Table 1. 1970 and 1971 corn yields, plant analyses and soil tests in Martin county according to broadcast phosphorus treatment.
(200+0+300+20 Zn applied over all phosphorus plots)

P_2O_5 lbs/acre	Yields bu/acre 1970	Yields bu/acre 1971	% P leaves 1970	% P leaves 1971	Soil Test P lbs/acre 1970	Soil Test P lbs/acre 1971
0	155	137 a	.26	.28	46	37
50	151	137 a	.26	.27	36	39
100	162	156 b	.27	.30	56	55
150	146	146 ab	.28	.30	65	63
200	145	154 ab	.28	.30	64	55

	1970	1971
Avg. starter response	4*	2
Avg. % N in leaves	-	2.7
Avg. K soil test	268	352
Avg. % K in leaves	1.70	1.88
Avg. soil pH	7.7	7.2
Avg. Zn leaves ppm	19 low	17 low
Avg. Zn soil ppm	-	5.3 high

Table 2. 1970 and 1971 corn yields, plant analyses and soil tests in Waseca county according to broadcast phosphorus treatment.
(200+0+200 applied over all phosphorus plots)

P_2O_5 lbs/acre	Yields bu/acre 1970	Yields bu/acre 1971	% P leaves 1970	% P leaves 1971	Soil Test P lbs/acre 1970	Soil Test P lbs/acre 1971
0	133	139	.31	.28	34	27
50	136	133	.30	.27	31	33
100	132	132	.28	.27	31	40
150	136	135	.29	.30	40	44
200	138	130	.29	.30	53	45

	1970	1971
Avg. starter response	13*	4
Avg. % N in leaves	-	2.8
Avg. K soil test	1.68	1.82
Avg. soil pH	6.4	6.1
Avg. Zn leaves ppm	26	16
Avg. Zn soil ppm	-	2.6 high

Table 3. 1970 and 1971 corn yields, plant analyses and soil tests in Martin county according to broadcast potassium treatment. (200+150+0+20 Zn applied over all potassium plots)

K_2O	Yields bu/acre		% K leaves		Soil Test K lbs/acre	
lbs/acre	1970	1971	1970	1971	1970	1971
0	156	148	1.7	1.8	202	230
50	147	154	1.7	1.8	212	258
100	152	149	1.6	2.1	222	278
200	147	143	1.8	2.1	270	328
400	160	149	1.8	1.9	243	320

	1970	1971
Avg. starter response	16*	3
Avg. % N in leaves	-	2.8
Avg. P soil test	50	62
Avg. % P in leaves	.25	.29
Avg. soil pH	6.4	6.1
Avg. Zn leaves ppm	22	22
Avg. Zn soil ppm	-	8.4 high

Table 4. 1970 and 1971 corn yields, plant analyses and soil tests in Waseca county according to broadcast potassium treatment. (200+150+0 applied over all potassium plots)

K_2O	Yields bu/acre		% K leaves		Soil Test K lbs/acre	
lbs/acre	1970	1971	1970	1971	1970	1971
0	134	123	1.6	1.4	260	210
50	129	120	1.7	1.7	275	213
100	139	131	1.7	1.7	260	220
200	132	116	1.8	1.8	262	223
400	134	120	2.2	1.9	312	310

	1970	1971
Avg. starter response	10*	7*
Avg. % N in leaves	-	2.7
Avg. P soil test	53	52
Avg. % P in leaves	.27	.31
Avg. soil pH	6.4	6.0
Avg. Zn leaves ppm	26	14
Avg. Zn soil ppm	-	3.0 high

ANALYSES OF TILE AND OPEN DITCH DRAINAGE WATERS IN SEVERAL SOUTH CENTRAL MINNESOTA COUNTIES (1968-71)

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, crop species and also on stage of crop growth, or fallow it was not possible to sample each location on a uniform interval schedule. The present report is a brief summary of results obtained during 1971. Some data obtained in the preceding 3 growing seasons has been previously reported in Soil Series 87.

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.

Accurate estimation of areas drained by tile lines is extremely difficult and per acre N and P losses are at best only an estimation. Drainage engineers have advised the assumption of 100' on each side of the tile rather than assuming the entire drainage basin area. Differences in calculated loss per acre are shown for NO_3-N and PO_4-P in drainage waters from 12 farm fields during six summer months in 1971 by the following table.

It is apparent that some tile drains are removing appreciable amounts of nitrate nitrogen (NO_3-N), even disregarding the method of estimation of drainage area nitrate N losses in drainage water is not consistent with amounts of fertilizer N applied in 1970 and 1971. Phosphorus loss is extremely small.

Estimated NO_3-N and PO_4-P Loss in Tile Waters From Twelve South Central Minnesota Farm Fields in 1971 (4/2 to 11/2).

(Textures vary from loam to silty clay loam)

	1970+1971 fertilizer (lbs/A)				Drainage basin	NO_3-N Loss in lbs/A assuming:		PO_4-P Loss in lbs/A assuming:	
County	N	P	1971 Crop	Ft. Tile	(acres)	200'	basin	200'	basin
Meeker	None	None	Corn	1800	15	23.6	12.6	0.02	0.01
Meeker	152	None	Corn	1500	40	0.6	0.1	0.40	0.07
McLeod	118	3	Soybeans	1500	15	3.4	1.6	0.02	0.01
McLeod	354	51	Corn	4000	80	33.0	7.5	0.04	0.01
Sibley	307	44	Corn	14000	130	27.4	13.5	0.02	0.01
Sibley	None	None	Fallow	1430	8	23.0	18.6	0.03	0.02
Sibley	20	42	Corn	2400	38	2.4	0.7	Tr.	Tr.
Sibley	175	26	Corn	2000	35	1.6	0.4	Tr.	Tr.
Renville	375	33	Corn	9000	45	28.0	25.4	0.02	0.02
Kandiyohi	140	26	Oats-alf.	600	10	8.6	2.4	0.12	0.03
Kandiyohi	12	53	Alf.-grass	1250	15	2.5	1.4	0.06	0.03
Kandiyohi	350	44	Corn	1200	8	32.6	32.6	0.01	0.01

METHOD OF PLANTING STUDY FOR CORN

Lancaster, Wisconsin Experimental Farm - 1971

William Paulson, James Swan, Arthur Peterson

Lancaster 1971

Alfalfa Sod No-Till Planting vs. Wheeltrack Planting (WTP).

Yield Summary (Bu/A)

Treatment	Rep I	Rep II	Rep III	Avg.
WTP	123.9	112.8	120.4	119.0
Sod No-Till	144.1	109.9	153.7	135.9

ANOVA

	DF	Sum of Squares	Mean Square	F	F 5%	10%
Reps	2	788.5433	394.2717	2.35	NS	(0.00=F) NS
Treatments	1	426.7267	426.7267	2.54	(18.51) NS	(8.53=F) NS
Error	2	335.9433	167.9717			

CV = 10.17%

No-tillage (on bare soil) vs. No-Till (mulched) vs. WTP.

