2015 Annual Report for the Agriculture Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Nitrogen Response to Modern Fall Rye Varieties

Project Number: 20140298

Producer Group Sponsoring the Project: Western Applied Research Corporation

Project Location(s):

- Indian Head, Saskatchewan, R.M. #156
- Scott Saskatchewan, R.M. #380 Legal land description: NE 17-39-20 W3
- Melfort Saskatchewan, R.M. # 429
- Redvers Saskatchewan, R.M. # 61 **did not seed trial this year*

Project start and end dates (month & year): July 2014 to November 2015

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Objectives and Rationale

Project objectives:

The objective of this trial was to demonstrate the nitrogen requirements of a hybrid versus conventional fall rye variety. This demonstration will show farmers the yield potential, as well as compare the benefits and negative attributes of conventional vs hybrid fall rye varieties under high input systems.

Project Rationale:

Recent breeding efforts have improved the yield potential and other agronomic qualities of fall rye. Hazlet, the newest fall rye variety released by AAFC has 13 % higher yield potential than the older variety, Prima, in Saskatchewan's Zone 1 & 2 (SaskSeed Guide, 2015). New European fall rye varieties have shown up to 30 % higher yields (Winter Cereals Canada, 2013). Fall rye is traditionally grown as a low-input crop, likely because it has relatively high nitrogen use efficiency compared to winter wheat. However, farmers may require higher rates of nitrogen fertilizer to reach maximum yield potential of modern fall rye varieties.

Methodology and Results

Methodology:

At Scott, Indian Head and Melfort, the demonstration was set up as a randomized complete block design with four replicates. A complete 2 x 6 factorial set of treatments include two rye varieties (Hazlet and Brasetto) and six nitrogen (N) fertilizer rate (ranging from 0 to 250 kg N/ha) (Table 1). At Scott and prior to seeding, soil samples were collected at three depth increments (0-15cm, 15-30cm and 15-60 cm) in order to determine fertilizer rates (Table 2). Fall rye seed was treated with Cruiser Maxx at a rate of

225 ml/ 1000 kg of seed prior to seeding. On August 29th 2014, the fall rye was direct seeded into chem-fallow using 10" row spacing at 61 kg/ ha. At seeding, nitrogen was applied as urea and side-banded, while 25 lb of phosphorous (11-52-0) was applied in the seed-row.

At Indian Head, both fall rye varieties were seeded at 200 seeds/m^2 and MAP (11-52-0) was side-banded to supply 30 kg P_2O_5/ha. K_2SO_4 (0-0-53-18) was seed-placed to supply 16 kg S/ha whiles Urea (46-0-0) in granular form was side-banded as per the treatments.

At Melfort, soil residual N was 18 lb/ac at 0-6 inch depth, and 7 lb/ac at 6-12 inch depth while available P2O5 exceeded 60 lb/ca and K exceeded 600 lb/ac. Available SO_4 was 12 lb/ac at 0-6 inch depth and 7 lb/ac at 6-12 inches prior to seeding the trial in fall of 2014. Prior to seeding, 1 l/ac of Roundup Transorb was applied for broad spectrum weed control. Fall rye seed treated with Cruiser Max was seeded September 11, 2014 at 300 viable seeds per square meter, along with 20 kg/ha of seed placed P_2O_5 as 12-52-0 fertilizer. Urea (46-0-0) in granular form was side-banded as per the treatments. The fall rye crop was harvested August 28, 2015.

