SOIL NITRATE TESTING: A GUIDE FOR ADJUSTING MICHIGAN NITROGEN RECOMMENDATIONS FOR CORN [1]

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Previous attempts to use soil nitrate tests in Michigan for adjusting N fertilizer recommendations for corn have been less than satisfactory. Soil tests were typically performed on fall or spring samples taken weeks or months prior to planting. The use of residual nitrate to adjust N fertilizer recommendations in the semi humid regions of the U. S. has never been considered very reliable because of the large fluctuation in soil nitrate from the time of sampling to the time of maximum uptake. Soil nitrate N is subject to loss by denitrification or by leaching from the root zone due to excess moisture. Hence under Michigan's climate, by the time the crop reaches its peak N demand, the N status of the soil may have changed quite dramatically.

In Michigan, the soil nitrate status must be determined close to the period of maximum N uptake to be of potential benefit. With corn the opportunity exists for sampling soils and determining the nitrate status just prior to the time of sidedressing. Soil nitrate testing during the growing season has never been popular or practical because of the long turn-around time normally involved to obtain the analysis, however with today's modern equipment and technology this information could be available in a matter of minutes or hours from the time of sampling.

Nitrogen sidedress applications were common when anhydrous ammonia was first introduced in the 1950's. Today, cheap N fertilizers, new sources of N, the risk of wet weather at sidedress time and the easy of applying preplant N has caused many farmers to abandon sidedress N applications even though it is well known that sidedress N applications are more efficient than preplant N. The return of sidedress N applicators to the Michigan agricultural scene, if widely adopted, could significantly reducing fertilizer nitrate N losses to groundwater.

In 1987 numerous on-farm demonstrations and experiments were conducted in Michigan to determine the feasibility of implementing a pre-sidedressing soil nitrate testing program for corn. These studies were conducted after one of the wettest fall seasons on record, many areas of the state recording 12 to 24 inches of rainfall from September 10th to October 15th. Fall soil moisture conditions were very conducive to extreme leaching and denitrificaiton.

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On-Farm Pre-Sidedress Nitrate Testing Studies

Cooperative Extension agricultural agents in six counties, Calhoun, Eaton, Gratiot, Huron, Ingham and Saginaw assisted in lining up farm cooperators and helping with collection of soil samples and yield data. Ten to 14 days prior to sidedressing, soil samples were collected from the 0-12, 12-24 and 24-36 inch depths. Soil samples were collected from 28 fields. The soil samples were brought to the MSU Soil Testing Lab and immediately dried in an oven at 55 C. Both nitrate and ammonium N were then determined in potassium chloride extracts.

Based on the N content in the three foot profile and the farmer's yield goal, a recommendation was given for the appropriate amount of N to sidedress (Table 1). The cooperators were asked to apply the recommended N rate and their normal rate in strips and then leave a small area where no N was sidedressed. The actual N rates applied sometimes differed from the recommended rate. Most of the cooperators were reluctant to leave a zero N area, however ten cooperators did.

Corn yields were measured by harvesting 50 foot of row in each of the different treatment areas. Due to problems experienced in applying the appropriate N rates, 9 sites were not useable. At harvest time soil samples were again collected from the remaining 19 sites from the 0-12 and 12-24 inch depths and analyzed for nitrate and ammonium N.

The soil nitrate and ammonium N contents prior to sidedressing supplemental N in early June and at harvest in September are presented in Tables 2, 3, 4, 5 and 6, respectively for Calhoun, Eaton, Gratiot, Huron and Ingham counties. Prior to sidedressing all fields contained appreciable levels of indigenous nitrate and ammonium N. The values were higher than anticipated due to the wet fall of 1986 and only minimal amounts of N were applied at planting time to all fields, less than 20 pounds per acre. Some fields contained very high levels of nitrate which apparently was residual N from applications made in previous years. In Ingham county (Table 6) two fields contained over 100 pounds of nitrate N per acre in the top foot of soil. One field (J) received hog manure in the past whereas field (S) had a high organic matter content in the 0-12 inch zone being an organic soil.

In general the nitrate content was higher in the top 12 inches of all soils, but high levels present deeper in the profile indicate that some downward movement had occurred. The most serious downward movement was apparent in fields which received animal manure and/or high N rates in the past. Fields receiving manure in past years were J in Ingham county and W in Gratiot county. Fields R-1 and R-2 in Huron county had accumulated high levels of nitrate in the top three feet of the soil profile apparently as the result of excess N fertilizer previously applied.