Yield Summary (Bu/A)

Treatment	Rep I	Rep II	Rep III	Rep IV	Avg.
No-Till (bare)	78.7	96.4	87.7	78.8	85.4
No-Till (mulched)	131.2	106.5	116.9	104.7	114.8
WTP	99.3	99.6	95.7	121.8	104.1

ANOVA

	DF	Sum of Squares	Mean Squares	F	5%F	10%F
Reps	3	14.74917	4.916389	.03	NS	NS
Treatment	2	1774.062	887.0308	4.97	(5.14) NS	(3.46=F) Significant at 10% level
Error	6	1071.398	178.5664			

CV = 13.17%

Treatments are significantly different at 10% level, but not at 5% level.

Higher yields on mulch would appear to warrant further investigation of possible yield benefits from mulches.

No-Till (stalk residue) vs. WTP.

	Yield Summary (Bu/A)				
Treatment	Rep I	Rep II	Rep III	Rep IV	Avg.
No-Till (stalk)	115.6	99.0	76.4	107.9	99.7
WTP	114.2	114.4	98.2	93.8	105.2

ANOVA

	DF	Sum of Squares	Mean Squares	F	5%F
Reps	3	810.2938	270.0979	2.04	NS
Treatment	1	58.86125	58.86125	0.44	NS
Error	3	397.7237	132.5746		

CV = 11.24%

FERTILIZER RATE STUDY WITH "NEW" VARIETIES OF TIMOTHY AND KENTUCKY BLUEGRASS -- 1971

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

Four experiments were established on mineral soils in fall of 1970 to study effects of NPK rates on seed production of timothy and bluegrass varieties that are being introduced in northwestern Minnesota.

Past experimental work in Minnesota has been mainly with Park Kentucky bluegrass and Climax timothy. Attention has been focused on optimum rates of fertilizer, time of fertilization, and the needs for secondary and trace elements.

Grass seed production in Minnesota is expanding and undergoing some changes. A number of growers are producing timothy seed under contract for foreign markets, and seed of several new bluegrass varieties is produced by some growers. Continued research is required to keep abreast of these new developments.

General information on the experimental sites is given in Table 1. Soil test results are shown in Table 2.

Table 1. Location, soil type and other information concerning the experiments.

Field No.	Location	Soil Type	Species, Variety	Age of Stand	Burned
1.	Roy Kveen Roseau County	Bearden sil	Timothy Lorain	1969 Seeding	Spring 1971
2.	Ernest Brandli Roseau County	Glyndon fsl	Timothy Erecta	1968 Seeding	----
3.	Richard Jackson Roseau County	Glyndon sil	Timothy Evergreen	1969 Seeding	Spring 1971
4.	Lenard Johnson Roseau County	Unnamed sl	K.Bluegrass Primo	1969 Seeding	Post-Harvest Burn

Table 2. Soil Test Results*

Depth of Sampling, Inches	pH	Extractable P pp2m	Exchangeable K pp2m
		Field No. 1	
0- 6	8.0	26	280
6-12	8.2	6	210
		Field No. 2	
0- 6	7.2	9	40
6-12	7.4	4	40
		Field No. 3	
0- 6	8.1	15	80
6-12	8.3	3	60
		Field No. 4	
0- 6	8.0	10	100
6-12	8.2	2	80

* Samples collected in June 1971.

A randomized block design was used with nine treatments replicated four times. Individual plots were 9 feet wide and 20 feet long. The fertilizer treatments were as follows:

TREATMENT	N	P_2O_5	K_2O
	LBS/ACRE		
A	Check		
B	0 +	40 +	40
C	20 +	10 +	10
D	40 +	20 +	20
E	60 +	30 +	30
F	80 +	40 +	40
G	100 +	50 +	50
H	120 +	60 +	60
I	80 +	40 +	40 plus Cu, Mn, Zn.

The nutrients for treatment B were supplied with 0-25-25 grade of fertilizer, while treatments C to I received various rates of 20-10-10 fertilizer. Fertilizer materials were top-cressed with a Gandy spreader on October 14, 1970. Trace elements Cu, Mn and Zn for treatment I were applied in the sulfate form at the rate of 50 lbs/acre

of Cu-, Mn-, Zn-Sulfate. These materials were applied by hand on May 4, 1971.

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. Two square-yard samples were harvested from each plot to measure seed yields.

Seed yields and the chemical composition of tissue are reported in Tables 3, 4, 5, 6 and 7.

Lorain timothy seed yields on a Bearden silt loam were nearly tripled by fertilization. The highest seed yield of 505 lbs/acre was produced with the 100+50+50 fertilizer treatment, compared to 157 lbs/acre from the check plots. There was some lodging in the 100+50+50 and 120+60+60 plots. The addition of trace elements, Cu, Mn, Zn, to the 80+40+40 treatment increased the seed yield by nearly 100 pounds per acre.

The concentration of several chemical elements in the tissue of this variety was affected by fertilization. Nitrogen content was increased from 1.66% in tissue from the check to 3.18% from 120+60+60 treatment. Tissue from the 100+50+50 treatment, that produced the highest yield, had 2.95% of N, 0.27% P and 1.64% of K.

Erecta timothy on Glyndon fine sandy loam showed only a slight yield response to fertilization. The seed yield was increased from 87 lbs/acre without fertilizer to nearly 200 lbs/acre with the 0+40+40 treatment. Some lodging resulted from 80+40+40 and higher fertilizer treatments. Trace element application increased the concentration of Cu, Mn, Zn in tissue but had no effect on seed yield. Fertilization also increased the contents of N and P in timothy but had no effect on K concentration.

The lack of response to fertilization and relatively low seed yields obtained on this field of Erecta may not be typical to this variety. Apparently the plots were harvested too early. The seed yields of grass receiving the higher rates of fertilizer (nitrogen) would be affected most seriously by this.

This field of Evergreen timothy was extremely variable in plant type. It appeared that this variety is extremely susceptible to lodging under higher soil fertility levels. These two factors made it difficult to obtain representative yield measurements on this field.

The highest seed yield of 639 lbs/acre was produced with the 80+40+40 treatment compared to 486 lbs/acre on check plots. Lodging was observed on all plots receiving 40+20+20 or higher fertilizer treatments.

Primo Kentucky bluegrass on a sandy loam soil showed highly significant seed yield increases to fertilization. The seed yields were increased from 129 lbs/acre without fertilizer to a maximum yield of 602 lbs/acre with the 100+50+50 treatment. Some lodging occurred on the plots receiving the 100+50+50 and 120+60+60 treatments.

