Winter Cereal Forage Opportunities

Purpose:

Many producers are looking for ways to get more production out of their land base. Any time land can be covered with a living crop reduces the potential for soil erosion, improves soil structure and reduces the potential off site movement of nutrients. Where livestock operations exist, planting winter cereals in the fall following corn silage, soybean or even grain corn harvest, provides the opportunity for additional forage harvested in early spring. Virtually no Ontario data exists to help guide producers trying to capitalize on this opportunity. New York State data suggest Triticale is the crop of choice, with early planting dates and fall nitrogen important to success (Kilcer, 2012). This trial is designed to evaluate the best winter cereal crop (rye, triticale, winter barley, wheat) and accompanying management practices to produce a spring forage crop and follow forage harvest with a grain crop planted after forage harvest. Early harvest and minimal impact on the subsequent crop will be key factors in making this option viable.

Methods:

Small plot, 4 replicate trials were established at 2 locations in 2012, 6 in 2013 and 3 in 2014. Four different crops (fall rye, triticale, winter wheat and winter barley) were seeded at 140 lbs/acre. Most of the sites (6) were planted between Oct 3rd and Oct 15th. Two sites had both an early September and a late September planting date to see if planting date made any difference in relative performance between crop types, harvest dates based on crop stage, and total final yield of each species. The seed was no-tilled into corn silage, soybean, or wheat stubble using a 1560 John Deere Drill. Five different nitrogen (N) rates (0, 30, 60, 90, and 120 lbs of actual N) were applied across these strips, using urea as the source, in late April. Yields were measured at flag leaf and boot stage. Yields were measured using a Carter forage plot harvester that cut and weighed a 1.5 X 3 metre (5’ X 10’) strip through each plot. Plants were cut at or near ground level. A sub sample was collected, dried and chopped to determine moisture, phosphorus and potash tissue levels, along with quality analysis to calculate relative feed value across the treatments (ADF, NDF, protein, Mg, Ca, etc).

Results:

Unfortunately the extreme cold, ice, and hard winter of 2014 and 2015 caused severe winterkill, with several of the sites emerging in the spring very uneven. Across all sites, rye had the best winter survival. However, at 2 sites the stands were simply too variable to retrieve reliable data from. The yield results from the 7 remaining sites are summarized in Tables 1 and 2. Table 1 (flag leaf stage) and Table 2 (boot stage) show yield data. All yields are expressed as tonnes of Dry Matter (0% moisture) per acre. As expected, not all the crops reached the boot stage at the same time, thus harvest took place over multiple days. Rye was the first crop to reach the flag leaf stage during mid-May (ranging from May 17 to May 21). Barley was the second crop to reach the flag leaf stage about a week later (May 21 – 28), while triticale and wheat were the slowest (May 28 – June 2).

Table 1: Yield Data at the Flag Leaf Stage

Crop	Crop Stage	Fertilizer N Rate (lbs/ac)				
		0 N	30 N	60 N	90 N	120 N
		Forage Yield (t DM 0%/ac)				
Rye	Flag	0.89	1.23	1.43	1.47	1.56
Barley	Flag	0.52	0.72	0.99	1.07	1.14
Triticale	Flag	0.74	1.05	1.25	1.34	1.56
Wheat	Flag	0.54	0.68	0.85	0.84	0.99

Not only was rye the first crop to reach the flag leaf stage but it also had the highest yields. At higher N rates triticale appears to be catching up to the rye, which is consistent with New York data indicating triticale requires high levels of management for best results. Barley and wheat trail behind for yield. The barley yields in 2013 were very poor (data not shown) but rebounded nicely in 2014 and 2015. Barley yields still fell short of rye and triticale, even with much improved performance in 2014 and 2015.

Total yield of all species increased significantly at the boot stage (Table 2). As expected rye was the first crop to reach the boot stage, ranging from May 21 to May 26. Barley continued as the second crop to reach the boot stage (May 27 – 31), while triticale and wheat were again the slowest (June 3 - 6).

Yields from Table 1 and 2 cannot be compared to each other. The boot stage harvest of rye was missed at one location so it has been dropped from Table 2, while another site with a complete boot stage harvest has been added to the average data in Table 2.