By harvest time the nitrate levels in the soil were significantly reduced presumably due to uptake by the corn crop. In most fields the residual soil nitrate content was higher in the plot areas which received the higher rates of sidedress N. In field S in Ingham County (Table 5) the residual soil nitrate level in September was very high in the two sidedress N areas, but was considerably lower where no N was applied. The zero N area produced slightly higher corn yields than the area which received N (Table 12). Soil nitrate testing prior to sidedressing at this site was very beneficial, both economically and environmentally.

Corn ear leaf samples were collected at silking time from five fields and analyzed for total N (Table 7). In most cases the N content of the ear leaf was increased by sidedress N, however increasing the sidedress N rate beyond the amount recommended did not appreciably increase the N content and yields were generally unaffected by the increase in N content.

Corn yield data along with soil nitrate tests prior to sidedressing and after harvest for the corresponding sidedress N rates are summarized in Tables 8, 9, 10, 11 and 12, respectively for Calhoun, Eaton, Gratiot, Huron and Ingham counties. Corn grain yields were somewhat variable between N plot areas possibly due to the small harvest area and natural field variability. Variations in plant stands were not due to the N treatments, therefore some of the yield variability may be due to stand variability and does not completely reflect the effect of the sidedress N rates. Corn yields were also affected by drought conditions which occurred during the 1987 growing season. In those fields where zero N plots were included, yields were improved by N in six of the 10 locations. Two of the four fields not responding contained over 120 pounds of nitrate N in the top two acre feet of soil in June.

The N rates applied by the farm cooperators were not necessarily the rates we suggested. Therefore, it was not always possible to determine whether or not the suggested rates based on the soil nitrate content were suitable. In 8 of 17 fields corn yields produced by the lower N sidedress rate were equal or better than those produced with a higher N rate. Recognizing natural field variability and the variability involved in selecting the small harvest areas, a yield difference of 15 bushels per acre or less is probably not statistically significant. Only 3 of the 17 fields produced yields greater than 15 bushels per acre at the higher N sidedress rates. Hence, pre-sidedress nitrate testing in 1987 was very useful in determining the most economical and environmentally sound N rate.

MSU Agronomy Farm Experiments

In 1987 two experiments were conducted at the MSU Agronomy farm at East Lansing on two soil types, Metea loamy sand and Capac loam. Both sites were used in 1985 and 1986 for high yield corn and soybean studies. In 1985 both sites were planted to corn and received 300 lbs of N fertilizer. In 1986 the sites were planted to soybeans and received 100 lbs of N. In 1987 corn was planted on April 24th at both sites without any starter fertilizer or any preplant N fertilizer. Soil samples were taken at 3 depths (0-12, 12-24 and 24-36 inches) on May 20th for nitrate and ammonium N analysis. On June 4th, 5 rates of sidedress N (0, 30, 60, 90, and 120 lbs N/acre) were applied as anhydrous ammonia and replicated 6 times in each experiment.

Table 13 shows the nitrate and ammonium contents of the soil samples taken on May 20th. The Capac l. soil which has a higher organic matter content than the Metea l.s. (3.7 % vs. 1.0%), had the highest nitrate level in the 0-12 inch depth. The 5-6 ppm of nitrate and ammonium are considered to be normal background values for these kinds of soils; however, the 10 and 29 ppm nitrate values in the 0-12 inch depth represent either residual N fertilizer or mineralization of organic matter. Because of the wet fall of 1986 with 11 inches of rain in September and October and the warm dry spring in 1987 most of the nitrate is probably from mineralization of organic matter and not fertilizer carryover.

Although the values in Table 13 may seem to be small, they still represent a sizeable quantity of available N to the corn crop. Assuming that one acre of soil 6 inches deep weighs 2 million lbs, these concentrations add up to 85 lbs of nitrate N for the Metea l.s. 3 foot profile and 177 lbs of nitrate N in the Capac profile.

The yield data and grain N content for the sidedress N treatments are shown in Table 14. The first 30 lbs of sidedress N gave a significant yield response at both locations. Additional amounts of sidedress N did not give any additional yield. The grain N content on the Metea soil is well correlated with the amount of sidedress N from the lowest N to the highest N rate. On the Capac soil, the grain N content increased with only the first two rates of sidedress N.

