Crookston

Table C-5. Wheat - 3 year rotation

Treatment	lbs/ac $N-P_2O_5-N_2O$	Average Yield bu/ac	Diff.	Treatment effect
None	0-0-0	18.3		
N	20-0-0	22.9	4.6	12.8**
P	0-40-0	16.4	-1.9	7.4*
K	0-0-20	20.5	2.2	
NP	20-40-0	39.1	20.8	
NK	20-0-20	31.4	13.1	
PK	0-40-20	27.8	9.5	
NPK	20-40-20	39.7	21.4	
NPK+	40-80-40	49.9	31.6	

Table C-6. Sugar Beets

Treatment	lbs/ac $N-P_2O_5-K_2O$	Average Yield T/ac	Diff.	Treatment effect
None	0-0-0	14.7		
N	40-0-0	15.9	1.2	
P	0-120-0	15.7	1.0	3.46**
K	0-0-40	14.9	0.2	
NP	40-120-0	20.0	5.3	
NK	40-0-40	16.9	2.2	
PK	0-120-40	20.9	6.2	
NPK	40-120-40	19.7	5.0	
NPK+	80-240-80	16.9	2.2	

Crookston

Table C-7. Soil test results on three year rotation

Treatment	Total 5 year Fertilizer Application	lbs. P/A	lbs. K/A	pH
Check	0-0-0	12.7	473	8.0
N	280-0-0	14.0	437	8.0
P	0-440-0	64.7	460	7.8
K	0-0-160	11.3	587	8.0
NP	280-440-0	56.0	427	8.0
NK	280-0-160	15.0	427	7.9
PK	0-440-160	66.0	577	7.9
NPK	280-440-160	72.3	430	7.8
NPK+	360-880-320	134.7	510	7.9

Table C-8. Soil test results on four year rotation

Treatment	Total 5 year Fertilizer Application	lbs. P/A	lbs. K/A	pH
Check	0-0-0	6.3	357	7.8
N	160-0-0	8.0	270	7.9
P	0-200-0	22.0	357	7.9
K	0-0-100	7.3	403	7.9
NP	160-200-0	23.7	423	7.9
NK	160-0-100	6.3	437	7.8
PK	0-200-100	25.7	400	7.9
NPK	160-200-100	17.3	363	7.9
NPK+	200-680-280	84.0	473	7.7

Manuring, Liming and Fertilizing Experiment (1960)

Northeast Experiment Station
Dale E. Baker and A. C. Caldwell

Potatoes:

Because of poor drainage, the yields from these plots were quite variable. The effect of applying manure over a period of years is reflected in the yields of potatoes. Although applications of lime alone resulted in somewhat higher yields, the highest yields were obtained where both lime and fertilizer were applied.

Oats:

Yields of oats showed the same trends as those for potatoes with one important exception. The response to lime and commercial fertilizer was very small, especially where manure had been applied in the rotation. This is disturbing, and indicates that more than nitrogen, phosphate and potash is needed by this soil.

Hay:

As with oats, hay responded to applications of manure and also some to lime. The response to fertilizer, however, was small for first year hay where the crop was depending on residual fertility from the oat crop. The response to fertilizer applied to the second year hay was more encouraging.

MANURING, LIMING, AND FERTILIZING EXPERIMENT

YIELDS OF 1 ST. YEAR HAY IN 1960

Plot Nos.	Manure Treatments	Lime and Fertilizer Treatments			
		Check T./Ac.	Lime T./Ac.	Lime & Fert. T./Ac.	Ave. Yield
7 & 13	Check	1.16	1.41	2.02	1.53
8 & 14	5 T/A on Stubble	1.76	2.08	2.05	1.96
9 & 15	10 " " "	2.06	1.89	2.16	2.04
10 & 16	20 " " "	2.16	2.20	2.59	2.32
11 & 17	10 " " Sod	1.40	2.73	2.21	2.11
12 & 18	5 " " "	1.95	2.32	2.40	2.22
	Average	1.75	2.10	2.22	

MANURING, LIMING, AND FERTILIZING EXPERIMENT

YIELD OF 2 ND. YEAR HAY IN 1960

Plot Nos.	Manure Treatments	Lime and Fertilizer Treatments			
		Check T./Ac.	Lime T./Ac.	Lime & Fert. T./Ac.	Ave. Yield
7 & 13	Check	1.15	1.55	1.77	1.49
8 & 14	5 T./Ac. on Stubble	1.90	1.78	2.60	2.09
9 & 15	10 " " "	2.10	2.19	2.68	2.32
10 & 16	20 " " "	2.50	2.29	2.92	2.57
11 & 17	10 " " Sod	1.69	1.68	2.61	1.99
12 & 18	5 " " "	1.55	1.52	2.20	1.76
	Average	1.81	1.84	2.49	

MANURING, LIMING, AND FERTILIZING EXPERIMENT (1960)

Yields of Oats in Bushels per Acre from Series 12

Plot Nos.	Manure Treatments	Lime and Fertilizer Treatments: Check	Lime	Lime & Fertilizer	One Yield
7 & 13	Check	56.4	52.9	65.6	58.3
8 & 14	5 T/A. on Strubble	64.3*	58.0*	63.6*	61.6
9 & 15	10 " " "	70.2	58.5*	58.6	62.4
10 & 16	20 " " "	72.2	80.0*	80.5	77.6
11 & 17	10 " " "	80.8	77.5	62.5*	73.6
12 & 18	5 " " "	62.5	64.7	61.2	62.8
	Average	67.7	65.3	65.3	

MANURING, LIMING AND FERTILIZING EXPERIMENT

YIELDS OF POTATOES (Bu./Ac.) in 1960

Plot Nos.	Manure Treatments	Check	Lime	Lime & Fertilizer	Ave.
7 & 13	Check	48	79	108	78.3
8 & 14	5 T./Ac. on Strubble	47	60	130	79.0
9 & 15	10 " " "	88	64	96	82.7
10 & 16	20 " " "	97	102	111	103.3
11 & 17	10 " " Sod	48	91	114	84.3
12 & 18	5 " " "	80	72	117	89.7
	Average	68.0	78	113	

RATES AND SYSTEMS OF FERTILIZATION EXPERIMENT

Dale E. Baker, Wallace W. Nelson and A. C. Caldwell

Purpose:

This experiment was initiated in 1955 for the purpose of determining the most economical rate of fertilizer and the best system for applying phosphorus and potash to a small grain-meadow rotation.

Procedure:

All plots received 40 pounds of nitrogen per acre when the grain was seeded. The rates of phosphorus and potash applied during the rotation of oats and four years of meadow were as follows:

1. 100# P_2O_5 and 100# K_2O per acre.
2. 200# " " " " " "
3. 400# " " " " " "

The systems of fertilization were as follows:

1. All fertilizer on grain.
2. 1/5 P_2O_5 and K_2O each year.
3. 1/2 P_2O_5 and K_2O on grain and 1/2 on 2nd. year hay.
4. All P_2O_5 on grain and 1/5 K_2O each year.
5. 1/5 P_2O_5 on K_2O each year plus 40 lbs. N/Ac. after 1st hay cutting.
6. 1/2 P_2O_5 on grain and 1/2 on 2nd year hay with 1/5 K_2O being applied each year.
7. Check (No fertilizer).

The experiment consisted of 21 plots replicated four times. The plots within each replication were randomized. The entire area was limed to correct the soil reaction prior to seeding.

The phosphorus and potash were applied as 0-30-30 where amounts applied were equal, and 0-47-0 and 0-0-60 were applied where amounts of P_2O_5 and K_2O were unequal. The plots were seeded to a grass-legume mixture of 7# alfalfa, 2# timothy and 5# brome, with oats as a nurse crop.

The meadow seeding failed on all plots in the 1955 seeding. The same experiment was repeated on a different area in 1956 and the meadow seeding was established more successfully.

The yields of oats in 1955 (Table I) and also in 1956 (Table II) indicate a response to all rates of phosphate and potash, although the greatest response was to the 0-100-100 treatment over the unfertilized plots. System No. 4 in which all the phosphate was applied on the grain and 1/5 of the potash was applied each year resulted in the highest yields of oats in both years. System No. 1 also received all the phosphate on grain. System (1) might have been inferior to No. 4 for production of oats because of too much muriate of potash. However, one must not overlook the fact that the phosphate applied in system No. 4 was water soluble superphosphate; whereas that applied in system No. (1) was water insoluble calcium meta-phosphate. A comparison between systems two and six also indicates that the superphosphate was superior to calcium meta-phosphate as a source of phosphorus for oats.

The high yields of oats obtained from system (4) where all the phosphate was applied as superphosphate had a depressing effect on hay yields for the next four years, Table III. The yields of hay were higher each year where the larger amounts of fertilizer had been applied. Yields of hay the 1st year were higher for system (1) where all the phosphate and potash had been applied to the grain. However, over a five year period system No. 6, in which 1/2 the phosphate was applied to the nurse crop and 1/2 to the 2nd. year meadow with 1/5 of the potash being applied each year, was the most profitable method of applying phosphate and potash. Applications of 40 pounds of nitrogen per acre after the first cutting increased hay yields over the four year period but not enough to make the practice economical, Table IV. However, the response to the nitrogen on the 4th year hay was almost enough to pay the cost of the fertilizer, Table VI.

Calculations of the value of the increase in oats and hay as a result of fertilizer applications, Table IV, show that the largest hay and grain increase were obtained where 400 pounds of both P_2O_5 and K_2O were applied over the five year period. With the high fixed cost for seeding and harvesting this would result in the most profitable fertilizer level. However, the calculations also show that application of 200 pounds of both P_2O_5 and K_2O resulted in the most return for each dollar spent for fertilizer.

Conclusions:

1. Water solubility of phosphate might be a factor affecting the yield of oats.
2. Establishment of grass-meadow seeding with an oat nurse crop was most successful and economical when the nurse crop was fertilized with 40+200+80.
3. Maintenance of hay yields was successful when 80 pounds of K_2O was applied annually and 200 pounds of P_2O_5 was applied to the 2nd year per meadow.
4. Annual applications of nitrogen to meadows where the stand of alfalfa was good was not profitable.

Further Consideration of Experiment:

Quality of forage as affected by the different treatments has not been evaluated. It would probably be worthwhile to determine the botanical and chemical composition of forage produced on these plots next year, which will be the fifth year for the meadow. I would suggest that only one replication be sampled. Since the stand of alfalfa will vary, the vegetation for each plot sampled should be sorted by hand so the yield and composition of alfalfa and grass can be determined separately.

RATES AND SYSTEMS OF FERTILIZATION EXPERIMENT (1955)

Table I

YIELDS OF OATS IN BUSHELS PER ACRE AS AFFECTED DIFFERENT RATES OF FERTILIZERS AND DIFFERENT SYSTEMS OF APPLYING FERTILIZERS:

	Fertilizer Treatments			
SYSTEMS OF FERTILIZING	0-100-100	0-200-200	0-400-400	Grand Means
All Fertilizer on Grain	62.1	64.0	61.7	62.6
1/5 P_2O_5 & K_2O Each Year	60.4	50.9	66.6	59.3
1/2 P_2O_5 & K_2O on Grain & 1/2 on 2nd. Year Hay	59.2	67.6	65.6	64.1
All P_2O_5 on Grain & 1/5 K_2O Each Year	61.0	67.7	66.4	65.0
1/5 P_2O_5 & K_2O Each Year Plus 40 Lbs. N/Ac. after 1st Cut.	62.0	57.4	64.8	61.4
1/2 P_2O_5 on Grain & 1/2 on 2nd. Yr. Hay; 1/5 K_2O Each Year	55.3	60.8	57.7	57.9
Unfertilized	45.5	44.3	51.2	
GRAND MEANS	60.0	61.4	63.8	

RATES AND SYSTEMS OF FERTILIZATION (1956)

Table II

YIELDS OF OATS IN BUSHELS PER ACRE AS AFFECTED BY DIFFERENT RATES OF FERTILIZERS AND DIFFERENT SYSTEMS OF APPLYING FERTILIZERS:

	FERTILIZER TREATMENTS			
Systems of Fertilizing	0-100-100	0-200-200	0-400-400	Grand Means
All Fertilizer on Grain	57.6	62.8	75.7	65.4
1/5 P_2O_5 & K_2O Each Year	56.3	53.8	55.1	55.0
1/2 P_2O_5 & K_2O on Grain & 1/2 on 2nd Year Hay	55.0	62.4	69.5	62.3
All P_2O_5 on Grain & 1/5 K_2O Each Year	68.4	63.0	78.4	69.9
1/5 P_2O_5 & K_2O Each Year Plus 40 Lbs. N/Ac. after 1st. Cut.	58.6	55.8	66.8	60.4
1/2 P_2O_5 on Grain & 1/2 on 2nd Yr. Hay; 1/5 K_2O Each Year	69.3	51.6	72.1	64.3
Check	60.9	51.6	56.9	56.4
GRAND MEANS	60.9	58.2	69.6	

RATES AND SYSTEMS OF FERTILIZATION EXPERIMENT

TABLE III

DIFFERENT YIELDS OF HAY IN TONS PER ACRE OVER A FOUR YEAR PERIOD AS AFFECTED RATES OF FERTILIZERS AND DIFFERENT SYSTEMS OF APPLYING FERTILIZERS.

System No.	1st Year Hay (1957) Lbs./Ac. of P_2O_5 & K_2O Applied 100	200	400	Means	2nd. Year Hay (1958) Lbs./Ac. of P_2O_5 & K_2O Applied 100	200	400	Means
1	1.89	2.10	2.35	2.18	2.38	2.78	2.74	2.63
2	1.62	1.67	2.17	1.82	2.47	2.49	3.20	2.72
3	1.78	1.92	2.47	2.06	2.24	2.84	2.98	2.69
4	1.67	1.68	1.90	1.75	2.22	2.32	2.99	2.51
5	1.65	1.87	2.19	1.90	2.63	3.14	3.56	3.11
6	1.94	2.07	2.34	2.12	2.62	2.54	2.95	2.70
7*	1.55	1.18	1.47	1.40	2.32	1.95	2.65	2.31
Means	1.77	1.89	2.24	1.965	2.43	2.69	3.14	2.730

System No.	3rd. Year Hay (1959 Lbs./Ac. of P_2O_5 & K_2O Applied 100	200	400	Means	4th. Year Hay (1960) Lbs./Ac. of P_2O_5 & K_2O Applied 100	200	400	Means
1	2.14	2.24	2.84	2.41	0.98	1.09	1.32	1.13
2	2.46	2.55	3.41	2.81	1.04	1.11	1.68	1.28
3	2.25	2.59	2.99	2.61	1.02	1.23	1.57	1.27
4	2.34	2.56	2.80	2.57	1.09	1.24	1.83	1.39
5	2.44	2.43	3.14	2.67	1.14	1.38	1.83	1.45
6	2.62	2.68	3.12	2.81	1.10	1.21	1.57	1.29
7*	2.02	1.89	2.15	2.02	0.90	0.82	1.02	0.93
Means	2.33	2.51	3.10	2.644	1.06	1.21	1.66	1.302

* System No. 7 was not used in statistical calculations.

