2020 Annual Report

for the

Saskatchewan Ministry of Agriculture's

Agricultural Demonstration of Practices & Technologies (ADOPT) Program

Project Title: Input Contributions to Spring Wheat Yield, Quality, and Profits

(Project #20190432)

Principal Applicant: Chris Holzapfel, MSc, PAg

Indian Head Agricultural Research Foundation, PO BOX 156, Indian Head, SK, S0G 2K0

Correspondence: cholzapfel@iharf.ca or (306) 695-7761

Project Identification

1. **Project Title:** Input contributions to spring wheat yield, quality, and profits
2. **Project Number:** 20190432
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(s):** April-2020 to February-2021
6. **Project contact person & contact details:**

Chris Holzapfel, Research Manager
Indian Head Agricultural Research Foundation
PO BOX 156, Indian Head, SK, S0G 2K0
Mobile: 306-695-7761
Office: 306-695-4200
Email: cholzapfel@iharf.ca

Objectives and Rationale

7. **Project Objectives:**

The objective of this project was to demonstrate the agronomic and economic responses of CWRS wheat to numerous crop inputs individually and in various combinations. The project was designed to show the contributions of individual crop inputs when either added to low input systems or removed from high input systems. The project was a continuation from 2019 and intended to build upon and increase the extension value of that work.

8. **Project Rationale:**

Wheat, regardless of the class, is an important rotational crop and a major contributor to the Saskatchewan economy. Most 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. Since assessing all possible input combinations was not feasible, the scope was narrowed to include combinations of seed treatments, higher seeding rates, enhanced fertility, plant growth regulator, and foliar fungicide applications. Basic information on the individual inputs included in this demonstration follows.

Seed-Applied Fungicide

Seed-applied fungicides, or seed treatments, 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 when seed is planted into stressful environments such as cold and wet, or even very dry soils. In any case, 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, utilizing seed-applied fungicide products has become a 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; therefore, the focus was on fungicide products.

Higher Seeding Rates

The traditional recommended range of plant populations for spring wheat is 215-270 plants/m^2; however, especially in environments where drought is unlikely, but disease pressure can be high, some growers are targeting populations exceeding 300 plants/m^2. The rationale for the higher populations is usually 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 variety and environmental conditions) and, under drought conditions, higher plant populations can lead to earlier maturity and potentially even have a negative impact on yield.

Fertility

Yield responses of spring wheat to the major crop nutrients have 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 in Saskatchewan, soils low in N and P are common. Furthermore, N fertility is the most important management factor affecting grain protein, a key quality parameter for CWRS wheat where minimum standards must be met to achieve top grades.

Plant Growth Regulator

The plant growth regulator (PGR) chlormequat chloride (Manipulator™ 620) has been available to for Canadian producers to use on wheat since 2018. Leading up to this time, chlormequat chloride performed consistently well in field trials at Indian Head resulting in mean 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 can frequently occur, most PGR products are not registered for this purpose, but rather, for reducing plant height and, potentially, lodging. Shorter, more upright plants can also increase harvest efficiency which can be difficult to quantify but is also quite valuable. Past work suggests that PGR applications are most likely to be beneficial under more intensive management where both yield potential and the risk of lodging are high.

Foliar Fungicide

Fusarium head blight (FHB) is one of the most important factors reducing yield and quality of wheat in Saskatchewan, particularly in wet years/regions. While improved genetic resistance will become increasingly important for managing FHB in wheat, foliar fungicides are the most 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.

Methodology and Results

9. Methodology:

A field demonstration with CWRS wheat was initiated near Indian Head in 2019 and repeated in 2020. Indian Head is located within the thin Black soil zone of southeast Saskatchewan (R.M. #156). The project aimed to evaluate responses to several key inputs when either added to a low input agronomic package or removed from an intensively managed package. The inputs that were varied included seed-applied fungicide, seeding rate, fertility, PGR, and foliar fungicide. The treatments are described in greater detail in Table 1.

Table 1. Treatments evaluated in ADOPT Wheat Input Demonstration at Indian Head in 2019-20.

#	Name	Seed Trt (no/yes)	Seed Rate (seeds/m^2)	Fertility (kg/ha N-P_2O_5-K_2O-S)	PGR (no/yes)	Foliar Fung. (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 with the variety CDC Utmost chosen for its midge tolerance and potential susceptibility to both lodging and FHB. The wheat was seeded approximately 2 cm (0.75") deep directly into canola stubble with seeding rates adjusted for seed size and germination and varied as per protocol. Seed-applied fungicide was 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, not adjusted for residual nutrient levels, and all products were side-banded. Weeds were controlled using registered pre-emergent and in-crop herbicides. 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 and Prosaro XTR (125 g/L prothioconazole and 125 g/L tebuconazole) was applied as per protocol at anthesis. Insecticides were not deemed necessary or applied in either season. Pre-harvest glyphosate was applied at physiological maturity and the centre five rows of each plot were combined.

Various data were collected during the growing season and from the harvested grain samples. Residual nutrient levels were estimated from spring composite soil samples for two depths, 0-15 cm and 15-60 cm. 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 just prior to harvest on a scale of 0-9 where a value of zero indicated no lodging. Fusarium head blight infection was rated for 25 spikes per plot in 2019 and 40 in 2020 with these measurements completed during the late milk/early dough stage, prior to senescence. The ratings were used to calculate the percentage of infected heads for each plot (FHB incidence) and the overall average level of infection (FHB index), but overall FHB pressure was low and only incidence values are reported. Grain yields were determined from the mass of the harvested grain samples and are corrected for dockage and to 14.5% seed moisture content. Test weight was determined for each plot using standard Canadian Grain Commission methods. Seed size, or weight, was determined by counting and weighing a minimum of approximately 1000 seeds and calculating g/1000 seeds. Protein was determined using an NIR instrument. Daily temperatures and precipitation amounts were recorded at an Environment and Climate Change Canada weather station situated within 3 km from the plot sites.

Table 2. Selected agronomic information from wheat input demonstrations completed at Indian Head.

Factor / Operation	2019	2020
Previous Crop	Canola	Canola
Pre-emergent herbicide	894 g glyphosate/ha May-12	894 g glyphosate/ha May-14
Seeding Date	May-6	May-8
Seed Treatment	1 g tebuconazole + 5 g prothioconazole + 2 g metalaxyl per 100 kg seed (as per protocol)	1 g tebuconazole + 5 g prothioconazole + 2 g metalaxyl per 100 kg seed (as per protocol)
Plant Density	Jun-3	Jun-3
In-crop Herbicide	400 g 2,4-D ester/ha + 100 g fluroxypyr + 15 g pyroxsulam/ha Jun-17	400 g 2,4-D ester/ha + 100 g fluroxypyr + 15 g pyroxsulam/ha Jun-15
Plant Growth Regulator	1118 g chlormequat chloride/ha Jun-24 (as per protocol)	1118 g chlormequat chloride/ha Jun-22 (as per protocol)
Foliar Fungicide	100 g prothioconazole/ha + 100 g tebuconazole/ha Jul-9 (as per protocol)	100 g prothioconazole/ha + 100 g tebuconazole/ha Jul-9 (as per protocol)
Plant Height	Jul-26	Jul-22
Fusarium Ratings	Aug-1	Aug-4
Lodging Ratings	Aug-20	Aug-13
Pre-harvest herbicide	894 g glyphosate/ha Aug-15	894 g glyphosate/ha Aug-14
Harvest date	Sep-5	Aug-20

Response data were analyzed using the Mixed procedure of SAS with the effects of year (Yr), treatment (Trt), and the Yr x Trt interaction considered fixed and replicate effects treated as random. Heterogeneity in variance components between years was permitted; however, the more complex analyses were only utilized where doing improved the model fit. Predetermined contrasts were used to test the averaged effects of individual inputs for each response variable. All treatment effects and differences between means were considered significant at $P \leq 0.05$ and the Tukey's range test was used to separate individual treatment means. The relative profitability of each treatment was estimated using basic assumptions regarding input costs, grain prices, and protein premiums/discounts (provided in the Appendices) along with actual yield and protein values.

10. Results:

Growing season weather and residual soil nutrients

Mean temperatures and total precipitation amounts for May-August of each season are presented with the long-term averages in Table 3. Overall, growing season temperatures were slightly below average in 2019 and approximately average in 2020. Both seasons were drier than normal with a total of 213 mm of precipitation in 2019 and 113 mm in 2020 compared to the long-term average of 244 mm (May-August). Although total precipitation in 2019 was not especially far below the long-term average, 45% of the rain fell in August and was likely too late to prevent drought from being a yield limiting factor to at least some extent. Importantly, given the specific treatments being evaluated, this dry weather resulted in relatively low lodging and disease pressure compared to what might be expected in wetter years.

Table 3. Mean monthly temperatures and precipitation amounts along with long-term (1981-2010) averages for the 2019 and 2020 growing seasons at Indian Head, Saskatchewan.

