though less fall N is applied in that area. NH_3 was applied after November 1 in all experimental fields (Table 2). Eight of the seventeen fields had N-Serve added to the NH_3 (Table 2).

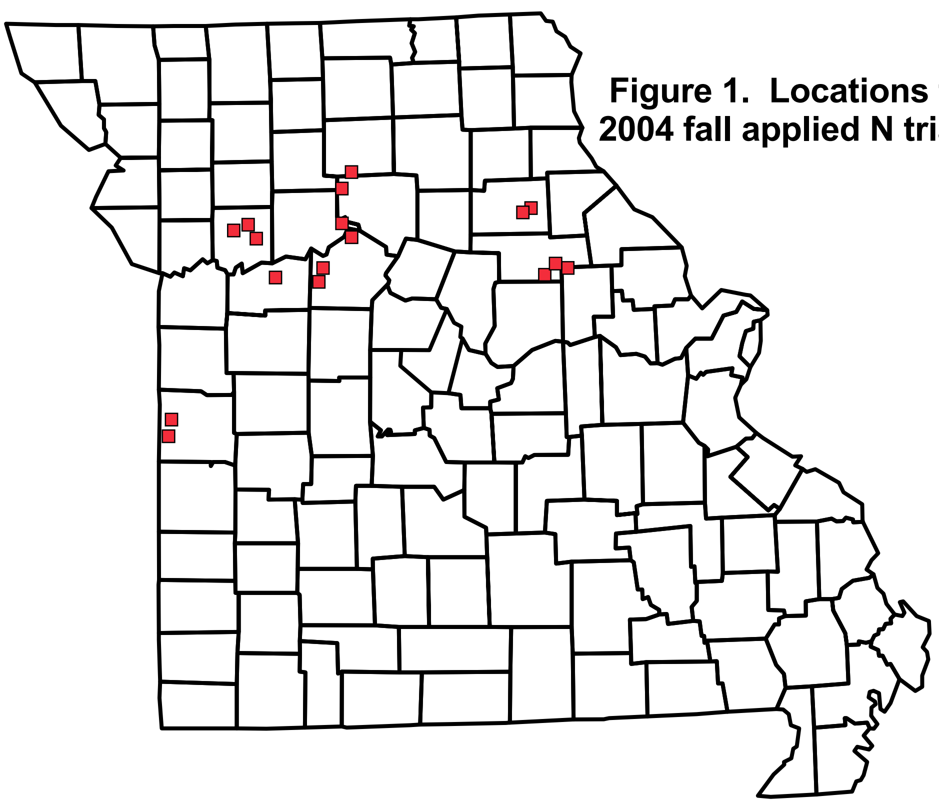

Figure 1. Locations for 2004 fall applied N trials.

Table 1. 2004 LOCATIONS FOR FALL APPLIED NITROGEN TRIALS.

COUNTY	LOCATION	SOIL SERIES	HYBRID
Vernon	Deerfield	Barden Silt Loam	Pioneer 34P14
Vernon	Hong	Parsons Silt Loam	NC+5411P
Linn	Brookfield	Lagonda Silt Loam	?RR
Chariton	Minden	Grundy Silt Loam	Asgrow RX 752 YG
Carroll	DeWitt	Gilliam Silty Clay	Dekalb DKC 63-50
Saline	Miami	Leslie Silt Loam	Mycogen 2A775
Saline	Elmwood	Higginsville Silt Loam	Asgrow RX 752 RR YG
Saline	Blackburn	Sibley Silt Loam	Asgrow RX 752 RR YG
Lafayette	Higginsville	Marshall Silt Loam	Pioneer 32A85 [A]
Ray	Dockery	Grundy Silt Loam	Stone E33D
Ray	Morton 1	Sibley Silt Loam	Pioneer 33P67 [B]
Ray	Morton 2	Sibley Silt Loam	NC+4880
Monroe	Paris 1	Putnam Silt Loam	Golden Harvest 9461
Monroe	Paris 2	Putnam Silt Loam	Golden Harvest 9229
Audrain [C]	Martinsburg 1	Putnam Silt Loam	Na
Audrain	Martinsburg 2	Putnam Silt Loam	Na
Audrain	Martinsburg 3	Mexico Silt Loam	Na