Confidence Intervals ($D_{.05}$) for comparing means:
1. Systems within each year = 0.35
2. Rates Within each year = N.S. Interaction
3. Yields for different years = 0.091

RATES AND SYSTEMS OF FERTILIZATION EXPERIMENT

TABLE IV

AVERAGE YIELDS OF HAY IN TONS PER ACRE OVER A FOUR YEAR PERIOD AS AFFECTED BY DIFFERENT RATES OF FERTILIZATION AND DIFFERENT SYSTEMS OF APPLYING FERTILIZERS.

System No.	Systems of Fertilizing	Lbs./Ac. of P_2O_5 & K_2O Applied 100	200	400	Grand Means
1	All Fertilizer on Grain	1.87	2.05	2.31	2.082
2	1/5 P_2O_5 & K_2O Each Year	1.90	1.96	2.62	2.156
3	1/2 P_2O_5 & K_2O on Grain & 1/2 on 2nd. Year Hay	1.82	2.14	2.50	2.157
4	All P_2O_5 on Grain & 1/5 K_2O Each Year	1.83	1.95	2.38	2.053
5	1/5 P_2O_5 & K_2O each year plus 40 Lbs. N/Ac. After 1st Cut.	1.97	2.20	2.68	2.283
6	1/2 P_2O_5 on Grain & 1/2 on 2nd Yr. Hay; 1/5 K_2O Each Year	2.07	2.12	2.50	2.230
7	Unfertilized*	1.70	1.46	1.82	1.660
	Grand Means	1.909	2.072	2.498	
	Cost of Fertilizer	$12.90	$25.80	$51.60	
	Value of Grain Increase	0.00	5.28	10.16	
	Value of Hay Increase	16.80	48.96	54.40	
	Increased Returns over Fertilizer Costs	3.90	28.44	12.96	

*Data for System No. 7 was not used in statistical calculations.

Confidence Intervals ($D_{.05}$) for comparing Means:

Grand Means for Systems = 0.149
Grand Means for Rates = 0.068
Rates within Systems = 0.296

RATES AND SYSTEMS OF FERTILIZATION EXPERIMENT (1960)

TABLE VI

YIELDS OF FOURTH YEAR HAY IN TONS PER ACRE AS AFFECTED BY DIFFERENT RATES OF FERTILIZERS AND DIFFERENT SYSTEMS OF APPLYING FERTILIZERS:

SYSTEMS OF FERTILIZING	Fertilizer Treatments*			Grand Means
	0-100-100	0-200-200	0-400-400	
All Fertilizer on Grain	0.98	1.09	1.32	1.130
1/5 P_2O_5 & K_2O Each Year	1.04	1.11	1.68	1.274
1/2 P_2O_5 & K_2O on Grain & 1/2 on 2nd Year Hay	1.02	1.23	1.57	1.272
All P_2O_5 on Grain & 1/5 K_2O Each Year	1.09	1.24	1.83	1.387
1/5 P_2O_5 of K_2O Each Year Plus 40 Lbs. N/Ac. after 1st. Cut.	1.14	1.38	1.83	1.452
1/2 P_2O_5 on Grain & 1/2 on 2nd. Year Hay; 1/5 K_2O Each Year	1.10	1.21	1.57	1.334
Unfertilized**	0.90	0.82	1.02	
GRAND MEANS	1.081	1.211	1.632	

Confidence interval ($D_{.05}$) for comparing grand means for fertilizer Treatments = 0.131

Confidence interval ($D_{.05}$) for comparing grand means for systems of Fertilization = 0.227

* All plots received 40 pounds of nitrogen per acre on grain.

** Data for the unfertilized plots were not used in the statistical analysis.

Complete Fertilization Experiment (1960)

Dale E. Baker and A. C. Caldwell

Potatoes:

During the third week in August the tops of potato plants growing on plots that had received no potassium were dying prematurely. Early symptoms present on the leaves of deficient plants appeared as a purplish-green or bronzing appearance followed by scorched tips and margins. The premature withering collapsing of the haulms or main tops of the plants was the plants was the symptom of a severe deficiency. I think we should get some publicity out on this about the first week in August, so potato growers will watch for the deficiency symptoms.

The yields of potatoes reflected the potassium deficiency. Addition of potassium was more beneficial than additions of nitrogen and phosphorus in increasing yields.

The potato yields were quite variable this year so small differences don't mean much. It does seem, however, that there was a response to lime, especially where no manure had been applied. There was a very good response to manure on unlimed plots. A (70) bushel per acre potato increase from (10) tons of manure is quite significant and should be checked for over a period of years.

Oats:

In all cases the yields of oats were too low to be very profitable. There was a small yield response to phosphorus, potash and nitrogen. The most significant results obtained this year was from the effect of the treatments on the stand of alfalfa remaining at oat harvesting time. The nitrogen only plots had much better stands of alfalfa than plots treated with phosphate and potash. This is difficult to explain because it does not seem that a 50 bushel oat crop should completely eliminate the alfalfa seeding regardless of the fertilizer treatments. It would seem a cropping sequence study is needed for this area.

Hay:

A good response was obtained from phosphate, potash and lime on both first and second year meadow. However, addition of nitrogen, alone or with phosphate and potash, to small grain had very little effect on hay yields the following years.

COMPLETE FERTILIZATION EXPERIMENT (1960)

Yields of Potatoes (bu./Ac.) from Series 15-S.

Fertilizer Treatments	Lime Treatments		
	East (Limed)	West Unlimed	Average
Check	88	64	76
K	138	55	96
PK	152	105	128
P	68	63	66
Urea	78	52	65
NH_4NO_3	88	67	78
NK	167	82	124
NPK	172	117	144
NP	104	95	100
NPK & 10 T./A. Manure	110	187	148
Average	116.5	88.7	

COMPLETE FERTILIZATION EXPERIMENT (1960)

Yields of Oats in Tons per Acre and % stand of Alfalfa at harvest time as affected by different NPK treatments.

No.	Fertilizer Treatments	East (Limed)		West (Unlimed)		Average	
		Bu/Ac.	% Alf.	Bu/Ac.	% Alf.	Bu/Ac.	% Alf.
1	Check	41.2	5	40.8	5	41.0	5
2	K	45.6	0	42.8	5	44.2	2.5
3	PK	48.2	5	49.4	5	48.8	5
4	P	53.6	5	48.0	5	50.8	5
5	Urea	43.4	50	46.4	35	44.9	42.5
6	NH_4NO_3	40.8	65	43.6	30	42.2	47.5
7	NK	50.0	0	47.5	5	48.8	2.5
8	NPK	52.8	5	55.6	0	54.2	2.5
9	NP	55.5	0	46.6	0	51.0	0.0
10	NPK + 10T./A. Manure	54.6	0	53.5	0	54.0	0.0
	Average	48.57	13.5	47.42	9.0		

COMPLETE FERTILIZATION EXPERIMENT (1960)

Yields of Hay (Tons/Acre) from 1 St. year meadow on Series 17-S

Fertilizer Treatments	Lime Treatments		
	East (Limed)	West (Unlimed)	Average
Check	1.73	1.32	1.52
K	2.48	2.07	2.28
PK	2.99	2.58	2.78
P	1.74	1.76	1.75
Urea	1.78	1.72	1.75
NH_4NO_3	1.44	1.58	1.51
NK	2.04	1.89	1.96
NPK	2.78	2.08	2.43
NP	1.87	1.70	1.78
NPK & 10 T./A. Manure	2.61	2.42	2.52
Average	2.15	2.01	2.08

COMPLETE FERTILIZATION EXPERIMENT (1960)

Yields of Hay (Tons/Acre) from 2 Nd. Year Meadow on Series 16-S

Fertilizer Treatments	Lime Treatments		
	East (Limed)	West (Unlimed)	Average
Check	1.50	1.43	1.46
K	2.40	2.11	2.26
PK	2.84	2.20	2.52
P	1.88	1.76	1.82
Urea	1.39	1.26	1.32
NH_4NO_3	1.44	1.22	1.33
NK	2.30	1.82	1.56
NPK	2.52	1.94	2.23
NP	1.95	1.64	1.80
NPK & 10 T./Ac. Manure	2.85	2.18	2.52
Average	2.11	1.76	1.94

N, P, and K Experiment on Continuous Corn
Rosemount, 1960

A. C. Caldwell and J. B. Weber

This experiment was designed to study the effects of different combinations and rates of N, P, and K on the yields of continuous corn. Twenty-two treatments were laid out in two replicates, of five blocks each, in the spring of 1957.

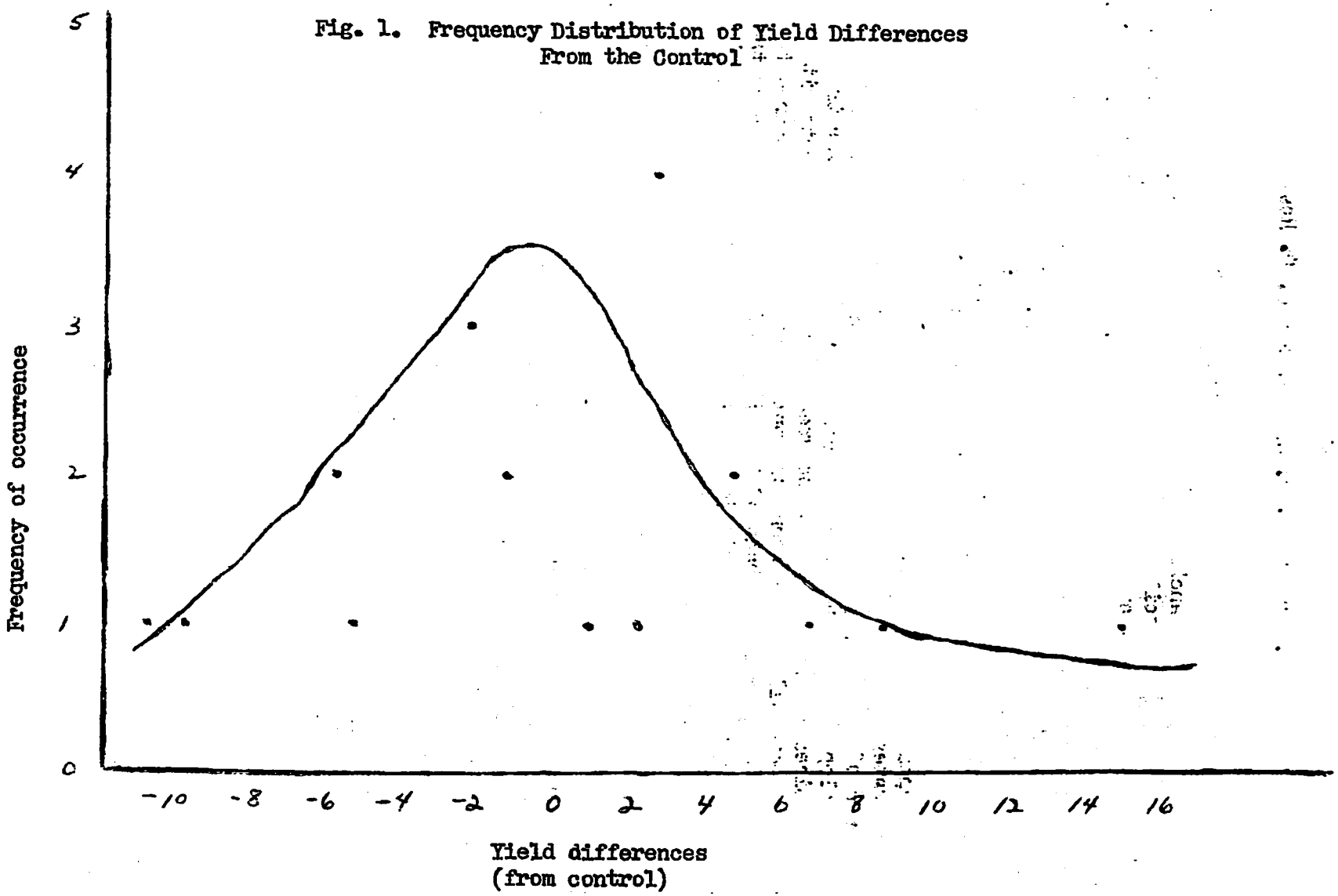
In 1958 through 1960, no fertilizer was applied in order to study the residual effects of the previously applied fertilizer.

Corn yields for 1960 are included in Table 1. No significant differences were found. A plot of the frequency distribution of yield differences, figure 1, indicates that as many increases or decreases in yields resulted. This would tend to indicate that the residual fertilizer effect has vanished and the yields on all treatments are approaching that of the control.

Table 1. The effect of residual N, P, and K fertilizers on the yields of continuous corn, 1960.

Fertilizer $N-P_2O_5-K_2O$ lbs/A.	Yield bu/A.	Diff.
0-0-0	69.3	---
0-60-37	84.5	15.2
0-60-83	58.5	-10.8
37-0-60	68.0	-1.3
37-120-60	67.0	-2.3
60-37-0	72.0	2.7
60-37-120	78.0	8.7
60-60-60	70.2	0.9
60-83-0	59.5	-9.8
60-83-120	64.0	-5.3
83-0-60	67.0	-2.3
83-120-60	72.0	2.7
120-60-37	63.5	-5.8
120-60-83	71.5	2.2
23-23-23	74.0	4.7
23-23-97	76.0	6.7
23-97-23	68.0	-1.3
23-97-97	67.0	-2.3
97-23-23	72.0	2.7
97-23-97	74.0	4.7
97-97-23	63.5	-5.8
97-97-97	72.0	2.7

Fig. 1. Frequency Distribution of Yield Differences From the Control



The Effect of Fertilizer Placement on Root Development, Maturity, Quality and Yield of Corn.

