USE OF SOIL TESTING TO PREDICT NITROGEN FERTILIZER NEEDS OF BARLEY AND RAPESEED IN ALBERTA

by J.A. Carson, Soil & Feed Testing Lab., Alberta Department of Agriculture;
J.T. Harapiak, Western Co-operative Fertilizers Ltd., Calgary;
A.M.F. Hennig, Research Branch, C.D.A., Beaverlodge, Alberta;
W.E. Janke, Sherritt Gordon Mines Ltd., Fort Saskatchewan, Alberta;
M. Nyborg,* University of Alberta, Edmonton;
D.C. Penney, Soils Branch, Alberta Department of Agriculture;
D.R. Walker, Research Station, C.D.A., Lacombe, Alberta

INTRODUCTION

This report summarizes results of numerous field experiments conducted during 1969 to 1973 to calibrate soil tests for nitrogen with response of cereal grains and rapeseed to nitrogen fertilizers in various areas of the province. Preliminary work was conducted in 1969 and 1970 by the Research Station, Beaverlodge; the Soils Branch, Alberta Department of Agriculture; and the Soil Science Department, University of Alberta. The preliminary work consisted of simple field plot experiments placed at approximately 100 sites in farm fields on Gray Wooded, Black, and Thin Black soils. That work showed fairly good correlation between soil content of NO_3-N at time of seeding and yield response from an application of 60 to 100 lb. per acre of fertilizer N to barley and oats. In addition, NO_3-N in soil samples taken to a depth of only 6 inches had nearly as good a predictive value as samples taken to depths of 2 feet or more.

A more comprehensive co-operative project was conducted in 1971 to 1973 with field experiments at approximately 150 sites in various areas of the province. The experiments were conducted by several groups: the C.D.A. Research Stations at Beaverlodge and Lacombe; Western Co-operative Fertilizers Ltd.; Sherritt Gordon Mines Ltd.; the Soils Branch of the Alberta Department of Agriculture; and the Soil Science Department of the University of Alberta. However, experiments were all of a similar design with various rates of nitrogen fertilizer at up to 240 lb. N per acre. One of the main objectives was to determine the response curves of barley and rapeseed to nitrogen fertilizers for different areas of the province, as related to soil tests for nitrogen. That project is not yet complete, and this report presents only some of the preliminary results from the project.

---

*Presented by M. Nyborg

METHODS AND MATERIALS

In 1969 and 1970 a total of 96 small-plot field tests were conducted in the Peace River region, and in north-central Alberta. The tests in the Peace River region were placed on Gray Wooded soils and sown to Pendek oats. Nitrogen treatments consisted of none and 80 lb N per acre as NH_4NO_3. The tests in north-central Alberta were located in an area bounded by Westlock to the north and west, Lloydminster to the east, and Camrose to the south. The tests were placed mostly on Black or Thin Black soils, and were sown to Galt barley. Nitrogen treatments consisted of none and NH_4NO_3 applied at a rate of 100 lb N per acre on stubble or 60 lb N on fallow. In all field tests both the "no nitrogen" and "nitrogen" treatments received PKS; and treatments were replicated either 3 or 4 times.

Approximately 150 field tests were conducted in 1971 to 1973 in the Peace River region, throughout Central Alberta, and as far south as Fort McLeod. Rates of nitrogen were in most instances 0, 30, 60, 90, 120, 150, 180, and 240 lb N per acre, and the nitrogen fertilizer (usually NH_4NO_3) was placed away from the seed. A blanket application of PKS was used, and treatments were replicated 3 times. All experiments were sown to Galt barley, and some were sown to Span rapeseed as well.

Soils were sampled in the spring before seeding from all field tests. Depths of soil samples were 0 to 6, 6 to 12, and 12 to 24 inches and in some cases 24 to 36 inches as well. Soil test nitrogen was determined by the Soil and Feed Testing Lab. using the phenoldisulfonic acid method.

RESULTS

Preliminary field tests in 1969 and 1970 using only one rate applied nitrogen

Soil test nitrogen was closely correlated to grain yield without nitrogen fertilizer in the 96 field tests (Table 1). The correlation was improved very little when soil test nitrogen was determined on the 0-24 inch depth or 0-12 inch depth as compared to the top 6 inches. When the yield response to nitrogen fertilizer was expressed as percent yield without nitrogen, the correlation coefficient increased from 0.73 for the top 6 inches of soil, to 0.78 for the 0-12 inch depth, and to 0.80 for the 0-24 inch depth (Table 1).

