2019 Annual Report
for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Input Contributions to Wheat Yield, Quality, and Profitability

(Project #20180507)

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Project Identification

1. **Project Title:** Input contributions to spring wheat yield, quality, and profitability
2. **Project Number:** 20180507
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):** May 2019 to February-2020
6. **Project contact person & contact details:**

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Objectives and Rationale

7. **Project objectives:**

The project objectives were to demonstrate the agronomic and economic responses of CWRS wheat to numerous crop inputs both individually and in various combinations. The treatments were selected to demonstrate the contributions of individual crop inputs when either added to a low input system or removed from a high input system.

8. **Project Rationale:**

Wheat, regardless of the class, is an important rotational crop for farmers and a major contributor to the Saskatchewan economy. The majority of wheat acres are seeded to high protein milling classes such as CWRS and CWAD. Provided that top grades and protein can be achieved along with high yields, wheat can also be quite profitable; however, consistently achieving both yield and quality while also managing input costs is a challenge for growers. Since assessing all possible input combinations was not feasible, the scope was narrowed to include various combinations of seed treatments, higher seeding rates, enhanced fertility, plant growth regulator, and foliar fungicide applications. Basic background information on the individual inputs that were varied in this demonstration follows.

Seed-Applied Fungicide

Seed-applied fungicides are registered to protect plants against soil borne pathogens and root diseases. Replicated research showing yield benefits to seed-applied fungicides is limited and generally shows they are most likely to be beneficial when using diseased seed or, perhaps to a lesser extent, in stressful environments such as cold and wet, or even very dry soils. That said, a large percentage of producers see these products as a form of insurance and, given that wheat tends to be one of the earliest seeded crops, applying seed-applied fungicides has become common practice for many growers. Seed-treatments are also frequently used to manage insect pests; however, in this case no specific insect issues were foreseen and the focus was on seed-applied fungicide products.

Higher Seeding Rates

The traditional recommended range of plant populations spring wheat is 215-270 plants/m^2; however, especially in environments where drought is reasonably unlikely and disease pressure is moderately high, some growers are targeting populations exceeding 300 plants/m^2. The rationale for the higher populations is primarily to reduce the infection window for fusarium head blight and make fungicide applications easier to time. That said, increasing seeding rates can increase the risk of lodging (depending on the variety and environmental conditions) and, under drought conditions, higher plant populations can lead to earlier maturity and potentially even negatively impact yield.

Fertility

The general response of spring wheat to the major crop nutrients has been well researched and all nutrients can potentially be limiting, depending on crop needs and the soil's capacity to meet them. Spring wheat has an estimated total uptake of 1.9-2.3 lb N/bu, 0.73-0.88 lb P_2O_5/bu, 1.63-2.00 lb K_2O/bu and 0.2 lb S/bu. While K and S are less likely to be limiting throughout most of Saskatchewan, soils low in N and P are common. Nitrogen fertility is also one of the most important management factors affecting grain protein concentrations, an important quality parameter for CWRS wheat where minimum standards must be met for top grades.

Plant Growth Regulator

The plant growth regulator (PGR) chlormequat chloride (Manipulator™ 620) was officially launched and clear for use in time for the 2018 growing season. This product has been evaluated in numerous industry and publicly funded trials dating back to 2013 and has performed consistently well at Indian Head with average yield increases of 12 bu/ac in 2013 (16%), 9 bu/ac in 2014 (12%), 7 bu/ac in 2015 (10%), 9 bu/ac (15%) in 2016 and 7 bu/ac (10%) in 2017. While yield increases are frequently observed, Manipulator is not registered for this purpose, but rather, for reducing plant height and, potentially, lodging. Shorter, more upright plants can increase harvest efficiency and, in many cases, yield. Past work suggests that PGR applications are most likely to be beneficial under intensive management where yield potential along with the risk of lodging are higher.

Foliar Fungicide

Fusarium head blight (FHB) is one of the most important factors reducing yield and quality of wheat in western Canada, particularly in wet years/regions. While improved genetic resistance will likely become increasingly important for managing FHB in wheat, foliar fungicides are the most commonly used tool for minimizing the impact of this disease on yield and quality. Even when FHB is not a yield limiting factor, the products used to control this disease are also effective against leaf spot diseases and, particularly when a fungicide is not applied at the flag-leaf stage, much of the yield responses can often be attributed to reduced leaf disease. In order to prevent potentially confounding effects, no fungicide products were applied at the flag-leaf stage in the current demonstration.

Methodology and Results

9. Methodology:

A field trial with spring wheat was initiated in 2019 near Indian Head, Saskatchewan (50.552 N, 103.606 W, thin-Black soil zone) to evaluate responses to several key inputs when either added to a low input agronomic package or removed from an intensively managed crop. The inputs that were varied included seed-applied fungicide, seeding rate, fertility, PGR, and foliar fungicide. The various treatments are described in Table 1. This project was intended to build upon a similar demonstration that was completed at Indian Head in 2018.

Table 1. Treatments evaluated in ADOPT Wheat Input Demonstration at Indian Head in 2019.

#	Name	Seed Trt (no/yes)	Seed Rate (seeds/m^2)	Fertility (kg/ha N-P_2O_5-K_2O-S)	PGR (no/yes)	Foliar Fungicide (no/yes)
1	Low Input	No	250	90-20-10-10	No	No
2	Low + Seed Treatment	Yes	250	90-20-10-10	No	No
3	Low + Seed Rate	No	400	90-20-10-10	No	No
4	Low + Fertility	No	250	135-40-20-20	No	No
5	Low + PGR	No	250	90-20-10-10	Yes	No
6	Low + Fungicide	No	250	90-20-10-10	No	Yes
7	High - Seed Treatment	No	400	135-40-20-20	Yes	Yes
8	High - Seed Rate	Yes	250	135-40-20-20	Yes	Yes
9	High - Fertility	Yes	400	90-20-10-10	Yes	Yes
10	High - PGR	Yes	400	135-40-20-20	No	Yes
11	High - Fungicide	Yes	400	135-40-20-20	Yes	No
12	High Input	Yes	400	135-40-20-20	Yes	Yes

Selected agronomic information is provided in Table 2. Certified, high quality seed was utilized and the variety CDC Utmost was chosen because it was midge tolerant but also reasonably susceptible to both lodging and fusarium head blight. The wheat was direct-seeded approximately 2 cm (0.75”) deep into canola stubble with seeding rates varied as per protocol and adjusted for seed size and germination. Seed treatments were utilized as per protocol and the product was Raxil PRO (3 g/L tebuconazole, 15.4 g/L prothioconazole, and 6.2 g/L metalaxyl) at a rate 325 ml/100 kg seed. Fertilizer rates were varied as per protocol, were not adjusted for residual nutrient levels, and all products were side-banded. Weeds were controlled using registered pre-emergent and in-crop herbicide applications. Manipulator 620 (620 g/L chlormequat chloride) was applied as per protocol at early stem elongation. No foliar fungicides were applied at the flag-leaf stage while Prosaro XTR (125 g/L prothioconazole and 125 g/L tebuconazole) was applied as per protocol at anthesis. Insecticides were not considered necessary or applied. Pre-harvest glyphosate was applied at physiological maturity and the centre five rows of each plot were straight-combined as soon as possible after it was fit to do so.