<u>Montcalm Research Farm</u>

A residual N study on corn following potatoes was also conducted in 1987 at the Montcalm Research Farm on a McBride sandy loam soil. Corn was grown on a site previously used for a potato N rate and time study. Following potato harvest in 1986, a rye cover crop was established. In the spring of 1987 the rye was killed with a herbicide and corn was no-till planted without any fertilizer. Soil tests for phosphorus and potassium were very high at this site. The corn crop was not irrigated, but left to scavenge any nutrients and water it could obtain.

The yield data for this experiment are shown in Table 15. Corn yields ranged form 90 to 107 bushels per acre but the differences are not statistically significant.

Soil nitrate and ammonium data before planting and after harvest are shown in Table 16. The amounts of N found in the spring were quite low, averaging 5.6 ppm of nitrate and 1.6 ppm of ammonium, but when converted to pounds per acre this represents 60 lbs of nitrate N and 17 lbs of ammonium N per acre. Only 35 lbs of nitrate N was found in the fall of 1986 after 16 inches of rain in September. The explanation for the slight increase in nitrate from fall to spring may be due to mineralization of organic N although soil samples were taken very early before soil temperatures reached 50 degrees F. Other possible explanations include sampling variability, differences in soil sample storage and N in winter precipitation.

Data for total N uptake, not shown here, were between 88 and 113 lbs of N per acre for the above ground corn plants at harvest. We estimate that 40 lbs of N came from mineralization of soil organic matter and the remaining 60 to 70 lbs came from the residual N (87 lbs) found in the 3 foot profile in the spring of 1987.

Saginaw Valley Sugar Beet Study

Another soil N study in 1987 on sugar beet fields in the Saginaw Valley shows that large amounts of mineral N (both ammonium and nitrate) can be found in these soils and that fall to spring carryover was also very significant (Table 17). There is great concern within the sugarbeet industry that too much N is being used on sugar beets resulting is lower quality sugar and less recoverable sugar. These data also provide evidence that corn following sugar beets could benefit from the residual levels of N remaining from previous applications to sugar beets.

Summary

In summary, these studies demonstrate the feasibility of using the soil nitrate status prior to sidedressing N to a corn field as a basis for determining an economical and environmentally sound N rate. Some refinement of the approach may be needed. Nitrogen sidedress rates based on the nitrate status of the top acre 3 feet produced corn yields which were similar or better than those produced by the higher N rates utilized by the farmer in 14 of 17 fields. Recognizing the difficulty in collecting soil from the 24-36 inch depth it will be more practical to be able to base N recommendations on the nitrate content in the top 24 inches of soil. Farmers and soil sampling services would be more likely to utilize a recommendation based on the top 24 inches of soil. As shown in Table 1, N recommendations based on the nitrate content of the top 24 inches of soil are substantially less than recommendations based solely on yield goal.

The 1987 experimental data and the information from the Saginaw valley would also indicate that significant amounts of nitrate N can be found in Michigan soils and should be taken into account when making N fertilizer recommendations.

In subsequent studies of this diagnostic approach for recommending appropriate sidedress N rates for corn the following changes are suggested. Sidedressing N recommendations should be based on the nitrate content of the soil samples taken from the top 24 inches approximately 10 days prior to when sidedressed N applications will be made. Sidedress N application treatments, both those recommended and those used by the farmer, should be compared in demonstration strips across the fields. At harvest yields should be determined by harvesting the entire strip and weighing the grain with a weigh wagon or separately at an elevator. This will provide a more accurate reflection of the treatment effects than small hand harvested areas as was done this past year. Soil samples collected from the 0-24 inch depth at harvest-time will help determine the effectiveness in minimizing the potential for nitrate leaching. With the on going collection of field data to serve as a base, this soil nitrate diagnostic testing service can become the basis for economical use of N in corn production which is compatible with maintenance of a quality environment.

Table 1. Nitrogen recommendations based on yield goal and soil nitrate levels for corn fields in five counties.

