

NITROGEN AND PHOSPHORUS REQUIREMENTS  
OF WINTER WHEAT  
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Maintenance of a snow cover during the winter is the first requirement for successful winter wheat production in most areas of the Canadian prairies outside of southern Alberta. Direct seeding into standing stubble has proven to be the best means of accomplishing this objective. But there are other management factors which the winter wheat producer must also consider. High on this list is the provision of adequate nutrients to the crop. In most areas of the Canadian prairies, this means the addition of nitrogen and phosphorus fertilizer.

Materials and Methods

A total of 12 rate of nitrogen fertilizer, 9 date of nitrogen fertilizer and 10 phosphate fertilizer trials were conducted in the years 1974-78 and 1981-82. All trials were direct seeded into commercial stubble fields. Sites were located in the east-central and south-east area of the province in the Weyburn, Oxbow and Yorkton soil associations. Soil textures ranged from loam to heavy clay. Soil tests indicated an available nitrogen level ranging from 15 to 55 kg/ha in the surface 60 cm and a P<sub>2</sub>O<sub>5</sub> level ranging from 7 to 20 kg/ha in the surface 15 cm.

Soil was moist to a depth of at least 60 cm in the spring for all trials. Rainfall for the growing season was variable and the following arbitrary classes were established when crop responses to nitrogen fertilizer were considered:

- Wet - Above average rainfall which was well distributed during the growing season.  
Normal - Normal rainfall for the growing season. No extended dry periods.  
Dry - Below normal rainfall for the growing season. Extended dry periods.

Winter wheat cultivars Sundance or Norstar were direct seeded into standing stubble with a hoe-press drill the last week of August or the first week of September. Fertilizers utilized were ammonium nitrate (34-0-0) and mono-ammonium phosphate (11-55-0 or 11-48-0). All phosphate fertilizer was banded with the seed at the time of seeding. Unless otherwise stated ammonium nitrate fertilizer was broadcast in early May.

Results and Discussion

I. NITROGEN FERTILIZATION

Most stubble fields will not have sufficient available nitrogen (N) to provide for the needs of a winter wheat crop. The previous

crop will have made a large drain on the available N reserves of the soil, and N released through stubble decay will not contribute significantly to the available N pool until the next summer. Most of the N demand of the winter wheat crop will occur before the end of June (Fig. 1). Therefore, the addition of N fertilizer usually has a dramatic effect on the yield of winter wheat. Field trials have demonstrated that this response is much greater for winter wheat than spring wheat (Fig. 2).