Various data were collected during the growing season and from the harvested grain samples. Spring plant densities were determined by counting the number of seedlings in 2 x 1 m sections of crop row approximately one month after seeding. The average plant height was estimated by measuring eight plants per plot to the nearest 1 cm. Lodging was rated at maturity on a scale of 0-9 where a value of zero indicates no lodging. Fusarium head blight infection was rated for 25 heads per plot during the dough stage (prior to senescence) to calculate the fusarium index, or overall average infection, for each plot. Grain yields were determined from the harvested grain samples and are corrected for dockage and to a uniform moisture content of 14.5%. Test weight was determined for each plot using standard Canadian Grain Commission methods and protein was determined using an NIR instrument. Daily temperatures and precipitation amounts were recorded at an Environment Canada weather station located approximately 3 km from the plots.

Table 2. Selected agronomic information from the ADOPT wheat input demonstration (Indian Head, 2019).

Factor / Field Operation	Details / Description
Previous Crop	Canola
Pre-emergent herbicide	894 g glyphosate/ha May-12-2019
Seeding Date	May-6-2019
Seed Treatment	1 g tebuconazole + 5 g prothioconazole + 2 g metalaxyl per 100 kg seed (as per protocol)
Plant Density	Jun-3-2019
In-crop Herbicide	400 g 2,4-D ester/ha + 100 g flurox + 15 g pyroxsulam/ha Jun-17-2019
Plant Growth Regulator	1118 g chlormequat chloride/ha Jun-24-2019 (as per protocol)
Foliar Fungicide	100 g prothioconazole/ha + 100 g tebuconazole/ha Jul-9-2019 (as per protocol)
Plant Height	Jul-26-2019
Fusarium Ratings	Aug-1-2019
Lodging Ratings	Aug-20-2019
Pre-harvest herbicide	894 g glyphosate/ha Aug-15-2019
Harvest date	Sep-5-2019

All response data were analysed using the Mixed procedure of SAS with treatment effects considered fixed and replicate effects considered random. Individual treatment means were separated using Tukey’s studentized range test. For more powerful comparisons, contrast statements were also utilized to compare all treatments with and without each of the five inputs which were evaluated (i.e. no seed treatment versus seed-treatment applied, low fertility versus high fertility, etc.). All treatment effects and differences between means or groups of means were considered significant at $P \leq 0.05$.

10. Results:

Growing season weather and residual soil nutrients

Overall moisture reserves going into the 2019 growing were low and conditions were drier than normal for much of the spring with little moisture left over from the 2018 crop and less than 60% of normal precipitation from October 2018 through April 2019. Weather data for May through August 2019 is presented with the long-term (1981-2010) averages in Table 3. The dry weather persisted through May and early June at which point soil moisture conditions began to improve, eventually to the extent where precipitation amounts were above normal for the month of August. With the exception of June where temperatures were approximately normal, the growing season was cooler than average, by 1.1 °C when averaged over the four-month period. Overall environmental conditions were conducive to approximately average yields but relatively little lodging and low disease pressure.

Table 3. Mean monthly temperatures and precipitation amounts along with long-term (1981-2010) averages for the 2019 growing season at Indian Head, SK.

Year	May	June	July	August	Avg. / Total
	---------- Mean Temperature (°C) ----------				
IH-2019	8.9	15.7	17.4	15.8	14.5
IH-LT	10.8	15.8	18.2	17.4	15.6
	---------- Precipitation (mm) ----------				
IH-2019	13.3	50.4	53.1	96.0	148
IH-LT	51.8	77.4	63.8	51.2	244

A composite soil sample was collected in the early spring (0-15 cm, 15-60 cm) and analyzed for basic properties and residual nutrients (Table 4). At 6.1%, the site had reasonably high organic matter levels for the region and residual N levels were also higher than expected with an estimated 62 kg NO_3-N/ha for the 0-60 cm depth. Olsen-P levels were reasonably low at 11 ppm while K and S levels were both relatively high and unlikely to be limiting to wheat yield. The pH levels of 7.1 (0-15 cm) and 7.7 (15-60 cm) were also considered fairly typical for soils in the region.

Table 4. Selected soil test results for 4R N management demo at Indian Head, Saskatchewan (2018-19).

Attribute / Nutrient	0-15 cm	15-60 cm	0-60 cm
pH	7.1	7.7	–
S.O.M. (%)	6.1	–	–
NO_3-N (kg/ha)^Z	18	44	62
Olsen-P (ppm)	11	–	–
K (ppm)	706	–	–
S (kg/ha)	18	27	61

Field Trial Results

For selected response variables, individual treatment means are presented graphically with the results of the multiple comparisons tests in Figs. 1-7. More detailed results are provided in Tables 6-12 of the Appendices.

The overall F-test for plant density was highly significant ($P < 0.001$; Table 6) with individual treatment means ranging from 172-349 plants/m^2. While there was a tendency for plant densities to increase with the seed treatment and decrease with higher fertility, only increasing the seeding rate significantly changed plant populations relative to the low input package according to the multiple comparisons test

(Fig. 1). These results were more-or-less expected. Seed treatments have occasionally been shown to improve establishment, high rates of side-banded urea can reduce stands (particularly in sensitive crops or under dry conditions), and the direct result expected from increasing seeding rate is higher initial plant populations. Due to the much higher statistical power of the contrast comparisons, these tests suggested that all inputs affected plant populations (Tables 8-12); however, the observed differences between means cannot always be attributed to the treatments as some were not even yet applied when these measurements were completed (i.e. PGR, foliar fungicide) and many of the differences were too small to be of any practical importance.

