1958 TRACER FERTILIZER RESEARCH REPORT

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FIELD EXPERIMENTS

The radioactive $NH_4H_2PO_4$ used for the soil member investigations was obtained from the Bureau of Plant Industry, Beltsville, Maryland. All active fertilizers used in the growth chamber experiments were prepared using P_{32} obtained from the Atomic Energy of Canada Limited, Ottawa, Ontario.

The field plots were seeded with a six furrow opener, double disc, V-belt rodrow seeder mounted on a Bolens Ridemaster tractor. A Flexicoil packer was pulled behind the seeder.

Each treatment constituted three rows 25 feet long; 20 feet of the centre or 'active' row was taken for yield determinations. All plots, with the exception of one of the residual plots at Rosetown (which was seeded with oats), were seeded with Thatcher wheat at a rate of 2 bu. per acre. The grain was harvested at maturity, dried at 55 - 60° C, threshed and weighed. Radiophosphorus analyses were carried out using the hollow cylinder technique.

Composite soil samples were taken from the 0-6" depth from all plot sites for chemical analysis. The analytical data obtained on the samples are given in Table 1.

Table 1: Analytical date from surface samples taken from the plot area

Name of Cooperator	Soil type	Texture	pH	Extractable - P ppm CO_2	$NaHCO_3$	Total N(%)
Blyth, Zehner	Oxbow loam catena					
NE32-19-18 W2	(1)Columnar (prismatic) calcareous	L	7.3	23.2	7.8	0.350
	(2)Columnar (prismatic)	L	6.4	29.0	17.6	0.345
	(3)Moderately degraded podzol	L	6.2	12.1	8.6	0.244
	(4)Depressional podzolic (Bluff Podzol)	CL	6.1	21.0	19.0	0.104
Hleck, Watson SE13-37-19-W2	Yorkton loam	L	7.3	24.3	14.6	0.441
Hutchison, Naicam SW27-39-18 W2	Naicam loam	L	7.3	12.7	7.8	0.419
Purdy, Tisdale NE9-45-15 W2	Tisdale clay loam	CL	6.4	55.9	39.6	0.390
Swenson, Hagen SE1-46A-25 W2	Hoey loam	SiCL	6.2	25.9	22.0	0.400
Hutcheon, Rosetown NW8-31-14-3	Elstow clay loam	CL	6.4	11.8	11.6	0.193
Cowan, Rosetown	Regina heavy clay	HvC	7.5	25.3	16.6	0.215

Effect of varying rates of N and P on yield of grain sown on stubble land

(Conducted in co-operation with members of the Sask. Advisory Fertilizer Council)

A 5 x 5 balanced lattice designed experiment was laid down on the farm of Mr. Hleck, Watson (SE13-37-19 W2). The NH_4NO_3 (33.5-0-0) and $Ca(H_2PO_4)_2$ (0-52-0) were used as nitrogen and phosphorus sources respectively. The various treatments, together with yield results, are given in Table 2.

Moisture conditions at seeding time were reasonably good. The soil below 28" was dry (below the W.P.). Approximately 3" of available water were present in the upper two feet of soil (May 15). The crop germinated uniformly. Growing conditions in the area were drier than normal for the district. The crop was harvested August 20.

Results

Table 2: Effect of varying rates of N and P on yield of grain (bu/ac.) sown on stubble land. (Hleck, Watson - Yorkton L - Black Soil Zone)

Lb. P_2O_5 per acre	Lb. nitrogen (N) per acre 0	10	20	40	60
0	22.6	24.5	25.5	26.0	24.0
10	25.5	28.0	30.2	27.8	28.8
20	25.6	28.4	28.4	31.0	31.1
40	26.0	31.3	27.7	29.6	29.6
60	23.9	28.9	31.9	30.3	31.0

L.S.D. $(P = .05) = 4.8$ bu/ac.

It is apparent from the data given in Table 2 that a fertilizer application of nitrogen alone, or phosphorus alone, did not result in satisfactory yield increases, but where these nutrients were applied together satisfactory yield increases were obtained. Treatments supplying between 10 to 20 lb. of both N and P_2O_5 (i.e. 50-90 lb. 23-23-0) resulted in maximum economic returns. It is interesting to note that even under relatively dry conditions a minimal application of 10 lb. of N and P_2O_5 respectively resulted in significant and highly satisfactory yield increases.

Experiments of this type have been conducted on stubble land (under a variety of soil and climatic conditions) for a period of six years. While the results have differed appreciably between plots laid down in different locations in any one year, or on the same farm in successive years, the following general conclusions are justified at this time.

(1) The degree of nitrogen defficiency in the soils investigated ranged from very marked to not at all.

(2) In practically all instances, a response to phosphates was recorded.

(3) Applications of nitrogen alone or phosphorus alone did not result in satisfactory yield increase.

(4) The magnitude of the phosphate response was dependent, particularly in nitrogen deficient soils, on the rate of nitrogen application.

(5) The 1:1 ratio of $N:P_2O_5$ (equivalent to the commercial 23-23-0) proved most satisfactory under all soil and climatic conditions. A 2:1 rate resulted in more favorable responses only where a marked soil nitrogen defficiency was prevelent; the 2:1 rate (equivalent to 27-14-0) was inferior to the 1:1 rate where yield responses to nitrogen were low.

(6) In view of the fact that predictions of nitrogen fertility needs of stubble soils cannot be made with any degree of assurance at the present time, it would appear that a carrier such as 23-23-0 should receive first preference as a general stubble fertilizer.

<u>Effect of placement of N on yield of grain sown on stubble land</u>

(Conducted in co-operation with members of the Sask. Advisory Fertilizer Council)

A 25 treatment balanced lattice experiment, including the treatments outlined in Table 3, was laid down on the farm of Mr. Purdy, Tisdale (NE9-45-15-W2). Sources of N and P included NH_4NO_3 (33.5-0-0) and $Ca(H_2PO_4)_2$ (0-52-0). Soil moisture reserves at time of seeding (May 14) were excellent, the soil being moist to a depth ranging from 30 to 45". Nitrogen, where applied as a top dressing, was broadcast on the surface after the plot was seeded, and was raked in.