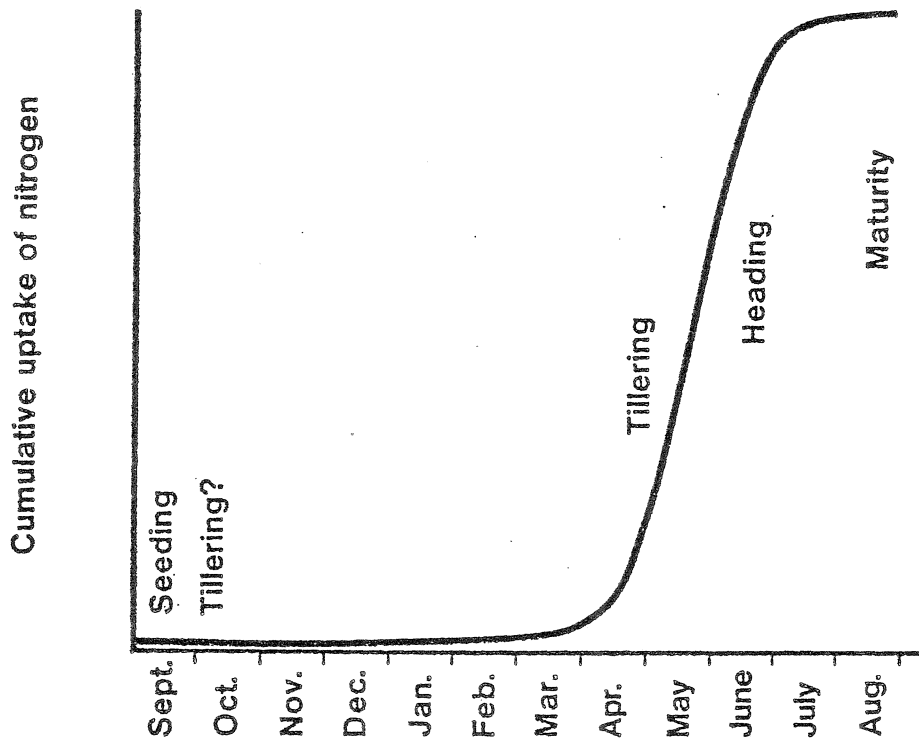


Fig 1. Nitrogen uptake by winter wheat

Soil moisture has a large influence on the response of winter wheat to N fertilizer (Fig. 3). Where moisture is not limiting winter wheat has a high production potential and a large N response. However some caution must be exercised when fertilizing for high yields. Cool, moist spring conditions will produce heavy stands when N is not limiting. If these stands do not continue to have access to sufficient moisture supplies high temperatures in June and July can be particularly damaging (Fig. 3). Fortunately this combination of conditions occurs rarely.

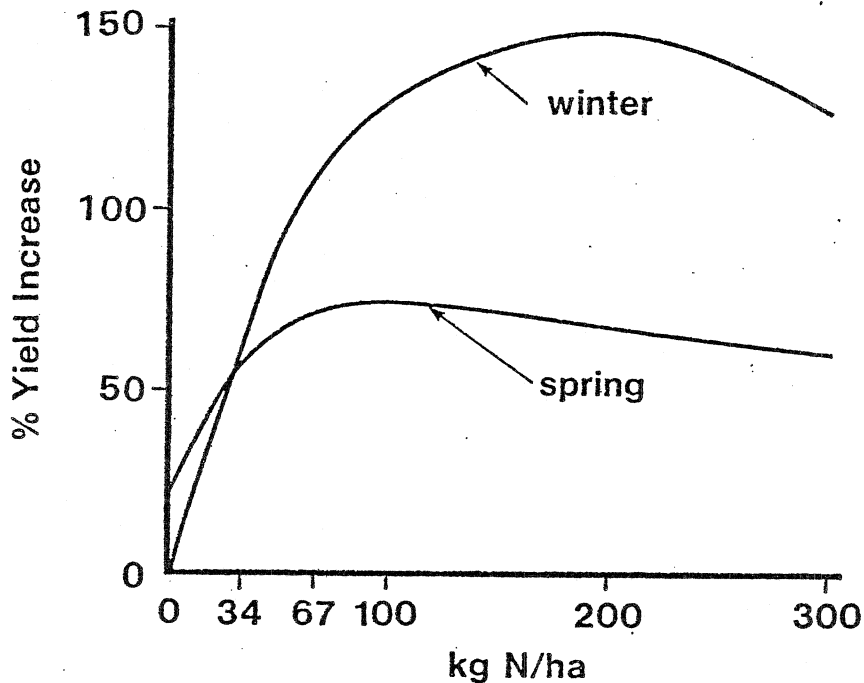


Fig 2. Effect of nitrogen fertilizer on yield of spring and winter wheat, where moisture is sufficient.

The type of N fertilizer utilized can be influenced by a number of factors, including timing and method of application, relative costs, equipment and labor availability and possible N losses after application. For this reason it is important that the producer have an understanding of the complex environment into which the N fertilizer is being introduced.

#### a) Plant Utilization

Most N fertilizer is applied in the ammonia ( $\text{NH}_3$ ), ammonium ( $\text{NH}_4$ ) or nitrate ( $\text{NO}_3$ ) form. Urea is an exception to this generalization; however, in the presence of water and the ever-present enzyme "urease" it is quickly converted to  $\text{NH}_3$ . In the soil environment  $\text{NH}_3$  is quickly converted to  $\text{NH}_4$ . Therefore only the  $\text{NH}_4$  and  $\text{NO}_3$  forms are of direct importance to the plant.

Plants utilize  $\text{NH}_4$  as efficiently as  $\text{NO}_3$  when the soil pH is near neutrality and the soil temperature is high (3). However, when soil temperatures are low,  $\text{NO}_3$  is utilized more readily by wheat than is  $\text{NH}_4$ . Winter wheat makes rapid growth in the early spring. Therefore,  $\text{NO}_3$  fertilizers could offer an advantage over  $\text{NH}_4$  fertilizers if applied in the spring or late fall. However, if  $\text{NH}_4$  fertilizers are applied when soil temperatures are high, the  $\text{NH}_4$  is rapidly converted to  $\text{NO}_3$  by Nitrosomonas and Nitrobacter bacteria through a process known as nitrification (4). Therefore, N source should not be an important factor if  $\text{NH}_4$  fertilizers are applied in the fall before soil temperatures drop below approximately  $10^\circ\text{C}$ .