By

Paul M. Burson, R. D. Curley, and C. O. Rost*

In 1960 a study was conducted in cooperation with the Tennessee Valley Authority on root development with different fertilizers, methods of application, time of application, root anchorage, and different nitrogen:phosphate:potash ratios. On the basis of soil tests all plots received a total of 120 lbs. of N, a maximum of 40 lbs. P_2O_5 and a total of 120 lbs. of K_2O. All phosphorus was applied as starter but the N was applied all as a starter or as a starter-sidedressing combination. In the case of potash, a part was applied as starter while the remainder was broadcast and plowed under. The starter was applied in ratios of 1:1:0, 1:1:1, 1:4:0 and 3:1:0. In the 3:1:0 all the N for the season was applied in the band as starter. Soil tests showed a medium to high in organic matter, medium in phosphorus and potassium and a pH of 6.0 to 6.4.

The purpose of these trials was to observe the effects of various N:P:K ratios and rates of fertilizer that could be applied in a band as a starter, the response of potash applied as starter and broadcast and the difference in root development with the different combinations of fertilizer treatments. The most noticeable difference was the great mass of fibrous roots with the 3:1:0 ratio where all the nitrogen was applied as starter as compared to limited fibrous roots in the band of the 1:3:0 and 1:4:0 ratios where the nitrogen was applied later as sidedressing. With the 3:1:0 ratio and the 1:1:1 ratio, containing potash, practically all proliferated roots were concentrated in the single fertilizer band.

From the results with potash contained in the starter it appears that at least 40 lbs. of N should be present to get the maximum root proliferation. Adding 40 lbs. of N in the starter with a 1:1:1 ratio was better than adding greater amounts of N with no potash in the starter. With the 1959 and 1960 work it appears certain that the higher levels of N with phosphate controls the development of the corn roots systems with maximum development of roots in the fertilizer band. For this reason if the corn is to obtain sufficient potash for optimum growth and crop yield, adequate amounts of potash must also be included in the starter fertilizer band.

The following tables give the effect of fertilizer on yield, lodging, maturity, quality and anchorage of corn for 1960. Similar results were obtained in 1959 but will not be reported at this time.

The Effect of Fertilizer Treatments on Yield, Lodging, Maturity and Quality of Corn

		Fertilizer Treatments in lbs. per acre					
		Check	40-40-40 starter +80# N side-dressed	40-40-0 starter +80# N side-dressed	120-40-0 starter + No N side-dressed	60-20-0 starter +60# N side-dressed	10-40-0 starter +110# N side-dressed
I.	Yields per acre	88.2	124.0	112.0	122.7	113.3	106.2
II.	Lodging (%) (1)	Trace	0	45	15	65	5

(1) Stalks were bowed and leaned at least 45 degrees. All showed potash deficiency on the leaves during the growing season.

Percent in each maturity class

III. Maturity Class(2)						
			Sept. 8, 1960			
Milk	50	2	30	20	40	20
Late Dent	48	8	5	35	5	50
Early Dent	2	90	65	45	55	30
			Oct. 12, 1960			
Milk	0	0	0	0	0	0
Late Dent	25	0	10	0	15	0
Early Dent	75	100	90	100	85	100

(2) Milk - 100% would be damaged by early frost.
Late Dent - At least 50% would be damaged by frost. Started to dent.
Early Dent - 100% would not be damaged by early frost.
Killing frost date Oct. 4.

Ear Size (Percent in each class)

IV. Ear Class						
8" + (3)	44.0	63.7	48.0	69.8	52.7	57.8
5 to 7" (4)	47.5	32.7	49.6	27.0	37.5	36.4
Nubbins (5)	11.5	3.6	3.4	3.2	3.8	5.8

(3) Marketable, well filled, uniform ears
(4) Low grade marketable, poorly filled, variable size and chaffy ears.
(5) Nonmarketable, very short, curved, partially filled tips and sides and chaffy ears.

The Effect of Fertilizer Treatments on Root Anchorage

V.	No. stalks Pulled	Average pull per single stalk (6)
Check	16	179
All fertilizer treatments	58	259
No potash in starter	28	217
Potash in starter	35	251
Rates of Nitrogen per Acre in Starter Fertilizer		
Under 10 lbs. N	10	200
11 to 20 lbs. N	15	252
21 to 40 lbs. N	15	262
Over 40 lbs. N	18	250

(6) Pounds of vertical pull on one stalk of corn at the time the roots released from the soil.

Summary

1. Nitrogen and phosphate in the starter markedly control root proliferation and intensity of root growth.

2. If high rates of nitrogen and phosphate are used in the starter, potash should be included.

3. All three nutrients of nitrogen, phosphate and potash should be included in the starter.

4. High rates of starter fertilizer will not injure germination and stand if placed in a band to the side and below the seed.

5. All fertilizer nitrogen can be applied in the starter fertilizer if desired provided the fertilizer is placed in a band to the side and below the seed.

6. Fertilizer in proper balance and in sufficient amounts speeds up maturity, reduces moisture content and increases quality of corn grain and improves size and uniformity of ears.

7. Nitrogen, to be most effective, should be applied not later than late spring whether the season is wet or dry.

8. July and August, 1960, was extremely dry (1.6 inches of rain). No more drought injury was noticeable on corn with all the fertilizer in the band as compared to split applications of starter and sidedressing combined and with lower rates in the starter band.

Continuous Corn - High Fertility Experiment

Rosemount Experiment Station
Soils

W. P. Martin and H. W. Kramer

Yield Results - 1960

Re: 1959 results, "A Report on Soils and Soil Fertility", p. 97, Department of Soils, Mimeo., April, 1960.

Experiment Started: 1953

Soil type: Port Byron silty clay loam

Object: To determine profitable rates of fertilization for continuous corn.

Site: Fairly level with minimum erosion hazard; protected from hill pastures with terrace; tile drained.

Past results: Yields have varied from 45 bushels to 133 bushels (as an average of the treatments) from 1953-1960. Highest yields were obtained in 1954 and lowest in 1957 (excessive precipitation). Yields have consistently reflected fertilizer responses.

		16,000 plants	20,000 plants
1.	Check	69 Bu./acre	86 Bu./acre
2.	H*	92	104
3.	HS_1	92	108
4.	HS_2	94	118
5.	B_1H	90	106
6.	B_1HS_1	103	110
7.	B_1HS_2	96	116
8.	B_2H	94	113
9.	B_2HS_1	97	114
10.	B_2HS_2	99	116
	LSD (5%)	9.8	10.7

*H = 200 lbs. 10-20-20 hill drop
S_1 = 100 lbs. 33-0-0 sidedress
S_2 = 200 lbs. 33-0-0 sidedress
B_1 = 400 lbs. 6-24-12 broadcast
B_2 = 800 lbs. 6-24-12 broadcast

Continuous Corn - High Fertility Experiment

Rosemount Experiment Station
Soils

John Grava

Soil Test Results 1956, 1958 and 1960

Treatment No. and Replication No.	Annual Application of N	P_2O_5 Lbs/Acre	K_2O	Soil pH	Extractable Phosphorus (P) Lbs/Acre	Exchangeable Potassium (K) Lbs/Acre
1) Sampling Date: July 5, 1956						
1 - IV	0	0	0	5.9	13 M	90 L
4 - III	82	32	32	6.0	9 L	80 L
6 - IV	73	128	80	5.5	58 VH	145 M
9 - III	97	224	128	5.7	115 VH	185 M
2) Sampling Date: July 18, 1958						
1 - (4 Replications)	0	0	0	5.8	17 M	105 M
4 - (4 Replications)	82	32	32	5.8	27 H	135 M
6 - (4 Replications)	69	112	112	5.7	91 VH	218 M
9 - (4 Replications)	89	192	192	5.4	143 VH	278 VH
3) Sampling Date: August 1, 1960						
1 - IV	0	0	0	5.9	13 M	120 M
4 - III	82	32	32	6.1	21 H	160 M
6 - IV	69	112	112	5.7	90 VH	210 M
9 - III	89	192	192	6.0	95 VH	210 M

Organic Matter = 3.7% Med.

Fertilizer Experiment on Continuous Soybeans
Rosemount, 1960

by A. C. Caldwell and J. B. Weber

An experiment was set up in 1957 to study the effects of P, K and barnyard manure on the yields and plant composition of soybeans. Plots were laid out considting of four replications and fifteen treatments.

In 1958 through 1960, no fertilizer was applied in order to study the residual effects of the 1957 applied fertilizer.

Yield results for 1960 are shown in Table 1. Significant increases in yields occurred only on the plots which had received the relatively high rates of P and K. The increases of about 4 bushels per acre above the control are in agreement with the 1959 data.

Selected soil samples were analyzed in 1960 to determine the relative changes in available P and in exchangeable K. Table 2 shows a comparison of the levels of these nutrients for the years 1957 through 1960 for selected samples. The levels of P and K are relatively similar for the control plots, but have decreased substantially on the plots that received fertilizer in 1957. The largest decrease occurred from 1957 to 1958, and seems to be leveling off to a point where it will decrease at a much slower rate. The levels of both nutrients are still considerably higher on the plots that received fertilizer when compared to the control plots. The P level on the control plots has remained relatively constant over the period 1957 to 1960, while the K level has decreased slightly.

Table 1. Effect of residual fertilizer on yield of continuous soybeans, 1960

Treatment $N-P_2O_5-K_2O$ lbs/A	Yield bu/A	Diff.
0-0-0	19.8	----
0-0-20	18.3	-1.5
0-0-80	18.9	-0.9
0-0-400	20.7	0.9
0-20-20	19.5	-0.3
0-40-40	21.0	1.2
0-60-60	21.6	1.8
0-80-80	21.4	1.6
0-400-400	24.1	4.3
0-400-400 + *6T	24.0	4.2
0-20-0	18.6	-1.2
0-80-0	19.6	-0.2
0-400-0	19.1	-0.7
0-20-0 + 6T	20.1	0.3
* 6T	19.7	-0.1

* 6T refers to 6 tons manure/A.
lsd (.05) = 3.3

Table 2. Effect of fertilizers on exchangeable K and available P in the soil.

Treatment $N-P_2O_5-K_2O$ LBS/A.	1957 P	1957 K	1958 P	1958 K	1959 P	1959 K	1960 P	1960 K
	lbs/A.							
0-0-0	9	115	11	108	9	100	11.5	85.0
0-80-0	21	100	14	110	13	95	15.8	87.5
0-0-80	8	106	9	108	8	93	11.0	87.5
0-80-80	15	143	12	103	10	98	12.0	90.0
0-400-0	106	113	33	115	26	105	27.3	77.5
0-0-400	9	305	9	145	9	148	10.8	117.5
0-400-400	84	365	39	170	29	163	33.8	127.5

The Effect of Phosphate and Phosphate-Potash Fertilization on the Ten Year Yield of a Ranger Alfalfa at Rosemount.

J. M. MacGregor and R. G. Hanson

In the fall of 1949, a fertilizer experiment with Ranger alfalfa was commenced on the Port Byron silt loam of the Soils Unit of the Rosemount Experiment Station. The project was designed by Dr. C. O. Rost, and over the eleven year period, the study has been continued by W. W. Nelson, later by J. R. Brownell, and presently by R. G. Hanson. The primary object was to determine whether alfalfa stands could be satisfactorily maintained by good soil fertility over many years, and what kind, rate, and time of fertilization would most economically accomplish a desirable longevity of a satisfactory alfalfa stand. The initially acid loess soil was limed at the rate of 6 tons per acre before the experiment was commenced late in 1949.

The following table indicates the effect of the various treatments on the ten year yields obtained from these annual cuttings, the treatments being arranged in decreasing effectiveness of the total ten year yield obtained. The initial 1951 and the final 1960 hay yields are also shown to give a more complete outline over the ten years. The most effective fertility treatments have produced an average of nearly 1.5 tons more alfalfa hay annually than was obtained from the unfertilized areas, an increase of approximately 50%. Using 1961 fertilizer prices, the fertilizer treatment most effective for increasing alfalfa yield, (300#/A of 0-20-20 annually plus 200#/A topdressing annually) now represents an investment of $75 per acre - or $5 for each additional ton of hay produced. Several detailed publications on various phases of this study are available.

TOTAL YIELDS - ROSEMOUNT ALFALFA - 1951-1960
AVERAGE OF SEVEN REPLICATIONS - THREE CUTTINGS

10 year yield rank	Treatment	(Tons/Acre at 15% moisture) 1951	1960	Ten year total yield	Increase
30	Check	3.10	2.33	29.06	-
1	300# 0-20-20 SBS+ 200#AS	3.96	3.90	44.02	14.96
2	300# 0-20-20 FBS+ 200#AF	3.89	3.77	43.20	14.14
3	300# 5-20-20 SBS+ 200AS	4.03	3.47	42.86	13.80
4	1000# 0-20-20 SBS+ 200#AS	4.42	3.86	42.53	13.47
5	1000# 0-20-0 SBS+ 100# KCl A 1st cut.	4.26	3.85	42.12	13.06
6	1000# 0-20-20 SBS+ 200# 5-20-20BS	4.34	3.53	42.10	13.04
7	200# 0-20-20 AS	3.25	3.73	41.79	12.73
8	1000# 0-20-0AS+ 200# 0-20-20 AS	4.14	2.97	41.00	11.94
9	300# 0-20-20FBS+ 200# BF	3.51	3.62	39.70	10.64
10	200# 0-20-20 AF	3.60	3.53	39.60	10.54
11	100# 0-20-20 SBS+ 200# BS	4.30	2.87	37.62	8.56
12	300# 0-20-20 SBS+ 200# BS	3.79	3.06	37.40	8.34
13	100# 0-20-0 SBS+ 200# 0-20-20 BS	3.95	3.37	36.01	6.95
14	300# 0-20-0 SBS+ 200# AS	3.77	2.58	35.44	6.38
15	300# 0-20-20 SBS	3.90	2.98	34.27	5.21
16	1000# 0-20-20 SBS	4.09	2.62	34.06	5.00
17	200# 0-20-0 AS	3.64	2.47	33.45	4.34
18	200# 0-20-0 AF	3.84	2.35	33.32	4.26
19	1000# 0-20-0 SBS+ 200# AS	4.04	2.57	33.24	4.18
20	300# 0-20-0 FBS+ 200# BF	3.68	2.54	32.79	3.73
21	300# 0-20-0 FBS+ 200# AF	3.77	2.51	32.49	3.43
22	300# 0-20-20+ Trace elements SBS	3.88	2.28	32.18	3.12
23	300# 0-20-0 SBS+ 200# BS	3.64	2.41	31.55	2.49
24	300# 5-20-20 SBS+ 20# N AS	3.75	2.28	31.53	2.47
25	300# 0-20-0 FBS	3.61	2.48	31.25	2.19
26	300# 0-20-20 SBS+ 20# B SBS	3.84	2.02	30.04	0.98
27	1000# 0-20-0 SBS	4.01	2.22	29.71	0.65
28	300# 5-20-20 SBS	3.82	2.26	29.49	0.43
29	300# 0-20-20 FBS	3.78	2.22	29.09	0.03
31	300# 0-20-0 SBS	3.59	2.12	28.49	-0.55

SBS - Spring before seeding
FBS - Fall Before seeding
AS - Annual Spring
Trace elements - $CuSO_4$ 25#/A; $ZnSO_4$ 25#/A; $MnSO_4$ 25#/A; $FeSO_4$ 25#/A; Boron 20#/A

BS - Biennial Spring
AF - Annual Fall
BF - Biennial Fall
N - Nitrogen
B - Boron

Conclusions

Some of the better fertilizer treatments have maintained alfalfa stands very well over the ten year period, whereas others have been badly invaded by grasses (largely Kentucky bluegrass) and weed growth, and alfalfa stands are now comparatimely poor. Many important comparisons may be made from the results in the table, but the following are some of the more important findings:

1. Potassium fertilization is essential along with the phosphorus for the maintenance of alfalfa stands over many years. This is evident from the fact that the thirteen most productive fertilizer treatments all included potassium.

