2018 Annual Report
for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Demonstrating 4R Nitrogen Management Principles for Canola

(Project #20170320)

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Project Identification

1. **Project Title:** Demonstrating 4R Nitrogen Principles for Canola
2. **Project Number:** 20170320
3. **Producer Group Sponsoring the Project:** Indian Head Agricultural Research Foundation
4. **Project Location(s):** Indian Head, Saskatchewan, R.M. #156
5. **Project start and end dates (month & year):** October 2017 to February-2019
6. **Project contact person & contact details:**

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Objectives and Rationale

7. **Project objectives:**

Developing Best Management Practices (BMPs) for nutrient applications has long been focussed on the 4R principles which refer to using the: 1) right source, 2) right rate, 3) right time, and 4) right placement. These factors are not necessarily independent of each other. For example, depending on the source, application timings or placement options that normally might be considered high risk can become more viable. The objective of this project was to demonstrate canola response to varying rates of nitrogen (N) fertilizer along with different combinations of formulations, timing, and placement options relative to side-banded, untreated urea as a benchmark. While certainly not all inclusive, the treatments evaluated encompassed all four considerations for 4R nutrient management (source, rate, time and placement) and included several practical options for Saskatchewan canola growers.

8. **Project Rationale:**

Nitrogen is the most commonly limiting nutrient in annual crop production and N fertilizer is often one of the most expensive crop inputs, particularly for crops with high N requirements like spring wheat. Most inorganic N fertilizers contain NH_4-N but some, such as urea ammonium-nitrate (UAN), also contain NO3-N. Since the advent of no-till and innovations in direct seeding equipment, side- or mid-row band applications and single pass seeding / fertilization quickly became the standard and most commonly recommended BMP for N fertilizer. Side- or mid-row banding is effective with the major forms of N including anhydrous ammonia (82-0-0), urea (46-0-0) and UAN (28-0-0) with the combination of concentrating fertilizer (safely away from the seed-row) and placing it beneath the soil surface dramatically reducing the potential for environmental losses while maintaining seed safety compared to previous options. Fall applications of N have always been popular, at least on a regional basis, in that fertilizer prices are usually lower, and applying N in a separate pass can reduce logistic pressure during spring seeding when labour and time are more limited. It is primarily for these logistical reasons that an increasing number of producers have been considering two-pass seeding/fertilization strategies. While the N fertilizer timing and/or placement options associated with two-pass approaches are usually not ideal, enhanced efficiency formulations (EEF) can reduce the potential risks associated with applying N well ahead of peak crop uptake (i.e. fall applications) or sub-optimal placement methods (i.e. surface broadcast). The most common examples of EEF products include polymer coatings (i.e. ESN), volatilization inhibitors (i.e. Agrotain) and volatilization / nitrification inhibitors (i.e. Super Urea) Enhanced efficiency N products are more expensive than their more traditional counterparts; however, this higher cost may be justified by the potential improvements in efficacy and logistics advantages of alternative fertilization practices.

This project is relevant to producers because, for many, there has been a movement back to two-pass seeding fertilization systems in order to increase efficiency at seeding. While the intent is not necessarily to encourage two-pass seeding/fertilization system, it is important that they have flexibility in how they manage N fertility on their farms. By demonstrating different N fertilization strategies according to the 4R principles and providing data on their efficacy relative to benchmark BMPs, we can help farmers make informed decisions while taking into consideration both the advantages and potential disadvantages of various options. Canola is a good candidate for this project since it is amongst the most economically important crops in Saskatchewan, highly responsive to fertilization and a large user of N. A similar project was also conducted with CWRS wheat (ADOPT #20170321).

Methodology and Results

9. Methodology:

A field trial with canola was initiated near Indian Head, Saskatchewan (50.544 N, 103.605 W) to demonstrate the overall crop response to N rate and a selection of management strategies where N fertilizer rate, application timing, and placement were varied. Indian Head is situated in the thin-Black soil zone of southeast Saskatchewan and the soil is classified as an Indian Head clay with typical organic matter concentrations of 4.5-5.5%. The design was a four-replicate RCBD with 14 treatments (Table 1). The rates were 0, 0.5, 1 and 1.5x of a baseline soil-test adjusted target of 145 kg N/ha (residual NO_3-N plus fertilizer N). The placement/timing options were side-banding at seeding, fall surface application, and fall in-soil band while the forms included untreated urea, Agrotain (volatilization inhibitor), SuperUrea (volatilization plus denitrification inhibitors) and ESN (polymer coated urea). ESN was excluded from the fall broadcast treatments due to budget limitations and because broadcasting this product without incorporation is generally not recommended in potentially dry environments. The 1x rate was utilized in all N management strategies and was chosen to be close to optimal for maximizing yield potential but not excessive and therefore likely to reduce our ability to detect differences in efficiency amongst the treatments.