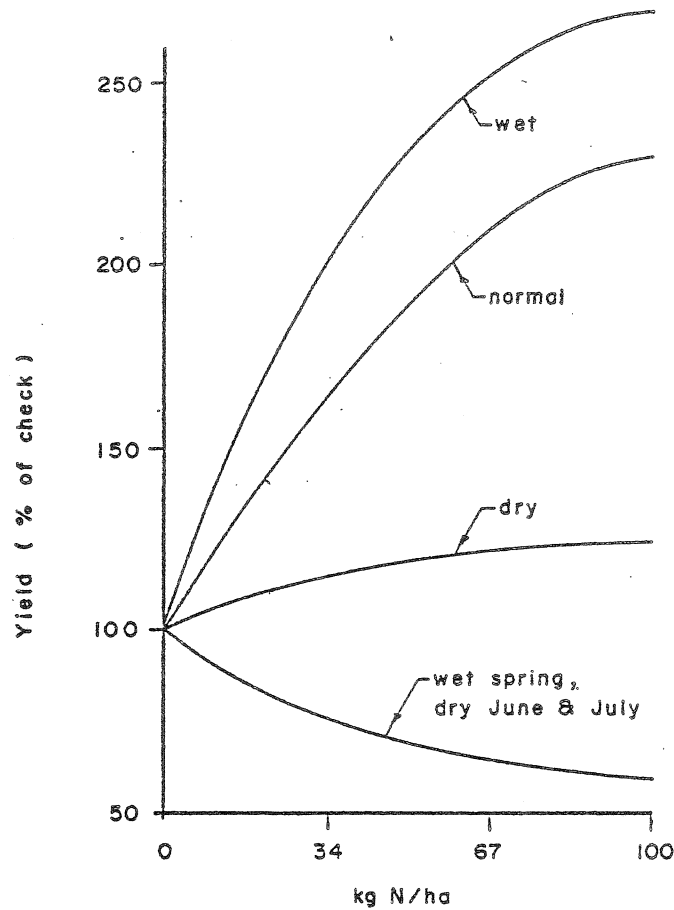


Fig 3. Effect of moisture and nitrogen fertilizer on yield of winter wheat.

#### b) Nitrogen Availability and Losses

The amount of N available to the plant from applied fertilizers is influenced by a number of factors. These include: 1) ammonium fixation, 2) leaching, 3) immobilization, 4) erosion, 5) denitrification and 6) ammonia volatilization (8).

Fixation and Leaching - Ammonia ions ( $\text{NH}_4^+$ ) carry a positive charge and as a result can be fixed in the soil by a number of mechanisms. Although of minor significance, this partial absorption can result in a reduced or delayed uptake of  $\text{NH}_4$  by the plant. In contrast, nitrate ions ( $\text{NO}_3^-$ ) are negatively charged and there is little tendency for them to be fixed by the soil. While this tends to increase availability, it also makes  $\text{NO}_3$  more subject to movement in the soil water and leaching. However, from a practical standpoint, losses from  $\text{NH}_4$  fixation and  $\text{NO}_3$  leaching should be small for "stubble-in" winter wheat.

Immobilization and Erosion - Successful overwintering of winter wheat is dependent upon the maintenance of standing stubble for snow trapping. This surface trash has both positive and negative implications for N availability and losses. A surface trash cover should practically eliminate N losses from erosion. However, the decay of crop residue can result in an immobilization of N, which is thought to be greater for  $\text{NH}_4$  than  $\text{NO}_3$ . While this N is not lost, it is temporarily unavailable to the growing crop. Band placement of N below the surface trash should decrease the level of N immobilization.

Denitrification - Denitrification is the major mechanism of N loss in areas which remain cool and damp in the spring (7). Denitrification is the enzymatic reduction of  $\text{NO}_3$  caused primarily by anaerobic bacteria. It results in the gaseous loss of N as  $\text{N}_2$  or oxides of nitrogen.  $\text{NH}_4$ -N and urea are much less susceptible to denitrification losses unless there has been an opportunity for nitrification (5,6). Our experience with fall surface-applied ammonium nitrate (34-0-0) suggests that denitrification losses for "stubble-in" winter wheat can be quite large. In a series of trials an attempt was made to determine yield losses associated with denitrification on well-drained soils. It was found that yields of plots fertilized with surface-applied ammonium nitrate in the early fall were 27 percent less than yields of plots receiving the same fertilizer application but in the early spring (immobilization could account for part of this reduction in yield); plots fertilized in the late fall fared somewhat better - producing yields 11 percent less than plots fertilized in the early spring (Fig. 4). Losses observed in low lying areas which remain cool and damp in the spring have been much higher.

