Managing Nitrogen in Spring Wheat to Boost Grain Yield, Quality, and Nitrogen Use Efficiency

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Wheat (Triticum aestivum L.) is an important grain crop in Canada, which provides nutrition to most of the population, and is well adapted to a wide range of environmental conditions. According to the Alberta Wheat Commission, approximately 9 million tonnes of wheat are produced annually in Alberta. The main goals in wheat production are grain yield and protein content for milling and baking quality. These goals are, however, limited due to available N, moisture, and temperature conditions, as producers choose between yield or quality. This has led to many wheat producers discounting the sale of their produce after harvest as wheat with grain protein below certain limits for CWRS (13.0 - 13.5%), is discounted most times depending on the year.

Nitrogen is the most limiting nutrient for wheat production that affects growth, and grain yield, and quality. Currently, the increasing N application has largely contributed to bread wheat yield rise. However, the cost of N fertilizer production and application is increasing and environmental concerns make it necessary to enhance crop nitrogen use efficiency (NUE). Application of N fertilizer before or at the time of planting has the potential for minimizing N deficiency early in the growing season. On the other hand, applying all N in advance may result in N immobilization before plant uptake can take place or results in higher rates of lodging. Mid-season N fertilization enables matching the N supply with the crop's N requirements and provides vital nutrients at the time when N uptake is at maximum, which facilitates efficient N fertilizer use.

What is the Split Nitrogen application?

Split applying crop nitrogen needs is a tool that is gaining widespread popularity among Canadian grain farmers. Many grain farmers today are splitting their nitrogen (N) applications (not apply all of their nitrogen at seeding but withheld a portion of the nitrogen and applied when the crop is ready for it (typically mid-to-late-June). A split nitrogen application can be beneficial from an agronomic, economic, and environmental perspective. Used in conjunction with a nitrogen stabilizer, it can reduce N loss and improve nitrogen uptake for a healthier, higher-yielding crop.

This trial aims to :

Evaluate varying rates of N fertilizers on grain yield and quality

Evaluate which stage of spring wheat growth is optimal to boost grain yield and protein

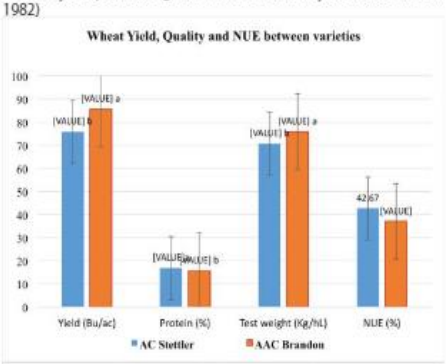
Evaluate the nitrogen use efficiency of varying rates of N fertilizer

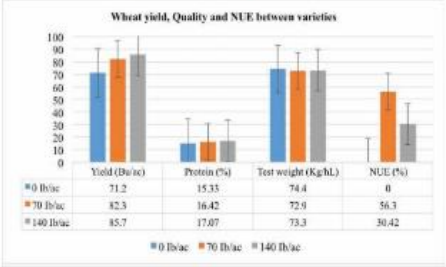
Evaluate which wheat cultivar meets the milling and baking qualities

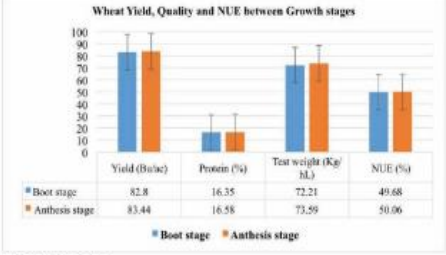
Evaluate which wheat cultivar has a better nitrogen use efficiency.

