Table 3. 1970 soil tests of P and K and corresponding treatment one year after application

P_2O_5 LBS/A	Martin Co. LBS/ACRE P	Waseca Co.	K_2O LBS/A	Martin Co. LBS/ACRE K	Waseca Co.
0	46	34	0	202	260
50	36	31	50	212	275
100	56	31	100	222	260
150	65	40	200	270	262
200	64	53	400	243	312
Avg. pH	7.7	6.4		6.4	6.4

Table 4. 1970 tissue tests (July) and relationship to P and K treatment

P_2O_5	Martin Co.		Waseca Co.		K_2O	Martin Co.		Waseca Co.	
LBS/A	S*	NS*	S	NS	lbs/A	S	NS	S	NS
					%				
0	.26	.27	.31	.30	0	1.8	1.6	1.6	1.5
50	.26	.24	.30	.31	50	1.8	1.6	1.7	1.6
100	.27	.26	.38	.26	100	1.6	1.6	1.6	1.7
150	.28	.26	.29	.29	200	1.7	1.7	1.7	1.8
200	.28	.25	.29	.31	400	1.7	1.7	2.2	2.1

* S= starter
NS= no starter

Significant yield increases from N, shown in table 1, indicate the importance of high yearly treatments even when past treatments of N have been very high. Results for one year are never conclusive, but the need for nitrogen is very apparent and the starter response as high as 16 bushels per acre demonstrates the need to continue this practice even on high testing soils. The plot work must continue for some time to best evaluate the need for large broadcast rates of P and K.

SUMMARY

It has been our observation that most farmers when planning a higher fertility program, increase the nutrients N, P, K in about equal proportion. Yields, no doubt, have increased considerably. Evidence form earlier experiments in Minnesota and neighboring states indicates that the high corn yield increases are due primarily to nitrogen and starter fertilizer. Experiments where yields, tissue tests and soil tests are observed under intensive corn production will be continued to better understand P and K broadcast needs.

IRRIGATED ALFALFA PRODUCTION

H. L. Meredith and J. O. Jacobson

In 1967 alfalfa plots were established on an Estherville sandy loam near Verndale to determine maximum alfalfa production under irrigation. The fertility treatment follows.

Year	Treatment / acre
1966	3 tons lime*
1967	3 tons lime 70 + 280 + 605 + 50S + 2B
1968	0 + 70 + 315 + 2B
1969	30 + 150 + 410 + 40S + 2B
1970	30 + 150 + 410 + 40S + 2B

*Agricultural limestone, Bryant Quarry

Lime and 1000 pounds 7-14-29-5S were broadcast and incorporated prior to seeding. Fall 1967, 700 pounds of 0 - 10 - 45 + 2B was topdressed and topdressing accomplished in fall thereafter.

Vernal alfalfa at the rate of 16 pounds per acre and a companion nurse crop of oats at the seeding rate of one bushel per acre were seeded in late April, 1967.

Yield history of this plot is as follows:

Date	Cutting	Yield Tons/acre**	Total yield - Tons/acre
7/15/67	1	1.5	
9/3/67	2	1.5	3.0
6/20/68	1	2.0	
7/23/68	2	2.5	
8/23/68	3	1.4	5.9
5/29/69	1	1.5	
7/16/69	2	2.4	
8/19/69	3	1.2	5.0
6/17/70	1	3.2	
7/15/70	2	1.7	
8/10/70	3	1.2	6.1

**Alfalfa Hay @ 15% moisture, average of three yield checks per cutting. Total production of 4 years = 20.0 tons or an average production of 5.7 tons per year excluding the seeding year. Obviously, a production rate of this magnitude is impractical. Most well managed alfalfa fields with reasonable water holding capacities can produce a comparable yield without irrigation.

It becomes clear, therefore, that higher yields are paramount to justify the added cost of irrigation. A fourth cutting must be harvested. Trial-error methods have taught us that a second-year stand or later most often will not survive if cut after August 25 and before October 1. This is primarily due to regrowth and depletion of root sugars, lowering of root osmotic concentration and the consequent rupture of root cells due to formation of large ice crystals. Generally after October 1, in this area, growth ceases. The root reserves are not depleted by cutting alfalfa at this time and early growth in the spring is not hampered by the late cutting. Alfalfa growth continues at average temperatures above 40°F. Experience has shown that 1 1/2

to 2 tons of additional alfalfa could be produced after August 10-15 if harvested after October 1.

Insects are the primary deterrent to production of high quality hay at this time. Insects must be controlled through the use of chemical border treatment and/or periodic field application.

Analyses of Tile and Open Ditch Drainage Waters in Several South Central Minnesota Counties (1968-70)

J. E. Ellis, L. D. Hanson, J. M. MacGregor, and R. Munter

Nitrate nitrogen is formed in soils as organic matter decomposes, and is an essential step in making soil nitrogen available for growing plants. Nitrogen fertilization also increases nitrate supply in soils. In mid-1968 it was decided to collect water samples from several farm drainage tile outlets and from open drainage ditches to provide information on losses of nitrates and phosphorus. Water samples were collected in Kandiyohi, Meeker, McLeod, Renville, Sibley and in Wright Counties, and analyzed for nitrate-nitrogen (NO_3-N). The primary objective was to establish the relative amounts of NO_3-N lost in drainage waters under differing soil fertility management practices-especially the time and rate of N fertilization. Since tile (or open ditch) flow is dependent on amount and distribution of precipitation, and also on stage of crop growth, it was not possible to sample each location on a uniform interval schedule. The present report is a brief summary of results obtained during the 30 month period in which the survey has been conducted.

Initially, the water analyses were limited to NO_3-N alone, but early in 1969 phosphorus as PO_4-P was included, along with nitrite nitrogen (NO_2-N), ammonium N (NH_4-N), potassium (K) and electrical conductivity (a measure of soluble salts). Sulfate (SO_4) and chloride (Cl) were also determined on a few samples. Since each of the 6

counties were represented by either 3 or 4 sampling locations, samples were obtained from a total of 22 or more comparatively small drainage systems. Soil management practices were recorded for all locations, and the soil management effect on crop nutrient losses in drainage waters is now being studied in depth. A brief summary of the nitrate nitrogen and orthophosphorus content of these drainage waters during the 30 month study is shown in the following table.

Nitrate Nitrogen and Phosphate Phosphorus Concentrations in Drainage Waters of Six South Central Minnesota Counties (K, M, Mc, R, S, W) in 1968-69-70

NO_3-N			PO_4-P		
ppm range	Number of samples	%	ppm range	Number of samples	%
0 - 10	123	30	0.0 - 0.1	271	82
10 - 20	141	34	0.1 - 0.2	33	10
20 - 30	88	21	0.2 - 0.3	11	4
30 - 40	32	8	0.3 - 0.4	7	2
40 - 50	24	6	0.4 - 0.5	2	1
50 - 60	5	1	0.5 - 1.0	4	1
60 - 70	1	---	1.0 +	1	---
	414	100		329	100

While it was not possible to determine the total amounts of water passing through these drainage systems, some calculation as the importance of their NO_3-N or PO_4-P content is of interest.

One inch of water spread uniformly over an acre (one acre inch) contains 27,204 gallons weighing 113.4 tons or 226,800 pounds. An acre inch of water containing 10 ppm of NO_3-N would contain 2.268 lbs. of N. Therefore, every acre inch of drainage water in the 10 ppm NO_3-N level would mean that some 2 1/4 pounds of N was being lost in the drainage waters from this field. Similarly, in the case of phosphorus, the same amount of water containing 0.1 ppm PO_4-P would be removing 0.02668 pounds of this form of P.

Although 64% of the analyzed samples contained 20 ppm NO_3-N or less, it is evident that substantial amounts of N are being lost from some farm fields and these could increase pollution of our rivers to some extent. However, it is possible that much of this denitrifies and is lost to the air before entering the larger streams. Dilution with other waters also occurs and nitrates are quickly utilized by water plants during the growing season. There has been little increase in NO_3-N content of our major river waters during the last 50 years, but these must be closely monitored in the future with increasing amounts of NO_3-N of sewage and higher fertilization rates. An additional interest is the amounts which enter ground waters below that affected by drain tile and ditches.

Although the P level of the drainage water is much lower, this element is also a contributor to eutrification of lake or river waters and losses from soil should be maintained at the lowest possible level consistent with optimum crop production.

In final analysis, both NO_3-N and P are essential to both plant and animal life, and must be present for natural biological processes. Nitrogen and phosphate fertilization is a well recognized essential for optimum crop production. Increasing our knowledge of the fate of these elements will promote better soil management practices for optimum crop production and minimum pollution of the environment.

1970 METHOD OF CORN PLANTING STUDY

Lancaster, Wisconsin
University of Wisconsin, Lancaster Experiment Farm
William Paulson, Supt., A. Peterson, J. Swan

Soil: Fayette Silt Loam, 6 to 8% south slope

Previous crop: Corn

Planting date: May 6, Tillage May 5

Tillage Treatments: Planting method

Chisel: A C coulter planter

Spring plow: wheeltrack plant

None: A C coulter plant

Soil temperature was measured in 3 of the 6 reps of the corn on corn study and in 2 reps of the sod - wheeltrack study. Each plot had 4 couples arranged in parallel.

Weather summary: (Table 1).