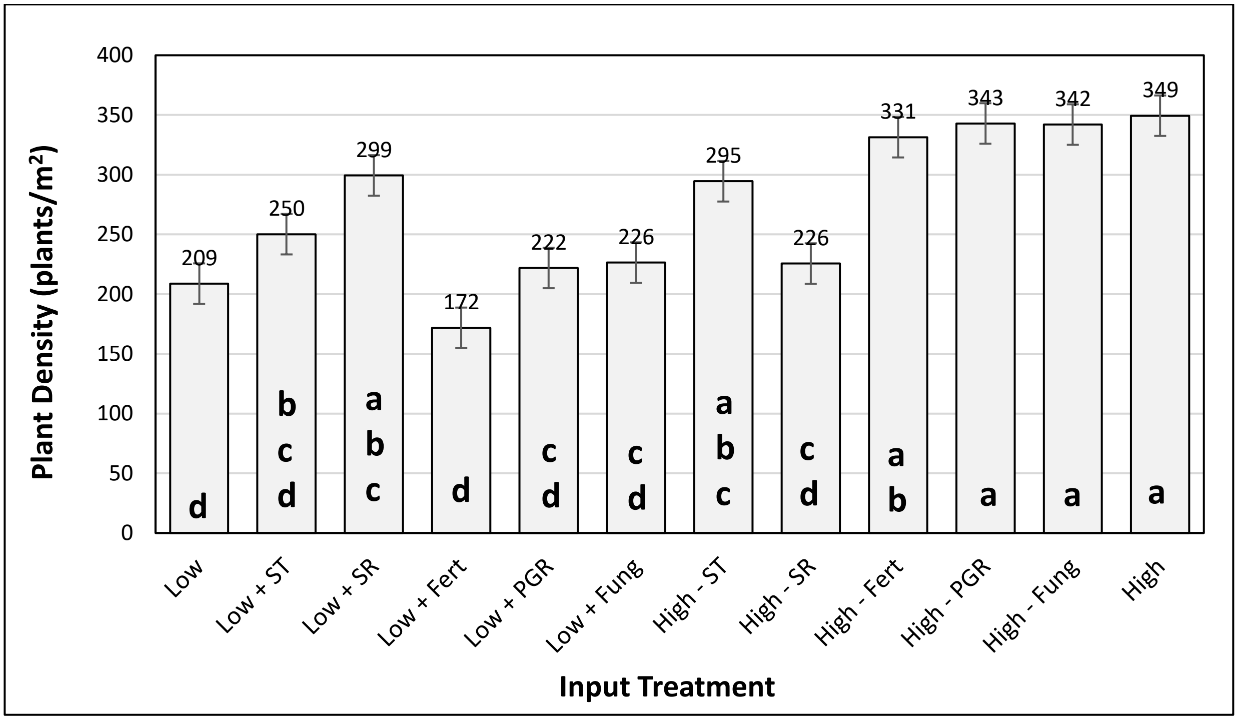

Figure 1. Individual input effects on wheat plant densities when either added to a low input package or removed from a high input package (Indian Head 2019).

The overall F-test for plant height was highly significant ($P < 0.001$) with treatment means ranging from 64-74 cm. Focussing on individual treatments, the PGR applications appeared to be the only inputs to have significantly impacted plant height, regardless of whether being added to the low or removed from the high input package (Fig. 2). Similar to plant density, the contrasts for height were all significant due to the power of these comparisons but the effect was strongest for the PGR where heights were reduced by 6.3 cm or 9% (Table 11) compared to ~2-5% for some of the other inputs (Tables 8-10 and 12). While plant height is not a yield component and not necessarily correlated with yield, shorter plants tend to be desirable in that they are less prone to lodging and result in less material other than grain to put through the combine during harvest.

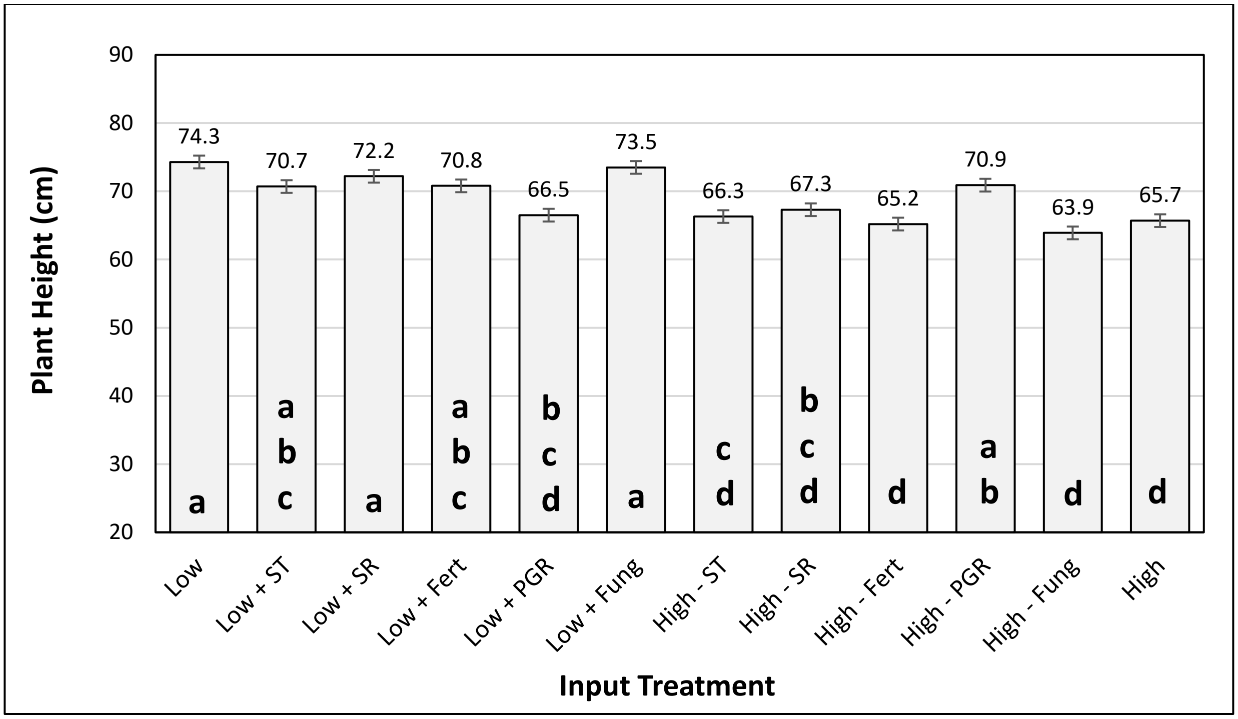

Figure 2. Individual input effects on wheat plant height when either added to a low input package or removed from a high input package (Indian Head 2019).

Fusarium incidence and fusarium index are closely related and the overall F-tests for both of these variables were at least marginally significant at P = 0.036 and P = 0.056, respectively (Table 6). Fusarium index takes into account both disease incidence and severity and the individual treatment means ranged from 0-4.4% (Fig. 3). The highest disease levels were observed when high fertility was added to the low input package but, given the relatively low values and high variability, significant differences between individual treatments were rare. This would suggest that high fertility combined with an otherwise low input package (i.e. low seeding rates and no foliar fungicide) can increase the risk of FHB; however, as a single site with low disease pressure, high variability and a relatively small sample size (25 heads per plot), this result is not conclusive. According to the contrasts, the only input to significantly affect fusarium index when averaged across all treatments was foliar fungicide which reduced the values from 1.9% to 0.3% when averaged across all treatments.

Although lodging ratings were planned for the current project, no lodging was observed and all plots received a rating of zero; therefore, these results were neither presented nor statistically analyzed.