Year	May	June	July	August	May-Aug
			Mean Temperature (°C)		
2019	8.9	15.7	17.4	15.8	14.5 (93%)
2020	10.7	15.6	18.4	17.9	15.7 (101%)
LT	10.8	15.8	18.2	17.4	15.6
			Total Precipitation (mm)		
2019	13.3	50.4	53.1	96.0	213 (87%)
2020	27.3	23.5	37.7	24.9	113 (46%)
LT	51.8	77.4	63.8	51.2	244

Soil test results for each season are provided in Table 4. The soil at this location is classified as an Indian Head heavy clay. The surface (0-15 cm) pH was 7.1-7.8 while organic matter was 5.0-6.1%. Focussing on residual N and P, the 2019 site was much more fertile overall with 62 kg NO_3-N/ha (0-60 cm) and 11 ppm Olsen-P compared to 22 kg NO_3-N and 4 ppm Olsen P for the 2020 site. Neither potassium nor sulphur were likely to have been limiting to yield in either year considering the high residual levels and/or relatively low crop requirements for these nutrients.

Table 4. Soil test results for the sites of spring wheat input demonstrations at Indian Head, Saskatchewan.

Attribute / Nutrient	0-15 cm	15-60 cm	0-60 cm	0-15 cm	15-60 cm	0-60 cm
Crop Year		2019			2020	
pH	7.1	–	–	7.8	–	–
S.O.M. (%)	6.1	–	–	5.0	–	–
NO_3-N (kg/ha)	18	44	62	9	13	22
Olsen-P (ppm)	11	–	–	4	–	–
K (ppm)	706	–	–	534	–	–
S (kg/ha)	18	27	45	20	128	148

Crop Responses to Nitrogen Management Treatments

Overall tests of fixed effects and model fit statistics are presented in the Appendices (Table A-1) along with the individual treatment means (within and across years) and results of the multiple comparisons tests (Tables A-2 through A-8). Graphical representations of the treatment means, and results of the contrast comparisons follow within the main body of the report.

Emergence was affected by both year and treatment ($P < 0.001$) while a non-significant Yr x Trt interaction ($P = 0.093$) indicated that the treatment effects were reasonably consistent between years. Most notably, the individual means show that any treatments that received the higher seeding rate had greater plant populations than those which did not (Fig. 1; Table A-2). This was confirmed by the contrast comparisons which showed average densities of 324 versus 217 plants/m^2 for high versus low seeding rates in 2019 and 324 versus 217 plants/m^2 in 2020 (Table 5). The only other input effect that the contrasts picked up for plant density was a slight increase with the seed-applied fungicide in 2019 but this did not occur in 2020 or when averaged over the two seasons.

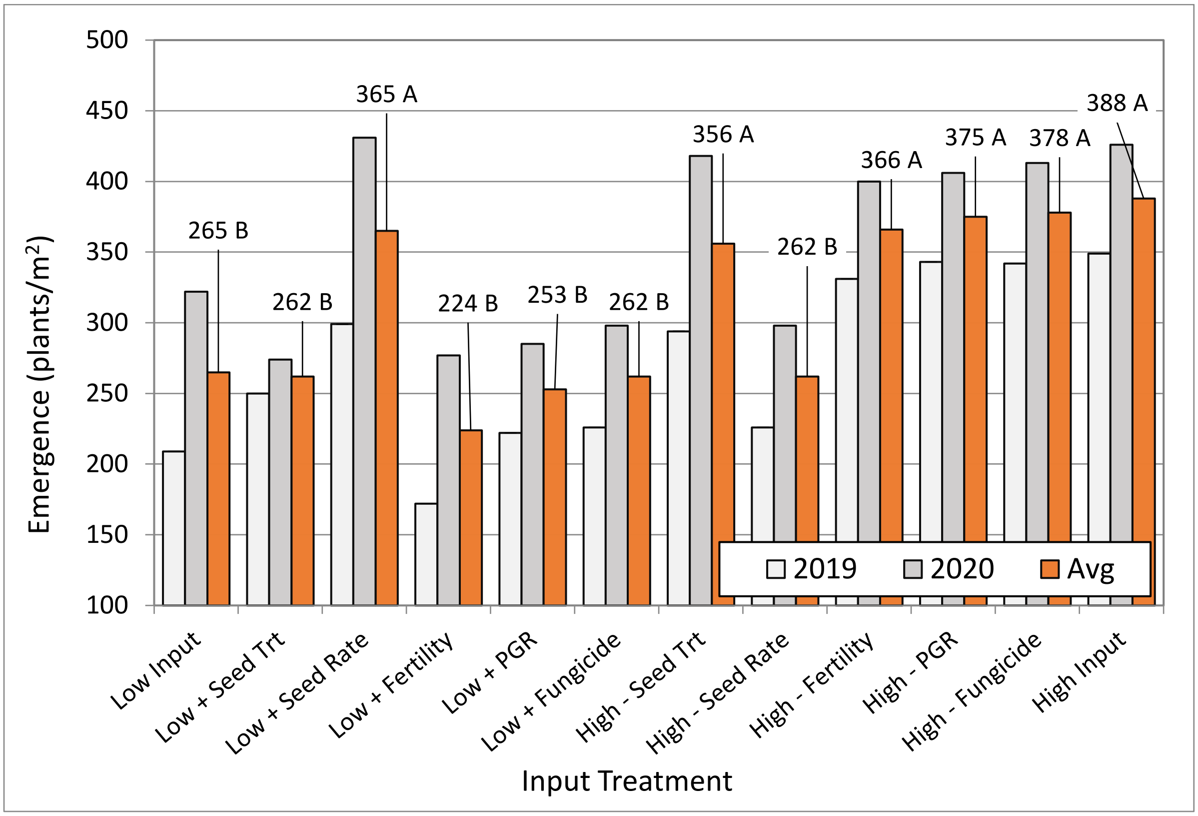

Figure 1. Individual treatment means for plant density expressed both for individual years and averaged across years. Detailed results are provided in Table A-2 of the Appendices and main effect means followed by the same letter do not significantly differ (Tukey's range test, Pr ≤ 0.05).

Table 5. Predetermined contrast comparisons for spring wheat emergence. Comparisons were made both across years and for each season individually. P-values less than or equal to 0.05 indicate that the groups being compared did not significantly differ.

Contrast Comparison	Group A	Group B	Pr > F
	----- Emergence (plants/m^2) -----		---- p-value ----
Seed Treatment (2,12) vs. None (1,7)	325 A	311 A	0.236
2019	300 A	252 B	0.005
2020	350 A	370 A	0.230
High Seed Rate (3,12) vs. Low (1,8)	376 A	263 B	<0.001
2019	324 A	217 B	<0.001
2020	428 A	310 B	<0.001
High Fertility (4,12) vs. Low (1,9)	306 A	315 A	0.424
2019	261 A	270 A	0.571
2020	351 A	361 A	0.572
Plant Growth Regulator (5,12) vs. None (1,10)	320 A	320 A	0.966
2019	286 A	276 A	0.555
2020	355 A	364 A	0.596
Foliar Fungicide (6,12) vs. None (1,11)	325 A	321 A	0.762
2019	288 A	275 A	0.454
2020	362 A	367 A	0.748

Plant height was affected by both year and treatment with a significant Yr x Trt interaction (Table A-1; $P < 0.001$). When averaged over the two years, PGR applications were the only input to consistently affect plant height whereby all treatments that received this input were significantly shorter than all those that did not (Fig. 2; Table A-3). Although individual treatment differences were not always significant, the results from each site-year were similar and the contrasts showed that the PGR effects on height were significant both years individually and on average (Table 6). As per the interaction, there was greater separation between treatments in 2019 and some additional treatment effects which were difficult to explain. For example, in 2019 the contrast comparisons also showed a slight reduction in height when a seed treatment ($P = 0.026$) was applied and at the higher seeding rate ($P = 0.048$). Since plant densities were also higher in 2019 when a seed treatment was applied, it may be that the higher plant densities resulted in slightly shorter plants under the specific conditions encountered.

Lodging ratings were completed both seasons and we expected that inputs such as seeding rate, fertility level, and PGR applications could all impact this variable; however, all values were zero (i.e., no lodging) in 2019 and negligible in 2020. Consequently, lodging rating values were neither statistically analyzed nor reported. The lack of lodging was attributed to the dry weather that occurred over the duration of this project.