Conclusions:

1. Very severe crusts of up to one-inch in thickness were created by heavy rains in the latter part of May. Plant stands were seriously reduced on all treatments; stands ranged from 6 to 9,000 plants per acre. This terminated the experiment for 1970. Assuming that crusting was at least partly the reason for the reduced stands, none of the treatments provided sufficient protection to prevent severe damage to stands by crusting.
2. Spring soil temperatures were measured during May.

   a. Corn on corn -

   PM Plow-wheeltrack soil temperature (4-inch depth) was warmer than the chisel and no-till treatments by as much as 2°F. AM soil temperature differences between treatments were generally less than

0.5°F.

b. Corn on alfalfa sod -

Both 1-inch and 4-inch soil temperatures were measured. Immediately after planting wheeltrack planting was much warmer. The PM 4-inch soil temperature for wheeltrack planting on the 8th of May was 6°F warmer than no-till and the 1-inch soil temperature was 10°F warmer. After this, the PM soil temperatures for wheeltrack planting were generally warmer by up to 2°F at the 4-inch depth and by up to 4°F at the 1-inch depth compared to no-till. AM soil temperature differences were generally small and at the 4-inch depth no-till was consistently warmer than wheeltrack plowing by up to 2°F. At the 1-inch depth, differences in AM temperature were not consistent.

TABLE 1

WEATHER SUMMARY - 1970 Growing Season
U.W. EXPERIMENTAL FARM - LANCASTER, WIS.

Month	Temperature mean max. (Degree F)	mean min.	mean	departure 1/ from normal	Precipitation 1970 total (in)	departure 1/ from normal	Growing Degree Days Base 50° 1970	departure 1/ 2/ from normal
April	59.2	37.4	48.3	.9	1.92	-1.27	-	-
May	70.2	40.0	59.6	2.1	7.48	4.16	320	58
June	78.3	57.3	67.8	.7	2.56	-2.06	532	17
July	82.6	59.9	71.2	.1	7.16	3.07	657	- 7
August	80.8	58.5	69.7	1.1	2.57	-.76	603	22
September	70.8	50.6	60.7	.2	8.00	3.81	329	3
October	60.3	41.0	50.6	-.3	2.16	.29	-	-
Total					31.85	7.24	2441	97

1/ Departure from normal values determined from U.W. Exp. Farm Weather data accumulated since 1963 and by using the current seasons records in arriving at the long term mean values.

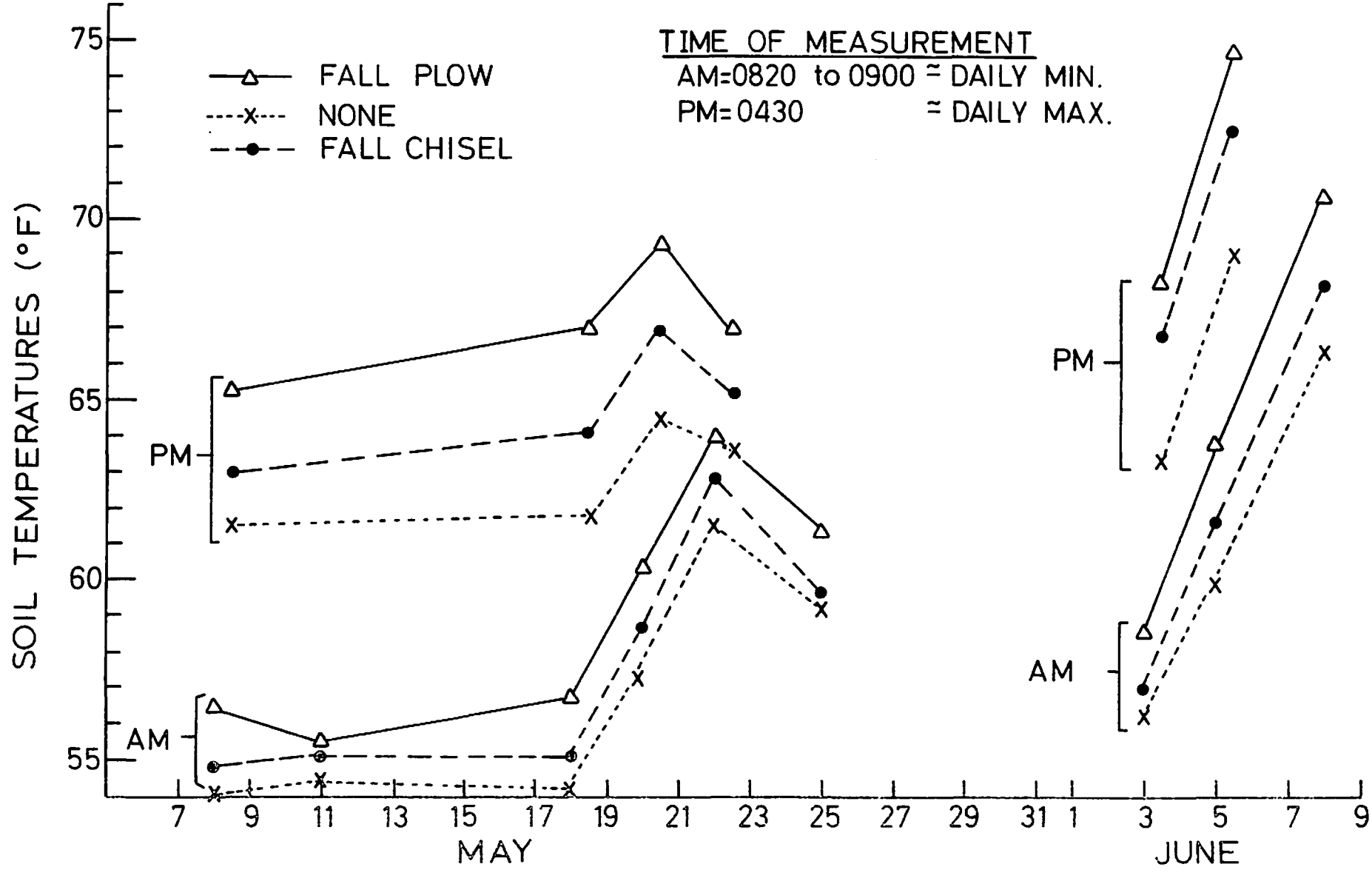
2/ Degree Days calculated using actual temperature values for the period and not ignoring values 50° or 86°, but including these in the determination of the daily mean temperature.

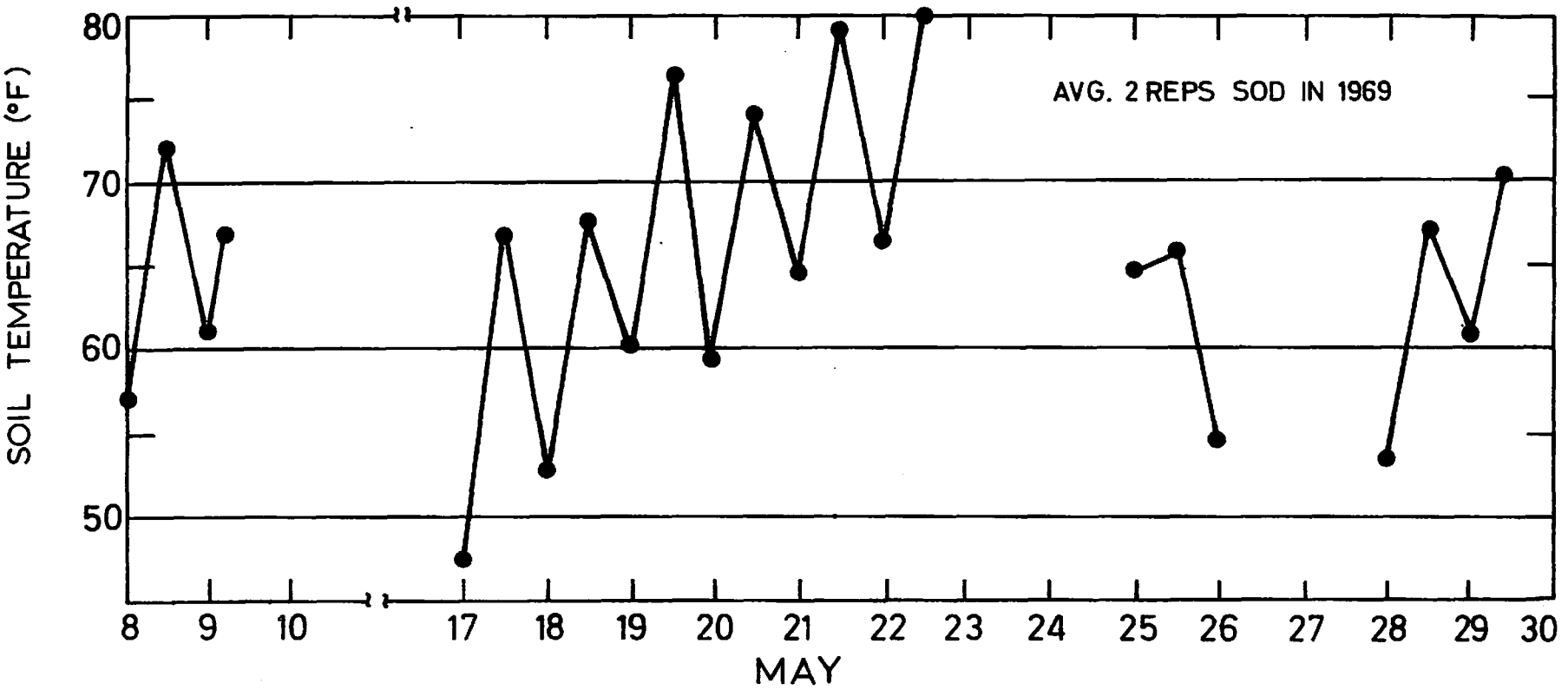
Last Day in Spring with Minimum Temperature - 32° or below : 5/2-20°
28° or below : 4/4-22°

