Corn Nitrogen Tests in Missouri

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Experiments were carried out in farmer fields starting in 1995 with the objective of evaluating or developing field-specific tests to optimize N fertilizer rates for corn. Because some of the soil nitrate tests seem to work differently when manure or alfalfa is in the cropping system, most farms had pairs of experiments, one with an organic N source and the other with none. Descriptions of the experimental locations are given below.

Location	Year	County	Organic N source	Organic N history
1	1995	Callaway	hog lagoon water	>10 years lagoon water
2	1995	Callaway	none	lagoon water in 1989
3	1995	Cooper	none	none
4	1995	Cooper	solid dairy manure	>10 years dairy manure
5	1995	Cooper	none	turkey manure in 1992, alfalfa killed spring 1994
6	1995	Callaway	injected hog slurry	none
7	1995	Callaway	none	none
8	1996	Saline	surface hog slurry	20 years hog slurry
9	1996	Saline	none	none
10	1996	Holt	solid hog manure	none
11	1996	Holt	none	none
12	1996	Holt	alfalfa, plowed	5 years alfalfa
13	1996	Holt	none	none
14	1996	Callaway	none	none
15	1996	Callaway	none	none
16	1996	Callaway	none	none

PROCEDURES

Except for nitrogen fertilization, farmers used their normal cultural practices in all experiments. Due to an extremely wet spring in 1995, most experiments were planted in early June, and even then conditions were wet enough to cause significant stand losses. Most 1996 experiments were planted in late April and stands were good.

Nitrogen rate treatments were applied to small plots at locations 1 to 13 (hand-applied ammonium nitrate) and to large strips at locations 14 to 16 (sidedressed anhydrous ammonia). For the 1995 experiments and the 1996 strip-plot experiments, N was applied at sidedress in 50 lb increments. For the 1996 small-plot experiments, N was hand-applied in 25 lb increments either preplant, sidedress, or 100 lb at planting followed by sidedress N rates. Rates ranged from 0 to 300 lb/acre in the small-plot experiments, and 0 to 150 or 200 lb/acre in the strip-plot experiments. Although the 300 lb N rates are impractically high for farmers, they help to establish the yield plateau accurately, which is in turn important in establishing the optimum N rate accurately. Measuring the optimum N rate and seeing whether it can be predicted using field-specific tests is the main objective of this research.

Soil samples were taken at planting and again at sidedress to a depth of 3 feet in 1 foot increments and analyzed for ammonium and nitrate. Whole-plant tissue samples were taken at sidedress time and analyzed for total nitrogen content. SPAD chlorophyll meter readings were also taken at sidedress time, and stalk samples were collected at harvest for nitrate analysis. Small plots were hand-harvested, shelled, weighed, and yield was calculated corrected to 15% moisture. Strip plots were combined, weighed, and yield was calculated corrected to 15% moisture.

RESULTS

Only 1995 results are included in this paper. If possible, 1996 results will be added to the poster presented at the Conference.

Yield response to sidedress nitrogen rate for 1995 experiments is shown in Figure 1. Optimum N rates are shown in these graphs and were calculated using $3.00/bu corn and $0.30/lb N; using different prices would not shift the optimum N rate by more than a few pounds in either direction. The average optimum N rate in these experiments was 51 lb/acre and was the same for the manured and non-manured experiments (Table 1). The average yield at the optimum N rate was 120 bu/acre and again was the same for the manured and non-manured experiments. Yields were good considering planting dates and stands.

The low average N requirement of the manured plots was not very surprising, but the low average N requirement of the non-manured plots was. None of the non-manured experiments had received more than one manure application in the last ten years, and none since 1992. Location 5 was in the second year coming out of alfalfa and that probably contributed some N to the corn. Excellent soil moisture conditions from planting until mid-August may have caused more mineralization of soil organic N than would happen in most years.

Table 1. Optimum sidedress N rates and yields for 1995 experiments.

Location	manured?	optimum N rate	yield at opt. N rate
		lb/acre	bu/acre
1	yes	0	142
2	no	0	114
3	no	50	111
4	yes	150	92
5	no	50	121
6	yes	0	128
7	no	110	134
average		51	120
manured average		50	121
non-manured average		52	120

The high N requirement at location 4 (150 lb N/acre, Figure 1) was also a little surprising. Ten tons/acre of dairy manure was applied in November 1994 and should have made a contribution to the N needs of the corn. For some reason this field was still clearly N-deficient. It was the only 1995 experimental location in which the check plots appeared N-deficient at silking, and the only location in which the check yield was less than 80 bu/acre. There was some straw in the dairy manure which would have tied up some N, but the farmer estimated that it was no more than 10% by weight. This much straw shouldn't tie up more than 10 lb N/ton manure.