2. The addition of nitrogen to alfalfa was not profitable. By the end of the 1960 growing season, the third highest yielding treatment (300 pounds of 5-20-20 spring before seeding and 200 pounds topdressed each spring) produced 13.80 tons alfalfa per acre more than the unfertilized check yields. This nitrogen application over the eleven years cost approximately twelve dollars per acre and resulted in somewhat lower alfalfa production than fertilization with the same amounts of phosphorus and potassium with no nitrogen present (14.96 tons per acre).

3. Annual topdressing of the established alfalfa stand was very beneficial, and much more effective than where applied in alternate years. The additional fertilizer used in the annual applications (1200 pounds of 0-20-20) would cost a total of 35 more, but produce an extra half ton of hay each year.

4. Moderate amounts of starter fertilizer in addition to the later topdressings are effective. Starter fertilizer plus annual topdressings produced 2.9 tons more hay per acre over the 10 year period than did the topdressings alone.

5. High initial rates of fertilization alone were not economical. Initial application of 1000 pounds per acre increased yields during the first few years, but these declined rapidly.

6. Initial trace element applications (copper, boron, zinc, manganese, and iron) did not increase alfalfa yields and apparently were not essential to good alfalfa production.

7. Fall topdressing produced a slightly lower increase in alfalfa yields compared to the same fertilizer applied in the spring.

8. Alfalfa should be topdressed at least every second year, as the beneficial fertilizer effect will otherwise largely disappear, even though large amounts of fertilizer were originally applied.

Good soil fertility management is an essential for efficient alfalfa production irrespective of the soil on which it is grown. Such management is especially true where the more steeply sloping lands are to be utilized, since lower fertility levels frequently ends in the loss of good alfalfa stands, and in serious soil erosion. One of the first steps in making better use of our more marginal sloping areas must be a thorough soil testing program, and a strict adherence to the best fertility and general soil management practices.

Fertilized Legumes for Seed Production Increase Yields of Succeeding Crops

Paul M. Burson and Henry W. Kramer*

The forage legumes are the basis for a sound permanent agriculture. They are the most important livestock feeds and are essential in a sound soil fertility, management and landuse program. Their varied uses are being increasingly recognized and utilized. Therefore, the acreage being planted to these legumes is increasing, and hence greater quantities of seed are required.

In the past Minnesota had a flourishing legume seed industry of alfalfa, alsike clover, sweet clover and red clover. At various times the state has held first place in the production of alfalfa, alsike clover and sweet clover. Today it is outranked by all other legume seed producing states in the production of alfalfa and red clover, whiel the total seed produced of all four crops has decreased to the point where farmers have gone out of the business. This decrease is the result of the decreased yields per acre of all four crops so the acreage devoted to seed production is low.

Today the most important problems facing the seed producer are those concerned with soil type selection, fertilization, adequate pollination and the control of injurious insects.

Research work and observations by the Department of Soils have indicated that soil type, drainage, and proper fertilization are the important basic soil factors in legume seed production. A certain soil type may be suitable for one legume crop but not suitable for another. Determination of the proper soil type suitable to the various legume seed crops is basic. It goes without saying, that a legume plant will not produce seed abundantly unless it has an adequate and balanced nutrient supply on properly selected soil conditions. Results show a relationship between soil type conditions for different legume crops, proper fertilization and seed production. Observations further suggest a possible relationship between soil conditinns, fertilization and the attractiveness of the plant to pollinators. The information reported here will give the results of the response to fertilizer used in legume seed production and the residual response on succeeding crops that are grown in the rotation system.

Since 1952 over 40 different fields of all four legume seed crops have been studied. In the years 1952 through 1955 phosphate and phosphate + potash fertilizers were applied at the rates shown in Table i, to insure adequate amounts of both phosphate and potash.

Table 1. Fertilizer used in the experimental fields.

Grade	Pounds per acre
0-0-0	(check)
0-20-0	500
0-20-0	1000
0-20-20	500
0-20-20	1000
0-20-40	500
0-20-40	1000

*Professor and Experimental Plot Supervisor respectively, Department of Soils, University of Minnesota.

Since 1956 the same grades of fertilizer have been used but the rates per acre have been at 300 and 500 lbs. instead of 500 and 1000 lbs. Each of the seven fertilizer treatments were repeated four times in each field. All fertilizer was applied broadcast either at the time of seeding or topdressed in early spring of the year that the crop was to produce seed. No difference was noted as to the time of fertilization. The legume stands were equally good in all cases except where the legume was not adapted to the soil conditions such as too wet or too dry for the particular crop in a certain year.

The phosphate and phosphate + potash treatments were made on the basis of soil test. All plots were sprayed with DDT emulsion spray at 1 1/2 to 2 lbs. per acre at the onset of flowering. Adequate pollination was provided in all fields.

Minor nutrients of boron, manganese, copper, zinc and sulphur were studied but no responses were obtained from any of these treatments.

In Table 2 the acreage yields of the four seed crops are given for the best fertilizer treatments in those fields where the legume crop was definitely adapted to the soil type conditions, as compared to the average yield of these seed crops for Minnesota over the 10 year period of 1942-51.

Table 2. Average yield of seed from the best treatments and soil conditions in experimental fields compared with average seed yield of each crop for the state.

Crop	Average yield Minnesota, 1942-51*	Average yield, best treatment experimental fields
	(pounds per acre)	
Alsike clover	114	808
Red clover	59	761
Alfalfa	49	740
Sweetclover	180	1,438

*"Acreage, yield, and production of field seed crops. Revised estimates 1939-51 by States." USDA Bureau of Agricultural Economics, June, 1952.

Table 3 shows what seed yields are possible when the crops are grown on adaptable soil conditions, sufficient fertilization, adequate pollination and injurious insects are controlled.

Table 3. A summary of seed yields from fertilizers on representative fields with proper selection of soil, adequate pollination and control of injurious insects.*

Crop	Year	Yields in lbs. per acre			Fertilizer Rate per acre
		No fertilizer	With fertilizer	Increase from fertilizer	
Alsike clover	1952	154	691	537	0-20-20 (1000 lbs)
Alsike clover	1953	236	685	449	0-20-20 (1000 lbs)
Alsike clover	1953	368	808	440	0-20-40 (1000 lbs)
Red clover	1953	387	662	175	0-20-40 (500 lbs)
Red clover	1954	397	761	364	0-20-20 (500 lbs)
Alsike clover	1954	297	691	394	0-20-40 (1000 lbs)
Alfalfa	1954	322	740	418	0-20-20 (1000 lbs)
Sweet clover	1955	1078	1438	360	0-20-0 (1000 lbs)
Alsike clover	1956	54	308	254	0-20-40 (300 lbs)
Alsike clover	1957	188	427	239	0-20-20 (300 lbs)
Alsike clover	1958**	181	710	529	0-20-20 (500 lbs)
Sweet clover	1958**	674	1032	358	0-20-20 (500 lbs)

* Most of the pollination was by honey bees located near the experimental fields.
** In 1958 the entire plot areas were sprayed to control injurious insects.

Under the usual farming operations the seed fields are plowed following the harvest and then other crops such as small grains or flax are grown for one or more years and then the land is reseeded to one of the legumes. These experiments were carried out in the northern one-third of the state since the climate there is most favorable for legume seed production.

The residual yields of the experiments are shown in Table 4. It will be noticed the increase in yield of the succeeding crop was generally higher on the higher rates of fertilization than when the lower rates were used.

The results obtained on field No. 5 deserves special consideration because of the longer yield records. On this field the fertilizer was applied for alsike clover. Yields were increased from 154 lbs. to 691 lbs. per acre on the 1000 lbs. of 0-20-40. Two crops of barley followed and the residual effect was pronounced.

In the fourth year the land was in fallow and this was followed again by barley. Yields were not determined on the barley that year although very definite effects from the fertilizer were observed.

Alsike clover again was seeded with the barley and a crop of seed taken in the following year which was the sixth crop following the application of the fertilizer. Yields of alsike clover seed were still increased from 145 lbs. to 381 lbs. per acre on the 1000 lbs. of 0-20-20 per acre.

Using present day prices the annual increase from the crops clearly show that the residual carry-over effect on the crops which followed the alsike clover seed more than paid for the fertilizer.

Furthermore, these data show that higher rates of fertilization produce greater carry-over effects. This emphasizes the importance of making fertilizer applications heavy enough to supply all the nutrients needed to produce maximum crop yields under prevailing soil and weather conditions.

Table 4. Residual or Carry-over Effect of Fertilizer Applied for Legume Seed. All the fertilizer applied for 1st year crop. Yields per acre for each treatment.

Field No.	Year	Crop	Check	0-20-0 500 lb.	0-20-0 1000 lb	0-20-20 500 lb	0-20-20 1000 lb.	0-20-40 500 lb.	0-20-40 1000 lb.
1	1st	Red clover seed*	84 lbs.	80	78	93	108	94	94
	2nd	Corn	52.9 bu.	56.3	60.8	84.4	83.6	86.3	89.1
2	1st	Red clover seed	129 lbs.	135	159	129	128	166	157
	2nd	Corn silage	20 tons	23	23	26	26	23	24
3	1st	Red clover seed**	166 lbs.	235	222	240	267	216	211
	2nd	Flax	16 bu.	21	22	22	24	22	23
4	1st	Red clover seed	387 lbs.	670	653	654	637	662	622
	2nd	Red clover seed	151 lbs.	245	287	281	271	302	280
5	1st	Alsike clover seed	154 lbs.	570	620	641	657	614	691
	2nd	Barley	32 bu.	51.5	57.8	59.0	62.5	60.4	60.7
	3rd	Barley	37.4	51.6	52.7	51.0	50.3	44.4	50.5
	4th	Fallow	---	---	---	---	---	---	---
	5th	Barley***	visible increase in yield from fertilizer.						
	6th	Alsike clover seed	145 lbs.	267	330	264	381	278	352
6	1st	Sunflowers	79.8 bu.	100.9	101.9	105.2	96.0	97.6	91.9

* Inadequate pollination and first crop clipped too late for good seed set.
** Fertilizer rates at 300 and 500 lbs. per acre instead of 500 and 1000 lbs. per acre.
***Not sampled for yield.

Table 5. Residual or Carry-over Effect of Fertilizer Applied for Legume Seed, 1959 and 1960*

Crop	Check	0-20-0 300 lb.	0-20-0 500 lb.	0-20-20 300 lb.	0-20-20 500 lb.	0-20-40 300 lb.	0-20-40 500 lb.
				1959			
Barley	20.8 bu.	58.5 bu.	54.9 bu.	52.8 bu.	62.0 bu.	56.6 bu.	63.1 bu.
Oats	40.3	56.5	62.3	68.1	72.2	63.3	69.5
Oats	87.3	124.0	126.9	123.9	132.1	123.9	120.1
Flax	20.4	21.3	21.5	22.2	19.7	23.1	22.4
Alsike Clover	72.0 lb.	192.0 lb.	207.0 lb.	181.0 lb.	191.0 lb.	174.0 lb.	194.0 lb.
				1960			
Wheat	27.7 bu.	29.1 bu.	27.7 bu.	30.9 bu.	28.5 bu.	28.0 bu.	26.9 bu.
Oats	76.8	82.9	80.8	80.8	77.0	82.3	83.4
Oats	43.6	45.8	47.9	51.1	49.2	50.5	47.4
Oats	65.6	76.0	88.0	71.7	82.8	82.2	84.0
Wheat	47.4	52.7	51.9	51.9	51.5	52.6	51.7
Wheat	45.2	52.8	53.0	54.1	52.8	52.1	53.9

* All fertilizer applied previous years on legume seed crop.
** Individual fields

These consistent residual yield increases can be expected to carry through anywhere from 2 to 6 years or possibly more, after the initial fertilizer application.

The question now being asked by farmers in the legume seed producing areas of northern Minnesota as to what this fertilization program can mean to me on my farm in economic returns?

This residual response indicates that such a fertility program can apply to any type of farming regardless of the crops grown in the different agricultural areas of Minnesota.

In all the residual yield responses reported above on the 5 fields, the dollar return for fertilizer over fertilizer cost ranged from $3.00 for each $1.00 spent for the year of application up to as high as $9.00 return for a 6 year residual response. To illustrate what these dollar returns over fertilizer cost would mean field no. 5 is an excellent example.

On the basis of the 0-20-20 fertilizer, which gave the most consistent increase in all crop yields for the 6 years, when applied at two rates, 500 and 1000 pounds per acre, it would cost $17,00 and $34.00 per acre respectively. The acre return over fertilizer cost would be $164.00 for the 500 pound rate and $211.50 for the 1000 pound rate. The second 500 lbs. of fertilizer returned $47.40 per acre for $17.00 per acre additional investment in fertilizer. Crop prices were figured on the current farm price.

If a typical 50 acre Minnesota field was cropped in the same way as field no. 5, the return over fertilizer cost would amount to $8,205.00 for the 500 pound rate as compared to $10,575.00 for the 1000 pound rate for the 6 year residual period.