[A] White corn
[B] 6 Rows Pioneer 33P67 & 2 rows Pioneer 33D31
[C] Irrigated Site

Table 2. Fall N applications and spring N samples for 2004 experiments

COUNTY	LOCATION	NITROGEN APPLIED			N SERVE	SOIL SAMPLE DATE	NH_4 AMMONIUM 0-36" LBS/AC	NO_3 NITRATE 0-36" LBS/AC	TOTAL N 0-36' LBS/AC
		SOURCE [A]	N RATE LBS/AC	DATE [B]					
Vernon	Deerfield	NH_3	150	12/5/2003	YES	2/26/2004	54	90	144
		w/starter	27	Planting	-	6/1/2004	26	219	245
Vernon	Hong	NH_3	102	11/15/03	YES	2/26/2004	43	118	161
		DAP	24	Na	-	6/1/2004	18	211	229
Linn	Brookfield	NH_3	185	11/15/2003	YES	3/19/2004	103	82	185
		-	-	-	-	6/8/2004	35	259	294
Charition	Minden	NH_3	185	11/15/2003	YES	3/18//2004	44	95	139
		-	-	-	-	6/8/2004	8	210	218
Carroll	DeWitt	NH_3	200	11/15/2003	YES	3/19/2004	26	95	121
		UAN/UAN	40/100	PP/SD	-	6/4/2004	95	400	495
Saline	Miami	NH_3	185	12/05/2003	YES	3/18/2004	46	74	120
		w/starter	26	Planting	-	6/4/2004	59	268	327
Saline	Elmwood	NH_3	180	11/15/2003	NO	3/18/2004	35	71	106
		w/herbicide	20	Spring	-	6/4/2004	15	186	201
Saline	Blackburn	NH_3	180	11/30/2003	NO	3/18/2004	78	72	150
		w/herbicide	20	Spring	-	6/4/2004	20	344	364
Lafayette	Higginsville	NH_3	160	11/10/2003	YES	3/126/2004	60	80	140
		UREA	20	Fall	-	6/1/2004	33	225	2
Ray	Dockery	NH_3	135	11/15/2003	NO	3/11/2004	86	85	171
		AN/Starter	10/10	Fall/Planting	-	6/2/2004	15	259	274
Ray	Morton1	NH_3	165	11/03/2003	NO	3/11/2004	50	57	107
		DAP	30	Fall	-	6/2/2004	11	132	143
Ray	Morton 2	NH_3	195	11/5/2003	NO	3/11/2004	61	124	185
		DAP	23	Na	-	6/2/2004	5	113	118
Monroe	Paris 1	NH_3	135	11/30/2003	NO	3/21/2004	64	91	155
		AN	13	Na	-	6/8/2004	4	195	199
Monroe	Paris 2	NH_3	135	11/30/2004	NO	3/21/2004	141	126	266
		AN	17	Na	-	6/8/2004	11	268	279
Audrain	Martinsburg 1 [C]	NH_3	180	11/5/2003	YES	3/19/2004	19	173	192
		DAP/Urea	25/40	Fall/SD	-	6/16/2004	13	262	275
Audrain	Martinsburg 2	NH_3	150	11/5/2003	NO	3/21/2004	90	164	254
		DAP/Urea	30/40	Fall/SD		6/16/20045	11	185	196
Audrain	Martinsburg 3	NH_3	160	11/5/2003	NO	3/19/2004	54	90	144
		DAP/NH_3	36/50	Fall/SD	-	6/16/2004	55	217	272

[A] NH_3 - Annhydrous Ammonia, AN - Ammonium Nitrate, UAN-Liquid N
[B] When application dates were given as ranges the midpoint was used, PP-Preplant, SD-Side Dressed
[C] Irrigated Site