Table 1. Canola 4R N Management treatments evaluated at Indian Head in 2018

#	Rate (residual NO_3-N plus fertilizer)	Form	Time	Placement
1	0x (20 kg N/ha)	Urea	At Seeding	Side-band
2	0.5x (83 kg N/ha)	Urea	At Seeding	Side-band
3	1.0x (145 kg N/ha)	Urea	At Seeding	Side-band
4	1.5x (208 kg N/ha)	Urea	At Seeding	Side-band
5	1.0x (145 kg N/ha)	Agrotain	At Seeding	Side-band
6	1.0x (145 kg N/ha)	Super Urea	At Seeding	Side-band
7	1.0x (145 kg N/ha)	ESN	At Seeding	Side-band
8	1.0x (145 kg N/ha)	Urea	Late Fall	Surface Broadcast
9	1.0x (145 kg N/ha)	Agrotain	Late Fall	Surface Broadcast
10	1.0x (145 kg N/ha)	Super Urea	Late Fall	Surface Broadcast
11	1.0x (145 kg N/ha)	Urea	Late Fall	In-soil Band
12	1.0x (145 kg N/ha)	Agrotain	Late Fall	In-soil Band
13	1.0x (145 kg N/ha)	Super Urea	Late Fall	In-soil Band
14	1.0x (145 kg N/ha)	ESN	Late Fall	In-soil Band

Selected agronomic information along with dates of certain measurements are provided in Table 2. The trial was established in the fall of 2017 with soil nutrient sampling (September 21) and fertilizer applications (October 17) completed prior to any snowfall or frozen soils. The previous crop was wheat and the site was heavy harrowed prior to flagging. As required by protocol, fall-applied N fertilizer was either broadcast on the soil surface (no incorporation) or placed 4-4.5 cm beneath the surface in bands spaced 30 cm apart. For the side-band treatments, N fertilizer was placed at a similar depth as the fall band applications and was below and to the side of the seedrow. Fertilizer banding and seeding was completed with an eight opener SeedMaster drill. The glufosinate ammonium tolerant variety InVigor L233P was seeded on May 16. Nitrogen was applied as per protocol and 30-15-15 kg P_2O_5-K_2O-S/ha was applied to all treatments except in the control where no fertilizer was applied and it was assumed that N would be the most limiting nutrient. Weeds were controlled using registered pre-emergent and in-crop herbicides and foliar fungicide was applied at early bloom to prevent sclerotinia stem rot from becoming a yield limiting factor. No insecticides were required. Pre-harvest glyphosate was applied on August 10 (approximately 70% seed colour change) and the centre five rows of each plot were straight-combined using a Wintersteiger plot harvester on August 23.

Various data were collected over the growing season and from the harvested grain samples. The average NDVI of each plot was measured using a handheld GreenSeeker at three separate dates starting at the mid-bolting and continuing through the beginning of flowering. The relative chlorophyll content of the

2nd newest leaf was measured using a SPAD-502 meter at beginning of flowering (June 26) which coincided with the last of the NDVI measurements. The leaves from ten randomly selected plants per plot were measured and averaged. Lodging was negligible in all treatments, therefore detailed ratings were not completed. Grain yields were determined by weighing the harvested grain samples and are corrected for dockage and to a uniform seed moisture content of 10%.

All response data were analysed using the Mixed procedure of SAS with treatment effects considered fixed and replicate effects treated as random. Individual treatment means were separated using Fisher's protected LSD test and contrasts were used to describe the response to N rate and compare specific groups of treatments (i.e. side-band vs. fall broadcast; urea vs. Agrotain). All treatment effects and differences between means were considered significant at $P \leq 0.05$.

Table 2. Selected agronomic information for the canola 4R N management demo at Indian Head in 2018.

Factor / Field Operation	Indian Head 2017-18
Previous Crop	Wheat
Fall N Applications	October 17, 2017
Pre-emergent herbicide	894 g glyphosate/ha May 14, 2018
Seeding Date	May 16, 2018
NDVI	June 18, 21, & 25, 2018
In-crop Herbicide	500 g glufosinate ammonium/ha + 44 g clethodim/ha June 13, 2018
NDVI	June 18, 21, & 25, 2018
SPAD	June 26, 2018
Foliar Fungicide	242 g boscalid/ha + 82 g pyraclostrobin/ha June 30, 2018
Pre-harvest Herbicide	894 g glyphosate/ha August 10, 2018
Harvest date	August 23, 2018

10. Results:

Growing season weather and residual soil nutrients

The fall N treatments were applied relatively late in the season under cool conditions which is preferred to mitigate losses; however, the winter was dry with well below normal snow cover from November through February. While March snowfall improved conditions for seeding, the site was well drained and did not stay saturated for long in the early spring. Weather data for the 2018 growing season at Indian Head is provided with the long-term (1981-2010) averages in Table 3. Although there was less initial sub-soil moisture than previous seasons, the canola was seeded into adequate soil moisture for germination and timely late-May/early-June rains got spring seeded crops in the area off to a strong start.For May and June combined, precipitation was 88% of the long-term (1981-2010) average; however, July and August were much drier with only 34 mm of total precipitation, or 30% of the long-term average. Consequently, late season drought stress resulted in premature maturity and relatively low lodging and disease pressure. Temperatures were well-above average in May and, to a lesser extent, June but cool in July and approximately average in August. Over the four month period, the mean temperature was 16.4 °C compared to a long-term average of 15.6 °C.