Table 1. Fall rye varieties and nitrogen rates

Treatment #	Fall Rye Variety	N Rate (kg/ha)
1	Hazlet	0
2	Hazlet	50
3	Hazlet	100
4	Hazlet	150
5	Hazlet	200
6	Hazlet	250
7	Brasetto	0
8	Brasetto	50
9	Brasetto	100
10	Brasetto	150
11	Brasetto	200
12	Brasetto	250

Table 2. The soil residual nutrients based (lbs/ac)

Nutrients	0-15 cm	15-30 cm	15-60 cm	Total
NO_3	33	11	11	55
PO_4	>60	-	-	0
K	>600	-	-	0
SO_4	7	7	9	23

Data Collection:

At Scott, the plant densities were determined by counting numbers of emerged plants on 2 x 1 meter row lengths per plot at 10 days after first rows became visible. Lodging assessment was based on the Belgian Lodging Scale and was assessed when the plant reached maturity (Zadoks 87). Plant heights were collected from 5 plants per plot to determine the average height of each plot *(this was added to the protocol).* Yields were determined from the harvested grain samples which were cleaned and corrected to 14.5 % seed moisture content. Lastly, protein analysis was conducted to determine the effect of nitrogen on overall grain protein content. Weather data was estimated from the Scott Environment Canada weather station.

At Indian Head, lodging assessment was also based on the Belgian Lodging Scale and assessed once the plant reached maturity (Zadoks 87). Plant heights were collected from 4 plants per plot to determine the average height of each plot. Yields were determined from the harvested grain samples which were cleaned and corrected to 14.5 % seed moisture content. Grain protein analysis was conducted at Scott, SK.

At Melfort, the yields were determined from the harvested grain samples which were cleaned and corrected to 14.5 % seed moisture content. Fall head counts were conducted to determine the total plant heads/ m^2 for each plot. Grain protein analysis was also conducted at Scott, SK.

Growing Conditions:

Mean monthly temperatures, precipitation and growing degree days (GDD) data are presented relative to the long-term averages for Scott in Table 3, respectively. In 2014 at Scott, temperatures and precipitation amounts were close to normal for much of the growing season. Although, June was slightly cooler than normal and July received 178 % of the long-term normal precipitation. In 2015 at Scott, the early growing season was very dry with only 4.1 and 19.4 mm accumulated precipitation during the month of May and June, respectively. In contrast, August received approximately 39 % more moisture compared to the long term average. The mean monthly temperatures were comparable to previous years, but there was little precipitation in the early growing season. At Scott, the trial was located in a low lying area, resulting in an accumulation of moisture when the snow melted. This flooding resulted in poor germination and increased stress in two of the four replications within this trial. Therefore, most of the data from Scott was not combined with that of Indian Head and Melfort sites.

At Melfort, June of 2014 was abnormally cool and wet (Table 3 and 4) with near normal precipitation during August of 2014 (Table 4) adequate for crop establishment. The spring of 2015 was much drier than normal and this persisted until the first significant rainfall of 12 mmm was received June 12. Because conditions were so dry, plant counts were delayed in an attempt to wait until a more uniform stand was evident, and in the end were not done. July of 2015 was much wetter than normal and due to the short and intense downpour; much of the precipitation did not infiltrate into the soil, but ran off the trial site but did not incur any persistent flooding. However, near normal rain for the remainder of the 2015, along with slightly above normal temperatures did provide good growing conditions.

In 2014-15 at Indian Head, moisture conditions were considered excellent in the fall and the rye got off to a strong start. While there was adequate snow cover through the winter and good initial soil moisture reserves, most of the snow had melted by the second week in April and the rest of the spring was extremely dry with no significant precipitation events until late June. At this point the fall rye was already flowering and yields had already been limited by the lack of spring moisture. Moisture conditions remained adequate for the remainder of the growing season. Temperatures throughout the growing season were generally close to the long-term (1981-2010) average.

Table 3. Mean monthly temperatures amounts along with long-term (1981-2010) averages for the 2014 and 2015 growing season at Scott, Melfort and Indian Head, SK.