Table 3: Effect of N placement on yield of wheat (bu/ac.) sown on stubble land (Purdy, Tisdale - Tisdale CL - Grey Black Soil Zone)

Source of: $N = NH_4NO_3$; $P = Ca(H_2PO_4)_2$

Lb. P_2O_5 per acre	Lb. nitrogen (N) per acre 0	20	30	40	80
		(a) Nitrogen applied with the seed			
0	18.2	23.6	25.8	30.6	25.4
20		26.0	24.4	29.9	28.9
40		27.7	24.8	25.0	31.8
		(b) Nitrogen top dressed at seeding time			
0	18.2	20.2	26.0	24.7	26.2
20		24.8	28.4	28.0	31.0
40		21.7	23.7	24.1	30.8

L.S.D. (P = .05) = 4.3 bu/ac.

Results

The yield data obtained on the Tisdale Clay soil is given in Table 3. Average yield increases for the 20, 30, 40 and 80 lb. N treatments with the seed were 26.6, 25, 28.5 and 28.7 bu/ac. while for comparable broadcast applications were 22.2, 26.0, 25.6 and 29.4, respectively. There is evidence in the data that phosphorus fertilization will overcome, to some degree, the adverse effects of seed applied nitrogen. A direct comparison between nitrogen applied with the seed and broadcast is open to some doubt due to the very limited rainfall during the early stages of crop growth. In general, rates of N in excess of 20 lb. N/ac. (where phosphorus was applied as well) did not result in significant yield increases over that of the check.

Nitrogen placement experiments have been reported in the 1957, 1956, 1955 and 1954 Tracer Fertilizer Reports. Together with the 1958 data, it can be concluded that (1) nitrogen applied with the seed at rates less than 20 lb/ac. can be expected to be much more effective than comparable broadcast applications, (2) rates of nitrogen applied with the seed in excess of 20 lb/ac. may cause yield reductions, (3) the critical amount of N that can be safely applied with the seed can be expected to vary from year to year, (4) there is little indication that further experiments of this type will prove worthwhile.

Effect of trash management practices on yield of wheat

Representative soil areas were selected in the Grey Black soil zone (Mr. Purdy, Tisdale - Tisdale CL) and at two locations in the Black soil zone (Mr. Swensen, Hagen - Hoey L., and Mr. Hutchinson, Naicam - Naicam L)

Each site was subdivided into three subplots and the following straw management treatments were prepared:

(a) Straw and stubble removed but returned to the surface after seeding.

(b) Straw worked into the surface soil.

(c) Straw and stubble removed.

At all three sites approximately twice as much trash as that remaining from the 1957 crop were used on subplots (a) and (b) in order to magnify the influence of trash placement. The fertilizer treatments, arranged in a randomized block design on each of the subplots are outlined in Table 4.

The depth of moist soil in the Hoey and Naicam soil sites ranged from 10-16". Only the Tisdale CL site contained sufficient moisture reserves to guarantee a reasonable yield of wheat.

Table 4: Effect of trash management practices on the yield of grain (bu/ac.) with and without fertilizer.

A. Purdy - Tisdale CL

Fert. treatments - lb/ac.	Straw on surface	Straw worked in	Straw removed
Check	19.7	20.2	19.7
40 lb. P_2O_5 (11-48-0)	22.6	24.3	20.4
40 lb. P_2O_5 + 40 lb. $N(NH_4NO_3)$	31.8	35.6	26.3
40 lb. P_2O_5 + 80 lb. $N(NH_4NO_3)$	33.6	39.6	30.8
40 lb. $N(NH_4NO_3)$	26.9	32.2	21.8
80 lb. $N(NH_4NO_3)$	28.8	32.1	24.4
L.S.D. (P = .05)	4.7	4.4	3.9

B. Hutchinson - Naicam L

Fert. treatments - lb/ac.	Straw on surface	Straw worked in	Straw removed
Check	22.1	24.8	22.6
40 lb. P_2O_5 (11-48-0)	33.9	31.9	32.9
40 lb. P_2O_5 + 40 lb. $N(NH_4NO_3)$	35.1	33.0	32.2
40 lb. P_2O_5 + 80 lb. $N(NH_4NO_3)$	34.8	33.0	34.3
40 lb. $N(NH_4NO_3)$	21.0	22.3	22.2
80 lb. $N(NH_4NO_3)$	21.3	21.5	23.4
L.S.D. (P = .05)	3.2	3.4	3.0

C. Swensen - Hoey L

Fert. treatments - lb/ac.	Straw on surface	Straw worked in	Straw removed
Check	31.3	26.6	28.2
40 lb. P_2O_5 (11-48-0)	42.6	39.9	35.4
40 lb. P_2O_5 + 40 lb. $N(NH_4NO_3)$	42.6	40.0	41.4
40 lb. P_2O_5 + 80 lb. $N(NH_4NO_3)$	43.5	42.2	44.8
40 lb. $N(NH_4NO_3)$	33.5	28.1	30.0
80 lb. $N(NH_4NO_3)$	32.9	30.0	31.3
L.S.D. (P = .05)	3.3	5.9	5.8

Results

The effect of the various trash management practices on the yield of grain for the Tisdale CL, Naicam L and Hoey L sites is given in Table 4. A comparison of check yields indicates that incorporation of the straw into the soil did not alter yields appreciably as compared to where all trash was removed, or left on the surface, at the Tisdale CL and Naicam L sites. It is of interest to note that the check yield obtained on the Hoey L 'straw on surface' treatment was 4.7 bu. higher than where the straw was incorporated, and 3.1 bu, higher than where all trash was removed. This could be attributed to a reduction in evaporation losses of water.

Only at one site, the Tisdale C, was there a greater response to both N and P fertilization on the subplot where the trash was incorporated, than where the trash was removed.