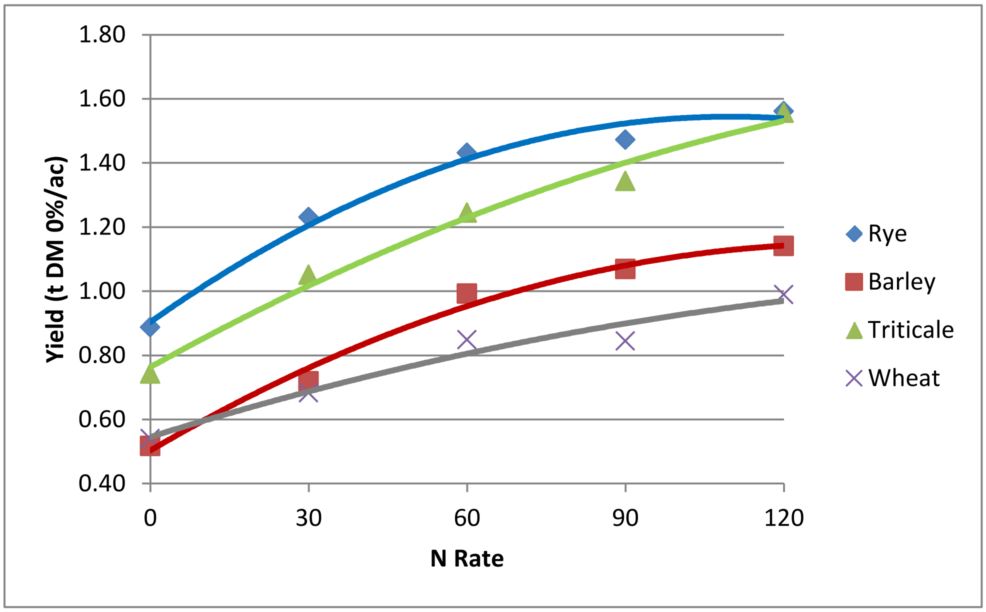
Table 2: Yield Results From Boot Stage

Crop	Crop Stage	Fertilizer N Rate (lbs/ac)				
		0 N	30 N	60 N	90 N	120 N
		Forage Yield (t DM 0%/ac)				
Rye	Boot	1.03	1.21	1.63	1.67	1.79
Barley	Boot	0.51	0.69	1.00	1.08	1.17
Triticale	Boot	1.08	1.30	1.57	1.60	1.65
Wheat	Boot	0.84	1.01	1.30	1.29	1.38

Rye remains the highest yielding crop, but triticale closed the gap and has yields similar to rye at the boot stage. Total barley yields showed minimal yield gain between the flag and boot stage at several locations: this may be due to variability caused by winter injury, which affected the barley the most.

Nitrogen response curves for each crop at the flag leaf stage are shown in Figure 1. While the dataset is not perfect, it shows the general trend. Rye and wheat seem to be approaching maximum yields with 60 N, while barley yields show a slight increase up to 120 N. Triticale is the most responsive to N and it appears that response could continue with even higher N rates.

Figure 1: Flag Leaf N Response



At the boot stage rye, triticale and wheat all approach maximum yields with 60 N, with small yield increases to additional N. Barley continues to show the most N response, with yields increasing more consistently all the way to 120 N. Again, this added N response for barley may be the result of thinner stands from winter injury.

The results from all 5 locations with both flag and boot yield data are summarized in Table 3. This data is based on fewer sites than Tables 1 and 2 but gives a more accurate comparison of yield increase between the flag and boot stage. Wheat and triticale appear to gain much more yield at boot than rye or winter barley. This may be a factor of the later maturity of wheat and triticale. Generally harvest at the boot stage occurred 5 days after flag leaf harvest for all crops. This is a very short time period to wait for the added yield: but quality also drops. The net effect of this on profit will depend on the livestock being fed the forage. The 5-day delay would be expected to reduce soybean yields by 2 bu/ac, on average.

