# Winter Wheat Nitrogen Response

## Purpose:

Until recently, winter wheat nitrogen recommendations were based on research conducted 30 years ago. Production practices have changed significantly, with increased yield potential through the use of better genetics (varieties), and availability of fungicides, and growth regulators. As producers pursue higher wheat yields using improved management techniques, current N recommendations may not be sufficient. This study evaluates the Maximum Economic Rate of Nitrogen (MER-N) under current management regimes. N recommendations have been increased (2012) based on this research. This research continues to validate and fine tune N recommendations with latest genetics and management techniques.

## Methods:

Multiple nitrogen rates were applied to generate nitrogen response curves and determination of MER-N. Additional treatments were included at selected sites to evaluate the impact of fall nitrogen on wheat yield and economic return. Post-harvest soil nitrate tests were collected to determine if higher N rates increased residual soil-N, which could be an environmental concern or need to be managed another way.

Two replicate, randomized field scale trials were set up in 2010 (3 sites), 2011 (9 sites), 2012 (14 sites), and 2013 (9 sites) (35 sites total). Except for the nitrogen rate all variables at each location were held constant following the producer's normal production practices. At 27 of the 35 sites spring nitrogen was applied by broadcasting urea with a Valmar airflow applicator. The remaining 8 sites applied 28% UAN using the cooperators equipment. Treatments are listed below. Not all the treatments were included at every site.

1. Check (No Nitrogen applied)
2. 60 lbs actual Nitrogen (60 N) applied in the spring
3. 90 lbs actual Nitrogen (90 N) applied in the spring
4. 120 lbs actual Nitrogen (120) applied in the spring
5. 150 lbs actual Nitrogen (150 N) applied in the spring
6. 30 lbs actual Nitrogen in the Fall + 90lbs (30+90 N) actual N applied in the spring
7. 30 lbs actual Nitrogen in the Fall + 120lbs (30+120 N) actual N applied in the spring
8. 180 lbs actual Nitrogen (180 N) applied in the spring

Treatment 6 and 7 were included at 5 sites in 2011, 9 sites in 2012, and 4 sites in 2013. 30 pounds of actual N was applied in the fall using the Valmar airflow. In 2010 urea fertilizer was broadcast between Nov 9 to the 11th while in 2011 ammonium nitrate was applied between Oct 10$^{th}$ and Nov 7$^{th}$. In 2013 urea was spread between Oct 12$^{th}$ and Nov 7$^{th}$.

Harvest measurements included yield, moisture, test weight, 1000 kernel weights, protein and lodging. Soil nitrate samples were collected post-harvest to examine the environmental implications of increased nitrogen application.

## Results:

Yields increased dramatically with the addition of N (Table 1). There was a whopping 22 bushel gain from 0 N to 60 N. Additional N continued to increase yield: 6.8 bu/ac gain from 60 N to 90 N, 5.2 bu/ac from 90 N to 120 N. An average 2.8 bu/ac gain resulted when increasing N from 120 to 150 lbs/ac.

**Table 1: Average Wheat Yields (bu/ac @ 32 Locations)**

| Treatment | 2010 | 2011 | 2012 | 2012 | Trial Average | Incremental Gain |
|---|---|---|---|---|---|---|
| 0N | 67.2 | 52.8 | 53.5 | 52.3 | 55.0 | |
| 60N | 85.5 | 74.2 | 78.7 | 74.1 | 77.6 | 22.6 |
| 90N | 91.0 | 81.4 | 83.4 | 81.0 | 84.4 | 6.8 |
| 120N | 95.7 | 87.6 | 90.9 | 84.4 | 89.6 | 5.2 |
| 150N | 94.9 | 89.5 | 94.1 | 87.2 | 92.4 | 2.8 |

**Economic analysis:** Using urea at $500/tonne ($0.49/pound of actual N) and soft red wheat at $5.76/bushel, 2.6 bushels of wheat are required to cover the cost of 30 units of N ($0.49/lb*30lbs= $14.79/$5.76/bushel= 2.6 bushels). At these values there is a clear financial return, on average, up to 120 N, with 150 N breaking even.

Only 7 of 32 sites had a maximum economic nitrogen rate below 120 N (22%). It is interesting to note that of these 7 sites, 4 of them did not receive any fungicides. Table 2 contains a comparison of the sites with fungicide versus sites without. The sites without fungicide reached a maximum yield with 120 N and MER-N at 90 N. Only 2 of the 7 sites without fungicide had an economic advantage to applying more than 90 N.

**Table 2: Breakdown Of Yields With And Without Fungicide (bu/ac)**

| Treatment | 26 Sites with Fungicide | Incremental Gain | 6 Sites no Fungicide | Incremental Gain |
|---|---|---|---|---|
| 0 | 52.8 | | 64.3 | |
| 60 | 76.5 | 23.7 | 82.4 | 18.1 |
| 90 | 83.8 | 7.3 | 87.1 | 4.7 |
| 120 | 89.9 | 6.1 | 88.6 | 1.5 |
| 150 | 93.4 | 3.6 | 87.8 | -0.8 |

The sites with fungicide tell a completely different story. There was a substantial yield increase of 6.1 bushels between 90 and 120 N. This supports recent research that has shown an interaction between nitrogen and fungicides (SMART trials). An additional 3.6 bushels was gained by increasing to 150 N. Only 3 of the 26 sites (12%) with fungicide required less than 120 N to reach MER-N and surprisingly over 60% of the sites had MER-N of 150 N or greater. 150 N was the highest rate of N applied at nearly all of the sites so calculation of MER-N at these sites is difficult. However, 5 of the sites did include a 180 N treatment so we can get an idea of what would happen with higher N rates. The yield results from these 5 sites are summarized in Table 3. Yield continued to increase up to 150 N but an additional 30 N caused yields to decrease. All 5 of the sites had a negative yield response with the 180 N treatment. This suggests that 150 N is the maximum N rate for sites that responded to 150 N but did not include a 180 N treatment.