Volatization - Potential N losses through  $\text{NH}_3$  volatization (gaseous) loss are greatest for anhydrous ammonia, aqua ammonia and urea. Deep banding of these N sources in fall or spring has been the main method of reducing this loss. However, attempts to deep band fertilizer in "stubble-in" winter wheat have exposed the following problems:

- 1) Finding time for the seeding of "stubble-in" winter wheat is usually difficult enough without adding a fertilizer banding operation prior to seeding in the fall.
- 2) When soil moisture is poor, a fall banding operation prior to seeding may result in additional moisture loss and poor seed germination.
- 3) Fall banding operations will result in increased stubble breakdown and, hence, reduced snow-trapping ability.
- 4) If fall banding is done after emergence of the winter wheat, there will be damage to the stand. This will result in greater susceptibility to winterkill, delayed maturity (up to 2 weeks), and increased weed competition following banding. Spring banding will also result in delayed maturity and increased weed competition. Most of these problems can be avoided if banding is done as part of the seeding operation. There are seed drills available which will allow for deep banding of fertilizer during seeding. Seed and fertilizer placement appear to be satisfactory, but the horsepower and fuel requirements to pull this equipment are very high.

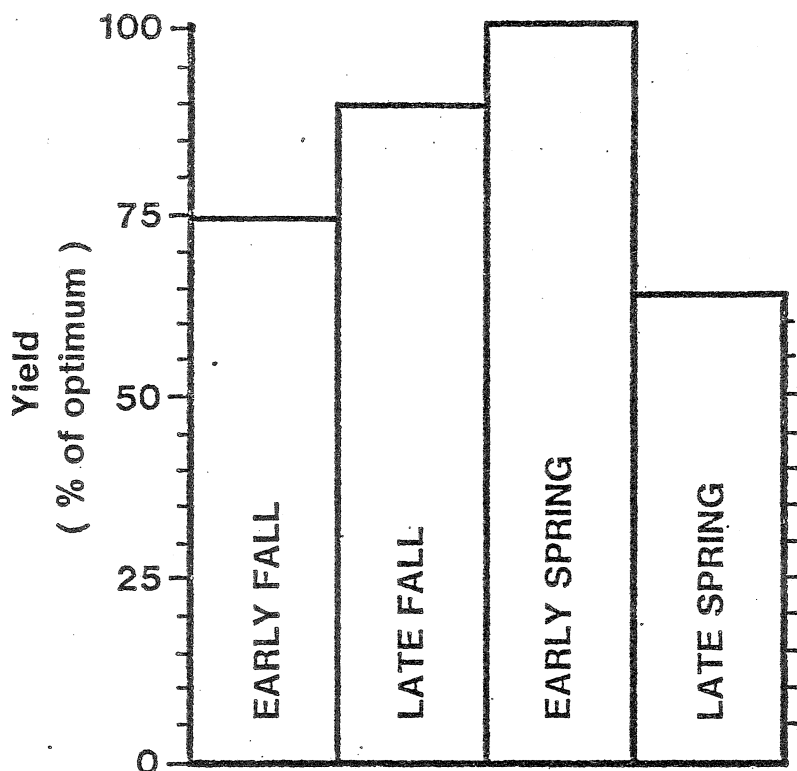


Fig 4. Effect of timing of nitrogen fertilizer (34-0-0) application on yield of winter wheat, where moisture is sufficient.

Until some of the problems with deep banding are solved, the producer is left with few options for N fertilizer application on "stubble-in" winter wheat. Unfortunately, fertilizer suppliers have indicated that the supplies of ammonium nitrate (34-0-0) will decrease in the future. This leaves urea-based fertilizers as the main dry source of nitrogen. However, experience with surface application of urea on "stubble-in" winter wheat has been variable (1,2,7,9), with volatilization losses as high as 100 percent being reported. N fertilizer represents a significant proportion of the production cost for "stubble-in" winter wheat. For this reason continued reports of large N losses from the volatilization of urea combined with the yield losses resulting from associated N deficiencies could create a considerable deterrent to efforts to establish "stubble-in" winter wheat as a cropping option. Therefore it is important that this problem is resolved as quickly as possible. The main factor determining losses from urea is length of time before a significant rainfall or the addition of water from another source. If application is followed immediately by a rain or irrigation, then losses with urea should be no greater than with ammonium nitrate.