Location	Year	May	June	July	August	Average
	------------------------------*Temperature (^{O}C)*--					
Scott	2014	9.3	13.9	17.4	16.8	14.4
	2015	9.3	16.1	18.1	16.8	14.3
	Long-term	*10.8*	*15.3*	*17.1*	*16.5*	*14.9*
Melfort	2014	10.0	14.0	17.5	17.6	14.8
	2015	9.9	16.4	17.9	17.0	15.3
	Long-term	*10.7*	*15.9*	*17.5*	*16.8*	*15.2*
Indian Head	2015	10.3	16.2	18.1	17.0	15.4
	Long-term	*10.8*	*15.8*	*18.2*	*17.4*	*15.6*

Table 4. Mean monthly precipitation amounts along with long-term (1981-2010) averages for the 2014 and 2015 growing season at Scott, Melfort and Indian Head, SK.

Location	Year	May	June	July	August	Total
	----------------------------------*Precipitation (mm)*--					
Scott	2014	23.1	60.4	128	30.1	241.6
	2015	4.1	19.4	46.4	74.5	224.5
	Long-term	*36.3*	*61.8*	*72.1*	*45.7*	*215.9*
Melfort	2014	24.3	167.3	38.8	57.9	288.3
	2015	7.1	54.8	149.8	57.4	269.1
	Long-term	*42.9*	*54.3*	*76.7*	*52.4*	*226.3*
Indian Head	2015	15.6	38.3	94.6	58.8	192
	Long-term	*51.8*	*77.4*	*63.8*	*51.2*	*244*

Table 5. Accumulated Growing Degree Days with long-term (1981-2010) for the 2015 growing season at Scott and Melfort, SK.

Location	Year	May	June	July	August	Accumulated
	------------------------------*Growing Degree Days*--					
Scott	2015	140.3	332.0	405.1	365.8	1243.2
	Long-term	*178.3*	*307.5*	*375.1*	*356.5*	*1217.4*
Melfort	2015	171.7	342.0	399.9	372.0	1286.6
	Long-term	*191.7*	*327.0*	*387.5*	*365.8*	*1272.0*

Analysis:

All data was statistically analysed using the PROC MIXED of SAS 9.3. The residuals were tested for normality and equal variance to meet the assumptions of ANOVA. If these assumptions were not met, the data was transformed using either square root or LOG transformation. All data presented was back-transformed for ease of reporting. The means were separated using a Tukey's Honestly Significant Difference (HSD) test with level of significance at 0.05. Both site and replications were treated as random effect factors whiles treatments (varieties and nitrogen rates) as fixed effect factors.

The plant emergence was representative of the Scott site, to depict the difference in emergence within the trial caused by early season flooding. Plant height, lodging, and yield data from Scott was analyzed separately due to discrepancies in results compared to the Indian Head and Melfort data. The yield data presented was a combined analysis from Indian Head and Melfort. The protein data was a combined analysis from Scott, Indian Head and Melfort.

Results

Plant Emergence

At the Scott site, variety played a significant role (P = 0.0096) in overall plant emergence with the Hazlet variety having a 34 % increase in emergence compared to the Brasetto variety. Although not statistically significant, there was a tendency for the plant emergence to decrease as nitrogen rates increased (Table 6). This trend may be due to the sensitivity of young and emerging plants to higher N availability as noted in a study by Chmelìková and Hejcman (2014). Chmelìková and Hejcman (2014) reported the highest mortality rate in treatments with N supply, due to the sensitivity of young plants to high N availability in zigzag clover (*Trifolium medium* L.). We expected a significant difference between treatments as plant density ranged from 105 plants/ m^2 to 67 plants/ m^2. This non-significant result between nitrogen treatments could be associated with the high degree of variability within the trial. This trial was located in a low lying area that captured an excessive amount of water during the spring run-off. The variability is therefore likely attributed to the excessive moisture at the beginning of the growing season, resulting in poor emergence throughout the trial.

Table 6. The effect of variety and nitrogen rates on mean plant emergence (plants/ m^2) at Scott, 2015.