Figure 2: N Response Curve at the Boot Stage

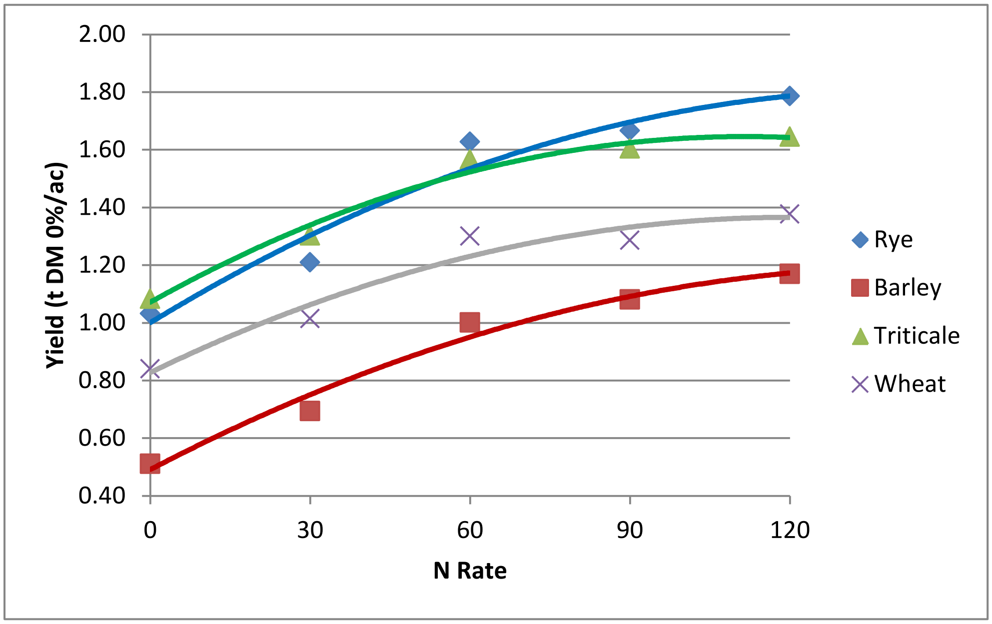


Table 3: Comparable Flag and Boot Yields

Crop	Crop Stage	Fertilizer N Rate (lbs/ac)				
		0 N	30 N	60 N	90 N	120 N
		Forage Yield (t DM 0%/ac)				
Rye	Flag	0.91	1.26	1.45	1.50	1.57
Rye	Boot	1.08	1.25	1.67	1.70	1.81
Barley	Flag	0.40	0.56	0.73	0.83	0.95
Barley	Boot	0.57	0.76	1.12	1.18	1.23
Triticale	Flag	0.60	0.86	1.02	1.11	1.24
Triticale	Boot	1.18	1.38	1.64	1.63	1.63
Wheat	Flag	0.46	0.60	0.69	0.75	0.92
Wheat	Boot	0.91	1.04	1.32	1.26	1.37

Quality is a critical factor when deciding which cereal crop to grow as forage. The 2014 and 2015 forage quality data is still pending so the forage quality data is based on very limited data from 2013. There is not enough data to be able to compare forage quality at the flag leaf stage to the boot stage within that dataset, so results from the two stages have been averaged together. The relative forage value (RFV) from 2013 is summarized in Table 4. RFV incorporates potential intake along with digestibility to produce one value to represent forage quality. There seems to be little difference in RFV across N rates and crops. Wheat appears higher in RFV than the other crops but there is not enough data to make any conclusions.

Table 4: Relative Feed Value

Crop	Fertilizer N Rate (lbs/ac)				
	0 N	30 N	60 N	90 N	120 N
Rye	113.5	112.9	113.8	117.1	116.7
Barley	119.4	124.2	118.9	119.4	118.0
Triticale	115.1	117.7	117.5	116.1	115.7
Wheat	132.7	131.7	127.9	132.8	133.1

Crude protein results are summarized in Table 5. Again results from the flag leaf and boot stages have been averaged together. As expected protein levels increased as N rates increased. At any given N rate, rye, triticale and barley are all similar in protein, with wheat being higher in protein, particularly at the lower N rates. Again, the 2014 and 2015 samples will need to be analyzed before any conclusions can be made.