The main goal of these experiments was to see whether the soil nitrate measurements or any other measurements could be used to predict how much N was needed. Nitrogen rate recommendations for each experiment using different recommendation strategies are shown in Table 2. The Missouri N recommendation is based on yield goal (120 bu/acre was used for all locations), population, and soil organic matter (credit 20 lbs N for each percent organic matter). Wisconsin developed a system where they measure soil nitrate to two

Figure 1. Yield response to sidedress N rate for 1995 experiments.

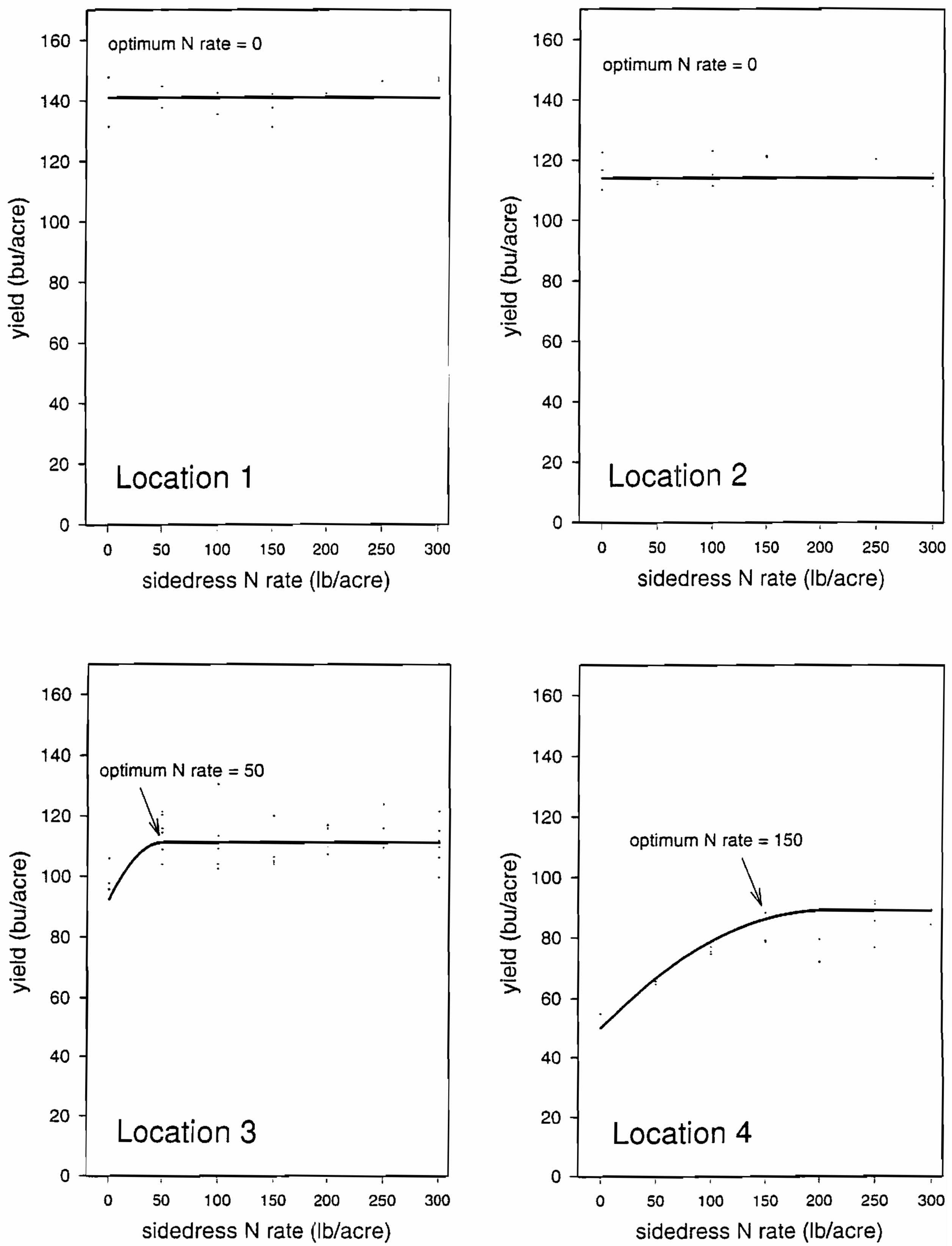
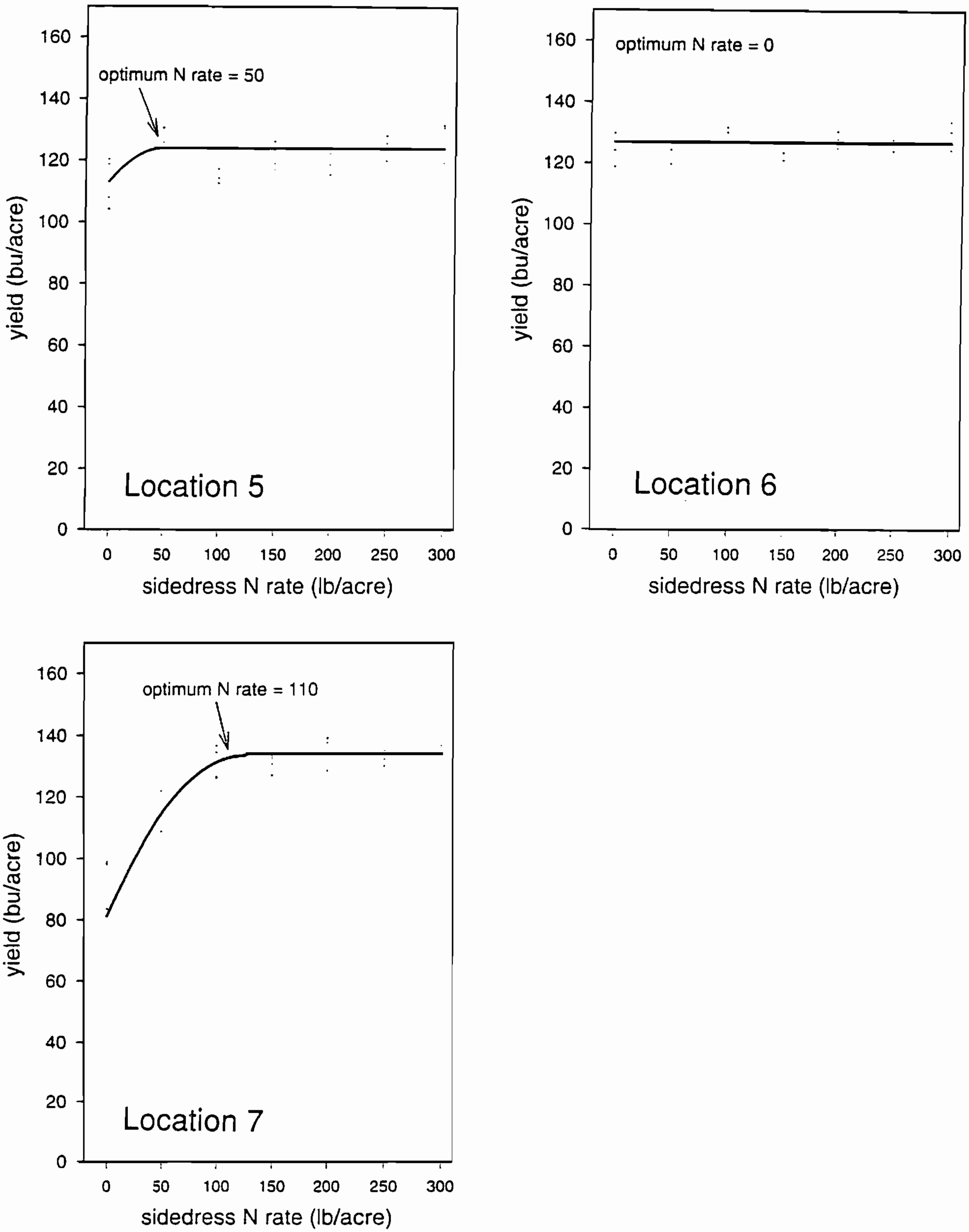