Table 3. Mean monthly temperatures and precipitation amounts along with long-term (LT; 1981-2010) averages for the 2018 growing season (May through August) at Indian Head, SK.

Year	May	June	July	August	Avg. / Total
	---------- Mean Temperature (°C) ----------				
IH-2018	13.9	16.5	17.5	17.6	16.4
IH-LT	10.8	15.8	18.2	17.4	15.6
	---------- Precipitation (mm) ----------				
IH-2018	23.7	90.0	30.4	3.9	148
IH-LT	51.8	77.4	63.8	51.2	244

A composite soil sample was collected on May 4 (0-15 cm, 15-60 cm) and analyzed for basic properties and residual nutrient levels (Table 4). The site had a pH of 7.8 and soil organic matter content of 4.8% in the upper 15 cm profile. Residual N and P levels were considered low and likely to be limiting while K and S levels were considerably higher and relatively unlikely to be limiting.

Table 4. Selected soil test results for wheat 4R N management demo at Indian Head, Saskatchewan (2018).

Attribute / Nutrient	0-15 cm	15-60 cm	0-60 cm
pH	7.8	8.1	–
S.O.M. (%)	5.0	–	–
NO_3-N (kg/ha)[Z]	5	12	17
Olsen-P (ppm)	4	–	–
K (ppm)	401	–	–
S (kg/ha)	11	18	29

<u>*Field Trial Results*</u>

Individual treatment means and contrast results are deferred for the Appendices (Tables 5 and 6) while key results are presented graphically below in Figs. 1-6.

While NDVI is affected by factors other than nutrient status such as crop type and growth stage, the relative values can be useful for quantifying differences in vegetative growth between treatments and have been shown to be well-correlated with grain yield. Measurements were completed three times over a seven day period and the values for each plot were averaged. The overall F-test for canola NDVI was highly significant ($P < 0.001$) with means ranging from 0.373-0.630. The NDVI response to N rate was quadratic ($P < 0.001$) with a substantial increase in NDVI going from the 0-0.5x N rates followed by smaller increases with further increases in N rate (Fig. 1). The values amongst the various N management strategies, all of which received the 1x rate, were generally similar and the only significant difference was between fall-broadcast versus fall-banded SuperUrea, favouring the in-soil band (Fig. 2). The contrast comparisons (Table 6) showed only a marginally significant trend for higher NDVI with fall-banded versus broadcast N fertilizer (P = 0.055).

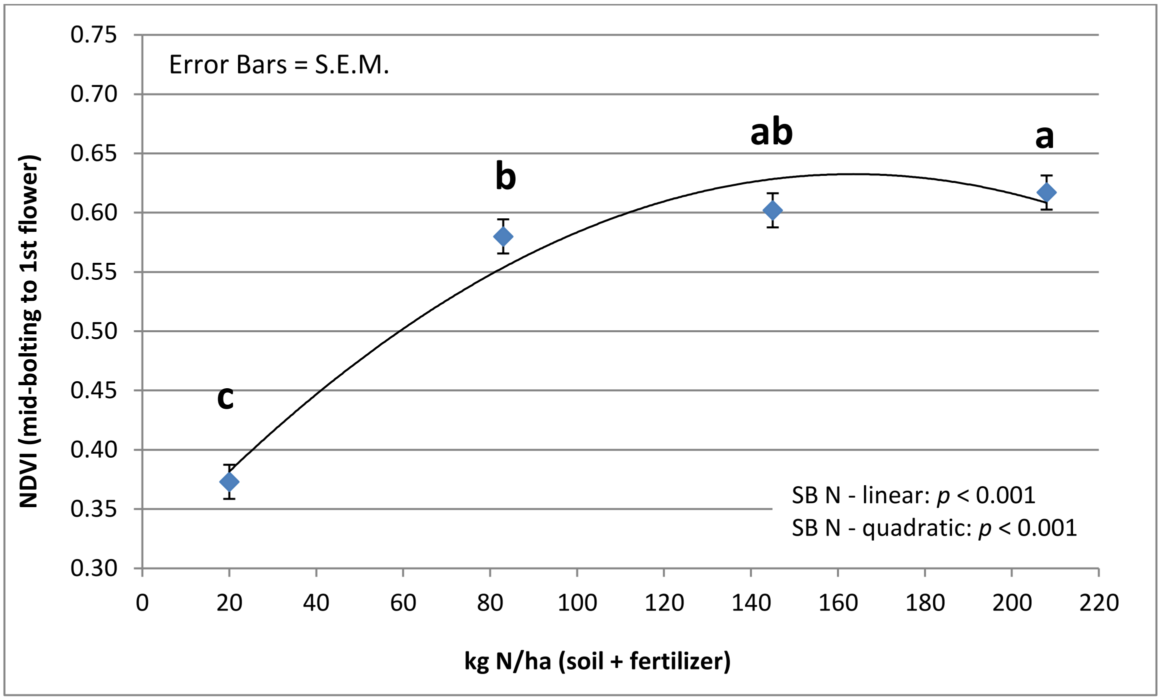

Figure 1. Side-banded urea rate effects on mean NDVI values in canola (3 dates from June 18-25, mid-bolting to 1st flower) at Indian Head in 2018.