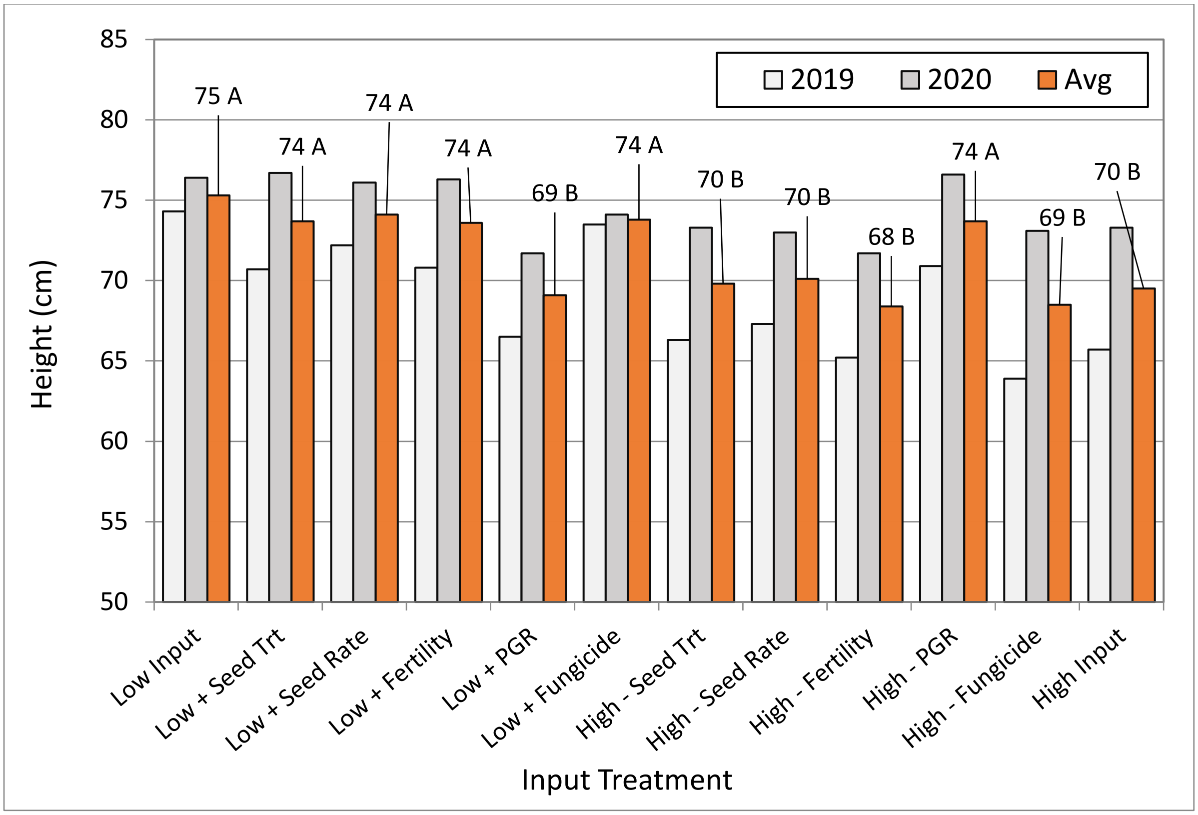

Figure 2. Individual treatment means for plant height expressed both for individual years and averaged across years. Detailed results are provided in Table A-3 of the Appendices and main effect means followed by the same letter do not significantly differ (Tukey's range test, Pr ≤ 0.05).

Table 6. Predetermined contrast comparisons for spring wheat plant height. Comparisons were made both across years and for each season individually. P-values less than or equal to 0.05 indicate that the group means being compared did not significantly differ.

Contrast Comparison	Group A	Group B	Pr > F
	--------- Plant Height (cm) ---------		---- p-value ----
Seed Treatment (2,12) vs. None (1,7)	71.6 A	72.6 A	0.134
2019	68.2 B	70.3 A	0.026
2020	75.0 A	74.9 A	0.889
High Seed Rate (3,12) vs. Low (1,8)	71.8 A	72.7 A	0.150
2019	69.0 B	70.8 A	0.048
2020	74.7 A	74.7 A	0.967
High Fertility (4,12) vs. Low (1,9)	71.5 A	71.9 A	0.574
2019	68.3 A	69.7 A	0.109
2020	74.8 A	74.0 A	0.411
Plant Growth Regulator (5,12) vs. None (1,10)	69.5 B	74.5 A	<0.001
2019	66.1 B	72.6 A	<0.001
2020	72.5 B	76.5 A	<0.001
Foliar Fungicide (6,12) vs. None (1,11)	71.6 A	71.9 A	0.657
2019	69.6 A	69.1 A	0.558
2020	73.7 A	74.8 A	0.227

With the dry weather, visible symptoms of FHB were also quite low over the 2019 and 2020 growing seasons. The two indicators of FHB infections that were calculated were percent incidence (the number of heads with at least trace levels of infection present) and FHB index (the overall average percentage of the spike area infected, including heads with no infection). The FHB index data were statistically analyzed but, due to the low level of infection, the values were miniscule with few meaningful or significant treatment effects; therefore, only percent incidence values are presented. Fusarium head blight incidence was affected by treatment ($P = 0.011$), but not year ($P = 0.501$), and the Yr x Trt interaction was not significant at the desired probability level ($P = 0.080$; Table A-1). Due to high natural variability and low overall disease pressure, differences between individual means were rarely significant for FHB incidence (Fig. 3; Table A-4); however, a few trends were observed. The highest infection levels were observed when high fertility levels were combined with an otherwise low input package (6.2% of spikes infected) while the lowest levels occurred in the high input treatment (0.5% of spikes infected). Not unexpectedly, the contrast comparisons indicated that foliar fungicide application had the most consistent impact on FHB incidence resulting in a slight but significant reduction in infection for both seasons (Table 7). When averaged across seasons and input levels, foliar fungicide reduced FHB incidence from 4.3% to 1.1%. According to these comparisons, increasing the seeding rate also had potential to reduce FHB incidence (particularly in 2020) but did not do so consistently and, when averaged over the two seasons, the reduction associated with higher seeding rates was not significant at the desired probability level ($P = 0.082$).

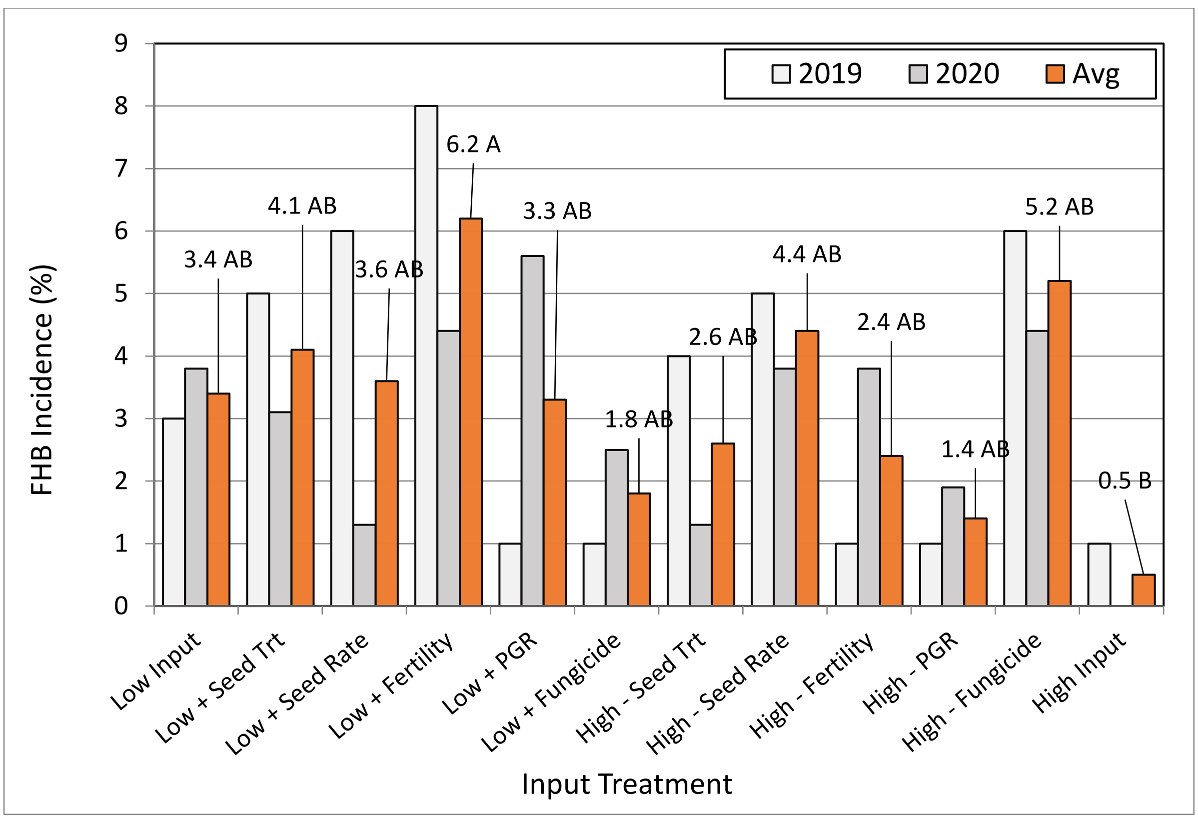

Figure 3. Individual treatment means for FHB incidence (the percentage of spikes with infection present) expressed both for individual years and averaged across years. These values are based on assessments of 25 individual spikes in 2019 and 40 spikes in 2020. Detailed results are provided in Table A-4 of the Appendices and main effect means followed by the same letter do not significantly differ (Tukey's range test, Pr ≤ 0.05).

Table 7. Predetermined contrast comparisons for spring wheat Fusarium Head Blight (FHB) Incidence values. These values are based on assessments of 25 individual spikes in 2019 and 40 spikes in 2020. Comparisons were made both across years and for each season individually. P-values less than or equal to 0.05 indicate that the group means being compared did not significantly differ.

