EFFECT OF NEWLY AND PREVIOUSLY APPLIED NITROGEN ON YIELD AND RECOVERY OF NITROGEN BY BARLEY

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ABSTRACT

Nitrogen was applied to 4 consecutive crops of barley planted on an Almasippi LFS at MacGregor and Snowflake CL at Purvis, Manitoba. Rates of N applied were 0, 34, 68, 101, 134 kg ha^{-1} using urea fertilizer. In the fifth crop year no nitrogen was applied to monitor the effect of residual N on yield, N-uptake and protein content of barley.

Yields of barley varied between years, but were generally greater at MacGregor than at Purvis. In the fifth crop year yields of barley at MacGregor were increased by residual N from the 68, 101 and 134 kg $N.ha^{-1}$ plots. At Purvis residual N from all previously applied treatments increased yield. Protein content of grain, and total N uptake by the crop was also increased by residual nitrogen. Indication of residual N effect on crop growth could be predicted from NO_3-N analysis of soils taken before the residual N monitoring crop was planted.

OBJECTIVES

Nitrogen fertilizer applied to soils is seldom completely recovered by crops in the year of application. Analysis of the above ground portion of cereal crops in Manitoba indicates that crop recovery is often as low as 30 to 60%. The fate of unused N has not been determined. It may be permanently lost through volatilization, leaching or denitrification. It may also remain in the soil as unused fertilizer N or be immobilized, and thus be available for future crops. With the high rates of nitrogen now being applied to crops annually, residual N could be an important source of nitrogen and affect both crop yields and quality.

The objectives of this study were to determine the effect of repeated applications of nitrogen fertilizer on barley yields and quality and to determine the residual effect of previously applied nitrogen.

MATERIALS AND METHODS

A field experiment was established on two soil types in Manitoba in 1978: (1) Snowflake CL at Purvis (Orthic Black Chernozem developed on mixed glacial till) and (2) Almasippi LFS at MacGregor (Carbonated Rego Black Chernozem developed on deltaic sand). The experiment consisted of 15 treatments in randomized block design with 5 replicates. Plots were 7 m x 3.2 m and treatments were placed on the same plots for 4 years. In the fifth crop year, no N was applied to monitor residual effect. Barley (c. Conquest) was planted each year at 100 $kg.ha^{-1}$. Phosphorus fertilizer was applied with the seed on all plots at 18 $kg.P.ha^{-1}$ using 0-0-60, mixed with the phosphorus.

Nitrogen treatments included rates, times and methods of application of N. In this paper, only the rate treatments are reported and are an average of banded and broadcast methods of application since analyses indicated that there was no significant difference between the methods. The rates of N were: 34, 68, 101 and 134 $kg.ha^{-1}$ using urea 46-0-0, and a control.

RESULTS AND DISCUSSION

The two soil types were selected to provide comparisons of results from two common but different soils in Manitoba. Almasippi LFS is characterized by having a coarse texture and is saturated to the surface in spring. It also has free lime at the surface. These conditions could cause loses of N by denitrification and volatilization. Snowflake CL is characterized by having a medium texture and moderately good drainage, but is not calcareous. Losses by denitrification and volatilization would not be expected to be as severe as for Almasippi LFS.

Regression analyses was conducted on barley yields for both sites and all crop years. Lines of best fit for the data are shown in Figure 1A and 1B.