Variety		**Nitrogen Rate**	
---------------------*p value* ----------------		---------------------*p value* -------------------	
0.0096		0.5822	
Treatment	*Means*	*Treatment (kg/ha)*	*Means*
Hazlet	103^{A}	0	105 ^{A}
Brasetto	68^{B}	50	94 ^{A}
		100	88 ^{A}
		150	76 ^{A}
		200	74 ^{A}
		250	67 ^{A}

Plant Height & Lodging

Plant height was significant between varieties, as the hybrid variety (Brasetto) was 21 % shorter compared to Hazlet. Lodging was not significant at the Scott site, however, this was not expected as lodging is a typically characteristic of the Hazlet variety (Gross, 2012). Cereal varieties that are less prone to lodging typically result in a yield bump for two reasons: (1) a reduced stem growth rate during seed development could result in more fertile florets and therefore more grain per square metre and (2) they could respond to greater amounts of fertilizer because they were less susceptible to lodging (Berry et al. 2004). For these reasons, Brasetto, the shorter variety, will likely result in a yield increase compared to taller variety, such as the Hazlet.

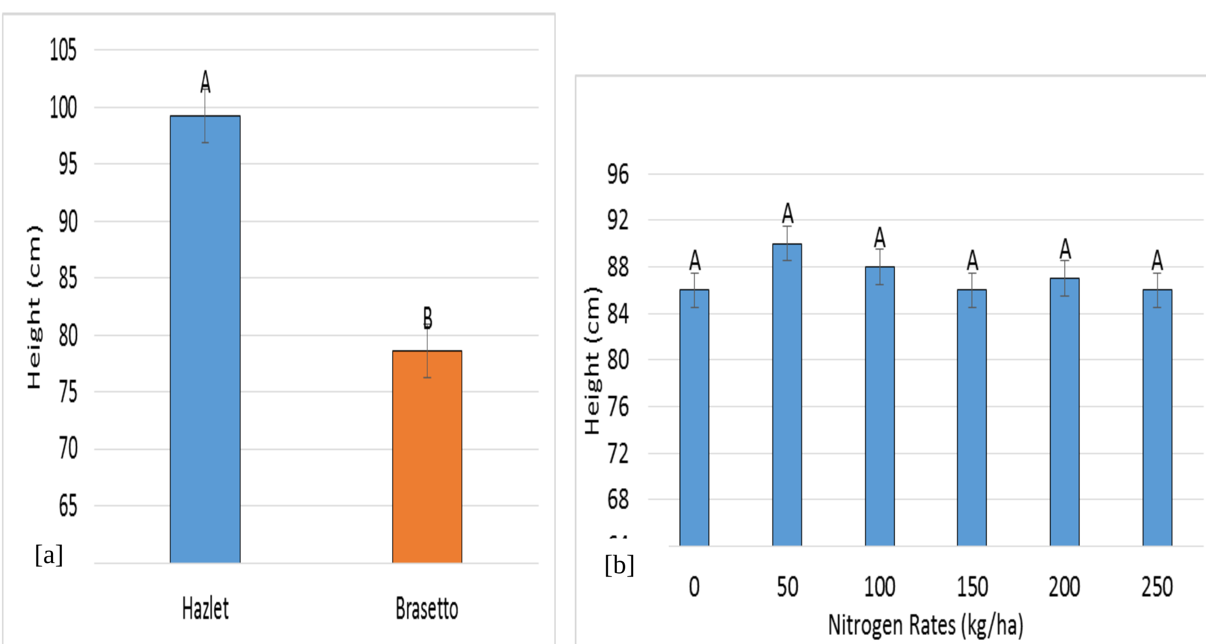

Figure 1. The effect of variety [a] and N rates [b] on plant height at Scott

Grain Yield

Yield and plant height can be strongly interrelated, as a taller variety will put more energy and resources into plant growth relative to seed production (Flintham et al. 1997). There was an inverse correlation (r = -1) between plant height and yield (Figure 2) at the Scott site. The shorter variety, Brasetto, produced a 16 % greater yield but was 20 % shorter compared to Hazlet (Figure 2). This demonstrated that a greater portion of N was allocated for seed production rather than stem elongation.