The difference in the return over fertilizer cost between the two rates of application per acre then is $2,370.00 in favor of the 1000 pound rate. This means that the second 500 pounds per acre of fertilizer added to the 50 acre field brought this additional return.

How much longer these residual responses may continue beyond the 6 years is not known, but such a fertility program is now in progress on the other 5 fields. These fields are being cropped with different kinds of crops and in a different sequence than field no. 5, but all are showing similar yield increases and similar ratios of dollar returns over fertilizer costs for the different crops.

There is no substitute for good soil fertility and management. It is the best insurance and investment a farmer can make, no matter how large or how small his scale of farming operations may be. Proper fertilization means efficiency of production and greater economic return in any farming operation.

PASTURE FERTILITY AND BEEF PRODUCTION

P.M. Burson, Soils; A.R. Schmid, Agronomy
A.L. Harvey and O.E. Kolari, Animal Husbandry

On May 16, 1960, steers from the winter feeding experiment were lotted and turned onto pasture. One-half of each of the three pastures was fertilized and the other one-half unfertilized. Each pasture received an annual topdressing of 200 lbs. per acre of 0-20-20 and 200 lbs. of 33-0-0, ammonium nitrate (66 lbs. of nitrogen). The 0-20-20 was applied in early spring while the nitrogen was applied at different times during the spring and summer as shown in table 2. Pastures B and F are mainly brome grass and bluegrass. Pastures A and C are a mixture of alfalfa, brome and orchard grass, while pastures B and F are brome and orchard grass. Table 1 shows the production of beef for 1960. The total production of beef per acre ranged from 134 lbs. on the unfertilized B and F pastures to 280 lbs. on the fertilized renovated A and C pastures. It should be noted that the greatest beef production per acre was from the fertilized renovated pastures which also gave the greatest beef return per acre over seed, tillage and fertilizer costs. The carrying capacity as shown by steer-clays per acre ranged from 86 on the unfertilized grass to 132 on the fertilized grass to a top of 181 on the fertilized renovated pastures. The average pounds gained per steer for the 113 days of grazing ranged from 155 on the unfertilized to 175 on the fertilized renovated to 187 lbs. on the fertilized grass.

As shown in table 2, the application of nitrogen fertilizer on pastured B, D, F and G was made at two different times in the spring. This was compared with a split application with one-half put on in the spring and one-half during mid-summer. The effect of nitrogen fertilizer on the yield of forage produced per acre was determined. The difference in time of application or the use of split applications had no major effect on the amount of forage produced per acre over a single application all applied in early or late spring. In some areas where rainfall is sufficient and well distributed during the summer months, the split application of nitrogen may boost pasture yields during mid-summer. A split application may be important where the soils are eroded to the extent that no topsoil remains. Where no topsoil remains higher rates of nitrogen should be used at the spring application along with the mid-summer application. The application of nitrogen fertilizer did boost pasture yields from .31 ton per acre on the unfertilized B1 pasture to 2.70 tons on the nitrogen fertilized D1 pasture. The percentage of grass in the pasturage was increased by nitrogen fertilizer. However, no difference in the percentage of grass could be noted as to the time of nitrogen application.

Table 1. Beef produced with yearling steers on unfertilized and fertilized pastures grazed in rotation. May 16, 1960 to September 6, 1960. (113 days)

	Unfertilized	Fertilized a/	
	Grass B_3, B_4, F_1 5.65 acres	60# N on Grass B_1, B_2, F_1 5.65 acres	Renovated b/ A_2, A_3, C_1 7.50 acres
No. steers at start	6 c/	10 d/	12
Initial weight, lb.	636	634	628
Final weight, lb.	791	821	803
Gain/steer, lb.	155	187	175
Daily gain, lb.	1.56	1.59	1.55
Steer days/acre	86	132	181
Beef produced/acre, lb.	134	210	280
Value beef produced/acre @ 21.00 cwt.	28.14	44.10	58.80
Fertilizer and lime cost/acre	—	15.00	8.00
Tillage and seed cost/acre	—	—	6.00
Value beef produced/acre less seed, tillage and fertilizer cost	28.14	29.10	44.80

a/ 200#/acre 0-20-20 annual

b/ Renovation - three workings with deep tiller and once with disk. Seeded to alfalfa 5#, alsike 1#, Lincoln brome 6#, and orchard grass 2# per acre

c/ 2 steers removed 6/2/60

d/ 4 steers removed 6/2/60

Table 2. Clipping yields from fertilized pastures B, D, E, F, and G comparing nitrogen fertilization as to time of application and split versus one application.

P.M. Burson, Soils; A.R. Schmid, Agronomy
A.L. Harvey, Animal Husbandry [a]

Treatments Lbs. N/acre [b]	Total tons and average per acre for each pasture at 15% moisture [c]							
	B1	B2	D1	E1	F	G2	G5	Av.
No fertilizer	.31	1.30	1.55	1.21	1.28	.63	.54	.97
66#April 22	.56	1.43	2.30	1.27	2.17	1.00	1.42	1.45
33# April 22 - 33# July 13	.52	1.32	2.50	1.25	1.33	.95	1.44	1.34
66# June 13	.40	1.27	2.31	1.11	1.94	.89	1.69	1.37
33# June 13 - 33# July 13	.67	1.49	2.70	1.39	1.36	.82	1.44	1.41

[a] Acknowledgement is due Ed. Bonnell and Lawrence Olson who harvested the sample.

[b] Annual application - 200# per acre 0-20-20, April 22, 1960

[c]

Pastures	Number of Clippings
D1, B2, and G5	3
F and G2	2
B1 and E1	1

Pastures D1 and E1 legume-grass mixture

BEEF PRODUCTION FROM RENOVATED AND FERTILIZED GRASS PASTURES

A. R. Schmid, Agronomy; P. M. Burson, Soils;
A. L. Harvey and O. E. Kolari, Animal Husbandry

Four types of pasture were compared on "G" for the third successive year. The four types were renovated, grass with no fertilizer, grass with nitrogen and grass with manure. All pastures were limed in the fall of 1956 with 3 tons of ground limestone per acre. The area for renovation was cultivated three times in the fall and one time in the spring with a Deep Tiller. Then it was disced, packed and seeded to flax and a mixture of Ranger alfalfa, 5 pounds per acre; alsike clover, 1; Lincoln bromegrass, 6; and orchard grass, 2.

For the manure treatment on grass, applications were made each fall. Commercial fertilizer used on the various treatments was applied in the spring. The rates of fertilization, manure and lime are shown in Table 1.

Results - In 1958 the beef produced per acre was 251 pounds from the check (grass with no fertilizer), 272 pounds from manure (6 tons per acre), 265 from nitrogen (80 pounds N per acre), and 394 pounds from the renovation (fertilizer-legume-grass).

In 1959 the manure treatment was increased from 6 to 8 tons of manure per acre and because of an error the nitrogen treatment was reduced from 80 pounds to 60 pounds per acre. The beef produced per acre was 146 pounds from the control; 216 pounds from the manured; 233 pounds from the nitrogen and 263 pounds from the renovated. Returns above costs for both years plus the 1960 data are shown in Table 1.

In 1960 the beef produced per acre was 172, 247, 289, and 240 pounds respectively from the check, manure, nitrogen and renovated. In returns per acre above costs no spectacular differences were obtained. Steers on the pasture treated with nitrogen returned $5.22 more per acre than the control, the manure $3.60 less and the renovated $8.75 less per acre than the control. The legume in the renovated pastures had pretty well disappeared and the stand was not the best to begin with.

The three year averages of returns per acre over costs show the removated to be $10.29 per acre better than the control. The manure and nitrogen treatments although not showing any important advantage over the control in returns did have a higher carrying capacity. At times during the three year period the lack of moisture did not allow for maximum yields from the manure and nitrogen treatments.

Table 1. Beef produced from brome-timothy and renovated pastures (2 pasture rotation-G). May 16, 1960 - August 16, 1960. (79 days)[a]

		Control (G4,G6)	Manure[b] (G1,G7)	Nitrogen[c] (G2,G5)	Renovated[d] (G3,G8)
No. steers at start		4	6	6	6
Initial weight, lb.		718	719	718	715
Final weight, lb.		864	874	890	862
Gain/steer, lb.		138	132	154	128
Daily gain, lb.		1.74	1.67	1.95	1.62
Steer days/acre		99	148	148	148
Beef produced/acre, lb.		172	247	289	240
Value beef produced/acre at $21.00 cwt.		$36.12	$51.87	$60.69	$50.40
Fertilizer, lime and manure cost/acre[a]		$ 0.97	$20.32	$20.32	$17.36
Tillage and seed cost/acre					$ 6.64
Value beef produced/acre less fertilizer and tillage costs	1960	$35.15	$31.55	$40.37	$26.40
	1959	$38.91	$38.83	$45.27	$54.61
	1958	$68.31	$58.37	$53.17	$92.24
	ave.	$47.46	$42.92	$46.27	$57.75

a/ Not grazed 7/7/-7/20 (13 days) in 1960

b/ Manure, 8 tons/acre annually, value $9.60. Also 300 lbs. 0-20-20 in 1957 and 200 lbs. annually since 1957, annual cost $9.75.

c/ Nitrogen, 80 lb N/acre annually, cost $9.60. Also same amount 0-20-20 as on manure. (due to erroe only 60 lb. N was applied in 1959).

d/ Renovated, four workings with a deep tiller and once with disk, cost at $3.00 per operation per acre $15.00 or $5.00 per year over 3 years. Seed was alfalfa 5 lb/acre, alsike 1, Lincoln bromegrass 6, orchardgrass 2 lbs. per acre; cost $4.92, or $1.64 per year over a 3 year period.

e/ Lime, all pastures @ 3 tons per acre, cost $0.97 per year over 10 year period.

THE EFFECTS OF PASTURE FERTILIZATION AND STILBESTROL IMPLANTS ON BEEF PRODUCTION

A. L. Harvey, O. E. Kolari, Animal Husbandry
P. M. Burson, Soils and A. R. Schmid, Agronomy

Comparisons were started in 1953 to determine the effect of fertilization on yield, palatability and utilization of various pasture mixtures as well as carrying capacity and the amount of beef produced per acre. An average of seven years' results (1953-1959) shows that fertilizing alfalfa-brome pastures increased: (1) carrying capacity 55 steer days (114 to 169 days) or 48%; (2) beef produced per acre 85 pounds (206 to 291 pounds) or 41%; (3) value of beef produced per acre less fertilizer costs $10.04 per acre ($47.64 to $57.68) or 21%. When weather conditions were favorable, as in 1958, 461 pounds of beef were produced per acre on the fertilized pastures, which was 159 pounds more than produced on similar unfertilized pastures. The additional beef produced from the fertilized pastures (valued at $28 per hundredweight) increased the margin, after deducting costs of fertilizing ($15 per acre), $29.52 per acre. There was only one year in seven (1959) when the application of fertilizer did not prove profitable. This was probably due to winter killing of alfalfa and orchard grass the preceding winter and extreme drought the following spring.

Implanting steers with 24 mg. stilbestrol at the start of the pasture season has been a very profitable procedure. Average results for three years' (1957-1959) grazing on legume grass mixtures showed an increase of 51 pounds beef per acre (280 to 331 pounds) or 18% more beef produced by implanted steers. Fifty-one pounds of beef at $28 per hundredweight, less cost of implants ($0.10),

[a]Acknowledgment is due Charles Pfizer & Co., Terre Haute, Indiana for stilbestrol implants; College of Veterinary Medicine for veterinary service; E. Swanson and G. Tompkins who fed and cared for the cattle; and to L. Williamson who assisted in the conduct of the experiment.

resulted in a margin of $14.08 per acre in favor of the implanted steers.

When steers were implanted with 24 mg. stilbestrol and grazed on fertilized alfalfa-brome pastures, the amount of beef produced per acre was 139 pounds (241 vs. 380 pounds) or 58% greater than the amount produced by steers not implanted and grazed on unfertilized pastures. The two procedures increased the return per acre $23.82 over costs of implanting and fertilizing.

During 1959, one group of steers was grazed on pastures (B and F) which consisted principally of bromegrass. Even though the fertilized pastures produced 45 pounds more beef per acre than the controls (125 vs. 170 pounds) it was not sufficient to cover the cost of fertilizer. Furthermore, the steers implanted with 24 mg. of stilbestrol at the start of grazing produced less beef per acre regardless of whether the pastures had been fertilized or not. Because of the unfavorable pasture conditions in 1959 it was decided to repeat the experiment in 1960.

Procedure

"Medium-to-good" grade yearling steers were lotted as uniformly as possible into three groups, each grazed on a three-pasture rotation. Group I consisted of 6 steers (reduced to 4 steers after 17 days) on unfertilized bromegrass pastures (B3, B4, F2) totaling 5.65 acres; group II consisted of 10 steers (reduced to 6 steers after 17 days) on fertilized bromegrass pastures (B1, B2, F1) totaling 5.65 acres; and group III consisted of 12 steers on fertilized alfalfa-brome pastures (A2, A3, C1) totaling 7.5 acres.

Steers in these pasture trials and one other (Report B-29b) had been used in an experiment the preceding winter (Report B-24). One-half had been implanted with 12 mg. stilbestrol November 24, 1959. One-half of those implanted and one-half those not implanted in the fall of 1959 were implanted with 24 mg. when turned onto pasture May 16, 1960, to determine whether previous implanting affected pasture gains (repeat of preceding year).

Results and Discussion

The amount of beef produced per acre from all pastures in this experiment averaged 41 pounds per acre (167 vs. 208 pounds) or 25% more than 1959, while the fertilized pastures averaged 56 pounds (189 vs. 245 pounds) or 30% more than 1959. This was probably due to ample rainfall during the spring months even though August was drier than normal. Table 1 contains a summary of results.

Table 1. The effect of stilbestrol implants on steers grazed on unfertilized and fertilized pastures. May 16, 1960 - September 6, 1960, (113 days).