Trash placement experiments of a design similar to that conducted in 1958 were reported in the 1957 and 1956 Tracer Fertilizer Reports. In general, the results recorded from this three year study indicate (1) that while a somewhat greater response to nitrogen and phosphorus fertilization was obtained where trash was incorporated as compared to where all trash had been removed, the indigeneous deficiency of both nutrients in the soil (possibly due to removal by the previous fallow crop) appeared to be a major factor contributing to a deficiency of nitrogen in the soil. Thus, fertilization of stubble crops appears to be necessary irrespective of whether the trash is incorporated into the soil, anchored at the surface, or removed (by burning!) In effect, these results refute the contention that the deficiency of nitrogen in particular, in second, third and fourth crop land is due solely to the temporary tieup of available soil nitrogen by the organisms decomposing the stubble. (2) the need for phosphorus in conjunction with nitrogen fertilization was clearly demonstrated. In certain cases, the response to phosphorus fertilization was much greater than that resulting from additional nitrogen. (3) the benefits that accrue from surface placement of straw in years of limited rainfall were demonstrated in both 1957 and 1958. This was attributed to increased moisture efficiency - reduced evaporation of moisture from the surface soil. (4) in no instance was the 'mooted' toxic effect of wheat straw evident during this three year study. Where a satisfactory seed bed was prepared, highly satisfactory yields, in many cases exceeding those where trash was removed, were obtained on plots where the straw was left either at the surface or incorporated. (This conclusion was verified with and without fertilization).

Comparative productivity of member profiles of the Oxbow soil catena

Fallow plot sites were selected on the farm of Mr. Blyth, Zehner, (NE32-19-18 W2) in an area largely dominated by modal black soils occurring on medium textured brownish grey to yellowish brown, moderately calcareous and moderately stony till. The predominating surface texture was a loam, but textures ranging up to sandy clay loam and light clay loam were commonly encountered.

Four treatments, consisting of 20 and 40 lb. P_2O_5/ac. as 11-48-0, 20 lb. per acre of 23-23-0 and a check, arranged in a randomized block design, were laid down on the following soil member sites; these sites were all located within a ten acre block in the north east corner of the quarter section.

(1) Columnar (prismatic) calcareous black

Moderately well developed A, B(ca), C profile occurring on upper intermediate slope, just below the shallow, truncated member on the knoll. Lime carbonates present throughout the brown, columnar (prismatic) B horizon. Surface texture - loam.

(2) Columnar (prismatic) black

Well developed A B C profile with free lime carbonates leached from the A, B_1 and B_2 horizons. Dark brown well developed prismatic B horizon, slightly heavier in texture than the loam surface or Ap horizon. Site location on intermediate slope position.

(3) Moderately degraded black

A B C profule occupying the lower intermediate slopes; reddish brown 'B' horizon (B_1), nutty structure, very firm to hard consistence, and distinctly heavier in texture than the light clay loam surface soil.

(4) Depression Podzolic (Bluff Podzol)

A B C profile occupying the upland depressions. Very dark greyish brown 'B' horizon with rusty streaks, and mottling particularly in the B_2 - much heavier textured than the clay loam surface soil. The surface or Ap horizon was distinctly greyish-white in color, and at time of seeding, was loose and powdery.

Results

(1) Yield of grain

Yield comparisons between the four members of the Oxbow catena are given in Table 5(a). The marked differences in check yields between the different soil members were in most instances increased in magnitude with the use of 11-48-0. Only on one member, the columnar calcareous, was an additional response obtained from 23-23-0 as compared to the 11-48-0 treatment (20 lb. P_2O_5/ac. rate of application). The low yields recorded for the Depressional podzolic member can, in part, be attributed to the poor tilth of the Ap horizon; the soft and loose structured condition of the surface soil favoured a rapid loss of surface moisture immediately after seeding, thus resulting in erratic germination. In addition, the tendency of the Ap horizon to form a hard compact surface crust following subsequent rains undoubtedly retarded growth and stooling.

Table 5(a): Comparative data obtained on four member profiles of the Oxbow Catena

Yield of grain, bu/ac.

		Fertilizer treatment, lb. P_2O_5/ac.			
Soil member	Check	11-48-0 at 20	11-48-0 at 40	23-23-0 at 20	LSD
Columnar calcareous	15.9	21.4	24.8	23.0	1.9
Columnar (prismatic)	30.8	42.9	45.4	42.8	5.8
Moderately degraded black	17.7	31.5	32.5	28.7	4.6
Depressional podzolic	10.3	16.0	15.2	13.6	3.4
L.S.D. (P_2O_5)	2.2	2.6	5.0	3.4	

(2) Percentage utilization of applied fertilizer

The uptake of fertilizer phosphorus, (Table 5(b))while in part reflecting total yield, is also influenced by the level of available soil phosphorus; wheat grown in soils high in available phosphorus will utilize less applied fertilizer phosphorus than when grown on phosphorus deficient soils. These data indicate that percentage utilization of applied phosphorus varied greatly for the different member profile sites. It is of interest to note that the wheat utilized more of the phosphate from 23-23-0 than from 11-48-0 (comparing equivalent rates of application) at all member sites. This can be attributed to the higher ammonium ion content of the 23-23-0 carrier. (Rennie, D.A. and Soper, R. J. 1958 J. Soil Science. 9:155-167.)

Table 5(b): % utilization of applied fertilizer (in grain only) Oxbow Catena

Soil member	Fert. treatment, lb. P_2O_5/ac. 11-48-0 at 20	11-48-0 at 40	23-23-0 at 20
Columnar calcareous	15.2	12.6	17.0
Columnar (prismatic)	29.2	24.8	32.4
Moderately degraded black	31.0	23.4	33.0
Depressional podzolic	14.9	10.4	13.7
L.S.D. (P = .05)	4.1	3.5	3.8

Table 5(c): Fertilizer-P as a percentage of total-P in the grain Oxbow Catena

Soil member	Fert. treatment, lb. P_2O_5/ac. 11-48-0 at 20	11-48-0 at 40	23-23-0 at 20
Columnar calcareous	27.6	39.8	28.4
Columnar (prismatic)	27.7	43.1	30.8
Moderately degraded black	39.1	55.1	45.3
Depressional podzolic	30.9	45.1	33.9
L.S.D. (P = .05)	4.3	4.0	4.8

Fertilizer-P as a percentage of total-P in the grain

It is evident, from the data given in Table 5(c) that the amount of fertilizer phosphorus in the grain (expressed as a percentage of total phosphorus) varried significantly between members.