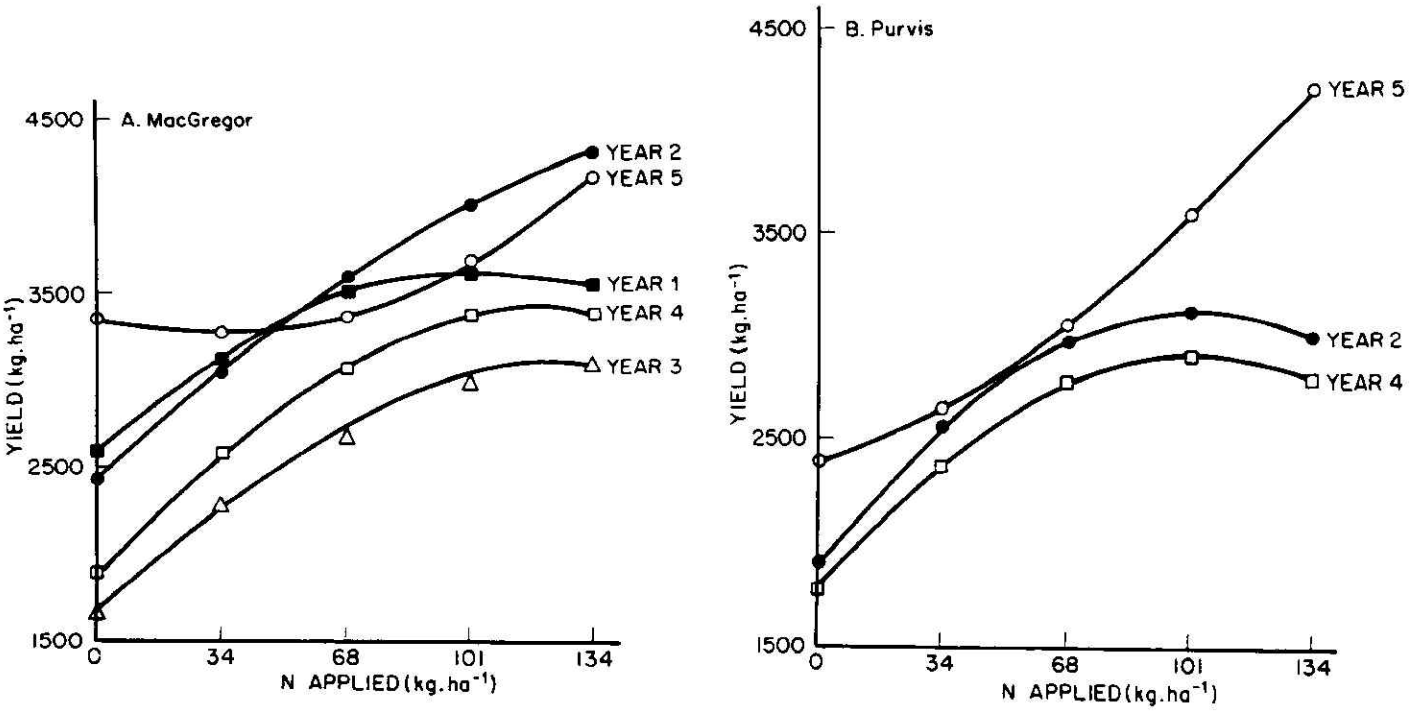

Figure 1. Effect of newly and previously applied N on yields of barley at A. MacGregor and B. Purvis.

The r^2 values calculated were: MacGregor: 0.53; 0.79, 0.70; 0.70; 0.45 for years 1978 to 1982 respectively, and Purvis: 0.63; 0.69; 0.80 for 1979, 1981 and 1982 respectively. All r^2 values are highly significant. Barley was not harvested at Purvis in 1978 because of hail damage to the crop, and in 1980 because of poor crop emergence.

At MacGregor, crop yields were increased by the application of urea-N for that crop, at rates of N up to 101 $kg.ha^{-1}$ in years 1, 3 and 4. In year 2, the highest rate of N applied (134 $kg.ha^{-1}$) was not sufficient to produce maximum yields. In crop year 5 (1982) no N was applied, however, yields were very high. This was attributed to an exceptionally good growing year in Manitoba. Examination of crop yield statistics for the province showed that yields of wheat in 1982 were 7.6% higher than the previous high. Despite the high yields where no or low rates of N were applied in previous years (Figure 1), yields were even greater where high rates of N were applied.

At Purvis, crop yields were increased by the application of urea-N for the crop at rates of N up to 101 kg.ha^{-1} in years 2 and 4. (Crops were not harvested in years 1 and 3). In crop year 5 (1982) no N was applied, however, yields were greater than those obtained with the application of N to the crop in previous years. This, similar to MacGregor, was attributed to an exceptionally good growing year. Yields, however, were highest on plots where N had been applied in previous years, indicating a response to residual N. Response to residual N was considerably greater at Purvis than at MacGregor and may be due to fertilizer application in the first 4 crop years, but no crop harvest in 2 of the years.

Nitrogen uptake in the above ground portion of the barley crops, and grain protein contents were increased by high rates of previously applied N at both sites (Table 1). At MacGregor, N uptake from the no N applied plots was slightly

Table 1. Total N uptake in above ground portion of barley crop and crude protein content (%) of grain in 5th crop (1982).

Previously applied N	N uptake		% protein	
(kg.ha^{-1}.year^{-1})	MacGregor	Purvis	MacGregor	Purvis
0	68	41	10.1	9.4
34	63	48	10.1	9.5
68	63	53	9.9	9.5
101	77	78	10.9	11.1
134	87	103	11.5	12.6

greater than when low rates of N had previously been applied. This is consistent with a high protein content (10.1%) and high yield. At Purvis both nitrogen uptake and percent protein in grain increased directly with increasing rates of previously applied nitrogen.

Soil analysis for NO_3-N was conducted on samples taken after the fourth crop (Table 2). At MacGregor, the amount of NO_3-N found at 0-60 cm depth was greater in

Table 2. Soil nitrate-N content in September 1981 prior to cropping in the final year.