	Implanted[a]			Control		
Pastures	Unfert. grass (B3,4,F2)	Fertilized grass (B1,2,F1)	Fert. leg.x grass (A2,3,C1)	Unfert. grass (B3,4,F2)	Fertilized grass (B1,2,F1)	Fert. leg. x grass (A2,3,C1)
No. steers at start	3[b]	5[c]	6	3[b]	5[c]	6
Initial weight, lb.	640	625	623	632	644	633
Final weight, lb.	833	818	822	750	824	784
Gain/steer, lb.	193	193	199	118	180	151
Daily gain, lb.	1.89	1.69	1.76	1.23	1.49	1.34
Steer days/acre	86	132	181	86	132	181
Beef produced/acre, lb.	162	223	318	105	196	242
Increase due to implants, lb.(%)	57(54%)	27(14%)	76(31%)	-	-	-
Value of beef produced /acre at $21.00/cwt.	$34.02	$46.83	$66.78	$22.05	$41.16	$50.82
Daily gain, av. all pastures, lb.		1.78			1.35	
Beef produced/acre, av. all pastures, lb.		234			181	
Increase due to implants, lb.,(%)		53(29%)			-	
Value of beef produced/acre, av. all pastures		$49.14			$38.01	

[a]Implanted with 24 mg. stilbestrol May 16, 1960.
[b]1 steer removed 6/2/60
[c]2 steers removed 6/20/60

Implanting steers with 24 mg. stilbestrol when turned on pasture:

1. Increased average daily gain per head 0.43 pounds (1.35 to 1.78 pounds).
2. Increased beef produced per acre 53 pounds (181 to 234 pounds), or 29%.
3. Increased the value of beef produced per acre $11.13 ($38.01 to $49.14).
4. Increased the beef produced per acre from:
   a. Unfertilized grass pastures 57 pounds (105 to 162 pounds) or 54%.
   b. Fertilized grass pastures 27 pounds (196 to 223 pounds) or 14%.
   c. Fertilized legume-grass pastures 76 pounds (242 to 318 pounds) or 31%.

Table 2 shows the effect on subsequent pasture gains of implanting calves with 12 mg. stilbestrol at the beginning of the wintering experiment and/or implanting with 24 mg. stilbestrol at the beginning of the pasture trial.

Table 2. Effect of various stilbestrol implanting regimes on average daily gains on pasture

Feeding period	Implanted[a]		Not implanted	
Wintering	1.45(12 steers)		1.38(16 steers)	
	Implant[b]	No implant	Implant	No implant
Pasture	1.81 (6 steers)	1.28 (6 steers)	1.72 (8 steers)	1.39 (8 steers)

[a]12 mg. implant, 11/24/59
[b]24 mg. implant, 5/16/60

In these experiments implanting steers with stilbestrol:

1. Increased the average daily gain .07 pound (1.38 to 1.45 pounds), or 5% during the winter but decreased the average daily gain .09 pound (1.39 to 1.28 pounds), or 6%, during the following pasture season.

2. At the start of the pasture season only, increased the average daily gain .33 pounds (1.39 to 1.72 pounds), or 24%.
3. At the beginning of the wintor and at the start of the pasture season increased the average daily gain .42 pounds (1.39 to 1.81 pounds), or 30%.

Results of several years' experiments show that when moisture conditions are favorable implanting steers with stilbestrol at the start of the pasture season, regardless of previous wintering implanting, is a profitable procedure.

Sherburne County Potato Fertility Demonstration - 1960

Merle Halverson, J. M. MacGregor and O. C. Turnquist

Location: Odin Odegard farm, 2 miles S.W. of Princeton, Minnesota
Soil: Type: Zimmerman loamy sand (irrigated)
pH: 5.9
O.M. content: 1.2% (low)
Extractable P: 100 lbs/A, (very high)
Exchangeable K: 110 lbs./A, (medium)
Texture: loamy sand
1959 crop: Rye (no manure)
Variety: Waseca
Crop Details: Row spacing: 40" between, 10" within
Planting Date: 22 April, 1960
Irrigations: Four (1 1/4" each)
Plot Size: 6'8" (2 rows) x 2640' (0.39 acres)
Harvest area: 6'8" (2 rows) x 2640' (0.39 acres)
Sprayed: DDT, 23 May
Millers 658 9 July
Vines Killed: Aug. 4 2 gal/A Atlas "A" applied.
Harvest date: August 12
Fertilizer: Nitrogen: 75 lbs/A N applied sidedress to all plots (including check) on May 27, 1960
Grades and Rates: 8-16-24 at 0, 300, 600, 900 and 1200 lbs/A
4-12-36 at 0, 400, 800, 1200 and 1650 lbs/A
Both grades and all rates applied in the row at planting time.
Note: The treatments were not replicated; however, each yield sample was of such size (0.39 acres) as to give the data considerable reliability.

Results:

Fertilizer grade	Rate, lbs/A	Yield of #1 tubers cwt/A	Specific gravity	% of total yield due to #1 tubers
check	---	105.1	1.070	88.0
8-16-24	300	118.9	1.068	84.9
"	600	128.6	1.068	84.9
"	900	134.3	1.066	86.1
"	1200	122.2	1.067	84.1
4-12-36	400	116.6	1.068	87.0
"	800	120.7	1.065	83.4
"	1200	121.7	1.067	82.5
"	1600	111.0	1.066	80.8

Marked yield declines occurred at rates of application exceeding 900 lbs/A of 8-16-24 and 1200 lbs/A of 4-12-36 when these materials were placed in the row. Failure of the 4-12-36 to increase yields as effectively as the 8-16-24 at equal rates of P_2O_5 cannot be explained because the ratios of nitrogen to potash in the two fertilizer grades are different.

Failure of yields to attain higher maximum values can probably be attributed to the early potato variety planted. It is also possible that considerable of the nitrogen applied May 27 was lost to undrainage in the irrigation water on this coarse-texture soil.

Clay County Potato Fertility Demonstrations, 1960

O. A. Daellenbach, O. C. Turnquist and Merle Halverson

Location: Gary Smith Farm, 2 miles south of Baker, Minnesota
Soil: Type: Bearden silt loam
pH: 8.2
O.M. content: 4.6% (medium)
Extractable P: 1 lb/A (very low)
Exchangeable K: 190 lbs/A (medium)
1959 crop: soybeans (spring plowed 1960, no manure)
Variety: Irish Cobbler
Crop Details: Row Spacing: 38" between, 12" within
Date of Planting: June 3, 1960
Harvest Date: September 21, 1960
Plot Size: 0.01 acre 12'8" (4 rows) x 34'5"
Harvest Sampling Area: 6'4" (2 rows) x 16'6"
Experimental:
Nitrogen: (as ammonium nitrate) a broadcast preplant and disced in.
3 rates: 0, 42, and 80 lb. nitrogen per acre.
P_2O_5: (as concentrated superphosphate) applied in row at planting
1 rate: 100 lb. P_2O_5 per acre
K_2O: (as muriate of potash) broadcast preplant and disced in.
4 rates: 0, 42, 80 and 120 lb. K_2O per acre
Replicates: 4
Note: Two potash sources (muriate and sulfate) were also compared at 3 application rates - using 100 lbs. P_2O_5/A row placed at one rate of nitrogen (40 lbs N/A) only.

(1) Main effects of nitrogen
(Each figure is an average from 16' plots receiving that nitrogen rate)

N rate lbs/A	Yield of #1 tubers cwt/A	Specific gravity	% of total yield due to #1 tubers
0	137.0	1.085	93.5
40	154.7*	1.083	93.0
80	159.4*	1.084	92.9

(2) Main effect of potash (muriate)
(Each figure is an average of 12 plots receiving that potash rate)

K_2O rate lbs./A	Yield of #1 tubers cwt/A	Specific gravity	% of total yield due #1 tubers
0	148.1	1.086	92.3
40	149.6	1.085	93.5
80	153.9	1.083*	93.3
120	149.8	1.083*	93.6

(3) Effect of 3 rates and 2 sources of potash on yield of #1.
Cobblers using 40 lb. nitrogen and 100 lbs. available phosphate per acre throughout.
(Each figure is an average of 4 replicates receiving that combination of potash rate and source)

K_2O Source	Chloride		Sulfate	
K_2O Rate	Yield, cwt/A	spec. grav.	Yield, cwt/A	spec. grav.
40 lbs/A	161.2	1.086	160.5	1.087
80 lbs/A	172.9	1.084	173.2	1.086
120 lbs/A	167.1	1.083	171.5	1.086
Average	168.4	1.084*	168.4	1.086*

* denotes significant differences when compared with 0 rate, in the case of (1) and (2), and between potash sources in the case of (3).

Specific gravity tests give an indication of relative cooking quality in potatoes. The test is a measure of total dry matter content and will vary with variety, soil type, season, moisture, fertilization, pest control and maturity. Dry matter content is, however, only one measure of cooking quality. It tells largely the texture or mealiness which can be expected upon cooking. Potatoes having a high specific gravity contain more dry matter than those with a low specific gravity. The following classification ranges are commonly used.

Specific Gravity	Total Dry Matter (approximate)	Texture	Best Use
Below 1.061	less than 16%	very soggy	Good pan fryers and salads. Fair boilers
1.061-1.070	16 to 18%	soggy	Good pan fryers and salads. Fair boilers
1.071-1.080	18 to 20%	waxy	Good bakers and mashers
1.081-1.090	20 to 22%	mealy	Good bakers, mashers, chippers and french fryers.
1.091-1.110	22 to 24%	very mealy	Good Bakers, chippers and fryers.

In the opinion of extension specialists in Horticulture and Soils, the nitrogen rates and potash rates and sources used in this work had no deleterious effect upon potato cooking quality from the consumer standpoint. While measurable differences in specific gravity were observed, these differences were so small as to make them undetectable and unimportant to the consumer.

It should be noted that the nitrogen and potash materials used in this work were applied broadcast and not row placement.. As such, the effects noted herein are not necessarily the same as might have occurred had the same materials been used in row placement.

Fertility Studies on Peat at Hollandale - 1960

R. S. Farnham

The object of this study on peat at Hollandale, Minnesota was to compare the effect of several rates and grades of commercial fertilizers on the yield and quality of Irish Cobbler potatoes.

The organic soil used is a decomposed peat with about 20% mineral matter. The pH varied from 7.0 to 7.3 in the plot area and extractable P by soil test was very high (200 + lbs./acre) and K very high (400-500 lbs/acre). The plot area was adequately drained by tile drainage.

The experiment was a split plot randomized block designed including four replicates. Three fertilizer grades 0-20-20, 4-12-36, and 0-12-36 were applied broadcast in late May prior to seeding at 0, 300, 600 and 900 pounds/acre rates. The plots were harvested October 12, 1960, and total yields of potato tubers and specific gravity data are shown in Table 1.

The highest yield of potatoes was obtained with the 0-12-36 grade at the 900 pound/acre rate, however, the 300 pound rate was the most economical showing an increase of over 4500 pounds per acre over the check. Nitrogen additions appear to depress the yield at the lower rates of 4-12-36 although the 900 pound rate gave a 28 bag increase.

The 0-20-20 grade having a 1 to 1 P to K ratio is not as effective as the 0-12-36 grade with a 1 to 3 P to K ratio. This indicates a definite response to potassium despite a very high initial soil test (400-500) for K.

Increased phosphorus rates using 0-20-20 grade did not increase yields as much as when the 0-12-36 grade was used although the 1 to 1 ratio did give some yield increases.

The 300 and 600 pound rates of 4-12-36 decrease the specific gravity more than any other treatment. This is probably due to a nitrogen effect as the 0-12-36 grade without nitrogen did not decrease the specific gravity except at the 900 pound rate. Indications are that the highest potassium rates generally lower the specific gravity of potatoes.

Table 1. Yield and Specific Gravity of Cobbler Potatoes on an Organic Soil at Hollandale, 1960.

	0-20-20		4-12-36		0-12-36	
Rate	Yield	Sp. Gr.	Yield	Sp. Gr.	Yield	Sp. Gr.
	cwt/acre		cwt/acre		cwt/acre	
0	320.2	1.0690	316.5	1.0692	328.2	1.0718
300	339.0	1.0720	315.1	1.0685	373.9	1.0705
600	351.4	1.0690	328.9	1.0672	365.2	1.0708
900	344.1	1.0715	344.1	1.0692	392.8	1.0695

Fertilization for Grass Seed Production in Northern Minnesota

J. M. MacGregor, P. M. Burson, and H. W. Kramer

An investigation to determine the effect of commercial fertilizer on grass seed production in northern Minnesota was commenced late in 1959. With the development of Park Kentucky bluegrass and its seed production in Roseau county, there was considerable interest in establishing the possible economic effects of applying different kinds of fertilizers at different rates and at different times during the year, to both new and established stands on both organic and inorganic soils. Fertilization of fields for grass seed production in Roseau County is a well established practice, but there has been no detailed study of what ratios and rates per acre are most effective in grass seed production.

Greenhouse Experiments

While the major portion of the investigation was to be undertaken in the grass seed production areas of Roseau County, greenhouse studies were also initiated on these soils late in 1959, at the time the first field fertilizer treatments were made. Bulk samples of a mineral soil and a peat soil were transported from Roseau County to St. Paul, and an extensive fertilization experiment was initiated. While an excellent vegetative production resulted in the greenhouse with some fertilizer treatments, no seed production has yet been obtained in these trials. It appears that this lack of seed development may be due to unfavorable light conditions, and further research will be done in an attempt to induce flowering of the Park Kentucky bluegrass in the greenhouse in order to determine fertilizer effect.

Field Experiments

Four fields of Park Kentucky bluegrass (two on peat soils and two on mineral soils) and two fields of Climax timothy were fertilized in the September of 1959, and adjacent comparative plots were fertilized with the same treatments in the following May. In addition, a high nitrogen treatment experiment was established in May on one field of Park Kentucky bluegrass located on a mineral soil.

The treated plots were harvested in 1960 and the samples were passed twice through a hammer mill, and then repeatedly passed through a fanning mill until sufficiently clean. The seed yields obtained with the different fertilizer treatments are shown in the following tables. Four replications of each treatment were employed on the seven field experiments.

Table 1. The effect of different fertilizer treatments on the 1960 yield of Park Kentucky bluegrass seed, growing on peat soils in Roseau County, Minnesota

Fertilizer Treat. (lb/A) N P_2O_5 K_2O	Pounds of harvested grass seed per acre			
	Charles Habstritt - Roseau (new seeding on peat)		Stanley Roadfeldt - Badger (seeding 2 years old)	
0-0-0	54		205	
	Fall fertilized	Spring fertilized	Fall fertilized	Spring fertilized
0-80-0	167	237**	382**	300
0-80-80	196*	242**	349**	334*
30-80-0	164	218*	327*	387**
30-80-80	197*	146	306	372**
60-80-80	128	255**	377**	409**
90-80-80	250**	221*	331*	365**
40-20-80	186*	179		
33-33-33 (winter)	173		279	
Average	184	213	345	361

* L.S.D. (5%) = 128#/A.
** " (1%) = 170#/A.