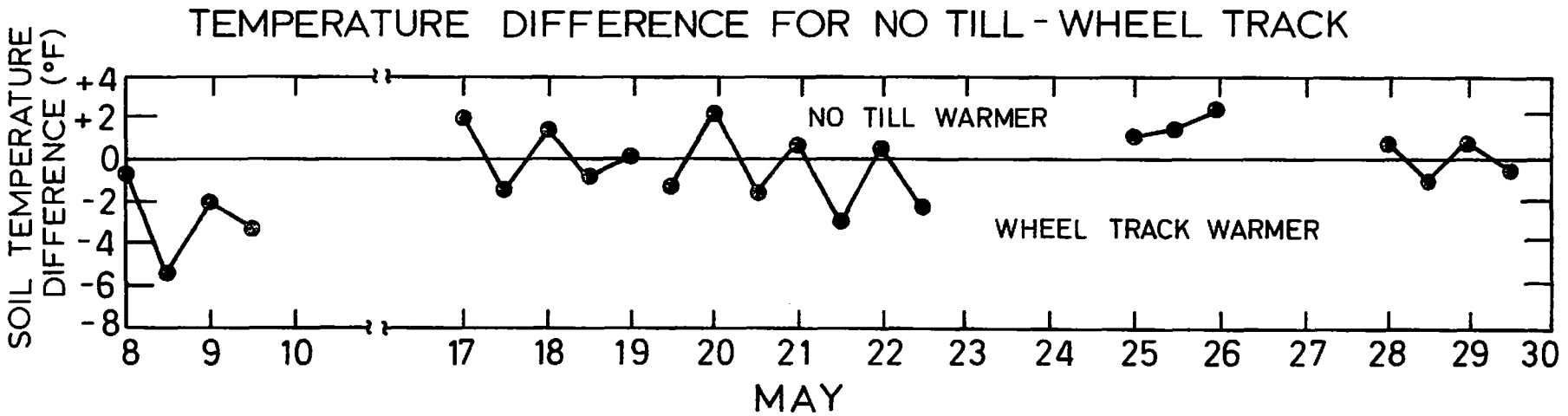
First Day in Fall with Minimum Temperature - 32° or below : 10/4-31°
28° or below : 10/16-25°

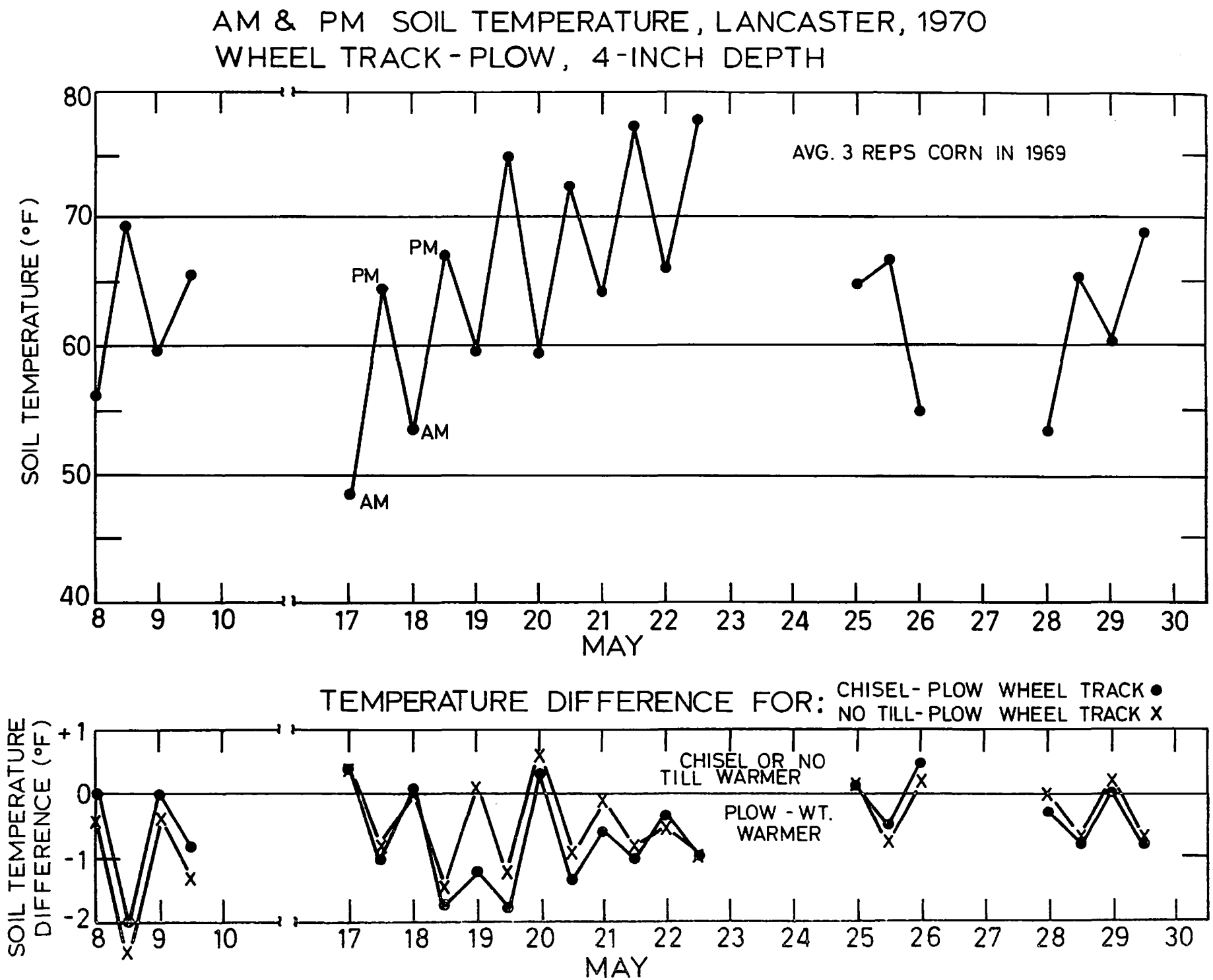
Growing Season above 32° : 155 days.

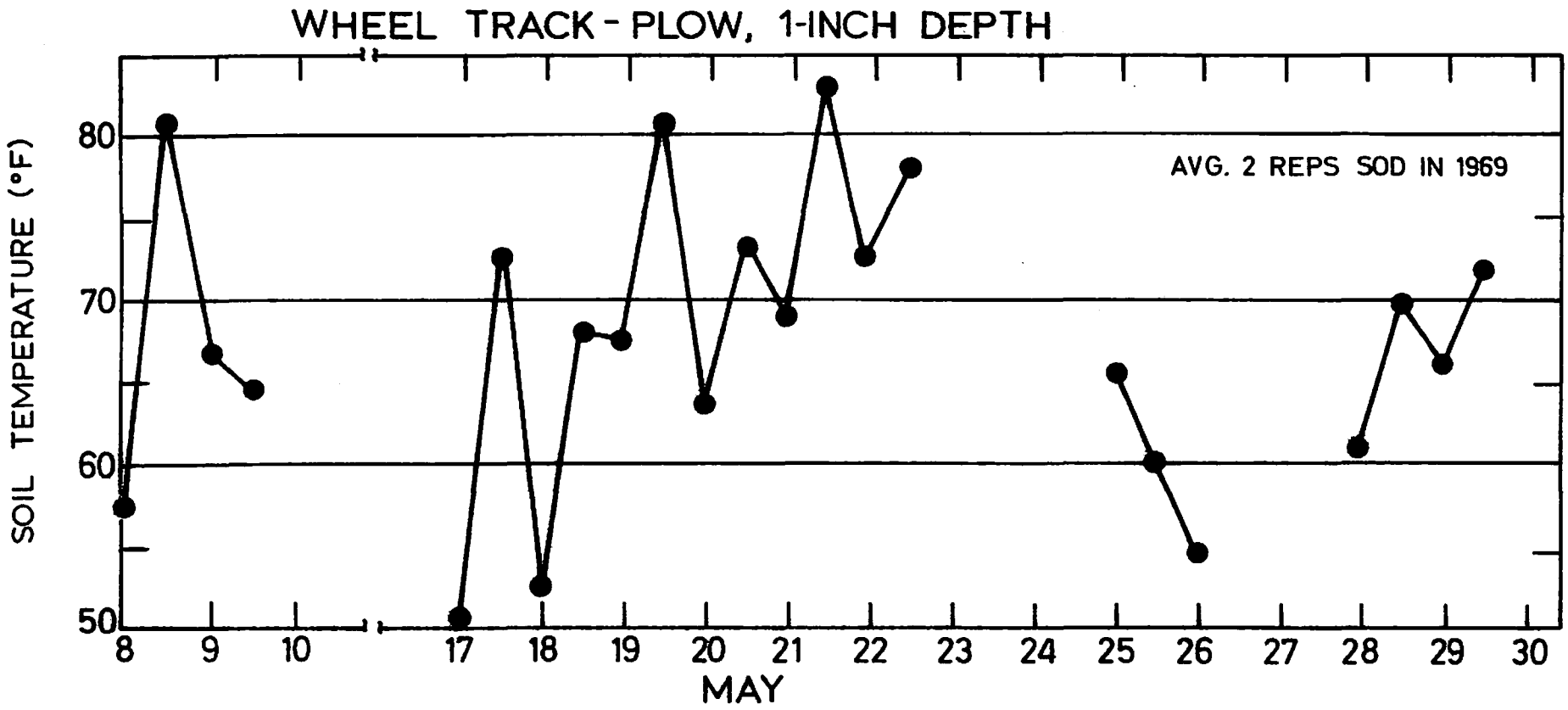
1970 TILLAGE EXPERIMENT
WASECA 4-INCH SOIL TEMPERATURES

