SOIL PLANT NUTRIENT RESEARCH REPORT

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INTRODUCTION

As in the past, this report is intended to provide a summary and current status of the research projects being conducted by the staff and their graduate students. Detail is provided only for the numerous projects supported by research grants from industry and the National Research Council. Additional details for many of the projects summarized in the next section of this report will eventually be contained in publications of scientific journals.

The following personnel assisted on a full or part-time basis in the research work of the department during the past year.

Departmental Assistants

Niyazi, O.; Rice, W.A.

Technicians

Coke-Kerr, D.; Fraser, J.; Johns, L.; Radford, F.

Research Assistants - Academic term

Acton, T.; Stewart, R.

Student Assistants - Summer

Babiuk, L.; Bole, J.; Delarue, B.; DeYong, E.; Dyck, R.; Head, K.; Jamieson, D.; Luciuk, G.; Schappert, H.

The staff of the Department acknowledge the numerous research grants from industry, the National Research Council, the Saskatchewan Research Council and the Canada Department of Agriculture.

In particular, the extensive Stubble Fertilizer Research Project, which was supported entirely by grants from producers and distributors of fertilizer materials in Western Canada (Cominco, Ltd., Federated Cooperatives Ltd., National Grain Co. Ltd., Northwest Nitro Chemicals, Ltd., the North-West Line Elevators Association, the Saskatchewan Wheat Pool, and Sherritt Gordon Mines, Ltd.) warrants special mention, as this jointly financed project has already made it possible to establish preliminary benchmarks which we are confident will make it possible to provide sound recommendations for fertilizer usage on stubble land.

Four of these companies are supporting additional studies closely related to the Stubble Fertilizer Research Project - the Saskatchewan Wheat Pool is financing research into methods of fertilizer placement which includes fertilizers carrying both phosphorus and nitrogen. The National Grain Company's grant (in conjunction with N.R.C. grants) is supporting a study designed to provide needed information on the complex cycle that nitrogen undergoes in the soil. Cominco, Ltd. is supporting a Post-Doctorate student who is studying the role played by the amorphous aluminum constituents in soils; this inorganic soil constituent appears to hold most of the available soil phosphorus.

SUMMARY OF RESEARCH PROJECTS

The highlights of the various research projects for 1965 are summarized below. More details for certain of the projects are given in the following sections of this report.

Soil Fertility

1. Stubble Fertilizer Research Project - This is an extensive project with the dual objective of calibrating soil testing procedures, and also tracing with the aid of N15 tagged nitrogen carriers, the fate of fertilizer nitrogen applied to cereal grains seeded on selected soil types in Brown, Dark Brown, Black and Grey Wooded soil zones in Saskatchewan (initiated in 1964 - Rennie and Paul).

2. Phosphorus Fertilizer Placement for Small Grains - A study of the efficiency of uptake of fertilizer phosphorus by the grain, where the fertilizer is applied using the drill, discer or broadcast (initiated in 1964 - Rennie).

   This study has been completed for cereal grains seeded on fallow land. The superiority of the drill was evident in all field trials during the two-year study period. An application of 20 lb. of P per acre applied with the discer is equivalent to approximately 10 lb. of P applied with the drill. The efficiency of plant utilization of broadcast phosphorus was very low and, although responses occasionally occurred, these were seldom economic.

   Complementary research on diffusion rate of phosphorus from the point of placement and movement of plant roots towards the phosphorus is being carried out.

3. Fertilizer Experiments Utilizing Urea as a Source of Nitrogen - Urea-phosphorus mixtures proved equally as effective as ammonium

nitrate-phosphorus mixtures at six test locations in 1965. These studies are being continued and expanded in scope during the coming year (initiated in 1965 - Rennie).

4. <u>Plant Utilization of Soil and Fertilizer Nitrogen</u> - This study was designed to elucidate the complex cycle that nitrogen undergoes in nature. Both Thatcher and new high-yielding (unlicensed) wheat varieties have been used under growth chamber conditions and in the field as the test crops to measure the fate of fertilizer nitrogen tagged with N15. The nitrogen tracer will enable an indirect measurement of the variations occurring in available soil nitrogen during the growth of the plant (initiated in 1965 - Paul and Rennie).

5. <u>The Measurement of Available Nitrogen in the Laboratory</u> - The phenoldisulphonic method of measuring nitrate nitrogen, the standard method used in most laboratories, is laboriously time consuming and not readily adapted for use in a soil testing laboratory. A new method involving reduction of the nitrate to ammonia, followed by distillation of the ammonia into boric acid, was extensively investigated during the past winter. Contrary to claims of research workers in other areas, the reduction method was found to be unsatisfactory (initiated in 1965 - Paul).

6. <u>Phosphorus Fertilizer Placement for Flax</u> - Flax has not responded economically to phosphate fertilization in the past, irrespective of available soil phosphorus. One possible explanation that has been put forward is that flax, in contrast to cereal

grains, has a much greater capacity to adsorb soil phosphorus. However, it has been clearly demonstrated that seed placement of fertilizer phosphorus brings about sharp reductions in the stand of the crop. Using a specially constructed drill, field trials have been set out with a phosphorus carrier (11-48-0) placed one inch to the side and one inch above or two inches below the seed band (initiated in 1966 - Rennie).

Soil Microbiology and Biochemistry

1. C14 Dating of Soil Organic Matter Fractions - The contribution of soil organic matter to the fertility of the soil and its role in the geochemistry of carbon in nature has been shown in previous research to be reflected in the mean residence time (average age) of the soil carbon. Data obtained from carbon dating of various organic matter fractions are being used to estimate the contribution of each individual fraction of organic matter to the cycling of carbon in nature. As the carbon: nitrogen ratio remains fairly constant for most of these fractions, a measure of the nitrogen cycle in the soil system can also be estimated. A particular humic acid hydrolysate representing less than 15% of the soil organic matter has been shown to account for 80% of the nitrogen released per year (initiated in 1962 - Paul).
2. The Microbiology and Biochemistry of Organisms Capable of Utilizing Soil Humic Acids - One species (Penicillium sp.) has been shown to be capable of degrading up to 85% of the carbon of humic materials. The pathways of enzymatic attack on humic acids,

together with the intermediate products formed, are being studied using this species (Paul).

3. Nitrogen Fixation by Anaerobic Organisms - Using N15 and normal Kjeldahl techniques, it has been shown that selected soils contain organisms which are capable of fixing substantial amounts of atmospheric nitrogen. Initial data suggest that approximately 40 pounds of N per acre can be produced in the presence of small quantities of crop residues. Where large amounts of crop residues are added, up to 1,000 pounds of N per acre have been fixed. These data are being confirmed by more detailed investigations (Paul).

Pedological Investigations

1. The Nature and Distribution of Lime Carbonates in Soils - This study initially has involved the checking of available methods of differentiating between Calcite and Dolomite forms of lime carbonate in soils. The purpose of this study is to develop procedures which will differentiate between the pedogenic and indigenous carbonates in the genetic soil horizons (St.Arnaud).
2. Comparison of Chernozemic and Podzolic Bt Horizons - In the present Canadian Soil Classification System, the surface soil color is the main criteria used to separate the Black, Dark Grey, Dark Grey Wooded and Grey Wooded soils. Differences in the nature of the B horizon of these soils is recognized, but as yet no satisfactory means of evaluating the differences have been found (St.Arnaud).

3. Micropedological Studies - This study involves the investigation of microfabrics of soils. Current work involves an evaluation of factors affecting the development of specific fabric types (St.Arnaud).

4. Additional Pedological Studies being Carried out by the Pedologists with the Sask. Institute of Pedology are reported in the Annual Report of the Institute.

Soil Chemistry

1. The Amorphous Aluminum Constituents of Soils - Amorphous aluminum compounds with differing Al:OH molar ratios have been adsorbed on selected inorganic soil colloids - Kaolinite, Montmorillonite and Hydrous Micas. Characterization of these prepared colloid systems has included base exchange analyses in addition to X-ray and differential thermal techniques. Various extractants to remove the amorphous aluminum compounds are being investigated. The purpose of this study to develop an extractant which can be used to remove the amorphous aluminum constituents from the soil systems (Stewart).

2. Reactions of Soluble Phosphorus with X-ray Amorphous Soil Constituents - Studies to date have shown that aluminum compounds of various Al:OH molar ratios have the capacity to remove large quantities of soluble phosphorus from solution. The adsorptive capacity of clay free of amorphous aluminum constituents is negligible. The studies to date have shown that in natural soil

systems, phosphorus is removed from solution primarily by an adsorption reaction. Very little of the soluble phosphate precipitates (Rennie and Stewart).

3. The Mineralogical Composition of Selected Soils - Representative soil profiles taken from similar parent materials within major soil zones of the Province are being analyzed for amorphous constituents, montmorillonite, mica, chlorite, kaolinite, quartz, and feldspar (Huang).

4. The Potassium Reserve of Saskatchewan Soils - The equilibria and kinetics of the release of potassium from standard potassium bearing minerals are being investigated. This work will be extended to include the major potassium bearing minerals of selected soils (Huang).

Soil Physics

1. The Measurement of Plant Water Deficits - Various methods of measuring water stress in plant tissue are being compared. The Thermocouple Psychrometer would appear to be the best approach, but presents many experimental difficulties. Other methods such as a beta-ray attenuation technique and a dye method have not proven too successful (de Jong).

2. The Rheology of Clay Water Systems - The research data obtained during the past year support the theory that adhesion is equal to soil moisture suction. The progress of this project has been hampered by inadequate equipment (not available in North America) (de Jong).

Soil Productivity Investigations

The objective of this research to evaluate the contribution of components such as profile type, hydrology, nutrient level, aeration, and density on the growth, yield and quality of wheat. Special emphasis during the past year has been placed on consumptive use of water of wheat grown on Calcareous, Orthic and Eluviated profiles. Weekly measurements of moisture use were made using a neutron probe. At the same time, air temperature and relative humidity were recorded six inches above the ground; the evaporation from black Belani plates was also observed on a weekly basis. An evaluation of the moisture use data and climatic variables has proven disappointing. Little or no difference was found between the three profiles in relative humidity, air temperature or evaporation, yet crop growth varied widely.

Approximately 100 profiles selected within the extensive field fertilizer research project of the department were identified and an attempt was made to relate consumptive use of water to yield and response to fertilization. The results of this study are reported in the 1965 Soil-Plant Nutrient Research Report (staff).

FIELD FERTILIZER INVESTIGATIONS

In continuation of a long-range program of field experiments, the Soil Science Department of the University of Saskatchewan conducted a series of fifty-two field strip fertilizer trials in 1965. The bulk of the tests were placed on stubble land.

Essentially, three different procedures were followed in selecting locations and setting up test plots:

A. Ten plots were set out using the Soils Department's own equipment. Eight of these were on stubble land; the other two were on summerfallow. Seed application was made with a discer and a drill. The discer was mounted on a two-plow tractor by means of a three-point hitch. The drill and a packer were pulled behind the discer at all times.

B. School of Agriculture Cooperative Tests

Eighteen field fertilizer test plots on stubble were set out on the farms of Vocational Agriculture students. The farmers used their own equipment to set out the plots. The selection of the plot site and the complete operation of setting out the plot was supervised by personnel from the Soils Department. Urea-phosphate fertilizers manufactured by Sherritt Gordon Mines, Ltd. were tested on five of these plots.

C. V.L.A. Cooperative Tests

Twenty-four stubble fertilizer tests were conducted in co-operation with the Department of Veterans Affairs, Veterans Land Act. The Soil Science Department supplied the Veterans and their respective Credit Advisors with fertilizers, soil sampling equipment and instructions. Soil samples were taken and depth of moisture recorded at seeding time. Rain gauges were also installed in the vicinity of each plot.

Soil Analysis

The soil samples were characterized according to chemical and physical properties, and were analyzed for available nitrogen and phosphorus. Available phosphorus was determined in the 0-6" samples only.

Note

Three of the test plots were located on soil associations not described in Soil Survey Reports #12 and #13. These associations have been set up to provide a more precise separation, and will be used in future

Soil Survey Reports and Maps. Brief descriptions of these associations are as follows:

Sutherland association consists of a group of Chernozemic Dark Brown soils developed on variable fine textured, lacustrine deposits with profile textures of clay loam and clay.

Hamlin association consists of a group of dominantly Black Chernozemic soils developed on medium to moderately fine textured sandy alluvial-lacustrine deposits with profile textures of fine sandy loam, very fine sandy loam, loam, and sandy clay loam.

I Phosphate Placement Studies on Summerfallow

The field fertilizer experiments on summerfallow were designed to compare the effect of phosphate fertilizer placement in discer and drill seeded crops. Broadcast applications were also tested. The fertilizer was broadcast on the soil surface and incorporated into the soil as the seed bed was being prepared.

A modification of the International #10 Grain Drill was used. The usual double disc furrow opener drill was modified by the addition of a set of single disc furrow openers which can be adjusted to give varying depths of placement of the fertilizer in addition to the regular placement with the seed.

In addition to the field strip placement studies set out on the Anderson and Belhumeur summerfallow fields, smaller research plots on which tagged ammonium phosphate was used were laid down. The same tillage and seeding equipment was used to seed these small plots; the fertilizer, however, was applied utilizing V-belt applicators mounted on both the drill and the discer. The treatments included three levels of ammonium phosphate, 10, 20, and 40 pounds of P per acre, applied by broadcasting and with the drill and discer. In addition, at the 10 lb. rate of P application, the phosphorus was applied 1" to the side, and 1" below the seeding depth.

The treatments were sampled at five stages of growth, in order to obtain some measure of the effect of placement on the rate of uptake of the applied phosphate.

The following observations can be drawn from data given in Table 1 and 2.

1. Significant yield increases resulting from 11-48-0 fertilization were recorded at both locations.

2. In one case (Anderson), the check yield with the discer was superior to those obtained with the drill. In the other case, the unfertilized discer and drill yields were equal.
3. The yield increase due to 48 lbs. of 11-48-0 was higher with the drill than with the discer-seeded crops.
4. Broadcasting 11-48-0 at 48 lbs/acre resulted in small, but in one case (Belhumeur), a significant yield increase. At the higher rates of application, some substantial increases were observed. However, as observed in previous years, broadcasting phosphate fertilizer proved the least effective placement.
5. In studies of placement of the band of phosphate fertilizer, it was observed that fertilizer placed 1 inch below the seed resulted in higher yields than when the fertilizer was placed beside the seed or above it. In one case (Belhumeur), the placement 1 inch below the seed was superior to placement with the seed. In both cases, the placement of the fertilizer 1 inch above the seed was least effective.
6. The yield data from the radioactive phosphate placement studies (not reported here), in general, support the above conclusions drawn from the field strip trials.
7. The plant utilization of the fertilizer phosphorus occurred at a much more rapid rate at early stages than later stages of growth (Table 2). At the shotblade stage, for example, the plant had produced only 15% of its total final weight, whereas, at this time, a major portion of the final uptake of fertilizer -P had occurred.
8. The uptake of fertilizer -P from the drill-seeded treatments was above the discer and broadcast treatments at all stages of growth. The uptake of phosphorus from the discer treatment was above the broadcast only in the earlier stages of growth on the Belhumeur site. As the response from the discer-placed phosphate, in terms of yield increase, is greater than that from the broadcast application, these data suggest that early uptake of phosphorus is essential in determining final yield.