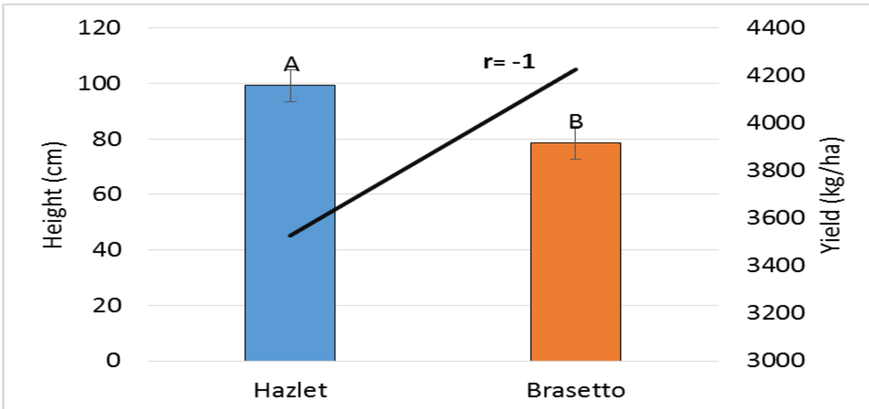

Figure 2. An inverse correlation between plant height and yield, demonstrating the allocation of resources from stem elongation to seed production

The yield data collected from Indian Head and Melfort also suggested that both varieties reached their maximum yield at a rate of 185 to 190 kg of N/ ha (Figure 3). This indicated that both varieties were very responsive to the N applications. The response curve of the two varieties was parallel, but Brasetto (hybrid variety) produced 16 % more yield compared to Hazlet. This indicates that Brasetto required the same amount of N as Hazlet to reach maximum yield, but it has a higher N use efficiency, as it was able to convert more N to yield compared to the conventional variety.

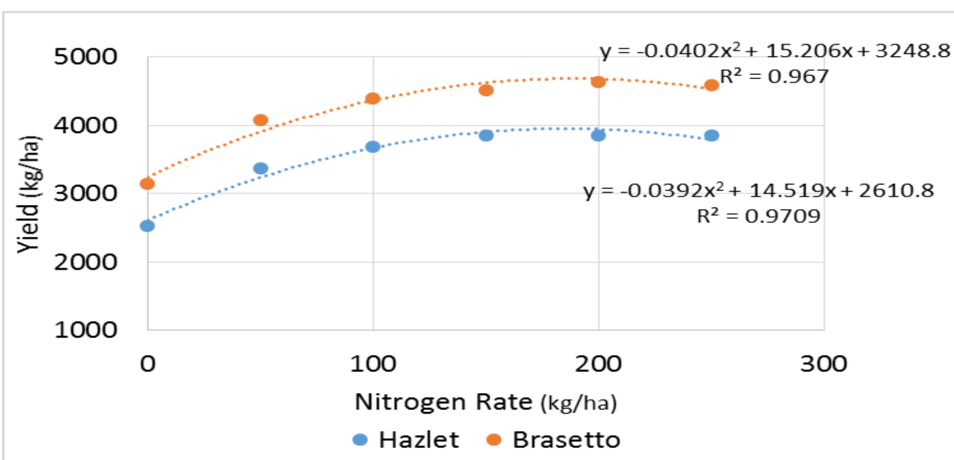

Figure 3. Yield response of Hazlet and Brasetto to N applications at Indian Head and Melfort, 2015

Although Indian Head and Melfort saw a varietal difference in yield production, the results contrast the findings at Scott. There was not a significant difference in yield due to varieties or varying N rates (Table 7). The contrast in results between sites could be attributed to the poor germination previously discussed. However, the inconsistency could also signify that under unfavourable growing conditions of excess moisture, both varieties might preform equally. In Indian Head and Melfort, moisture was not a limiting factor and therefore the varieties were better able to utilize the available nitrogen, resulting in a yield difference.

Table 7. The effect of variety and nitrogen rates on the mean yield (kg/ha) at Scott, 2015.

