MANAGEMENT OF POST-EMERGENCE NITROGEN ON SPRING WHEAT

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Why are Producers Interested in Post Emergence N Applications?

Increase in nitrogen (N) fertilizer prices combined with rewards for achieving high grain protein concentration in wheat has led to increased interest in post-emergence applications of N to spring seeded crops. Traditionally, N fertilizer prices decrease in the month of June, thus post-emergence applications may be an economical alternative to applying all the N requirement either in the previous fall or spring (pre-seed or at seeding) of the year. Post-emergence applications are also considered a means of managing risk and possibly reducing fertilizer N costs, since they can be implemented if favorable moisture conditions during the growing season increase N needed for optimum crop yield and protein content (Johnston et al. 2003; Karamanos et al. 2004). A variety of options are available in terms of products and methods of application for post-emergence N; however, the question still remains whether, on a wide area basis on the prairies, the practice of splitting N is a viable alternative to placing N fertilizer prior to or at seeding time. The objective of this study was to utilize a series of experiments conducted over a period of four years to evaluate whether post-emergence N applications would be an efficient method of increasing grain yield and/or protein of hard red spring wheat and, at the same time, derive the appropriate rates, timing and products for N application.

A series of five experiments containing a total of 49 trials conducted between 1995 and 1998 were compiled in order to assess the effectiveness of a number of rate splits and timing of post-emergence applications and the effectiveness of a number of products in enhancing grain yield and protein content of hard red spring wheat. Grain yield and protein from individual trials were subjected to ANOVA for the corresponding statistical design and effects were separated via orthogonal contrasts using SYSTAT 8.0 (SPSS Science Inc. 1998). When combined analysis for all trials of an experiment was required, we followed the analysis of a series of experiments described by Cochran and Cox (1992) considering that all effects were fixed (Baker 2002).

Is There a Difference in Grain and Protein Response to Rates Applied at Seeding and Post-Emergence?

Yes; it depends on soil organic matter (SOM). Grain yield increased by 16 kg ha^{-1} for each kg N applied at seeding per ha and by 3 kg ha^{-1} for each kg N applied post emergence per ha on soils containing greater than 5% SOM in the 0-15 cm depth (Fig. 1a). On soils with SOM concentration less than 5% the grain yield increased by 10 kg ha^{-1} for each kg N applied at seeding per ha and had no significant increase with post emergence N applications (Fig 1b).

In contrast to grain yield, protein concentration in the grain was influenced by both N applied at seeding and post emergence (Fig. 1c,d). However, the impact of N applied at seeding was greater when SOM levels were less than 5% (Fig. 1d). Soils with lower SOM levels are commonly found in agroecological zones that are characterized with lower growing season precipitation and lower yield potential; hence, it is conceivable that N applied at seeding contributes to grain protein to a greater degree than on soils with greater SOM concentration and greater yield potential. Hence, post emergence applications of N had a 5-fold impact on protein concentration on soils containing more than 5% SOM and only 2-fold on soils containing less than 5% SOM. Overall, average increase in grain protein over all sites ranged between 0.7 and 1.5 % (Fig. 2). The greatest increase was obtained from post-emergence application of N on the control treatments and the lowest at of soil N applied at seeding (20 kg ha^{-1}).

In this study, both yield and protein increased with increasing N when the N supply was moderate. However, yield increased and protein concentration fell, when the N supply was very low relative to yield potential. When N supply was high relative to yield potential, yield remained constant and was accompanied by increase in protein concentration. Finally, when both N supply and yield potential were very high, neither yield nor protein increased.

What is the Impact of the Rate of N Application on Grain Yield?

Grain yield increases due to post-emergence N application were higher at low soil + fertilizer N levels (<100 kg N ha^{-1}) and diminished to zero thereafter (Fig 3). An increase in protein concentration at low soil + fertilizer levels (<90 kg N ha^{-1}), on the other hand, was followed by slight decrease and a subsequent increase at soil + fertilizer N level greater than 140 kg N ha^{-1} (Fig. 3). Hence, this study verified that maximum protein concentration (and protein increases) occurs at a soil plus fertilizer N rate that is higher than that required to obtain a maximum yield (Selles and Zentner 1998). Further, post-emergence applications at late growth stages of wheat (after Feekes growth stage 10.4) do not afford an efficient and reliable means of overcoming an N deficiency; however, they could contribute to increasing grain protein concentration, providing N deficiency has been corrected.

What is the Impact of the Timing of Post-Emergence N Applications?