Contrast Comparison	Group A	Group B	Pr > F
	-------- FHB Incidence (%) --------		---- p-value ----
Seed Treatment (2,12) vs. None (1,7)	2.3 A	3.0 A	0.485
2019	3.0 A	3.5 A	0.770
2020	1.6 A	2.5 A	0.412
High Seed Rate (3,12) vs. Low (1,8)	2.1 A	3.9 A	0.082
2019	3.5 A	4.0 A	0.770
2020	0.6 B	3.8 A	0.008
High Fertility (4,12) vs. Low (1,9)	3.3 A	2.9 A	0.649
2019	4.5 A	2.0 A	0.148
2020	2.2 A	3.8 A	0.173
Plant Growth Regulator (5,12) vs. None (1,10)	1.9 A	2.4 A	0.627
2019	1.0 A	2.0 A	0.560
2020	2.8 A	2.8 A	1.000
Foliar Fungicide (6,12) vs. None (1,11)	1.1 B	4.3 A	0.003
2019	1.0 B	4.5 A	0.044
2020	1.3 B	4.1 A	0.016

Grain yields were affected by both year and treatment with a significant Yr x Trt interaction ($P < 0.001$; Table A-1). Despite the drier weather, yields were considerably higher in 2020 with an overall average of 4717 kg/ha compared to 3468 kg/ha in 2019. Although there was greater separation amongst the treatments under the higher yielding conditions of 2020, the general trends were similar for both seasons (Fig. 4; Table A-5). For example, in 2019 there was only a 7% yield increase going from the low input system to the most intensively managed treatment while in 2020 the increase was 18%. Focussing on individual treatment means averaged over the two seasons, only higher fertility increased yields when combined with the low input system. When taken away from the high input system, both reducing fertility and failing to apply a foliar fungicide led to lower yields. According to the contrast comparisons (Table 8), neither seed treatment nor seeding rate affected yield in either season individually or when averaged over the two years. Fertility had the largest and most consistent impact on yield. Both foliar fungicide and PGR applications had a positive impact with foliar fungicide being the more important of the two when averaged over the two-year period (5% increase with fungicide compared to 2.5% with PGR). The contrast looking at PGR effects on yield over the two seasons was not quite significant at the desired probability level ($P = 0.064$). The PGR response was more prominent in 2019 while the fungicide response was greater in 2020; however, as previously specified, both lodging and disease pressure were relatively low over the entire duration of this project. Again, the contrasts take the effects of both adding the inputs to the low input system and removing them from the high input system into account.

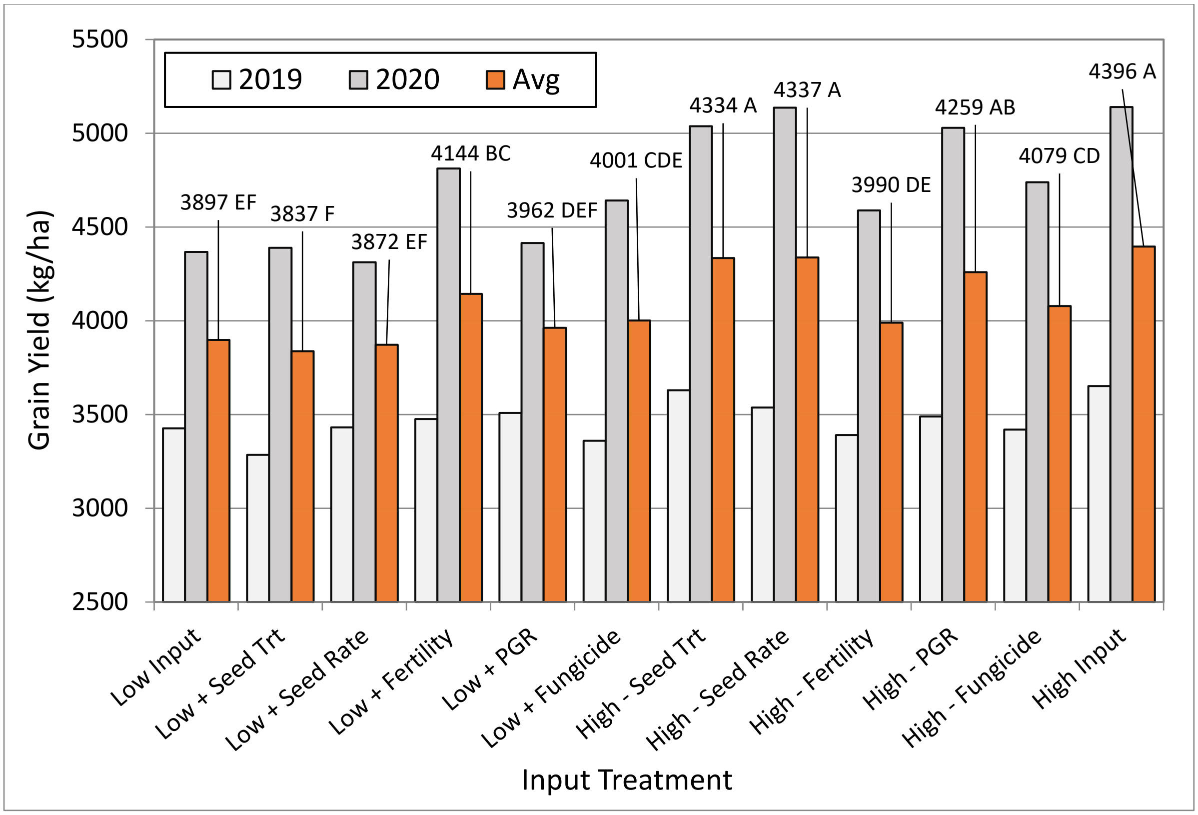

Figure 4. Individual treatment means for grain yield expressed both for individual years and averaged across years. Detailed results are provided in Table A-5 of the Appendices and main effect means followed by the same letter do not significantly differ (Tukey's range test, Pr ≤ 0.05).

Table 8. Predetermined contrast comparisons for spring wheat grain yield. Comparisons were made both across years and for each season individually. P-values less than or equal to 0.05 indicate that the group means being compared did not significantly differ.

Contrast Comparison	Group A	Group B	Pr > F
	-------- Grain Yield (kg/ha) --------		---- p-value ----
Seed Treatment (2,12) vs. None (1,7)	4117 A	4115 A	0.970
2019	3469 A	3529 A	0.162
2020	4764 A	4702 A	0.147
High Seed Rate (3,12) vs. Low (1,8)	4134 A	4117 A	0.569
2019	3542 A	3483 A	0.167
2020	4726 A	4751 A	0.559
High Fertility (4,12) vs. Low (1,9)	4270 A	3943 B	<0.001
2019	3564 A	3409 B	<0.001
2020	4976 A	4477 B	<0.001
Plant Growth Regulator (5,12) vs. None (1,10)	4179 A	4078 B	0.001
2019	3581 A	3459 B	0.006
2020	4778 A	4697 A	0.064
Foliar Fungicide (6,12) vs. None (1,11)	4198 A	3988 B	<0.001
2019	3506 A	3423 A	0.056
2020	4891 A	4552 B	<0.001

The test weight of the harvested grain samples was affected by both year and treatment with a significant Yr x Trt interaction (*P* < 0.001; Table A-1). Test weights were higher overall in 2020 compared to the previous season but there was more separation between treatments in 2019 (Fig. 5; Table A-6). In 2019, test weights were generally lower with the more intensively managed treatments; however, the effect was small and of little agronomic consequence. In 2020, test weights were statistically similar for all treatments and this difference in responses resulted in the significant Yr x Trt interaction. Consistent with the results of the multiple comparisons tests, the contrast comparisons indicated that input effects on test weight were small and somewhat inconsistent (Table 9).