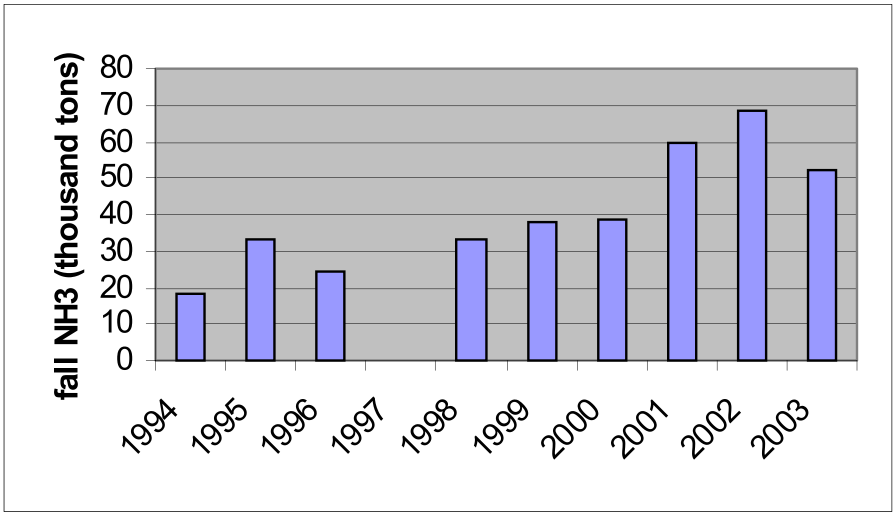

Figure 2. More fall N was applied in Missouri during each of the three years of this study than during any of the seven previous years. Increasing farm size has pressured corn producers to apply N in the fall, leaving more spring work days available for planting and other spring operations.

Results:

Soil sample results

Soil samples were taken in all experiments to a three foot depth in February or March and again in June. These samples were analyzed for nitrate and ammonium (Table 2).

- Many fields had results in March that seemed to show a moderate level of N loss between application and the March sampling. However, the values for many fields went up dramatically for the samples taken in June. We normally expect soil organic matter to release N during the March to June period, but not as much as was observed at many of these locations. Four of the producers applied sidedress N to these fields, which is responsible for the increased soil N levels in those fields, but still some of the values for June seem too high to be true. Thus we are cautious about trusting the numbers reported in Table 2 too much until they have been double-checked. We have stored these soil samples in the freezer, and several months ago submitted some of them again to see whether the results come back the same, but are still waiting on those results.
- Precipitation for northern Missouri was near normal for November to March, and much higher than the previous two winters. Little loss of fertilizer N was seen in the previous two years of the study, but with the added precipitation it seems possible that some N may have been lost during the winter, as indicated by the results from the samples taken in March.
- More than half of the N found in the March samples was in the nitrate form for 13 of the 17 fields studied. This indicates that most of the fall-applied ammonia had been converted to nitrate by this time, which is the form of N most susceptible to loss.
- The amount of N in the nitrate form was related to the date of N application (Figure 3). Producers applied N between November 1 and December 5. On average, for N applied around November 1, 70% had been converted to the nitrate form by March, but only 50% had been converted for applications in early December (based on line in Figure 3).

- N-Serve did not statistically affect the amount of N found in the nitrate form in March, but fields with N-Serve had an average of 46% of N as nitrate, while fields without had an average of 58% of N as nitrate.
- N-Serve did statistically affect the amount of N found in the nitrate form in June: fields with N-Serve had an average of 90% of N as nitrate, while fields without N-Serve had an average of 95% of the N as nitrate. This is a small difference that does not make much difference from a practical standpoint, but it suggests that the slightly larger difference seen in March is also real.
- Apparent N loss in March was statistically higher for fields with more N in the nitrate form, and for fields that received higher N rates.
- Apparent N loss in March was statistically higher for fields in the deep loess and loess and drift soil regions, and lower for fields in the claypan and southwest/Osage plain regions. This is probably related to the slow permeability and low leaching potential of soils in the claypan and Osage plain regions.