The phosphate placement studies on fallow do not alter the current recommendations that phosphate fertilizers should be placed in close proximity with the seed. Yield increases with the discer were generally less than when the drill was used, except at high rates of fertilization. Broadcasting phosphate fertilizers proved to be the least effective placement.

The data reported in this section are a portion of the results of a long term project to study the effect of phosphate placement. A complete report on this subject will be available at a later date.

Table 1. Phosphate Placement Studies on Summerfallow
(Each value is the mean of 10 replicates)

Seeding Unit	Fertilizer Treatment (lb/ac)	Yield of Grain, bu/ac	
		Sutherland C (Anderson) SE7-37-4-W3	Melfort SiL-SiCL (Belhumeur) NW29-45A-26-W2
Drill	Check	24.2	15.9
	11-48-0 @ 48U	29.3	25.9
	11-48-0 @ 48S	28.5	20.6
	11-48-0 @ 48A	26.3	16.7
	11-48-0 @ 48	32.8	23.3
	11-48-0 @ 48B	25.5	19.6
	11-48-0 @ 95	36.2	20.4
	11-48-0 @ 95B	30.3	16.4
	11-48-0 @ 190	32.2	24.8
	11-48-0 @ 190B	31.9	23.7
	L.S.D. (P= .05)	3.9	3.4
Discer	Check	26.6	15.9
	11-48-0 @ 48	27.3	22.4
	11-48-0 @ 95	34.1	21.3
	11-48-0 @ 190	37.2	23.7
	L.S.D. (P = .05)	5.5	4.2
Means*			
Drill		31.4	21.1
Discer		28.2	20.8
Broadcast		28.0	18.9

U - fertilizer placed 1 inch below seed.
S - fertilizer placed 1 inch to the side of the seed.
A - fertilizer placed 1 inch above seed.
B - fertilizer broadcast and worked into the soil prior to seeding.
*Means of comparable treatments.

Table 2. Effect of placement on the rate of uptake of applied phosphate (P^{32})

	% fertilizer - P* uptake	
	Anderson	Belhumeur
Three leaf		
Drill	5.20	2.70
Discer	1.89	1.60
Broadcast	2.36	0.77
Shot blade		
Drill	20.83	18.08
Discer	8.33	8.93
Broadcast	15.98	7.00
Heading		
Drill	22.33	25.43
Discer	11.55	15.71
Broadcast	22.25	16.75
Soft dough		
Drill	22.43	26.75
Discer	12.41	13.95
Broadcast	22.38	17.93
Mature		
Drill	25.61	25.70
Discer	13.08	14.41
Broadcast	25.65	16.68

*P applied at a rate of 20 lb/acre.

II Nitrogen Fertilizer Tests on Stubble

The results of the fertilizer tests on stubble land are shown in Tables 3a, 3b, 4, 5, 6, and 7, from which the following observations and conclusions can be made:

1. The responses to nitrogen fertilizer on stubble were variable from location to location, and in some cases extremely variable between sampling sites at any one location.
2. The yield increase resulting from the application of 87 lbs. of 23-23-0 varied from 2 to 15 bu/acre, with the average being about 5 bu/acre. In some cases, the application of 40 lbs. of 11-48-0 resulted in appreciable yield increases, particularly in the Black Soil Zone.

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the check yields obtained with the discer where the drill was used (Table 3a, 3b). ncrease due to fertilization obtained with discer er than the increase obtained with the drill; however, difference between the two was less than 1 bu/acre, (Table 7). actual difference between the mean of discer and drill treatments varied considerably from location to location. It is suggested that the prior condition and preparation of the seed bed may have considerable influence on the difference between discer and drill yields and yield increases.

4. The results of broadcasting 120 and 180 lb. of 33.5-0-0 were quite variable. Significant increases over the check yield were usually observed, but the yield was not always superior to the application of 87 lbs. of 23-23-0. (Table 3a, 3b, 4, 5, 7).
5. Rapeseed on stubble responded well to 20 lbs. of phosphate and to 40 lbs. of nitrogen. The check yield was low because of heavy competition from weeds (Table 6).
6. Nitrogen produced good yield increases in the oats - barley plot at Marshall (Turvey). 40 lbs. of N. plus 20 lbs. of P_2O_5 resulted in a 1.56 ton/acre increase. It was noted at harvest time that the oats responded to nitrogen to a greater extent than the barley (Table 6).
7. Fertilization did not produce any significant yield increases on the Durum plot on breaking (Table 6).

Fertilizer tests on stubble land have shown that average yield increases were similar when 20 lbs. of nitrogen per acre was placed with the seed (23-23-0), and when 40 lbs. of nitrogen was broadcast and worked into the soil prior to seeding. However, the yield increases with broadcast nitrogen treatments were quite variable, and some plots gave a profitable response to 40 lbs. of nitrogen. In general, the check yields obtained with the discer on stubble land were higher than when the drill was used. Yield increases due to nitrogen fertilizer were also slightly higher with discer than with the drill.

A large number of the stubble test plots responded to 40 lbs. of 11-48-0. This could be expected from the relatively high available nitrogen content of the soils in the spring. However, good responses to nitrogen were obtained, in some cases, even when the top two feet of soil contained up to 100 lbs. N/acre.

Table 3a. Department of Soil Science Field Fertilizer Tests on Stubble (Dark Brown Soil Zone)

Seeding Unit	Fertilizer Treatment (lb/ac)	Yield of Wheat (bu/ac)			
		Sutherland C-CL (Anderson) SW8-37-4-W3	Elstow CL (Goodale) NE32-35-3-W3	Elstow CL (Popoff) SW6-36-3W3	Weyburn L (Shields) N30-29-21-W2
Drill	Check	25.4	14.2	20.4	22.4
	11-48-0 @ 40	26.7	16.3	25.5	21.7
	23-23-0 @ 87	28.2	15.6	27.6	30.6
	11-48-0 @ 40 plus:				
	(1)33.5-0-0 @ 120B	27.3	14.8	26.0	28.6
	(2)33.5-0-0 @ 180B	28.1	14.7	26.6	29.4
	L.S.D. (P = .05)	N.S.	N.S.	4.2	6.3
Discer	Check	22.7	14.9	21.8	24.7
	11-48-0 @ 40	25.0	15.0	30.4	26.4
	23-23-0 @ 87	28.8	17.7	24.2	31.9
	L.S.D. (P = .05)	3.0	N.S.	4.7	5.0
Means*					
Drill		26.8	15.4	24.5	24.9
Discer		25.5	15.8	25.5	27.7

B - The nitrogen was broadcast and worked into the soil prior to seeding.

*Means of comparable treatments.

Table 3b. Department of Soil Science Field Fertilizer Tests on Stubble (Black and Grey Wooded Soil Zones)

Seeding Unit	Fertilizer Treatment (lb/ac)	Yield of Wheat (bu/ac)			
		Melfort SiCl (Bellamy) NE20-46-24-W2	Hamlin FL (Hoey) E14-45A-27-W2	Waitville L (Parkin) SW16-35-8-W2	Oxbow L (Wagner) W25-41-5-W3
Drill	Check	21.4	16.9	8.4	18.2
	11-48-0 @ 40	26.7	22.9	9.2	26.1
	23-23-0 @ 87	26.8	19.9	12.6	26.6
	11-48-0 @ 40 plus:				
	(1)33.5-0-0 @ 120B	24.3	21.6	16.5	24.6
	(2)33.5-0-0 @ 180B	24.6	21.6	16.4	23.9
	L.S.D. (P = .05)	3.1	3.5	3.0	4.7
Discer	Check	22.6	19.1	9.3	23.8
	11-48-0 @ 40	27.4	24.7	11.9	22.3
	23-23-0 @ 87	24.0	24.4	16.8	23.4
	L.S.D. (P = .05)	2.5	2.2	4.3	N.S.
Means*					
Drill		25.0	19.9	10.1	23.6
Discer		24.7	22.7	12.7	23.2

B - The nitrogen was broadcast and worked into the soil prior to seeding.

*Means of comparable treatments.

Table 4. School of Agriculture Field Fertilizer Tests on Stubble
Yield of Wheat (bu/ac)

	Check	11-48-0 @ 40	23-23-0 @ 87	11-48-0 +33.5-0-0 @120B	L.S.D (P = .05)
Weyburn - Estevan CL (Clay) N34-9-11-W2	29.6	29.3	32.5	35.3	N.S.
Weyburn-Estevan CL (Froh) 6-8-19-W2	18.2	25.3	22.2	27.6	3.9
Estevan L (Good) 7-11-10-W3	26.0	26.0	29.3	28.6	N.S.
Waseca L (Hult) 29-47-24-W3	29.2	35.1	37.2	36.8	5.2
Regina-Sceptre HvC Weyburn CL 36-29-22-W3	20.7	23.5	22.7	23.5	N.S.
Elstow-Weyburn CL (Wallace) 29-39-24-W3	20.8	28.0	31.2	35.0	6.8
Yorkton L (Wallin) 31-33-9-W3	22.2	27.0	27.7	24.6	3.3
Oxbow-Weyburn L (Kuffner)[1] 16-18-18-W2	35.2	51.9	47.8	63.2	11.2
Elstow SiCL (Latrace)[2] 2-34-11-W3	69.4	70.0	75.7	71.0	N.S.
Weyburn L (Stewart)[2] 19-11-10-W2	31.3	38.4	44.9	37.3	4.9

B - The nitrogen was broadcast and worked into the soil prior to seeding.

[1] Oats

[2] Barley

Table 5. Department of Soil Science -- V.L.A. Cooperative Field Fertilizer Test on Stubble

		11-48-0		23-23-0		33.5-0-0 B* + 11-48-0	
	Check Yield bu/ac	Fert. Rate lb/ac	Yield bu/ac	Fert. Rate lb/ac	Yield bu/ac	Fert. Rate lb/ac	Yield bu/ac
Ws-SbLL Andres (Wheat) SW5-50-10-3	16.0	60	18.2	90	23.8	120	21.7
SbLL-BSiCL Beddome (Wheat) 32-46-26-W2	24.5	55	32.0	92	29.7	117	31.6
TiC-SiC Casavant (Barley) SE24-44-15-W2	65.1	40	65.8	84	74.8	100	64.6
ESiCL Clark (Wheat) NW11-30-9-W3	22.0	37	26.0	95	24.1	135	23.9
WL-LL Currie (Wheat) SW12-24-23-W2	10.6	40	13.5	85	23.9	120	26.7
CyL-WmCL Derkson (Wheat) SW19-13-13-W3	29.9	41	41.3	80	43.1		
BL-CL Ford (Wheat) NW28-37-23-W2	23.8	40	26.3	85	27.5	95	30.6
MeFL Frolek (Wheat) SW9-44-17-W3	16.5	40	21.1	80	21.6	80	21.6
HRCL-ScHvC Hayward (Wheat) S22-8-30-W2	21.4	43	24.5	86	23.0	114	23.1

* B - broadcast

Table 5. Cont'd.

		11-48-0		23-23-0		33.5-0-0 B* + 11-48-0	
	Check Yield bu/ac	Fert. Rate lb/ac	Yield bu/ac	Fert. Rate lb/ac	Yield bu/ac	Fert. Rate lb/ac	Yield bu/ac
CaSiCL-CL Keith (Wheat) SW33-26-3-W2	31.0	36 53	26.3 34.3	53 130	37.7 37.0		
HRCL Kiss (Barley) NE21-7-18-W3	35.7	40	38.5	75	45.0	130	25.8
OL Kulovany (Wheat) SE15-19-2-W2				Insufficient samples taken			
YL-LL Lindstrom (Wheat) SE4-35-13-W2	21.0	42	25.5	30 75	30.3 27.0	115	31.8
CdSiL McLeod (Barley) SW14-8-3-W2	37.0	40	37.1	84	49.0	100	56.4
ESiC Nowosad (Wheat) SE32-36-27-W3	12.8	41	15.0	82	16.9	102	21.3
E-WCL Peckham (Wheat) SE32-36-26-W3	19.9	40	21.0			109	19.7
MSiC Porter (Barley) SE6-45-21-W2	54.1	43	75.7	67	68.6	115	75.7
RHvC Powell (Wheat) SW4-31-15-W2	22.0	40	24.0	85	25.7	115	22.7

* B - broadcast

Table 5. Cont'd.

		11-48-0		23-23-0		33.5-0-0 B* + 11-48-0	
	Check Yield bu/ac	Fert. Rate lb/ac	Yield bu/ac	Fert. Rate lb/ac	Yield bu/ac	Fert. Rate lb/ac	Yield bu/ac
TiC-CL Rushmer (Barley) SE28-49-14-W2	38.8	37	41.6	58	41.4	92	42.9
TCL Stadnick (Wheat) SW5-7-18-W2	25.0	35	23.2	70	21.9	70	26.2
OL-CL Tosh (Wheat) SW22-14-3-W2	19.9	38	24.0	70	27.3	120	28.6
RHvC Towriss (Wheat) SW28-17-25-W2	16.2	40	18.0	100	17.6	100	18.6
OL Yakubowich(Wheat) N20-25-5-W2	17.2	20 40	18.2 23.4	73	24.1	94	29.3
E-WL-CL Zunti (Wheat) NW34-38-25-W3	19.0	44	21.3	74	25.7	116	25.2

* B - broadcast

Table 6. School of Agriculture - Micellaneous Field Fertilizer Tests

		Check	11-48-0 @ 40 lb/ac	23-23-0 @ 87 lb/ac	33.5-0-0 @ 120B + 11-48-0 @ 40 lb/ac
Waseca L (Coolidge) 18-48-25-W3	lb/acre Rapeseed on stubble	621	920	897	1136
Waseca L (Turvey) 31-49-25-W3	tons/acre Oats-Barley on stubble (forage)	1.98	2.62	2.72	3.64
Asquith LL (Veale) 11-18-24-W2	bu/acre Durum on breaking	33.5	35.1	36.0	34.9

Table 7. Summary Data of Stubble Field Tests (Wheat)

Treatment	Department Plots		School of Agriculture Plots	V.L.A. Plots
	Drill	Discer		
Check	18.4	19.9	24.4	19.4
11-48-0 @ 40	21.9	22.9	29.0	24.5
23-23-0 @ 87	23.5	23.9	30.0	25.0
11-48-0 @ 40 plus				
(1) 33.5-0-0 @ 120B	23.0		34.9	25.0
(2) 33.5-0-0 @ 180B	23.2			
Means*	21.3	22.2		

*Means of comparable drill and discer treatments.

III Comparison of Full-run Seeding and Alternate-run Seeding

Treatments in which alternate seed and fertilizer runs were plugged were also set out. The seeding rate adjustments on the discer and drill were not altered from the usual setting and the fertilizer attachments were set to deliver, with all runs open, 87 lbs. of 23-23-0 per acre in the stubble plots and 48 lbs. of 11-48-0 per acre in the fallow plots. In effect, the seeding and fertilization rates were halved, the grain being seeded in rows 14 and 12 inches apart for the drill and discer, respectively.