Previous Applied N	Soil Nitrate-N (kg.ha^{-1})			
(kg.ha^{-1}.year^{-1})	MacGregor		Purvis	
	0-60 cm	0-120 cm	0-60 cm	0-120 cm
0	39	59	27	33
34	24	31	30	44
68	26	40	37	54
101	34	52	52	76
134	33	72	99	138

the control plot than in any of the previously fertilized plots. Measured at 0-120 cm depth, the control plot NO_3-N was also greater than any other treatment except when 134 kg.ha^{-1} of N had been applied. Examination of single plot data from each replicate showed that 2 out of 10 samples taken from the controls were much higher in NO_3-N, N-uptake and yield than in the other eight samples. No reason for this was evident. If these two samples were omitted from the analyses, data would have been similar to that obtained from the 34 kg N.ha^{-1} treatment. Thus the control data for MacGregor may be considered high. At Purvis, soil NO_3-N content was increased consistently with increasing rates of N previously applied when measured at both the 0-60 cm and 0-120 cm depth. It is assumed that this NO_3-N remained available for the fifth crop and was thus partially responsible for the residual N response obtained. Additional N required to account for both high yield and protein obtained presumably came from mineralization of immobilized fertilizer N.

Residual nitrogen effect on barley yields were greater at Purvis than at MacGregor. Protein content and N-uptake were also greater than at MacGregor, but only at the highest rate of previously applied N. It is not clear if this is due to soil type differences whereby N was lost from the Almasippi soil at MacGregor or if the two unharvested crops resulted in more available N at Purvis.

ADDITIONAL SOIL FERTILITY RESEARCH IN THE DEPARTMENT OF SOIL SCIENCE, THE UNIVERSITY OF MANITOBA

Effect of soil erosion on soil productivity.

1. Yield, potassium uptake and potassium use efficiency of barley affected by soil magnesium.

   Yields of barley decreased with increases in the Mg content of soils. High concentration of Mg in soils had only minor effects on K uptake. Yield reductions on high Mg soils appears to be due to lower plant availabilities of Zn, Fe and/or Mn in these soils. G.J. Racz.

2. Maximum production research with wheat.

   Field experiments were conducted for several years to determine P and K requirements and methods of application for maximum yields of wheat. Soils deficient in P and K required a large application of P and K initially, and small amounts annually thereafter. Soils medium to high in P and K produced high yields with only small annual amounts applied with the seed. R.J. Soper.

3. A study of N-fixation by lentils, soybeans and fababeans.

   Early maturing varieties of soybeans required supplemental N over that supplied by the soil or by dinitrogen fixation. In reducing days to maturity, some N_2 fixation capacity of soybeans was lost. Lentils were found to be poor fixers of dinitrogen and normally don't fix enough N_2 for plant requirements. Lentils have also been found to be dependent on mychorizae for nutrition. Fababeans have the capacity to fix all nitrogen required. R.J. Soper.

4. Dual N-P placement.

   The movement and solubility of P in dual bands as affected by the kind of nitrogen fertilizer and soil type is being studied. Uptake of P from dual bands by various crop species is being evaluated in environmental cabinet and field studies. G.J. Racz.

5. Effect of copper and zinc fertilizers on yield and chemical composition of wheat grown on coarse textured soils.

   Micronutrient contents of crops grown on coarse textured soils in Manitoba are often depressed when N and P fertilizers are applied at heavy rates. Fertility studies with Cu and Zn are being conducted to determine methods of application that will overcome detrimental effects of high rates of phosphorus. J.M. Tokarchuk.

6. Mechanisms of denitrification. Oxygen transport and denitrification in soil profiles.

   The magnitude of fertilizer and native soil nitrogen loss by denitrification processes is investigated. Soil temperature, oxygen and biological activity within the profile are used to estimate the denitrification. C.M. Cho.

7. Determination of energy requirements, production potential and economics of winter and spring wheat under zero and conventional tillage practices employing intensive fertilizer management.

   Field studies are being conducted at two sites. In the first crop year, winter wheat survived at only one of the sites, but yields at that site exceeded 5 tonnes.ha^{-1}. Spring wheat under zero and conventional tillage yielded between 4.5 and 4.7 tonnes.ha^{-1}. Economic evaluation is being conducted on a large data base assembled by the Department of Agricultural Economics. Models generated will be tested with the field data. A.O. Ridley and D.F. Kraft.

8. Effect of soil erosion on soil productivity.

   Erosion was simulated by physically removing various portions of the Ap horizon of several soils. Losses in productivity were measured by crop growth. The extent to which these losses could be overcome by nutrient application was assessed. C.F. Shaykewich.

9. Effect of organic matter on soil properties and crop yields.

   Two types of crop residue; cereal straw containing 0.6% N; and alfalfa hay containing 3.4% N were added at the equivalent rate of 50 tonnes per hectare to pots in a growth chamber. Results obtained by the addition of residues are bing compared with those obtained with the use of mineral fertilizers. R.A. Hedlin.

10. Management of sandy soils.

    Manitoba contains large areas of coarse textured soils. These are often low in fertility and subject to erosion. Various tillage practices (including zero tillage) are being investigated in addition to nutrient requirements for maximum yields. G.J. Racz and J.M. Tokarchuk.