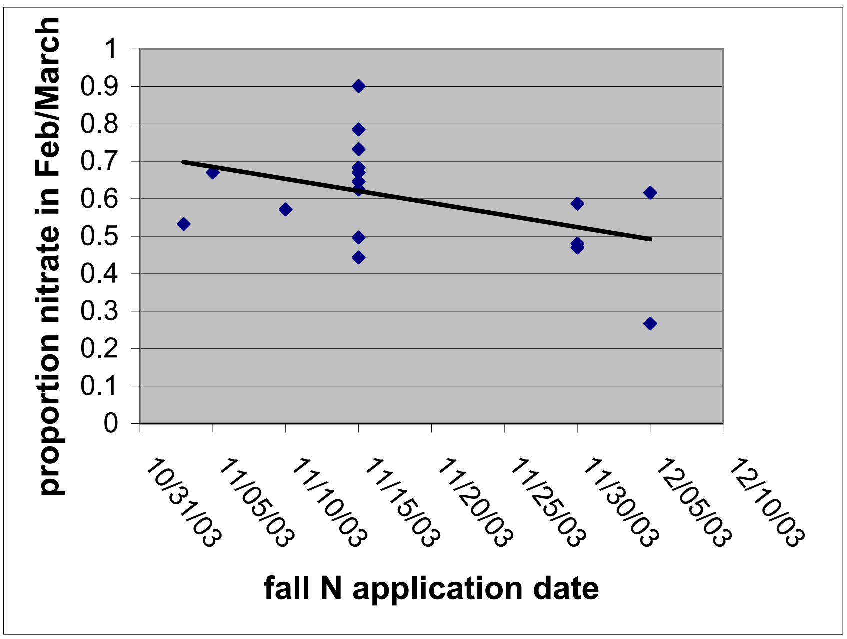

Figure 3. The proportion of anhydrous ammonia that had converted to nitrate by the time of our February/March soil samples was lower for later-applied N. A lower proportion of nitrate means less risk of loss.

<u>Yield response to supplemental spring N</u>

Average yield for these 17 experiments was 214 bu/acre. Yield levels were the highest ever seen for corn in Missouri. Frequent rain and relatively cool night temperatures created ideal conditions for corn growth.

When fall-applied N is lost, N availability can limit yields. In this case, there is potential for yield response to supplemental spring N. We applied either 0, 50, or 100 lb N/acre to small plots in the experimental fields when the corn was 12 to 18 inches tall. In each field, six plots received no spring N, six received the 50 lb N/acre rate, and three received the 100 lb N/acre rate. Also, three additional plots received zinc fertilizer to test for the possibility of yield response to zinc. These small-plot experiments were hand-harvested before the cooperating producers harvested the surrounding field.

In four of the fields, producers sidedressed N due to concerns that N might have been lost. In these fields, N availability would not be expected to limit yield, and these fields were omitted when calculating average yield response to our N additions.

Average yield response

- On average, there was a 8 bu/acre yield response to additional spring-applied N (with 99% confidence). This suggests that some of the fall-applied N may have been lost, as was also suggested by the February/March soil samples.
  - The cost of applying 50 lb of N is about the same as the cost of 8 bu of corn, so sidedressing 50 lb on the 15 fields that were not sidedressed by the cooperating producers would have been about a break-even proposition.
  - The 8 bu/acre of lost yield potential can be used in making economic comparisons to spring N management options, many of which would not have resulted in this loss of yield potential. This year, the average cost of the convenience of fall N application was 8 bu/acre.

Statistics of yield response for individual fields

- Statistical analysis indicated that there were five locations with a high (> 80%) probability that yield responded to additional N (Table 3).
  - At three of these five locations, yield response to both the 50 and 100 lb N rates was statistically significant.
  - At the other two locations, only the yield response to the 100 lb N rate was statistically significant, but the yield with the 50 lb N rate was intermediate, and regression analysis was statistically significant, indicating a true yield response for both the 50 and 100 lb N rates.
  - Many other locations had higher average yields with additional N than without, but statistical confidence that these were real was below 80%.

Yield response to additional N was related to check yield with no additional N.

- For fields with yields above 220 bu/acre without additional N, no response to the N that we applied was seen.
- For fields with yields less than 220 bu/acre in our check plots, average yield response to additional N was 10 bu/acre, bringing average yield in these fields to 218 bu/acre.
- I find it more helpful to think of it this way: many fields had 220 bu yield potential in this exceptional year, but some fields fell a little short of achieving this potential due to slight N limitations, which we could overcome by adding more N to get them to the 220 bu level.