The yield results for the alternate-run seeding and comparable full-run seeding treatments are shown in Table 9. The following observations can be made:

1. The alternate-run seeded treatments yielded 53.8% to 75.4% for the drill and 48.2% to 82.9% for the discer as compared to the full-run seeding.
2. The alternate-run discer-seeding resulted in higher yields than the alternate-run drill-seeding.
3. The trends were similar on stubble with 23-23-0 and on summerfallow with 11-48-0.
4. From field observations it was noted that the alternate-run discer-seeded crop was able to compete more successfully with weeds than the alternate-run drill-seeded crop. This was undoubtedly because the discer-seeding distributes the seed over a wide area, rather than restricting it to individual rows.

Table 8. Yields When Alternate Seed and Fertilizer Runs Were Plugged as Compared to Full-run Seeding and Fertilizing

Stubble
bu/acre

	Drill		Discer		% Y*	
	23-23-0 @ 87	23-23-0 @ 87/2	23-23-0 @ 87	23-23-0 @ 87/2	Drill	Discer
Anderson	28.2	19.4	28.8	21.0	68.8	72.9
Bellamy	26.8	18.6	24.0	19.9	69.4	82.9
Goodale	15.6	11.1	17.7	13.2	71.2	74.6
Hoey	19.9	14.6	24.4	17.3	73.4	70.9
Parkin	12.6	8.6	16.8	8.1	68.2	48.2
Popoff	27.6	15.8	24.2	18.7	57.2	77.3
Shields	30.6	16.6	31.9	21.7	54.2	68.0
Wagner	26.6	14.3	23.4	18.6	53.8	79.5
Mean	23.5	14.9	23.9	17.3	63.4	72.4

Summerfallow

	11-48-0 @ 48	11-48-0 @ 48/2	11-48-0 @ 48	11-48-0 @ 48/2		
Anderson	32.8	20.8	27.3	21.4	63.4	78.4
Belhumeur	25.3	14.7	22.4	15.8	63.1	70.5
Mean	28.0	17.8	24.8	18.6	63.6	75.0

$$* \% Y = \frac{\text{Alternate-run yield}}{\text{Full-run yield}} \times 100$$

IV Comparison of Urea-Phosphate and Ammonium Nitrate - Phosphate Fertilizers

A small plot, designed to test urea-phosphate fertilizers was placed on the stubble field at Nokomis. The plot consisted of 25 treatments in a balanced lattice, using six replicates. Each sub-plot within a replicate consisted of one 25 foot row. The type of fertilizer and rates are shown in Table 9. Five field strip plots, with urea-phosphate fertilizers, were also set out (Table 10). The following observations were made:

1. Although emergence counts were not conducted, there was no evidence of germination damage in any of the urea-phosphate treatments.
2. No difference in yield from sources of nitrogen in nitrogen-phosphate fertilizers applied at 15, 20, and 30 pounds applied P_2O_5. The yield increases appear to have resulted mainly from phosphate, with little response from nitrogen (Table 9).
3. There was no significant difference in yield between treatments with regular 23-23-0 and 23-23-0 urea-phosphate in three of the five field strip plots (Table 10). In one case the urea-phosphate increased the yield above regular 23-23-0, in the other case it lowered the yield. The yield of grain, when fertilized with 120 lbs. of urea-phosphate 27-14-0, was comparable with the treatment of 11-48-0 at 40 + 33.5-0-0 at 120B.

Table 9. The Effect of Various Sources and Rates of Nitrogen Applied With the Seed on Wheat Yield

Fertilizer	Type	Lb. N	Lb. P_2O_5	Yield	
				Grain bu/ac	Straw cwt/ac
23-23-0	A	15	15	32.4	34.8
23-23-0	A	20	20	32.7	34.7
23-23-0	A	30	30	34.8	37.5
			Mean Yield	33.3	35.7
23-23-0	B	15	15	31.0	34.4
23-23-0	B	20	20	31.7	34.5
23-23-0	B	30	30	34.7	39.1
			Mean Yield	32.5	36.0
23-23-0	C	15	15	32.0	36.0
23-23-0	C	20	20	30.4	33.0
23-23-0	C	30	30	33.9	35.4
			Mean Yield	32.1	34.8
27-14-0	A	29	15	32.0	35.0
27-14-0	A	39	20	34.1	37.2
27-14-0	A	58	30	34.2	38.1
			Mean Yield	33.4	36.8
27-14-0	B	29	15	31.1	38.3
27-14-0	B	39	20	33.0	37.4
27-14-0	B	58	30	36.6	42.1
			Mean Yield	33.6	39.3
27-14-0	C	29	15	32.1	36.4
27-14-0	C	39	20	33.2	37.0
27-14-0	C	58	30	34.8	37.7
			Mean Yield	33.4	37.0

Table 9. con't.

Fertilizer	Type	Lb. N	Lb. P_2O_5	Yield Grain bu/ac	 Straw cwt/ac
11-48-0	D	3	15	30.2	31.0
11-48-0	D	4	20	28.9	33.6
11-48-0	D	7	30	29.6	31.6
			Mean Yield	29.6	32.1
26-26-0	E	15	15	31.6	32.7
26-26-0	E	20	20	34.2	34.3
26-26-0	E	30	30	33.0	35.0
			Mean Yield	32.9	34.0
Check		0	0	24.7	27.8
L.S.D 5%				4.0	4.4

A urea phosphate Sherritt Gordon urea prills coated with MAP, plus 21-0-0.

B mechanical mix of 11-48-0 and 33.5-0-0.

C mechanical mix of urea, 21-0-0 and 11-48-0.

D mono-ammonium phosphate (MAP)

E mechanical mix of urea and 11-48-0.

Table 10. School of Agriculture Field Fertilizer Tests on Stubble
Sherritt Gordon Fertilizers

Fertilizer Treatment (lb/ac)	Yield of Wheat (bu/ac) Regina HvC (A. Bruce)* 2-19-26-W2	Regina HvC (R. Bruce) 5-19-25-W2	Waseca L (Coolidge) 18-48-25-W3	Weyburn L (Hamilton) SW27-33-17-W3	Asquith LL (Veale)* 11-18-24-W2
Check	40.8	27.2	21.3	15.8	21.1
11-48-0 @ 40	41.9	29.7	26.8	17.0	38.1
23-23-0 @ 87	42.0	30.2	31.9	17.6	35.1
23-23-0SG @ 87	42.3	40.6	30.8	17.2	26.3
27-14-0SG @ 120	45.0	47.7	35.5	15.0	38.7
11-48-0 @ 40 +33.5-0-0 @ 120B	45.2	50.1	36.6	-	40.8
L.S.D. (P = .05)	N.S.	7.0	7.2	1.5	6.9

* Durum

B - The nitrogen was broadcast and worked into the soil prior to seeding.

SG - Sherritt Gordon Urea-phosphate fertilizers.

V Soil Moisture, Precipitation and Moisture Use

A complete inventory of the water budget was maintained at the eight stubble plots set out with the Soils Department equipment. This involved the installation of two seamless aluminum tubes at each of the ten sub-plot sites at each test, to enable the use of the neutron moisture meter at depths below six inches. The moisture content in the surface soil was measured using standard gravimetric techniques. Rain gauges were also installed in the vicinity of each plot site.

The amount of soil moisture at seeding time and the growing season rainfall were recorded at all other plot sites.

1. In general, the spring moisture conditions were good. Only four locations had less than 24 inches of moist soil at seeding time.
2. The amount of precipitation during the growing season was generally quite substantial, but most of it occurred in May and June. As a result of the warm, dry period in July, a moisture stress was imposed on the crop causing a deterioration of the potential yield.

3. The evapotranspiration ratios varied considerably from location to location. The high evapotranspiration ratios reported for three of the locations (Goodale, Parkin and Wagner) can be attributed to excessive runoff from heavy rains and moisture loss from weed growth.

Table 11. Moisture Use and Evapotranspiration Ratio of Wheat Grown on Stubble Land

	Spring Inches H_2O/4 ft	Growing Season Rainfall (inches)	Fall Inches H_2O/4 ft	Water Used Inches/4 ft	Evapo- trans. Ratio
Anderson	17.06	6.56	13.30	10.32	1536
Bellamy	14.12	4.60	10.27	8.45	1493
Goodale	12.66	7.68	10.25	10.09	2687
Hoey	12.19	4.55	7.98	8.76	1950
Parkin	13.11	9.78	10.71	12.18	5483
Popoff	12.18	7.68	9.95	9.91	1837
Shields	10.78	11.05	8.46	13.37	2257
Wagner	10.12	10.12	6.99	13.25	2753

Table 12. Spring Moisture Conditions and Growing Season Rainfall

	Soil Texture	Average Depth of Moist Soil (inches)	Estimated Available Moisture (inches)	Growing Season Rainfall (inches)	Average Check Yield (bu/ac)
Anderson	C-CL	48	8.0	6.56	25.4
Bellamy	SiCL	48	7.2	4.60	21.4
Goodale	CL	48	7.2	7.68	14.2
Hoey	FL	48	5.2	4.55	16.9
Parkin	L	48	6.4	9.78	8.4
Popoff	CL	48	7.2	7.68	20.4
Shields	L	48	6.4	11.05	22.4
Wagner	L	48	6.4	10.12	18.2

Table 12. Con't.

	Soil Texture	Average Depth of Moist Soil	Estimated Available Moisture (inches)	Growing Season Rainfall (inches)	Average Check Yield (bu/ac)
A. Bruce	HvC	48	8.8	10.80	40.8
R. Bruce	HvC	48	8.8	10.80	27.2
Clay	CL	48	7.2	8.87	29.6
Coolidge	L	48	6.4	11.93	21.3
Froh	CL	48	7.2	-	18.2
Good	L	48	6.4	8.45	26.0
Hamilton	L	24	3.2	8.07	15.8
Hult	L	36	4.8	9.86	29.2
Kuffner	L	36	4.8	-	35.2 (oats)
Latrace	SiCL	-	-	7.89	69.4 (barley)
Longmire	HvC	48	8.8	-	20.7
Stewart	L	48	6.4	4.10	31.3 (barley)
Veale	LL	42	5.6	12.60	21.1
Wallace	CL	36	6.6	7.66	20.8
Wallin	L	48	6.4	11.25	22.2
Andres	LL	26	3.5	10.44	16.0
Beddome	SiCL	24	3.6	-	24.5
Casovant	C-SiC	34	6.2	11.56	65.1 (barley)
Clark	SiCL	32	4.8	9.67	22.0
Currie	L	24	3.2	-	10.6
Derkson	CL	22	3.3	-	29.9
Ford	CL	38	5.7	11.08	23.8
Frolek	FL	36	3.3	11.75	16.5
Hayward	CL-HvC	22	3.7	8.51	21.4
Keith	SiCL	36	5.4	6.14	31.0
Kiss	CL	19	2.9	-	35.7 (barley)
Lindstrom	L	44	5.9	16.27	21.0
McLeod	SiL	42	5.6	11.43	37.0 (barley)
Nowosad	SiC	22	4.0	-	12.8
Peckham	CL	26	3.9	-	19.9
Porter	SiC	22	4.0	13.70	54.1 (barley)
Powell	HvC	23	4.2	5.36	22.0
Rushmer	C-CL	40	6.7	9.22	38.8 (barley)
Stadnick	CL	36	5.4	-	25.0
Tosh	L-CL	23	3.3	8.61	19.9
Towriss	HvC	48	8.8	-	16.2
Yakubowich	L	30	4.0	10.59	17.2
Zunti	L-CL	36	5.1	10.08	19.0

VI Soil Test Correlation Studies on Stubble Land

The yield and soil test data from 43 stubble test plots was used to calculate profitable responses in relation to available N and P (Table 13 and 14). The cost of fertilization was calculated from current fertilizer costs plus application costs of $0.25/acre for each application (i.e. 33.5-0-0 + 11-48-0 - $0.50/acre).

In Table 13 the profit is divided into two ranges - less than $3.00 per acre profit and greater than $3.00 per acre profit. In Table 14 the profit is calculated from the average yield increase for each fertilizer treatment which gave a profitable response. The following observations can be made from the data in Table 13 and 14:

1. 74% of the stubble test plots responded profitably to 40 lbs. of 11-48-0.
2. 81% responded profitably to 87 lbs. of 23-23-0, however, in only 63% of the plots was this response partly due to nitrogen.
3. 37% of the plots showed no response to nitrogen. Although the average lbs. N per acre - 2 ft. was 88.9, none of these plots had available N contents between 85-150 lbs./acre - 2 ft.
4. The test for available NO_3 - N showed very high levels of N in the soils; only two locations had less than 37.5 lbs. of available - N/acre in the top two feet.
5. Even though the available N content of the soil was high, profitable responses to 20 and 40 lbs. of N were realized. Sixteen of the 43 plots showed a profitable response to 40 lbs. of N and 27 of the 43 plots showed a profitable response to 20 lbs. N (Table 14).
6. There does not appear to be any correlation between the average available N and P content of the soils and response to any given treatment. However, it can be noted that the 3 plots showing no response to any treatment were low in available N and P in relation to the other groups. (Table 14).

Table 13. Nitrogen and Phosphate Responses on Stubble Land in Relation to available NO_3 - N Content of the Soil

		Number of Tests Giving Profitable Response lbs. NO_3 - N/acre - 2 ft							
Treatment	Profit	<37.5	37.5 -50	50-62.5	62.5 -75	75-100	>100	Sub Total	Total
11-48-0 @ 40	<\$3.00/acre	0	0	3	4	2	5	14	32
	>\$3.00/acre	0	4	2	1	5	6	18	
23-23-0 @ 87	<\$3.00/acre	1	1	4	1	1	4	12	35
	>\$3.00/acre	0	3	3	2	8	7	23	
33.5-0-0 @ 120 + 11-48-0 @ 40	<\$3.00/acre	0	0	1	2	2	3	8	23
	>\$3.00/acre	1	1	4	1	5	3	15	
Any treatments	<\$3.00/acre	0	0	1	4	1	4	10	40
	>\$3.00/acre	1	4	6	2	8	9	30	
Total number of tests		2	4	7	7	10	13		43

Table 14. Average Yield Increase and Profit From Nitrogen and Phosphate Fertilization in Relation to Available N and P on Stubble Land

	Number of tests out of total of 43	Mean lbs N per acre - 2 ft	Mean lbs P per acre - 6 in	Mean Yield incr bu/acre	Profit Dollars Per acre
No response to any treatment	3	55.6	21.9	-	-
Response to:					
- 11-48-0 @ 40	32	90.4	28.0	4.87	5.00
- 23-23-0 @ 87	35	88.8	28.2	6.59	5.80
- 33.5-0-0 @ 120 + 11-48-0 @ 40	23	83.1	26.4	10.31	8.30
No response to N over 11-48-0 @ 40	16	88.9	23.8	5.19*	5.50
Response to:					
- 20 lb N over 11-48-0 @ 40	27	90.5	29.7	6.56	5.80
- 40 lb N over 11-48-0 @ 40	16	85.5	26.4	10.62	8.70

* increase of 11-48-0 @ 40 over check

VII Productivity of Sub-Group Profiles

Table 15 shows the check yields in relation to Sub-Group profiles. Ten profile sites were selected within each of the plots set out with the Soils Department equipment. The number of replicates for each Sub-Group profile were selected to coincide with the profile distribution in the plot. Thus, in a plot containing 60% Orthic and 40% Eluviated profiles, six Orthic and four Eluviated profile sites were selected. Profile sites were selected such that a profile was continuous across all treatments within the plots.