Fertilization with NPK increased the P concentration in grass tissue but had no effect on the N and K contents. Application of Cu, Mn and Zn increased the concentration of these trace elements in tissue but had no effect on seed yield.

Table 3. Effect of fertilization on the seed yield of timothy and K. Bluegrass, 1971.

Treatment* N P_2O_5 K_2O	Field 1 Lorain Timothy	Field 2 Erecta Timothy	Field 3 Evergreen Timothy	Field 4 Primo K.Bluegrass
Lbs/Acre		Yield of Seed, Lbs/Acre		
Check	157a*	87a	486ab	129a
0 + 40 + 40	136a	194b	552ab	207ab
20 + 10 + 10	298b	178b	515ab	340bc
40 + 20 + 20	320bc	247b	567abc	399cd
60 + 30 + 30	426dc	251b	440a	524de
80 + 40 + 40	438dc	242b	689c	524de
100 + 50 + 50	505dc	264b	612bc	602e
120 + 60 + 60	408cd	264b	619bc	542de
80 + 40 + 40 + trace elements	527c	268b	563abc	487de
Significance	**	**	**	**
CV, %	19	27	15	23

* Any letter (letters) different from another letter in a column indicates a significant difference between the means at the 5% level.

Table 4. Effect of fertilization on chemical composition of Lorain timothy tissue, 1971. Roy Kveen, Roseau County.

Treatment	N	P	K	Ca	Mg	B	Cu	Mn	Mo	Zn	Al	Fe
	----------Percent in Dry Matter-------					-------Parts Per Million in Dry Matter----------						
None	1.66a	.21	1.51a	.19a	.21a	9	3.3a	19a	5.7	14a	13b	40
0 + 40 + 40	1.66a	.20	1.49a	.21abc	.23b	9	3.3a	20a	7.0	14a	17c	46
20 + 10 + 10	1.95b	.22	1.62bc	.20ab	.23b	9	3.7ab	19a	6.3	15ab	12ab	43
40 + 20 + 20	2.21c	.23	1.59b	.22abc	.24c	10	3.6a	20a	6.8	15ab	11ab	46
60 + 30 + 30	2.47d	.25	1.64bc	.23bc	.25d	9	4.3bc	22ab	6.9	16bc	11ab	53
80 + 40 + 40	2.61e	.25	1.61bc	.24c	.26ef	9	4.4c	23abc	6.8	17cd	10ab	48
100 + 50 + 50	2.95f	.27	1.64bc	.24c	.28g	9	5.2d	24bcd	7.4	18cd	11ab	55
120 + 60 + 60	3.18g	.23	1.68c	.25c	.29h	8	5.8d	26cd	7.4	19de	11ab	55
80 + 40 + 40 + trace elem.	2.62e	.25	1.61bc	.23bc	.26ef	8	5.6d	27d	6.8	20e	10a	53
Significance	**	NS	**	*	**	NS	**	**	NS	**	**	NS
CV, %	5	5	3	11	9	11	10	12	11	8	18	16

Table 5. Effect of fertilization on chemical composition of Erecta timothy tissue, 1971. Ernest Brandli, Roseau County.

Treatment	N	P	K	Ca	Mg	B	Cu	Mn	Mo	Zn	Al	Fe
	---------Percent in Dry Matter---------					---------Parts Per Million in Dry Matter----------						
None	1.98a	.20a	1.62	.27a	.14a	12	3a	18a	7.1	15a	24b	55
0 + 40 + 40	2.18a	.20a	1.52	.35ab	.18bc	14	3a	24a	6.3	16a	15a	48
20 + 10 + 10	2.20a	.21a	1.49	.34ab	.16ab	13	3a	22a	5.8	15a	15a	48
40 + 20 + 20	2.48b	.23b	1.61	.35ab	.19cd	13	3a	23a	6.7	16a	13a	50
60 + 30 + 30	2.81c	.26c	1.72	.37ab	.19cd	12	3a	31b	6.3	19b	10a	49
80 + 40 + 40	2.90cd	.27c	1.60	.38b	.19cd	13	3a	31b	6.6	20b	10a	51
100 + 50 + 50	2.92cd	.27c	1.61	.39b	.20cd	14	3a	32b	6.2	20b	11a	52
120 + 60 + 60	3.08d	.28c	1.69	.38b	.21d	11	3a	32b	6.7	20b	10a	53
80 + 40 + 40 + trace elem.	2.74c	.25b	1.64	.38b	.19c	13	6b	49c	6.2	26c	11a	48
Significance	**	**	NS	**	**	NS	**	**	NS	**	**	NS
CV, %	6	6	6	8	8	11	16	15	9	6	33	11

Table 6. Effect of fertilization on chemical composition of Evergreen timothy, 1971. Richard Jackson, Roseau County.

Treatment	N	P	K	Ca	Mg	B	Cu	Mn	Mo	Zn	Al	Fe
	----------Percent in Dry Matter--------					----------Parts Per Million in Dry Matter----------						
None	2.31a	.22a	1.31	.32	.23a	9	3.7a	17ab	6.8	12ab	10	46a
0 + 40 + 40	2.33a	.23a	1.40	.39	.23a	9	4.1ab	16a	5.9	12a	11	47ab
20 + 10 + 10	2.66ab	.24a	1.30	.38	.27ab	9	3.9ab	19bc	7.0	13abc	10	50ab
40 + 20 + 20	2.75bc	.23a	1.23	.36	.28b	9	3.9ab	18abc	6.7	13abc	10	49ab
60 + 30 + 30	3.08cd	.26bc	1.24	.37	.29b	9	4.1ab	20c	7.1	14abc	9	59bc
80 + 40 + 40	3.29d	.27bc	1.29	.40	.29b	8	4.5bc	21cd	6.6	14abc	10	64cd
100 + 50 + 50	3.44d	.29c	1.27	.37	.28b	9	5.0c	23dc	7.3	14c	10	74de
120 + 60 + 60	3.38d	.27bc	1.24	.38	.30b	8	4.9c	22dc	7.5	13abc	9	79e
80 + 40 + 40 + trace elem.	3.14d	.26b	1.26	.40	.26ab	8	8.2d	24c	6.4	23d	11	56bc
Significance	**	**	NS	NS	*	NS	**	**	NS	**	NS	**
CV, %	8	7	6	12	10	11	9	18	11	6	12	13

Table 7. Effect of fertilization on chemical composition of Primo Kentucky Bluegrass tissue, 1971. Lenard Johnson, Roseau County.