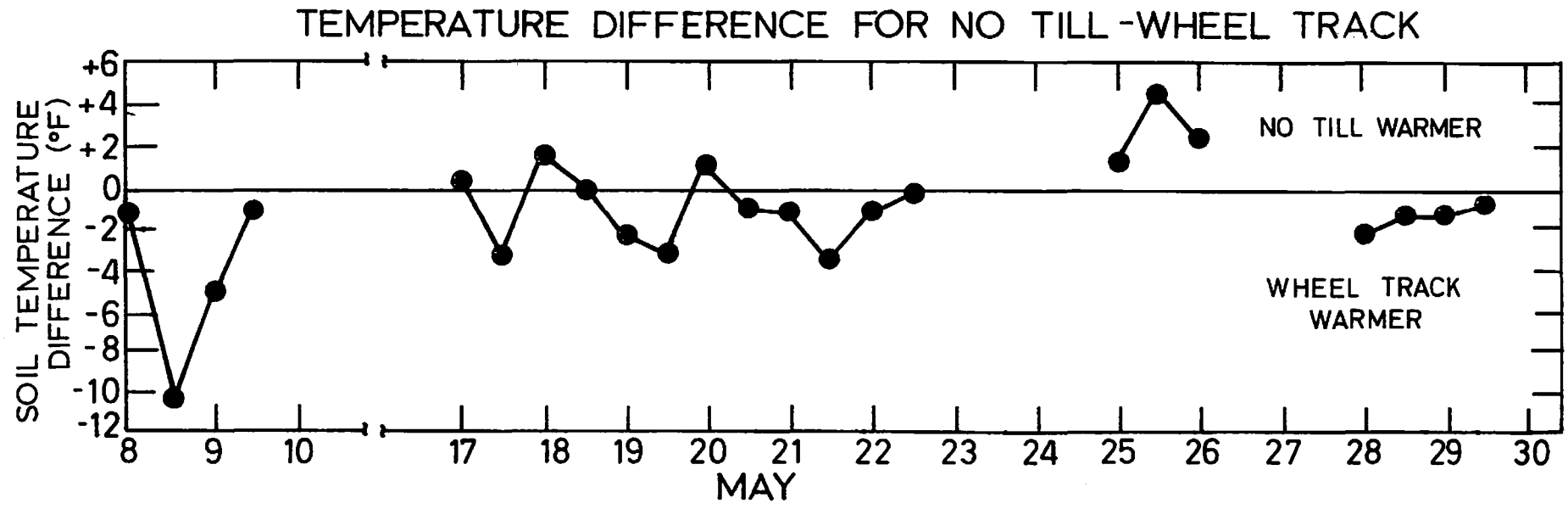



AM & PM SOIL TEMPERATURE, LANCASTER, 1970
WHEEL TRACK-PLOW, 4-INCH DEPTH
AVG. 2 REPS SOD IN 1969
SOIL TEMPERATURE (°F)
80
70
60
50
8
9
10
17
18
19
20
21
22
23
24
25
26
27
28
29
30
MAY


TEMPERATURE DIFFERENCE FOR NO TILL - WHEEL TRACK
SOIL TEMPERATURE DIFFERENCE (°F)
+4
+2
0
-2
-4
-6
-8
NO TILL WARMER
WHEEL TRACK WARMER
8
9
10
17
18
19
20
21
22
23
24
25
26
27
28
29
30
MAY


AM & PM SOIL TEMPERATURE, LANCASTER, 1970
WHEEL TRACK - PLOW, 4-INCH DEPTH
AVG. 3 REPS CORN IN 1969
SOIL TEMPERATURE (°F)
80
70
60
50
40
PM
AM
8 9 10 17 18 19 20 21 22 23 24 25 26 27 28 29 30
MAY
TEMPERATURE DIFFERENCE FOR: CHISEL-PLOW WHEEL TRACK ●
NO TILL-PLOW WHEEL TRACK X
SOIL TEMPERATURE DIFFERENCE (°F)
+1
0
-1
-2
CHISEL OR NO TILL WARMER
PLOW - WT. WARMER
8 9 10 17 18 19 20 21 22 23 24 25 26 27 28 29 30
MAY


WHEEL TRACK - PLOW, 1-INCH DEPTH
AVG. 2 REPS SOD IN 1969
SOIL TEMPERATURE (°F)
80
70
60
50
8
9
10
17
18
19
20
21
22
23
24
25
26
27
28
29
30
MAY


TEMPERATURE DIFFERENCE FOR NO TILL-WHEEL TRACK
NO TILL WARMER
WHEEL TRACK WARMER
SOIL TEMPERATURE DIFFERENCE (°F)
+6
+4
+2
0
-2
-4
-6
-8
-10
-12
8
9
10
17
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30
MAY

SULFUR FERTILIZATION OF KENTUCKY BLUEGRASS

John Grava, D. S. Fairchild, B. D. McCaslin and R. S. Farnham

In the spring of 1970 an experiment was initiated involving the use of sulfur fertilizer on Park Kentucky bluegrass grown for seed production. The plots were set up on Spooner very fine sandy loam located in Lake of the Woods County on E. Helmstetter farm. The soil contained 9 ppm of extractable sulfur (0-3 inch depth), indicating medium sulfur availability. The test is used by the University of Minnesota Soil Testing Laboratory and involves turbidimetric determination of soluble and adsorbed sulfate with barium chloride in monocalcium phosphate (500 ppm P) extracts.

The field had been renovated by plow-back in 1967 and had been burned in fall of 1969. All plots received a uniform application of 90 + 40 + 40 lbs./acre of plant nutrients, expressed as N, P_2O_5 and K_2O. A randomized block design was used with the two sulfur treatments (0, 20 lbs./acre S) replicated nine times. All fertilizer materials were top-dressed on May 5, 1970. The dimensions of individual plots were 10 by 20 feet. Plant tissue samples were collected at the beginning of the emergence of panicles. The sulfur content of tissue was determined in nitric and perchloric acid digests according to the method described by Blanchar et al.,1965, SSSA Proc. 29:71-72.

Seed yields of bluegrass were not significantly increased by applications of sulfur (table 1). However, the sulfur concentration in bluegrass was increased from 0.25 to 0.30% by the application of 20 lbs. per acre of sulfur. Both values were higher than the 0.23% S considered

to be the "critical level" for mixed perennial grasses (McNaught et al, 1961, New Zealand J. Agr. Research 4:177-196).

Table 1. Effect of sulfur treatment on seed yield and concentration of Kentucky bluegrass tissue, 1970.

Treatment	Yield of Seed	Sulfur in Grass Tissue
	lbs./acre	Percent
None	244	0.25a
20 lbs./acre of S as $NaSO_4$	281	0.30b
Significance	NS	**
CV	23	8

THE EFFECT OF NITROGEN FERTILIZATION ON SEED YIELD AND CHEMICAL COMPOSITION OF GRASSES WHEN APPLIED ALONE OR WITH PHOSPHORUS AND POTASSIUM 1970

JOHN GRAVA, D.S. FAIRCHILD, B.D. McCASLIN AND R.S. FARNHAM

Most grass seed production fields in northwestern Minnesota receive annual applications of commercial fertilizers. Nitrogen, where used at rates of 90 pounds per acre or less, seems to be used up during the growing season and no carry-over effects are evident in the following crop. However, there is some phosphorus and potassium carry-over as shown by the build-up of P and K soil test levels in the top three inches of soil from topdressed fertilizer.

The objective of this study was to find out whether nitrogen alone would insure high seed yields on soils in which P and K levels have been built up by past fertilization.

In the spring of 1970 two field experiments were established in Lake of Woods county. General information on the experimental sites is given in Table 1. Soil test results are shown in Tables 1 and 3.

TABLE 1 LOCATION, SOIL TYPE, AGE OF STAND AND OTHER INFORMATION CONCERNING THE EXPERIMENTS

Field Number	Location	Soil Type	Species, Variety	Age of Stand	Burned
4	F. Baade L.O.W. County	Ulen Very fine sandy loam	Timothy, Climax	4th seed year	May 5, 1970
5	E. Helmstetter L.O.W. County	Spooner Very fine sandy loam	K. Bluegrass Park	1967 plow-back	Fall, 1969

TABLE 2. PHOSPHORUS AND POTASSIUM SOIL TEST LEVELS, FIELD NO. 4.

Depth of Sampling	Extractable P	Exchangeable K
INCHES	PP 2 M	PP 2 M
0-3	24	90
3-6	6	60
6-12	6	50

TABLE 3. PHOSPHORUS AND POTASSIUM SOIL TEST LEVELS, FIELD NO. 5.

Depth of Sampling	Extractable P	Exchangeable K
INCHES	PP 2 M	PP 2 M
0-3	72	130
3-6	50	90
6-12	10	70

A randomized block design was used with six treatments replicated seven times. Individual plots were 10 feet wide and 20 feet long. The nitrogen treatments (60, 90, 120 lbs/acre N) were topdressed by hand. The P and K treatments (0+40+40 lbs/acre P_2O_5 and K_2O) were topdressed with a Gandy spreader. All of these fertilizer treatments were made on May 5, 1970. Plant tissue samples were collected at the beginning of the emergence of heads or panicles Total nitrogen in tissue was determined by the Micro-Kjeldahl method, and the other elements were determined in a multi-element emission spectrophotometer. A strip 17 feet long and 34 inches wide up the center was cut for seed yields.

Seed yields and the N, P, K concentrations in tissue of grasses are reported in Tables 4 and 5.

TABLE 4. THE EFFECT OF NITROGEN FERTILIZATION WHEN APPLIED ALONE OR WITH PHOSPHORUS AND POTASSIUM ON SEED YIELD AND CHEMICAL COMPOSITION OF CLIMAX TIMOTHY F. BAADE, L.O.W. COUNTY

TREATMENT		YIELD OF SEED	N	P	K
N	LBS/ACRE	LBS/ACRE	PERCENT IN DRY MATTER		
	60	288 a	2.92 a	.35	2.45
	90	349 ab	3.24 b	.37	2.42
	120	360 b	3.34 b	.38	2.44
Significance		*	**	NS	NS
PK					
	None	338	3.31 b	.35 a	2.31 a
	0+40+40	327	3.05 a	.38 b	2.55 b
Significance		NS	*	*	**

The seed yield of timothy was increased significantly by increasing the N treatment from 60 to 120 lbs/acre. The N content of tissue from 90 lbs/acre treatment was significantly higher than that in tissue collected from the 60 lbs/acre treatment of nitrogen.