The following observations are drawn from Table 15:

1. The comparison with the largest volume of supporting data is between the Orthic and Eluviated profiles. The average yield of all Eluviated profiles (18.9 bu/ac.) is almost identical with that of Orthics (19.2 bu/ac.). However, there is one difference worthy of note. In the Wagner plot on Oxbow loam the Eluviated profiles yielded 6.1 bu/ac. less than the Orthic profiles. The Eluviated profiles in the Wagner plot were highly leached and characteristically possessed a fine platy Ae horizon of 3" - 4" in depth and an Ah horizon of no greater depth than the associated Orthics. Eluviated profiles in other plots usually had a much shallower and less distinct Ae horizon than the Wagner Eluviated profiles and a deeper Ah horizon than their Orthic counterparts.
2. The low productivity of Grey Wooded soils in comparison to Chernozemic soils is shown by the low yield obtained on the Dark Grey Wooded profiles in the Waitville loam plot.
3. The evidence with regard to productivity of Rego Chernozemic profiles on fine textured lacustrine material is contradictory. In the summerfallow plot the Orthic profiles yielded higher than the Rego profiles while the trend was reversed on the stubble plot. It should be noted, however, that Rego and Orthic profiles are morpholgically similar, on fine textured parent materials and the difference in productivity would not be expected to be very great.
4. Calcareous and Gleysolic profiles are represented by too few replicates to provide a reasonable basis for comparison. Several of the Gleysolic sites were flooded due to excessive rainfall and, therefore, were not sampled. Much more data must be obtained to establish the productivity of Sub-Group profiles.

Table 15. Check Yields (bus./acre) as Related to Sub-Group Profiles

	Rego	Calcareous	Orthic	Eluviated	Humic Eluviated Gleysol	Dark Grey Wooded
Sutherland C-CL A. Anderson	26.7(5)*		24.2(5)			
Elstow CL-L J. Goodale			13.5(8)	17.1(2)		
Elstow CL-L W. Popoff			19.8(5)	20.8(5)		
Weyburn L J. Shields	18.0(1)	13.1(1)	25.4(4)	18.5(1)	27.9(1)	
Oxbow L H. Wagner		22.1(1)	22.5(2)	16.4(7)		
Hamlin FL R. Hoey			16.2(7)	18.3(3)		
Melfort SiCL-CL J. Bellamy			20.5(6)	23.2(3)	22.2(1)	
Waitville L R. Parkins						8.5(9)
(Summ.) Melfort SiL-SiCL R. Belhumeur			15.9(7)	15.6(3)		
(Summ.) Suth. C. A. Anderson	22.2(4)		25.8(5)			

* ( ) number of replicates

VIII Nutrient Analysis and Fertilizer Response on Sub-Group Profiles

Table 16 and 17 show the results of available phosphorus ($NaHCO_3$ extraction) and nitrate analysis and response to fertilization on a Sub-Group profile basis.

The following observations are drawn from data presented in Tables 16 and 17:

1. The nitrate level at time of seeding was high in almost all plots. Noteable exceptions are the Eluviated sites on the Shields plot, the Gleysolic site on the Bellamy plot, and all sites in the plot on Grey Wooded soils.
2. With the exception of the Shields and Hoey plots the Eluviated profiles were found to have a somewhat higher nitrate level than the associated Orthic profiles. Data on nutrient levels of other Sub-Group profiles is not sufficient to show definite trends. The nutrient status in relation to Sub-Group profile is important in determining the sampling pattern required for fertilizer recommendations based on a soil test. More data will be required to determine the differences in nutrient status of Sub-Group profiles.
3. Very few significant yield increases due to nitrogen fertilization were observed as would be expected from soil test data. The high responses to nitrogen on the Shields plot are difficult to explain in view of the associated spring nitrate level.
4. Very little difference was observed in available phosphorus levels (Table 17) of Orthic and Eluviated profiles. Gleysolic profiles (Shields and Bellamy) appeared to have a somewhat more favourable phosphorus status than all other profiles, although the data is insufficient to be conclusive. Good responses to phosphorus on summerfallow were observed (Anderson and Belhumeur). The available phosphorus level at time of seeding was low to medium and the reported increases were to be expected on the basis of soil test data.

Table 16. Nitrate Status and Response to Nitrogen Fertilization (Stubble Plots)

		Rego	Calcareous	Orthic	Eluviated	Humic Eluviated Gleysol	Dark Grey Wooded
Sutherland C-CL (Anderson)	N[1]	87.0(5)		102.5(5)			
	Inc.[2]	1.3		1.5			
Elstow CL-L (Goodale)	N			155.5(8)	177.4(2)		
	Inc.			-0.8	-0.7		
Elstow CL-L (Popoff)	N			75.3(5)	85.4(5)		
	Inc.			1.9	2.3		
Weyburn L (Shields)	N		126.4(1)	140.2(4)	25.2(1)	48.0(3)	
	Inc.		16.8	9.8	15.7	24.0(1)	
Oxbow L (Wagner)	N	86.0(1)	115.6(1)	108.4(2)	177.4(8)		
	Inc.	9.4	-5.4	-0.5	1.7(7)		
Hamlin FL (Hoey)	N			151.6(7)	138.6(3)		
	Inc.			-3.4	-2.0		
Melfort SiCL-CL (Bellamy)	N			163.5(6)	215.5(3)	29.4(1)	
	Inc.			1.7	1.8		
Waitville L (Parkins)	N					51.8(1)	46.4(9)
	Inc.						3.4

[1] lbs./acre nitrate nitrogen to 2'.

[2] Increase (bu./ac.) of 23-23-0 @ 87 over 11-48-0 @ 40

Table 17. Available Phosphorus Status and Response to Phosphorus Fertilization

	Rego	Calcareous	Orthic	Eluviated	Humic Eluv. Gleysol	Dark Grey Wooded
Available Phosphorus (ppm)						
Anderson	6.1(5)		10.0(5)			
Goodale			22.4(8)	19.5(2)		
Popoff			14.6(5)	12.7(5)		
Shields		16.1(1)	16.2(4)	18.8(1)	24.3(3)	
Wagner			10.9(1)	9.6(7)		
Hoey			9.1(6)	9.8(2)		
Bellamy			8.8(6)	13.9(3)	46.5(1)	
Parkins					5.6(1)	5.3(9)
Belhumeur Summerfallow						
Avail. P (ppm)			7.0(7)	11.9(3)		
11-48-0 over check (bu/ac)			7.4(7)	3.2(3)		
Anderson Summerfallow						
Avail. P (ppm)	9.0(4)	6.5(1)	16.0(4)			
11-48-0 over check (bu/ac)	10.8(4)		6.8(5)			

SUMMARY OF SOIL TEST CORRELATION STUDIES ON FALLOW LAND

During the years 1956-1963, a total of 1,471 field fertilizer test trials were set out on 22 soil associations. The tests ranged throughout the Brown, Dark Brown, Black, Grey-Black, and Grey Wooded soil zones.

Surface soil samples taken from the plot sites were analyzed for both sodium bicarbonate and carbonated water soluble phosphorous, pH (saturated paste), and conductivity (saturated extract), qualitative lime, sulfates and chlorides, and approximate mechanical composition.

The multiple regression analyses carried out on the data were programmed for the Fortran computer by Dr. Wehrhahn. Of the 13 variables included in the analyses, only 3 were shown to have significantly affected yield increases resulting from an application of 40 lb of 11-48-0 per acre; these included the check yield, and the sodium bicarbonate and carbonated water extractable phosphorus. These variables accounted for 42% of the variations in yield increases. Presumably 58% of the variations in yield increases due to phosphate fertilization resulted from factors other than those measured in the experiments.

The sodium bicarbonate extractable phosphorus accounted for 3.1 of the mean 5.1 change in yield due to phosphorus fertilization. The carbonated water extraction was reflected in an average effect of 1.4 bushels whereas the check yields accounted for .26 bushels per acre.

While the multiple regression analysis was not too meaningful, it did clearly suggest the superiority of the sodium bicarbonate extraction as an index of available phosphorus in the soil. Summary comparisons of the soil test analyses are illustrated in the Tables 1 to 7 inclusive. The summary comments following each table, in general lend further weight to the use of the sodium bicarbonate extraction as a means of estimating the phosphate fertilizer requirements of soil.

Table 1. Mean Values Obtained on 1471 Samples

Check Yield = 26.6 ± 10.9
Yield Increase = 5.1 ± 5.3
pH = 7.13 ± 0.69
H_2CO_3-P (ppm) = 23.9 ± 11.6
$NaHCO_3$-P (ppm) = 17.0 ± 8.6

COMMENTS: The standard deviation following each mean value indicates the statistical range in 66% of the cases. Check yields, for example, range from a low of 15.7 to a high of 47.5 bushels per acre. Similarly, it is evident that yield increases resulting from phosphate fertilization range from zero to approximately 10 bushels per acre. Very little variation in pH was recorded. While the carbonated water extracted a greater amount of phosphorous out of the soil than the sodium bicarbonate extractants, the range, when expressed on a percentage basis, is approximately 50 for both extractants.

Table 2. Summary of Phosphorus Correlation Studies on Fallow Land for the Years 1956-1963

Soil Association	No. of Tests	pH	Extractable-P - ppm $NaHCO_3$ M	SD	H_2CO_3 M	SD	Check Yield (bu/ac) M	SD	Yield Increase (bu/ac) M	SD
Waitville	76	7.5	6.6 ±	2.6	20.0 ±	8.7	25.5 ±	6.7	11.5 ±	7.2
Regina	38	7.3	8.3 ±	2.0	17.7 ±	7.3	22.2 ±	5.9	7.0 ±	4.8
Melfort	86	6.3	10.4 ±	2.6	20.5 ±	10.7	31.8 ±	10.0	7.8 ±	5.1
Meota	54	6.3	11.6 ±	3.4	18.0 ±	8.6	23.3 ±	11.6	8.0 ±	4.7
Oxbow	123	7.4	12.3 ±	3.5	21.9 ±	9.8	27.1 ±	7.8	6.1 ±	4.7
Asquith	123	6.2	13.8 ±	3.9	15.9 ±	7.5	22.4 ±	8.4	6.4 ±	4.9
Waseca	60	6.1	14.0 ±	2.1	17.0 ±	5.9	32.4 ±	14.9	5.2 ±	4.5
Yorkton	129	7.7	14.4 ±	6.3	28.4 ±	14.6	27.2 ±	9.7	6.2 ±	4.9
Blaine Lake	135	6.6	14.8 ±	4.4	24.0 ±	12.2	27.1 ±	10.0	5.7 ±	5.4
Elstow	395	7.1	15.4 ±	7.7	22.1 ±	10.6	26.8 ±	9.6	5.1 ±	5.3
Weyburn-Elstow	45	7.7	16.1 ±	12.2	29.3 ±	20.8	26.3 ±	14.1	5.8 ±	4.8
Tuxford	139	7.5	18.1 ±	9.7	23.6 ±	11.1	26.3 ±	8.6	4.5 ±	4.3
Weyburn	305	6.7	18.7 ±	7.4	23.8 ±	8.9	22.1 ±	9.8	4.7 ±	6.2
Sceptre	110	7.3	24.3 ±	8.1	26.6 ±	11.1	37.9 ±	13.8	11.3 ±	7.5
Naicam	20	7.5			27.7 ±	11.4	27.8 ±	6.1	4.8 ±	4.8
Flaxcombe	36	6.7			24.2 ±	7.5	58.0 ±	8.1	4.1 ±	7.7
Kindersley	25	7.1			22.8 ±	8.4	41.1 ±	15.0	6.5 ±	7.9

COMMENTS: The data given in Table 2 has been summarized on the basis of soil associations. All the data obtained in this study has not been included. It was considered that unless there were at least 20 plot sites, the mean data would not be too significant. For ease in interpretation, the data for the various associations has been arranged in order of increasing sodium bicarbonate phosphorus values. The mean sodium bicarbonate values correlated highly with yield increases (-0.89). The correlation between the carbonated water values and yield increases was low (-0.43), and not significant.

These data would suggest that the level of sodium bicarbonate extractable phosphorus is related to the genetic soil factors used to separate soil on the association basis. Presumably, the major factors include the parent material and possibly the O.M. content. This relationship warrants further investigations. For example, more detailed studies on the member profiles making up each association may enable establishment of soil test benchmarks for selected groups of the major soil associations in the Province.

Where the sodium bicarbonate extraction values are high, the range in yield increases (standard deviation) usually exceed the mean increase value. This suggests that the higher the "available phosphorus", the greater the expected variation in yield increases. In other words, yield increases some years may not pay for the fertilizer. However, on the average, profitable yield increases can be expected. In contrast, the standard deviation did not exceed the mean yield increase where 14.8 ppm or less of sodium bicarbonate extractable phosphorus was present in the soil. Thus, the chances of obtaining paying yield increases each year are good.

Table 3. Variations in Soil Test and Yield Data During the Period 1959-1963[1]

Year	No. of Tests	pH	Extractable-P, ppm H_2CO_3 M	SD	$NaHCO_3$ M	SD	Yield, bu/ac Check M	SD	Increase M	SD
ELSTOW ASSOCIATION										
1959	68	6.3	19.2	6.7	16.3	7.9	24.0	8.0	6.4	4.0
1960	74	7.4	22.7	9.3	15.3	7.2	33.9	7.7	8.5	5.4
1961	70	7.8	20.5	12.0	14.6	9.7	22.7	7.9	5.1	3.9
1962	69	7.5	15.4	8.6	13.8	7.7	19.0	8.8	4.5	4.1
1963	49	7.3	26.8	11.8	16.2	7.5	31.7	7.0	3.2	4.6
WEYBURN ASSOCIATION										
1959	80	6.6	22.7	10.5	16.8	6.1	21.9	5.9	7.6	6.0
1960	60	6.8	26.8	7.7	19.2	4.5	27.7	6.6	4.9	4.0
1961	50	6.6	22.2	9.1	20.0	10.9	10.6	4.4	3.3	2.6
1962	39	6.7	19.5	8.3	20.5	7.3	12.9	5.5	5.9	4.5
1963	44	6.8	27.6	6.8	18.2	7.4	32.4	6.5	3.6	7.1
TUXFORD ASSOCIATION										
1960	65	7.6	26.1	6.8	12.7	3.6	30.8	6.6	5.7	4.5
1961	50	7.5	28.6	11.3	22.7	11.8	24.5	8.3	4.1	3.5
1962	50	7.6	17.3	7.3	13.6	4.4	27.7	8.3	6.2	4.6
1963	45	7.5	25.3	7.4	18.2	5.8	26.6	4.3	4.4	3.6

[1] Tests on the same farm, but not necessarily the same field. Five locations selected on each of the three soil associations.