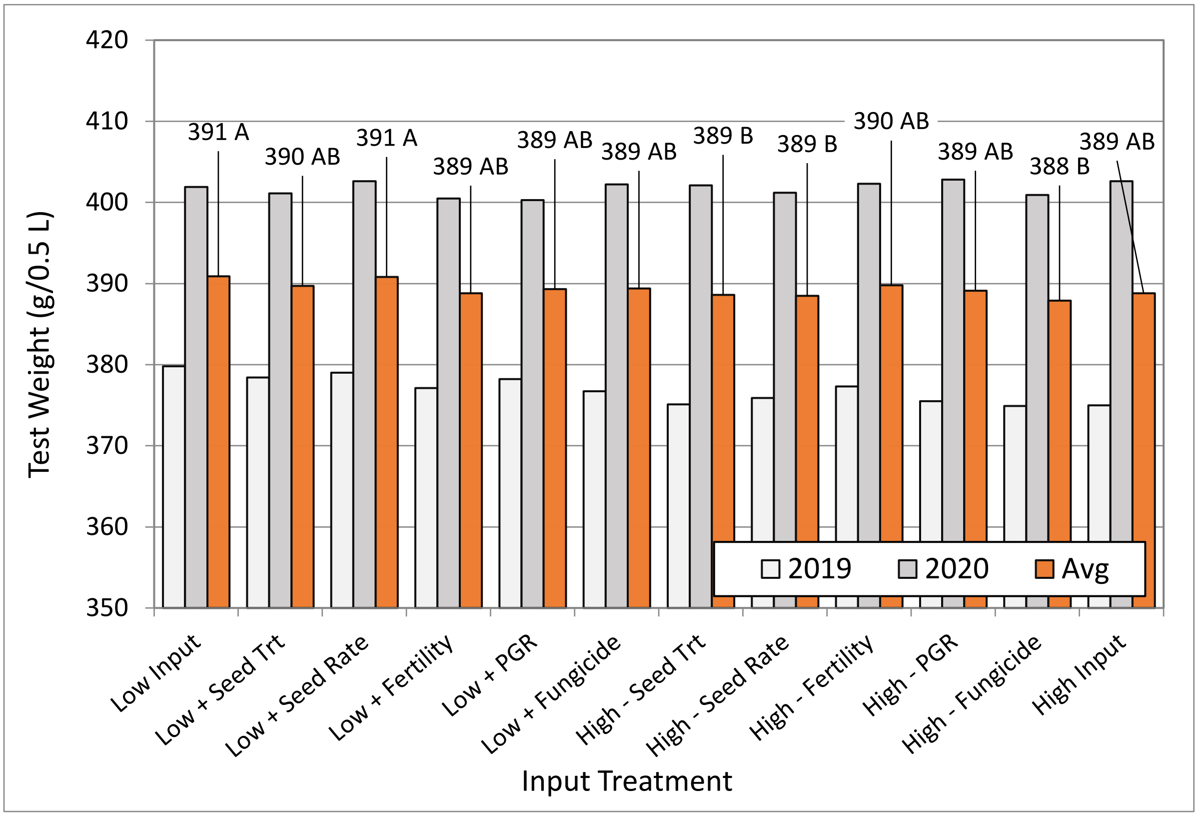

Figure 5. Individual treatment means for test weight expressed both for individual years and averaged across years. Detailed results are provided in Table A-6 of the Appendices and main effect means followed by the same letter do not significantly differ (Tukey's range test, Pr ≤ 0.05).

Table 9. Predetermined contrast comparisons for spring wheat test weight. Comparisons were made both across years and for each season individually. P-values less than or equal to 0.05 indicate that the group means being compared did not significantly.

Contrast Comparison	**Group A**	**Group B**	**Pr > F**
	------ Test Weight (g/0.5 L) ------		---- p-value ----
Seed Treatment (2,12) vs. None (1,7)	389.3 A	389.7 A	0.296
2019	376.7 A	377.4 A	0.312
2020	401.8 A	402.0 A	0.669
High Seed Rate (3,12) vs. Low (1,8)	389.8 A	389.7 A	0.820
2019	377.0 A	377.8 A	0.276
2020	402.6 A	401.6 B	0.040
High Fertility (4,12) vs. Low (1,9)	388.8 B	390.3 A	0.001
2019	376.0 B	378.6 A	0.001
2020	401.5 B	402.1 A	0.266
Plant Growth Regulator (5,12) vs. None (1,10)	389.0 B	390.0 A	0.032
2019	376.6 A	377.6 A	0.166
2020	401.4 A	402.4 A	0.066
Foliar Fungicide (6,12) vs. None (1,11)	389.1 A	389.4 A	0.536
2019	375.8 B	377.3 A	0.046
2020	402.4 A	401.4 B	0.051

Seed size, or thousand kernel weight (TKW) varied between the two seasons ($P < 0.001$) but was not affected by treatment ($P = 0.071$) and no Yr x Trt interaction was detected ($P = 0.676$; Table A-1); thus, indicating that the lack of response was consistent for both seasons. These results were consistent with those of the contrast comparisons whereby none were significant, regardless of the specific input in question or the growing season. Averaged across treatments, the harvested seeds were 30.1 g/1000 seeds in 2019 compared to 33.7 g/1000 seeds in 2020.

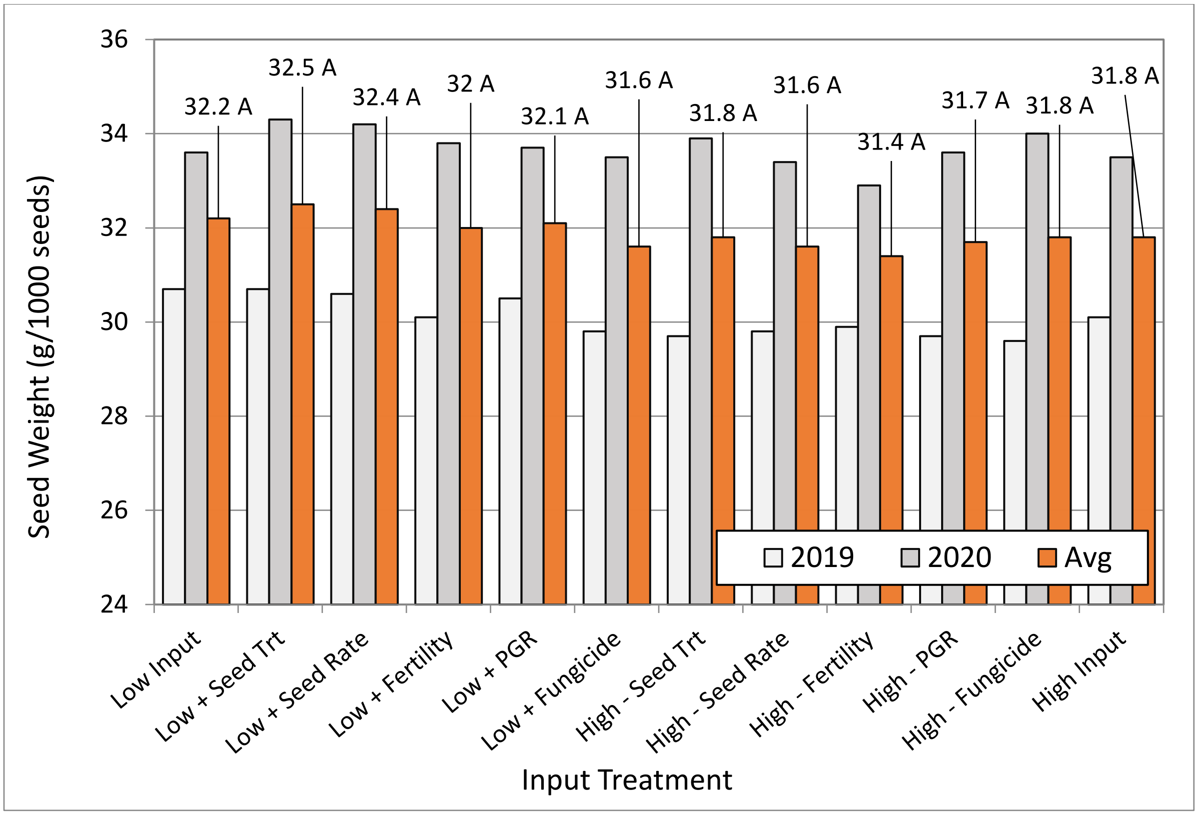

Figure 6. Individual treatment means for seed weight expressed both for individual years and averaged across years. Detailed results are provided in Table A-7 of the Appendices and main effect means followed by the same letter do not significantly differ (Tukey's range test, Pr ≤ 0.05).

Table 10. Predetermined contrast comparisons for spring wheat seed weight. Comparisons were made both across years and for each season individually. P-values less than or equal to 0.05 indicate that the group means being compared did not significantly differ.

Contrast Comparison	Group A	Group B	Pr > F
	-- Seed Weight (g/1000 seeds) --		---- p-value ----
Seed Treatment (2,12) vs. None (1,7)	32.2 A	32.0 A	0.441
2019	30.4 A	30.2 A	0.570
2020	33.9 A	33.8 A	0.601
High Seed Rate (3,12) vs. Low (1,8)	32.1 A	31.9 A	0.343
2019	30.4 A	30.3 A	0.753
2020	33.9 A	33.5 A	0.305
High Fertility (4,12) vs. Low (1,9)	31.9 A	31.8 A	0.675
2019	30.1 A	30.3 A	0.552
2020	33.7 A	33.3 A	0.237
Plant Growth Regulator (5,12) vs. None (1,10)	32.0 A	31.9 A	0.832
2019	30.3 A	30.2 A	0.770
2020	33.6 A	33.6 A	0.994
Foliar Fungicide (6,12) vs. None (1,11)	31.7 A	32.0 A	0.305
2019	29.9 A	30.2 A	0.528
2020	33.7 A	33.8 A	0.411

Grain protein concentrations were affected by year and treatment with a significant Yr x Trt interaction ($P < 0.001$; Table A-1). Overall, protein concentrations were substantially higher in 2019 (15.3%) than in 2020 (13.2%). This was attributed to the combination of lower yields and higher residual N levels in 2019. Averaged over the two seasons, grain protein was highest when extra fertility was added to the low input system and lowest when fertilizer was removed from the high input system. Grain protein was also relatively high when fungicide was removed from the high input system as this treatment also received the extra fertility but yielded lower in the absence of a foliar fungicide. Overall, there was greater treatment separation in 2020 with the higher yields and lower background fertility levels. Focussing on the contrast comparisons, fertility had, by far, the largest and most consistent impact on grain protein. Averaged over both seasons, extra fertility increased grain protein from 13.7% to 14.7%. In 2019, protein increased from 15.0% to 15.5% with extra fertility while, in 2020, the values increased from 12.3% to 13.8%. In addition to the greater treatment separation in 2020, the Yr x Trt interaction was attributed to somewhat inconsistent fungicide effects. For example, foliar fungicide had relatively little effect on yield or protein in 2019 but, in 2020, this input had a greater effect on yield but reduced protein from 13.3% to 12.9%.