Three separate experiments (containing eight, four and ten trials, respectively) were conducted to evaluate timing of post emergence N application on wheat grain yield and protein with post-emergence applications made at various growth stages starting from Feekes growth stages 3-4 (tiller formation to leaf-sheaths beginning to lengthen), continuing to Feekes 6 (first node visible), and finishing as late as Feekes 10.5 (three-quarters of heading process completed to all ears out of the sheath) or 11 (ripening) (Large 1954).

Two main patterns emerged in this portion of the study: (i) both grain yield and protein increased linearly with application of increasing N rates, however, when these rates were split into a portion applied at seeding time and a post-emergence application of 20 kg N ha^{-1} a significant decrease in yield ensued (Fig. 4); and, (ii) the decrease in grain by delaying application of a portion of N resulted in an increase of grain protein concentration only in one experiment (ten trials).

These results demonstrate a strong dependence of the effectiveness of post-emergence applications on agroclimatic conditions and, thus, the relatively high risk associated with post emergence N applications, especially when they are utilized as a means of increasing wheat grain yield by splitting the total N requirement into a portion applied at seeding and a post-emergence application.

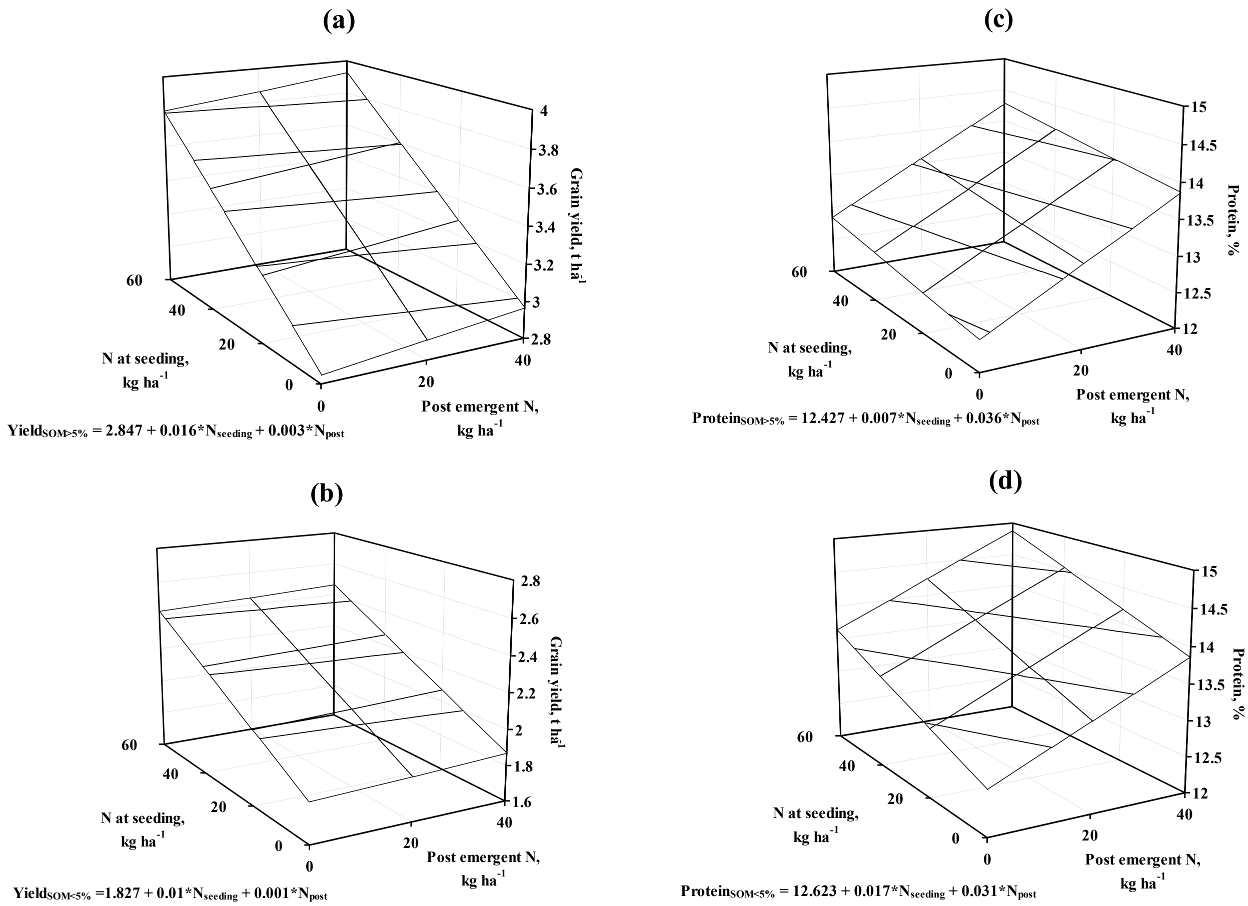

Fig. 1. The effect of N applied at seeding and post emergence on the grain yield of wheat grown on soils with soil organic matter (SOM) concentration greater (a) and less (b) than 5% and corresponding grain protein concentration (c and d).

