1983-02-14

Interaction of snow management × N & P fertilizer and their effect on spring wheat yields

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INTERACTION OF SNOW MANAGEMENT X N & P FERTILIZER AND THEIR EFFECT ON SPRING WHEAT YIELDS

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INTRODUCTION

The Canadian Wheat Board suggests that there will be a need to increase grain production by 50% between 1980-1990. At the Prairie Production Symposium held in Saskatoon on October 29-31, 1980, it was concluded that to achieve this goal farmers in the Prairie Provinces would need to do the following:

(1) Reduce fallow significantly
(2) Practice better snow conservation
(3) Use more fertilizer
(4) Make more efficient use of fertilizers
(5) Use more extended rotations
(6) Move to more minimum tillage

At Swift Current we have, for several years, been studying ways to increase the conservation of overwinter precipitation. But, none of these studies involve fertilizer treatments. Similarly, we have embarked on zero till studies, but again these studies do not include fertilizer treatments. Furthermore, questions are being asked as to the efficacy of deep banding fertilizers and of applying fertilizer in the fall rather than in the spring. It was with these questions in mind that we embarked on this study with the financial assistance of the Potash and Phosphate Institute

MATERIALS AND METHODS

Two separate experiments, one with spring wheat and the other with winter wheat, were implemented in 1982 after establishing the stubble treatments in 1981 (Fig. 1). Only the results of the spring wheat experiment are reported here.

For each crop there were 4 replicates (blocks 2.5 ha each). Each replicate consisted of a short (standard) and a tall (alternate height) stubble sub-block. Each stubble sub-block was partitioned into three year-blocks so that the experiment could be moved to previously unfertilized land each year. The Year 1 sub-blocks were divided into various fertilizer treatments to compare (a) time of application ... viz., fall vs spring; (b) method of N placement (broadcast vs banded); (c) rate of N; and (d) rate of P (Fig. 2). Urea was applied in case of spring wheat. In the case of Year 1 plots, P (treble super) and K (KCl) were banded at 12.5 to 15 cm depth on a 30-cm spacing in the fall. Sulfur was broadcast in the fall. A zero-till procedure was followed. Some preliminary economic analyses were made.