Table 1. Correlation of soil test nitrogen in different soil depths and grain yields in 96 field tests conducted in 1969 and 1970.

Sampling Depth (inches)	Correlation coefficient (r)	
	Yield of grain not fertilized with N	% Yield without N $\left(\frac{\text{Yield without N}}{\text{Yield with N}} \times 100\right)$
0 - 6	0.80	0.73
0 - 12	0.81	0.78
0 - 24	0.81	0.80

Yield increase from applied nitrogen fertilizer was not closely correlated with soil test nitrogen when all 96 field tests were considered. However, within an area in a given year soil test nitrogen was very closely correlated to the yield increase (Table 2). Table 2 also shows that there was little increase in the predictive value of the soil test when soils were sampled deeper than 6 inches.

Table 2. Correlation of response of Galt barley to nitrogen fertilizer and soil test nitrogen for 25 field tests conducted in north-central Alberta in 1970.

Sampling Depth (inches)	Correlation coefficient (r)	
	Yield Increase	% Yield without N $\left(\frac{\text{Yield without N}}{\text{Yield with N}} \times 100\right)$
0 - 6	- 0.78	0.87
0 - 12	- 0.81	0.90
0 - 24	- 0.83	0.90
0 - 36	- 0.82	0.88

The average yields of grain grown with and without nitrogen fertilizer on stubble and fallow are shown in Table 3. When nitrogen fertilizer was applied yields were similar for fallow and stubble on Black and Thin Black soils and fallow on Gray Wooded soils. Yields were somewhat lower for stubble on Gray Wooded soils, but later work showed the nitrogen application rate of 80 lb N per acre used in the field tests was inadequate for those soils.

Table 3. Yields of grain on stubble and fallow in 96 field tests conducted in 1969 and 1970.

Soils	Condition	No. of tests	Yield of Grain (cwt/ac)	
			PKS	NPKS
Gray Wooded	Stubble	32	14.0	28.0
	Fallow	5	35.3	41.6
Black and Thin Black	Stubble	22	17.6	35.0
	Fallow	37	35.3	38.5

Field tests conducted in 1971 to 1973 with various rates of nitrogen applied to barley and rapeseed

The correlation of soil test nitrogen and yield, or yield response to nitrogen fertilizer, is given in Table 4. Yield of barley when not fertilized with nitrogen was predicted fairly closely by soil test nitrogen for the 112 field experiments so far included in the computations (r = 0.75 to 0.77, depending on depth of the soil sample). The relationship was slightly closer when only Black and Gray Wooded soils were considered (r = 0.82 to 0.76). The correlation of percentage yield without nitrogen (i.e., yield without N as a percentage of yield with the optimum rate of N) was fairly close for all sites and for sites on Black and Gray Wooded soils (r of about 0.80). The correlation with yield increase was slightly lower (r = -0.72 to -0.77).

Deep sampling of soils (i.e., to 12 or 24 inches) increased the predictive value of soil test nitrogen only slightly when all sites were considered (Table 4). For the Black and Gray Wooded soils only, predictive

Table 4. Correlation of soil test nitrogen and barley yields for 112 field tests conducted in 1971 to 1973 with barley.

Area	Yield measure	r values when soils sampled to different depth (inches) 0-6	0-12	0-24
Gray Wooded, Black, Thin Black, and Dark Brown soils	Yield without N	0.75	0.77	0.77
	% yield*	0.79	0.81	0.82
	Yield increase**	-0.73	-0.74	-0.75
Black and Gray Wooded soils	Yield without N	0.82	0.81	0.76
	% yield*	0.82	0.82	0.78
	Yield increase**	-0.77	-0.76	-0.72

* (Yield without N/Yield obtained with optimum rate of N)100.
** Increase in yield from optimum rate of N.

value tended to decrease with increased depth of sampling. The average amounts of soil test nitrogen at depths of 0 to 6, 0 to 12, and 0 to 24 inches were in the ratio of approximately 1:1.5:2.0 for both stubble and fallow sites (Table 5). In addition the amount of soil test nitrogen in the 0 to 6 inch depth was very closely correlated to the nitrogen in the 0 to 12 inch and 0 to 24 inch depths (Table 5).

Table 5. Average amounts of soil test nitrogen at different depths in 110 field tests conducted in 1971 to 1973.