Field I.D.	Yield Goal	Nitrogen Recommendations STP[a]	0-36[b]	0-24[c]	Sidedress N Rate[d]
C-KS	140	163	80	94	85
C-KW	130	150	84	102	85
C-VC	130	150	40	74	-
E-DKB-1	170	204	105	148	100
E-DKB2	170	204	100	144	100
E-SW	150	177	60	100	60
E-W1	110	123	40	65	60
E-W2	110	123	0	13	50*
G-H	150	177	71	94	90
G-S	150	177	81	105	80
G-W	150	177	20	75	60
H-R1	150	177	0	24	80*
H-R2	150	177	0	38	80
H-SD1	110	123	35	54	20
I-F	124	143	40	63	40
I-FL	110	123	40	60	60*
I-J	150	177	0	28	0
I-S	200	245	100	121	125

[a] Nitrogen recommendation based on yield goal provided by the MSU soil testing program.
[b] Sidedress nitrogen recommendation based on the nitrate content in the top 36 inches of the soil.
[c] Sidedress nitrogen recommendation based on the nitrate content in the top 24 inches of the soil.
[d] Sidedress nitrogen rate actually applied.
* Fields in which the nitrogen rate higher than the approximate recommended sidedress rate produced greater than 15 bushel of corn more per acre.

Table 2. Soil nitrate and ammonium-nitrogen contents of soils prior to sidedress nitrogen applications in mid-June and in late September 1987. Calhoun County.

Sample ID	Soil Depth	June NO_3-N	June NH_4-N	September NO_3-N	September NH_4-N
	inches	lb/A ft		lb/A ft	
KS-0	0-12	48	21	11.1	8.3
	12-24	21	16	7.6	9.5
	24+	16	19	-	-
KS-85	0-12			11.1	8.9
	12-24			10.5	6.6
	24+			-	-
KS-100	0-12			18.7	8.2
	12-24			9.0	4.3
	24+			-	-
KW-0	0-12	34	26	8.6	6.3
	12-24	14	13	6.1	5.1
	24+	18	18	-	-
KW-85	0-12			11.1	8.2
	12-24			20.5	3.5
	24+			-	-
KW-100	0-12			9.4	7.4
	12-24			8.8	5.4
	24+			-	-
VC-0	0-12	53	13	7.4	5.7
	12-24	23	20	4.3	2.8
	24+	37	31	-	-
VC-140	0-12			13.5	7.3
	12-24			6.7	15.9

Table 3. Soil nitrate and ammonium-nitrogen contents of soils prior to sidedress nitrogen applications in mid-June and in late September 1987. Eaton County.

Sample ID	Soil Depth	June NO_3-N	June NH_4-N	September NO_3-N	September NH_4-N
	inches	lb/A ft		lb/A ft	
DKB-1-R	0-12	39	7	14.0	10.0
	12-24	17	1	-	-
	24+	18	5	-	-
DKB-1-GR	0-12			14.1	10.2
	12-24			-	-
	24+			-	-
DKB-2-R	0-12	25	4	9.2	7.5
	12-24	35	9	5.2	4.2
	24+	19	6	-	-
DKB-2-GR	0-12			14.1	8.1
	12-24			10.4	3.6
	24+			-	-
SW-R	0-12	49	9	10.4	6.1
	12-24	28	3	11.0	3.1
	24+	25	2	-	-
SW-145	0-12			16.9	4.7
	12-24			18.7	2.8
	24+			-	-
W-1-R	0-12	34	11	16.1	7.7
	12-24	24	15	26.0	4.8
	24+	24	12	-	-
W-1-GR	0-12			11.3	4.3
	12-24			11.8	2.1
	24+			-	-
W-2-R	0-12	52	16	14.0	8.7
	12-24	58	14	14.1	1.3
	24+	41	21	-	-
W-2-GR	0-12			12.2	6.4
	12-24			13.2	6.4
	24+			-	-

Table 4. Soil nitrate and ammonium-nitrogen contents of soils prior to sidedress nitrogen applications in mid-June and in late September 1987. Gratiot County.

Sample ID	Soil Depth	June NO_3-N	June NH_4-N	September NO_3-N	September NH_4-N
	inches	lb/A ft		lb/A ft	
H-0	0-12	58	17	10.2	ND
	12-24	25	16	11.9	ND
	24+	23	19	-	-
H-90	0-12			13.3	ND
	12-24			7.1	ND
H-170	0-12			8.5	ND
	12-24			6.4	ND
S-0	0-12	35	35	3.4	ND
	12-24	37	21	7.0	ND
	24+	24	15	-	-
S-80	0-12			2.0	ND
	12-24			7.5	ND
S-160	0-12			3.4	ND
	12-24			8.1	ND
W-0	0-12	54	19	9.5	0.6
	12-24	48	12	5.5	ND
	24+	61	19	-	-
W-60	0-12			15.3	ND
	12-24			21.6	ND
W-150	0-12			18.2	0.5
	12-24			16.6	ND

ND - None detected

Table 5. Soil nitrate and ammonium-nitrogen contents of soils prior to sidedress nitrogen applications in mid-June and in late September 1987. Huron County.