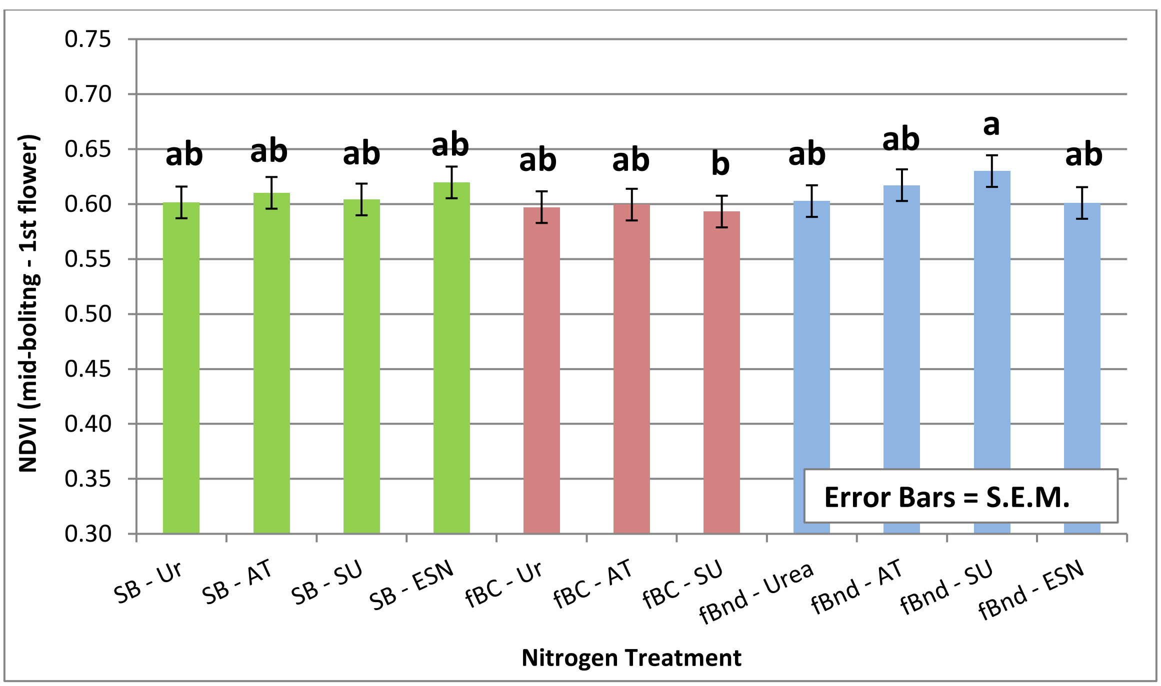

Figure 2. Nitrogen form/placement/timing effects on mean NDVI values in canola (3 dates from June 18-25, mid-bolting to 1st flower) at Indian Head (2018). SB – side-band, fBC – fall surface broadcast, fBnd – fall in-soil band, Ur - untreated urea, AT– Agrotain (NBPT) treated urea, SU – SuperUrea (NBPT + DCD), ESN – polymer coated urea.

Leaf chlorophyll (SPAD) measurements increased quadratically with the rate of side-banded urea (P = 0.002) in a similar manner as NDVI. The observed values were lowest in the control (47.7), intermediate at the 0.5x rate (54.1), and highest at the 1-1.5x N rates (57.7-58.8). There were a few noteworthy differences amongst the various N management strategies which all received the 1x N rate (Fig. 4). The lowest values were observed with fall surface broadcast urea and Agrotain (55.0-55.1) while the highest values were with side-banded urea and fall banded ESN (57.7-57.8). Aside from these extremes, few differences amongst the treatments fertilized at the 1x rate were significant and the only significant group comparison was for side-banded versus fall broadcast N, favouring the side-banded treatments.