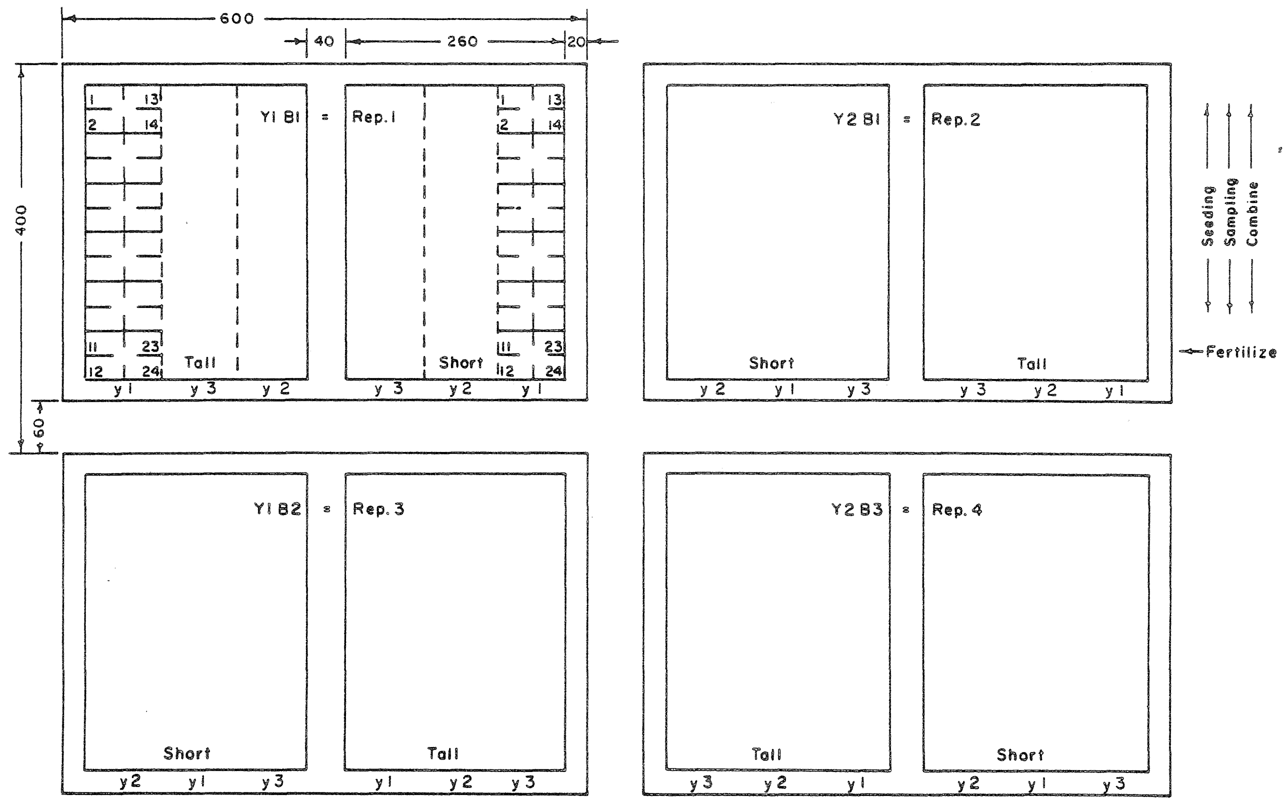

Fig. 1. Field layout

RESULTS AND DISCUSSION

Growing Season Conditions

The tall stubble trapped about 37 cm of snow while short stubble trapped 17.5 cm; however, in the spring, tall stubble only conserved about 0.9 cm more soil water than did short stubble (Table 1).

The 1982 growing season generally had good moisture. Precipitation between April and the end of August was 295 mm; the long-term average for this period is 232 mm. Rainfall distribution could have been better towards the end of the growing season. For example, rainfall in April, May, June, July and August was 10, 82, 42, 120 and 41 mm, respectively.