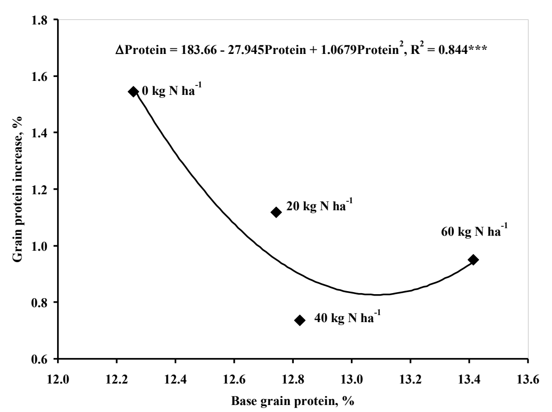

Fig. 2. Average increase in wheat grain protein resulting from post-emergence applications of three rates of N.

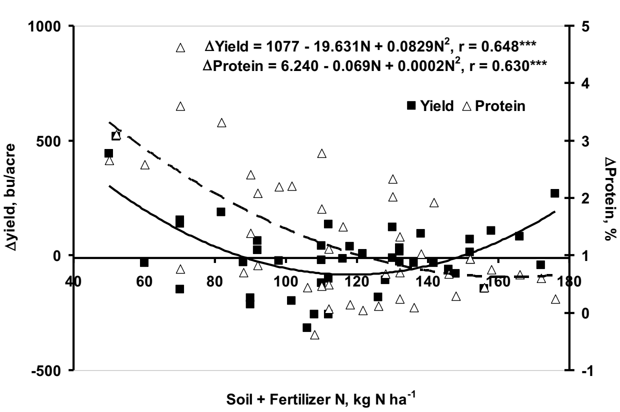

Fig. 3. Increases/decreases in grain yield and protein of wheat grain as a function of soil plus fertilizer N rates.

The only benefit arising from splitting an application is associated with reducing fertilizer application rates in response to persistently dry conditions after seeding, hence, minimizing the cost of excessive N fertilization when yields are limited by lack of water. Further, the results of this portion of the study also demonstrate that an increase in wheat grain protein by post-emergence N applications was achieved only when the final yield was considerably less than the potential yield under the agroecological conditions and that, in most cases, both optimum wheat grain yield and protein content can be achieved by a single application at (and presumably prior to) seeding.

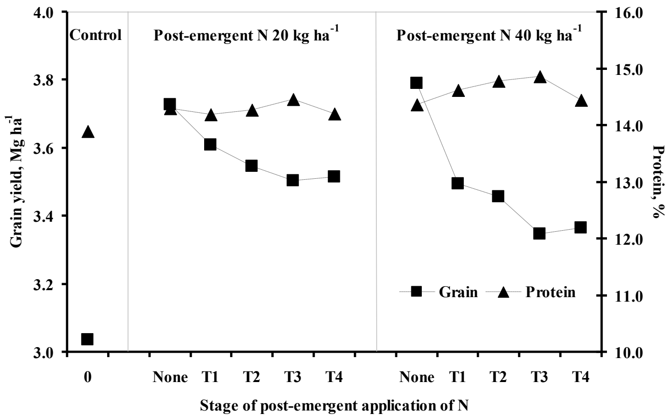

Fig. 4. Effect of splitting fertilizer N rate between seeding and post-emergence at various growth stages on the yield and protein concentration of wheat (T1, T2, T3, and T4 refer to Feekes growth stages 3-4, 6, 10.5 and 11, respectively).

Is there a Difference in the Effectiveness of Various N products?

A number of N products {urea (granular and liquid), ammonium nitrate, ammonium sulphate, ProN (liquid 18-0-0-7), N Sure (liquid 28-0-0) and urea/ammonium nitrate (28-0-0)} were evaluated in an experiment that included fifteen trials at which 40 kg N ha^{-1} were either side-banded at seeding or split into two applications. No general trends in grain yields emerged. In four of fifteen trials carried out to examine this, spraying the liquid fertilizer directly on the crop resulted in greater protein content compared to dribbling on the ground; however, overall there was no impact of the method of post-emergence application on the protein of hard red spring wheat. A number of significant differences between products on an individual trial basis resulted in both significant protein increases and decreases; hence, overall there were no significant effects. Dividing the locations into those with soils containing either greater than or less than 5% SOM did not result in any unique trends. Therefore, no consistent trends could be derived in relation to product type and use.