Area	Condition	Soil test N (lb N/ac) in different soil depths (inches) 0-6	0-12	0-24
Gray Wooded, Black, Thin Black, and Dark Brown soils	Stubble	18	27	37
	Fallow	34	52	72
Black and Gray Wooded soils	Stubble	11	16	21
	Fallow	35	52	64

Correlation of soil test N in 0-6 inches and 0-12 inches (all sites): r = 0.96
Correlation of soil test N in 0-6 inches and 0-24 inches (all sites): r = 0.90

Yield response curves to increasing rates of applied nitrogen are quite different for each of several ranges of soil test nitrogen (Figure 1). With soil test nitrogen (to 24 inches) in the range of 0 to 10 lb N per acre, yield without nitrogen fertilizer averaged 12 cwt per acre, and yield increased with rate of nitrogen application to a maximum at about 180 lb N per acre (Figure 1). Even with soil test nitrogen in the range of 31 to 50 lb N per acre, yield was increased by 11 cwt per acre from nitrogen fertilizer, and a rate of more than 60 lb N per acre was needed to obtain that increase. Only when soil test nitrogen was more than 80 lb per acre was there no increase from nitrogen fertilizer, and with that level of soil test nitrogen, yield remained at about 34 cwt per acre regardless of rate of applied nitrogen. It is significant that with all levels of soil test nitrogen, yields were brought into the range of 32 to 36 cwt per acre after the application of sufficient nitrogen. It is also significant that only 20 of the 110 sites shown in Figure 1 were in the range of soil test nitrogen where applied nitrogen did not increase yield substantially.

We are only now starting to derive equations that can be used to predict crop yield or yield increase from soil test nitrogen. So far we have obtained the following equation for barley grown on Black and Gray Wooded soils in north-central Alberta:

$$\text{Yield} = 3.7 + 3.8 \left[3(\text{soil test N to 6"}) + (\text{applied N})\right]^{0.4}$$

where yield is in cwt/acre and N in lb/acre.

Apart from prediction of yield or yield increases from soil testing, the average yield on fallow and stubble in different areas is of interest. Yields of nitrogen-fertilized barley on fallow and stubble were similar, and yields were also similar in different areas of the province (Table 6). However, when barley was grown without nitrogen fertilizer, yields were usually much higher on fallow than stubble. Nevertheless, many fallow fields benefited from nitrogen fertilizer, and the average yield increase on fallow was 7.9 cwt per acre, as compared to 14.1 cwt per acre on stubble (Table 6).

Rapeseed also produced fairly similar yield on fallow and stubble when fertilized with nitrogen (Table 7). The effect of nitrogen fertilizer was slightly greater for rapeseed than barley.