The 33-33-33 winter applied was the farm operator application of 12-12-12 at the rate of 275#/A.

Phosphate was the mineral nutrient most effective for increasing grass seed yield. Potash and nitrogen had little beneficial effect and spring fertilization resulted in a greater average seed yield than was obtained with the fall fertilization. This beneficial effect of spring fertilization was probably a result of the greater availability of the spring applied phosphate in comparison to that spread in the preceding autumn, with the cold soil conditions of the spring growing season.

Table 2 shows the fertilizer effect produced on two fields of mineral soil.

Table 2. The effect of different fertilizer treatments on the 1960 yield of Park Kentucky bluegrass seed growing on two mineral Soils of Roseau County, Minnesota

Fertilizer treat. (lbs/A.) N P_2O_5 K_2O	Pounds of harvested grass seed per acre: Oliver Wold - Roseau (new seeding)		Helmer Halvorson - Roseau (4 year old seeding)	
0-0-0	80		21	
	Fall fertilized	Spring fertilized	Fall fertilized	Spring fertilized
0-80-0	117	108	39	35
0-80-80	123	101	26	23
30-80-0	202**	235**	98**	77*
30-80-80	183*	228**	65*	61
60-80-80	368**	284**	146**	100**
90-80-80	379**	371**	196**	89*
48-48-48	-	-	-	71
Average	229	221	95	64

* L.S.D. (5%) = 88#/A. 42#/A.
** L.S.D. (1%) = 118#/A. 57#/A.

On these two mineral soils, phosphate and phosphate-potash tended to increase grass seed yields, but the inclusion of nitrogen in the fertilizer treatment was considerable more effective. Fall fertilization was equally effective as the spring application. These results suggest that more fertilizer nitrogen could be profitably used on these mineral soils than is now commonly used by farmers for grass seed production in the Roseau area.

The Helmer Halvorson field was 4 year old grass stand and was approaching a condition commonly termed "sod-bound". An additional experiment which included heavy nitrogen applications therefore was initiated, to try to determine whether such treatment might at least partially relieve this condition. All treatments were applied late in April of 1960, and the seed yields obtained are shown in Table 3.

Table 3. The effect of mineral and heavy nitrogen treatments made in the spring on the 1960 seed yield of a four year stand of Park Kentucky bluegrass on mineral soil of the Helmer Halvorson Farm at Roseau.

Fertilizer Applied (lbs/A)	Bluegrass seed Yield in lbs/A	Increase in yield above check
0-0-0	44	--
0-0-80	37	-7
0-80-0	39	-5
0-80-80	44	0
60-0-0	93	49
60-0-80	124*	80*
60-80-0	100	56
60-80-80	82	38
120-0-0	79	35
120-0-80	96	52
120-80-0	108*	64*
120-80-80	123*	79*
480-0-0	59	15
480-0-80	107	63
480-80-0	92	48
480-80-80	127*	83*
*L.S.D. (5%)		64
** " (1%)		85

It is obvious that some yield increases resulted from the use of nitrogen combined with phosphate or with phosphate-potash, but even the heaviest nitrogen treatments applied failed to substantially increase the seed yield of the Park Kentucky bluegrass on this field.

Field Experiments with Climax Timothy

Since there is considerable timothy seed grown in the area, it was desirable to determine the effect of fertilizing this crop, and one field was selected on mineral soil and fertilized late in September of 1959. A second field was located in early May of 1960, and both fields were fertilized at this time. The effect of these treatments on the two mineral soils in resultant Climax timothy seed production is shown in Table 5.

Table 5. The effect of different fertilizer treatments on the 1960 yield of Climax timothy seed grown on two mineral soils of Roseau County, Minnesota.

Fertilizer Treat. (lbs/A) N P_2O_5 K_2O	Pounds of grass seed per acre		
	Clifford Foss - Badger		Andrew Skaar -Thief River Falls
0-0-0	159		225
	Fall fertilized	Spring fertilized	Spring fertilized
0-80-0	209	144	235
0-80-80	176	170	226
30-80-0	378	609**	568**
30-80-80	414	596*	634**
60-80-80	621**	808**	815**
90-80-80	785**	861**	892**
Average	431	531	---
* L.S.D. = (5%)	341		115
** L.S.D. = (1%)	455		159

Phosphate and phosphate potash applications tended to produce a slightly increases seed yield, but the inclusion of nitrogen produced substantial increased. On the one field where fall and spring fertilization effect was compared, it appeared to be mainly one of nitrogen availability, with spring applications producing an average of 100 pounds more timothy seed per acre than on the plots receiving the fall fertilization.

Summary

Although the yield results reported are for one year only, they indicate that:

1. The organic (peat) soils response is mainly to phosphate and to phosphate-potash treatments.
2. The mineral soils are responsive to nitrogen treatments where minerals are adequate. The applications of phosphate or of phosphate-potash (minerals) alone, were much less effective for increasing the yields of either Park Kentucky bluegrass seed or of Climax timothy seed.
3. The relative effectiveness of fall or spring fertilization appears to be associated with nitrogen need and availability in the spring under the cool growing conditions. Where nitrogen was very effective as on the mineral soils, it appeared that the spring applied fertilizer nitrogen was considerably more available to the grasses than were the same treatments made in the previous fall.
4. Top rates of N may be 90# beyond which lodging occurred on the bluegrass. Lodging is not a problem on timothy.

1960 Soil Erosion Experimental Results at Rosemount

J. M. MacGregor

Continuous corn was grown for the second year on a 9% slope of Port Byron silt loam, following six years of a corn, oats, alfalfa, alfalfa rotation. Four of the eight plots receive the common seedbed preparation of fall plowing, on the contour and spring discing, whereas the matching four plots have a seedbed preparation of deep surface cultivation on the contour in the fall, and again in the spring before planting. Total rainfall and intensities are recorded from April 1st to November 1st. Losses of soil and water of each rain are measured and corn yields are also studied.

The total rainfall for the seven month period was 21.8" of which 5.8" fell in May. Eight rains of one inch or more occurred during the seven months. Three rains produced runoff water, but there was no measurable loss of soil during this period. The largest and highest intensity rainfall occurred on May 26th, with 1.7" total fall of which 1.5" fell within one two hour period.

The total water loss from the four plowed plots during the three heaviest rains was only 0.65" or 3% of the total seven month rainfall. The cultivated seedbed plots lost a total of 0.34 inches during the same time, representing only 1.5% of the total seven month precipitation.

The average yield of ear corn was 87.6 bushels per acre on the four plots where the seedbed was prepared by plowing, and 74.2 where deep cultivation was used; a difference of 13.4 bushels in favor of the plowing.

During the same months of 1959, there was a total rainfall of 32.5 inches, and 18% of this was lost as runoff water. There was a soil loss of approximately 2 tons per acre, and corn yields averaged 121 bushels per acre. The cultivated soil produced a few bushels more corn per acre, and also had lower losses of both soil and water. It would appear that the results obtained with the two methods of soil preparation vary considerably from year to year with this variation being primarily due to weather conditions during the growing season. In years of ample to excessive precipitation, it is probable that the deep cultivation method of seedbed preparation is more desirable than plowing and discing the seedbed in the saving of both soil and water which frequently results in higher corn yields.

Progress Report 1960
Minnesota Agricultural Experiment Station

Project: 2517RH Soil Structure: Its evaluation with reference to plant growth and development.

Principal Personnel: G. R. Blake, W. P. Martin, J. M. MacGregor, E. P. Adams, J. K. Aase

Major Results:

I. Rosemount, Waukegan silt loam

Compaction studies at this site were terminated this year. Observations on residual effects of surface and subsurface packing last imposed in 1958 were as follows:

1. At low fertilizer rate, yields of corn were slightly higher on plots packed in 1957 and 1958. This was not true at a high fertility rate.

2. A residual packed layer remained from 1957 and 1958 packing below 9 inches and extending to 24 inches depth as measured by bulk densities at 3 inch intervals and by the penetrometer. (See following page)

II. East Grand Forks, Bearden silty clay loam (Cooperative with Am. Cry.Sug.)

Compaction study was also terminated at this site in 1960, residual effects of packing in 1955, 1957 and 1958 being observed in 1960. In addition potatoes were planted on all plots so that crop sequences since 1955 were as follows:

a) Beets, potatoes, wheat, clover-fallow, beets, potatoes
b) Potatoes, wheat, clover-fallow, beets, potatoes, potatoes
c) Wheat, clover-fallow, beets, potatoes, wheat, potatoes
d) Clover-fallow, beets, potatoes, wheat, clover-fallow, potatoes

Results were as follows:

1. Residual effect of 1955, 57 and 58 packing was measured in all crop sequences between 6 and 18 inches in 3 inch intervals by bulk density sampling. (See following page)

2. There was no reduction in yield from residual packing. Potato yields were 292 bu/A after fallow, 291 after beets, 284 after wheat and 246 after potatoes.

3. Clods over digger, draft on digger, specific gravity of tubers and depth from soil surface to potato tubers were unaffected by residual packing and by preceding crop.

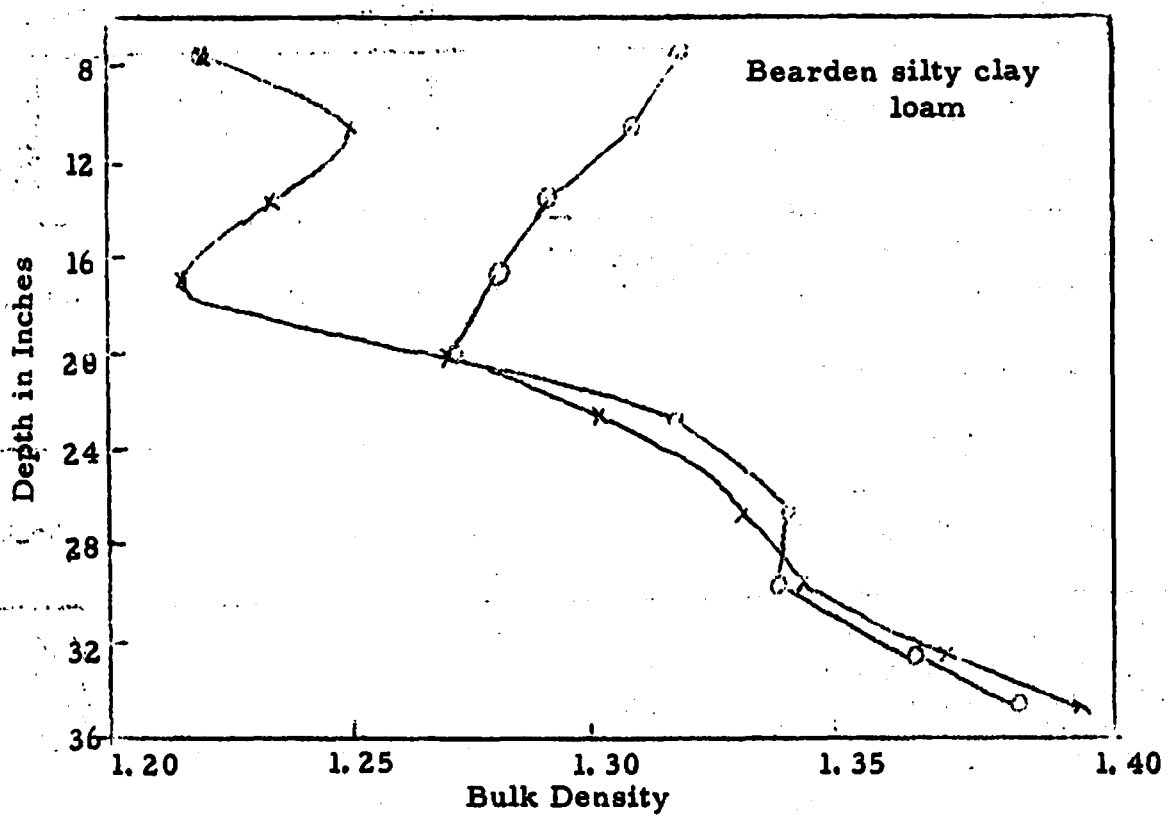
III. Soil structure as related to seedbed preparation and nitrogen level.

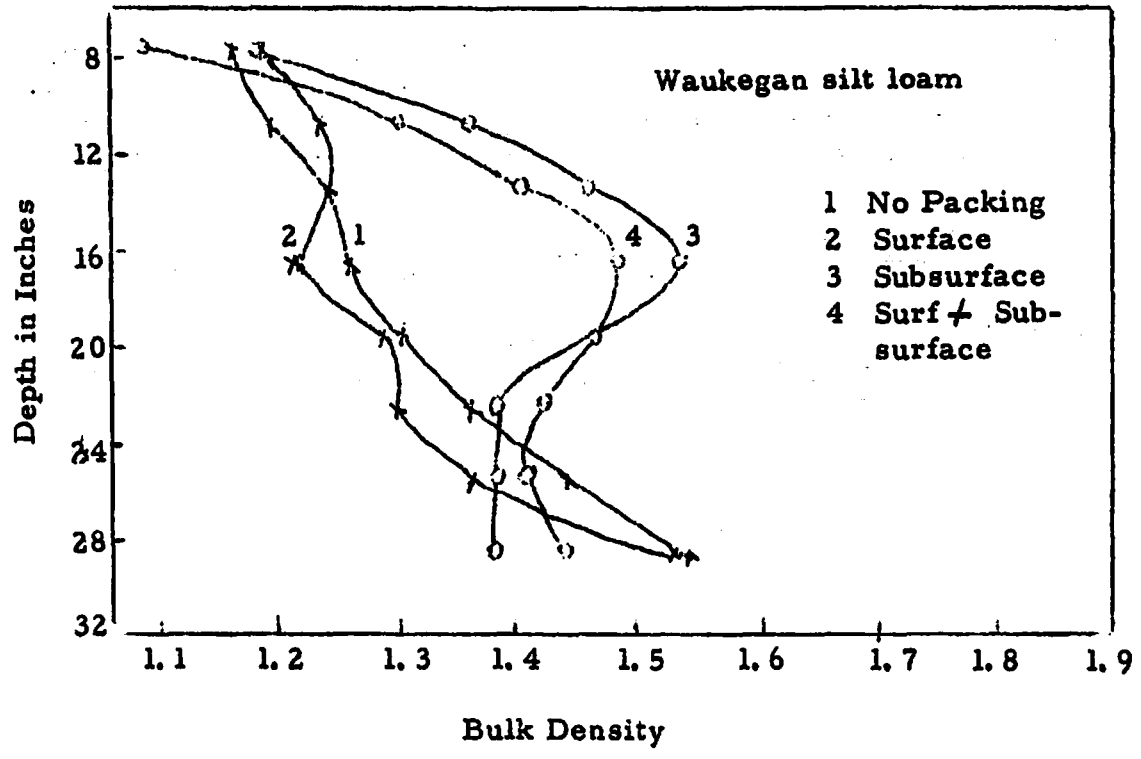
Three experiments at branch stations (two on corn, one on potatoes) are being continued comparing seedbed preparation methods of variable intensity. On corn, various nitrogen levels are also imposed to determine their effect on buildup of structure-producing organic constituents.