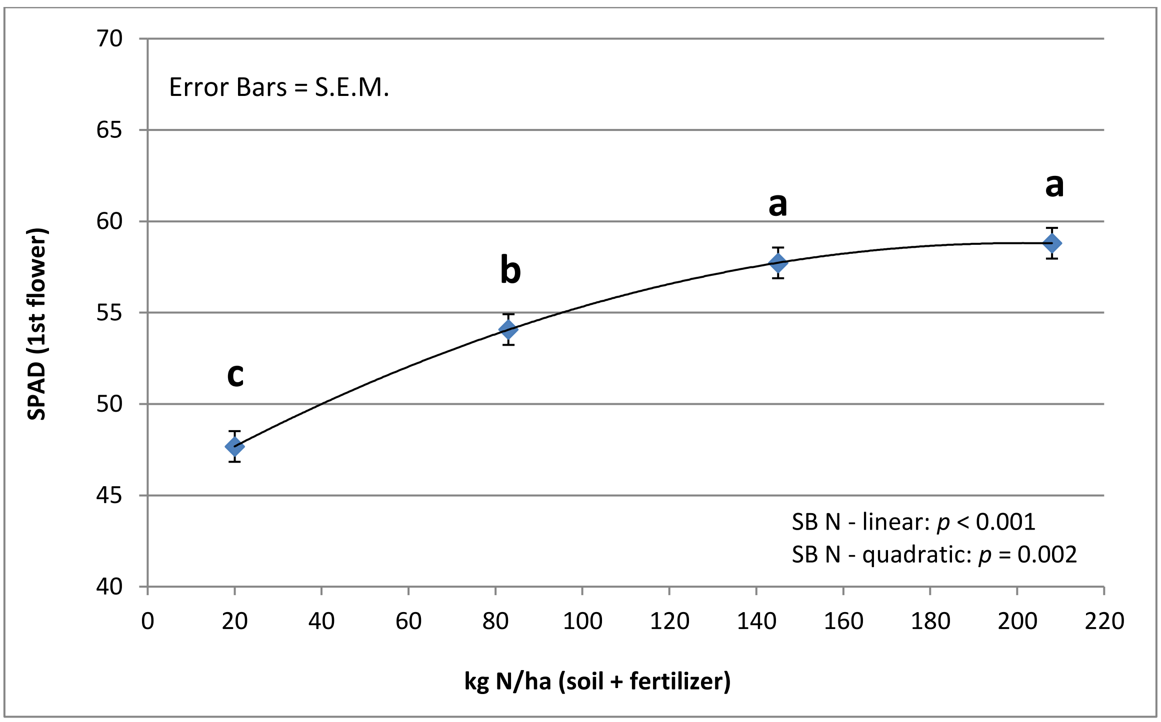

Figure 3. Side-banded urea rate effects on leaf chlorophyll (SPAD) values in canola (June 26, start of bloom) at Indian Head (2018).

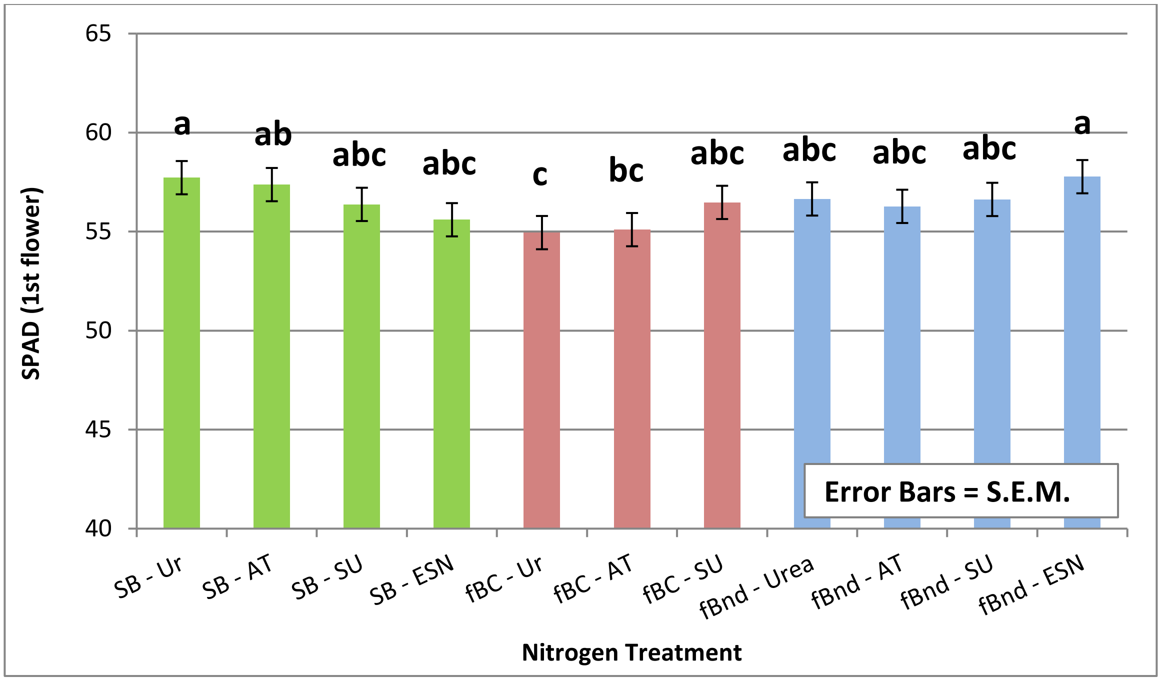

Figure 4. Nitrogen form/placement/timing effects on leaf chlorophyll (SPAD) measurements in canola (June 26, start of bloom) at Indian Head (2018). SB – side-band, fBC – fall surface broadcast, fBnd – fall in-soil band, Ur - untreated urea, AT– Agrotain (NBPT) treated urea, SU – SuperUrea (NBPT + DCD), ESN – polymer coated urea.