However, with the inclusion of growth regulators and better fungicides, evaluation of 180 N rates should not be discarded.

**Table 3: Summary Of Trials Including 180 N Treatments**

| Location | Applied Fertilizer N (lbs/ac) | | | | | |
|---|---|---|---|---|---|---|
| | 0N | 60N | 90N | 120N | 150N | 180 N |
| | Wheat Yield (bu/ac) | | | | | |
| **5 sites** | **46.9** | **69.2** | **74.4** | **80.6** | **86.8** | **83.3** |
| **Incremental Gain** | - | 22.3 | 5.2 | 6.2 | 6.2 | -3.6 |

Wheat yield responses from fall applied N are summarized in Table 4. Fall N had no significant impact on yield, moisture, test weight, 1000 kernel weight, or protein. The 2.4 bu/ac advantage from 30 N fall plus 90 N in the spring over 90 N spring only pales compared to the 6.2 bu/ac gain of 120 N spring over 90 N spring only. Calculating this, it quickly becomes apparent that fall N does not pay. Even less gain was seen with the 30+120 N treatment. Add to this that fall nitrogen applications are a potential environmental concern, and clearly fall N should not be recommended by anyone in the Province of Ontario!

**Table 4: Summary of trials including fall N treatments (18 Locations)**

| Treatment (lbs N/ac) | 2011 | 2012 | 2013 | Average | Gain vs 90N |
|---|---|---|---|---|---|
| | Wheat Yield (bu/ac) | | | | |
| 90N Spring | 81.4 | 84.6 | 79.2 | 82.2 | |
| 120N Spring | 86.4 | 91.9 | 83.7 | 88.4 | 6.2 |
| 150N Spring | 88.9 | 95.2 | 86.0 | 91.1 | 8.9 |
| 30 fall N + 90 Spring N | 82.0 | 88.4 | 81.1 | 84.6 | 2.4 |
| 30 fall N + 120 spring N | 86.5 | 92.6 | 84.7 | 88.7 | 6.5 |

As N rates increased, protein levels in the grain increased. Differences in protein levels between 0 and 60 N were minimal to even negative, as yield increases were so large that all additional N went to yield, rather than protein. As N rates were increased further, protein levels consistently increased by 0.4% for every additional 30 units of N. Protein levels increased by 1.2% from 60 to 150 N. The impact of this increase is dependent on the market being targeted. Some domestic users prefer low protein soft wheat, while other markets and export buyers prefer high protein. In general, increased protein levels would fit the majority of market opportunities somewhat better, but there is no price premium associated with this increase.

## Summary:

The results from this trial show a great opportunity to increase wheat yields with additional N. The data strongly supports recent research that has proven an interaction between N and fungicides. If no fungicide is applied, responses to additional N are minimal and fit the older N rate recommendations very well. If fungicides are applied responses to N become much more significant, and new N recommendations are in order. Concern over lodging, originally thought to be a major issue at high N rates, has failed to materialize as a major problem. However, the negative impacts of lodging due to excess N should not be ignored. Fall N has proven unsuccessful based on 3 years of data. With the potential for environmental impacts associated with fall N applications, no fall N should be applied or recommended on winter wheat in Ontario at this time.

Growers are warned to proceed with caution as they increase N rates. Where lodging has not been an issue in the past several years, growers should place 2 test strips of an additional 30lbs N/ac to evaluate results on their farm. If yield increases warrant, and standability is acceptable, the majority of wheat acres can be moved to the higher N rate over the next few years, and strips of another additional 30 lbs N/ac can then be evaluated. This stepwise approach should avoid growers having lodging disasters by jumping N rates too quickly.

## Next Steps:

This was the final year of this project (2010 – 2013). The data generated from this project will be used in multiple articles and presentations. The data will also be used to try and create a nitrogen calculator for winter wheat. Further research will be undertaken to examine the relationship with split nitrogen, growth regulators, planting dates, new fungicides and their response to nitrogen rates.

## Acknowledgements:

We are indebted to our many co-operators, many of whom stick with us year after year. Thanks to all the summer assistants. Special thanks to technician Shane McClure, administrator Marian Desjardine, and statistician Ken Janovicek. This project would not be possible without the financial support of Agriculture and Agrifood Canada through the CanAdvance and Farm Innovation Programs, the Grain Farmers of Ontario and their staff with ongoing support, the many Soil and Crop Improvement Associations that work with us, both as cooperators and with financial support, along with many agribusiness' that support this work. Dr. David Hooker, Scott Jay, Gerald Backx and the wheat research team at the University of Guelph are valued contributors to many of our projects as well. Heartfelt thanks to you all!

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## Location of Project Final Report:

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