While the 0+40+40 fertilizer treatment did not affect the seed yield, it increased the P and K concentrations in tissue. The N content of tissue was significantly lowered by the PK treatment.

The N X PK interaction (not reported here) was nonsignificant. Thus, the effects of the nitrogen treatments on yield and chemical composition of grass tissue were the same with or without the PK treatment.

TABLE 5 THE EFFECT OF NITROGEN FERTILIZATION WHEN APPLIED ALONE OR WITH PHOSPHORUS AND POTASSIUM ON SEED YIELD AND CHEMICAL COMPOSITION OF PARK KENTUCKY BLUEGRASS. E. HELMSTETTER, L.O.W. COUNTY

TREATMENT		YIELD OF SEED	N	P	K
N	LBS/ACRE	LBS/ACRE	PERCENT IN DRY MATTER		
	60	146 a	2.59 a	.39 a	1.96
	90	189 ab	2.99 b	.40 ab	1.96
	120	203 b	3.30 c	.42 b	1.89
Significance		*	**	**	NS
PK					
	None	170	2.92	0.39 a	1.70
	0+40+40	189	3.00	0.42 b	2.16
Significance		NS	NS	**	NS

The seed yield, and the N and P contents of bluegrass tissue were increased by increasing the N rate from 60 to 120 pounds per acre. The only effect the 0+40+40 fertilizer treatment had was an increased content of P in tissue.

The N X PK interaction was nonsignificant. Thus, the effects of the nitrogen treatments on yield and the N,P,K content of grass tissue were the same with or without the PK treatment.

TRACE ELEMENT STUDY WITH KENTUCKY BLUEGRASS ON PEAT - 1970[1]

John Grava, D. S. Fairchild, B. D. McCaslin and R. S. Farnham

In 1968 an investigation was initiated to determine whether the seed yields of grasses can be increased by fertilization with trace elements. A second objective of this study was to determine what effect would trace element additions to various soils have on the chemical composition of grass tissue. There were three reasons for this:

1. Judging from the keen interest in trace element needs shown by farmers of other areas of the state, it was expected that sooner or later the grass seed producers of northwestern Minnesota would raise similar questions.
2. Previous investigations had shown that the copper content of grass tissue grown on peat was well below the critical concentration, and lower than the content in tissue from mineral soils.
3. Some beef producers in the area had expressed concern about the quality of forage, especially the trace element content of hay produced on peat soils.

In 1968, four field experiments were conducted in Roseau and Lake of the Woods counties. Boron (B), copper (Cu), manganese (Mn) and zinc (Zn) treatments were made to bluegrass and timothy on mineral

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[1] See"A Report on Field Research in Soils", Soil Series 84, March 1969, pp. 172-176, and Soil Series 86, March 1970, pp. 133-138 for results obtained from similar investigations conducted in 1968 and 1969.

and peat. No yield increases were obtained. In one trial on mineral soil boron decreased bluegrass seed yield by about 100 pounds per acre. The concentration of trace elements in tissue was not affected on some fields. Therefore, the rates of Mn and Zn were doubled in the 1969 and 1970 trials.

In 1969, seed yields of grasses were not affected by trace element treatments on mineral soils. On peat, however, the yield of bluegrass was increased by 124 pounds per acre with the combined treatment of all four trace elements. Copper alone increased the seed yield on this soil by 60 pounds per acre. The trace element contents in grasses were increased with the rates used on organic as well as on mineral soils. The copper content of bluegrass tissue on peat was increased to 8 ppm by an application of 50 lbs/acre of copper sulfate. Only 2 or 3 ppm of Cu were found in tissue without the copper treatment. According to studies conducted elsewhere, when the plant tissue contains less than 6 ppm Cu, responsive crops are likely to show copper deficiency.

Copper, when used in the sulfate form, is rather expensive. The cost of 50 lbs/acre of copper sulfate is about $17. Copper chelate treatments, if effective, would cost only about $6 per acre. For this reason the copper chelate as well as copper sulfate forms were used in the 1970 trials.

In 1970, three field experiments with Kentucky bluegrass and timothy were conducted to study the effects of trace element applications on seed yields and chemical composition of tissue. All materials were top-dressed on established stands of grasses on growers' fields. General information on the experimental sites is given in Table 1, and soil test results are shown in Table 2.

Table 1. Location, age of stand and other information concerning the experiments.

Field No.	Location	K. Bluegrass variety	Age of Stand	Burned
1.	Ed Baumgartner Roseau County	Park	1968 seeding	Fall 1969
2.	C. Habstritt Roseau County	Park	1968 seeding	No
3.	Earl Swenson Clearwater County	Merion	1968 seeding	No

Table 2. Extractable copper and zinc in the top three inches of soil.

Location	Copper* ppm	Zinc* ppm
Field 1	0.1	2.2
Field 2	0.7	2.2
Field 3	0.3	5.1

* Extracted with 0.01 M EDTA-1.0 M $(NH_4)_2CO_3$. This solution is used by the University of Minnesota Soil Testing Laboratory in the test for zinc. Extracts are analyzed on the atomic absorption spectrophotometer.

A randomized block design was used with six treatments replicated seven times.

Following amounts and sources of trace elements were used:

Treatment	Rate and Material
1. None	---
2. Copper sulfate	50 lbs./acre $CuSO_4 \cdot 5H_2O$.
3. Copper chelate	1 or 2 lbs./acre of sequestrene copper chelate, 13% Cu.*
4. Zinc sulfate	50 lbs./acre $ZnSO_4 \cdot H_2O$
5. Copper sulfate + zinc sulfate	Same as above
6. Copper chelate + zinc sulfate	Same as above

* 1 lb/acre rate of Cu - chelate was used on fields 1 and 2; field 3 received 2 lbs/acre of Cu - chelate.
All trace elements were applied on May 5, 1970. The copper sulfate and zinc sulfate were spread by hand. The copper chelate was dissolved in water and applied with a funnel-top sprayer.

All treatments received a uniform application of the following plant nutrients, expressed as N, P_2O_5, K_2O in lbs./acre: Field No. 1, 15 + 60 + 60 fall 1969; Field No. 2, 10 + 60 + 40, fall 1969; Field No. 3, 12 + 48 + 48, May 5, 1970.

The individual plots were 10 feet wide and 20 feet long. Plant tissue samples were collected at the beginning of the emergence of panicles. Contents of the four trace elements were determined in a multi-element emission spectrophotometer. A strip 17 feet long and 34 inches wide up the center was cut for seed yields.

Table 3. Effect of trace element applications on the seed yield of Kentucky bluegrass on peat, 1970.

Treatments of trace elements	Field 1 Park (E.B.)	Field 2 Park (C.H.)	Field 3 Merion (E.S.)
	Yield of seed, lbs./acre		
1. None	184	354	260
2. Copper sulfate	180	397	285
3. Copper chelate	179	326	314
4. Zinc sulfate	176	346	294
5. Cu-sulfate + Zn-sulfate	188	367	300
6. Cu-chelate + Zn-sulfate	165	360	285
Significance	N.S.	N.S.	N.S.
CV	23	20	18

Table 4. Effect of trace element applications on the chemical composition of Kentucky bluegrass tissue grown on peat, 1970. Field 1, Park, E. B.

Treatment	B	Cu	Mn	Zn
	Parts per million in dry matter			
1. None	10	2	45c	27ab
2. Cu-sulfate	9	6	41ab	26a
3. Cu-chelate	10	3	41ab	29abc
4. Zn-sulfate	10	3	44bc	31bc
5. Cu-sulfate + Zn-sulfate	10	5	41ab	31bc
6. Cu-chelate + Zn-sulfate	9	4	39a	32c
Significance	N.S.	N.S.	*	*
CV	12	108	8	11

Table 5. Effect of trace element applications on the chemical composition of Kentucky bluegrass tissue grown on peat, 1970. Field 2, Park, C.H.

Treatment	B	Cu	Mn	Zn
	Parts per million in dry matter			
1. None	12	1a	79	31ab
2. Cu-sulfate	13	4bc	76	30a
3. Cu-chelate	14	4bc	82	31ab
4. Zn-sulfate	13	2ab	73	33ab
5. Cu-sulfate + Zn-sulfate	12	5c	65	34b
6. Cu-chelate + Zn-sulfate	12	5c	73	37c
Significance	N.S.	**	N.S.	**
CV	13	50	17	10

Table 6. Effect of trace element applications on the chemical composition of Kentucky bluegrass tissue grown on peat, 1970. Field 3, Merion, E.S.

Treatment	B	Cu	Mn	Zn
	Parts per million in dry matter			
1. None	12	2a	66	33a
2. Cu-sulfate	12	10bc	63	33a
3. Cu-chelate	11	6ab	59	33a
4. Zn-sulfate	12	2a	60	43b
5. Cu-sulfate + Zn-sulfate	12	11c	58	44b
6. Cu-chelate + Zn-sulfate	12	5a	59	46b
Significance	N.S.	**	N.S.	**
CV	12	67	10	10

Seed yields of bluegrass grown on peat were not affected by applications of copper sulfate, copper chelate or zinc sulfate (Table 3).

Effects of trace element treatments on the chemical composition of grass tissue are shown in Tables 3, 4 and 5.

Copper

On Field 1 (Table 4), the grass tissue had only 2 ppm of Cu. Copper treatments resulted in slight, but nonsignificant, increases in the concentration of copper.