Yield response to additional N was highest in fields where N was applied earliest

- The two largest yield responses to additional N were seen on the two fields that had received the earliest N applications in the fall out of the 17 fields (Figure 4).
- Applications in these two fields were made on November 3 and November 5, 2003.
- These two fields were only slightly above average in fertilizer conversion to nitrate by March (Figure 3), however they were sampled about a week before most other fields. Additional conversion to nitrate would have occurred during that week.

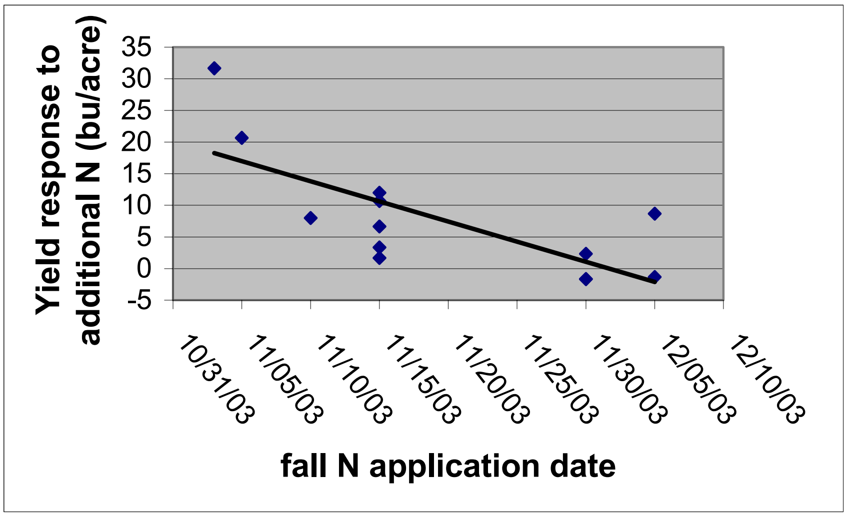

Figure 4. Yield response to additional N was greatest in the two fields which had received the earliest fall N applications. Anhydrous ammonia was applied the first week of November in these two fields. The last fields had N applied in the first week of December.

Low soil nitrate in June predicted yield response to additional N

- Soil nitrate to a 12 inch depth, sampled in June, was the best predictor of yield response to N among the soil N measurements that we made (Figure 5). This was mainly due to two fields which had the lowest soil nitrate values and also had the largest yield responses to additional N. Both fields were on well-drained soils in Ray County, and had received fall N earlier than any other fields.
- Heavy May-June rains, especially in northwest Missouri, may have contributed to the low soil nitrate levels seen in the top foot of soil in these fields (Figure 6).

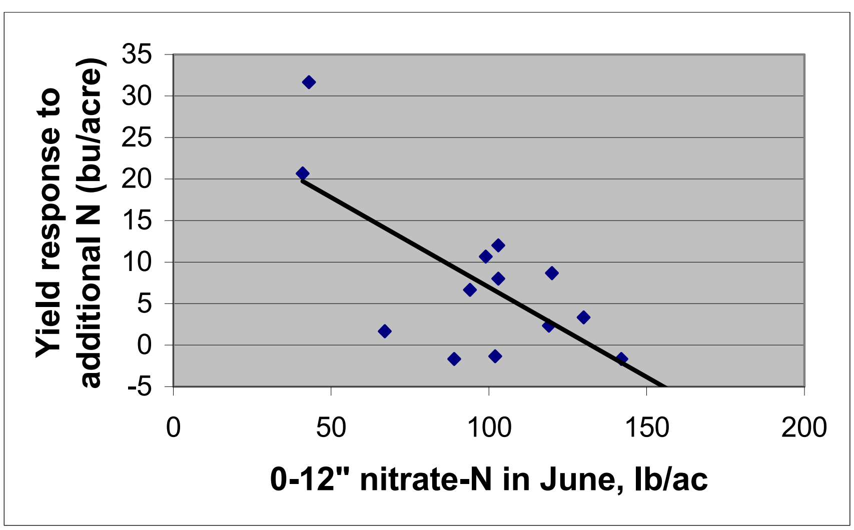

Figure 5. Among all soil N measurements that we made, soil nitrate to a 12" depth in June was the best predictor of yield response to N. This was because the two fields that got the earliest N applications (Figure 4) had the lowest nitrate levels by June, and the largest yield response to additional N.