Figure 1 (continued from previous page)



feet at planting, subtract 50 lb that they say would be there normally, then credit any amount in excess of 50 lb (Bundy and Sturgul, 1994). Using this approach to adjust current Missouri recommendations, only locations 1 and 2 got significant credit. Nitrate levels were very high at location 1 (Table 4), which has a long history of hog lagoon irrigation, and this test correctly predicted that no N fertilizer was needed. Using the same approach (2' sample at planting, credit all but 50 lb) but crediting both ammonium and nitrate resulted in significant credits at several locations. Using these credits gave N rate recommendations much closer to actual needs and improved profit compared to current Missouri recommendations (Tables 2 and 3).

Table 2. N fertilizer rates recommended by different N management strategies

Location	Missouri N rec.	MO adjusted w/PPNT*	MO adjusted w/PPMN†	PSNT‡ (Iowa)	actual optimum
	lb/acre				
1	100	0	0	50	0
2	95	75	0	105	0
3	135	130	105	95	50
4	120	120	90	105	150
5	115	115	90	75	50
6	125	125	60	50	0
7	120	120	120	95	110
average	115	100	65	80	50

*PPNT is the preplant soil nitrate test as developed and interpreted by Wisconsin. Soil nitrate is measured to a 2 foot depth at planting time. Anything above 50 lb/acre is credited against the normal N recommendation.

†PPMN is preplant mineral N, which is nitrate plus ammonium. It is the same as the PPNT except that ammonium is credited as well as nitrate.

‡PSNT is the pre-sidedress nitrate test as interpreted by Iowa. Nitrate is measured to a 1 foot depth at sidedress time. Above 25 ppm nitrate-N no N fertilizer is recommended; in a wet year like 1995, no N fertilizer is recommended above 20 ppm nitrate-N (Blackmer, A.M., personal communication). Eight lb fertilizer N/acre is recommended for each ppm the test is below 20 ppm.

Iowa and a number of other states are now using a soil nitrate test taken to one foot at sidedress time to make sidedress rate recommendations (Blackmer et al., 1995). The advantage of this test over preplant soil nitrate tests is that it gives an indication of how much mineralization of organic N is taking place in the field. This is especially important in fields with major organic N sources like manure or a previous alfalfa crop. All three tests increased estimated profit more at the manured sites than at the non-manured sites.

Table 3. Estimated profit[§] using different N recommendation strategies

Location	Missouri N rec.	MO adj. w/PPNT*	MO adj. w/PPMN†	PSNT‡ (Iowa)	actual optimum
	----------	----------	$/acre	----------	----------
1	143	173	173	158	173
2	64	70	92	60	92
3	42	44	52	57	68
4	-40	-40	-47	-42	-38
5	88	88	95	100	108
6	94	94	113	116	131
7	114	114	114	112	115
average	72	78	84	80	93

§Profit was estimated as (yield x $3.00/bu) - (N rate x $0.30/lb N) - $250/acre other production costs

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Both the preplant soil nitrate test, as interpreted by Wisconsin, and the pre-sidedress soil nitrate test, as interpreted by Iowa, did a good job of improving sidedress N rate recommendations averaged over these seven experiments. Average N rate was reduced and profit increased compared to current Missouri recommendations. Using an approaching like Wisconsin's preplant nitrate test but crediting both nitrate and ammonium improved N rate recommendations and profit even more.

Because there is no yield or quality penalty for overapplication of N fertilizer, the only economic advantage that can be gained from tests that predict how much N will be needed is in N fertilizer savings. Because the optimum N rate was only 50 lb/acre in these experiments (Table 2), there was a large economic difference ($21/acre, Table 3) between applying N at typical rates as recommended by our current system and applying the optimum N rate. This may not be a typical or representative situation. Optimum N rates will probably be higher in many years and potential N savings will be lower.

Another situation where test-based N rate recommendations may pay off is in manured fields. The University of Missouri encourages N credits for manure applications, especially if the manure has been analyzed for nutrient content; however, manure analysis is not widely available and is little used. However, even analyzed manure does not always seem to provide the N that laboratory recommendations suggest that it should. The pre-sidedress test gives a measure of how much N is actually becoming available in the field and can be very useful in verifying that reduced N rates will not cause yield reductions. This test correctly predicted that the manured experiments at locations 1 and 6 did not need as much fertilizer N as the manured experiment at location 4 (Table 2).

Measurements of soil ammonium and nitrate, soil organic matter, sidedress tissue N content, and sidedress chlorophyll meter reading are given in Tables 4, 5, and 6. Sidedress tissue N content and chlorophyll meter reading both were strongly related to optimum sidedress N fertilizer rate (Figure 2). These measurements show promise as the basis for developing a sidedress N rate recommendation system.

Table 4. Preplant soil nitrogen test results.