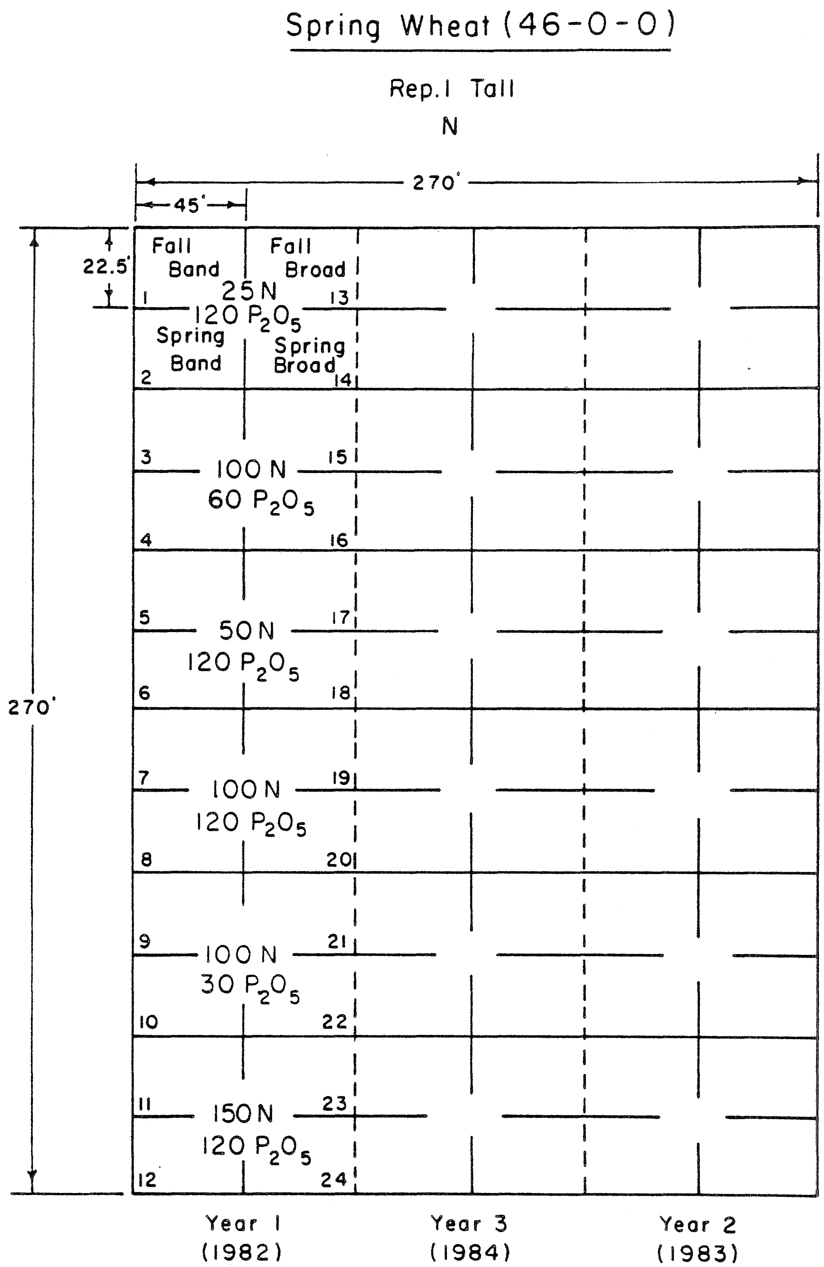

Fig. 2. Details of a Year 1 sub-block showing fertilizer treatments

Grain Yields

Yields as high as 3351 kg/ha (49 bu/acre) were obtained. Yields were 7% greater when fertilizer N was deep banded than when broadcast; yields were also greater when fertilizer was applied in spring compared to fall (Fig. 3). Average yield for spring banded treatments was 2509 kg/ha (37.3 bu/acre), for spring broadcast 2402 kg/ha (35.7 bu/acre), for fall banded 2381 kg/ha (35.4 bu/acre) and for fall broadcast 2186 kg/ha (32.5 bu/acre). The economics of these comparisons are discussed later. Yields were increased slightly by phosphorus (Fig. 3). But, phosphorus was more important in hastening maturity, particularly when N fertility was high (data not shown).

Table 1. Overwinter conservation of snow and water in tall and short stubble - 1981-82

	Spring wheat	
	Tall	Short
	-------- cm --------	
Snow depth	37.0	17.5
Water conser. in soil	4.7	3.8
Advantage tall over short	(+ 0.9)	