COMMENTS: During the period 1959-1963 inclusive, farms were selected within the Elstow, Weyburn and Tuxford soil associations, and tests were laid down each year on the same farms, but not necessarily on the same field. The data confirm that variations in yield increases from phosphate fertilization can be expected from year to year. The average reaction from many of the farmer cooperators for 1963 was that fertilizers didn't pay. However, the data obtained in the four previous years clearly demonstrated that profitable yield increases could be expected.

Table 4. Benchmark $NaHCO_3$ Values vs. Yield of Check, Yield of Increase, and pH

Benchmark $NaHCO_3$-P (ppm)	No. of Samples	pH	Yield, bu/ac Check M	SD	Increase M	SD
Less than 8	119	7.6	21.6	8.6	7.0	5.2
8.1 - 14.0	472	7.3	25.5	9.3	6.0	5.2
14.1 - 20.0	444	7.0	25.0	9.6	4.9	5.0
20.1 - 26.0	202	7.0	27.5	10.7	3.5	5.0
Greater than 26.0	181	6.9	28.5	12.7	4.3	5.2

COMMENTS: The different ranges of sodium bicarbonate extractable phosphorus that resulted in statistically different yield increases are labelled 'Benchmark Sodium Bicarbonate-P'. The number of samples following in each category suggest that the large majority of soils in the province contain levels of phosphorus ranging from 8.1 to 26 ppm. It is interesting to note that there is an inverse relationship between the pH and the benchmark ranges. Equally interesting is the direct relationship between yield of check and extractable phosphorus; soils with less than 8 ppm extractable phosphorus yielded considerably less than those with greater than 26 ppm.

Yield increases ranged from a high of 7 bu per acre for the very low phosphate status soils (less than 8 ppm) to 3.5 for the soils falling in the 20.1 to 26 ppm P range. The reason for the slight increase in mean yield increase between the very high (greater than 26.1 ppm P) and the high, is not immediately evident.

Table 5. Benchmark $NaHCO_3$ Values vs. Mean $NaHCO_3$ and H_2CO_3-Phosphorus

Benchmark $NaHCO_3$-P (ppm)	No. of Samples	Phosphorus - ppm $NaHCO_3$ M	SD	H_2CO_3 M	SD
Less than 8	119	6.5	1.2	13.3	5.8
8.1 - 14.0	472	11.2	1.6	19.4	8.6
14.1 - 20.0	444	16.6	1.6	23.6	9.2
20.1 - 26.0	202	22.5	1.8	29.3	9.9
Greater than 26.0	181	34.6	8.4	37.0	73.0

COMMENTS: The comparisons between the box values for sodium bicarbonate extractable phosphorus and the mean sodium bicarbonate and the carbonated water values are self-explanatory. The wide discrepancy in the standard deviation for each of the mean sodium bicarbonate values as compared to the carbonated water values reflects the lack of agreement between these two extractants.

Table 6. Benchmark H_2CO_3 Values vs. Yield of Check, Yield Increase and pH

Range in H_2CO_3-P (ppm)	No. of Samples	pH	Yield, bu/ac Check M	SD	Increase M	SD
Less than 12	215	6.8	21.7	8.3	7.9	6.3
12.1 - 20.0	839	6.8	24.9	10.2	6.9	5.6
20.1 - 28.0	709	7.1	28.8	10.7	5.5	5.8
28.1 - 36.0	351	7.2	30.6	12.3	5.1	6.2
Greater than 36.0	271	7.3	30.1	13.0	5.8	5.4

COMMENTS: It could be concluded on the basis of the data given in Table 6 only that the carbonated water extractant is equally as good as the carbonated water as a means of estimating the phosphorus fertility status of soils. It should be noted, however, that there are many more samples included in the comparisons given. These data were obtained during the years 1953-1963 inclusive. It was noted on the basis of the data given in Table 4 that the pH in the soil decreased as the sodium bicarbonate extractable phosphorus increased. The reverse trend is evident in Table 6.

Table 7. Benchmark H_2CO_3 Values vs. Mean H_2CO_3 and $NaHCO_3$ Values

Range in H_2CO_3-P (ppm)	Phosphorus - ppm H_2CO_3 M	SD	$NaHCO_3$ M	SD
Less than 12	9.9	1.8	9.6	4.2
12.1 - 20.0	16.2	2.3	13.6	5.3
20.1 - 28.0	23.6	2.3	16.9	6.6
28.1 - 36.0	31.4	2.3	20.6	7.5
Greater than 36.0	46.4	11.3	27.7	11.2

COMMENTS: The same observations drawn from the data in Table 5 are applicable to those given in Table 7.

Table 8. Sub-Group Profile Plot Data Including Two Rates of $NH_4H_2PO_4$ Application

Benchmark $NaHCO_3$-P (ppm)	No. of Plots	Mean Yield Increase bu/ac 8.75 lb P	17.5 lb P
Less than 8	8	6.8	12.0
8.1 - 14.0	14	5.7	6.9
14.1 - 20.0	10	6.6	7.6
20.1 - 26.0	10	7.0	7.4
Greater than 26.0	11	6.1(1.2)*	8.5(2.2)*

*Mean yield increase excluding Gleysolic plot data

COMMENTS: The majority of the radio tracer experiments set out since 1955 included two rates of ammonium phosphate applications, 8.75 and 17.5 lb P per acre. The mean yield increase obtained from 53 field experiments set down on selected sub-group profile types have been summarized in Table 8. The data suggest that up to 80 lb of 11-48-0 per acre should prove profitable, where the sodium bicarbonate extractable phosphorus in the soil is low. With increasing soil phosphorus levels, rates in excess of 40 lb per acre of 11-48-0 do not appear justified.

The majority of the yield increases included in the greater than 26.0 category were obtained on gleysolic profile sites. These poorly drained soils are usually much cooler at time of seeding in the spring, and presumably this factor has maintained the higher than expected yield increase from phosphate fertilization. Where the gleysolic data is excluded, small, non-economic yield increases were obtained.

Table 9. Phosphorus Fertilizer Practices Based on $NaHCO_3$ Soil Test Data (Cereal grains seeded on fallow land)

Benchmark $NaHCO_3$-P		Fertilizer Recommendations
Range in ppm	P-Status	11-48-0 lb/ac
Less than 8	Very low	60 - 80
8.1 - 14.0	Low	50 - 60
14.1 - 20.0	Medium	40 - 50
20.1 - 26.0	High	40
Greater than 26.0	Very high	40 Not recommended if seeding date later than May 21

COMMENTS: The fertilizer recommendations given for the five phosphate status categories are those which will be used by the soil-testing laboratory. These recommendations are, to a large degree based on the following observations drawn from the data given in Tables 1 to 8 inclusive.

1. The ranges in sodium bicarbonate extractable phosphate given for the very low through to the very high phosphorus status soils have been shown to reflect not only a decreasing response to 40 lb of 11-48-0, but also an increase in the risk of obtaining a paying response.

2. The data from the radiotracer plots clearly support the 60-80 lb. per acre application of 11-48-0 for the very low phosphorus status soils. Unfortunately, rates intermediate between 40 and 80 lbs have not been used in any of the field experiments reported in Tables 1 to 8 inclusive. Logic, however, suggests that a somewhat higher rate of application should be used on the low than the medium or high phosphorus status soils respectively. Further verification of optimum rates of 11-48-0 applications for cereal grains seeded on these intermediate phosphate status soils is required.

3. There is considerable evidence in the individual data obtained from the field strip tests that early seeded crops almost invariably respond better to phosphate fertilization than those seeded after June 1. The data obtained from the radio tracer plots suggests that good responses can be expected even on very high phosphorus status soils where (presumably) soil temperature is cooler than average and perhaps moisture conditions are optimum or above optimum. For this reason, 40 lb of 11-48-0 is recommended for cereal grains seeded on very high phosphorus status soils, providing the crop is seeded in the early spring. An arbitrary cut-off date of May 21 is suggested, but it must be realized that this should not be considered a rigid date.

ADSORPTION OF PHOSPHORUS BY AMORPHOUS HYDROXY ALUMINUM-CLAY MIXTURES

J. W. B. Stewart

Non-exhangeable groups containing aluminum form in many soils (19, 13) and alter markedly many of the properties of the clay minerals to which they are attached. Aluminum containing groups have been formed on a synthetic cation exchanger (7) on vermiculite (14), and on montmorillonite (9). Barnhisel and Rich (1) also looked at the effect of time and hydroxy/aluminum ratios on groups adhered to montmorillonite.

From these and other investigations (4, 11, 15) it was concluded that:

(a) the aluminum group formed was fixed against exchange by KCl as a hydroxy group or polymer having an average OH/Al ratio of 2.

(b) the cation exchange capacity of the mineral was reduced by the actual coverage and neutralization of the exchange sites rather than blocking of the pathway to these sites by $Al(OH)_3$. Most of the "fixed" Al had a positive charge and occupied interlayer positions.

(c) as the molar OH/Al ratio of the solution in which the experimental interlayer was found rose into the range 2.25 - 3.00 and was aged, gibbsite was formed. The mineral then regained its cation exchange capacity showing that the gibbsite precursor, presumably an amorphous aluminum hydroxide had a charge and was attached to the mineral by means of this charge.

Jackson, in a review paper (10), stated that it is clear from the chemical weathering relationship of acid soils that interlayer precipitation of aluminum hydroxide gel in expanded layer silicates tends to occure preferentially to precipitates of a separate free gibbsite phase. Jackson presents two categories of evidence:

(1) clays interlayered with OH/Al occur in acid and alkaline soils.

(2) additional adsorption of aluminum from solution of Al saturated mixtures occurs at a solubility product less than that of gibbsite.

Cation exchange capacity, X-ray, DTA, surface area, exchangeable aluminum and fixed aluminum measurements have all been used to characterize the type of compound formed.

In this study with three standard clay minerals an attempt was made to fix aluminum in these minerals and then to determine the nature of the fixed aluminum prior to using the aluminum clay mixtures in phosphate sorption studies.

Experiment 1. The formation and characterization of amorphous aluminum oxide - clay mixtures

Material and Methods

The standard clay minerals obtained in rock form included Montmorillonite from Otay, California, A.P.I. Reference No. 24, Illite[1] from Morris, Illinois, A.P.I. Reference No. 36, and Kaolinite[2] from Bath, South Carolina, A.P.I. Reference No. 6. These minerals were dispersed in water and treated to remove impurities from the planar surfaces. Particles of less than 2 μ diameter were separated off and used in the preparation of Al-clays. The clays were saturated with Ca^{++} by a centrifuge method using 1N calcium chloride solution. Excess salts were removed with one wash of water followed by washes with 95% ethanol until Cl^- was not detected in the wash solution.

To the different 0.2% solutions of the calcium clays in a Waring Blendor, 0.5 N $AlCl_3$ and 0.5 N NaOH solutions were simultaneously added dropwise so that the OH/Al molar ratio varied from 0.00 to 1.50. This method was essentially that of Slaughter and Milne (18), and Shen and Rich (17). The samples were allowed to remain in solution for six weeks with daily shaking and mixing. After this time had elapsed, the clays were centrifuged, washed free of Cl^- as indicated previously, and the samples were air dried.

Cation exchange capacity was determined by calcium saturating the sample, washing out excess salt and then exchanging the calcium with neutral 1 N magnesium acetate. Calcium in solution was determined using the Unicam atomic absorption instrument.

Exchangeable Al was determined by displacing the Al from 0.1 g samples with 5 washes of 1 N NaCl. The clay was washed similarly with 0.1 N HCl to remove the "fixed" or extractable Al. Studies by Shen and Rich (17) showed that most of the "fixed" Al was removed in the first HCl wash. The results were corrected for Al released from the lattice by subtracting the amount removed from the Ca clay by the same treatment. Al was determined colorimetrically using the Aluminon method (9).

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[1] - obtained from Ward's Rochester, N.Y.

[2] - obtained from R. T. Vanderbilt Company, Inc. New York
(trade name Peerless No. 1)

Surface area determinations were carried out using ethylene glycol as described by Bower and Goertzen (2). X-ray diffraction patterns were obtained with a Phillips Norelco Refractometer using Cu $K\alpha$ radiation. The samples were prepared for analysis by sedimenting and drying a clay water suspension containing approximately 0.20 mg clay on glass slides. Other samples were treated with ethylene glycol and X-ray diffraction patterns were obtained both before and after heating to 500°C for 16 hours.

Samples for differential thermal analysis were mixed with equal amounts of allundum and equilibrated at 52% RH over a saturated $Mg\ (NO_3)_2$ solution. The sample and inert materials were held in platinum cups and alumel-chromel thermocouples were used to detect temperature differences which were registered by a Brown Honeywell potentiometric recorder. A heating rate of 10°C.min. was used and temperature of inert material was measured.

RESULTS

In each of the three types of clay under observation, four different treatments were applied. This resulted in a Ca-clay and three Al-clays formed in solutions with different OH/Al molar ratios - 0.375, 0.75 and 1.50 - for each clay mineral type. Table 1 presents the chemical characteristics of the treated clays.

(a) Montmorillonite clay

Cation-exchange capacity values decreased as the OH/Al molar ratio of Al-clays increased, presumably due to the formation of positively charged polymeric aluminum hydroxy compounds. Exchangeable aluminum values decreased as the OH/Al molar ratio increased while "fixed" Al values showed the opposite trend. These results gave a good general agreement with other workers, differences being attributed to a slightly different clay and different times of aging of the Al-clay samples.

Surface area values were also found to decrease as the OH/Al molar ratio increased. X-ray diffraction patterns show an increase in the (001) basal spacings due to the formation of amorphous aluminum hydroxy compounds in the interlayer space. When clay samples treated with ethylene glycol were X-rayed, at room temperature (25°C) and after heat treatment at 500°C for a few hours, further evidence on the formation of interlayer compounds was obtained. Al-montmorillonite with OH/Al ratios of 0.75 and 1.50 required prolonged treatment with ethylene glycol before the basal spacing on X-ray analysis was found to increase to approximately 18A° at 25°C. On heating these samples to 500°C and measuring the 001 spacing, values of approximately 14A° were obtained for the aluminum treated samples. Ca-montmorillonite spacings also expanded under ethylene glycol treatment to 17A° at 25° but decreased to 10A° after heating treatment 500°C.

Differential thermal analysis patterns also show definite changes due to the interlayer aluminum compounds. Shen and Rich (17) stated that the region 200-600°C is of interest in Al-clays and found that an endothermic peak in the 400-415°C range could be ascribed to interlayer $Al(OH)_3$. A small endothermic peak was found in this latter range in the Al-montmorillonites with OH/Al ratios 0.75 and 1.50 and was taken to be further evidence to the existence of an interlayer aluminum compound.