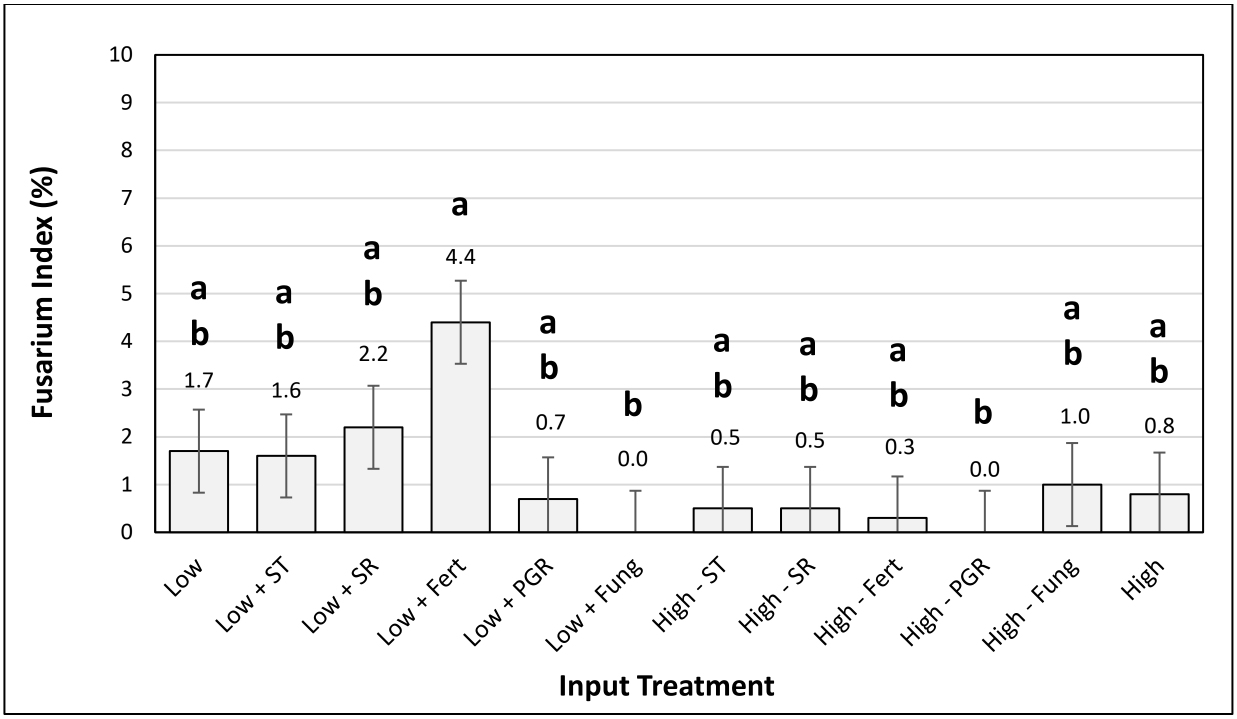

Figure 3. Individual input effects on wheat fusarium index when either added to a low input package or removed from a high input package (Indian Head 2019).

Although differences between individual treatments were small and only rarely significant, the overall F-test for grain yield was highly significant ($P < 0.001$; Table 7). There was no individual crop input that significantly increased yield when added to the low input package; however, reducing fertility in the otherwise intensively managed package led to a small but significant yield reduction (Fig. 4). Of the inputs varied in this demonstration and based on past experiences, higher fertility was one of the most likely to have a positive impact on yield, especially under the conditions encountered where both lodging and disease pressure were negligible. It is plausible that fertility had less of an impact than might normally have been expected with the combination of higher residual N levels and, possibly, higher than normal N mineralization with the relatively high organic matter and increase in soil moisture following initially dry weather. According to the contrasts, the only input that did not affect yield was the seed treatment ($P = 0.736$; Table 8). Of the remaining inputs, all had a significant and positive impact on yield but the increases were small ranging from 2% for the higher seed rate ($P = 0.022$; Table 9) to 4% with higher fertility ($P < 0.001$; Table 10). When averaged across individual treatments, the applications of a PGR and foliar fungicide resulted in average yield increases of 3.3% and 2.5%, respectively.

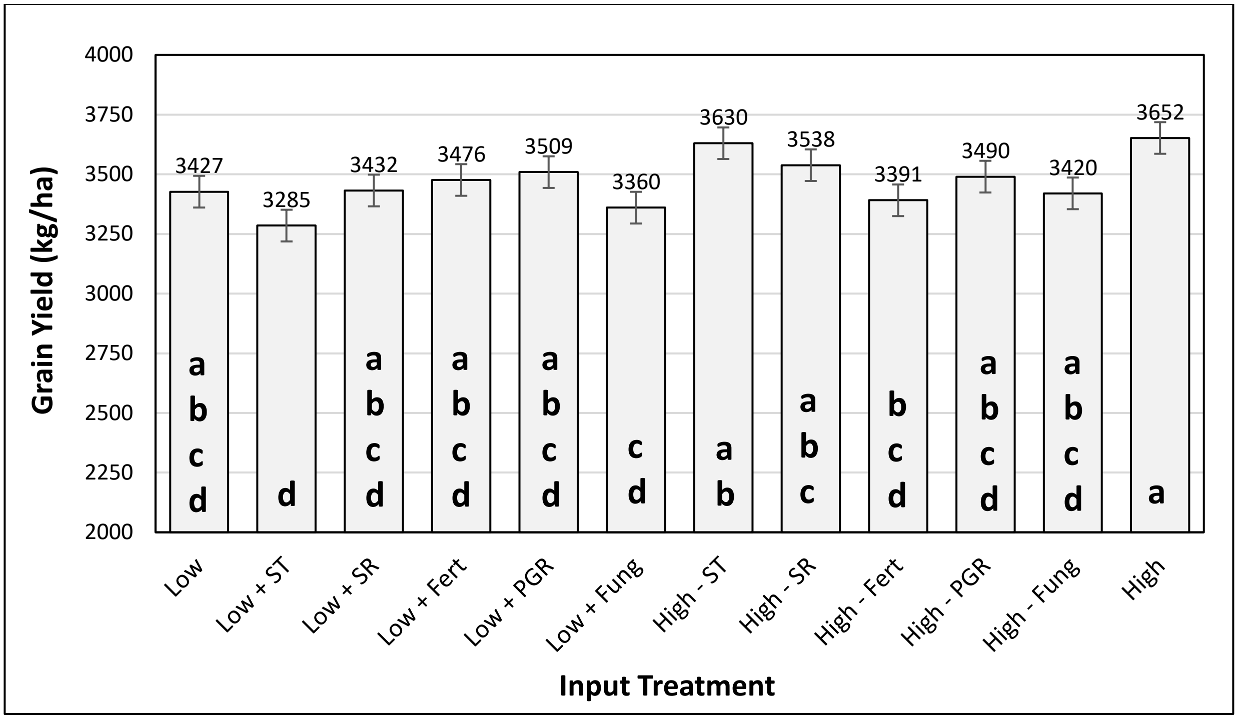

Figure 4. Individual input effects on wheat grain yield when either added to a low input package or removed from a high input package (Indian Head 2019).