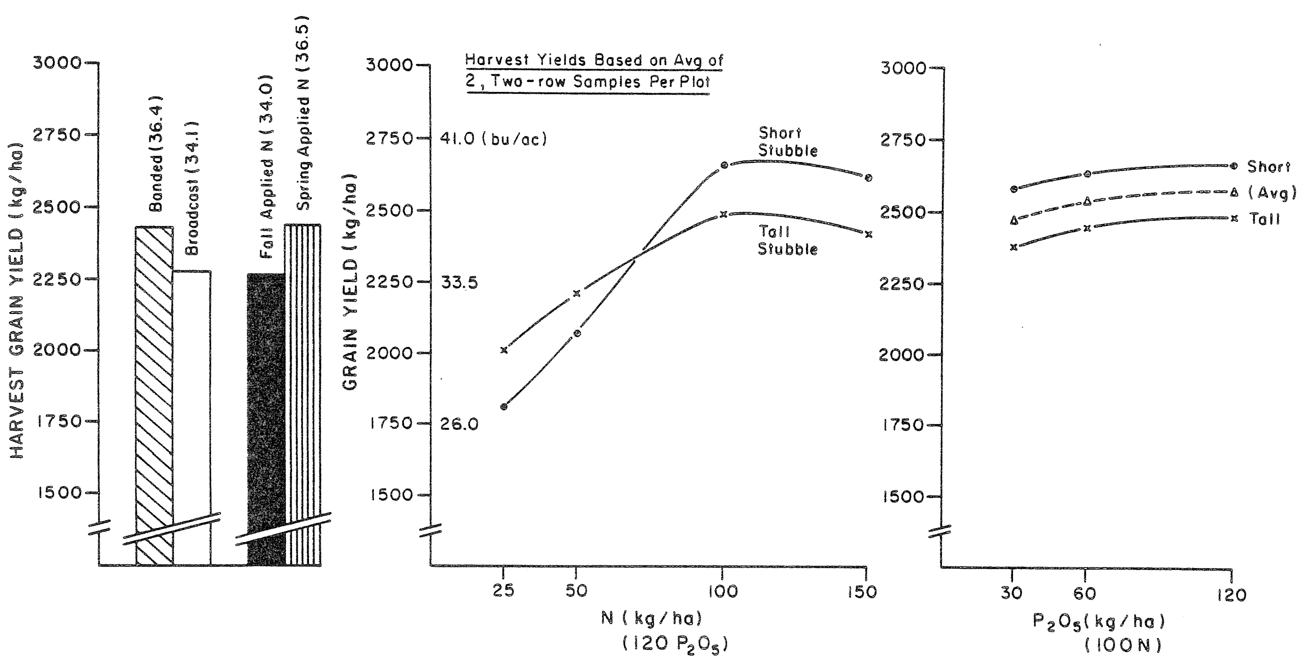

Fig. 3. Effect of rate of N & P, method and time of N application, and height of trap strips on harvest yields.

Yields increased with N fertilizer up to 100 kg N/ha, but the 150 kg N/ha rate did not increase yield further (Fig. 3). At 50 kg N/ha or less, tall stubble treatments produced greater yields than short stubble and at rates above 50 kg N/ha the converse was true (Fig. 3). Furthermore, the average yield on year 2 and 3 "filler" plots receiving 13 kg/ha of N alone was 1418 kg/ha (21.2 bu/acre) on tall stubble and 1131 kg/ha (16.9 bu/acre) on short stubble plots.

The interaction between rate of N and stubble height on harvest yield (Fig. 3) can be explained in terms of soil water use (Fig. 4). For example, by the soft dough stage there was little available water left in the top 90 cm of the soil profile at high rates of N. (The water held by this soil at wilting is 12.1 cm per 90 cm depth of soil). Furthermore, the moisture situation was worse in tall stubble plots than in short stubble plots, reflecting the generally greater dry matter production in tall stubble plots at each N level (Fig. 4). From August 1 to September 15 little rainfall was obtained (43 mm) to support the lush growth that had been produced at high levels of fertility.

The plants grown at high N rates produced larger amounts of dry matter early in their growth thus using up available water in the profile more rapidly. Those plants grown in tall stubble grew faster due to the better initial soil water (though it was not statistically significant) and perhaps lower evapotranspiration during early growth, caused by the protection from drying winds offered by tall stubble. Furthermore, the tall stubble treatments had a greater amount of initial NO_3-N (data not shown). Consequently, at the 25 and 50 kg N rates soil moisture was not limiting even during the dry spell at head filling time and the advantage of tall stubble and higher N rates were apparent. However, at 100 and 150 kg N/ha rates the plants were restricted by the limited soil water that their rapid early growth had induced. Thus the extra dry matter got "trapped" in leaves and stalks instead of being translocated effectively to grain. This is evidenced in the straw/grain ratios (Fig. 5) which shows that the ratio increases with N rate and is greater for tall stubble than for short stubble, especially at the 150 kg N rate. Note also that factors that resulted in more efficient N uptake (e.g., tall stubble, banding, spring application) and which delayed maturity (data not shown) increased the straw/grain ratio.

Economic Analysis

The following initial economic analysis was carried out. Readers are forwarned not to overemphasize these findings since they are based on only one year's results.