(b) Illite clay

The term illite was first applied to a mineral with a definite structure which has properties between those of micas and montmorillonite (2). This view has not been supported by later workers (2) who maintain that it consists of randomly interstratified layers of mica and montmorillonite. Assuming that the latter definition is correct, it is to be expected that illite would show the same pattern, if on a reduced scale, as that shown by montmorillonite. The results presented in Table 1 confirm this as the cation exchange capacity of the Al-illite was reduced as the OH/Al molar ratio increased. Exchangeable aluminum and "fixed" aluminum showed the same trends as that found in montmorillonite. X-ray diffraction results were also of interest as it was impossible to obtain a value for the Al-illites. Peaks, when obtained, were broad and too diffused to be measured. This is to be expected if illite consists of randomly interstratified layers of mica and montmorillonite. Differential thermal analyses of the treated illites did not differ markedly from calcium illite analyses.

(c) Kaolinite clay

Amorphous, aluminum hydroxide compounds are not interstratified in kaolinite clays and it was not expected that these compounds would be found on the planar surfaces of kaolinite. Exchangeable aluminum values, however, showed a decrease as the OH/Al molar ratio increased while "fixed aluminum" values were lower than those obtained for montmorillonite and illite but were still in a relatively high range.

This latter fact and other recently published work by Follett (5) which showed that amorphous, colloidal "ferric hydroxide" compounds were located on planar surfaces of kaolinite, suggested that the amorphous aluminum hydroxide compounds were in fact located on the planar surface.

X-ray analysis showed that the presence of this aluminum compound did not alter the basal spacing (001 reflection). Surface area measurements also remained constant. Differential thermal analysis showed that as the OH/Al molar ratio increased there was a corresponding increase in an endothermic peak at 925°C. A peak in this region had previously been attributed to a segment of the crystal retaining regularity up to approximtely 930°C ( ).

Experiment 2. Phosphate sorption studies on the prepared aluminum-clays

Materials and Methods

One-tenth gram duplicate samples (air-dry weight) of the prepared clays were placed in separate erlenmeyer flasks (50 ml). Fifty ml of NaH_2PO_4 solution containing 5 ml of sodium acetate buffer and from 0-2000 μ g P was added to the flask. The buffer was prepared by adding 0.144 equivalents NaOH to 60 ml of glacial acetic acid. The pH of the buffer solution was regulated so that it was equivalent to the pH of the solution in which the Al-clay was formed. The suspension was shaken for 48 hours and the final solution separated by centrifuging and decanting. The final concentration of phosphorus in solution and the pH value were determined on the supernatant solution.

This experiment was repeated except that the sodium acetate buffer was omitted from the equilibrating solution.

RESULTS

The results indicated that the relationship between the phosphate fixed and the concentration of phosphate in solution followed the Langmuir adsorption isotherm. Calculated adsorption maximum for all the clay samples are given in Table 2. Adsorption maxima differed between buffered and unbuffered solutions of the same clay as adsorption maxima values obtained in buffered solutions were much higher than those obtained in unbuffered solutions. This difference was attributed to the fact that exchangeable aluminum on the clay will hydrolize if placed in a solution at pH 7.0. On the assumption that the aluminum compounds were mainly responsible for phosphorus adsorption, and that the contribution of the clay mineral could be ignored, "fixed" aluminum plus three times the exchangeable aluminum value were plotted against phosphorus sorption maxima (Fig. 1, Table 3). The result was a linear relationship which gives justification to ignoring the contribution of the clay and concentrating on the form of aluminum present in solution. Attempts were made to explain the results obtained in unbuffered solution by assuming that the exchangeable aluminum became hydrolized.

In this case a straight addition of exchangeable aluminum and fixed aluminum values plotted against phosphorus sorption maxima would fall on the same graph as before, but this was not the case, and a much more extensive treatment of results must be carried out.

Table 1. Characteristics of Clays Used

*Type	Molar Ratio OH/AL	** C.E.C.	** Exch. Al (1N KCl)	** Extract Al (.1N HCl)	Surface Area M^2/g	X-ray diffraction (A°) (001) 25°C Et.Gl.	25°C Et.Gl.	500°C
MONTMORILLONITE								
Ca - M		120.0			876.0	13.8	17.3	10.3
Al - M	0.375	74.4	64.1	149	651.1	14.3	17.5	13.2
Al - M	0.750	42.2	40.0	283	484.6	14.7	16.4(17.9)	13.4
Al - M	1.500	20.9	11.7	405	340.1	15.2	15.2(18.0)	14.5
ILLITE								
Ca - I		30.6			235.8	10.9		10.1
Al - I	0.375	13.7	13.4	102	161.3			
Al - I	0.750	9.0	8.7	179	141.2	11.0		
Al - I	1.500	7.7	7.9	270	133.8			
KAOLINITE								
Ca - K		4.2			31.0	7.2	7.2	
Al - K	0.375	2.2	1.9	59		7.2	7.2	
Al - K	0.750	2.0	1.6	78		7.2	7.2	
Al - K	1.500	1.4	1.0	102		7.2	7.2	
MONTMORILLONITE								
(A) Shen and Rich								
Al - M	0.30	72	54			15.2	17.3	10.0
Al - M	0.75	44	30			15.8	17.7	13.2
Al - M	1.35	22	12			16.7	18.0	15.5
(B) Barnhisel and Rich (freshly ppt. Al.)								
Al - M	0.38	60						10.1
Al - M	0.75	42						11.2
Al - M	1.50	15						12.4

* as for Table 3.

** m.e./100g. clay

Table 2. Summarized Data from Langmuir Isotherms

*Type of Clay	Molar Ratio OH/Al	K (≃ bonding energy)	P adsorption maxima mg P/g	K= (≃ bonding energy) (me/µg P)	P adsorption maxima (mg P/g)
		Buffered Solutions		Unbuffered Solutions	
Ca - M				0.03	0.213
Al - M	0.375	1.10	17.60	0.303	11.57
Al - M	0.750	1.94	25.00	0.383	14.90
Al - M	1.500	2.28	27.13	1.11	18.18
Ca - I				0.16	0.32
Al - I	0.375		10.02	0.70	4.77
Al - I	0.750	0.68	14.69	0.82	6.43
Al - I	1.500	0.74	16.88	1.10	7.58
Ca - K					
Al - K	0.375	0.45	4.67		
Al - K	0.750	0.52	4.60	Not available	Not available
Al - K	1.500	0.92	5.17		

* as given in Table 3

Table 3. Relation Between P Adsorption and Aluminum on the Clay (Buffered Solutions)

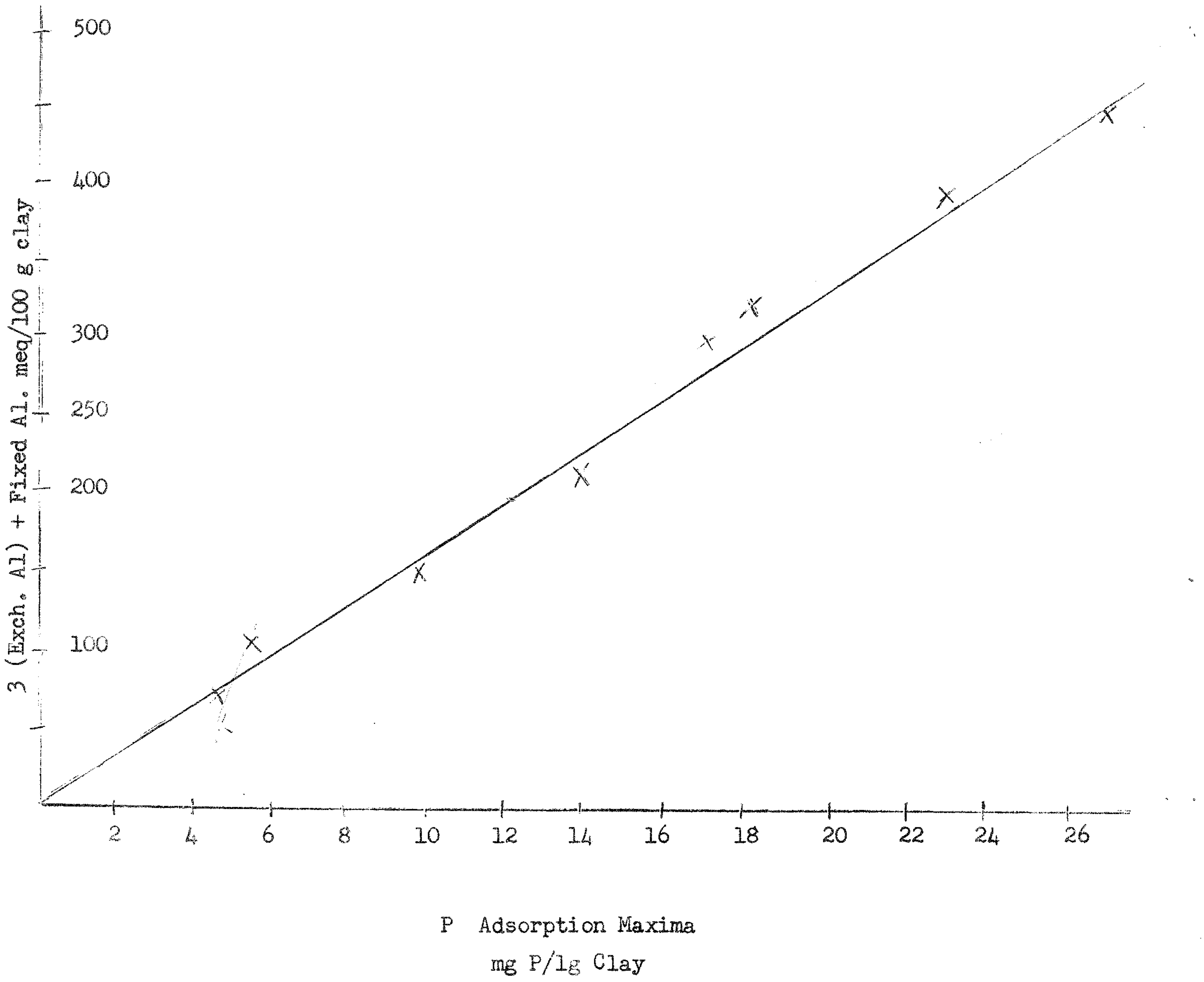
*Type	OH/Al	P adsorption mg. P/1g.	Exch. Al A me/100g	Fixed Al B	3A + B
Al - M	0.375	17.60	64.1	149	341
Al - M	0.750	25.00	40.1	283	403
Al - M	1.500	27.13	11.7	405	440
Al - I	0.375	10.02	13.4	102	140
Al - I	0.750	14.69	8.7	179	206
Al - I	1.500	16.88	7.9	270	294
Al - K	0.375	4.67		59	59
Al - K	0.375	4.60		78	78
Al - K	1.500	5.17		102	102

* Al - M = Aluminum - Montmorillonite

Al - I = Aluminum - Illite

Al - K = Aluminum - Kaolinite

Figure 1. Relation Between P Adsorption Maxima and the Exchangeable and Fixed Aluminum on the Clay



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COMPARISON OF THE SOIL PASTE AND 0.01M $CaCl_2$ METHOD OF DETERMINING SOIL pH

W. K. Janzen

The standard method used by the Saskatchewan Soil Survey for determining soil pH is the Riverside Salinity Laboratory soil paste procedure (1). The main advantage of this method is that soluble salts may be determined on the same sample used for pH determinations.

However, at the National Soil Survey Committee meetings held at Laval in 1965, it was suggested that the 0.01M $CaCl_2$ of Scholfield and Taylor (2) be used in preference to the soil paste procedure. Acting on this suggestion, a series of pH determinations by the 0.01M $CaCl_2$ method were run on a series of 633 samples on which the pH had been done by the soil paste method.

The soils used in these comparative determinations were Brown, Dark Brown, Black, Dark Gray Wooded, along with a few Gray Wooded profiles.

As may be seen in Tables 1 and 2, the average decrease in pH for the 0.01M $CaCl_2$ vs the soil paste method is 0.4 of a pH unit. Slightly more than half the samples at pH 6.3 or less show an average decrease of 0.6 of a pH unit, while the bulk of the samples above pH 6.3 (75%) show a decrease of 0.4-0.1 pH unit. Approximately 5% of the total samples show no change in pH value, and 6% show slight increase. There was no apparent relationship between decrease or increase in pH soil and texture.

The data presented conform to that which was expected on the basis of current knowledge of ion adsorption by charged colloids. The addition of 0.01N $CaCl_2$ would condense or compress the diffuse double layer (the volume of the mycellar solution would decrease), and more hydrogen would move out into the soil solution. Thus, for example, with a pH below neutrality, the decrease in pH should be greater for the most acid samples, and least for those approaching or at neutrality. On the basis of the data obtained, it can be concluded that the 0.01 N $CaCl_2$ method does not result in a pH measurement comparable to those existing in the field or those influencing the pH of the soil solution in which plants feed. Recognizing that the $CaCl_2$ method is preferable, if it is desirable to obtain a measure of the lime requirement of the soil, but since this factor is of little or no significance in Western Canada, it was concluded that soil paste method should remain the standard procedure used in the Pedology Research Laboratory. The calcium chloride method may be used for special projects, but will not be used in routine analyses.

Table 1. Number of Samples Showing a Decrease or Increase in pH at Designated pH Level.

	Number of Samples			
	Decreased by			Increased by
pH (Soil paste method)	>0.4 pH unit (As measured in 0.01 M $CaCl_2$)	0.4-0.1 pH unit	No change	0.1 or more pH unit
5.3 or less	21	10	1	1
5.4-6.3	77	59	1	1
6.4-7.3	41	97	7	4
7.4 or more	49	214	21	29
Totals	188	380	30	35
Average decrease or increase in pH unit	0.6	0.4	-	0.2
Range of decrease	0.5-1.0	0.4-0.1	-	0.1-0.4
Percent of total samples	29.6	60.0	4.7	5.7

Table 2. Percentage of Samples at Designated pH Level Showing a Decrease or Increase in pH.

pH (Soil paste method)	Percentage of Samples at Designated pH Level Showing a Decrease of >0.4 pH unit (As measured in 0.01 M $CaCl_2$)	Decrease of 0.4-0.1 pH unit	No change	Increase of 0.1 or more
5.3	63.6	30.4	3.0	3.0
5.4-6.3	55.7	42.7	0.8	0.8
6.4-7.3	27.5	65.1	4.6	2.8
7.4+	15.6	68.3	6.7	9.4

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COMPARISON OF SASKATCHEWAN SOIL SURVEY AND KILMER-ALEXANDER METHODS OF MECHANICAL ANALYSES

W. K. Janzen

The routine method of mechanical analyses used by the Saskatchewan Soil Survey for the past twenty years or more is a modified International A-method. (2)

The modification consists of reducing the pH of the sample to 3.5-4.0 with N-HCl, washing with distilled water and centrifuging to remove lime and other soluble salts, treating with 30% H_2O_2 on the steam plate overnight, and completing the analysis by the standard pipette method. Standard Ottawa soil samples with lime contents varying from 0-20% were analysed using this and the Kilmer-Alexander Method which omits the acid pretreatment. While absolute values for sand, silt and clay varied by the two methods, there was no change in textural grade of a given sample regardless of lime content. The Kilmer-Alexander gave a markedly lower fine clay content, however, than the Saskatchewan Soil Survey Method, particularly where lime was present. (1)

At a recent meeting of the Saskatchewan Soil Survey staff, it was suggested we might adopt the Kilmer-Alexander Method for the determination of field textures of samples, particularly calcareous samples.