Sample ID	Soil Depth	June NO_3-N	June NH_4-N	September NO_3-N	September NH_4-N
	inches	lb/A ft		lb/A ft	
R-1-80	0-12	68	-	3.9	1.5
	12-24	85	-	2.4	nd
	24+	40	-	-	-
R-1-180	0-12			43.1	2.6
	12-24			19.0	nd
	24+			-	-
R-2-80	0-12	63	-	15.5	nd
	12-24	76	-	4.3	nd
	24+	71	-	-	-
R-2-180	0-12			13.2	0.6
	12-24			4.3	nd
	24+			-	-
SD-1-20	0-12	34	-	12.4	nd
	12-24	35	-	1.7	nd
	24+	20	-	-	-
SD-1-135	0-12			5.2	nd
	12-24			16.6	nd
	24+			-	-
SD-2-135	0-12	35	-	23.6	9.6
	12-24	23	-	3.3	nd
	24+	20	-	-	-

nd - none detected

Table 6. Soil nitrate and ammonium-nitrogen contents of soils prior to sidedress nitrogen applications in mid-June and in late September 1987. Ingham County.

Sample ID	Soil Depth	June NO_3-N	June NH_4-N	September NO_3-N	September NH_4-N
	inches	lb/A ft		lb/A ft	
F - 0	0.12	47	23	18.7	1.6
	12-24	32	20	13.0	nd
	24+	32	23	-	-
F 40	0-12			19.6	2.3
	12-24			21.9	nd
	24+			-	-
F 40	0-12			8.5	nd
	12-24			10.4	-
	24+			-	-
FL 0	0-12	44	23	12.7	8.9
	12-24	22	18	5.1	2.2
	24+	20	17	18.9	5.2
FL 60	0-12			6.4	6.3
	12-24			1.5	1.5
	24+			9.3	1.4
FL 100	0-12			22.3	6.5
	12-24			7.3	2.7
	24+			7.4	3.3
J 20	0-12	105	34	9.3	0.6
	12-24	44	21	5.8	nd
	24+	89	29	-	-
J 80	0-12			10.9	1.4
	12-24			5.7	nd
	24+			-	-
S 0	0-12	100	18	3.4	nd
	12-24	21	16	5.7	nd
	24+	27	16	-	-
S 125	0-12			50.3	nd
	12-24			8.0	nd
	24+			—	—
S 170	0-12			48.3	6.9
	12-24			10.7	nd
	24+			—	—

nd - none detected

Table 7. Nitrogen content in corn ear leaves at silking in relation to sidedress nitrogen rates.

Field ID	Sidedress N Rate	Ear Leaf N Content	Grain Yield
	lb/A	%	bu/A
KW	0	3.02	144
	85	4.40	117
	100	4.37	140
VC	0	4.05	126
	50	4.40	-
	140	4.52	142
F	0	3.77	63
	40	3.72	62
FL	0	2.82	72
	60	3.05	86
S	0	3.30	143
	125	3.65	127

Table 8. Soil testing for nitrogen management in corn production - Calhoun County.

Grower ID		Pre-Sidedress Soil NO_3-N4	Sidedress N Rate	After Harvest Soil NO_3-N	Corn Yield	Grain Moisture	Plant Population
		lb/A 2 ft	lb/A	lb/A 2 ft	bu/A	%	plant/A
KS -	0	-	0	18	144	27.9	23,220
	85	69	85	26	117	22.5	22,350
	100	-	100	27	140	27.0	22,060
KW -	0	-	0	14	99	19.2	18,865
	85	48	85	31	151	29.2	22,930
	100	-	100	18	135	26.0	22,060
VC	0	76	0	11	126	20.3	19,525
	140	-	140	20	142	22.8	19,860

Table 9. Soil testing for nitrogen management in corn production - Eaton County.