The trial was established at the Mackenzie Applied Research Association Research Farm at Fort Vermilion, Alberta (SE-23-108-13-W5). The experiment had two levels: varieties (AAC Brandon and AC Stettler) and split nitrogen application (0:0, 70:0, 70:70, 140:0 lb N ac-1 at boot and anthesis stage of growth). The wheat varieties were seeded at 250 seeds/m2 to a depth of 3.8 cm with a 6-row Fabro plot seeder spaced 20 cm apart on May 21, 2020. Based on the soil test recommendation, 11-52-0 and 0-0-60 were broadcasted also with urea (based on the treatments) at the time of seeding at 60 and 20 lb ac-1, respectively. Urea-ammonium nitrate (28-0-0) was foliar applied to each variety at the boot and anthesis stage of growth.

Nitrogen use efficiency can also be calculated as nitrogen uptake efficiency (NUpE) x nitrogen utilization efficiency (NUtE) (Moll et al. 1982)







Wheat varieties

It was observed that AC Stettler produced higher protein content (16.88 vs. 15.79 %) relative to AAC Brandon. On the other hand, AAC Brandon recorded greater yield (85.70 vs. 75.82 Bu ac-1), test weight (75.84 vs. 70.72 kg hL-1), and relative to AC Stettler. Both wheat varieties produced 15-20% higher grain protein the acceptable grain protein for milling and baking. This confirms that both varieties can be seeded by grain producers in Mackenzie County without discounting sales of grain production. This also suggests that grain yield and protein can be influenced by the variety selected and seeded by grain farmers.

It was observed that nitrogen use efficiency (NUE) of AC Stettler was 13% higher than AAC Brandon wheat. This suggests that grain farmers seeding AC Stettler have a higher potential to maximize the nitrogen fertilizers applied and less loss via volatilization and denitrification.

Nitrogen Application Rates

Compared with the no N application (control), N at 70 and 140 lb N ac-1 increased grain yield and protein by 13 and 16% and 7 and 10%, respectively. This is well illustrated in figure 1. below.

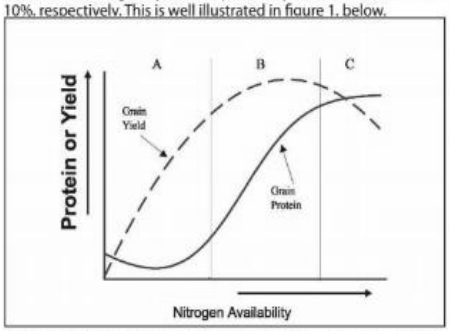


Figure 1. The typical response of grain yield and protein concentration to available N (adapted from Selles et al, 1997)

The fact that grain protein was higher (than milling and baking qualities) at no N application suggests that soil N and precipitation play a key role in meeting the protein limits for quality bread. Nitrogen use efficiency was observed to be higher at 70 lb N ac-1 compared to the 140 lb N ac-1 applied rates in the study. Previous studies have shown that nitrogen utilization efficiency (NUE), or N uptake per unit N applied, is greatest where the yield response to N is highest. Therefore, NUE is generally greatest with the lowest levels of applied N and decreases as the amount of N applied increases. The estimated 56.3 % NUE observed at 70 lb N ac-1 shows that there was minimal loss of N and more N uptake by crops for growth and productivity.

Stages of N application

The stages of N application (at the boot and anthesis stages of wheat growth) had no significant effect on grain yield, quality, and nitrogen use efficiency. However, N applied at the anthesis stage in all the parameters measured had higher values compared to N applied at the boot stage.

Conclusion

Split nitrogen application on spring wheat has the potential to boost yield and protein content in the north peace of Alberta. The results from this study also show that varieties with higher NUE values tended to have higher nitrogen response and that breeding for NUE could be a potential method to improve yields and response to nitrogen fertilizers. Improving N response and NUE would have many benefits. The most important would be the economic gains for producers by requiring fewer nitrogen fertilizers to reach maximum yields and more efficient use of applied N. The environment would also benefit from less applied N and more efficient use of fertilizers by reducing the risk of N loss to the environment through leaching or volatilization. This would allow producers to better meet the growing demand for food worldwide while protecting the environment.

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