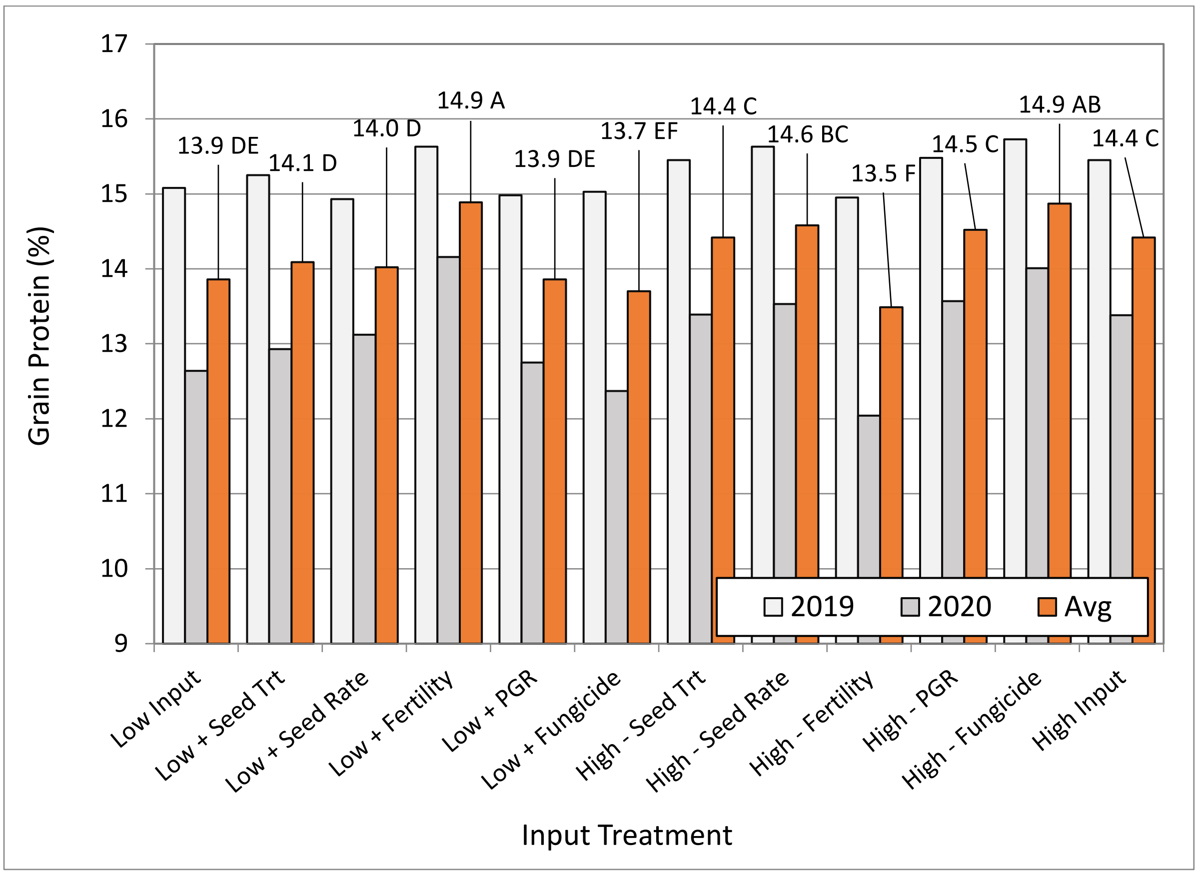

Figure 7. Individual treatment means for grain protein expressed both for individual years and averaged across years. Detailed results are provided in Table A-8 of the Appendices and main effect means followed by the same letter do not significantly differ (Tukey's range test, Pr ≤ 0.05).

Table 11. Predetermined contrast comparisons for spring wheat grain protein. Comparisons were made both across years and for each season individually. P-values less than or equal to 0.05 indicate that the group means being compared did not significantly differ and, subsequently, means within a row followed by the same letter do not significantly differ.

Contrast Comparison	Group A	Group B	Pr > F
	--------- Grain Protein (%) ---------		---- p-value ----
Seed Treatment (2,12) vs. None (1,7)	14.25 A	14.14 A	0.087
2019	15.35 A	15.26 A	0.348
2020	13.16 A	13.02 A	0.135
High Seed Rate (3,12) vs. Low (1,8)	14.22 A	14.22 A	0.977
2019	15.19 A	15.35 A	0.084
2020	13.25 A	13.08 A	0.077
High Fertility (4,12) vs. Low (1,9)	14.65 A	13.67 B	<0.001
2019	15.54 A	15.01 B	<0.001
2020	13.77 A	12.34 B	<0.001
Plant Growth Regulator (5,12) vs. None (1,10)	14.14 A	14.19 A	0.436
2019	15.21 A	15.28 A	0.502
2020	13.07 A	13.11 A	0.667
Foliar Fungicide (6,12) vs. None (1,11)	14.06 B	14.36 A	<0.001
2019	15.24 A	15.40 A	0.084
2020	12.88 B	13.33 A	<0.001

To aid in the interpretation of these results, the marginal economic returns associated with each treatment were calculated. This simplistic profit analyses did not consider any of the fixed costs associated with production (i.e., land, equipment, infrastructure) and only the inputs that were specifically varied were accounted for. More detailed information on the specific assumptions and calculations used is provided in Tables A-9 through A-11 while the net profit values are presented graphically below in Fig. 8. The actual grain yields were used to calculate gross revenues and a protein premium/discount was also applied. These results should be interpreted cautiously as actual input costs, grain prices, and protein discounts/premiums can vary from year-to-year and farm-to-farm. In 2019, with relatively small yield and protein increases associated with the increased management intensity, the low input treatment was the most profitable ($754/ha) while the high input treatment was amongst the least profitable ($597/ha). In 2020, profits for the low versus high input treatments were similar ($923-928/ha) while the low input with extra fertility was the most profitable ($1017/ha). Removing fertility from the otherwise intensively managed wheat resulted in the lowest profits in 2020 ($813/ha). Averaged over the two years, the low input treatment was also more profitable than the high input treatment ($845/ha versus $766/ha) while, like 2020, adding fertility to the low input treatment provided the highest profits and reducing fertility in the high input treatment was the least profitable option.

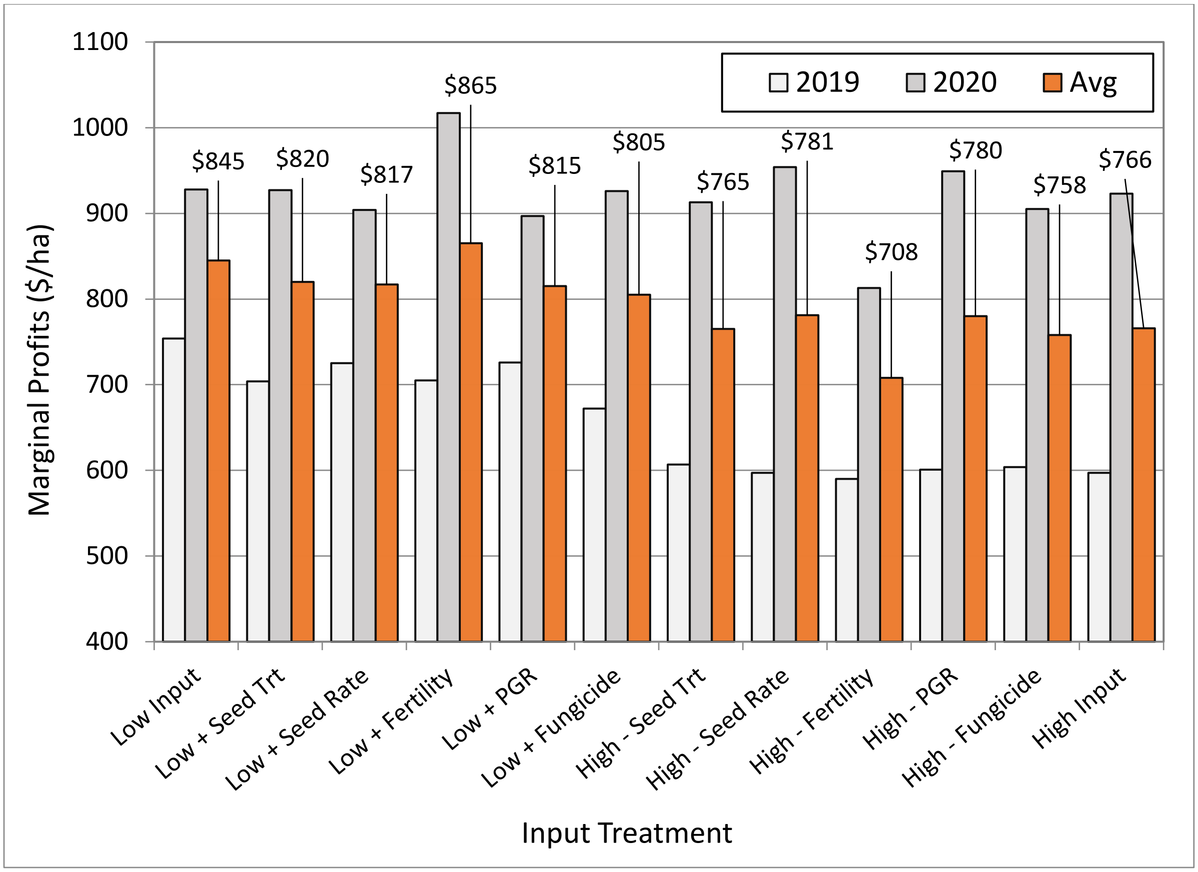

Figure 8. Marginal profits expressed both for individual years and averaged across years. These data were not statistically analyzed. Detailed information on assumptions and calculations are provided in Tables A-9, A-10, and A-11 of the Appendices.