Treatment	N	P	K.	Ca	Mg	B	Cu	Mn	Mo	Zn	Al	Fe
	----------Percent in Dry Matter--------					------Parts Per Million in Dry Matter----------						
None	1.95	.14a	1.34	.29a	.16a	8c	5a	36b	6.1	25a	37	85
0 + 40 + 40	1.75	.22e	1.50	.35ab	.17a	6abc	3a	32ab	6.1	20a	56	102
20 + 10 + 10	1.96	.14ab	1.39	.40bcd	.18a	7bc	4a	32ab	6.6	22a	41	91
40 + 20 + 20	1.94	.17cd	1.42	.37abc	.19a	8c	3a	32ab	6.7	22a	27	68
60 + 30 + 30	2.07	.17cd	1.55	.49d	.22b	6abc	3a	32ab	7.3	23a	52	100
80 + 40 + 40	2.12	.16bc	1.45	.45cd	.22b	7bc	4a	34ab	7.2	24a	42	86
100 + 50 + 50	2.32	.19d	1.46	.46d	.23b	5a	3a	29a	6.3	25a	32	75
120 + 60 + 60	2.30	.19cd	1.56	.45cd	.24b	6abc	3a	30ab	7.2	25a	38	88
80 + 40 + 40 + trace elem.	1.99	.20de	1.63	.45cd	.22b	7bc	8b	41c	6.7	36b	28	80
Significance	NS	**	NS	**	**	**	*	**	NS	**	NS	NS
Cv, %	12	10	21	14	10	12	49	10	12	10	49	28

SULFUR FERTILIZATION OF KENTUCKY BLUEGRASS--1971[1)]

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

A sulfur experiment with Park Kentucky Bluegrass was initiated in spring of 1970. The plots were set up on a Spooner very fine sandy loam located in Lake of the Woods County on Helmstetter Bros. Farm. The soil contained 9 ppm of monocalcium phosphate (500 ppm P) extractable sulfur, indicating medium sulfur availability. The field had been renovated by plow-back in 1967 and had been burned in 1970 soon after harvest. 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. Sodium sulfate, Na_2SO_4, was applied in May of 1970. The NPK fertilizer was topdressed on October 13, 1970. The dimensions of individual plots were 10 by 20 feet.

Seed yields of bluegrass were not increased by applications of sulfur (Table 1).

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1) See "A Report on Field Research in Soils," Soil Series 87, March 1971, pp. 114-115 for results obtained from this investigation in 1970.

Table 1. Effect of sulfur treatment on seed yield of Kentucky bluegrass, 1971.

Treatment	Yield of Seed
	lbs/acre
None	286
20 lbs/acre of S as $Na_2 SO_4$*	281
Significance	NS
CV, %	16

* Topdressed in May of 1970; all plots received 90 + 40 + 40 treatment, topdressed on October 13, 1970.

THE EFFECT OF NITROGEN FERTILIZATION ON SEED YIELD AND CHEMICAL COMPOSITION OF GRASSES WHEN APPLIED ALONE OR WITH PHOSPHORUS AND POTASSIUM—1971[1)]

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 the Woods County. General information on the experimental sites is given in Table 1.

A randomized block design was used with six treatments replicated seven times. Individual plots were 10 feet wide and 20 feet long. Ammonium nitrate (33.5-0-0) was used as the N source, and PK was supplied with 0-25-25 fertilizer. The fertilizer treatments were made with a Gandy spreader on October 12, 1970. Plant tissue samples were collected at the emergence of heads or panicles. Total nitrogen in tissue was determined by the Micro-Kjeldahl method, and the other elements were

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1) See "A Report on Field Research in Soils," Soil Series 87, March 1971, pp. 116-119 for results obtained from similar investigations conducted in 1970.

determined in a multi-element emission spectrophotometer. Two square-yard samples were cut from each plot at harvest time for the measurement of seed yields.

Seed yields and the N, P, K concentrations in tissue of grasses are reported in Tables 2 and 3.

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

Field No.	Location	Soil Type	Species, Variety	Age of Stand	Burned
5.	F. Baade L.O.W. County	Ulen VFSL	Timothy, Climax	5th Seed Year	April 1971
6.	Helmstetter Bros. L.O.W. County	Spooner VFSL	K.Bluegrass, Park	1967 Plow-back	Post-Harvest Burn

Table 2. 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
lbs/acre	lbs/acre	Percent in Dry Matter		
N				
60	256a	2.22a	.24	1.57b
90	317b	2.43a	.24	1.56b
120	277ab	2.87b	.25	1.41a
Significance	**	**	NS	**
PK				
None	284	2.53	.22a	1.40a
0 + 40 + 40	282	2.48	.27b	1.63b
Significance	NS	NS	**	**

The seed yield of timothy was increased significantly by increasing the N treatment from 60 to 90 lbs/acre. Increasing the N rate to 120 lb/acre did not result in higher seed yield. The N content of tissue from 120 lbs/acre treatment was significantly higher than N in tissues from the 60 or 90 lbs/acre nitrogen treatments.

While the 0 + 40 + 40 fertilizer treatment did not affect the seed yield, it increased the P and K concentration in tissue. This PK treatment, however, had no effect on the N content of tissue.

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 3. The effect of nitrogen fertilization when applied alone or with phosphorus and potassium on seed yield and chemical composition of Park Kentucky Bluegrass. Hemlstetter Bros., L.O.W. County.

Treatment	Yield of Seed	N	P	K
lbs/acre	lbs/acre	Percent in Dry Matter		
N				
60	193a	1.65a	.22a	1.25
90	245a	1.84b	.22a	1.24
120	363b	2.17c	.24b	1.27
Significance	**	**	**	NS
PK				
None	267	1.91	.21a	1.03a
0 + 40 + 40	267	1.86	.25b	1.48b
Significance	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 0 + 40 + 40 treatment increased the P and K contents of tissue but

had no effect on seed yield.

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 -- 1971[1)]

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

An investigation was initiated in 1968 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. 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.

2. Some beef producers had expressed concern about the quality of forage, especially the trace element content of hay produced on organic soils.

3. 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.

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 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 treatment of all four

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1) See "A Report on Field Research in Soils," Soil Series 84, March 1969, pp. 172-176, Soil Series 86, March 1970, pp. 133-138, and Soil Series 87, March 1971, pp. 120-128 for results obtained from similar investigations conducted in 1968, 1969 and 1970.

trace elements. Copper alone increased the seed yield on this field 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 $17.00. Copper chelate treatments, if effective, would cost only about $6.00 per acre. For this reason the copper chelate as well as copper sulfate forms were used in the 1970 and 1971 trials.

In 1970, three field experiments with Kentucky bluegrass were conducted to study the effects of copper and zinc applications to peat on seed yield and chemical composition of tissue. All materials were topdressed on established stands of bluegrass on growers' fields. Fertilization with trace elements increased the concentrations of Cu and Zn in grass tissue but had no effect on the seed yield.

In 1971, the three field experiments with Kentucky bluegrass, established in 1970, were continued. The carry-over effects of Cu-sulfate and Zn-sulfate made in spring of 1970 were studied. The Cu-chelate treatments that had received 1 or 2 lbs/acre of Cu-chelate in spring of 1970, received additional 4 lbs/acre of chelate in spring of 1971. General information on the experimental sites is given in Table 1.