Grower ID	Pre-Sidedress Soil NO_3-N4	Sidedress N Rate	After Harvest Soil NO_3-N	Corn Yield	Grain Moisture	Plant Population
	lb/A 2 ft	lb/A	lb/A 2 ft	bu/A	%	plant/A
DKB-1 R	56	100	14*	102	24.8	-
DKB-1 GR	..	180	14*	112	25.6	-
DKB-2 R	60	100	14	150	24.1	20,910
DKB-2 GR	..	180	24	165	26.6	21,605
SW R	77	60	21	139	22.6	-
SW GR	..	145	35	143	24.2	-
W-1 R	58	60	42	110	35.8	19,245
W-1 GR	..	130	23	98	36.0	18,970
W-2 R	110	50	28	118	26.1	22,271
W-2 GR	...	130	25	141	27.3	20,345

* pounds of nitrate-nitrogen in the top acre one foot only.

Table 10. Soil testing for nitrogen management in corn production - Gratiot County.

Grower ID	Pre-Sidedress Soil NO_3-N4	Sidedress N Rate	After Harvest Soil NO_3-N	Corn Yield	Grain Moisture	Plant Population
	lb/A 2 ft	lb/A	lb/A 2 ft	bu/A	%	plant/A
H-0	-	0	22	120	23.0	26,140
H-90	83	90	20	147	21.7	25,090
H-170	-	170	15	118	21.0	22,650
S-0	-	0	10	90	30.2	23,350
S-80	72	80	9	97	32.5	23,700
S-160	-	160	11	106	31.2	23,700
W-0	-	0	15	142	23.7	25,440
W-60	102	60	37	158	24.0	24,045
W-150	-	150	35	157	25.9	24,740

Table 11. Soil testing for nitrogen management in corn production - Huron County.

Grower ID	Pre-Sidedress Soil NO_3-N_4	Sidedress N Rate	After Harvest Soil NO_3-N	Corn Yield	Grain Moisture	Plant Population
	lb/A 2 ft	lb/A	lb/A 2 ft	bu/A	%	plant/A
R-1-80	153	80	6	108	25.8	25,440
R-1-180	...	180	62	140	28.9	26,135
R-2-80	139	80	20	118	29.0	32,060
R-2-180	...	180	17	134	29.5	28.225
SD-1-20	69	20	14	101	26.5	23,345
SD-1-135	..	135	22	87	32.5	24,390
SD-2-135	58	135	27	128	27.9	24,390

Table 12. Soil testing for nitrogen management in corn production - Ingham County.

Grower ID	Pre-Sidedress Soil NO_3-N4	Sidedress N Rate	After Harvest Soil NO_3-N	Corn Yield	Grain Moisture	Plant Population
	lb/A 2 ft	lb/A	lb/A 2 ft	bu/A	%	plant/A
F - 0	..	0	31	63	25.9	18,030
F - 40	79	40	35	62	28.4	18,030
F - 40	..	40	18	58	24.8	17,770
FL - 0	..	0	17	72	23.5	-
FL - 60	66	60	8	86	24.9	-
FL - 100	..	100	29	108	27.3	-
J - 20	149	0	15	147	19.3	20,630
J - 80	...	60	16	141	19.5	20,350
S - 0	..	0	9	143	21.2	25,785
S - 125	121	125	58	127	22.0	26,480
S - 170	...	170	59	131	21.6	24,390

Table 13. Soil Nitrate and ammonium contents.

Sample Depth	Soil type: Metea l.s. NO_3	NH_4	Capac l. NO_3	NH_4
-inches-	----------ppm-------------			
0-12	10	5	29	6
12-24	5	6	8	5
24-36	6	6	7	5

Table 14. Effect of sidedress nitrogen fertilizer on corn yield and percent nitrogen in grain.

Nitrogen Rate	Soil Type: Metea l. s. Yield	Grain N	Capac l. Yield	Grain N
-lb/A-	-bu/A[1]-	-%-	-bu/A-	-%-
0	114 b	1.25 d	124 b	1.34 c
30	119 a	1.41 c	130 a	1.42 b
60	120 a	1.46 bc	124 b	1.50 a
90	121 a	1.48 b	130 a	1.52 a
120	119 a	1.56 a	128 ab	1.52 a

[1] Any two means followed by different letters are significantly different as measured by the Duncan's multiple range test (p=0.05).

Table 15. Grain yield and other selected characteristics of Pioneer 3744 corn grown on 1986 potato site without fertilizer or irrigation water.