Extensive soil sampling is planned for the future. Generally, the least tillage has given as good or better crop yields than any greater amount.

Residual Effects of Packing in 1960

.....Soils Packed in 1958





Results are as follows:

A. Structure - Nitrogen Study, Crookston. Wheat yields for third crop in each sequence given in table.

Crop sequence	No Fertilizer	20-40-20	100-40-20
Wheat - Wheat - Wheat	28.6	42.1	48.3
Fallow - Fallow - Wheat	44.4	51.2	50.7
Fallow - Fallow - Wheat 1/	45.0	52.7	52.1
Corn - Soybeans - Wheat	44.0	56.1	52.2

1/ Straw added at wheat harvest each fallow year.
L.S.D. Crop (.01) 6.2; Fertilizer (.01) 3.5; Fertilize X Crop (.01) 7.0, (.05)6.2

B. Structure - Nitrogen, Morris

Seedbed Preparation Handling of residues Fall or spring plowed	0-40-40	40-40-40 fall	40-40-40	80-40-40	240-40-40	Average
Minimum - chop - spring	69.0	55.7	55.0	48.7	48.6	55.4
Minimum - Not Chop - spring	53.4	43.5	61.9	52.6	55.2	53.3
Minimum - Chop - fall	45.5	44.2	51.6	65.1	53.4	52.4
Conventional - Chop - fall	50.5	42.6	52.0	55.7	61.2	52.0
Chisel plow - Chop - Fall & Spring	48.1	55.2	54.8	46.3	43.9	49.6
Averages	53.3	48.2	55.0	53.7	52.5	

Differences between treatments not significant. Residual effects of manure, rock and superphosphate from earlier experiment on this land not significant.

C. Structure - Nitrogen Study, Waseca
Experiment was last for 1960. Will be continued on same plots in 1961.

D. Potato Tillage - Cultivation Study, Grand Forks
(Cooperative with Horticulture and A.R.S. at East Grand Forks). Three year summary underway.

IV. New Experiment, Lamberton. Nicollet silty clay loam (initiated May, 1960)
Since earlier packing experiments have shown that packed layers persist below the plow layer, an experiment was designed to study persistence of subsoil packed layers. Variables include:
a) Packing 9-24 inches vs. no packing
b) Crop: Corn vs. alfalfa
c) Moisture during winter, i.e., late fall irrigation vs. none

Packing was done with 4 passes of a tractor mounted packing wheel weighing 5600 lbs. giving pressures at 9" of the order of 100 to 200 lbs. inch^{-2}. A bulk density profile of packed and non-packed areas is shown in the accompanying graph.

Packing in 1960 reduced corn yields from 110 to 103 bu./A., corn forage 10%, and oat-alfalfa forage 29%.

Irrigation was applied to some plots in November, 1960. Persistence of the packed layer will be observed in subsequent years.

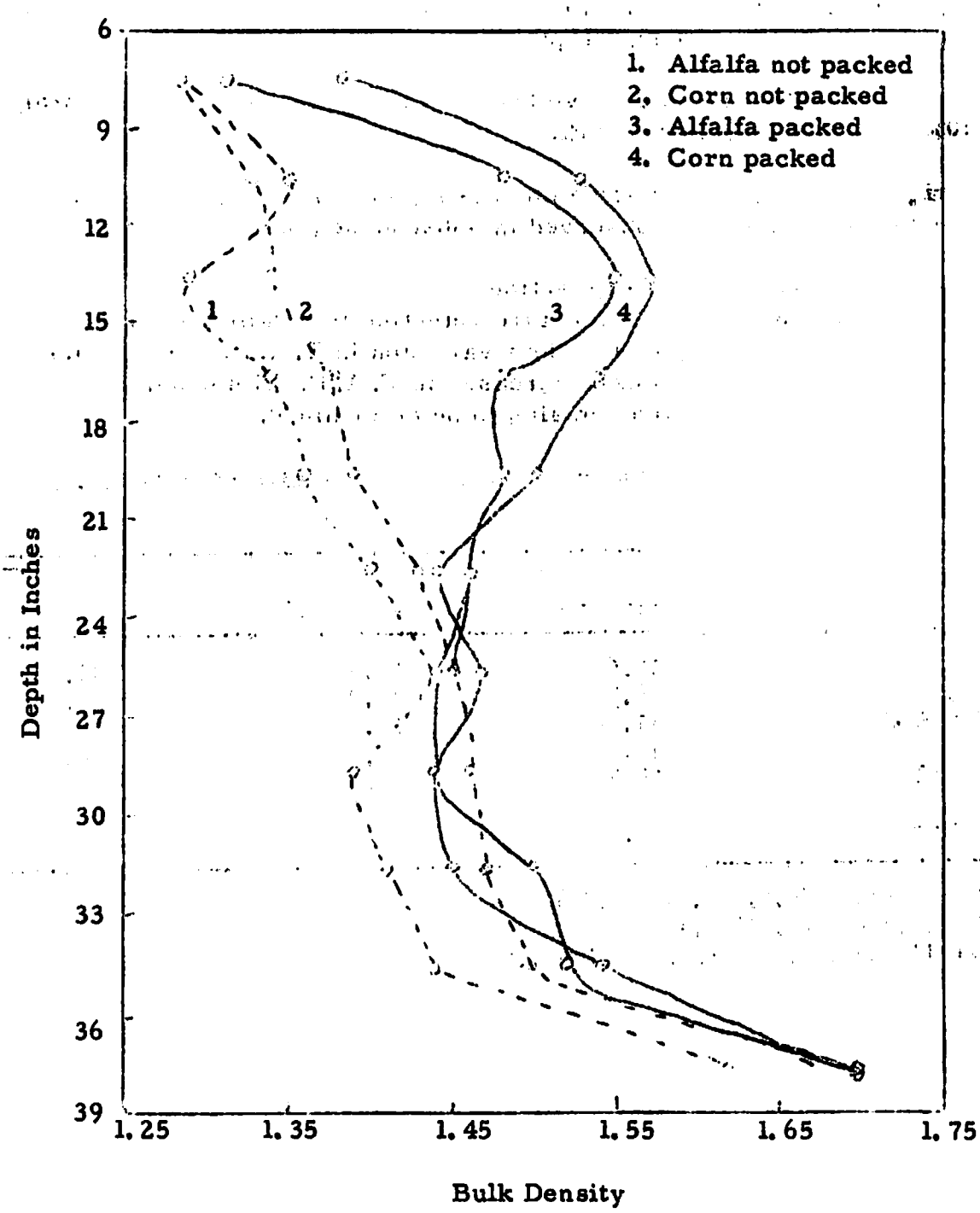
V. Packing and Soil Moisture Retention.
Studies are in progress on moisture retention in relation to compression of soils. As expected, tremendous variation in T.A.P. occurs with bulk density. Whether small increases in F.A.P. with density are real and can be duplicated remains to be determined.

VI. Green Manure Evaluation Study, Crookston (Cooperative with Schmid, Agronomy)

Green Manure Crop	Wheat Yield (Bu./A.)		Averages
	No fertilizer	0-40-0 annual	
Check	10.6	14.4	12.5
Orchard grass	8.3	10.7	9.5
Madrid Sweet Clover	11.8	24.0	17.9
Vetch	12.4	19.5	16.0
Vernal Alfalfa	14.4	23.0	18.7
Averages	11.5	18.3	

L.S.D. Green Manure (0.01) 8.9; (0.05) 6.3
Fertilizer (0.01) 6.1
Fertilizer X Green Manure (0.10) 8.2

Subsoil Regeneration Study
Lamberton
Bulk Density
Data book 17:180-200
June 28, 1960



Soil Test Correlation Project on Corn

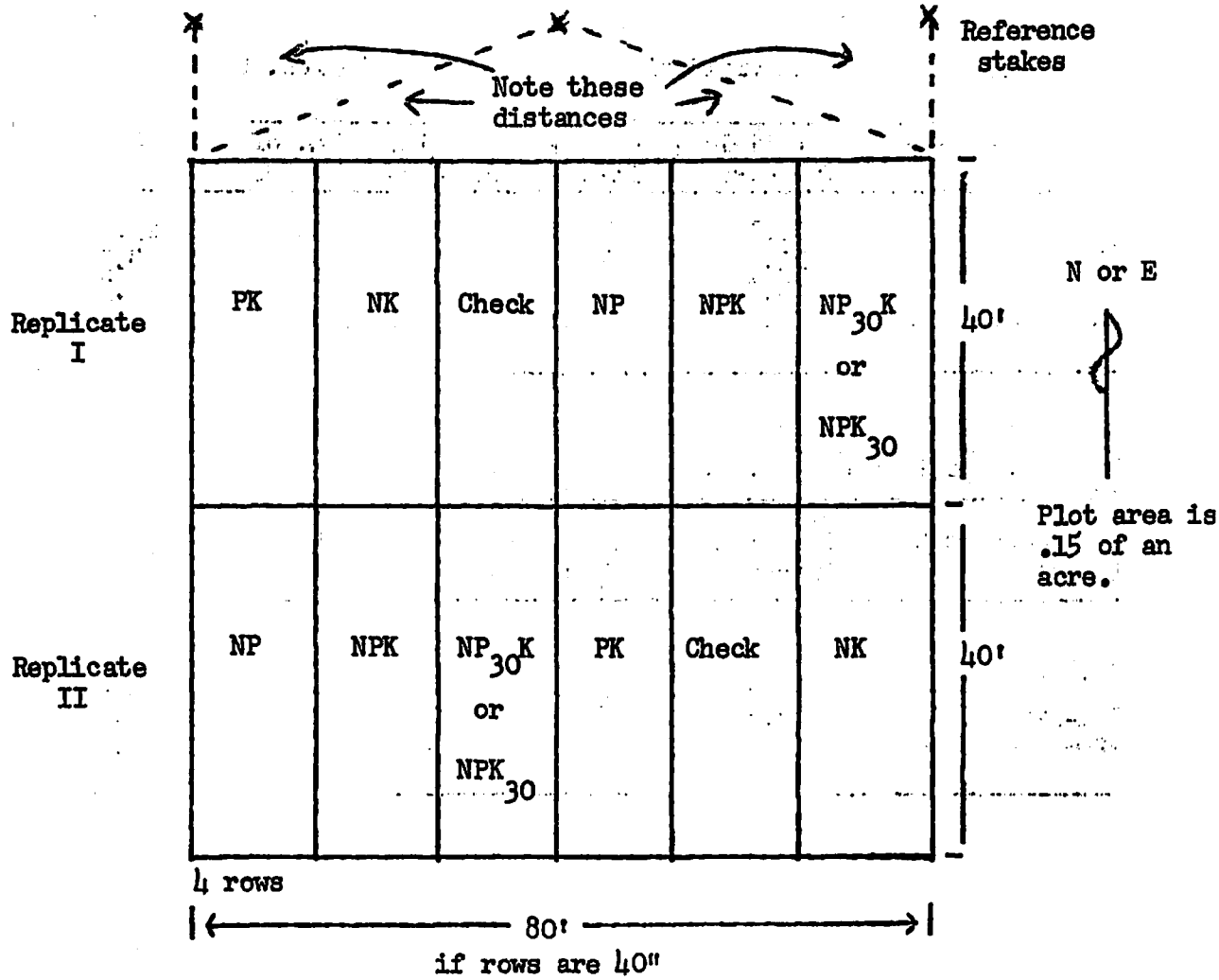
L. D. Hanson, John Grava,
C. J. Overdahl, and Merle Halverson

The 1960 soil test correlation project was carried out, as in 1959, cooperatively between the soil testing laboratory and the extension specialists. Materials for the field plots were assembled at the department and distributed to 50 cooperating counties. A total of 110 field plot kits were distributed of which 83 plots were harvested and reported.

Atrazine sufficient for a 3 pound per acre broadcast rate was applied on the plots for weed control. Heptachlor was also provided for corn root worm control.

All of the fertilizer was broadcast and incorporated in the surface soil except for an 8-32-0 starter applied beside the row on treatments receiving phosphate.

Following is the plot diagram and the fertilizer treatments.



Rates of plant nutrients used, pounds per acre.
(Row fertilizer used only on center two rows of plot).

	Nitrogen		Phosphate		Potash	
	Broadcast	Row	Broadcast	Row	Broadcast	Row
Check	0	0	0	0	0	0
PK	0	8	70	32	100	0
NP	100	8	70	32	0	0
NK	100	0	0	0	100	
NPK	100	8	70	32	100	0
*$NP_{30}K$	100	8	0	32	100	
*NPK_{30}	100	8	70	32	0	30

* One of these two treatments included in each field.

Some preliminary analysis of the data is given below.

Phosphate response with Bray's #1 P test

A summary of 63 fields from which rainfall data was available is given where the fields are divided into the two categories of above or below average rainfall.

Table 1. Difference in yield with 100 lbs. P_2O_5, 70 lbs. broadcast and 30 lbs. in row.

Range of P Test	Ave. Yield Increase	No. of Fields	Ave. Yield Decrease	No. of Fields	Ave. Yield Difference	No. of Fields
0-5	25.1	8	----	--	25.1	8
6-10	11.6	17	10.3	3	8.3	20
11-20	8.3	18	6.8	11	2.5	28
20+	7.1	18	9.3	7	2.4	25

Table 2. Difference in yield with broadcast potash at rate of 100 lbs. K_2O/A.

Exchangeable K lbs./A	Ave. Yield Increase	No. of Fields	Ave. Yield Decrease	No. of Fields	Ave. Yield Difference	No. of Fields
0-90	19.2	10	4.0	1	17.1	11
91-150	6.9	13	5.0	7	2.7	20
151-220	6.5	19	5.4	10	2.4	29
220+	5.5	11	6.2	9	2.1	20