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

Field No.	Location	K. Bluegrass Variety	Age of Stand	Burned
7.	ED Baumgartner Roseau County	Park	1968 Seeding	Post-harvest burn
8.	C. Habstritt Roseau County	Park	1968 Seeding	Post-harvest burn
9.	Earl Swenson Clearwater County	Merion	1968 Seeding	----

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**	4.0 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

* Copper sulfate and zinc sulfate applied once on May 5, 1970 at all locations.

** Copper chelate applied on May 4, 1971. First application of Cu-chelate was made on May 5, 1970; Field No. 7 -- 1 lb/acre, Field No. 8 -- 1 lb/acre, Field No. 9 -- 2 lb/acre.

All plots received a uniform application of the following plant nutrients, expressed as N, P_2O_5, K_2O in lbs/acre: Field No. 7, 15 + 60 + 60; Field No. 8, 10 + 60 + 40; Field No. 9, 12 + 48 + 48. All fields were fertilized on October 14-15, 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 trace elements were determined in a multi-element emission spectrophotometer. Two square-yard samples were cut from each plot at harvest time for the measurement of seed yields.

Seed yields of bluegrass grown on peat were not affected by copper or zinc treatments (Table 2).

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

The Cu content of grass tissue was increased at all three locations from 3 to 4, 5, 6 or 8 ppm by applications of the sulfate and chelate forms of copper. The Zn concentration in bluegrass tissue also was increased significantly at all locations. Thus, a carry-over effect was indicated by plant analysis from Cu- and zinc-sulfate treatments applied at 50 lbs/acre rates in spring of 1970. The rate of 4 lbs/acre of Cu-chelate was sufficient to increase copper concentration of tissue above the critical level.

Table 2. Effect of trace element applications on the seed yield of Kentucky bluegrass on peat, 1971.

Treatments of Trace Elements	Field 7 Park (E.B.)	Field 8 Park (C.H.)	Field 9 Merion (E.S.)
	Yield of Seed, lbs/acre		
1. None	288	196	105
2. Copper sulfate	242	190	83
3. Copper chelate	283	215	78
4. Zinc sulfate	288	203	80
5. Cu-sulfate + Zn-sulfate	223	182	80
6. Cu-chelate + Zn-sulfate	274	228	83
Significance	NS	NS	NS
CV, %	28	18	21

Table 3. Effect of trace element application on the chemical composition of Kentucky bluegrass tissue grown on peat, 1971. Field 7, Park, Ed Baumgartner.

Treatment	B	Cu	Mn	Zn
	Parts Per Million in Dry Matter			
1. None	8	3a	28	22a
2. Cu-sulfate	8	5b	27	24a
3. Cu-chelate	8	8c	27	22a
4. Zn-sulfate	8	3a	26	32b
5. Cu-sulfate + Zn-sulfate	8	5b	26	34b
6. Cu-chelate + Zn-sulfate	8	8c	26	32b
Significance	NS	**	NS	**
CV, %	10	26	7	8

Table 4. Effect of trace element application on the chemical composition of Kentucky bluegrass tissue grown on peat, 1971. Field 8, Park, C. Habstritt.

Treatment	B	Cu	Mn	Zn
	Parts Per Million in Dry Matter			
1. None	9	2.5a	49	23a
2. Cu-sulfate	9	4.3c	50	23a
3. Cu-chelate	9	7.7d	46	24a
4. Zn-sulfate	10	2.7b	50	31b
5. Cu-sulfate + Zn-sulfate	10	4.3b	46	32b
6. Cu-chelate + Zn-sulfate	9	8.2e	46	33b
Significance	NS	**	NS	**
CV, %	8	25	10	8

Table 5. Effect of trace element application on the chemical composition of Kentucky bluegrass tissue grown on peat, 1971. Field 9, Merion, Earl Swenson.

Treatment	B	Cu	Mn	Zn
	Parts Per Million in Dry Matter			
1. None	10	3a	63	28a
2. Cu-sulfate	10	6e	63	29a
3. Cu-chelate	9	6b	64	29a
4. Zn-sulfate	10	4a	66	41c
5. Cu-sulfate + Zn-sulfate	10	7b	61	42c
6. Cu-chelate + Zn-sulfate	11	6b	58	37b
Significance	NS	**	NS	**
CV, %	9	20	11	10

CLASSIFICATION OF NATURAL COMMUNITIES

David Grigal

It is often difficult both to duplicate and to extrapolate the results of field research. Much of this difficulty arises because of lack of control of environmental parameters in the field as opposed to the control that is attainable in the laboratory. Even if such parameters cannot be controlled, however, it is difficult even to decide which are important enough to be measured. If natural vegetation can be considered an integrator of environmental variables over time, then a quantitative vegetation classification system should logically lead to a kind of reference system which can be used as a basis in interpreting, extrapolating, and duplicating results of field research.

Members of the staff of the North Central Forest Experiment Station of the U.S. Forest Service and of the Department of Soil Science are attempting to implement multivariate techniques in the description and ultimate classification of forest ecosystems. We are attempting to define vegetation groups from northeastern Minnesota. We are basing the definitions on forest stand data collected during the past few years in the Boundary Waters Canoe Area. Our goal is a well-defined system of vegetation groups. In addition, we hope to offer a procedure by which other researchers in northeastern Minnesota can assign the forest stands in which they are working to one of our groups. Thus, an animal ecologist, an entomologist, a soil scientist, or a botanist could all quantitatively place their stands on our scheme. We hope to have a number of optional criteria available that can be used for such placement. One primarily concerned with animal populations, for example,

need only use limited floristic data (and sacrifice some precision in the placement of his stands) while another concerned with plant community dynamics can use more sophisticated floristic data, yielding more precise stand placement.

The computer programs for this work have been written and the analysis has begun. Next year we hope to report on the results of the analysis and present a quantitative vegetation classification scheme for northeastern Minnesota.

MASS, NUTRIENT AND ENERGY DYNAMICS OF SHRUB SPECIES IN NORTHEASTERN MINNESOTA

David F. Grigal

Shrubs as a life form in forest stands are important in their role as an integral part of the total vegetation, i.e., as they influence nutrient cycling, plant community dynamics, etc. They are also perhaps the most important life form linking populations of larger herbivores in forest ecosystems to the vegetative components of those systems. In northern forest communities, shrubs provide the major winter food for both small animals, such as hares, and larger herbivores, such as moose. Because of their importance, we are now conducting a study of the mass, energy, and nutrient dynamics of five species of shrubs from northern Minnesota. This study is being conducted in cooperation with members of the North Central Forest Experiment Station of the U.S. Forest Service.