1986 N rate[1] — N application date: 5-15	6-15	7-15	8-15	Total N	Selected characteristics[2]: Plant population	Grain moisture	Grain yield	Barren stalks
--------lbs. N per acre---------					plants per acre	--%--	bu per acre	--%--
60	60	0	0	120	22825	31.3	90.6	9.1
60	60	60	0	180	22738	31.8	106.7	-1.5
60	60	0	60	180	22913	30.7	102.5	12.1
60	60	60	60	240	22303	30.9	96.0	4.5
120	60	60	0	240	21867	31.4	94.7	7.5
120	60	0	60	240	21519	31.4	107.2	-1.8

[1] No nitrogen fertilizer or irrigation water was applied in 1987.
[2] None of the treatment means were found to be statistically different at the 0.05 probablity level.

Table 16. Spring and fall soil nitrate and ammonium levels as influenced by 1986 fertilization rate and uptake by Pioneer 3744 corn on a Montcalm-Mcbride sandy loam soil.

1986 N rate: N application date 5-15	6-15	7-15	8-15	Total N	Soil depth	Spring[1] NO_3^-	Spring[1] NH_4^+	Fall[2] NO_3^-	Fall[2] NH_4^+	Difference NO_3^-	Difference NH_4^+
lbs. N per acre					-in-	parts per million					
60	60	0	0	120	0-12	6.76	4.38	4.16	1.88	-2.60	-2.50
					12-25	3.38	0.35	3.42	0.02	0.04	-0.33
					24-36	4.31	0.15	3.26	0.07	-1.05	-0.08
					36-48	---	---	4.11	0.10	---	---
					Average	4.82	1.63	3.74	0.52	-1.20	-0.97
60	60	60	0	180	0-12	7.71	3.19	5.12	2.03	-2.59	-1.16
					12-24	6.83	0.34	3.34	0.19	-3.49	-0.15
					24-36	3.62	0.39	3.96	0.21	-2.54	0.03
					36-48	---	---	5.17	0.05	---	---
					Average	6.05	1.31	4.40	0.62	-2.87	-0.43
60	60	0	60	180	0-12	7.56	5.85	5.07	2.37	-2.49	-3.48
					12-24	3.62	0.39	3.96	0.21	0.34	-0.18
					24-36	4.75	0.37	3.05	0.11	-1.70	-0.26
					36-48	---	---	3.99	0.03	---	---
					Average	5.31	2.20	4.02	0.68	-1.28	-1.31
60	60	60	60	240	0-12	6.78	2.42	5.00	1.96	-1.78	-0.46
					12-24	3.92	0.04	3.88	0.09	-0.04	0.05
					24-36	5.12	0.09	3.39	0.02	-1.73	-0.07
					36-48	---	---	4.54	0.14	---	---
					Average	5.27	0.85	4.20	0.55	-1.18	-0.16
120	60	60	0	240	0-12	8.42	2.97	4.80	2.02	-3.62	-0.95
					12-24	4.04	0.42	4.08	0.12	0.04	-0.30
					24-36	4.34	0.32	3.62	0.00	-0.72	-0.32
					36-48	---	---	4.11	0.02	---	---
					Average	5.60	1.24	4.15	0.54	-1.43	-0.52
120	60	0	60	240	0-12	8.73	6.88	5.30	2.07	-3.43	-4.81
					12-24	5.48	0.57	3.55	0.22	-1.93	-0.35
					24-36	5.62	0.38	3.38	0.04	-2.24	-0.34
					36-48	---	---	3.23	0.06	---	---
					Average	6.61	2.61	3.86	0.60	-2.53	-1.83

Nitrate and ammonium levels — Soil sample collection time.

[1] Sampled April 20, 1987.
[2] Sampled October 15, 1987.

Table 17. Mixed nitrogen levels for selected fields where sugar beets were grown in 1987.

Farmer	Soil Type	Spring 1987	Fall 1987	Spring 1988
		- - - lb N/acre 3 feet - - - -		
Brabrant	Lenawee loam	233	135	114
Peart	Ithaca clay loam	175	102	123
Pickelman	Parkhill loam	186	96	111
Weiss (C)	Capac clay loam	131	90	94
Weiss (B)	Lenawee clay loam	121	106	90
Ruyts	Bellville fine sandy loam	122	86	-
Reinbold	Capac clay loam	129	100	-
Humphert	Tappan clay loam	124	97	93
Wildner	Parkhill clay loam	126	98	86
Brown	Tappan laom	152	77	72
Eisenman	Londo clay loam	113	85	-
English	Capac clay loam	202	74	167

PROCEEDINGS OF THE EIGHTEENTH

NORTH CENTRAL EXTENSION - INDUSTRY SOIL FERTILITY WORKSHOP

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CREDITS

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