Is There an Economic Benefit from Post-Emergence Applications?

A brief and generalized economic analysis of post-emergence N applications was carried out by utilizing historical trends in protein premium by the Canadian Wheat Board (2004) and using a CWRS wheat price of CAN$250 t^{-1} for 13.5% protein wheat (conversion on January 1, 2006, 1 US$= $1.15 CAN$), CAN$0.90 kg^{-1} N and CAN$6.50 ha^{-1} for topdressing the post-emergence applications. Wheat protein premiums varied from CAN$0 t^{-1} for 10.8% grain protein content or lower to an additional CAN$26.83 t^{-1} for 15.5% protein content or higher.

The return less fertilizer expense was calculated by subtracting the expense of the fertilizer rate applied at seeding plus that of a post-emergence application, including the application expense.

The results from two experiments (total of twenty-two trials) were utilized. Fertilizing wheat at seeding with a single N application of 60 to 80 kg N ha^{-1} resulted in an overall economic benefit of approximately CAN$160 ha^{-1} and CAN$195 ha^{-1}, respectively (Fig. 5a,b). A similar trend emerged from both experiments that matched that of the agronomic assessment of the same results, namely, application of post-emergence N when there was insufficient N to supply the crop's needs resulted in an economic loss, albeit a higher protein content; further, application of post-emergence N in addition to the optimum N rate applied at seeding overall resulted in either no economic benefit (Fig. 5a) or slight economic loss (Fig. 5b).

CONCLUSIONS

1. This study has verified that maximum grain protein content occurs at a soil plus fertilizer N rate that is higher than that required to obtain a maximum yield.
2. Delaying application of N by splitting the total application into at portion applied at seeding and a post-emergence N application contributed to increasing grain protein concentration, provided that N deficiency was corrected by the former; however, this practice did not result in an economic advantage. If N deficiency was not corrected by the application of N at seeding, post-emergence applications at late growth stages of wheat resulted in less yield and a higher grain protein concentration than for equivalent rates of N applied at seeding.
3. The increase in protein concentration was not sufficient to economically compensate for the loss in grain yield.
4. Post-emergence application of N to enhance either the grain yield or protein of hard red spring wheat was shown to be a relatively high risk practice under dryland conditions in the western Canadian prairies.

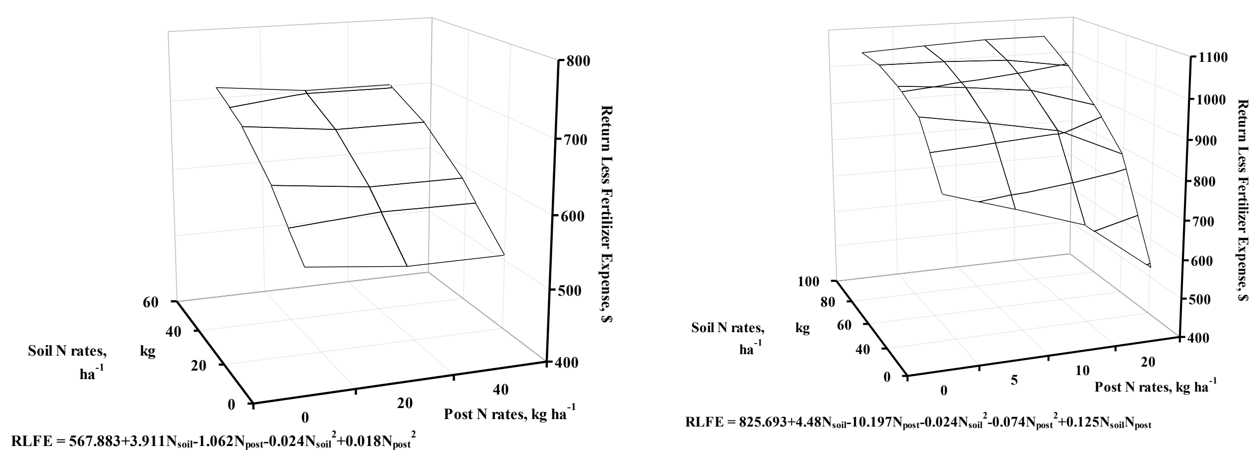

Fig. 5. Return less fertilizer expense for the various treatments of two different experiments.

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