With this in mind, a total of 272 samples, whose lime content ranged from a trace to about 30% were selected for comparative analyses.

Only 12 out of the 272 samples showed a shift in textural grade by one method as compared to the other. In 9 out of these 12 samples, a shift of less than 2% in the sand fraction would have resulted in a textural change, i.e. they were border-line cases between two textural grades.

Fifty-seven percent of the 272 samples showed differences of less than 2% in the sand fraction, and 83.1% showed differences of less than 4%.

In the silt fraction, the figures are 45.6% less than 2%, and 76.5% less than 4%.

In the clay fraction, the figures are 64% less than 2%, and 85% less than 4%.

The median values for the difference between sand, silt and clay for the two methods (Saskatchewan Soil Survey result minus the Kilmer-Alexander result).

Sand - +0.8
Silt - -2.0
Clay - +0.7

The difference between the two methods were not consistent as to sign, i.e. in each of the fractions (sand, silt and clay) about 50% of the samples gave positive differences (S.S.S. minus K.A.) and about 50% of the samples gave negative differences (S.S.S. minus K.A.) again regardless of lime content.

Since the amount of work by either method is about the same, it is concluded that neither method has any particular advantage over the other for routine analytical characterization of survey samples. However, where information is required on the medium and fine clay fractions, the Kilmer-Alexander method is unsatisfactory.

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Difference (S.S.S.-K.A.)

				Texture		
No.	Sand	Silt	Clay	S.S.S.	K.A.	%CaCO$_3$
1	0.5	-8.7	8.2	SiCL	SiL	20.25
2	1.4	-3.9	2.4	SiL	SiL	27.50
3	-0.2	-3.6	3.8	SiCL-SiL	SiL-SiCL	27.10
4	0.0	-3.5	3.6	SiCL-SiL	SiL-SiCL	26.75
5	0.4	-9.7	9.6	SiCL	SiL	8.65
6	-0.4	-5.6	5.9	SiCL-SiL	SiL	30.10
7	-0.5	-1.0	1.5	SiCL	SiCL	28.50
8	-0.5	-0.4	0.9	SiCL-SiL	SiCL-SiL	27.25
9	-0.9	3.6	-2.7	SiCL	SiCL	27.80
10	+0.4	5.1	-5.5	SiC	SiC	24.90
11	-0.7	-1.5	2.2	SiCL	SiCL	17.50
12	-0.6	0.8	-0.2	SiL	SiL	28.30
13	0.7	-5.7	4.0	SiL	SiL	27.25
14	-0.7	2.0	-1.4	SiCL	SiCL	29.10
15	1.2	-5.3	4.1	SiCL-CL	SiCL-CL	14.10
16	0.3	0.0	-0.3	SiCL-CL	SiCL-CL	12.30
17	-1.1	-1.1	2.2	SiCL	SiCL	13.10
18	1.8	-4.7	2.8	C	SiC-C	15.50
19	0.3	-5.2	4.9	HC	C-HC	14.60
20	2.9	-3.1	0.2	CL	CL	16.60
21	3.4	-1.0	-2.4	CL	CL-SiCL	28.40
22	3.0	-5.5	2.5	CL	CL	21.65
23	1.1	-5.3	4.2	SiCL-CL	SiCL-CL	23.15
24	-0.2	6.7	-6.5	L	CL	2.35
25	-0.9	0.8	0.1	CL	CL	0.65
26	4.0	-6.6	2.6	CL	CL	25.25
27	1.8	-2.8	1.0	CL	CL	24.75
28	-0.5	-8.3	8.8	C-HC	C	-
29	-1.3	-5.0	6.3	C	C	-
30	-0.5	0.6	-0.1	HC	HC	4.90
31	-0.2	-4.7	4.9	C	C	3.60
32	-0.5	-2.8	3.3	C	C	1.85
33	0.2	-0.4	0.2	C	C	5.75
34	0.9	-7.9	7.0	SiL	SiL	8.40
35	-0.2	-0.4	0.6	SiL	SiL	25.55
36	1.8	-1.5	-0.3	SiL	SiL	24.25
37	0.0	-2.7	2.7	SiCL-SiL	SiCL-SiL	23.30
38	+0.5	-7.8	7.3	SiCL-SiL	SiL	13.50
39	-0.6	-2.0	2.6	SiCL-SiL	SiL	27.30
40	-1.7	1.4	0.3	SiCL-SiL	SiL	22.50
41	-3.6	2.3	1.3	SiL	SiL	22.65
42	0.2	-1.9	1.7	SiL	SiL	6.35
43	-1.2	0.1	1.1	L	L	7.75
44	4.0	-5.4	1.4	SCL	L	8.50
45	2.3	-5.9	3.6	SCL	SL-L	2.25
46	-1.9	1.8	0.1	SCL	SCL	7.60

	Difference (S.S.S.-K.A.)			Texture		
No.	Sand	Silt	Clay	S.S.S.	K.A.	%$CaCO_3$
47	-1.6	0.3	1.3	CL-L	L-CL	6.40
48	-1.5	-0.2	1.7	CL	CL	11.75
49	-1.0	0.3	0.7	CL	CL	10.40
50	3.4	-8.0	4.6	SiCL	SiCL	9.40
51	-4.6	-2.3	6.9	SiCL	SiCL	7.00
52	-1.2	-0.7	1.9	SiCL	SiCL	9.60
53	-2.9	1.5	1.4	SiCL	SiCL	9.60
54	-0.6	-1.3	1.9	SiCL	SiCL	7.10
55	-2.5	-9.3	11.8	SiCL	SiL	2.75
56	-2.0	-3.7	5.7	CL	SiL	7.75
57	-0.5	-1.3	1.8	SiC	SiC	13.80
58	-1.5	-1.6	3.1	SiC-SiCL	SiCL	7.40
59	-0.9	-0.7	1.6	SiCL	SiCL	10.90
60	-1.0	1.0	0.0	SiCL	SiCL	11.30
61	0.3	-1.6	1.3	SiCL	SiCL	13.55
62	-3.1	2.1	1.0	SiL-L	L-SiL	T
63	-2.4	0.3	2.1	SiL	SiL	3.10
64	0.1	+2.1	-2.2	SiCL	SiCL	18.75
65	2.8	-4.3	1.5	SL	SL	13.25
66	3.1	-4.5	1.4	SL	SL	10.80
67	-2.2	2.2	0.0	SL	SL	11.25
68	4.7	-3.0	-1.7	SCL	SCL	11.10
69	4.9	-8.4	3.5	SCL	L	2.50
70	-0.6	-1.7	2.3	SCL-SL	SL	1.40
71	0.8	-5.5	4.7	SCL	L-SCL	0.0
72	2.2	-3.7	1.5	SCL	SCL	10.60
73	0.1	-1.2	1.1	SCL	SCL	12.10
74	-1.3	0.1	1.2	SCL	SCL	6.15
75	3.2	-4.3	1.1	SL-SCL	SCL-SL	12.75
76	4.9	-3.3	-1.6	SCL	SCL	18.00
77	1.3	-0.7	-0.6	SCL	SCL	14.90
78	3.1	-3.0	-0.1	SCL	SCL	9.90
79	2.8	-1.9	-0.9	SCL	SCL	4.75
80	2.8	-4.2	1.4	SCL	SCL	10.90
81	2.1	-2.6	0.5	SCL	SCL	10.65
82	2.2	-3.1	0.9	SCL	SCL	9.65
83	2.6	-5.5	2.9	SCL	CL	12.25
84	3.5	-3.1	-0.4	L	L	9.75
85	3.5	-2.0	-1.5	L-CL	CL	14.15
86	0.5	0.1	-0.6	SiCL	SiCL	10.80
87	-0.6	-1.2	1.8	SiCL	SiCL	9.40
88	0.0	0.2	-0.2	SiCL	SiCL	13.55
89	-1.6	0.9	0.7	L-CL	L-CL	12.05
90	-1.6	-12.7	14.3	HC	SiC	3.00
91	-0.1	-2.0	2.1	HC	HC	6.90
92	-0.1	-1.8	1.9	HC	HC	6.25
93	-0.6	-0.7	1.3	HC	HC	1.90

	Difference (S.S.S.-K.A.)			Texture		
No.	Sand	Silt	Clay	S.S.S.	K.A.	%$CaCO_3$
94	-0.5	-1.5	2.0	HC	HC	2.65
95	-3.7	1.2	2.5	L	L	-
96	3.0	-3.8	0.8	CL	CL	20.80
97	1.1	-2.5	1.4	SCL	SCL	15.80
98	3.7	-1.6	-2.1	SL	SL	17.40
99	4.0	-3.9	-0.1	SCL	CL	16.05
100	3.4	-3.2	-0.2	SCL	CL	16.00
101	4.9	-3.3	-1.6	SCL	CL	19.55
102	1.8	-2.4	0.6	SL	SL	5.35
103	0.5	-0.5	0.0	SL	SL	8.10
104	-1.1	1.3	-0.2	SCL	SCL	T
105	0.6	-1.8	1.2	SL	SL	T
106	-0.8	-2.3	3.1	C	C	7.90
107	-1.3	0.7	0.6	C	C	T
108	6.5	-6.3	-0.2	SL	SL	-
109	1.2	1.8	-3.0	HC	HC	0.50
110	-0.3	1.1	-0.8	HC	HC	0.0
111	-0.5	-1.4	1.9	HC	HC	T
112	-0.1	0.2	-0.1	SiC	SiC	4.10
113	-0.5	-2.3	2.8	HC	HC	T
114	-2.9	-1.8	4.7	C	C	6.35
115	-3.1	0.9	2.2	C	C	T
116	-0.4	0.3	0.1	HC	HC	-
117	-0.2	-2.2	2.4	HC	HC	6.00
118	0.4	-3.7	3.3	HC	HC	14.50
119	0.7	-13.9	13.2	HC	HC	19.55
120	0.2	-5.3	5.1	HC	HC	20.80
121	-0.5	-1.2	1.7	HC	HC	T
122	3.5	-5.6	2.1	CL	CL	-
123	-0.8	-2.9	3.7	SCL	SCL	T
124	0.2	-0.2	0.0	SCL-SL	SCL-SL	0.90
125	3.7	-2.5	-1.2	SL	SL	12.10
126	-0.1	-0.5	0.6	CL	CL	17.85
127	3.1	-3.7	0.6	L	L	17.80
128	0.9	-0.2	-0.7	L	L	0.85
129	1.6	-3.8	2.2	L	L	17.70
130	2.9	-3.6	0.7	C-CL	CL	14.05
131	3.2	-2.1	-1.1	SL	SL	15.10
132	-0.8	-2.6	3.4	SiC	SiC-SiCL	17.15
133	3.8	-3.4	-0.4	SiCL	SiCL	19.80
134	-2.1	2.3	-0.2	SiL	L-SiL	21.15
135	0.6	-2.0	1.4	L	L	20.05
136	1.1	-0.1	-1.0	Cl	CL	2.35
137	5.0	-3.4	-1.6	L	CL-L	22.40
138	4.3	2.1	-6.4	SiL	CL-SiL-L	29.25
139	1.7	0.1	-1.8	L	L	21.05
140	-1.3	0.1	1.2	SiL	SiL	21.50

Difference (S.S.S.-K.A.)

No.	Sand	Silt	Clay	Texture S.S.S.	 K.A.	%$CaCO_3$
141	0.3	-1.5	1.2	SiL	SiL	18.80
142	-1.1	-0.3	1.4	L	L	16.65
143	2.7	-1.6	-1.1	S	S	8.00
144	1.2	+0.2	-1.4	CL	CL	1.15
145	8.4	-1.6	6.8	SL	SL	19.90
146	4.6	-1.9	-2.7	SL	SL	21.40
147	2.1	-1.7	-0.4	SiL	SiL	22.40
148	4.5	-3.7	-0.8	SL	L	18.50
149	0.9	-2.2	1.3	SL	SL	9.65
150	2.8	-1.8	-1.0	L	L	18.50
151	-1.4	-2.9	4.3	SiCL	SiCL	0.75
152	-1.2	0.5	0.7	SiCL	SiCL	T
153	3.2	-3.9	0.7	SiCL	SiL-SiCL	5.60
154	0.4	-1.4	1.0	SiCL	SiL-SiCL	5.40
155	1.2	-2.2	1.0	CL	CL	13.85
156	1.3	-1.9	0.6	SL	SL	14.90
157	+5.9	-3.4	-2.5	SL	L	20.55
158	2.6	-0.6	-2.0	SL-L	L	16.90
159	0.4	-3.5	3.1	L	L-CL	2.40
160	0.5	-10.2	9.7	CL-L	L	9.15
161	3.7	-5.7	2.0	L	L	19.15
162	+3.1	-5.6	2.5	L	L	18.15
163	-1.0	-1.0	2.0	L	L	16.80
164	-1.0	-2.2	3.2	L	L	2.65
165	0.7	-4.3	3.6	L	L	11.75
166	2.6	0.5	-3.1	L	L	18.80
167	2.4	-1.0	-1.4	L	L	21.00
168	2.7	-3.7	1.0	SL	SL	23.05
169	2.8	-3.0	0.2	SL-L	L	17.55
170	-3.7	-7.3	+11.0	CL	L-CL	10.30
171	0.1	0.7	-0.8	SiCL	SiCL	30.55
172	3.2	-2.0	-1.2	CL	CL	28.05
173	9.1	-2.7	-6.4	SL	SL-SCL	19.40
174	4.5	-1.6	-2.9	SL	SL	
175	0.5	-1.6	1.1	SL	SL	
176	-0.1	-1.2	1.3	SL	SL	
177	-0.9	-1.6	2.5	SiCL	SiCL	
178	-1.2	1.4	-0.2	SiCL	SiCL	
179	-0.6	1.2	-0.6	SiC	SiC	
180	-2.2	-1.3	3.5	SiCL	SiCL	
181	-1.2	-3.0	4.2	SiC	SiC	
182	-1.4	9.4	-8.0	SiCL	SiL	
193	-0.1	-5.4	5.5	SiCL	SiL	
184	-0.9	-7.1	8.0	SiCL	SiL	
185	0.9	-4.8	3.9	SiCL	SiCL	
186	-0.5	-1.6	2.1	SiCL	SiCL	
187	-0.7	-1.4	2.1	SiCL	SiCL-SiL	