Ordinarily, some 20 to 30 percent of the phosphorus in the grain may be derived from the fertilizer (20 lb. P_2O_5 rate of application), but under drought conditions, this value may increase to approximately 80%. Other factors such as availability of soil-P, root distribution pattern, etc., can also be expected to materially alter the percentage of plant-P derived from the fertilizer. Thus, in the absence of climatic and soil moisture records, it is impossible to ascertain the reason for the significant variations recorded in the fertilizer phosphorus content of the grain.

Table 5(d) Available phosphorus lb. P/ac. Oxbow Catena

Soil Member	A Value		Extractable P	
	*11-48-0	23-23-0	H_2CO_3	$NaHCO_3$
Columnar calcareous	24.9	22.3	46.4	15.6
Columnar (prismatic)	23.6	20.1	58.0	35.2
Moderately degraded black	14.0	10.5	24.2	17.2
Depressional podzolic	20.5	17.5	42.0	38.0
L.S.D. (P = .05)	3.3	3.8		

H_2CO_3 + $NaHCO_3$ ext. P. reported on page 26 are exactly ½ the value of those reported here, for the same soil

* represents the average 'A' value for the 20 and 40 lb. P_2O_5 treatment.

Available soil phosphorus

Both 'A' value and 'quick' test data (Table 5(d)) suggest that marked differences in available soil phosphorus can, in part, explain the differences in crop yields obtained on the four related soil members. (It should be noted that the differing measurements orientate the soils in a somewhat different order of increasing phosphorus fertility levels.) Previous tracer reports (see 1956 and 1957 Tracer Fertilizer Reports), however, have suggested that 'A' values are a better index of available phosphorus levels than either the $NaHCO_3$ or H_2CO_3 extractants.

Using 'A' values as the determining criteria, it can be concluded that the moderately degraded podzolic member contained the least amount of available phosphorus, followed, in order of increasing levels of available phosphorus, by the depressional podzotic, the columnar, and columnar calcareous member.

Percentage P in the grain

Grain samples taken from the Depressional podzolic site contained considerably more phosphorus than the other three sites.

The percentage phosphorus in the grain, (Table 5(e)) from the columnar calcareous, columnar, and moderately degraded podzolic is statistically the same.

Table 5(e): Milligram percentage P in the grain, Oxbow Catena

Soil member	Check	Fert. treatment, lb. P_2O_5/ac. 11-48-0 at 20	11-48-0 at 40	23-23-0 at 20	LSD	Av.
Columnar calcareous	382	373	380	375	N.S.	378
Columnar (prismatic)	372	371	359	361	N.S.	367
Moderately degraded black	356	381	371	367	N.S.	369
Depressional podzolic	451	443	433	440	N.S.	442
LSD (P = .05)	24.8	22.5	18.9	22.7		10.9

General Comments

An important hypothesis in soil classification is that crop yield differences may be associated with pedogenic differences used to separate soils into differing units. In general, the criteria used to characterize the productivity and nutrient levels (N and P) of the four member profiles of the Oxbow catena clearly confirm the validity of the field separations. In addition, it can also be concluded that the differences in productivity between the four soil members may be as great or greater than between similar soil members developed on different parent material.

These data further suggest that productivity data (response to various fertilizers, etc.) obtained from any one small plot experiment cannot be considered as representative of a soil association, but are applicable only to one particular unit of that association, or the soil member on which the test was established. This conclusion has special significance particularly where recommendations with respect to fertilizer usage by farmers are to be made from the data, or where the data is to be used to characterize the productivity of any mapping unit comprising more than one soil member.

The Nature and Availability of Residual Fertilizer Phosphorus (M.Sc. Thesis - T. C. Day)

A problem which is becoming of increasing importance in Western Canada is the influence of residual (previously applied) phosphate fertilizer on the phosphorus fertility level of soils. Preliminary data obtained some years ago (see Tracer Fertilizer Reports for 1951 and 1952) indicated that significant increases in available soil phosphorus had occurred on a Melfort soil which had received annual applications of 11-48-0 for a period of ten years. Unfortunately, long term permanent phosphorus plot sites, from which further substantiating data might be obtained, were not available. The only alternative, therefore, was to set out 'residual' phosphorus plots on selected soils. Two such sites were selected near Rosetown in the spring of 1957, one on a Regina heavy clay, the other on an Elstow clay loam soil. Phosphorus was applied as a broadcast application in amounts ranging from 80 to 1280 lb. P_2O_5 ($NH_4H_2PO_4$ was used as the phosphorus source). Each treatment (replicated four times) covered an area of 10 x 25 feet. The entire plot area was fallowed for the remainder of the 1957 growing season.

Soil samples were taken from the various sub plots before broadcasting the fertilizer, and at various intervals since June, 1957. It is interesting to note that a year after the applications on the Regina soil, the 11-48-0 pellets were still readily visible; this was due to the very arid climatic conditions prevailing in the area since the plot was laid down. Bulk supplies were taken from each treatment (sub plot) for greenhouse and laboratory studies.

Yield data obtained from both locations for the 1958 crop are outlined in Table 6. It would appear that on the Regina soil, yield increases from the residual phosphate applied in excess of 160 lb. P_2O_5 per acre, are equal to that obtained from 80 lb. P_2O_5 applied with the seed. In effect, appreciable portions of the broadcast fertilizer were not 'fixed'. On the other hand, a somewhat different pattern of response was obtained on the Elstow soil in that yield increases from the broadcast (residual) phosphorus are in all instances less than that recorded for the seed applied phosphorus.

Table 6: Yield, bu/ac. obtained on the residual phosphorus plots

	Regina HvC (Cowan)	Elstow CL (Hutcheon)
Treatments	Wheat	Oats
(1) Check	32.0	30.3
(2) Check - fert. with 80 lb. P_2O_5 with the seed (1958)	42.4	38.4
(3) 80 lb. P_2O_5 broadcast, June/57	34.4	35.5
(4) 160 lb. " " "	40.2	-
(5) 320 lb. " " "	41.1	34.6
(6) 640 lb. " " "	42.4	29.5
(7) 1280 lb. " " "	42.2	34.5
L.S.D. (P = .05)	4.0	N.S.