## II. PHOSPHORUS FERTILIZATION

Most western Canadian soils are phosphorus ( $P_2O_5$ ) deficient. Field trials have demonstrated that significant yield increases result with "stubble-in" winter wheat when these deficiencies are corrected. In addition, added  $P_2O_5$  improves the winter wheat plants' ability to recover from winter damage and advances maturity. For maximum response to  $P_2O_5$  deficiencies in nitrogen should also be corrected (Fig. 5).

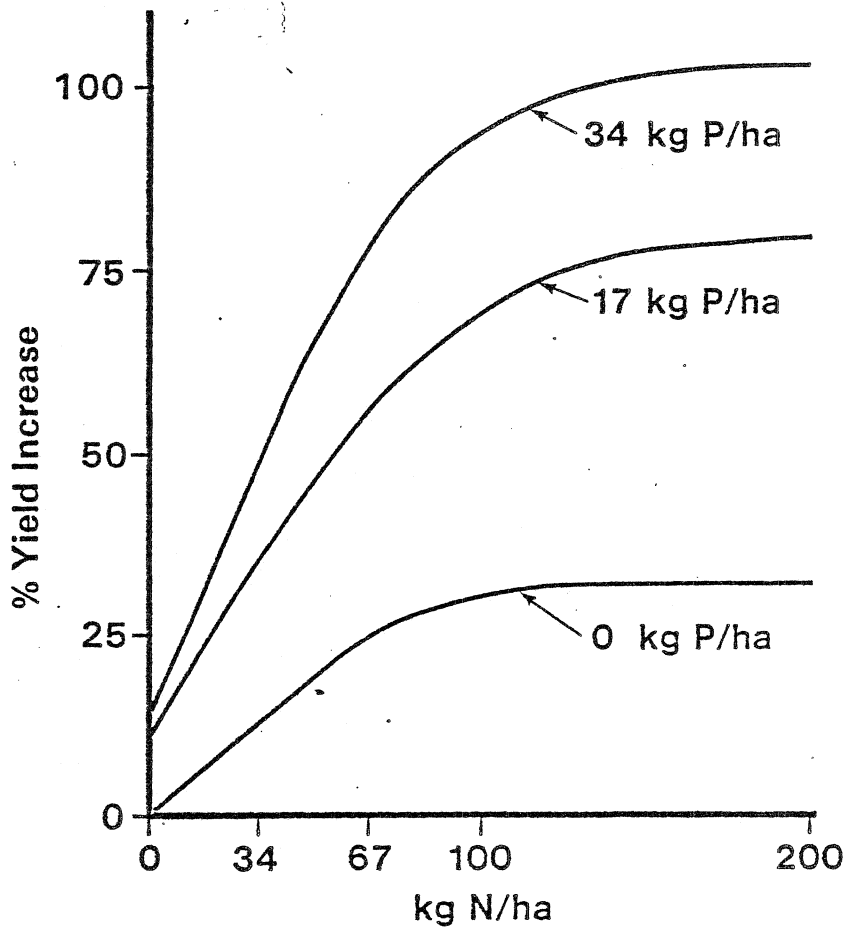


Fig 5. Effect of nitrogen and phosphorus fertilizer on yield of winter wheat, where moisture is sufficient.

#### SUMMARY OF RECOMMENDATIONS

1. Rates of fertilizer application should be based on the results of a soil test.
2. Phosphorus fertilizer should be applied at the recommended rate with the winter wheat seed.
3. Nitrogen deficiencies should be corrected by broadcasting ammonium nitrate (34-0-0) at the recommended rate in the early spring. Urea fertilizer should not be surface-applied.
4. Some producers have expressed concern that if dry spring conditions are encountered, movement of spring-applied ammonium nitrate to the root zone will be delayed. A partial solution is to apply some of the N fertilizer in the fall with the seed and the remainder in the spring. Present fertilizer recommendations suggest that up to 45 kg N/ha (30 kg N/ha for urea) may be applied with the seed. (Note: do not seed place more than 200 kg/ha of total fertilizer material). The remainder of the nitrogen deficiency could then be corrected with a spring broadcast of ammonium nitrate. A word of warning - the effect of high rates of seed-placed nitrogen on the winter survival of winter wheat requires a more thorough evaluation.
5. Phosphorus deficiencies must be corrected for maximum nitrogen fertilizer response. Conversely, nitrogen deficiencies must be corrected for maximum phosphorus fertilizer response.

#### Acknowledgements

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