Extension Activities

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 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, 2019 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. Due to COVID-19 restrictions, we were not able to show the field trials on any summer field tours or workshops during the 2020 season; however, highlights of this work were shared at IHARF’s Soil and Crop Management Seminar/AGM (virtual, February 3, 2021, approximately 170 attendees). Technical reports and extension materials will be available online through IHARF and/or Agri-ARM websites.

11. Conclusions and Recommendations

This project demonstrated the contributions of various crop inputs on wheat establishment, yield, quality, and profitability with contrasting yield potential environments but relatively low lodging and disease pressure. One broad comparison that can be made throughout is looking at the agronomic and economic performance of intensive management versus a low 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 environmental conditions encountered. Regarding establishment, increasing seeding rates had, by far, the greatest effect while seed treatments had a slight positive effect in 2019 but not 2020. Plant height was primarily affected by the PGR application which resulted in a 7% reduction when averaged over the two seasons; however, there was essentially no lodging in any treatments. Disease pressure was low and the only input that consistently affected FHB incidence was the foliar fungicide application, reducing the number of affected spikes from 4.3% to 1.1% when averaged over the two seasons. Increased seeding rates reduced FHB incidence in 2020 but not 2019. For yield, extra fertility had, by far, the largest and most consistent impact followed by foliar fungicide and then the PGR applications. Neither seed treatments nor higher seeding rates impacted yields over the two-year period. Although occasional responses were detected, none of the inputs evaluated had a consistent or agronomically important effect on test weight and there were no impacts on seed size (TKW). Extra fertility was the only input that increased protein and it did so consistently. Fungicide application tended to reduce protein concentrations, particularly in 2020, when it had a greater impact on yield. Similar effects have been observed with PGR applications, but this did not occur in the current project. Focussing on profitability, the economic analyses presented was crude but clearly showed that intensively managing wheat for the highest possible yield did not result in the highest profits. While specific responses will vary and all the inputs evaluated have their place and have been proven effective for their intended purposes, these results show the importance of carefully managing production costs when growing wheat. Products such as seed and fertility are generally known to build yield potential while crop protection products and plant growth regulators are for protecting yield potential and preventing losses due to factors such as disease or lodging. With that in mind, it makes sense that products intended to prevent yield loss often provide the greatest benefit when combined with adequate levels of the inputs that build yield potential up in the first place. 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

12. 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. Seed was provided in-kind by FP Genetics. IHARF provided the land, equipment, and infrastructure required to complete this project and IHARF also has a strong working relationship and memorandum of understanding with Agriculture & Agri-Food Canada which helps to make work like this a possibility.

13. Appendices:

Table A-1. Overall tests of fixed effects and model fit statistics for selected spring wheat response variables. Heterogeneous estimates of variance components (between years) were permitted but the more complex model was only utilized if doing so improved the model fit.

Variance Components	Plant Density	Plant Height	FHB Index	FHB Inc.	Grain Yield	Test Weight	Seed Size	Grain Protein
(Year)	---------------------------------- AICc [Z] (smaller is better) ----------------------------------							
Homogeneous	747.4	331.0	311.2	-265.6	906.2	284.0	167.2	11.9
Heterogeneous	749.6	332.6	312.6	-268.8	941.2	280.3	168.9	14.1
Source	-- p-values --							
Year (Yr)	<0.001	<0.001	0.492	0.501	<0.001	<0.001	<0.001	<0.001
Treatment (Trt)	<0.001	<0.001	0.052	0.011	<0.001	<0.001	0.071	<0.001
Yr x Trt	0.093	<0.001	0.214	0.080	<0.001	<0.001	0.676	<0.001

[Z] Akaike information criterion – used to determine the most appropriate model for each variable

Table A-2. Mean spring wheat emergence for individual years and averaged across years. Means within a column followed by the same letter do not significantly differ (Tukey's range test, *P* ≤ 0.05).

Treatment	2019	2020	Average
	------------------------------ *Emergence (plants/m²)* ------------------------------		
Low Input	209 de	322 bc	265 B
Low + Seed Treatment	250 b-e	274 c	262 B
Low + Seed Rate	299 abc	431 a	365 A
Low + Fertility	172 e	277 c	224 B
Low + PGR	222 cde	285 c	253 B
Low + Fungicide	226 cde	298 c	262 B
High - Seed Treatment	294 a-d	418 a	356 A
High - Seed Rate	226 cde	298 c	262 B
High - Fertility	331 ab	400 ab	366 A
High - PGR	343 a	406 ab	375 A
High - Fungicide	342 a	413 a	378 A
High Input	349 a	426 a	388 A
S.E.M.	16.8		11.9

Table A-3. Mean spring wheat plant height for individual years and averaged across years. Means within a column followed by the same letter do not significantly differ (Tukey's range test, *P* ≤ 0.05).

Treatment	2019	2020	Average
	---------- *Plant Height (cm)* ----------		
Low Input	74.3 a	76.4 ab	75.3 A
Low + Seed Treatment	70.7 ab	76.7 a	73.7 A
Low + Seed Rate	72.2 a	76.1 ab	74.1 A
Low + Fertility	70.8 ab	76.3 ab	73.6 A
Low + PGR	66.5 bc	71.7 b	69.1 B
Low + Fungicide	73.5 a	74.1 ab	73.8 A
High - Seed Treatment	66.3 bc	73.3 ab	69.8 B
High - Seed Rate	67.3 bc	73.0 ab	70.1 B
High - Fertility	65.2 c	71.7 a	68.4 B
High - PGR	70.9 ab	76.6 a	73.7 A
High - Fungicide	63.9 c	73.1 ab	68.5 B
High Input	65.7 c	73.3 ab	69.5 B
S.E.M.	0.95		0.67

Table A-4. Mean spring wheat Fusarium Head Blight (FHB) Incidence values for individual years and averaged across years. Values were based on assessments of 25 individual spikes in 2019 and 40 in 2020. Means within a column followed by the same letter do not significantly differ (Tukey's range test, *P* ≤ 0.05).

Treatment	2019	2020	Average
	---------- *FHB Incidence (%)* ----------		
Low Input	3.0 a	3.8 a	3.4 AB
Low + Seed Treatment	5.0 a	3.1 a	4.1 AB
Low + Seed Rate	6.0 a	1.3 a	3.6 AB
Low + Fertility	8.0 a	4.4 a	6.2 A
Low + PGR	1.0 a	5.6 a	3.3 AB
Low + Fungicide	1.0 a	2.5 a	1.8 AB
High - Seed Treatment	4.0 a	1.3 a	2.6 AB
High - Seed Rate	5.0 a	3.8 a	4.4 AB
High - Fertility	1.0 a	3.8 a	2.4 AB
High - PGR	1.0 a	1.9 a	1.4 AB
High - Fungicide	6.0 a	4.4 a	5.2 AB
High Input	1.0 a	0.0 a	0.5 B
S.E.M.	0.02	0.01	1.05

Table A-5. Mean spring wheat grain yields for individual years and averaged across years. Means within a column followed by the same letter do not significantly differ (Tukey's range test, *P* ≤ 0.05).

Treatment	2019	2020	Average
	---------- *Grain Yield (kg/ha)* ----------		
Low Input	3427 a-d	4366 ef	3897 EF
Low + Seed Treatment	3285 d	4389 ef	3837 F
Low + Seed Rate	3432 a-d	4312 f	3872 EF
Low + Fertility	3476 a-d	4812 bc	4144 BC
Low + PGR	3509 a-d	4415 def	3962 DEF
Low + Fungicide	3360 cd	4641 cd	4001 CDE
High - Seed Treatment	3630 ab	5038 ab	4334 A
High - Seed Rate	3538 abc	5136 a	4337 A
High - Fertility	3391 cd	4589 cde	3990 DE
High - PGR	3490 a-d	5029 ab	4259 AB
High - Fungicide	3420 bcd	4739 c	4079 CD
High Input	3652 a	5140 a	4396 A
S.E.M.	102.9		72.7

Table A-6. Mean spring wheat test weights for individual years and averaged across years. Means within a column followed by the same letter do not significantly differ (Tukey's range test, *P* ≤ 0.05).

Treatment	2019	2020	Average
	---------- Test Weight (g/0.5 L) ----------		
Low Input	379.8 a	401.9 a	390.9 A
Low + Seed Treatment	378.4 abc	401.1 a	389.7 AB
Low + Seed Rate	379.0 ab	402.6 a	390.8 A
Low + Fertility	377.1 abc	400.5 a	388.8 AB
Low + PGR	378.2 abc	400.3 a	389.3 AB
Low + Fungicide	376.7 abc	402.2 a	389.4 AB
High - Seed Treatment	375.1 bc	402.1 a	388.6 B
High - Seed Rate	375.9 abc	401.2 a	388.5 B
High - Fertility	377.3 abc	402.3 a	389.8 AB
High - PGR	375.5 bc	402.8 a	389.1 AB
High - Fungicide	374.9 c	400.9 a	387.9 B
High Input	375.0 c	402.6 a	388.8 AB
S.E.M.	0.81	0.57	0.50

Table A-7. Mean spring wheat seed weights for individual years and averaged across years. Means within a column followed by the same letter do not significantly differ (Tukey's range test, *P* ≤ 0.05).