Soil samples taken from the field plot sites were equilibrated (alternatively wetted and dried) for a year in the greenhouse: representative samples were then removed and a phosphorus fractionation analysis (Chang S. C. and Jackson, M. L. 1957. Soil Science 84, 133-144.) was carried out. The results indicate that calcium phosphate and 'reductant soluble' phosphorus comprise the majority of the indigeneous phosphorus in both soils; only minimal amounts of iron and aluminum phosphorus were extracted. On the other hand, practically all the residual fertilizer phosphorus could be accounted for in the aluminum phosphate extraction, with only minimal amounts in the iron, calcium, or loosely bound fractions. Even in the calcareous Regina heavy clay, only minimal amounts of the residual fertilizer phosphorus were found in the calcium phosphorus fraction.

Preliminary data comparing two standard 'quick' tests indicate that the $NaHCO_3$ extract removes appreciable quantities of aluminum phosphorus and only small amounts of calcium phosphorus while the carbonated water solubilizes relatively more calcium and less aluminum phosphorus.

II. THE RELATIONSHIP BETWEEN SOIL TYPE, CLIMATE AND FERTILIZATION ON THE PROTEIN CONTENT OF WHEAT AND BARLEY

Protein content of wheat grown on differing soil member sites

The protein content of grain samples taken from the Oxbow Soil Catena study are given in Table 7. The average protein content of the grain grown on the depressional podzolic, degraded podzolic, and prismatic member sites was approximately equal, but significantly lower than that obtained for the prismatic calcareous site.

Table 7: Oxbow Soil Catena - Protein Content of Grain

		*Percentage Protein				
Soil Member	Check	11-48-0-lb. P_2O_5/Ac. 20	40	23-23-0 at 20 lb. P_2O_5/Ac.	L.S.D. P=.05	Average Protein
Columnar calcareous	20.2	20.1	20.0	20.0	N.S.	20.1
Columnar	19.4	18.9	18.6	19.2	N.S.	19.0
Moderately degraded podzolic	19.6	19.2	19.2	19.3	N.S.	19.3
Depressional podzolic	19.3	19.3	19.3	19.1	N.S.	19.3
					L.S.D. (P = .05)	0.4

* based on grain dried at 60°C. for 48 hours

Fertilization did not, in any instance, alter the protein content of the grain. Previous experiments (See Tracer Fertilizer Report, 1957) suggested that both 11-48-0 and 27-14-0 could result in a significant decrease in protein content as compared to the check while earlier epxeriments (Rennie, D.A. Can. Journ. Agr. Sci. 36:491-504, 1956) conducted in 1952, 1953, and 1954 indicated that the protein content of wheat was not affected by either N or P fertilization.

Variation in protein content of wheat within any one field

Grain samples were taken for protein determinations from each of the 15 replicates from the unfertilized (check) and/or fertilized strips of 11 field strip fertilizer trials. The data obtained in this study are outlined in Table 8. A wide variability in protein content of the replicate grain samples was recorded for each of the 11 field locations. Even on soils which are normally considered to be relatively uniform, such as the Asquith soil, a difference of approximately 2 percent in protein content was recorded. An extreme example of the range in crude protein content that might be expected in any one field is afforded in the data obtained on the Yorkton loam trial near Watson; a range of 8.2% in protein between the lowest and highest protein sample occurred.

These data emphasize the great care that must be taken in attempting to assess the protein content of grain grown in any one field. It appears most important that representative samples are taken. In addition, it is important to note that these differences in protein content can be related to the differing soil members on which the grain was grown. While it is quite possible that the different protein contents of grain grown on the different soil members is closely related to variable soil moisture conditions, this has not as yet been verified. It is further evident from the data given in Table 8 that the range of protein content of grain grown on any one field is equally as great as that recorded for widely separated points.

Table 8: Percentage protein of wheat taken from differing soil member sites within 11 field strip tests.

Co-operator	Location	Soil Type	Fert. Treatment	*Range in Protein Content	Av. % Protein
Prosko	Watson	Yorkton loam	Check	13.1-21.3	16.7
Dickson	Wimmer	Yorkton loam	Check	13.2-18.5	15.5
Muggli	Muenster	Oxbow loam	Check	13.1-19.7	16.6
			**Fert.	13.7-19.5	16.9
Bergeman	Muenster	Oxbow loam	Check	10.9-16.4	14.1
			**Fert.	11.2-15.6	14.1
Flint	Speers	Blaine Lake clay	Check	13.1-18.7	15.8
			**Fert.	13.6-18.2	16.4
Wollberg	Speers	Blaine Lake clay	Check	12.3-16.1	14.3
Zelenski	Birch Hills	Melfort silty clay loam	Check	12.9-20.2	18.0
Edwards	Melfort	Melfort silty clay loam	Check	15.6-17.0	16.1
Decker	Sovereign	Elstow silty clay loam	Check	15.7-20.6	18.3
Cunningham	Zealandia	Elstow silty clay loam	Check	16.7-19.8	18.7
McGowan	Asquith	Fine sandy loam	Check	16.9-19.2	17.9

* Represents the low and high percentage protein of the 15 grain samples taken for yield comparisons from each field strip.