The overall F-test for test weight was highly significant ($P < 0.001$) and, perhaps somewhat unexpectedly, values tended to be lower in the more intensively managed treatments (Table 7; Fig. 5). Numerically, values were highest in the low input package (380 g/0.5 L) but this did not significantly differ from any of the treatments where inputs were added to this treatment individually. It was, however, slightly but significantly higher than the high input package (375 g/0.5 L) and most of the treatments where inputs were individually removed from this intensively managed wheat. According the contrast comparisons, all inputs significantly reduced test weight when averaged across treatments but, at a magnitude of less than 1%, the effects were of little practical importance. The overall F-test for kernel weight was not quite significant at the desired probability level ($P = 0.074$) and no significant differences were detected amongst individual treatments; however, the overall trends were similar to what was observed for test weight (Fig. 5; Table 7). Based on the contrasts, the only inputs to significantly affect kernel weight were fertility and fungicide but, again, the effects were extremely small and of little practical importance (Tables 8-12).

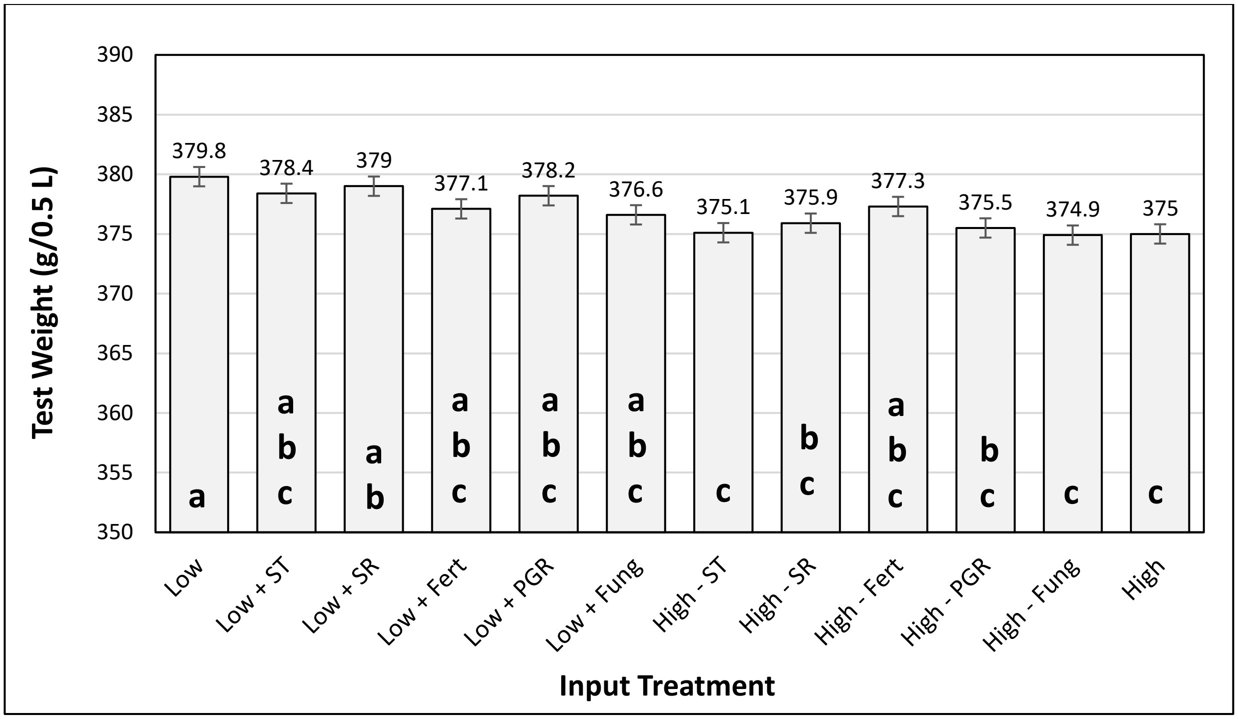

Figure 5. Individual input effects on wheat grain test weight when either added to a low input package or removed from a high input package (Indian Head 2019).

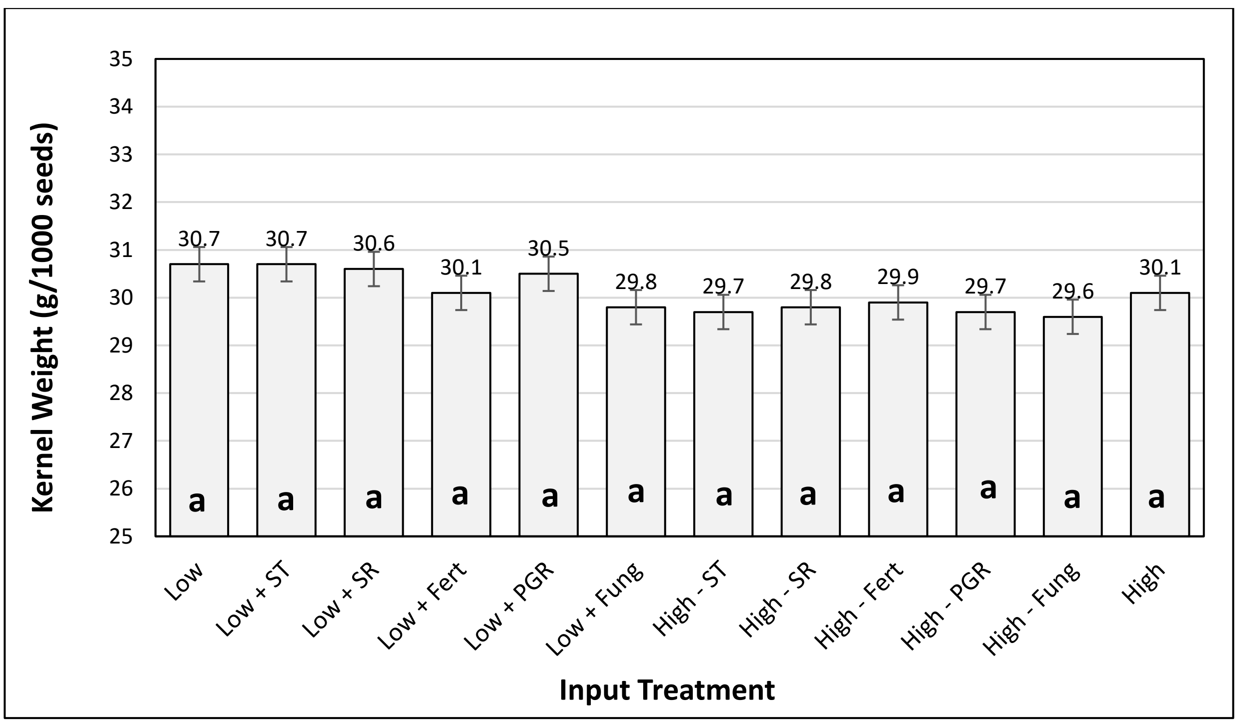

Figure 6. Individual input effects on wheat kernel weight when either added to a low input package or removed from a high input package (Indian Head 2019).

The overall F-test for grain protein concentrations was highly significant ($P < 0.001$) with individual treatment means ranging from 14.9-15.7% (Fig. 7; Table 7). As expected based on past experience and the fact that few inputs impacted yield, inspection of the individual treatments means suggested the only input to impact protein was fertility. Grain protein concentrations were increased significantly when fertility was increased in the low input treatment and, conversely, reduced when fertility was lowered in the intensively managed treatment. Although we simultaneously varied N, P, K, and S when adjusting fertility levels in the current demonstration, it is reasonable to assume that N was the main driver of the observed differences in protein. When averaged across all applicable treatments, mean protein concentrations were 15.0% with low fertility and 15.6% with high fertility. According to the contrasts, seed treatment and PGR effects were also significant; however the grouped means were within 0.2% of each other and of little practical importance.