Geographical location was related to yield response to additional N

- Fields with apparent yield response to N of 5 bu/acre or more were mainly concentrated in western Missouri (Figure 6), especially northwestern Missouri. This is probably related to rainfall patterns, which were heavier in northwestern Missouri in May and in southwestern Missouri in March.
- Areas with heavier rainfall probably had greater leaching losses of nitrate-N.
- Numerous fields with patches or streaks of N deficiency were seen in northwest Missouri in 2004 in an aerial survey (Figure 7).

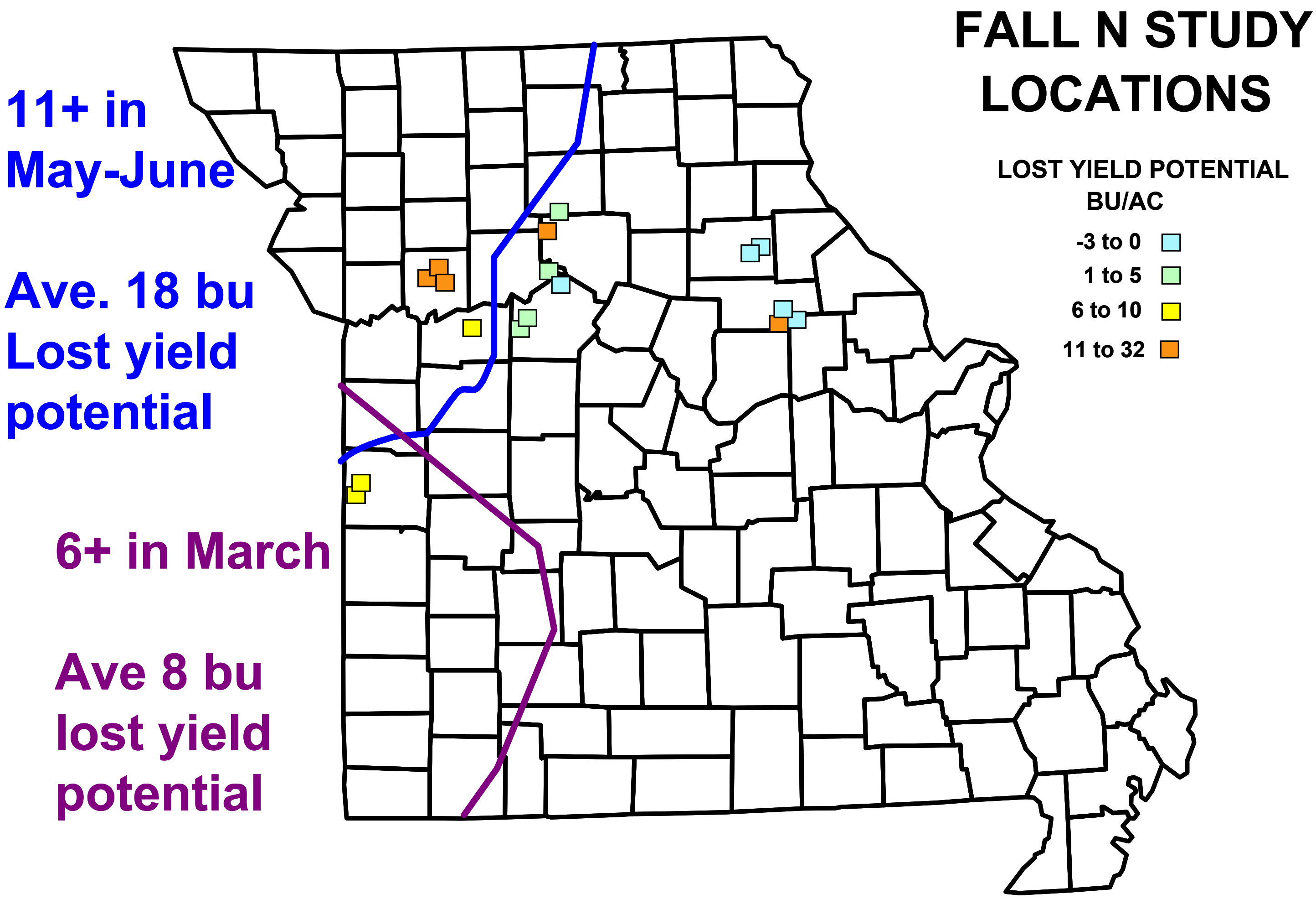

Figure 6. Spring precipitation was heaviest in western Missouri, and the largest yield responses to our N applications were also seen