	Soil nitrate-N for depth:			Soil ammonium-N for depth:			Soil mineral N* for depth:		
Location	0-1'	0-2'	0-3'	0-1'	0-2'	0-3'	0-1'	0-2'	0-3'
	lb/acre								
1	90	204	262	34	56	70	124	260	332
2	30	74	96	28	57	117	58	131	213
3	40	52	60	14	28	39	54	80	99
4	28	46	58	16	34	50	44	80	108
5	31	45	57	17	33	47	48	78	104
6	26	50	61	29	66	72	55	116	133
7	12	22	26	7	11	16	19	33	42

*Soil mineral N = nitrate-N + ammonium-N

SUMMARY

Optimum N fertilizer rate in these experiments was surprisingly low (51 lb/acre) and yields were good (120 bu/acre) considering the extremely late planting dates and poor stands. Preplant and presidedress soil tests were fairly accurate in predicting where lower than normal N fertilizer rates could be used without reducing yield. Both tests gave higher profits than current University of Missouri N fertilizer rate recommendations. Chlorophyll meter readings and tissue N content both looked promising as a possible basis for making sidedress N rate recommendations.

Table 5. Presidedress soil nitrogen test results.

Location	Soil nitrate-N for depth:			Soil ammonium-N for depth:			Soil mineral N* for depth:		
	0-1'	0-2'	0-3'	0-1'	0-2'	0-3'	0-1'	0-2'	0-3'
	lb/acre								
1	55	108	148	18	79	117	73	187	265
2	28	47	60	18	50	76	46	97	136
3	34	46	55	10	18	24	44	64	79
4	28	52	70	16	24	29	44	76	99
5	50	76	92	9	20	28	59	96	120
6	57	82	94	24	52	63	81	134	157
7	32	52	63	7	23	41	39	75	104

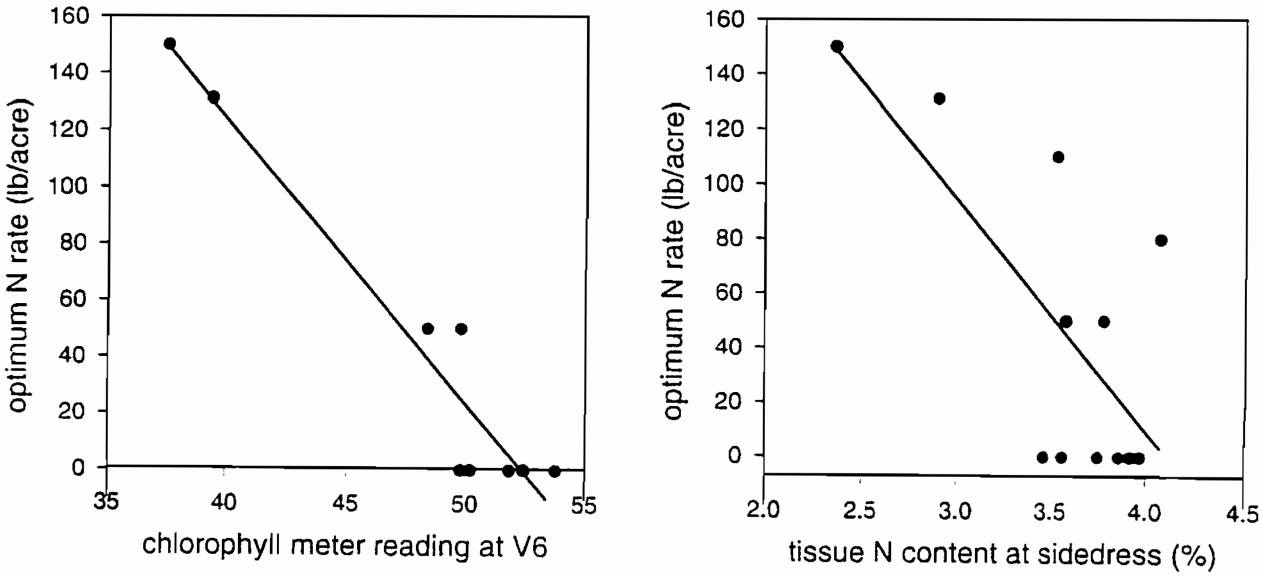
*Soil mineral N = nitrate-N + ammonium-N

Table 6. Soil organic matter, sidedress tissue N, and chlorophyll meter readings.

Location	Soil organic matter	Sidedress tissue N with N at planting=		Sidedress chlorophyll meter w/ N at planting=	
		0 lb/acre	50 lb/acre	0 lb/acre	50 lb/acre
	%				
1	3.5	3.86	3.75	51.8	53.7
2	3.5	3.46	3.56	52.4	49.8
3	2.2	--	3.58	--	48.4
4	2.4	2.36	2.90	37.5	39.4
5	3.0	3.78	3.92	49.8	50.2
6	2.5	3.97	3.97	--	--
7	2.8	3.53	4.07	--	--

*Soil mineral N = nitrate-N + ammonium-N

Figure 2. Relationship between optimum N rate and chlorophyll meter reading or whole-plant total N content at sidedress.



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