The field work for this study was completed during 1971. Samples of each of five shrub species common to northeastern Minnesota were collected biweekly for a 26 week period from June through November. Nine individuals of each species were randomly collected from within a single forest stand at each sample time. The collected shrubs were separated into seven components and each component was dried and weighed. These components included leaves, current annual woody growth, last year's woody growth, fruits, flowers, buds, and stems.

We have begun to analyze the nutrient concentration of the components collected. This, combined with the mass data previously collected, will enable us to make estimates of the quantity of nutrients contained in the various shrub species. More importantly, perhaps, the dynamics of movement within the plants themselves can be ascertained. The final portion of the study is the determination of the caloric content of the sampled material. This will be determined for representative samples of the material. All the data collected concerning these shrub species, and other data concerning their utilization as wildlife food, will be used to assess their importance in the ecosystems of which they are components.

STUDIES OF SOME EFFECTS OF FOREST FIRES

David F. Grigal

A 15,000 acre forest fire in and adjacent to the Boundary Waters Canoe Area (BWCA) of northeastern Minnesota on May 14-17, 1971, provides an exceptional opportunity to examine the effect of fire on a natural forest ecosystem. The fire started in an area of cutover forest along the Little Indian Sioux River south of the Echo Trail, and spread north and east, burning partially in virgin forest that had last seen fire in 1864 or 1759. The fire started in slash left from timber-cutting operations of the past decade. As it spread into the virgin forest, the fire was carried through an understory of balsam fire and white spruce that had been largely killed by the spruce budworm. Here the fire locally rose to crowns of the 100-200-year-old pine trees, killing them and providing further momentum for rapid downwind spread of the fire. Progress eventually slowed as the wind died down and the weather conditions changed. Up to 5 cm of moss and duff were burned, and all the ground cover and shrubs and most of the trees were killed. The organic layer was sufficiently moist at greater depth, however, to resist complete removal--a characteristic of a spring fire.

The ecological effects of fire on virgin forests are little known, because most studies of fire ecology have been concerned either with slash burning or with repeated litter burning. In these cases, other disturbance factors may be important in controlling plant succession. Burning of an old virgin forest can be expected to break down a very large biomass, living and dead. It results in the loss of some nutrient elements, which escape as volatiles and particulates in the smoke, but most nutrients are converted to soluble carbonates and bicarbonates and

retained in the ash and on the blackened vegetation. Rains can be expected to dissolve these compounds and make them available either for vigorous plant growth on the land surface or for transport by runoff to the lakes. With this fire-blackened area providing an excellent research opportunity, two relatively distinct studies are being carried out by the Department of Soil Science in cooperation with other organizations.

1. Study of Revegetation and Nutrient Immobilization Following the Burn.

In seven different virgin plant communities, a five year study has begun to assess the rate of growth and of nutrient immobilization by resprouting vegetation. A series of 10 randomly located plots were laid out within each of the plant communities selected for study. The plots were circular and each contained an area of 0.6052 square meters. All living plants within the plot were clipped at ground level and the collected material returned to the laboratory where the plants were separated into species. The number of individuals of each species was recorded. Each species was bagged, ovendried, and weighed. This collecting was done at midsummer, during the peak of vegetative growth. This collecting will be continued for four more years. The samples are now being analyzed for nutrient concentration. With these data we hope to be able to contrast different rates of growth and of nutrient immobilization.

Fast rates of revegetation can be expected to immobilize nutrients presumably released by fire, and prevent their potential loss from the system via runoff and deep seepage. As the mechanisms underlying plant succession begin to operate on the burn, we shall also be able to assess the role of plant species in succession as related to their mass

and nutrient content. In addition, we can contrast nutrient concentrations of plants resprouting on the burn with individuals of the same species from off the burn. We will then be able to determine if luxury consumption is occurring on the burn due to greater availability of nutrients.

2. Study of Nutrient Cycling Following the Burn.

The removal of vegetation by fire drastically alters the pathways of transfer and the cycling of mineral nutrients in the forest ecosystem. The amount and rate of runoff flow and soil-water flow (which carry nutrient ions) are usually accelerated by removal of vegetation and litter, because of the lower transpirational losses and because the canopy no longer delays the fall of rain to the ground. Such effects have been noted following removal of vegetation by forest cutting. Infiltration is also retarded, because of the hydrophobic effects of burned and extremely dry litter or soil. Soil erosion can be accelerated by rain impact and increased runoff. Increase in soil moisture, coupled with the high solubility of the ash relative to unburned organic matter, should yield a higher content of dissolved solids to the runoff and seepage water. Thus not only the hydrologic but also the nutrient budget of a lake can be greatly altered by fire in the drainage basin and the flora of the lake can be expected to respond to the nutrient additions.

The Department of Ecology and Behavioral Biology and the Department of Soil Science are cooperating in a study of the effects of the fire on mineral cycling on the watersheds of two small lakes within the burn, and as a control, on one lake outside the burn. The fire occurred in late May 1971, and we have been collecting samples from the area since that time. We plan to continue this sampling for at least an additional year.

Mineral capital of the ecosystems will be determined by sampling forest floor, soil, and standing vegetation. Mineral movement is being measured as follows:

At each watershed, twenty sampling points ("stations") have been established at 150 ft. intervals along compass transects approximately 100-150 ft. long paralleling the lakeshores. At each station the following sampling devices have been placed: a funnel and bottle to collect precipitation throughfall, a screen for litterfall, and a small plastic trough and bottle for collection of "runoff", i.e. transient water on the forest floor. A number of soil-solution tubes have also been placed at some of the stations, and more will be installed. Litter-bags have been set out in the fall of 1971 to study rates of litter decomposition; these have been placed at every station and are well replicated (60 bags per transect). Water samples (throughfall, runoff, and soil solution) are being collected bi-weekly from each station. Litterfall and samples of decomposing litter have been collected monthly. Litterfall will be divided into three components: leaf, wood, and other material (fruits, flowers, etc.). All these samples have been returned to our laboratories for subsequent chemical analysis.

Air temperature, humidity, and soil moisture levels will be monitored during the growing season. These data will be used to estimate differences between burned and unburned sites in evapotranspiration, and the consequent potential difference in runoff and/or seepage to the aquatic environment.

The study is important not only in assessing changes in cycling in terrestrial ecosystems, but directly relates to nutrient levels of the lakes in the monitored areas. Other studies are being conducted

in the burn area, including studies of vegetation dynamics, by the U.S. Forest Service, and limnological studies of water and sediments, by members of the Limnological Research Center. The combined results of all these studies will contribute to both basic understanding of the effects of fire in these systems, and will also aid in developing management policy involving the use of fire in natural ecosystems.

ALFALFA AND ALFALFA-BROMEGRASS YIELDS ON BLOWERS SANDY LOAM

Sebeka, Wadena Co.

R.H. Rust and E. Gross

Table 1. Alfalfa yields.