On Field 2 (Table 5), the grass tissue from check plots contained only 1 ppm Cu. Copper content was increased to 4 or 5 ppm by the copper treatments. The application of 1 lb/acre of Cu-chelate was as effective as the 50 lbs./acre of Cu-sulfate treatment in affecting the copper concentration of Park K. bluegrass on this field.

On Field 3 (Table 6), the copper content of Merion K. bluegrass tissue was increased from 2 ppm to 10 or 11 ppm by application of 50 lbs./acre of Cu-sulfate. Cu-chelate, applied at 2 lbs./acre increased copper in tissue to 5 or 6 ppm.

Zinc

The concentration of zinc in bluegrass tissue was increased at all three locations with the application of 50 lbs./acre of zinc sulfate.

THE COMPARATIVE EFFECT OF TWO NORTH DAKOTA LIGNITE BASE REINFORCED FERTILIZERS ON LAWN GRASS GROWTH IN 1970

J.M. MacGregor and B.D. McCaslin

The possible use of lignite extracted from North Dakota beds as a suitable organic material for the incorporation of additional fertilizer nutrients to be sold for lawn turf improvement was studied. Two grassed areas in the village of Falcon Heights were employed to compare available fertility present in these to similar amounts present in the usual mineral base fertilizers. Four replications of 11 fertility treatments were laid out in 10' x 15' plots on each of two fields with no supplemental sprinkling facilities. A comparable mix of ammonium nitrate (33-0-0), superphosphate (0-46-0) and nitrate of potash (0-0-60) to supply a 12-5-5 mineral fertilizer mixture was used for comparison. The three fertilizer materials were then broadcast to supply a total fertility equivalent of 24 lbs per 1000 sq. ft. of the 12-5-5 mineral mixture; of the lignite based 12-5-5, and of the 10-10-5 in either 1,2, or in 3 treatments (May,May and late June; May, late June, and mid-August.) In addition to these treatments, an extra heavy treatment was made of the 12-5-5 lignite base fertilizer was applied at the 24 pound rate in both the May and late June applications, making a total of 48 pounds per 1000 sq. ft. of lawn area. Each of the 11 treatments was replicated four times in a randomized block design on the two grassed areas. Clippings were harvested when appropriate and green weights were recorded.

The weights of grass clippings in pounds per plot are shown in Tables 1 & 2.

1.
This study was largely financed by Natro Gro. Inc.

TABLE 1.

GREEN WEIGHTS OF LAWN GRASS CLIPPINGS DURING 1970 FOLLOWING FERTILIZATION WITH COMMERCIAL SPECIALTY FERTILIZER OR WITH ONE OF TWO NORTH DAKOTA LIGNITE BASE FERTILIZER MIXTURES. (average of 4 replications)

(U. Farm lawn - fertilized May 24th, June 28th, and August 22nd)

Lbs per / 1000 sq. ft. per application	Fertilizer N P_2O_5 K_2O	Date of Clipping 6/2	6/17	7/1	8/10	8/21
		pounds of green clippings per plot				
None	None	1.8 a	2.7 a	1.1 a	3.2 a	1.0 a
8+8+8	12-5-5 (commercial)	3.6 bc	5.2 bc	1.2 ab	9.2 bc	1.4 a
8+8+8	12-5-5 (lignite base)	3.7 bc	5.3 bc	1.2 ab	8.5 bc	1.4 a
8+8+8	10-10-5 (lignite base)	3.0 b	4.9 b	1.3 ab	7.5 b	1.2 a
12+12	12-5-5 (commercial)	3.5 bc	7.4 c	2.6 c	12.8 d	1.8 a
12+12	12-5-5 (lignite base)	4.0 cde	6.3 bc	1.7 abc	12.4 d	1.8 a
12+12	10-10-5 (lignite base)	3.7 bcd	6.6 bc	1.4 ab	10.9 cd	1.6 a
24	12-5-5 (commercial)	4.3 cde	11.3 d	2.6 e	9.1 bc	1.5 a
24	12-5-5 (lignite base)	4.1 cde	11.7 d	2.9 c	8.4 bc	1.3 a
24	10-10-5 (lignite base)	4.9 e	11.1 d	2.4 bc	7.4 b	1.4 a
24+24	12-5-5 (lignite base)	4.6 de	11.2 d	2.8 c	21.5 e	3.3 b

Values (in vertical columns) followed by the same letters are not significantly different at the same level.

TABLE 2.

GREEN WEIGHTS OF LAWN GRASS CLIPPINGS DURING 1970, FOLLOWING FERTILIZATION WITH COMMERCIAL SPECIALTY FERTILIZER OR WITH ONE OF TWO NORTH DAKOTA LIGNITE BASE FERTILIZER MIXTURES (average of 4 replications)

(MacGregor lawn - fertilized May 5th, June 29th, and August 21st)

Lbs/1000 sq. ft. /application	Fertilizer N P_2O_5 K_2O	DATE OF CLIPPING								
		5/3	5/19	5/28	6/2	6/16	7/1	7/30	8/14	9/4
None	None	3.4 N.S.	2.6 a	3.1 a	1.4 a	2.8 a	1.5 a	1.4 a	1.7 a	1.2 a
8+8+8	12-5-5 (commercial)	4.0 N.S.	3.6 ab	4.5 b	2.3 b	42 ab	2.0 ab	4.1 bcd	3.8 cde	2.0 ab
8+8+8	12-5-5 (lignite base)	3.5 N.S.	3.4 ab	4.7 bc	2.3 b	4.3 ab	2.0 ab	3.6 bc	3.4 bcd	1.5 ab
8+8+8	10-10-5 (lignite base)	3.4 N.S.	3.5 ab	4.7 bc	2.2 b	3.9 ab	2.0 ab	3.3 ab	3.1 bc	1.6 ab
12+12	12-5-5 (commercial)	3.8 N.S.	3.6 ab	5.4 bc	3.0 c	5.4 b	2.y bc	5.9 de	5.0 e	2.4 b
12+12	12-5-5 (lignite base)	03.8 N.S.	4.0 ab	5.6 bc	2.9 bc	4.7 ab	2.0 ab	4.3 bcd	4.4 de	1.9 ab
12+12	10-10-5 (lignite base)	04.1 N.S.	4.0 ab	5.9 c	3.0 c	5.3 b	2.5 bc	5.2 cde	4.8 e	2.1 ab
24	12-5-5 (commercial)	4.2 N.S.	4.5 b	7.3 d	4.4 d	8.3 cd	4.0 e	2.6 ab	2.5 ab	1.6 ab
24	12-5-5 (lignite base)	3.8 N.S.	4.6 b	7.4 d	4.8 d	8.3 ce	3.5 de	2.4 ab	2.2 ab	1.3 a
24	10-5-5 (lignite base)	3.1 N.S.	4.0 ab	7.3 d	4.5 d	7.0 c	3.1 dd	2.5 ab	2.2 ab	1.2 a
24+24	12-5-5 (lignite base)	4.3 N.S.	4.8 b	7.9 d	5.0 d	9.2 d	4.0 e	6.2 e	7.3 f	3.5 b

NS - Not significant

Values (in vertical columns) followed by the same letters are not significantly different at the same level.

Green clipping weights showed that the two lignite base fertilizers were not superior to equivalent amounts of the same nutrients present in the commonly used mineral commercial lawn fertilizers. Therefore, they would be competitive with the present specialty lawn fertilizers only if they could be manufactured at the same or at lower cost and sold at approximately the same price.

The application of the large amounts of fertilizer at one time, or split into two or three treatments during the growing season produced much the same result with all three fertilizers. Where the 24 lb/1000 sq. ft. was applied all at one time initial grass growth was very rapid in comparison to that produced by the splitting the treatment for later application(s). However, by early September grass growth with all three methods of fertilization was not significantly different.

Growth on plots receiving the extra heavy lignite base fertilizer treatment (24 + 24 of 12-5-5) was significantly greater and remained at a significantly higher production level even at the close of the growing season.

SOILS WITH FRAGIPANS IN WEST CENTRAL MINNESOTA

R. H. Rust, P. P. Antoine, and E. R. Gross

Field studies have been continued on plots established in 1966 at Sebeka in Wadena Co. located on Rockwood and Blowers sandy loams. (Typic and Aquic Fragiboralfs).

A satisfactory growth of alfalfa and bromegrass has been maintained for 4 years on this soil with a fragipan at about 26 inches. The 4 year average yield is 3.4 tons per acre (adjusted to 15% moisture). Plant analyses indicate that supplemental P (40 lbs/acre/yr) and K (120 lbs/acre/yr) has been sufficient to maintain P content of alfalfa at 0.24% and K at 2.0%. The supplemental (annual) P and K treatment produces an additional 1 T/A yield. However, plant analysis also indicated that the plant content of Ca, Fe, Mg, Zn, Cu, and B were lower-by-half than in previous years. Boron deficiency was evident in mature plants for the first time in 1970. Protein content (8.7%) compared to the previous year, was less-by-half.

One of the objectives of the study has been to ascertain the problems in establishing and maintaining satisfactory alfalfa, or alfalfa-brome, hay and pasture on soils with fragipan. It seems fairly evident that an initial high fertility input (lime + P + K + S) is necessary. Maintenance of quality stand over a 3-5 year period depends on annual increments of P and K and probably boron and sulphur. The early and rapid growth of an adequately fertilized legume-grass will remove the perched water table by May 15 in most years. The rooting zone of the alfalfa-brome mixture does not extend into the fragipan to any appreciable extent, so the "spreading-root" alfalfa varieties performed little or no better than the usual "tap-rooted"

varieties.

A preliminary experiment in flooding demonstrated that the soil could be saturated to the fragipan but, after 48 hours, the fragipan and the soil horizon below remained at less than field capacity.