Overall canola yields were quite high considering the dry conditions with an overall average of 2833 kg/ha for the treatments that received the 1x N rate. The overall F-test was highly significant ($P < 0.001$) along with both the linear and quadratic response to N rate ($P < 0.001$; Fig. 5). Similar to the previous variables, yield was lowest in the control (1280 kg/ha), intermediate at the 0.5x rate (2525 kg/ha) and highest at the 1-1.5x rates (2940-2985 kg/ha). No significant differences between forms were significant within individual timing/placement options (Fig. 6; Table 5) and, further, none of the contrasts comparing forms across all applicable placement methods were significant (P = 0.362-0.849; Table 6). There were, however, significant differences amongst the timing/placement options which showed generally lower yields with fall surface broadcasting (particularly with urea and Agrotain) compared to the treatments where N was applied as either a fall in-soil band or side-banded during seeding. This observation was confirmed by the contrast results which indicated yield differences between both fall (in-soil) banded and side-banded N versus the fall surface broadcast N ($P < 0.001$) but no significant difference between fall-banded versus side-banded N ($P = 0.494$). Averaged across forms, yield with fall broadcast N were 2653 kg/ha, approximately 9% lower than the 2916 kg/ha and 2892 kg/ha achieved with fall-banding and side-banding, respectively. Within the fall surface-broadcast treatments, there was a tendency for higher yields with SuperUrea relative to either Agrotain or untreated urea. Yields with fall broadcast Super Urea did not significantly differ from those achieved with seven out of eight of the treatments where N was banded beneath the soil surface.

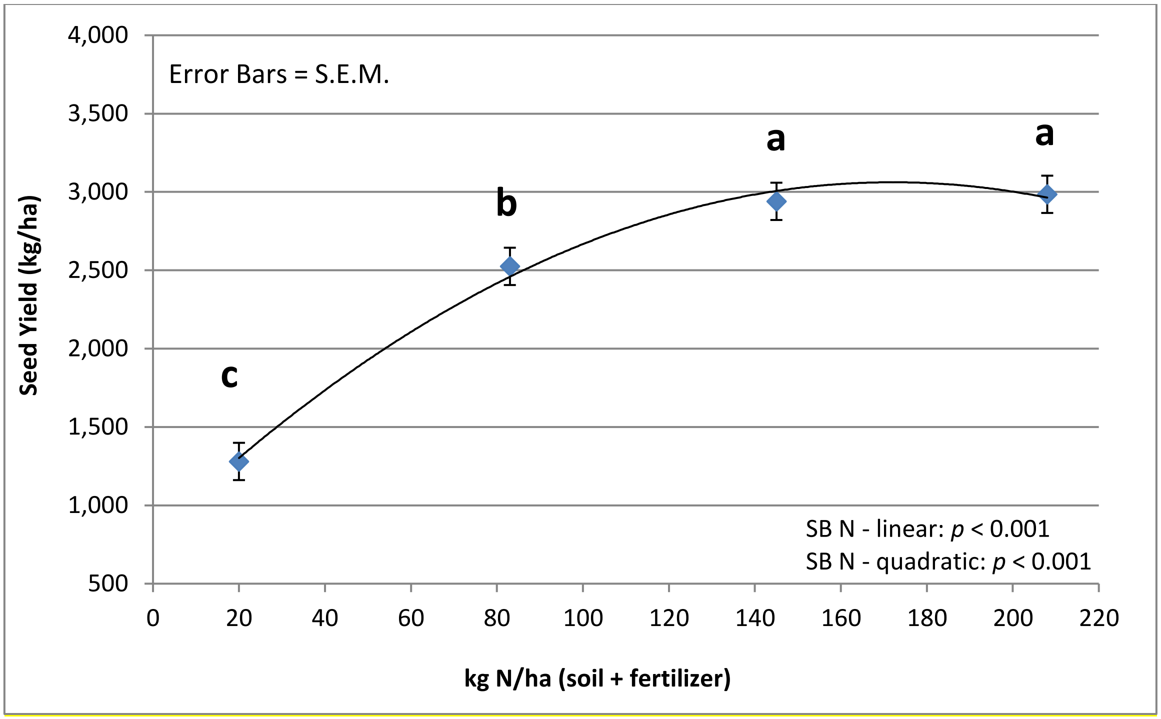

Figure 5. Side-banded urea rate effects on canola seed yield at Indian Head (2018).