Variety	2 yr. avg. (1971, 1969) tons/A	
Narragansett	3.6	
DuPuits	3.0	"Tap-root" varieties
Norseman	3.0	
Vernal	3.4	
Teton	3.9	
Nomad	3.5	"Spreading-root" varieties
Ladale	3.8	
Rhizoma	3.3	

Yields based on 2 cuttings perseason and adjusted to 15% moisture basis. No yields taken in 1970 due to labor shortage.

Blowers sandy loam is a soil having a fragipan zone at about 30 inches depth. It is suggested that the slightly better performance of the "spreading-root" varieties may be attributed to their adaptation to the shallower, somewhat restricted rooting zone.

Alfalfa plots were established in 1966. Annually top-dressed since fall 1968 with 200 lbs per acre 0-0-60 and 100 lbs per acre 0-45-0.

Table 2. Alfalfa-Bromegrass Hay Yields (Vernal alfalfa and Lincoln brome).

Treatment	3 yr. Avg. (60-71)	% Alfalfa	%P	%K	Soil Test P	Soil Test K
					--lbs/A---	
Initial only	2.4 T/a	35	.22	1.18	13	50
+ K	3.3	60	.24	1.85	10	80
+ K + P	3.8	75	.26	2.34	45	130

Plots established on Blowers sandy loam in 1966 with initial treatment of 4T/A lime, 500 lbs per acre 0-0-60, and 100 lbs per acre 0-45-0.

Beginning fall 1968 annual supplemental treatment has been 175 lbs per acre 0-0-60 and 100 lbs per acre 0-45-0, 300 lbs per acre $CaSO_4$.

"Percent alfalfa" is estimate of alfalfa remaining in stand. Percent K and percent P was determined on hay mixture as cut.

Soil tests made in summer, 1971.

Table 3. Soil temperatures at two depths under alfalfa-bromegrass, Blowers sandy loam, Sebeka, Wadena Co., south slope, .4 percent.

At 6 inches depth, F°

	Jan.15	Apr.15	May 15	June 15	July 15	Sept.15	Nov.15
1967	no record		54	64	68	61	35
1968	20	45	60	63	75	67	37
1969	35	49	54	62	75	67	39
1970	34	37	50	67	74	58	38
1971	28	36	61	80	79	61	41
Avg.	29	42	56	67	74	63	38

At 25 inches depth, F°

	Jan.15	Apr.15	May 15	June 15	July 15	Sept. 15	Nov.15
1967	no record		45	56	60	61	44
1968	30	44	53	63	68	65	39
1969	36	46	51	56	65	67	45
1970	38	36	50	62	66	65	43
1971	34	41	54	65	70	59	48
Avg.	34	42	51	60	66	63	44

5 yr. mean annual temperature
ct 25 inches - 48°F

Temperatures measured with thermistor probes in place.

SOIL RESIDUE STUDIES

R. S. Adams, Jr.

Triazine residue plots were established in 1970 on the old lime plots at the Rosemount Experiment Stations. In 1948 lime had been added to these plots at rates of 0, 3, 6, 12 and 24 tons per acre. In individual replications there is a range of soil pH from pH 5.5 (no lime treatments) to pH 7.5 (high lime treatments). Significant results were obtained on only the high lime treatments. Consequently only data for no lime and high lime treatments are reported.

In May 1970 corn was planted in the plots and three triazine herbicides applied at equivalent rates. A normal field rate and three times normal field rate was applied. Herbicide treatments were as follows: atrazine 3 and 9 pounds per acre; prometryne 3.36 and 10.08 pounds per acre; and GS 14254 3.5 and 9.45 pounds per acre. There were four replications of each treatment.

Corn yields for the three times normal treatments in 1971 are given in Table 1.

Improved weed control accounted for the increased corn yield with atrazine. A triple rate of prometryne and GS 14254 resulted in severe corn injury in the high lime plots. Bear in mind that GS 14254 will not be recommended for corn and prometryne is not recommended for use in this way. Corn injury occurred only with the triple rate and on the high lime plots.

oat

Table 1. Corn Yields In Old Lime Plots With Three Triazine Treatments.

Lime	Hand Weed Free plots	Atrazine 9lbs/A	Prometryne 10.08 lbs/A	GS-14254 9.45 lbs/A
	bu/A			
None	94	72	84	92
High	78	84	53	25

In 1971 residue persistence was followed by planting the plots to oats, counting the stand after four to six weeks, cultivating out the oats and replanting. Four crops of oats were grown in this way.

Not enough prometryne was used to cause injury to oats at the residue levels persisting. Those data are not reported here. Residue injury from normal rates of triazine application were insignificant. However, injury occurred from residues in the plots receiving triple rates of atrazine and GS-14254 throughout the summer. Data are given in Table 2.

Table 2. Percent Of Check Of Oat Stand As Affected By Previous Lime Treatments And Residues Of Three Triazines.

Herbicide Treatment	Lime	Crop 1	2	3	4
Atrazine, normal rate	none	87	112	89	102
	high	90	117	100	105
Atrazine, triple rate	none	102	94	86	97
	high	57	42	84	102
GS 14254, normal rate	none	109	88	96	84
	high	71	77	102	102
GS 14254, triple rate	none	86	81	91	79
	high	43	18	38	50

Early in the summer precipitation during the period of seedling establishment played an obvious role in the extent of triazine injury. As the season progressed and triazine residues dissipated the influence of precipitation was less obvious. These data are shown in Table 3.

Table 3. Percent Of Check Of Oat Stand As Affected By Precipitation During The First 21 Days After Planting.

Rainfall	Atrazine Normal	Atrazine 3X	GS 14254 Normal	GS 14254 3X
Inches	Percent of Check			
No lime				
1.11 (3)	89	86	96	91
1.51 (1)	87	102	109	86
2.47 (4)	102	97	84	79
4.82 (2)	112	94	88	81
High line				
1.11 (3)	100	84	102	38
1.51 (1)	90	57	71	43
2.47 (4)	105	102	102	50
4.82 (2)	117	42	77	18

() Numbers in brackets denote succession of crop.

Precipitation was greatest in the first 21 days after the June 3 planting of oats. Injury from the triazines was much more severe than with the April 15 planting where only about 1/3 as much precipitation fell.

These data confirm that soil pH and spring precipitation both have a pronounced affect on the occurrence of residue injury from the triazines. As soil pH increases or as spring precipitation increases triazine residue injury can be expected to be more severe.

LIME PLOTS, DAKOTA COUNTY, 1971

J. Grava, C. J. Overdahl, D. S. Fairchild, B. D. McCaslin

A field experiment was established in spring of 1971 on the Earl Almquist farm in Dakota County to study the effects of liming on yield and chemical composition of corn and chemical properties of soil under irrigation. Average soil tests of samples collected prior to the establishment of the experiment are given in Table 1. The soil texture is loam to sandy loam.