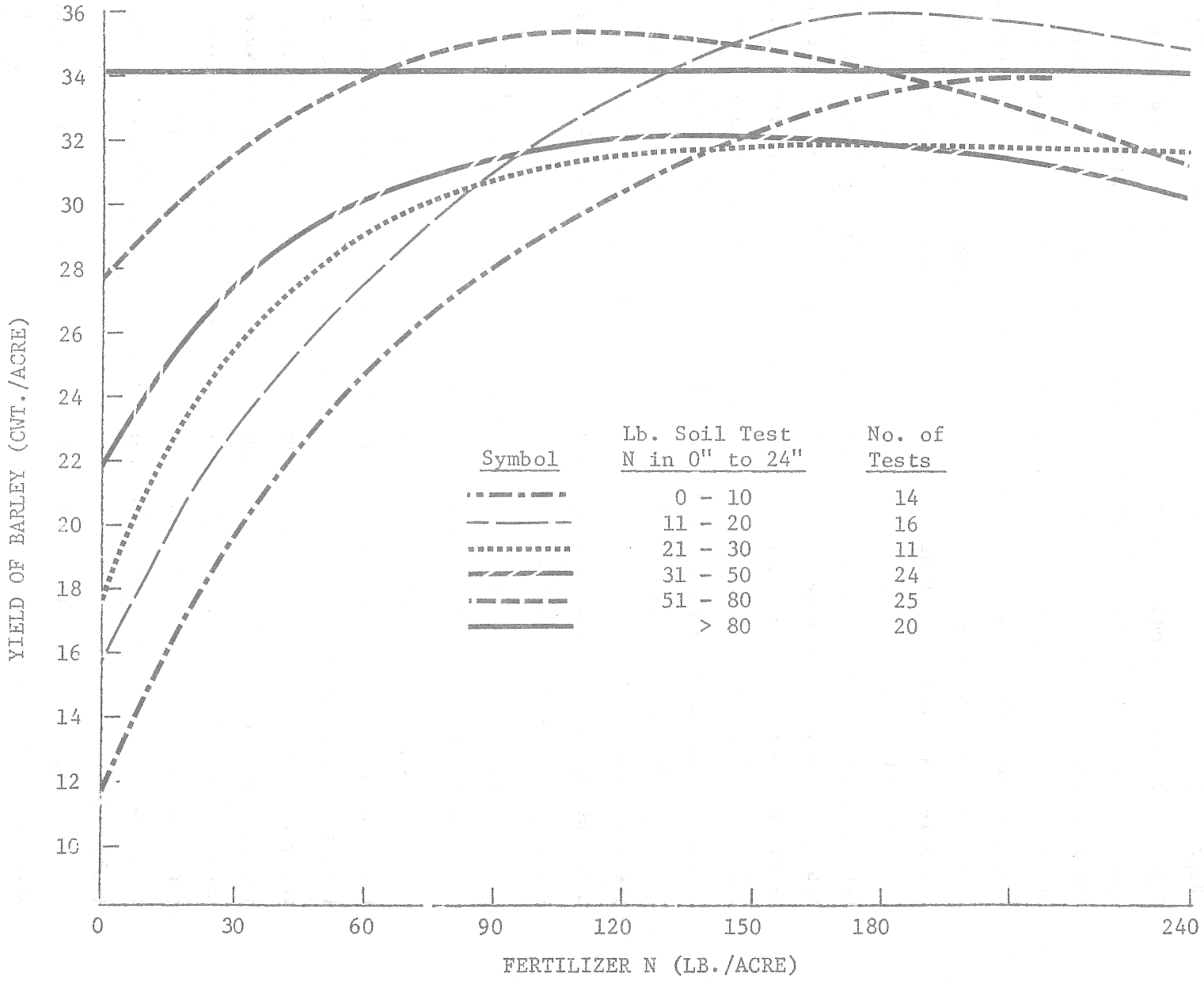

Figure 1. Yield of barley with different rates of fertilizer N (From 110 field tests conducted in 1971 to 1973).

Table 6. Yields of barley grown with and without nitrogen on fallow and stubble for 115 field tests conducted from 1971 to 1973.

Area and soils	Condition	No. of tests	Yield (cwt/ac) PKS	Yield (cwt/ac) NPKS
Peace River (mostly Gray Wooded soils)	Stubble	8	18.1	35.8
	Fallow	11	26.0	35.6
North-central Alberta* (mostly Black and Gray Wooded soils)	Stubble	21	16.8	33.4
	Fallow	9	31.7	36.4
Central and North-eastern Alberta** (mostly Black and Gray Wooded soils)	Stubble	23	24.8	36.4
	Fallow	5	22.6	35.4
South-central and Southern Alberta (Thin Black and Dark Brown soils)	Stubble	7	19.8	33.2
	Fallow	21	30.1	34.7
Average of all sites	Stubble	69	19.9	34.0
	Fallow	46	27.6	35.5

* Field tests conducted by Alberta Department of Agriculture.

** Field tests conducted by Research Station, Lacombe.

Table 7. Yields of rapeseed grown with and without nitrogen on fallow and stubble for 48 field tests conducted from 1971 to 1973.

Area and soils	Condition	No. of tests	Yield (cwt/ac)	
			PKS	NPKS
Peace River (mostly Gray Wooded soils)	Stubble	9	5.0	12.2
	Fallow	7	10.6	15.7
North-central Alberta (mostly Black and Gray Wooded soils)	Stubble	20	7.4	15.9
	Fallow	8	13.1	15.8
South-central and Southern Alberta (Thin Black and Dark Brown soils)	Stubble	4	5.0	13.9
	Fallow	--	--	--

CONCLUSIONS

Results of more than 200 field experiments over a five-year period showed that soil content of nitrate-nitrogen had a very good predictive value for estimating crop yield, and yield increase obtainable from nitrogen fertilizer. Soil sampling to a depth of only 6 inches gave nearly as good predictions as deeper sampling on Gray Wooded, Black and Thin Black soils.

On stubble fields, nitrogen fertilizer produced large increases in yield of barley for more than 80 percent of the randomly-placed field experiments. The average increase in yield on stubble was 14.1 cwt per acre. Barley grown on many fallow fields also gave large yield increases from nitrogen fertilizer. The average yield increase was 7.9 cwt per acre on fallow.

In all areas, and on both fallow and stubble fields, yields of barley usually fell in the range of 32 to 36 cwt per acre when sufficient nitrogen was added. Across the rather wide range of soils considered, the main determinant of yield apparently was the amount of nitrogen available to the crop. Although relatively few field tests were conducted on Dark Brown soils the limited results for these soils indicate they are similar to Black soils in need for nitrogen.