there. Northwest of the blue line, more than 11 inches of rain fell during May and June, mainly in May. This was also the geographical area where the largest yield response to additional N was seen, with an average of 18 bu/acre. The two fields south of Kansas City lost an average of 8 bu/acre of yield potential, likely due to heavy rains in this area in March.

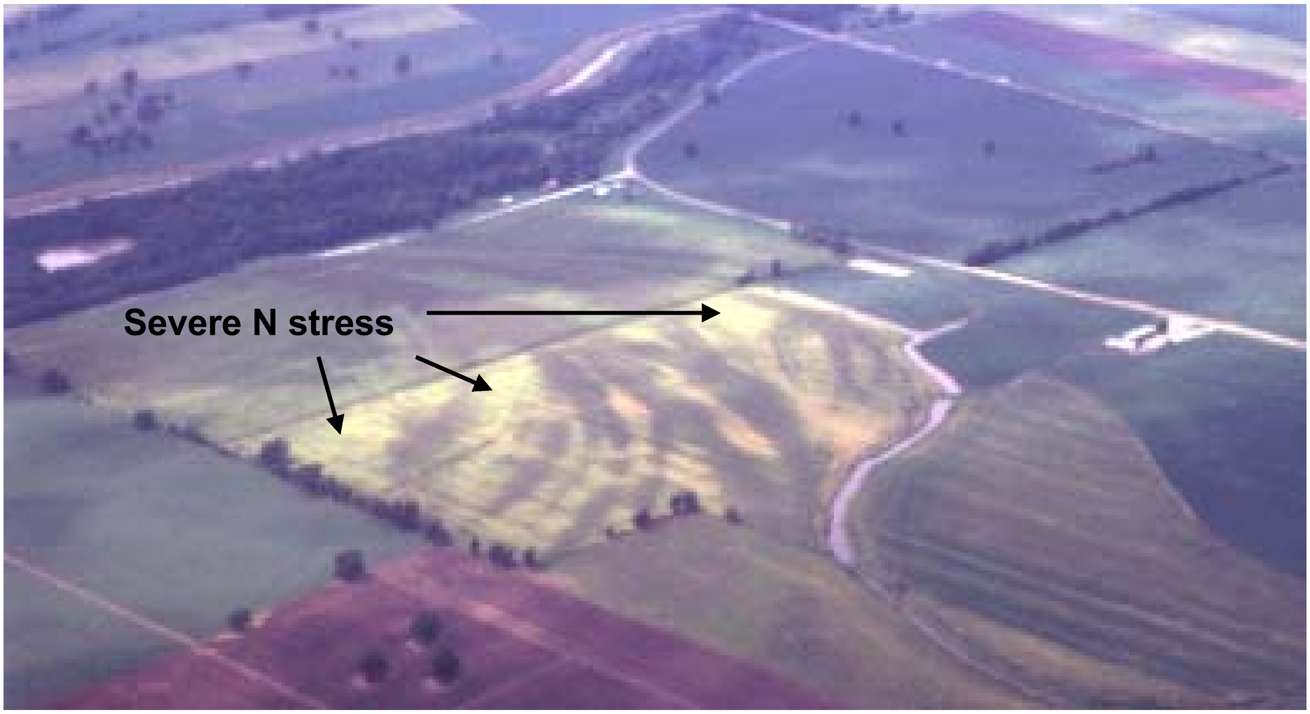

Figure 7. Aerial surveys revealed substantial N stress in northwestern Missouri in mid-August. My estimate was that one out of three corn fields in the area showed enough N stress to correspond to a field-average yield potential loss of 10 bu/acre or more. I would estimate lost yield potential in the field shown here at 30 to 40 bu/acre.