Table 1. Soil Test Results.

Soil pH	SMP Buffer Index	P Lb/A	K Lb/A	Zn ppm	S ppm	Lime Requirement - Tons/A
5.6	6.3	48	310	2.2	12	5 -- 6

Dolomitic limestone,used in this experiment, had the following quality characteristics:

Passing 8-mesh sieve	95.3%
Passing 60-mesh sieve	44.6%
Calcium carbonate equivalent	92.6%

Limestone was applied on April 13, 1971. The rates used were as follows: 0, 2.5, 5 and 10 tons per acre. The treatments are replicated six times. Individual plots are 25'4" wide (8-38" rows) and 40' long. All plots received the following: (a) 143 + 114 + 180 Lb/A of total plant nutrients, expressed as N, P_2O_5, and K_2O; (b) herbicide: 10 Lb/A Ramrod, banded; (c) insecticide: 7 Lb/A Bux 10. A 110 day corn variety was planted on May 15 at 25,000 kernels per acre. Due to some germination problems, final population was only 22,000 or less plants per acre. Corn was

irrigated about every 1 1/2 weeks after middle of July, applied 4 inches of water in four applications.

The yield of corn and chemical composition of sixth leaf at tasseling are given in Tables 2 and 3. Neither corn yields nor the chemical composition were affected by the lime treatments on this site in 1971.

Table 2. Yield of corn, Earl Almquist's farm, Dakota County, 1971.

Rate of Lime	Yield
Tons/Acre	Bu/Acre
0	125
2.5	131
5.0	142
10.0	126
Significance	NS[1]
CV%	12

[1]N.S. -- Treatment means not significantly different at the 5.0% level.

Table 3. Chemical composition of sixth corn leaf at tasseling, Dakota County lime plots, 1971.

Rate of Lime	N	P	K	Ca	Mg	Zn	Cu	Mo	Mn	B	Fe	Al
Tons/Acre	----- Percent in dry matter ------					---------- Parts per million in dry matter --------						
0	2.80	.27	2.08	.48	.38	15	6	13	99	3	187	82
2.5	2.84	.27	2.00	.51	.42	16	7	14	103	3	183	75
5.0	2.84	.27	1.95	.54	.43	15	6	13	94	3	195	87
10.0	2.82	.27	1.95	.51	.43	17	7	14	88	3	187	79
Significance	NS[1]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV	6	7	9	9	15	12	9	12	15	29	18	35

[1]N.S. -- Treatments means not significantly different at the 5.0% level.

PASTURE IMPROVEMENT THROUGH FERTILIZATION AND WEED CONTROL
(Results of Trials in Minnesota Red River Basin - 1971)

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Minnesota has more than 2 million acres of unimproved grasslands. Sods of cool season grasses, including mixture of Kentucky bluegrass, timothy, brome, orchard and quack grass serve as major sources of forage on many farms in Minnesota.

Land which is unsuited for cultivated crops is left in permanent stands of grass. To a lesser extent, some land which could be used as cultivated land is also devoted to permanent grass pasture or hayland. In numerous instances, without fertilization and management, this land provides forage for only a very short period of the year (6 to 8 weeks).

The yield response of such grasses has been the subject of repeated investigations. Research in New York, Maine, Wisconsin, Pennsylvania and Minnesota (4)(1)(7)(5)(3) has shown that yield increases of forage equal to 1.4 to 2.0 tons of dry matter per acre can be obtained from the use of 100 pounds of nitrogen per acre. These increases with nitrogen applications are obtained only when sufficient phosphorus and potassium are also available.

Numerous studies (6) indicate that a fertilizer program which supplies an annual equivalent of 50 pounds of P_2O_5 per acre can provide adequate phosphorus for intensive grass production on soils low to medium in available phosphorus.

The critical percentage of potassium in most grasses at harvest time is considered to be about 1 percent K on a dry matter basis. Grava, et al. (2) in Minnesota found an average of 2.19 percent K in Kentucky bluegrass and 2.6 percent in timothy collected from 50 fields in Northwest Minnesota.

Under general farm conditions in Minnesota, the use of fertilizer on grass pastures or haylands is characterized by an excessive use of phosphorus and potassium in relation to the nitrogen. The economical use of fertilizer on grass pastures must be based on (1) the plant food needs of the crop and its responses to nitrogen, phosphorus and potassium; equally important is (2) the management and harvest of the grassland crop.

Interest in beef cow-calf operations in northern Minnesota has stimulated many questions concerning the fertilization and management of existing grass pastures. Investigations on pasture fertilization and weed control were planned and carried out as a result of discussions and cooperation between farmers, University of Minnesota Extension Agents of the Red River Valley and Extension Specialists in Soils and Crops.

These studies were planned with several objectives in mind:

1. To determine the yield response of grass pasture or hayland to varying levels of fertilizer application. Specifically to compare the fertilizer rate common in farm use with a rate of fertilizer known to more nearly meet the needs of good grass growth.

2. To study the influence of weed control on the yield of grass pastures.

3. To determine the influence of fertilizer applications on the protein content of grass pasture.

4. To determine the influence of additions of phosphorus and potassium on yield of grass pastures in northwest Minnesota.

5. The trials were further intended to be used for the dual purposes of (a) collection of data which could help answer the above questions and (b) serve as demonstrations to farmers of the area.

The authors should like to express appreciation for the materials and assistance provided by the University of Minnesota Agricultural Experiment Station, Crookston, Minnesota. This cooperation, so generously extended, made the project possible.

METHODS

County agents in Marshall, Pennington, Roseau, East Polk, West Polk, Norman and Mahnomen counties selected typical pasture areas, assisted in the placement of tests and fencing of the trials. Eleven trials were placed in the seven counties.

Treatments as shown in Table 1 were broadcast on the surface of selected areas in April, 1971.

The trials were fenced to control livestock grazing. In May 1971, 2-4-D low volatile ester at the rate of 1 pound per acre was applied to those plots on which weed control was to be studied. Perennial weeds at this time were 3-4 inches in height. Principal weeds were Canadian thistle, dandelion, goldenrod, and common milkweed. Each trial consisted of 8 treatments replicated 2 times. Each plot was 1/100 acre in size.

During the past season, two cuttings and grazings have been made at all locations. An area equal to 1/2000 of an acre was harvested from each plot. A third has been taken at one location. It is anticipated that a third cutting will be taken at the other locations during the last week of October 1971. The first cutting on most locations was made during the week of June 7, 1971. Second cuttings were taken the last week of July 1971.

DISCUSSION OF RESULTS

The yields of hay obtained from the various treatments from the two cuttings are shown in Table 1. Yields are given for those locations which were predominantly mixed grasses, (quack, timothy, orchard, brome, Kentucky bluegrass) and for those locations which were predominantly Kentucky bluegrass.