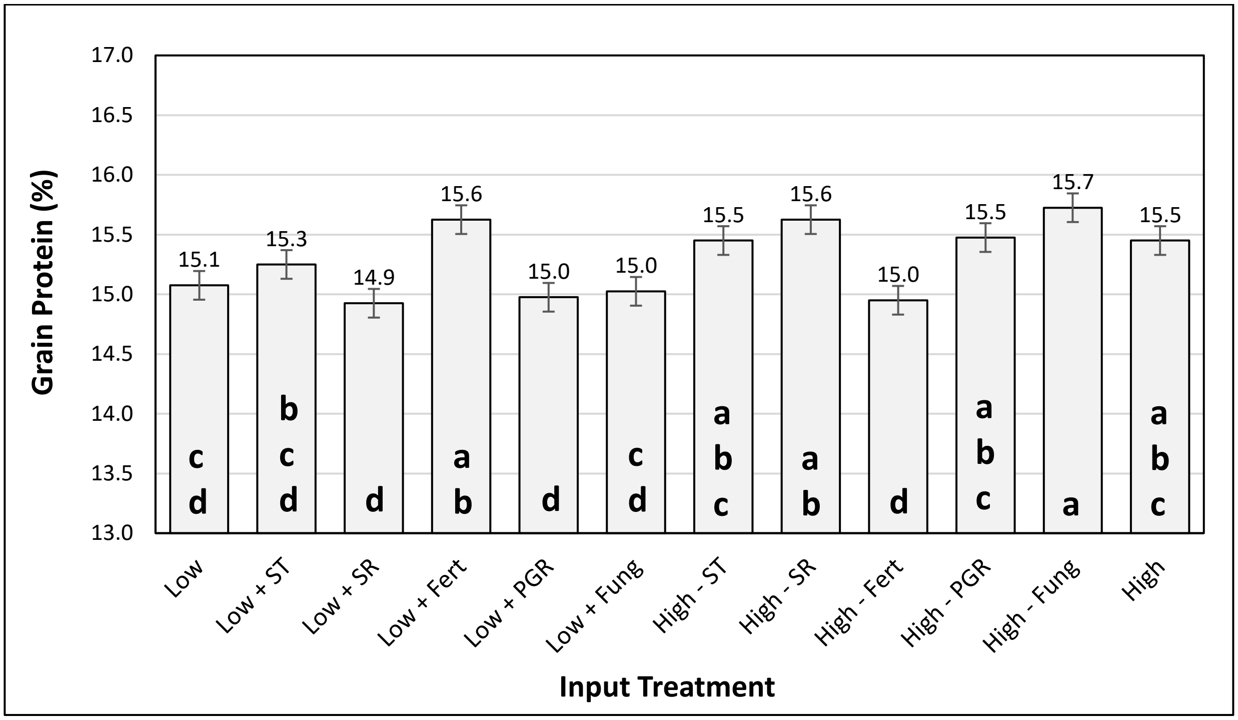

Figure 7. Individual input effects on grain protein concentrations when either added to a low input package or removed from a high input package (Indian Head 2019).

A simple economic analyses was completed to provide further insights for producers; however, the reported values do not take into account either potential differences in grain value related to quality or all of the expenses associated with wheat production. Consequently, the relative profit values presented in Table 8 are solely a reflection of the observed impacts on yield, the estimated grain value, and approximate input costs. Under the assumptions used and conditions encountered, the low input treatment was the most profitable while the high input treatments were generally the least profitable and relatively similar to one another. This is not to suggest that none of the inputs that were evaluated are likely to increase profits under more typical conditions; however, it does reinforce the importance of managing input costs carefully in dryland wheat production. Decisions should be made based on knowledge of the individual inputs and what they can or cannot do, knowledge of past pest issues or other yield limiting factors (i.e. nutrition), and vigorous crop scouting and monitoring of crop and environmental conditions. The observed results reinforce the notion that the highest yielding, most intensively managed treatments are not necessarily the most profitable. Again, these results should be interpreted with caution as actual input costs and grain revenues are likely to vary and certain quality parameters (i.e. grain protein) were not taken into consideration when calculating revenues.

Table 5. Partial input costs, estimated revenues, and marginal profits associated with the various treatments in the wheat input demo at Indian Head (2019).

Trt #	Seed Trt [Z]	Seed Rate[Y]	Fertility[X]	PGR[W]	Fungicide[W]	Revenue[V]	Profit[U]
	-- $/ha --						
Low Input	$0.00	$40.56	$126.04	$0.00	$0.00	$880.74	$714.14
Low + Seed Trt	$15.62	$40.56	$126.04	$0.00	$0.00	$844.25	$662.03
Low + Seed Rate	$0.00	$66.33	$126.04	$0.00	$0.00	$882.02	$689.65
Low + Fertility	$0.00	$40.56	$201.85	$0.00	$0.00	$893.33	$650.92
Low + PGR	$0.00	$40.56	$126.04	$46.95	$0.00	$901.81	$688.26
Low + Fungicide	$0.00	$40.56	$126.04	$0.00	$62.34	$863.52	$634.58
High - Seed Trt	$0.00	$66.33	$201.85	$46.95	$62.34	$932.91	$555.44
High - Seed Rate	$15.62	$40.56	$201.85	$46.95	$62.34	$909.27	$541.95
High - Fertility	$15.62	$66.33	$126.04	$46.95	$62.34	$871.49	$554.21
High - PGR	$15.62	$66.33	$201.85	$0.00	$62.34	$896.93	$550.79
High - Fungicide	$15.62	$66.33	$201.85	$46.95	$0.00	$878.94	$548.19
High Input	$15.62	$66.33	$201.85	$46.95	$62.34	$938.56	$545.47

[Z] Not adjusted for differences in seeding rate between Trt. 2 and 7

[Y] Assumes certified seed price of $0.478/kg

[X] Assumes $725/tonne for MAP and $525/tonne for urea – K and S costs excluded as these nutrients were unlikely to have been limiting

[W] Includes SRP of products plus $12.36/ha application cost

[V] Based on actual yields and a CWRS wheat price of $257/Mt ($7/bu) regardless of quality

[U] Values presented do not take into account all production costs and are only estimates – actual input costs and revenues may vary substantially

Extension Activities and Dissemination of Results

This project was discussed and the plots were toured by approximately 125 guests at the Indian Head Crop Management Field Day on July 16, 2019. Chris Holzapfel discussed the specific objectives of the project and also conferred results from a similar project conducted the previous year along with past experiences with the various inputs being evaluated. The plots were also visited on July 12 during a tour for approximately 60 Federated Co-operatives Limited (FCL) agronomists from throughout the province. Chris Holzapfel presented highlights from this demonstration during a talk entitled "Agronomy of High Yielding Wheat" at CropSphere 2020 (January 15) and during IHARF Agronomy Updates at a meeting for the Independent Consulting Agronomists Network (February 4) and the IHARF Winter Meeting and AGM. The estimated combined attendance of these three presentations was nearly 300 people. The full project report will be made available online on the IHARF website (www.iharf.ca) and potentially elsewhere in the winter of 2019-20 and beyond. Additionally, results will 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