Three years of continuous soil temperature monitoring were completed in May, 1970. Temperatures are measured at 6, 15, and 27 inches. Winter soil temperatures from December 15 - April 15 were nearly constant as a result of continuous snow cover and remained at about 34-37° F.

Mineralogical and micro-morphological studies of the fragipan lead to the conclusion that silicate clay is the principal bonding agent in the fragipan but that Al and Fe oxides as coatings on structural pieces also reinforce bridging between particles.

The nature of and depth to the fragipan as such preclude, at present, any economical amelioration. Calcareous soil materials are commonly below the fragipan in the Wadena drumlin areas and would be satisfactory materials in or near the rooting zones if economical mechanical means were available to incorporate them.

IRRIGATED CORN FOLIAR LEAF ANALYSES

H. L. Meredith and J. O. Jacobson

Foliar analyses have been used to compare nutrient values in the vegetative tissue and hence have provided a limited knowledge of possible visibly observed differences. The studies discussed here will concern only corn. Typically, tissue values have been based on an optimal or minimal level at "silking". For numerous reasons, fields cannot be sampled exactly at silking. Droughty conditions at this critical time in the development of the corn plant often result in low tissue values, especially for those elements moving to the root surfaces by the diffusion mechanism, particularly P and K.

During the 1970 growing season, corn leaves were sampled at nine different dates from June 30 until September 17. The hybrid was a single cross 83-day relative maturity. Samples were taken from two locations. Planting date was May 2. No fewer than 10 samples made up the single composite sample at each location and date. Plant selection was taken from the "middle" of the plant at all sampling dates. This corresponded to the 6th leaf from the top or ultimately the ear leaf. Leaves were counted from the bottom and top to ensure the same corresponding leaf was sampled at different stages of development.

The data appear in Table 1. In general, the soil moisture levels were below "field capacity" and above the "wilting point" throughout the growing season. Sampling was accomplished following irrigation from one to five days. The temperature during the growing season was

much above seasonal normal. Even though soil moisture was adequate, the plants were under moisture stress as evidenced by cellular turgidity. Transpiration exceeded moisture uptake under these conditions due to high temperature.

The data indicate a seemingly broad plateau for those elements normally included in fertilizers. The fertility level at both locations was quite "average". The relatively high value for phosphorus is likely due to the higher diffusion rate occurring under warm-moist conditions, high native phosphorus levels and coarse textured soil.

Table 1. Foliar composition from an irrigated single-cross 83-day relative maturity hybrid sampled at nine sampling dates during the growing season. Verndale, Minnesota.

Corn Sampling
Ear Leaf
Irrigated Corn
Staples, Minn.

1970	6/30	7/7	7/15	7/21	7/30	8/14	8/18	9/3	9/17
Element									
Phosphorus (P)	.46	.35	.36	.36	.39	40	42	.26	.19
Potassium (K)	3.4	2.9	2.0	2.2	2.1	1.8	2.1	1.9	1.3
Calcium (Ca)	.34	.39	.43	.42	.52	.50	.85	.90	.78
Magnesium (Mg)	.16	.18	.22	.21	.25	.25	.32	.34	.29
Iron (Fe)	176	236	191	201	237	233	325	425	500
Zinc (Zn)	22	29	32	22	23	24	19	25	12
Copper (Cu)	2.7	4.2	4.7	3.5	6.0	4.3	7.5	4.9	5.1
Molybdenum (Mo)	2.9	3.6	9	7	7.6	8.2	5	5	9.6
Manganese (Mn)	56	51	60	46	61	46	63	68	62
Boron (B)	19	9	16	14	9.3	14	11	8	10
Nitrogen (N)	3.74	3.58	3.07	2.91	2.72	2.79	2.77	1.36	1.22

The corresponding physical development to dates of sampling is as follows:

Date	Physical Development	Date	Physical Development
6/30	18" high*	8/4	90% silk
7/7	36" high	8/18	Late milk, early dough
7/15	Tasseled	9/3	Mature
7/21	40% silk	9/17	Fully mature
7/30	70% silk		

*Indicates average extension of all leaves of plant.

A second study involved sampling all leaves of the corn plant, same hybrid and growing condition as previously described.

This study was prompted by a September 10 sampling of a 95-day relative maturity hybrid in 1969. The values were interesting, Table 2.

Table 2. Foliar composition of a single-cross 95-day relative maturity hybrid grown under irrigated conditions, Verndale, Minnesota, 1969, fully dented and all leaves green and functioning.

Leaf No.*	Percent					Parts Per Million	
	N	P	K	Ca	Mg	Zn	B
1	2.2	.23	1.1	1.2	.22	56	11
2	2.2	.30	1.5	1.1	.27	59	9.0
3	2.5	.34	1.6	1.0	.31	52	8.4
4	3.0	.49	1.6	1.0	.37	49	7.9
5	3.0	.50	1.8	.86	.36	41	6.6
6(ear leaf)	2.7	.43	2.0	.84	.34	27	5.0
7	2.7	.39	2.4	1.0	.42	24	5.5
8	3.0	.43	2.3	.93	.39	28	5.2
9	2.6	.32	2.4	.84	.39	18	4.2

*Counting from top to bottom of plant.

In 1970 corn tissue was sampled at four different dates at two locations from July 15 to August 20.

All of the leaves were sampled starting at the top of the plant, Table 3.

Table 3. Averaged irrigated corn leaf values, sampled at two locations and four sampling periods July 15-August 20, Verndale, Minnesota, 1970.

	Percent					Parts Per Million				
Leaf No.**	N	P	K	Ca	Mg	Zn	Cu	Mo	Mn	B
1	3.07	.33	1.3	.59	.22	69	4.6	7.8	73	18
2	2.91	.37	1.6	.58	.22	58	5.1	7.6	69	18
3	2.93	.36	1.5	.59	.27	48	6.0	8.7	59	17
4	3.08	.40	1.8	.59	.26	34	4.5	8.0	56	12
5	2.99	.39	1.9	.56	.26	27	5.3	8.6	56	13
6	2.93	.40	2.1	.59	.29	21	5.2	9.7	56	12
7	2.84	.38	2.0	.57	.29	19	4.0	9.7	50	13
8	2.94	.35	2.1	.66	.33	15	4.8	9.7	53	12
9	2.81	.35	2.4	.72	.41	14	3.5	10	57	16
10	2.62	.31	2.6	.85	.46	14	3.5	11	61	15

**Counting from top to bottom of plant.

Plant tissue analyses indicate neither the leaf selected nor the time of sampling is critical. One should use discretion when sampling corn tissue for foliar analyses. Selection of leaves near the middle of the plant regardless of maturity level will provide data of value.

The Effect of Some Dry Ashing Factors on the Elemental Composition of Plant Tissue as Analyzed by Emission Spectroscopy

by

Robert C. Munter and Gary C. Halvorson

A review of the literature on method involving dry ashing shows a wide variety of recommended ashing temperatures (450° to 650°) and times (2 to 16 hours) for various elements. Acid pretreatments, including nitric acid treatments of ash have also been suggested. Sample weights and dilution of the sample ash must be sometimes be varied. Some samples have a high residual carbon remaining in the ash, and there is concern whether the oxidation was sufficient to release the elements sought.

This study is an attempt to measure some of these effects and also to arrive at some measure of variability that one can expect for the different elements. The primary objective was to establish the lowest temperature and shortest length of ashing time possible and yet obtain maximum elemental extraction form the ash. Parts of this study was carried out at different times so different samples were sometimes used to measure the different effects. Solutions of the sample ash were analyzed on a Jarrell Ash 1.5 meter spark emission, direct reading, spectrograph. The data was analyzed statistically by use of the computing centers SP33 analysis of variance program. Treatment means, overall means, coefficients of variability, and significance testing results are shown in tables 1 and 2.

Effect of Temperature

Copper and Zn were the only elements to be affected to a significant degree as the maximum temperature of the muffle furnace was in-

creased from a low of 475° C to a high of 625° C. Throughout this range Cu decreased from 11.8 to 5.8 ppm due to volatilization as shown in Table 1 under "Effect of temperature". Line increased nearly 20% upon reaching 625° C. Because of this abrupt increase and some inconsistency among the means, this data should be viewed with caution. Although not significant, K, Ca, Mg, and B show a slight decrease with increasing temperature.

Effect of Nitric Acid Treatment of Ash

The ash from the corn leaf sample used in studying this effect contained a considerable amount of residual carbon even after ashing at 575° C for 10 hours. The ash was saturated with a few drops of concentrated nitric acid and heated on a hot plate to near dryness. The treated samples were again placed in the muffle furnace for 2 hours at 525° C. No residual carbon remained after this treatment. The results of the significance test in table 1 under "Effect of acid Treatment", show a significant increase in Al and a highly significant decrease in Cu and boron. The treatment means for Cu and B were reduced by two-thirds. For most of the other elements the means for the acid treatment are somewhat lower but not of significance.

Effect of Dilution

The treatment means in Table 1 under "Effect of Dilution" show a slight decrease in the concentration for all elements with the greater dilution of the ash. Aluminum and boron are the only elements that show a significant decrease. A large difference occurs between the means for Zn, but was not significant due to the large variability that occurred within the treatments. In general a greater dilution is expected to decrease spectrochemical interferences. The 5 and 10 fold dilutions consisted of the additional of 2.5 and 5.0 ml of 0.5% Li-Hcl solution to the ash from

0.5 g sample. Some of the variability may be due to the lower accurracy and precision in the semi-automatic pipetting of 2.5 ml as compared to 5 ml. The addition of 5 ml of 0.5% Li - HCl to the ash form a 0.5 g sample is preferred in our situation. The 0.5% Li - HCl solution used is a standard mixture used for all analysis by this spectrograph. The acidity is about 1.02 N.