** Test treatment included a 40 lb./ac. application of 11-48-0.

Effect of phosphate fertilizer on the protein content of fallow wheat

The protein content of composite grain samples taken from 41 summerfallow fertilizer tests, are given in Table 9. While yield increases over the check ranged from approximately 10 to 100%, the protein content of the fertilized and unfertilized grain remained relatively constant; the average protein content

Table 9: Influence of 11-48-0 on percentage protein of wheat grown on fallow land. (1958)

Cooperator	Location	Soil Type	% Protein Check	% Protein *Fert.	Yield of grain, bu./ac. Check	Yield of grain, bu./ac. *Fert.
Stoll	Neudorf	OL	15.4	15.2	17.8	23.1
Myrah	Holdfast	WL-LL	15.6	16.2	23.6	28.9
Molstad	Domremy	MSiL	15.4	16.2	36.2	41.3
Muggli	Muenster	OL	16.6	16.9	41.3	48.4
Flint	Speers	BC	15.8	16.4	35.3	45.3
Brice	Wadena	YL-LL	16.8	16.5	25.1	34.1
Hauser	Neudorf	OL	17.6	17.5	19.6	27.7
Duval	Belleview	BSil	17.7	17.5	29.6	36.3
Swensen	Hagen	MSiCL	17.9	18.4	27.6	35.7
Bergerman	Muenster	OL	14.1	14.1	26.8	35.0
McArthur	Watrous	WL	13.4	14.5	52.8	59.2
Reckwell	Lashburn	WaL	15.5	15.1	33.7	38.1
Rugg	Elstow	ESiC	17.1	16.1	47.5	52.6
Smith	Kindersley	KcC	15.3	14.1	24.5	33.0
Lorenz	Marsden	BL	16.5	16.4	25.1	31.1
Appleby	Linkham	KcC	13.6	13.6	18.4	25.2
Johnson	Radisson	BL	17.9	17.8	21.9	28.9
Felsing	Naicam	NL	17.0	16.3	32.7	39.1
Fraser	Paynton	MeLL-FL	16.7	16.4	21.2	27.7
McMillan	Asquith	AFL-EL	18.6	19.3	16.0	22.5
Kuryluk	Yorkton	CaSiCL	17.5	17.2	16.5	24.2
Hansen	Neilburg	OL	17.2	17.1	24.2	28.9
Cumming	Adanac	ESiCL	18.3	18.6	16.4	22.5
Lawton	Tessier	ESiL	20.1	20.2	15.6	17.7
Foisy	Cutknife	OL	18.3	18.8	18.3	22.9
White	Flaxcombe	KcC	16.8	16.0	12.6	25.7
Nielsen	Adanac	W+OL	16.6	17.0	9.0	15.0
Millhouse	Cutknife	OL	18.0	18.3	16.0	21.8
Smith	Hagen	MSiCL	16.5	17.9	37.8	44.5
Kozakewich	Parkerview	WL	16.5	16.3	34.4	43.2
Knutson	Naicam	NL	17.0	16.6	26.1	32.6
Eley	Colonsay	ESiC	17.1	17.3	38.3	45.6
Byblow	Sheho	WvL	16.2	14.7	19.8	28.0
Sakundiak	Regina	RHvC	16.5	16.2	21.5	27.7
Marynowski	Paynton	MeLL	13.4	13.6	25.9	33.5
Weinmaster	Yorkton	O-CaSiL	16.8	15.6	28.2	35.8
Weinmaster	Yorkton	CaSiCL	16.1	15.8	23.4	32.8
Harris	Yorkton	CaSiCL	16.5	17.1	18.6	29.8
Barnsley	Abernethy	IC	16.9	16.7	28.0	33.3
Middleton	Abernethy	IC	15.3	15.5	29.9	39.4
Bobinski	Wadena	YL-LL	15.2	15.9	27.9	41.1
	Average protein content	-	16.5	16.5		

* the 11-48-0 was applied at 40 lb./ac.

of the check and fertilized grain for the 41 comparisons was identical - 16.5% for both treatments.

Both the data presented in Table 9 and that reported earlier (see 1957 Tracer Fertilizer Report) indicate that there is not necessarily a direct relationship between yield and protein content. This would suggest that total available moisture during the growing season does not necessarily dictate protein content, rather, the available moisture present during some critical stage of plant growth may be more significant. It is interesting to note that the average protein content of the grain grown at these 41 locations, 16.5%, is approximately the same as that obtained from the same locations in 1957 (16.8%).

Influence of fertilization on the protein content of barley

Composite barley samples taken from 4 stubble and 8 fallow fertilizer tests were analyzed for protein content. The stubble barley data given in Table 10 indicate that the crude protein percentage has been increased at all 14 locations as a result of fertilization. In comparison with the check treatments, the 16-20-0 applied at 100 lb. per acre resulted in an average increase in protein content of 1.2 percent for the 4 trials (13.1 compared to 14.3, respectively). Other fertilizer treatments involving heavier rates of nitrogen resulted in a slightly greater increase in protein content over that of the 16-20-0 treatment.

From the point of view of malting quality, it is not known how critical are these increases in crude protein resulting from fertilization. There is certainly a possibility that the recorded increases have lowered the malting quality of the barley somewhat since it is generally understood that the diastatic activity is very closely associated with percentage protein. However, the beneficial effects of fertilization as measured by yield increases would certainly appear to outweigh any possible associated detrimental influences on malting quality.

It is evident from the data presented in Table 11 that the protein content

Table 10: Influence of fertilizer treatments on percentage protein of barley grown on stubble land.

Fertilizer Treatments	% Protein (dry basis): Menzies, Melfort, Melfort SiC (OIIi barley)		Everitt, Brooksby, Tisdale CL		Messler, Naicam, Naicam L		Apesland, Weldon, Melfort SiC	
Check (Average)	13.6	(33.2)**	12.4	(39.5)	13.7	(24.1)	13.3	(48.6
16-22-0 at 100 lb./ac.	14.2	(48.8)	14.8	(52.1)	14.0	(38.9)	14.0	(60.8
11-48-0 at 40 lb. + *33.5-0-0 at 120 lb./ac.	13.9	(47.1)	-	-	15.0	(37.0)	14.5	(59.4
11-48-0 at 30 lb. + *33.5-0-0 at 90 lb./ac.	14.8	(44.5)	13.3	(47.6)	-	-	13.3	(59.4
27-14-0 at 75 lb./ac.	-	-	13.1	(51.1)	14.4	(33.7)	-	-

* Broadcast at seeding time.

** Figures in brackets represent yield bu./ac.

Table 11: Influence of 11-48-0 on percentage protein of barley grown on fallow land.