Variety		**Nitrogen Rate**	
---------------------*p value* ----------------		---------------------*p value* -------------------	
0.5829		0.5822	
Treatment	*Means*	*Treatment (kg/ha)*	*Means*
Hazlet	4503[A]	0	4373[A]
Brasetto	3927[A]	50	4550[A]
		100	4155[A]
		150	3702[A]
		200	3841[A]
		250	4668[A]

Grain Protein

Grain protein content is an important quality factor in cereals like wheat and rye, as it helps determine milling quality (Bushuk, 1977). Protein content for cereals is largely influenced by variety, N rate and environmental growing conditions such as moisture and temperature (Fowler et al. 1990; Campbell et al. 1977). From this study, the effect of variety was significant ($P = 0.0313$), with Hazlet (a low yielding variety), having a significantly greater protein content compared to Brasetto (Figure 4). Terman (1979) and Clark et al. (1990) found similar results, in which wheat cultivars with higher yield potential tended to have lower protein content than varieties with low yield potential. This corresponds with the yield results from Indian Head and Melfort (Figure 3), as Brasetto, a higher yielding variety, resulted in lower protein content. Higher yielding varieties typically have lower protein content because as yield increases it dilutes the available N and depletes the seed N required for protein synthesis (Campbell et al. 1977; Clark et al. 1990).

The application of N had the most significant ($P < .0001$) effect on protein content, as protein levels increased linearly with incremental increases of applied N (Figure 4). A 27 % increase in protein level was noted when available N ranged from 0 to 250 kg of N/ha. Protein content increased as a greater amount of seed N was available for protein production. However, both varieties did not reach their maximum protein content. It was concluded that an application of 308 kg of N / ha would be required to reach a maximum protein level of 12.7 %. Growing conditions also influence protein content, as a greater difference in yield and grain protein content tend to be larger under optimum growing conditions (Terman

1979). Under N limited conditions (0 kg of N/ha) the difference between the protein content of the high yielding (Brasetto) and low yielding (Hazlet) variety was less substantial (5.8 %) compared to when N was abundant (250 kg of N/ ha) (8.3%) (Figure 4). This is because under N deficient conditions, small additions of N will increase crop yield without significantly increasing protein (Gauer et al. 1992). Therefore, from this data it can be concluded that the higher yielding hybrid, Brasetto, had greater nitrogen use efficiency but a lower protein content compared to the conventional, open-pollinated variety, Hazlet. These results coincide with a similar study conducted at Brandon, Winnipeg (2011- 2012) in which Hazlet produced less yield and was taller.

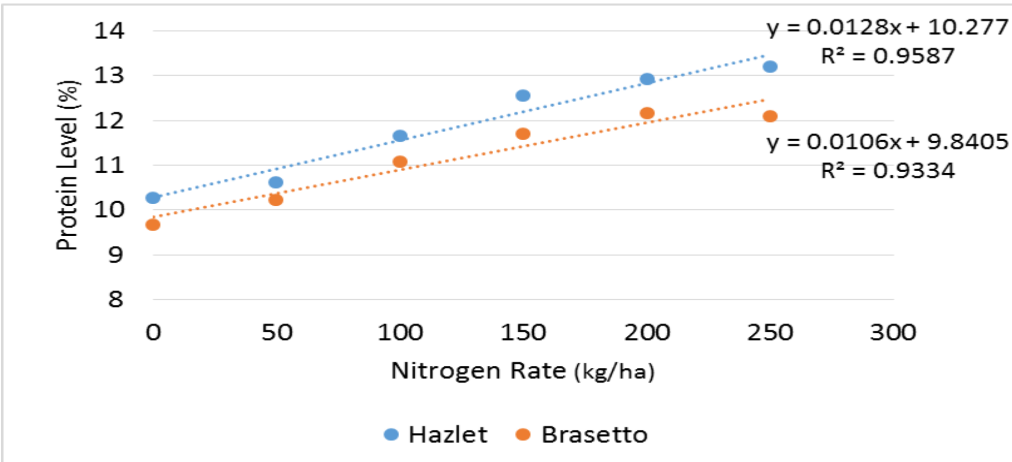

Figure 4. Protein percent response of Hazlet and Brasetto to N applications at Indian Head, Scott and Melfort, 2015