Effect of Sample Weight

Table 1 under "Effect of sample Weight", shows no significant differences between the concentration of elements between ashing a 0.5 g or a 1.0 g sample. The whiter ash from a 0.5 sample did not result in higher values. The muffle furnace used has a capacity of 196 samples and because of the large amount of smoke generated, 0.5 g samples are preferred. The minimum weight of plant tissue that will yield a sufficient concentration for analysis would in general be about 0.1 g with the ash dissolved in 1 ml of acid solution. Sampling and contamination errors would be expected to increase with a decrease in sample size.

Effect of Ashing Time

Table 2 shows that there are no significant differences in concentration between ashing at maximum temperature for 3 or 10 hours, or 10 and 20 hours. The treatment mean for Cu at 20 hours is considerably lower than for 10 hours, but is not significant because of the high degree of variability. The c.v. for Cu is 18.6%. The shorter ashing time would therefore be recommended not only because of economics but would thus enable one to routinely ash samples during daily working hours. In the past samples were ashed only in the evening with a timer controlling the length of the ashing period.

Summary

Although this study was limited in several areas it provided some essential background information regarding the variables studied including some indication of variability. It must be kept in mind that the variability shown is partially the result of the different treatments. The variability actually occurring in a routine situation would be expected to be less. Following are some general conclusions arrived at.

1. Most elements were not significantly affected increasing the ashing temperature from 475° C to 625°C.
2. Copper decreased significantly with increased temp., highest values at 475 °C.
3. Recommended ashing temperature is 475 - 500°C
4. No difference found between 3 or 20 hours at maximum temperature.
5. Longer ashing times did not result in more complete oxidation of samples that have a high carbon residue in the ash.
6. No essential difference between sample weights and dilutions were found.
7. Aluminum increased, but Cu and B losses were great when the ash was treated with nitric acid and re-muffled.
8. Treating a dark colored ash with nitric acid and heating on a hot-plate, not re-muffled, did not result in an increase nor a decrease for any of the elements.
9. The order of variability giving the average of all coefficients of variability for all treatments is as follows:

Cu 10.5 > Zn 10.1 > Mo 8.7 > Sr 8.1 > Al 4.4 > Ca 4.3 > Mg 3.7 = K 3.7 > Mn 3.6 > P 3.3 = B 3.3

TABLE 1

Means, Coefficients of Variability, and Significance Test for 12 Elements in "Effect of Temperature, Acid treatment, and Dilution" in Dry Ashing Study.

Treatments	%				PPM						
	P	K	Ca	Mg	Al	Fe	Zn	Cu	Mo	Mn	B
Effect of Temperature	Means of treatments (3 reps) for corn leaf tissue (sample A)										
475°C	.262	1.49	.687	.398	35.7	111	24.7	11.8	6.5	55.8	9.8
525°C	.255	1.45	.673	.390	-	113	26.1	10.8	6.4	54.9	9.5
575°C	.261	1.41	.676	.389	37.5	116	25.0	9.3	6.3	55.4	9.6
625°C	.254	1.34	1.651	.3.89	36.3	111	29.6	5.8	6.4	53.0	9.3
Overall mean	.258	1.42	.672	.391	36.5	113	26.4	9.5	6.4	54.8	9.6
% C.V.	5.6	6.6	3.7	3.2	3.4	7.6	3.4	14.6	7.1	2.8	4.8
Significance Test	NS	NS	NS	NS	NS	NS	**	**	NS	NS	NS
Effect of Acid Treatment"	Means of treatments (6 reps) for corn leaf tissue (sample B)										
No acid	.271	1.69	.587	.373	43.3	113	18.2	10.2	7.2	44.7	6.1
Acid	.272	1.63	.571	.362	49.6	110	14.4	4.0	7.4	41.9	2.1
Overall mean	.271	1.66	.579	.367	46.5	112	16.3	7.1	7.3	43.3	4.0
% C.V.	2.4	3.8	4.5	3.7	5.9	71	15.6	12.2	3.7	5.1	2.5
Significance Test	NS	NS	NS	NS	*	NS	NS	**	NS	NS	**
Effect of Dilution	Means of treatment (3 reps) for corn leaf tissue (sample B)										
5 fold	.277	1.74	.597	.378	46.4	119	20.9	10.9	7.3	45.7	6.0
10 fold	.265	1.68	.594	.361	40.6	110	16.5	9.6	6.9	45.0	5.7
Overall mean	.271	1.71	.585	.370	43.5	114	18.7	10.3	7.1	45.4	5.9
%C.V.	1.2	3.7	2.1	3.7	2.9	9.1	19.0	8.8	4.5	1.8	1.2
Significance test	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	*
Effect of Sample Weight	Means of treatments (3 reps) for corn leaf tissue (sample B)										
0.52	.265	1.68	.574	.361	40.6	110	16.5	9.6	6.9	45.0	5.7
1.02	.264	1.67	.582	.368	41.2	107	16.7	8.9	6.8	45.7	5.7
Overall mean	.265	1.68	.578	.365	40.9	109	16.6	9.3	6.9	45.4	5.7
%C.V	1.2	3.7	4.7	7.2	5.6	31	0.9	7.1	18.9	6.0	3.8
Significance Test	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

TABLE 2

Means, Coefficients of Variability, and Significance Test for 12 Elements in "Effect of Time at Maximum Temperature" in Dry Study.

	%				PPM							
	P	K	Ca	Mg	Sr	Al	Fe	Zn	Cu	Mo	Mn	B
	Means of treatments (3 reps) for a mixture of plant tissue (corn, alfalfa, oats)											
3 hours at 485°C	.255	1.72	.904	.468	29.7	-	130	16.6	61.5	14.7	61.5	20.7
10 hours at 485°C	.244	1.69	.915	.466	30.6	-	127	15.7	63.3	12.1	61.8	20.1
Overall mean	.250	1.71	.910	.467	30.1	-	128	16.2	62.4	13.3	61.6	20.4
%C.V.4	2.4	3.3	2.4	1.1	4.0	-	1.5	11.4	1.9	15.9	0.9	1.8
Significance test	NS	NS	NS	NS	NS	-	NS	NS	NS	NS	NS	NS
	Means of treatments (3 reps) for sugar beet leaf tissue											
3 hours at 485°C	.255	2.07	.561	1.05	3.27	-	132	164	12.5	22.4	58.8	46.0
10 hours at 485°C	.240	2.03	.602	1.02	3.97	-	151	203	12.9	21.4	59.4	44.0
Overall mean	.248	2.05	.582	1.04	.362	-	142	183	12.7	21.9	59.1	45.0
% C.V.	2.0	2.0	7.1	3.5	12.2	-	9.9	12.7	-	1.5	3.8	2.1
Significance test	NS	NS	NS	NS	NS	-	NS	NS	NS	NS	NS	NS
	Mean of treatments (3 reps) for corn leaf tissue (sample A)											
10 hours at 575°C	.261	1.41	.676	.389	-	37.5	116	25.0	9.3	6.4	55.4	9.6
20 hours at 575°C	.265	1.39	.666	.379	-	38.3	116	32.3	6.5	6.8	53.5	9.6
Overall mean	.263	1.40	.671	.384	-	37.9	116	28.7	7.9	6.6	54.5	9.6
% C.V.	8.5	2.6	6.6	3.8	-	4.5	8.6	7.4	18.6	9.4	5.2	7.1
Significance test	NS	NS	NS	NS	-	NS	NS	NS	NS	NS	NS	NS

Variability of Webster and Waukegan Soil Series for Some Soil Elements and Related Plant Composition

R. C. Munter and R. H. Rust

As a part of the 4 year (1965-69) study on Genetic Control of Physiological Processes, our field research effort had the following objectives:

1. To assess the soil variability in a field plot situation in respect to a number of essential mineral elements. The variability was measured in the surface (0-6 inches) and in the subsurface (6-12 inches).
2. To correlate the amounts of elements extracted by selected procedures with above ground plant uptake.
3. To evaluate time of soil sampling during the growing season as it might relate to plant uptake.

The following summary is not all-inclusive but is an indication of the nature of findings.

A. Relationship between ion availability and ion accumulation.

1. Using the 1966 data for Waukegan and Webster soils from barley plots where soil and plant samples were taken at 7-10 day intervals throughout the growing season a correlation matrix was constructed to examine the relationship between soil and, particularly whole plant values for the elements Ca, Mg, K, Sr, Cu, Zn, P, Fe, and Mn, Table 1. The extracting solutions were Bray's No. 1 for P, neutral 1 N NH_4Ac for Ca, Mg, K, Sr, and Mn, and 0.1 N HCl for Zn, Cu and iron.

Examination of Table 1 shows that (1) in respect to correlation of a soil value of a particular element and the amount of the same element in the whole barley plant only P was correlated for the majority of sampling dates but (2) in respect to soil values of particular elements and other elements in the whole plant several correlations seem significant -

soil P with plant P, K, and Mn

soil Mg with plant K, P, Zn, and Mn

soil Ca with plant K, P, and Zn

soil Fe with plant Mn

soil K with plant Sr

The last noted was correlated significantly and negatively on 5 of 7 sampling dates, i.e., high soil K was associated with low Sr.

On the Waukegan soil, Mn is particularly well correlated with plant Mg and P and, to a lesser extent, with plant Ca, K, Sr, Fe and Zn. (First and last samplings are on Waukegan soil only.)

By sampling dates (or intervals) the number of significant soil to whole plant correlations for the 9 elements was as follows: 1st (15); 2nd (24); 3rd (38); 4th (5); 5th (22); 6th (16); 7th (20).

Thus soil samples taken at the third sampling date about the 4th week of barley growth, were found to have highest number of significant correlations with whole plant content. This may correspond to a time of maximum utilization, or