Co-operator	Location	Soil Type	% Protein: Check	% Protein: 11-48-0 40 lb./ac.	Yield, bu./ac.: Check	Yield, bu./ac.: 11-48-0 40 lb./ac.
Hough	Glamis	RHvC	13.7	13.6	29.4	38.9
Webster	Kindersley	ScC	13.3	13.4	18.6	31.7
Schmidt	Kindersley	ScHvC	13.4	12.6	54.3	68.8
Jones	Marsden	BL	13.0	13.7	37.2	50.1
Dickson	Wimmer	YL	14.4	14.7	29.8	36.5
Ingham	Balcarres	IC	13.9	14.1	37.1	45.8
Flint	Speers	BC	12.1	12.0	65.3	72.0
Shular	Sheho	WvL	13.1	13.4	63.8	76.0

of barley on fallow fertilized with 11-48-0 is practically the same as the protein content of the unfertilized barley; the average protein content of both fertilized and unfertilized barley taken for the 8 locations was identical - 13.4%.

It is interesting to note the relative uniformity of the protein content of barley grown at widely separated points and under environmental conditions that vary greatly. In this respect these data compliment that reported by the Grain Research Laboratory in Winnipeg (Anderson, J.A., Grain Research Laboratory 1958 Report). In this latter report the protein content of barley grown in the various crop districts in both Saskatchewan and Manitoba was approximately 11%, and in no instances were deviations greater than 1%. It can thus be tentatively concluded that climatic and soil conditions appear to exert little if any effect on the crude protein content of barley. Why variable climatic conditions exert such a marked effect on the protein content of wheat (see Table 13), and are apparently ineffective in altering percentage protein in barley, is worth further investigation.

III LABORATORY AND GROWTH CHAMBER EXPERIMENTS

The reproducability of 'A' values obtained in the Growth Chamber

'A' value data obtained from two experiments, the first seeded October 1, 1958, and the second January 30, 1959, in a newly constructed growth chamber, are outlined in Table 12. Ten soils were used in these experiments.

In the majority of instances, the percentage uptake of applied fertilizer and 'A' values agreed very closely for the two growth periods. The difference between the average values (given at the bottom of the table) for the two growth periods are well within the expected experimental error. The uniformity of these data for the two growth periods afford marked contrast to that reported for concurrent experiments conducted in the greenhouse (see Tracer Fertilizer Research Report 1957). It would appear from the data given in Table 12 that the

Table 12: Growth chamber studies - reproducibility of 'A' values

Soil	October 1, 1958			January 30, 1959			% Field Capacity Moisture Content
	Yield Forage g./pot	% Fert. uptake	'A' value P_2O_5 lb./ac.	Yield Forage g./pot	% Fert. uptake	'A' value P_2O_5 lb./ac.	
Oxbow - prismatic calcareous	4.98	25.8	63	4.73	27.2	64	25.3
- prismatic	5.65	22.7	110	5.34	24.3	112	28.2
- degraded black	4.95	22.8	64	4.80	27.4	71	24.5
-depression podzolic	4.38	17.5	117	3.91	16.7	117	20.1
Regina HvC (Regina Exp. Farm) urea + N	4.18	20.8	82	4.22	21.9	91	38.1
Tisdale CL (Somme)	3.23	20.5	60	3.09	19.5	73	33.3
Scott L (Fs-S-508)	4.44	25.4	64	3.83	25.3	53	20.2
Blaine Lake Sil (Parkside)	5.50	20.9	74	4.70	21.9	73	29.3
Garrick L (Snowden)	4.62	20.5	110	4.54	23.3	113	21.5
Asquith FL (Guernsey)	4.75	26.7	95	4.56	27.1	99	21.0
Average	4.67	22.4	82.9	4.37	23.5	86.6	

environment conditions in the growth chamber are sufficiently uniform to enable direct comparisons of growth experiments conducted at different periods.

The October 1st experiment was grown at a temperature of 63°F while a constant temperature of 70°F was maintained during the six week growth period starting January 30th. It is apparent that small differences in temperatures of growth will not alter 'A' values significantly.

Greenhouse and laboratory tests for available phosphorus in soils from rodrow fieldtests

Soil samples taken from 23 field plot sites were analyzed for "available" P using .5 M $NaHCO_3$ and CO_2 saturated water. Ten of these samples were obtained from the 1958 tracer field plot sites and the remainder from tests laid down by the Regina, Scott and Melfort Experimental Farms respectively. In addition, 'A' values were determined in the growth chamber on 10 of these samples. These data, together with field yield data, are given in Table 13.

Correlation coefficients calculated on these data indicate that while both the $NaHCO_3$ and H_2CO_3 extractants result in very comparable available P values (r + 0.992), neither correlated with percentage yield. In effect, these data confirm the conclusions drawn from similar data reported in 1956 and 1957, that both quick tests are of doubtful value in predicting response from P fertilization.

The close relationship between 'A' values and percentage yield reported for the data collected in 1956 and 1957 is not evident in the limited 'A' value data given in Table 11.

A summary report of the soil test data collected during the 1956-1957 and 1958 growing seasons is currently being prepared and will be completed in the near future.