Table 5: Crude Protein (%)

Crop	Fertilizer N Rate (lbs/ac)				
	0 N	30 N	60 N	90 N	120 N
Rye	11.1	11.9	14.7	15.8	17.0
Barley	12.6	12.5	14.2	14.6	16.2
Triticale	11.5	12.6	14.1	16.2	17.2
Wheat	13.6	13.4	15.4	17.8	17.8

To show the difference yield and quality can make to livestock production, Table 6 provides an estimate of pounds of beef/acre that would be produced from the forage harvested for each treatment. These are simple estimates calculated using TDN and total yield. There was very little difference across crops and N rates in TDN so production closely follows yield. In a similar vein, milk per acre gain be calculated, and will be shown once more quality data is available from the 2014 and 2015 harvest.

Table 6: Pounds of Beef per acre

Crop	Crop Stage	Fertilizer N Rate (lbs/ac)				
		0 N	30 N	60 N	90 N	120 N
Rye	Boot	240.6	263.1	381.8	392.1	409.5
Barley	Boot	109.1	151.7	215.9	228.7	271.8
Triticale	Boot	260.7	297.2	357.8	368.2	374.9
Wheat	Boot	192.4	256.1	311.9	328.0	330.1

Another consideration when growing any forage is nutrient removal. Phosphorus and potash removal is summarized in Tables 7 and Table 8, respectively. The removal values are summarized as the amount of fertilizer needed to replace removal of the nutrient in the harvested forage. Phosphorus removal is given as P2O5 and potash as K2O, the equivalent form that commercial fertilizer is based on. Removal per acre is based on the nutrient concentration in the plant and the average yield: eg: rye with 60 lbs N applied removed 26.5 lbs of P2O5 and 126.3 lbs of K2O per acre (on average). These removal rates are extremely high**.** In high yield situations, over $100/acre can easily be removed in P and K fertilizer values alone. If growers remove forage, replacement of these nutrients through manure or fertilizer definitely needs to be part of the economic equation.

Table 7: P2O5 Removal (pounds/acre)

Crop	Fertilizer N Rate (lbs/ac)				
	0 N	30 N	60 N	90 N	120 N
Rye	16.3	19.4	26.5	29.7	28.6
Barley	9.1	12.3	18.8	19.8	21.0
Triticale	15.4	19.2	22.9	23.1	30.0
Wheat	11.3	16.2	19.1	20.8	21.2

Table 8: K2O Removal (pounds/acre)

Crop	Fertilizer N Rate (lbs/ac)				
	0 N	30 N	60 N	90 N	120 N
Rye	68.1	85.6	126.3	137.1	140.9
Barley	35.0	50.6	84.9	91.3	90.8
Triticale	57.8	78.3	98.3	99.9	146.9
Wheat	47.1	66.8	82.1	97.5	103.0

Potash concentrations (%) in all crops increase as nitrogen rates increase (Figure 3). While there is chatter in the data, the trend is clear. This finding is consistent with the results found in a previous summer cover crop project (Johnson, McClure 2012). This relationship is thought to be caused by ion balance in the plant, with higher N rates (negative charge) requiring higher potash uptake (positive charge) to maintain proper ion balance. This hypothesis has yet to be verified. However, the consistency of this outcome, and the huge impact on nutrient removal, means it must be considered when growing these crops.

Figure 3: Nitrogen impacts on Potash Concentration (2012/2013 avg)