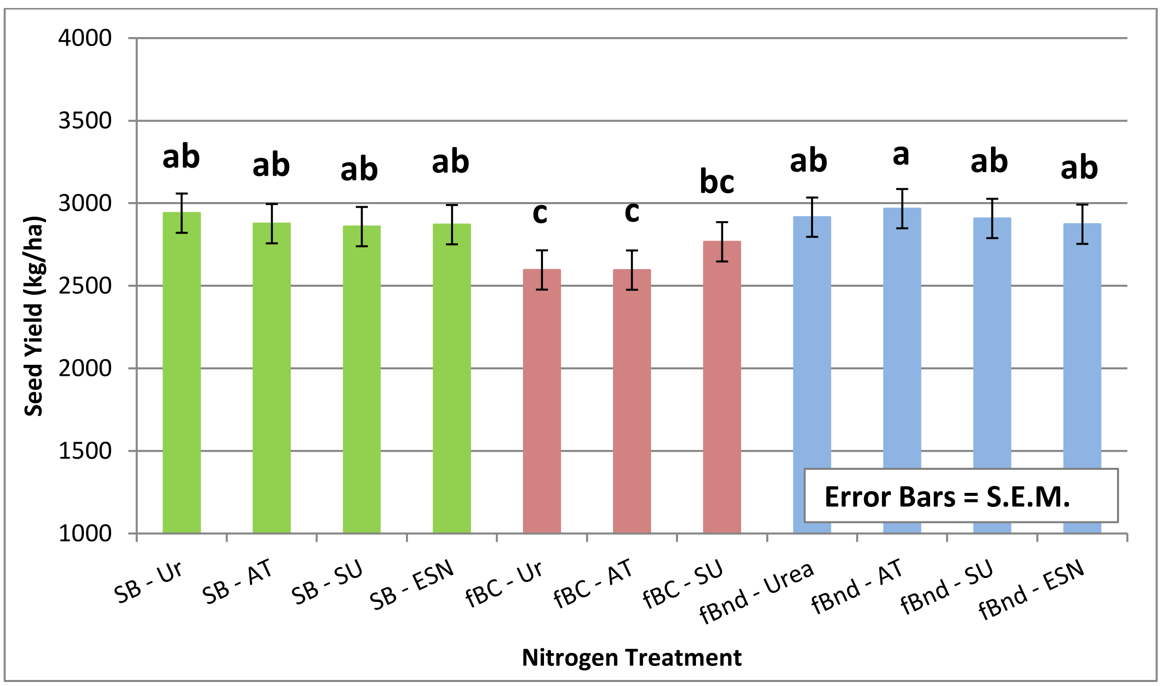

Figure 6. Nitrogen form/placement/timing effects on canola seed yield at Indian Head (2018). SB – side-band, fBC – fall surface broadcast, fBnd – fall in-soil band, Ur - untreated urea, AT– Agrotain (NBPT) treated urea, SU – SuperUrea (NBPT + DCD), ESN – polymer coated urea.

Extension Activities and Dissemination of Results

This specific demonstration could not be showcased during the main Indian Head Crop Management Field Day; however, the site was visited on numerous other smaller and/or informal tours throughout the season. Furthermore, the specific project details were discussed in detail at the wheat site (ADOPT #20170321) where Chris Holzapfel and Dr. Dan Heaney (Fertilizer Canada) led a discussion of both specific project details and opportunities for 4R Nutrient Stewardship designation and certification. The full project report will be made available online on the IHARF website (www.iharf.ca) and potentially elsewhere in the winter of 2018-19. Results may also be made available through a variety of other media (i.e. oral presentations, popular agriculture press, fact sheets, etc.) as opportunities arise and where appropriate.

Conclusions and Recommendations

Despite the dry weather, this project demonstrated strong canola responses to N fertilization along with the relative responses associated with several contrasting N management strategies. The in-season NDVI and SPAD measurements were both reasonably good indicators of the potential yield response to N. While the SPAD measurements tended to be more sensitive to the N status of the plants, NDVI has the advantage of being easier to measure over large areas and is generally better suited for characterizing spatial variability in productivity. Overall, the N response was strong with a maximum yield increase of 133% over the control with fertilization. Focussing on timing/placement, all of the options resulted in a strong N response and significant differences amongst individual treatments were relatively rare; however, there was an overall advantage to both side-banding and fall in-soil banding over the fall surface broadcast applications. The lack of significant contrasts comparing N fertilizer forms or differences between forms within timing/placement options suggests that canola responded similarly to all forms under the conditions encountered. The greatest exception to this was specifically for fall, surface-broadcasting where canola yields with SuperUrea tended to be higher than with untreated urea and Agrotain and did not significantly differ from 88% of the individual treatments where N fertilizer was banded beneath the soil surface. Nitrogen fertilizer management is very much affected by weather events and environmental conditions; therefore, the actual results that producers might experience with these N forms and placement options can vary greatly.

Supporting Information

11. Acknowledgements:

This project was supported by the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canada-Saskatchewan Growing Forward 2 bi-lateral agreement. Crop protection products used for both plot maintenance and treatments were provided in-kind by Bayer CropScience, BASF, Koch Agronomic Services and Nutrien. IHARF also has a strong working relationship and memorandum of understanding with Agriculture & Agri-Food Canada.