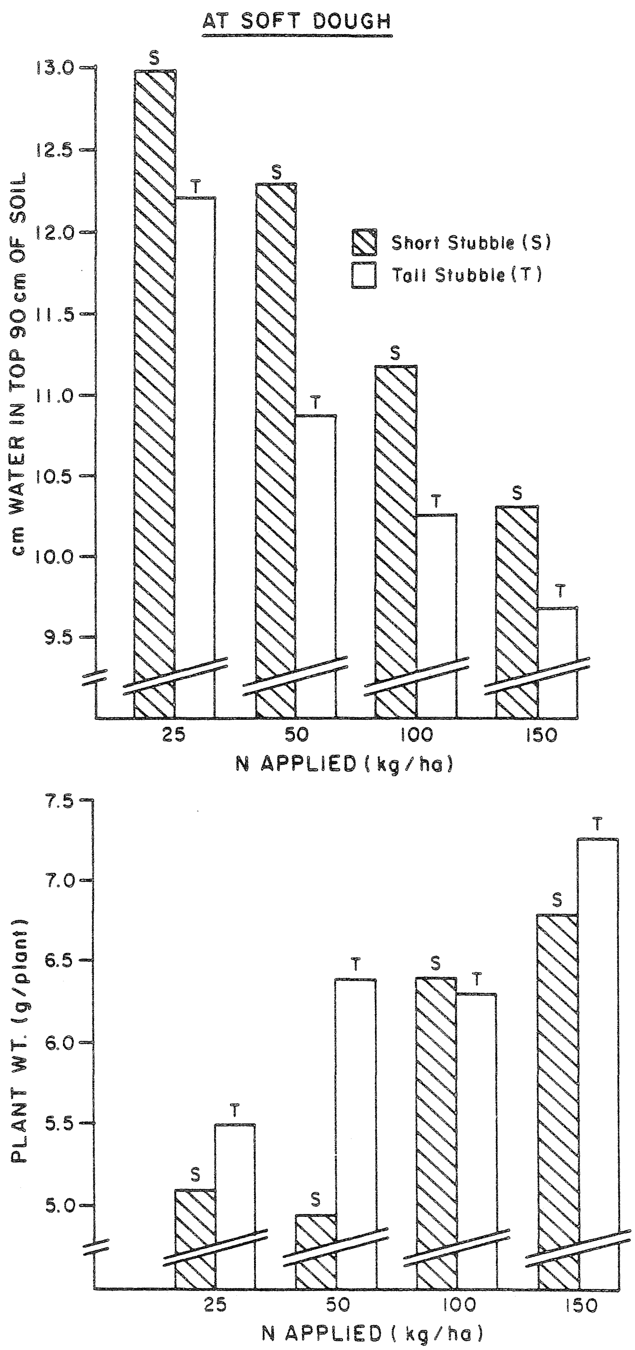

Fig. 4. Effect of N fertilizer and height of trap strips on plant weight and soil water reserves at soft dough stage. (At wilting, 90 cm of soil holds 12.1 cm of water)