Table 13: Greenhouse and laboratory tests for available phosphorus

Tracer and Regional Fertilizer Tests

Experimental Agency	Soil Type	Extractable-P ppm H_2CO_3	Extractable-P ppm $NaHCO_3$	'A' value ppm	Field plot data yield, bu./ac. Check	Field plot data yield, bu./ac. *Fert.	% Yield
Regina	R HvC						
1) Urea + A.N.	"	14.7	13.2	18	5.9	3.8	100
2) Rouleau	"	25.2	15.8		17	17.9	100
3) Riceton	"	26.6	14.0		no	yield	data
4) Regina	"	14.4	9.4		"	"	"
Scott	Scott L						
1) FS-S-502	"	5.6	4.6		9.7	11.6	83.6
2) FS-S-504	"	6.2	5.4		15.4	20.4	75.5
3) FS-S-506	"	17.9	10.4		stubble	plot - no	N check
4) FS-S-508	"	11.6	10.0	13.1	13.3	17.7	75.1
5) FS-S-510	"	7.8	6.4		13.4	16.1	83.2
Melfort							
1) Somme	Tisdale CL	20.9	15.7	13.1	48.7	58.6	83.1
2) Parkside	Blaine Lake Sil	14.1	13.4	16.2	23.6	36.8	64.1
3) Snowden	Garrick L	29.2	20.3	24.0	35.3	46.2	71.4
4) Quernsey	Meota FL	17.0	12.1	21.0	18.4	17.9	100
Univ. of Sask.							
	Yorkton L	24.3	14.6		26.0	29.6	87.8
	Naicam L	12.7	7.8		22.2	32.2	68.9
	Tisdale CL	55.9	39.6		21.8	26.3	83.0
	Hoey L	25.9	22.0		20.0	41.4	72.4
	Elstow CL	11.8	11.6		30.3	38.4	78.9
	Regina HvC	25.3	16.6		32.0	42.4	75.5
	Oxbow						
	Prismatic-calcar	23.2	7.8	14.0	15.9	24.8	64.1
	Prismatic	29.0	17.6	24.0	30.8	45.4	67.8
	Degraded black	12.1	8.6	14.0	17.7	32.5	54.5
	Depress. podzolic	21.0	19.0	25.3	10.3	15.2	67.8

* Fertilizer treatment receiving 40 lb. P_2O_5 (in majority of cases, 11-48-0 used as phosphate source).

Table 14: The relationship between CO_2 extractable P and % yield responses over check to 11-48-0 at 40 lbs. per acre in 1957 and 1958.

Soil type	Correlation coefficients for years 1957	1958	Both years
All soils	-0.339**	-	-
Sceptre	-0.603	-	-0.607*
Waitville	-0.269	-	-0.460
Yorkton	-0.603	-0.232	-0.325
Elstow	-0.366	-	-0.320
Blaine Lake	-0.264	-0.423*	-0.471
Oxbow	-	-0.211	-
Melfort	-	-0.570**	-
Regina	-	+0.168	-

* Significant at .05% level

** Significant at .01% level

Cooperative Soil Testing Program - Summary of Results

The cooperative soil testing program, carried out with assistance from Agricultural Representative Services and the fertilizer trade, was continued during the 1958 growing season. Including similar experiments conducted in 1956 and 1957 a total of approximately 3,300 yield comparisons have been recorded to date. A similar number of soil samples taken within the square yard area from which yields were sampled have been analysed for pH, texture and CO_2 extractable phosphorus. Certain of the statistical correlation data obtained from 1957 and 1958 data are given in Table 14. These, together with similar data obtained on additional soil associations included in the cooperative study clearly indicate that the CO_2 soluble phosphorus in the soils does not give a reliable indication of the need for phosphate fertilization. This poor relationship is perhaps indicated at an extreme from the 28 comparisons obtained on the

Regina soils; a positive correlation was obtained between CO_2 soluble phosphorus and yield response suggesting that as CO_2 extractable phosphorus increases, a yield increase might be expected.

In summary, it appears that the carbonated water test is not a suitable quick test for use in estimating the need for phosphorus in the 19 soils under investigation in Saskatchewan.

IV SOIL MEMBER INVESTIGATION - FIELD STRIP EXPERIMENTS

Preliminary investigations were carried out on certain of the 1958 fertilizer test locations to determine whether yield increases resulting from phosphate fertilization could be related to a particular soil member. These investigations were carried out on 7 field strips from which 15 yield comparisons had been taken. The results of this study are outlined in Table 15. Both average yield of checks and average response from phosphate fertilization indicate that the productivity and phosphorus fertility level of the 10 soil members varied considerably. However, the wide variation in the range of both check yields and yield increases for any one member limit any definite conclusions that might be drawn from this initial study. It is apparent that the number of sites investigated during the past year are insufficient to yield any accurate comparative information between the 10 soil members. Certainly many more sites would have been necessary to provide reliable average check yields.

One difficulty encountered in the study was the manner in which the soil member sites were selected. The sites were identified in the Fall in the vicinity of the square yard area from which these samples had previously been taken. It was obvious, in many instances, that the soil members were integrates between two or more typical members. This is perhaps exemplified best in the solonetzic members in which only two of the 39 would be classified as typical of the solonetz group, the remaining 37 grading all the way from the columnar through to the solonetz-like. In subsequent studies of this type it would appear imperative that the soil member sampling sites be selected prior to taking yield samples. This study is being continued in 1959.

Table 15: Soil member investigations - Field strip experiments (Yield, bu/ac.)

Profile Type	Numver of Comparisons	Soil Associations	Average Increase	Average Check Yield	Range of Increase	Range of Check Yield	Crop
Structureless	8	Asquith	4.02	38.1	0-12.1	19.2-75.2*	Barley
Soft Massive	6	Asquith	4.75	35.7	0-10.3	13.3-51.3*	Barley
Blocky Columnar & Weak Columnar	13	12 on Asquith 1 on Oxbow	5.02	24.2	0-11.5	19.1-25.6 on wheat	12 Wheat 1 barley
Leached Columnar	6	3 on Asquith 2 on Elstow 1 on Oxbow	8.01	20.6	0-16.5	19.6-23.7	Wheat
Columnar	2	Asquith & Elstow	5.25	19.7	1.5-8.5	14.8-24.5	Wheat
Calcareous Col.	2	Yorkton & Elstow	6.05	29.0	3.2-8.9	24.1-33.9	Wheat
Weak Solonetz Shallow Solonetz	39	Elstow Regina Oxbow Blaine Lake Yorkton	7.76	32.9	0-20.8	14.6-49.6	Wheat & Barley
Solod	6	Elstow Oxbow Blaine Lake	3.33	31.5	0-7.3	16.6-52.1	Wheat
Cloddy Granular Granular Calc.	13	Regina Oxbow Blaine Lake Yorkton	6.1	38.9	0-16.4	20.6-58.7	Wheat
Bluff Podzol	3	Oxbow Yorkton	2.55	34.5	0-7.1	25.2-41.3	Wheat

* Field suffered from uneven wind erosion in spring.

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