This project demonstrated the contributions of various crop inputs on wheat establishment, yield, quality, and profitability under somewhat below average yield conditions with relatively low lodging and/or disease pressure. One broad comparison that can be made throughout is looking at the agronomic and economic performance of intensive management versus a lower input, less intensive approach to growing wheat. Bear in mind that the low input wheat was still reasonably well managed (i.e. midge tolerant variety/certified seed, timely seeding and weed removal, modest but balanced fertility) and that the results are specific to the conditions encountered. With regard to establishment, increasing seeding rates had the greatest effect while seed treatments appeared to have a slight positive effect and the opposite occurred with higher fertility. Plant height was only affected by the PGR application which resulted in a 9% reduction; however, lodging was not observed in any plots. Again, disease pressure was low and the only input that significantly affect fusarium index levels when averaged across treatments was the foliar fungicide application. There were relatively few significant differences amongst treatments and the intensively managed wheat only yielded 7% higher the than the low input treatment. None of the inputs evaluated significantly increased grain yield when added to the low input treatment individually; however, reducing fertility levels in the otherwise high input package resulted in a small but significant yield reduction. Group comparisons suggested that all of the inputs except seed treatments had some positive impact on yield average but the increases were small. Any impacts on test weight or TKW were too small to be of much agronomic importance but, in general, these quality parameters were better in the less intensively managed treatments. Protein was increased from 15.1% to 15.6% when fertility was increased in the low input treatment and fell from 15.5% to 15.0% when fertility was reduced in the high input treatment. Fertility effects on protein were attributed specifically to nitrogen even though multiple inputs were varied simultaneously. Focussing on profitability, the assumptions used were somewhat crude but clearly showed the intensively managed treatments to be least profitable under the conditions encountered, considerably less so than the most profitable low input system. It is important to consider that these results were considered somewhat atypical for the region and actual responses may vary dramatically with environment. Nonetheless, with relatively low yield potential, lodging, and disease pressure combined with moderately high residual nutrient levels the observed responses are not necessarily unexpected. That being said, the results also show that it is important to carefully manage input costs in order to maximize profitability in wheat production. As a general recommendation, soil testing to determine fertility requirements and choosing crop protection products based on knowledge of past pest problems combined with frequent crop scouting will provide the best opportunity to optimize yields and quality while managing costs and maximizing economic returns.

Supporting Information

11. Acknowledgements:

This project was supported by the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canadian Agricultural Partnership bi-lateral agreement between the federal government and the Saskatchewan Ministry of Agriculture. Crop protection products were provided in-kind by Corteva Agriscience, Belchim Canada, and Bayer CropScience. IHARF also has a strong working relationship and framework agreement with Agriculture & Agri-Food Canada which helps to make work like this a possibility.

12. Appendices

Table 6. Overall F-test results and input treatment means for plant density, plant height, fusarium incidence (percentage of heads with infection present), and fusarium index (overall average infection). Means within a column followed by the same letter do not significantly differ (Tukey's, $P \leq 0.05$).

Source / Treatment	Plant Density	Plant Height	Fusarium Incidence	Fusarium Index
	---------- (p-value) ----------			
Overall F-test (input trt)	<0.001	<0.001	0.036	0.056
Input Treatments	-- plants/m^2 --	------ cm ------	------- % -------	------- % -------
1) Low Input	208.8 d	74.3 a	3.0 a	1.7 ab
2) Low + Seed Treatment	250.2 bcd	70.7 abc	5.0 a	1.6 ab
3) Low + Seed Rate	299.4 abc	72.2 a	6.0 a	2.2 ab
4) Low + Fertility	171.8 d	70.8 abc	8.0 a	4.4 a
5) Low + PGR	221.9 cd	66.5 bcd	1.0 a	0.7 ab
6) Low + Fungicide	226.4 cd	73.5 a	1.0 a	0.0 b
7) High - Seed Treatment	294.5 abc	66.3 cd	4.0 a	0.5 ab
8) High - Seed Rate	225.6 cd	67.3 bcd	5.0 a	0.5 ab
9) High - Fertility	331.4 ab	65.2 d	1.0 a	0.3 ab
10) High - PGR	342.9 a	70.9 ab	1.0 a	0.0 b
11) High - Fungicide	342.0 a	63.9 d	6.0 a	1.0 ab
12) High Input	349.4 a	65.7 d	1.0 a	0.8 ab
S.E.M.	16.95	0.93	1.8	0.87

Table 7. Overall F-test results and input treatment means for grain yield, test weight, kernel weight, and grain protein concentrations. Means within a column followed by the same letter do not significantly differ (Tukey's, $P \leq 0.05$).

Source / Treatment	Grain Yield	Test Weight	Kernel Weight	Protein Concentration
	---------------------------------- (p-value)			----------------------------------
Overall F-test (input trt)	<0.001	<0.001	0.074	<0.001
Input Treatments	----- kg/ha -----	---- g/0.5 l ----	g/1000 seeds	------- % -------
1) Low Input	3427 a-d	379.8 a	30.7 a	15.1 cd
2) Low + Seed Treatment	3285 d	378.4 abc	30.7 a	15.3 bcd
3) Low + Seed Rate	3432 a-d	379.0 ab	30.6 a	14.9 d
4) Low + Fertility	3476 a-d	377.1 abc	30.1 a	15.6 ab
5) Low + PGR	3509 a-d	378.2 abc	30.5 a	15.0 d
6) Low + Fungicide	3360 cd	376.6 abc	29.8 a	15.0 cd
7) High - Seed Treatment	3630 ab	375.1 c	29.7 a	15.5 abc
8) High - Seed Rate	3538 abc	375.9 bc	29.8 a	15.6 ab
9) High - Fertility	3391 bcd	377.3 abc	29.9 a	15.0 d
10) High - PGR	3490 a-d	375.5 bc	29.7 a	15.5 abc
11) High - Fungicide	3420 a-d	374.9 c	29.6 a	15.7 a
12) High Input	3652 a	375.0 c	30.1 a	15.5 abc
S.E.M.	66.3	0.81	0.36	0.12

Table 8. Contrast results comparing treatments that did not receive a seed-applied fungicide to those that did. P-values less than 0.05 indicate that the difference between groups was significant.