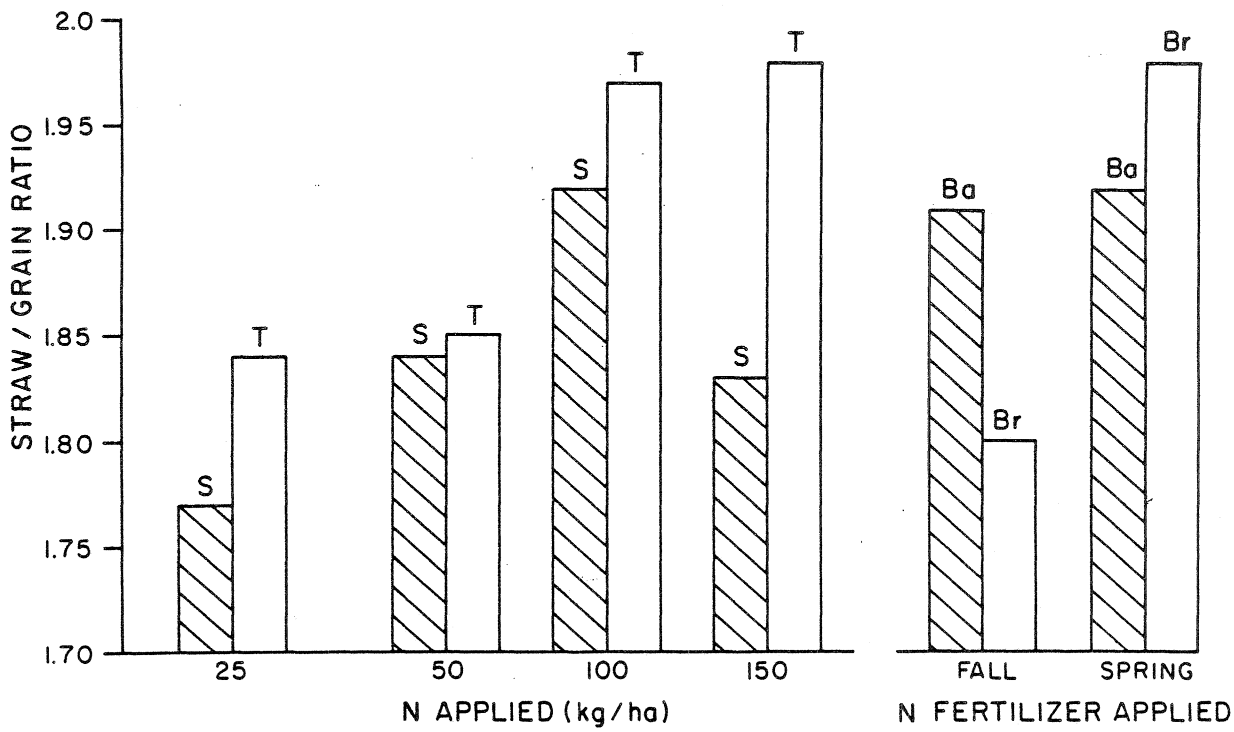

Fig. 5. Effect of rate of N and P fertilizer, method and time of N application, and height of trap strips on straw/grain ratio (based on 10 plants per treatment)

The assumptions and method of calculation used are outlined below:

<u>Assumptions (Base Situation)</u>

Price of wheat \$184/tonne (\$5/bu)
Price of N fertilizer (spring and fall) \$0.73/kg (\$0.33/lb)
Price of P_2O_5 fertilizer (spring and fall) \$0.66/kg (\$0.30/lb)
Opportunity cost of labor (spring and fall) \$12/hr
Cost of broadcasting (includes complete machine rental plus all operating costs except labor) \$4.32/ha (\$1.75/acre)
Cost of banding (includes complete machine rental plus all operating costs except labor) \$14.83/ha (\$6/acre)
Labor requirement for broadcasting 0.124 hr/ha (0.05 hr/acre)
Labor requirement for banding 0.201 hr/ha (0.08 hr/acre)

Assumptions (Seasonal Adjustment Situation)

Two changes were made in our assumptions: (1) that the cost of N fertilizer would be 20% cheaper if bought in the previous fall (i.e., \$0.58/kg), and (2) that the opportunity cost of labor in the fall was 50% of what it is in the spring (i.e., \$6/hr).

Returns above fertilizer, for each method and timing of application, was defined as:

$$R_{it} = A \cdot Y_{it} - C_t . N - B_t . P - L_i . W_t - M_i$$

where,

R_{it} = return above fertilizer for method i and time t (\$/ha),
A = price of wheat (\$/kg),
Y_{it} = grain yield for method i and time t (kg/ha),
C_t = price of nitrogen in time t (\$/ha),
N = rate of nitrogen fertilizer (kg/ha),
B_t = price of phosphorus in time t (\$/ha),
P = rate of phosphorus fertilizer (kg/ha),
L_i = labor requirement of method i (hr/ha),
W_{it} = opportunity cost of labor in time t (\$/hr), and
M_i = cost of applying fertilizer using method i (\$/ha).