Yield response to additional N was greatest in the fields with the best soil drainage

- Yield response to additional N was statistically related to soil drainage class for the fields in this study, as shown in the table below.
- Nitrogen losses were probably mainly due to leaching of the nitrate form of N. Water moves more easily downward in well-drained soils, taking nitrate with it. In my experience, poorly-drained soils are most susceptible to N losses when they are wet in June, when a combination of warm and wet conditions can lead to high nitrate losses through the denitrification process.

Soil drainage class	# of fields	Average yield response to additional N (bu/acre)
Well-drained	4	16
Moderately well-drained	1	9
Somewhat poorly drained	8	6
Poorly drained	4	0

Table 3. Yields From 2004 Fall Applied Nitrogen Trials.

COUNTY	LOCATION	YIELD WITH FERTILIZER TREATMENT:			
		CHECK	+ 50 N	+ 100 N	ZN
Vernon	Deerfield	208	216 *	218 *	210
Vernon	Hong	191	194	205 §	180
Ray	Dockery	212	221	226	223
Ray	Morton 1	198	226 **	237 **	219 †
Ray	Morton 2	202	221 **	226 **	204
Lafayette	Higginsville	219	227	227	220
Saline	Elmwood	220	223	219	226
Saline	Blackburn	221	226	218	223
Saline	Miami	218	215	220	211
Carroll	DeWitt SD	246	246	253	254
Chariton	Minden	198	206	218 †	183
Linn	Brookfield	211	216	211	221 §
Monroe	Paris 1	249	246	250	242
Monroe	Paris 2	217	218	210	218
Audrain	Martinsburg 1 SD, Irr	242	241	235	235
Audrain	Martinsburg 2 SD	216	226	228	220
Audrain	Martinsburg 3 SD	172	171	169	180
AVERAGE					

** This yield is statistically different from yield of the check with > 99% confidence.

* This yield is statistically different from yield of the check with 95 to 99% confidence.

† This yield is statistically different from yield of the check with 90 to 95% confidence.

§ This yield is statistically different from yield of the check with 80 to 90% confidence.

Irr Irrigated site

SD This field was sidedressed by the cooperating producer, and omitted from averages.

Yield response to zinc

Zinc treatments were also included in these experiments because of promising results in 2001 in another set of experiments. There were two of these 17 fields with some evidence of yield response to zinc. Over all 17 experiments, average yield response to zinc was 1.7 bu/acre, but this was not statistically different than zero. Averaged over 69 experiments from 2001 to 2004, yield response to zinc was 0.0 bu/acre.

Summary and Conclusions:

- Despite a normal-to-cold winter, fall NH_3 applications had more than half-converted to the nitrate form by March in 13 of the 17 experimental fields.
  - Conversion to nitrate created a situation with risk for N loss.
- Winter precipitation was normal, and there appeared to be moderate loss of fertilizer N by March.
  - In the previous two years, we had seen that much of the fertilizer had converted to nitrate, but that little was lost due to unusually dry winters.
- Wet weather in March and May created the potential for additional loss of N in some areas.
- Average yield response to our additional N applications (in the 13 fields that were not sidedressed by producers) was 8 bu/acre. This represents the average loss of yield potential due to loss of fall N for our 2003-04 experiments. In this year, the convenience of fall N applications was offset by either an average 8 bu/acre yield loss or the need to sidedress additional N to prevent this loss.
- Loss of yield potential was higher in fields with the following conditions:
  - Fields receiving the earliest N applications (first week of November).
  - Fields in western Missouri, which received more rain in March and May than the fields in central and eastern Missouri.
  - Fields with well-drained soils. This suggests that N loss was mainly by leaching in 2004.
  - Fields with the above conditions also had the lowest soil nitrate values when sampled in June, confirming that the response to our additional N treatments was due to loss of fall-applied N.