Conclusions and Recommendations

The open-pollinated conventional variety (Hazlet) was 20 % taller and more susceptible to lodging compared to the new, hybrid variety (Brasetto). Brasetto is less prone to lodging and it resulted in a yield increase. Shorter varieties allocate less energy for stem elongation and more for seed production. Brasetto produced 16 % more yield compared to Hazlet using the same amount of fertilizer N applied. This indicated that Brasetto had higher N use efficiency, as it utilize the same amount of N to reach a greater maximum yield compared to Hazlet. However, Hazlet had a greater protein content compared to Brasetto. This result was expected as a high yielding variety typically results in a lower protein content as more N is partitioned for seed production rather than protein synthesis. To conclude, Brasetto has the same N requirements but is better able to utilize the available N to produce greater yields. Brasetto has a greater yield potential, with a shorter height and is less prone to lodging while Hazlet provided better protein content. Therefore, depending on the target market (i.e. bread making vs. feed production) both varieties have value within their respective markets.

Technology Transfer:

This project was shown to people at the Scott Field Day in July 2014. Brian Fowler discussed the new developments and market for fall rye at the Scott Field Day in 2014. It was also featured in the Scott Field Day pamphlet and posters that were distributed throughout the surrounding Wilkie, Landis, and Unity. The site was also signed with an explanation of the project so that people going by can see the project. An article in the WARC newsletter and a fact sheet on the WARC website will also be part of transferring the information to producers. This trial was also discussed by Jessica Weber at the Melfort Field Day 2015. Signs stating the objective of this demonstration with acknowledgement of the ADOPT program and the Saskatchewan Ministry of Agriculture were posted in front of the plots. WARC, NARF and IHARF would like to express their appreciation for ADOPT funding provided by the Ministry of Agriculture for the project.

Supporting Information

Acknowledgements

The project was supported by the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canada-Saskatchewan Growing Forward 2 bi-lateral agreement. Acknowledgement of the Saskatchewan Ministry of Agriculture's support for this demonstration will be included as part of all written reports and oral presentations that arise from this work.

Appendices

Abstract

Abstract/Summary

Recent breeding efforts have improved the yield potential and nitrogen use efficiency of fall rye, particularly the hybrid varieties. The yield potential of AAFC's most recent fall rye variety Hazlet is 13 % higher than the older variety, Prima (SaskSeed Guide, 2015). While Brasetto, a newly available European hybrid, has shown up to 30 % higher yields compared to Prima (Winter Cereals Canada, 2013). Although these new varieties have a greater yield potential, they may require higher rates of N fertilizer to reach maximum yield potential.This study demonstrated the nitrogen requirements of a hybrid versus conventional fall rye variety and showed their yield potential and benefits under high input system. The experiment was carried out at three locations in SK (Scott, Indian Head and Melfort) with treatments arranged in a randomized complete block design with four replications. Results from the study showed that despite the non-significant effect of N rate at Scott, Hazlet had 34 % higher emergence than the Brasetto. Brasetto was 20 % shorter than Hazlet, but lodging was not a significant factor. Finally, yield was significantly affected by both variety and N rate with Brasetto having 16 % higher yield than the

Hazlet and both varieties maximizing their yield potentials at N rate between 185 to 190 kg N/ha. Protein % followed a reverse trend (Hazlet > Brasetto), possibly due to the dilution effects the extra yield in Brasetto might have on its % protein. The findings from this research is that, in order to maximize yield in fall rye, farmers may apply up to a maximum N of 200 kg N/ha. Brasetto required the same amount of fertilizer as Hazlet to reach their maximum yield, but Brasetto produced a higher yield. Therefore, Brasetto, has a higher N use efficiency and will produce greater yields with a lower protein content compared to Hazlet.

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