12. Appendices

Table 5. Treatment means, overall F-tests, and measures of variability for canola NDVI, chlorophyll (SPAD) measurements, and grain yield. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Treatment [Z]	NDVI (average)	SPAD (start of bloom)	Yield (kg/ha)
1. 0.0x N	0.373 d	47.7 f	1280 e
2. 0.5x N SB Ur	0.580 c	54.1 e	2525 d
3. 1.0x SB Ur	0.602 abc	57.7 ab	2940 ab
4. 1.5x SB Ur	0.617 ab	58.8 a	2985 a
5. 1.0x SB AT	0.610 abc	57.4 abc	2876 ab
6. 1.0x SB SU	0.604 abc	56.4 b-e	2859 ab
7. 1.0x SB ESN	0.620 ab	55.6 b-e	2870 ab
8. 1.0x fBC Ur	0.597 abc	55.0 de	2596 cd
9. 1.0x fBC AT	0.600 abc	55.1 cde	2595 cd
10. 1.0x fBC SU	0.593 bc	56.5 a-d	2766 bc
11. 1.0x fBnd Ur	0.603 abc	56.7 a-d	2916 ab
12. 1.0x fBnd AT	0.617 ab	56.3 b-e	2967 a
13. 1.0x fBnd SU	0.630 a	56.6 a-d	2908 ab
14. 1.0x fBnd ESN	0.601 abc	57.8 ab	2873 ab
$LSD_{0.05}$	0.0354	2.38	176.0
S.E.M.	0.0144	0.84	119.0
Pr > F (p-value)	<0.001	<0.001	<0.001

[Z] Including residual NO_3-N, total N rates were 20 (0.0x), 83 (0.5x), 145 (1.0x), and 208 kg N/ha (1.5x); SB (side band at seeding), fBC (fall surface broadcast) and fBnd (fall in-soil band) Ur - untreated urea, AT– Agrotain (NBPT) treated urea, SU – SuperUrea (NBPT + DCD), ESN – polymer coated urea

Table 6. Results of orthogonal contrasts and group comparisons for N management effects of selected canola response variables. Data were analyzed using the Mixed procedure of SAS and p-values greater than 0.05 indicated that a response or difference between groups of means was not significant.

Contrast	NDVI (average)	SPAD (start of bloom)	Yield (kg/ha)
	-------------------	p-value	-------------------
N Rate - linear	<0.001	<0.001	<0.001
N Rate – quadratic	<0.001	0.003	<0.001
fBC vs. fBnd	0.055	0.145	<0.001
SB vs. fBC	0.397	0.020	<0.001
SB vs. fBnd	0.666	0.916	0.494
Ur vs. AT	0.406	0.779	0.932
Ur vs. SU	0.397	0.942	0.587
Ur vs. ESN	0.509	0.551	0.362
AT vs. SU	0.987	0.724	0.530
AT vs. ESN	0.787	0.869	0.415
SU vs. ESN	0.589	0.823	0.849

[Z] SB (side band at seeding), fBC (fall surface broadcast) and fBnd (fall in-soil band) Ur - untreated urea, AT– Agrotain (NBPT) treated urea, SU – SuperUrea (NBPT + DCD), ESN – polymer coated urea

Figure 7. Canola growing without N fertilizer at Indian Head, Saskatchewan (2018).

Abstract

13. Abstract/Summary:

A field trial was established near Indian Head, Saskatchewan to promote 4R N stewardship and to demonstrate the overall canola response to N fertilization along with the relative performance of N fertilizer management strategies where the forms, timing of application and placement were varied. The weather was dry with below average snowfall the preceding winter and only 61% of the average growing season precipitation. For the first objective, 0x, 0.5x, 1.0x, and 1.5x of a baseline rate of 145 kg N/ha (soil residual plus fertilizer) was supplied as side-banded urea. Data collection included NDVI, leaf chlorophyll (SPAD) measurements, and yield, all of which were affected by N rate in a similar manner. The yield increase with N was 133% over the control with similar yields between the 1-1.5x rates. Focussing on N management strategies, the demonstration included four forms (untreated urea, Agrotain, SuperUrea, and ESN) and three timing/placement options (fall surface-broadcast, fall in-soil band, and side-band). Averaged across forms, yields with fall surface-broadcast applications were 9% lower than with either fall in-soil or side-banded N. Yields with were similar for fall banded versus side-banded N. Regarding forms, all performed similarly under the conditions encountered when averaged across timing/placement methods. Specifically with fall surface-broadcast placement, yields with SuperUrea tended to be higher than with either fall broadcast urea or Agrotain and did not differ from most individual treatments where N was banded beneath the soil surface. Nitrogen fertilizer management is sensitive to weather and environmental conditions; therefore, the actual results that producers might experience with these strategies can vary greatly. In general terms, soil testing is advised to account for the inherent fertility of the soil and better determine appropriate fertilizer rates. Side-banding continues to be recommended as a safe and effective practice that will provide consistent results over a broad range of environmental conditions. In the current demonstration, fall in-soil banding was also highly effective and, although the benefits can vary depending on the specific conditions encountered, enhanced efficiency fertilizer products can improve performance particularly with potentially risky practices such as fall-surface broadcasting.