Treatment	2019	2020	Average
	-------------------------- Seed Weight (g/1000 seeds) --------------------------		
Low Input	30.7 a	33.6 a	32.2 A
Low + Seed Treatment	30.7 a	34.3 a	32.5 A
Low + Seed Rate	30.6 a	34.2 a	32.4 A
Low + Fertility	30.1 a	33.8 a	32.0 A
Low + PGR	30.5 a	33.7 a	32.1 A
Low + Fungicide	29.8 a	33.5 a	31.6 A
High - Seed Treatment	29.7 a	33.9 a	31.8 A
High - Seed Rate	29.8 a	33.4 a	31.6 A
High - Fertility	29.9 a	32.9 a	31.4 A
High - PGR	29.7 a	33.6 a	31.7 A
High - Fungicide	29.6 a	34.0 a	31.8 A
High Input	30.1 a	33.5 a	31.8 A
S.E.M.	0.345		0.244

Table A-8. Mean spring wheat grain protein concentrations for individual years and averaged across years. Means within a column followed by the same letter do not significantly differ (Tukey's range test, *P* ≤ 0.05).

Treatment	2019	2020	Average
	---------------------------------- Grain Protein (%) ----------------------------------		
Low Input	15.08 bcd	12.64 ef	13.86 DE
Low + Seed Treatment	15.25 a-d	12.93 de	14.09 D
Low + Seed Rate	14.93 d	13.12 cde	14.02 D
Low + Fertility	15.63 a	14.16 a	14.89 A
Low + PGR	14.98 cd	12.75 ef	13.86 DE
Low + Fungicide	15.03 bcd	12.37 fg	13.70 EF
High - Seed Treatment	15.45 abc	13.39 cd	14.42 C
High - Seed Rate	15.63 a	13.53 bc	14.58 BC
High - Fertility	14.95 d	12.04 g	13.49 F
High - PGR	15.48 ab	13.57 bc	14.52 C
High - Fungicide	15.73 a	14.01 ab	14.87 AB
High Input	15.45 abc	13.38 cd	14.42 C
S.E.M.	0.119		0.084

Table A-9. Partial input costs, estimated revenues, and marginal profits associated with the various treatments in the wheat input demo at Indian Head in 2019.

Treatment	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	$920	$754
Low + Seed Trt	$15.62	$40.56	$126.04	$0.00	$0.00	$886	$704
Low + Seed Rate	$0.00	$66.33	$126.04	$0.00	$0.00	$918	$725
Low + Fertility	$0.00	$40.56	$201.85	$0.00	$0.00	$947	$705
Low + PGR	$0.00	$40.56	$126.04	$46.95	$0.00	$940	$726
Low + Fungicide	$0.00	$40.56	$126.04	$0.00	$62.34	$901	$672
High - Seed Trt	$0.00	$66.33	$201.85	$46.95	$62.34	$985	$607
High - Seed Rate	$15.62	$40.56	$201.85	$46.95	$62.34	$964	$597
High - Fertility	$15.62	$66.33	$126.04	$46.95	$62.34	$907	$590
High - PGR	$15.62	$66.33	$201.85	$0.00	$62.34	$947	$601
High - Fungicide	$15.62	$66.33	$201.85	$46.95	$0.00	$935	$604
High Input	$15.62	$66.33	$201.85	$46.95	$62.34	$991	$597

[Z] Not adjusted for differences in seeding rate; [Y] Assumes certified seed price of $0.478/kg; [X] Assumes $725/tonne for MAP and $525/tonne for urea – K and S costs were excluded as these nutrients were not 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) with a $0.73/Mt premium/discount for every 0.1% above/below 13.5% protein; [U] Values presented do not take into account all production costs and actual input costs may vary substantially

Table A-10. Partial input costs, estimated revenues, and marginal profits associated with the various treatments in the wheat input demo at Indian Head in 2020.

Treatment	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	$1,095	$928
Low + Seed Trt	$15.62	$40.56	$126.04	$0.00	$0.00	$1,110	$927
Low + Seed Rate	$0.00	$66.33	$126.04	$0.00	$0.00	$1,096	$904
Low + Fertility	$0.00	$40.56	$201.85	$0.00	$0.00	$1,260	$1,017
Low + PGR	$0.00	$40.56	$126.04	$46.95	$0.00	$1,110	$897
Low + Fungicide	$0.00	$40.56	$126.04	$0.00	$62.34	$1,154	$926
High - Seed Trt	$0.00	$66.33	$201.85	$46.95	$62.34	$1,291	$913
High - Seed Rate	$15.62	$40.56	$201.85	$46.95	$62.34	$1,321	$954
High - Fertility	$15.62	$66.33	$126.04	$46.95	$62.34	$1,130	$813
High - PGR	$15.62	$66.33	$201.85	$0.00	$62.34	$1,295	$949
High - Fungicide	$15.62	$66.33	$201.85	$46.95	$0.00	$1,236	$905
High Input	$15.62	$66.33	$201.85	$46.95	$62.34	$1,316	$923

[Z] Not adjusted for differences in seeding rate; [Y] Assumes certified seed price of $0.478/kg; [X] Assumes $725/tonne for MAP and $525/tonne for urea – K and S costs were excluded as these nutrients were not 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) with a $0.73/Mt premium/discount for every 0.1% above/below 13.5% protein; [U] Values presented do not take into account all production costs and actual input costs may vary substantially

Table A-11. Partial input costs, estimated revenues, and marginal profits associated with the various treatments in the wheat input demo averaged over a two-year period at Indian Head.

Treatment	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	$1,012	$845
Low + Seed Trt	$15.62	$40.56	$126.04	$0.00	$0.00	$1,003	$820
Low + Seed Rate	$0.00	$66.33	$126.04	$0.00	$0.00	$1,010	$817
Low + Fertility	$0.00	$40.56	$201.85	$0.00	$0.00	$1,107	$865
Low + PGR	$0.00	$40.56	$126.04	$46.95	$0.00	$1,029	$815
Low + Fungicide	$0.00	$40.56	$126.04	$0.00	$62.34	$1,034	$805
High - Seed Trt	$0.00	$66.33	$201.85	$46.95	$62.34	$1,143	$765
High - Seed Rate	$15.62	$40.56	$201.85	$46.95	$62.34	$1,149	$781
High - Fertility	$15.62	$66.33	$126.04	$46.95	$62.34	$1,025	$708
High - PGR	$15.62	$66.33	$201.85	$0.00	$62.34	$1,126	$780
High - Fungicide	$15.62	$66.33	$201.85	$46.95	$0.00	$1,089	$758
High Input	$15.62	$66.33	$201.85	$46.95	$62.34	$1,159	$766

[Z] Not adjusted for differences in seeding rate; [Y] Assumes certified seed price of $0.478/kg; [X] Assumes $725/tonne for MAP and $525/tonne for urea – K and S costs were excluded as these nutrients were not 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) with a $0.73/Mt premium/discount for every 0.1% above/below 13.5% protein; [U] Values presented do not take into account all production costs and actual input costs may vary substantially

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Abstract

14. Abstract/Summary

In 2019 and 2020, field trials near Indian Head, Saskatchewan demonstrated wheat response to low versus high input management. The inputs evaluated were seed treatments, higher seed rates, enhanced fertility, plant growth regulators (PGR), and foliar fungicides. In addition to the low versus high-input treatments, each input was individually added to the low input system or removed from the high input system. Increasing seeding rate had the greatest effect on plant populations while seed treatments had a slight positive effect in 2019 but not 2020. Plant height was primarily affected by the PGR which reduced height by 7% on average. Lodging was always negligible under the dry conditions. Fusarium head blight (FHB) pressure was low and the only input to consistently affect FHB incidence was foliar fungicide, but higher seeding rates also reduced infection in 2020. Yields were lower in 2019 compared to 2020 and there was also greater separation between treatments in 2020. For example, there was a 7% yield advantage to the high input treatment over the low input treatment in 2019 compared to 18% in 2020. Extra fertility was the input that most consistently increased yield, resulting in an average yield increase of 8% compared to 5% for foliar fungicide and 2.5% for PGR. Seed treatments and higher seeding rates did not increase yield. Impacts on test weight were small and of little agronomic importance while seed weight was not affected. Extra fertility was the only input that increased grain protein, from 13.7% to 14.7% when averaged across years. Fungicide slightly reduced protein due to its positive effect on yield. Basic

economic analyses showed the most intensively managed wheat to be less profitable than the low input package, but results varied depending on the specific inputs and the growing season. Extra fertility generally paid with the most profitable treatment (on average) being low input plus enhanced fertility and the least profitable being high input with reduced fertility. As a broad recommendation, soil testing to determine fertilizer rates and choosing crop protection products based on knowledge of past pest issues along with frequent crop scouting will provide the best opportunity to optimize yields and quality while managing costs and maximizing economic returns.