Response Variable	No Seed-Applied Fungicide	With Seed-Applied Fungicide	Pr > F (p-value)
Plant Density (plants/m^2)	237 b	307 a	<0.001
Plant Height (cm)	70.6 a	67.3 b	<0.001
Fusarium Incidence (%)	3.8 a	3.2 a	0.495
Fusarium Index (%)	1.6 a	0.7 a	0.080
Grain Yield (kg/ha)	3473 a	3463 a	0.736
Test Weight (g/0.5 l)	377.6 a	376.2 b	0.002
Kernel Weight (g/1000 seeds)	30.2 a	30.0 a	0.183
Grain Protein (%)	15.2 b	15.4 a	<0.001

Table 9. Contrast results comparing treatments with a relatively low seeding rate (250 seeds/m^2) to those where a high seeding rate (400 seeds/m^2) was used. P-values less than 0.05 indicate that the difference between groups was significant.

Response Variable	Low Seeding Rate (250 seeds/m^2)	High Seeding Rate (400 seeds/m^2)	Pr > F (p-value)
Plant Density (plants/m^2)	217 b	327 a	<0.001
Plant Height (cm)	70.5 a	67.3 a	<0.001
Fusarium Incidence (%)	3.8 a	3.2 a	0.495
Fusarium Index (%)	1.5 a	0.8 a	0.177
Grain Yield (kg/ha)	3433 a	3503 b	0.022
Test Weight (g/0.5 l)	377.7 a	375.1 b	0.001
Kernel Weight (g/1000 seeds)	30.3 a	30.0 a	0.096
Grain Protein (%)	15.3 a	15.3 a	0.217

Table 10. Contrast results comparing treatments where a low fertility package (90-20-10-10 kg N P_2O_5-K_2O-S/ha) was used versus those where a high seeding rate (135-40-20-20 kg N P_2O_5-K_2O-S/ha) was used. P-values less than 0.05 indicate that the difference between groups was significant.

Response Variable	Low Fertility (90-20-10-10)	High Fertility (135-40-20-20)	Pr > F (p-value)
Plant Density (plants/m^2)	256 b	288 a	0.003
Plant Height (cm)	70.4 a	67.5 b	<0.001
Fusarium Incidence (%)	2.8 a	4.2 a	0.177
Fusarium Index (%)	1.1 a	1.2 a	0.831
Grain Yield (kg/ha)	3401 b	3534 a	<0.001
Test Weight (g/0.5 l)	378.2 a	375.6 b	<0.001
Kernel Weight (g/1000 seeds)	30.4 a	29.9 a	0.005
Grain Protein (%)	15.0 b	15.6 a	<0.001

Table 11. Contrast results comparing treatments where no plant growth regulator (PGR) was applied versus those where a PGR (1118 g chlormequat chloride/ha) was used. P-values less than 0.05 indicate that the difference between groups was significant.

Response Variable	No PGR Applied	PGR Applied	Pr > F (p-value)
Plant Density (plants/m^2)	250 b	294 a	<0.001
Plant Height (cm)	72.1 a	65.8 b	<0.001
Fusarium Incidence (%)	4.0 a	3.0 a	0.308
Fusarium Index (%)	1.7 a	0.6 b	0.040
Grain Yield (kg/ha)	3412 b	3523 a	<0.001
Test Weight (g/0.5 l)	377.7 a	376.1 b	<0.001
Kernel Weight (g/1000 seeds)	30.3 a	30.0 a	0.091
Grain Protein (%)	15.2 b	15.4 a	0.017

Table 12. Contrast results comparing treatments where no foliar fungicide was applied versus those where foliar fungicide (100 g prothioconazole/ha + 100 g tebuconazole/ha) was used. P-values less than 0.05 indicate that the difference between groups was significant.

Response Variable	No Foliar Fungicide Applied	Foliar Fungicide Applied	Pr > F (p-value)
Plant Density (plants/m^2)	249 b	295 a	<0.001
Plant Height (cm)	69.7 a	68.1 b	0.005
Fusarium Incidence (%)	4.8 a	2.1 b	0.009
Fusarium Index (%)	1.9 a	0.3 b	0.003
Grain Yield (kg/ha)	3425 b	3510 a	0.006
Test Weight (g/0.5 l)	377.9 a	376.1 b	<0.001
Kernel Weight (g/1000 seeds)	30.4 a	29.9 b	0.005
Grain Protein (%)	15.3 a	15.3 a	0.217

Table 13. Treatment means, overall F-test, and multiple comparison results for selected response variables from a similar demonstration completed at Indian Head 2018. Means within a column followed by the same letter do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05). These results are included to compliment the 2019 project that is the subject of the current report.

Treatment	Grain Yield	Test Weight	1000 Kernel Weight	Protein Concentration
	---- kg/ha ----	------ g/0.5 l -----	-- g/1000 seeds --	-------- % --------
1) Low Input	3502 c	400.8 a	33.8 a	13.3 c
2) Low + Seed Trt	3510 c	400.2 a	34.0 a	13.4 c
3) Low + Seed Rate	3494 c	401.1 a	33.6 a	13.1 cd
4) Low + Fertility	3680 b	400.2 a	33.4 a	14.3 a
5) Low + PGR	3789 ab	400.3 a	33.3 a	12.9 de
6) Low + Fungicide	3768 ab	399.7 a	33.3 a	12.8 e
7) High Input	3896 a	397.2 b	32.0 b	13.9 b
S.E.M.	88.9	0.50	0.42	0.23
Pr > F (p-value)	<0.001	<0.001	0.006	<0.001

Figure 8. Low input wheat at approximately the time of physiological maturity (August 9, 2019).

Figure 9. High input wheat at approximately the time of physiological maturity (August 9, 2019).

Abstract

13. Abstract/Summary:

A field trial was established near Indian Head, Saskatchewan to demonstrate wheat response to low versus high input management systems. The inputs evaluated were seed-applied fungicides, higher seed rates, higher fertility, PGR and foliar fungicide. In addition to the low versus high-input treatments, each of these were individually added to the low or removed from the high input systems. Increasing seeding rate had the greatest effect on plant populations while seed treatments appeared to have a slight positive effect and the opposite occurred with higher fertility. Plant height was only affected by the PGR which reduced height by 9% on average. Lodging was not observed in any plots. Again, FHB pressure was low but the only input to significantly affect disease levels was the foliar fungicide. Although there were a few significant yield differences amongst individual treatments, the intensively managed wheat only yielded 7% more than the low input treatment. None of the inputs significantly increased grain yield when added to the low input treatment individually; however, reducing fertilizer rates in the high input package led to a small but significant reduction. Contrast comparisons suggested that, when averaged across treatments, all of the inputs except seed-applied fungicide had a positive impact on yield but the increases were always small. Impacts on test weight or TKW were small and of little agronomic importance but these parameters tended to be better in the lower input treatments. Protein was increased from 15.1% to 15.6% when fertility was increased in the low input treatment and fell from 15.5% to 15.0% when fertility was reduced in the high input treatment. A basic economic analyses showed intensively managed wheat to be the least profitable while the most profitable was the low input system. Actual responses will vary with environment; however, these results show that producers must carefully manage wheat input costs to maximize profitability. As a general recommendation, soil testing to determine fertilizer rates and choosing crop protection products based on knowledge of past pest issues along with thorough and frequent crop scouting will provide the best opportunity to optimize yields and quality while managing costs and maximizing economic returns.