You will recall that when averaged over rates of fertilizer the order of yield performance was spring banded > spring broadcast = fall banded > fall broadcast. Economic analysis showed returns above fertilizer costs of > \$200/ha (Fig. 6). When the base situation was used economic trends generally tracked the yield trends. Fall broadcast N was by far the least economical, but the other treatments tended to be no different. Like yields, economic returns increased to the 100 kg N rate and then decreased at the higher N rate.

When seasonal adjustments for fertilizer costs and labor were included in the analysis (Fig. 6) the fall banded N tended to outperform the other treatments except at the 25 kg N/ha rate. Fall broadcast N was still the least economical treatment. The difference was not great for spring placement of N.

CONCLUSIONS

Since this study is based on only one year's data in the field we will not draw any firm conclusions. However, there are a couple of points that should be noted: (1) trap strips may be beneficial to water use efficiency not only from a standpoint of conserving snow, but also by reducing evapotranspiration. This point requires researching; (2) trap strips may encourage lush growth in early spring and if extended periods of drought follow, plants may do less well than if they had been initially subjected to greater water stress.

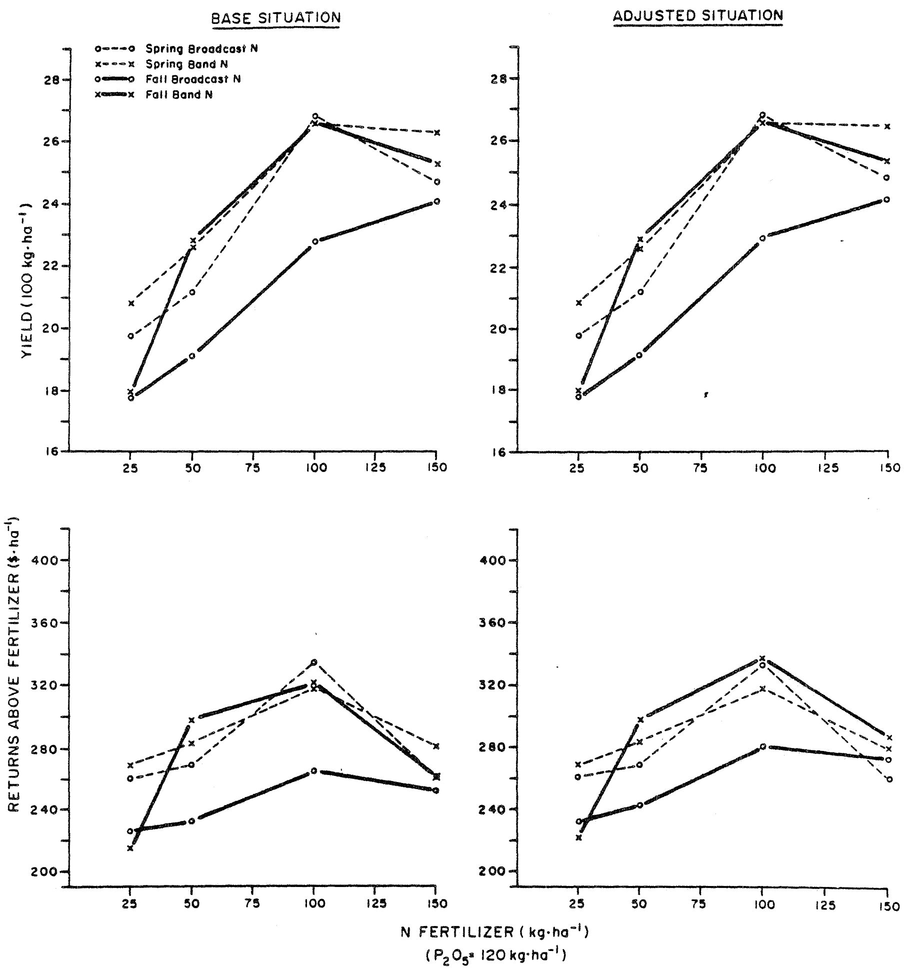

Fig. 6. Effect of rate, method and time of application of N fertilizer on net returns (based on only one year's results)

ACKNOWLEDGEMENT

This project is partly funded by the Potash and Phosphate Institute of Canada.