	Difference (S.S.S.-K.A.)			Texture		
No.	Sand	Silt	Clay	S.S.S.	K.A.	%$CaCO_3$
188	1.3	-0.9	-0.4	SiCL	SiCL	
189	-0.3	-1.2	1.5	SiC	SiC	
190	-3.0	1.0	2.0	SiL	SiL	
191	0.9	-0.8	-0.1	SiL	SiL	
192	-1.2	1.4	-0.2	SiL	SiL	
193	-0.7	1.4	-0.7	SiL	SiL	
194	-0.6	0.2	0.4	SiL	SiL	
195	1.1	-2.6	1.5	SiL	SiL	
196	2.0	-0.7	-1.3	SiL	SiL	
197	-1.0	-2.2	3.2	SiCL	SiCL	
198	3.8	-3.1	-0.7	LS	SL-LS	
199	4.0	-3.9	-0.1	LS-SL	SL	
200	4.3	-3.3	-1.0	LS-SL	SL	
201	1.3	-0.9	-0.4	SL-LS	SL	
202	-1.3	0.0	1.3	SL	SL	
203	4.2	-2.4	-1.8	SL	SL	
204	3.7	-2.9	-0.8	SCL	SCL	
205	2.8	-7.9	5.1	SCL	L-SCL	
206	4.8	-5.7	0.9	SCL	L-CL-SCL	
207	11.1	-5.2	-5.9	SCL	L-CL-SCL	
208	4.6	-2.9	-1.7	SL-SCL	L-SCL-SL	
209	1.5	-1.9	0.4	SCL-L	L	
210	3.5	-4.6	1.1	SCL	L-SCL	
211	2.1	-3.2	1.1	SCL-L	L-SCL	
212	1.4	0.6	-2.0	SCL	SCL	
213	2.1	-3.2	1.1	SCL	SCL	
214	4.8	-4.3	-0.5	SCL	SCL	
215	-0.2	-1.3	1.5	SCL	SCL	
216	4.3	-4.7	0.4	SCL	SCL-CL-L	
217	4.3	-1.9	-2.4	SCL	CL-SCL	
218	-0.2	1.2	-1.0	CL	CL	
219	-1.1	0.1	1.0	CL-SCL	CL-SCL	
220	4.1	-3.1	1.0	CL	CL	
221	2.9	-3.4	0.5	SCL-CL	CL-SCL	
222	2.8	-4.8	2.0	SCL	SCL	
223	1.9	-3.0	1.1	SCL	SCL	
224	0.2	-4.7	4.5	SCL	SCL	
225	0.7	-0.6	-0.1	SiCL	SiCL	
226	5.9	-7.9	2.0	SL	SCL	
227	5.9	-4.0	-1.9	SL	SL	
228	-1.6	2.3	-0.7	SL	SL	
229	1.2	0.0	-1.2	SL	SL	
230	2.2	-1.8	-0.4	SL	SL	
231	1.7	-3.3	1.6	SL	SL	
232	5.3	-5.6	0.3	SL	SL	
233	5.9	-5.7	-0.2	SL	SL	
234	1.2	-0.1	-1.1	SL	SL	

Difference (S.S.S.-K.A.)

				Texture		
No.	Sand	Silt	Clay	S.S.S.	K.A.	%CaCO$_3$
235	1.6	-4.2	-2.6	SL	SL	
236	10.9	-7.4	-3.5	SL	SL	
237	5.2	-2.6	-2.6	SCL-SL	SCL	
238	0.8	-1.2	0.4	SL	SL	
239	5.9	-5.3	-0.6	SL	SL	
240	8.6	-4.3	-4.3	SL	SL	
241	7.1	-3.4	-3.7	SL	SL	
242	5.5	-4.1	-1.4	SL	SL	
243	3.1	-1.7	-1.4	SL	SL	
244	6.4	-11.9	-5.5	SL	SL	
245	7.3	-3.9	-3.4	SL	SL	
246	3.6	-2.7	-0.9	SL	SL	
247	1.8	-2.1	0.3	SL	SL	
248	1.8	-4.5	2.7	CL	CL	
249	3.4	-3.4	0.0	CL	CL	
250	3.3	-5.0	1.7	SCL	L-SCL	
251	4.8	-6.0	1.2	SCL	L	
252	5.0	-4.5	0.5	SiL	SiL	
253	3.5	-2.3	-1.2	SCL	SCL	
254	0.6	-1.6	1.0	SiL-L-CL	SiL	
255	5.3	-3.6	-1.7	SiCL	SiCL	
256	0.7	-0.6	-0.1	SiL	SiL	
257	-1.1	-0.1	1.2	SiL	SiL	
258	1.6	-0.4	-1.2	SiCL	SiCL	
259	-1.9	-1.7	+3.7	CL	L-CL	
260	5.8	-1.4	-4.4	L	L	
261	6.2	-1.9	-4.3	SL	SL	
262	6.0	-3.4	-2.6	SL	SL	
263	9.3	-3.2	-6.1	SL	SL	
264	4.8	-3.4	-1.4	SL	SL	
265	-2.4	3.5	-1.1	L	L	
266	0.8	-1.5	0.7	SL	SL	
267	2.6	-1.6	-1.0	L	L	
268	5.9	-2.6	-3.3	SCL	SCL	
269	6.4	-5.0	-1.4	SCL	SCL	
270	-1.8	1.3	0.5	L	L	
271	-4.3	-3.6	0.7	L	L	
272	-0.3	0.9	-0.6	SL	SL	

A STUDY OF THE NITROGEN AND PHOSPHORUS REQUIREMENTS OF TWO WHEAT VARIETIES

A high yielding (25% higher than Thatcher), but low quality (1% lower protein), unlicensed variety of wheat[1] and Thatcher were compared under varying nitrogen and phosphorus fertility levels in experiments laid down on two subgroup profile types; the eluviated Dark Brown and Orthic Dark Brown soil types were located within a distance of approximately 50 yards on the farm of Mr. J. Shields, Nokomis.

The comparative yields of the two varieties with and without added nitrogen and phosphorus, together with the phosphorus uptake data and protein content, are included in Table 1 to 10 inclusive. The following observations can be drawn from the data.

1. Thatcher outyielded the S-31 variety by a significant margin on both areas. While this would appear to be contrary to the higher yielding characteristics of S-31 noted in the introductory paragraph above, it can be explained on the basis of a rather serious rust epidemic which affected the S-31 yield to a much greater extent than that of Thatcher. In addition, a very hot, dry spell during the latter part of July, appeared to have a greater adverse effect on the later maturing S-31 as compared with Thatcher.

The S-31 grain was badly shrivelled and graded in the feed range, while Thatcher grain ranged in grade from 3 to 4.

2. Soil samples taken from both plot areas at time of seeding were inadvertently discarded prior to analyses. However, available soil nitrogen, in an area immediately adjacent to the plots, was low on the eluviated (20 lbs. N per acre in the surface two feet) and relatively high on the Orthic (50 lbs. N per acre). Thus, the greater response to nitrogen fertilization recorded on the eluviated site as compared to the orthic was to be expected.

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[1] obtained from the collection of Dean W.J. White

3. A strong response to phosphorus fertilization occurred on both plot sites. These comments pertain primarily to the response pattern recorded for the Thatcher variety; the yield response to either nitrogen or phosphorus fertilization was erratic for the S-31 variety - this can presumably be attributed to the yield depressing affect of the rust and drought, which was much more pronounced on this variety.

4. The 20 lbs. of N placed with the seed proved equally as effective as 50 lbs. of N broadcast (based on Thatcher data only).

5. The phosphorus uptake data suggest that there were very few differences between the two varieties in their respective ability to feed on soil or fertilizer phosphorus. The almost identical 'A' values can be taken as good evidence of the similarity of the phosphorus feeding capacity of the two varieties.

6. The effect of the various fertilizer treatments and soil types on the protein content of the Thatcher and S-31 in grain varieties was markedly influenced by the shrivelled condition of the S-31 seed in particular. Thus, the protein content of the S-31 variety was consistently above that of comparable Thatcher treatments. The protein content of both varieties, however, increased with increasing nitrogen applications, and were unaffected by phosphorus fertilization. The higher protein content of the grain grown on the Orthic as compared to the Eluviated sites is a reflection of the more arid conditions existing on the upper slope position (Orthic).

Table 1. Yield of Grain (bu/ac) of Two Wheat Varieties Using Varying N and P Fertilizer Practices on Two Subgroup Profile Types

Treatments[1]	Eluviated	Orthic	Eluviated	Orthic
	0 - Nitrogen Broadcast		50 lb N/ac Broadcast	
Thatcher				
Check	18.7[2]	19.3	22.0	16.9
10 lb P + 20 lb N[3]	24.6	26.9	24.6	18.8
10 lb P	19.7	25.2	25.6	19.2
20 lb P	26.5	27.8	30.0	21.1
S-31				
Check	20.2	17.0	15.4	13.1
10 lb P + 20 lb N[3]	23.2	22.4	19.6	17.0
10 lb P	20.0	21.8	23.4	17.5
20 lb P	18.4	23.7	21.8	16.3
L.S.D. (P = .05)	1.9	2.1	1.7	2.0
	100 lb N Broadcast		200 lb N Broadcast	
Thatcher				
Check	21.8	20.4	23.7	20.5
10 lb P + 20 lb N[3]	29.6	28.0	30.8	25.0
10 lb P	25.3	26.0	32.4	23.0
20 lb P	26.2	30.8	35.8	24.6
S-31				
Check	20.6	20.5	20.6	17.5
10 lb P + 20 lb N[3]	21.8	26.8	26.1	18.8
10 lb P	26.0	25.2	27.1	19.6
20 lb N	25.3	27.3	27.1	21.5
L.S.D. (P = .05)	2.2	2.1	1.8	2.0

[1] fertilizer treatments applied with seed

[2] each value is the mean of six replicates

[3] the phosphorus carrier $NH_4H_2PO_4$ was tagged with P^{32} (150 μc P^{32}/g P31)

Table 2. Average Effect of Broadcast N on Yield (bu/ac)*

Treatment	Thatcher	S-31
Check	22.0	20.2
50 lb N	22.5	17.9
100 lb N	25.1	24.2
200 lb N	26.6	22.3
L.S.D. (P = .05)	1.2	3.1

* 10 lb P + 20 lb N treatment not included

Table 3. Average Effect of P Fertilization on Yield (bu/ac)

Treatment	Thatcher	S-31
Check	20.5	18.2
10 lb P	24.6	22.7
10 lb P - 20 lb N	26.1	22.0
20 lb P	27.9	22.8
L.S.D. (P = .05)	1.7	1.6

Table 4. Average Effect of Soil Type on Yield (bu/ac)*

Soil Type	Thatcher	S-31
Eluviated	25.6	22.1
Orthic	22.9	20.1
L.S.D. (P = .05)	1.1	1.0

* 10 lb P + 20 lb N treatment not included

Table 5. Phosphorus Uptake Data (mean of both plot areas) by Two Grain Varieties

	Check	50 lb N	100 lb N	200 lb N	Average
Mg P/g grain (total)					
Thatcher	4.314	4.393	4.712	4.755	4.543
S-31	4.563	4.6.6	4.813	5.248	4.810
L.S.D. (P=.05)	.10	.16	N.S.	.14	.11
Mg fertilizer P/g grain					
Thatcher	.889	.823	.992	1.020	.931
S-31	.938	.911	1.053	1.093	.998
L.S.D. (P=.05)	N.S.	N.S.	N.S.	N.S.	N.S.
Mg soil P/g grain					
Thatcher	3.425	3.570	3.720	3.735	3.612
S-31	3.625	3.705	3.760	4.155	3.812
L.S.D. (P=.05)	.12	N.S.	N.S.	.21	.17
A values					
Thatcher	38.5	48.5	37.5	36.6	38.8
S-31	38.6	40.7	35.7	38.0	38.2
L.S.D. (P=.05)	N.S.	N.S.	N.S.	N.S.	N.S.
% uptake of applied phosphorus fertilizer					
Thatcher	16.4	13.8	17.0	14.1	15.3
S-31	16.0	13.6	14.9	12.9	14.4
L.S.D. (P=.05)	N.S.	N.S.	N.S.	N.S.	N.S.

Table 6. Effect of Soil Type on Uptake of Phosphorus by Two Grain Varieties

	Total P (mg/g grain)	Fert. P (mg/g grain)	Soil P (mg/g grain)	A Values lb P/ac	% Uptake of Applied Fertilizer
<u>Eluviated</u>					
Thatcher	4.568	.788	3.780	48.0	14.0
S-31	4.756	.838	3.918	46.8	12.8
L.S.D. (P=.05)	.11	N.S.	N.S.	N.S.	N.S.
<u>Orthic</u>					
Thatcher	4.519	1.074	3.445	32.1	16.7
S-31	4.864	1.159	3.705	32.0	15.9
L.S.D. (P=.05)	.21	N.S.	N.S.	N.S.	N.S.

Table 7. Percent Protien of Two Wheat Varieties Using Varying N and P Fertilizer Practices on Two Subgroup Profile Types

Treatments[1]	Eluviated	Orthic	Eluviated	Orthic
	0-Nitrogen Broadcast		50 lb N Broadcast	
Thatcher				
Check	14.2[2]	15.7	14.9	15.6
10 lb P + 20 lb N[3]	14.0	15.8	14.9	15.5
10 lb P	14.1	15.9	14.7	15.9
20 lb P	14.2	15.6	14.9	15.4
S-31				
Check	14.5	16.7	15.3	15.7
10 lb P + 20 lb N[3]	14.1	16.6	15.1	15.4
10 lb P	14.3	16.9	15.1	15.7
20 lb P	14.2	16.3	15.1	15.5
	100 lb Broadcast		200 lb N Broadcast	
Thatcher				
Check	14.6	17.9	16.7	19.5
10 lb P + 20 lb N[3]	14.5	17.9	16.8	19.7
10 lb P	14.9	18.1	16.7	19.2
20 lb P	14.2	18.0	16.4	19.7
S-31				
Check	15.2	18.8	18.5	20.0
10 lb P + 20 lb N[3]	15.3	18.5	18.3	19.7
10 lb P	15.4	18.7	18.0	19.9
20 lb P	15.2	18.6	18.4	19.8

[1] fertilizer treatments used applied with the seed

[2] each value is the mean of six replicates

[3] the phosphorus carrier $NH_4H_2PO_4$ was tagged with P^{32} (150 μc P^{32}/g P31)

Table 8. Average Effect of Broadcast N on Protein Content (%)*

Treatment	Thatcher	S-31
Check	14.9	15.4
50 lb N	15.2	15.4
100 lb N	16.2	17.0
200 lb N	18.0	19.1

* 10 lb P + 20 lb N, treatment not included

Table 9. Average Effect of P Fertilization on Protein Content (%)

Treatment	Thatcher	S-31
Check	16.1	16.8
10 lb P	16.1	16.7
10 lb P + 20 lb N	16.1	16.6
20 lb P	16.0	16.6

Table 10. Average Effect of Soil Type on Protein Content (%)*

Soil Type	Thatcher	S-31
Eluviated	15.0	15.7
Orthic	17.2	17.7

* 10 lb P + 20 lb N treatment not included