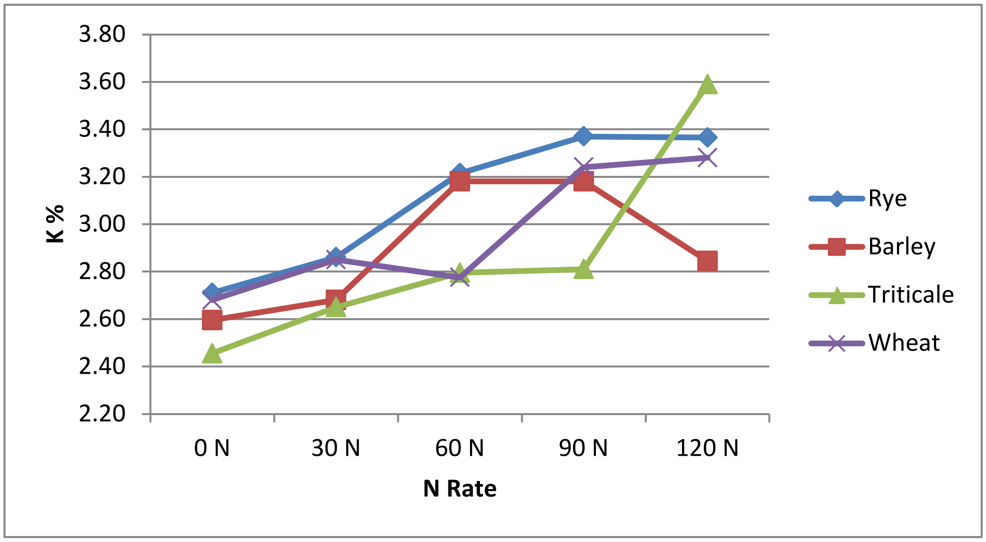


Table 9 contains an economic summary. There are many factors that will change from year to year and producer to producer. Results in Table 9 are based on an average yield at both the flag leaf and boot stage, with forage being valued at 8 cents per pound of dry matter. P and K nutrient removal has been accounted for, with P being valued at $0.52/pound and K at $0.42/pound. Producers who are spreading the manure back on the field may not consider these costs, as most of the nutrients will be going back on the field with the manure. Nitrogen applications were charged at $0.55/lb of actual N. Seed cost was included, assuming seeding at 130 lbs/acre. Any potential change in forage value between the crops has not been accounted for.

Rye has the highest revenue at every N rate. Even though triticale has yields essentially equal to rye, the high cost of triticale seed drags down revenue/acre. Assuming a forage value of 8 cents/lb DM, all crops had the highest return with 60 N. Highest return may be at higher N levels on years with less harsh winters and better winter survival, but this remains to be evaluated.

Changing the value of any of the factors will affect the results in Table 9, but this data gives an idea of potential returns. These numbers may look disappointing: remember that all costs have been included, that yields were relatively low in 2014 due to winterkill and winter injury, and that the price used is for dry matter at 0% moisture.

Table 9: Revenue per acre @ 8 cents/ lb DM 0%

Crop	Fertilizer N Rate (lbs/ac)				
	0 N	**30 N**	**60 N**	**90 N**	**120 N**
Rye	$62.04	$67.87	**$94.10**	$79.97	$70.21
Barley	$20.18	$30.57	**$49.10**	$42.87	$47.47
Triticale	$9.13	$22.84	**$35.00**	$20.75	$11.96
Wheat	$31.38	$44.74	**$60.80**	$39.33	$26.89

Summary:

Rye not only had the highest yields but reached the target stages 10 days quicker than triticale. A 10 day delay in planting the subsequent corn or soybean crop would have huge ramifications on yield (~10 bu/ac corn, ~4 bu/ac soybean). Based on data collected to date, 60 N appears to be the optimal N rate for rye. Rye consistently had highest revenue at 60 N based on current production costs. Rye has excellent winter survival, the best of all species evaluated in this trial. The winter of 2014 may have destroyed some of our sites but it gave us a great idea of winter hardiness between crops. This is no more evident than in Image 1. The strips of rye have survived from end to end, while the other crops are either non-existent or very thin from ice or low temperature kill.

Image 1: Winter Survival May 2014

Triticale has high yield potential but late maturity (10 days later than rye) and high seed costs. 60 N appears to be the optimal N rate for triticale, but results were variable across locations.

Barley yields were very poor in 2013. Something seemed wrong with the winter barley in this trial: many long term winter barley growers noted the same problems in other fields. Winter barley normally matures much quicker than wheat, but the barley was slow to mature and growth was extremely slow (2013). This may have been a result of the October planting date, or more likely is due to cold injury on the barley. Winter barley is the least cold tolerant of all the crops tested. In 2014 we again saw the effects the winter can have on winter barley. Winter barley was completely killed off at many locations. However, survival was much better at the sites planted in September, demonstrating how crucial planting date is with winter barley. Yields did increase in 2014 but still remained below rye. Barley had the highest response to high N rates, typically reaching highest profitability at 90 N.

Wheat is slow to mature in the spring: 10 days behind rye, just slightly later than triticale. Yields lagged well behind rye. Wheat as a forage generally reached maximum economic return with 60 N. Producers thinking of growing winter wheat for forage would be well advised to grow rye instead.

2014 forage analysis results will be summarized in subsequent reports.

Next Steps:

This trial is now complete.

Acknowledgements:

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