2020 Annual Report

for the

Saskatchewan Ministry of Agriculture's

Agricultural Demonstration of Practices & Technologies (ADOPT) Program

Project Title: Seeding Rates to Reduce Tillering and Flowering Duration for Fusarium Head Blight Management in Wheat

(Project #20190435)

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Project Identification

1. **Project Title:** Seeding rates to reduce tillering and flowering duration for fusarium head blight management in wheat
2. **Project Number:** 20190435
3. **Producer Group Sponsoring the Project:** Indian Head Agricultural Research Foundation
4. **Project Location(s):** Field trials were located at Indian Head (#156), Scott (#380), and Swift Current (#137), Saskatchewan
5. **Project start and end dates(s):** April-2020 to February-2021
6. **Project contact person & contact details:**

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Objectives and Rationale

7. **Project Objectives:**
The objectives of this project were:

    1. To demonstrate the potential for higher seeding rates to reduce tillering, duration of flowering, fusarium head blight (FHB) infection, and quality loss in durum wheat.
    2. To demonstrate the ability of foliar fungicide applications to increase grain yield and reduce FHB infection, and subsequent quality loss in durum wheat.
    3. To demonstrate the combined ability of higher seeding rates and foliar fungicide to optimize both yield and quality of durum wheat

8. **Project Rationale:**
While, on a broad scale, fusarium head blight (FHB) pressure in Saskatchewan has been less over the past few seasons due to drier conditions leading up to and during anthesis, this disease continues to be an important concern for wheat growers. Depending on the duration of heading/flowering and specific weather conditions, substantial disease and costly yield and grade reductions can still occur, even with a well-timed fungicide application. As such, integrated approaches to managing FHB are important for minimizing its impact and reducing our reliance on fungicide applications along with the potential for development of disease tolerance to current fungicide options. While choosing varieties with genetic resistance to FHB is an excellent starting point, such resistance is currently limited (i.e., especially with durum) and producers need additional options for managing this disease more consistently.

In addition to fungicide applications, one approach has been utilizing higher seeding rates to reduce tillering and the overall duration of flowering. In addition to shortening the window for infection, higher seeding rates also have potential to reduce field-scale variability in crop stage and make it easier to appropriately time fungicide applications. Although there was no interaction with fungicide application, May et al. (2014) reduced tillering (heads per plant) and fusarium damaged kernels (FDK) in durum while increasing yields and test weights by doubling the seeding rate from 150 to 300 seeds/m^2. In a previous ADOPT project, Holzapfel (2016) found that increasing the seeding rate from 200 to 400 seeds/m^2 did not affect yield or response to fungicide but significantly reduced FDK and tended to reduce visible FHB infection. In this project, fungicides were more effective for increasing yield than improving grain quality; however, the combination of higher seeding rates and fungicide application was advantageous when both grain yield and quality were considered. In recent, currently unpublished research, Randy Kutcher found that seeding rate had variable effects from site-to-site but did not detect any interactions with fungicide and seeding rate did not affect the optimal timing of application (i.e., Kutcher 2021). Part of the rationale for using higher seeding rates in commercial wheat production is that higher plant populations can reduce within field variability and make fungicide applications easier to stage. On the other hand, higher seeding rates can have drawbacks such as higher input costs and increased risk of lodging depending on the variety and environmental conditions.

The fungicide products registered to suppress FHB in Saskatchewan have been proven effective for their intended purposes through both the registration process and in 3rd party evaluations; however, the actual benefits realized can vary widely under field conditions. Factors such as timing/method of application, varietal susceptibility, and overall disease pressure are major factors that determine if, and to what extent, foliar fungicides are likely to be beneficial. There are many examples of regionally relevant research showing benefits to foliar fungicides for reducing FHB infection in wheat and/or the subsequent yield and quality loss that can occur (i.e., May et al. 2014; Holzapfel 2016; MacLean et al. 2018; Brar et al. 2019).

We hypothesise that the combination of higher plant populations and a fungicide application will result in the highest durum wheat yields and quality; however, it is important that producers also understand the limitations of these practices. Both higher seeding rates and fungicide applications increase production costs. Higher seeding rates also typically result in a denser crop canopy that can retain humidity or be more susceptible to lodging, conceivably even increasing the potential for disease and making the spikes more difficult to uniformly spray. This project aimed to demonstrate the feasibility and potential merits of combining higher seeding rates and foliar fungicide to manage FHB, with durum wheat as a test crop. Although CWRS is the dominant class of wheat grown throughout most of Saskatchewan, durum is an ideal test crop due its susceptibility to FHB infection.

Literature Cited

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Methodology and Results

9. Methodology:

Field trials with durum wheat were conducted near Swift Current, Scott, and Indian Head in 2020. These locations were selected to provide a range of potential yields and levels of disease pressure based on their soil characteristics and typical weather. The treatments were a factorial combination of four seeding rates and two fungicide treatments. Each treatment was replicated four times and arranged in an RCBD at Indian Head and Swift Current and a split plot design (with fungicide as the main plot) at Scott. The seeding rates were 125, 250, 375, and 500 seeds/m^2. The fungicide treatments were simply untreated (no fungicide applied) and treated, where a registered product was applied at approximately 50% anthesis (Zadok 65). The fungicide product was Prosaro XTR (Bayer CropSciences) and the application rate provided a total of 100 g/ha each of prothioconazole and tebuconazole. In cases where the seeding rates resulted in variable crop stage or prolonged tillering, we based the application timing on the 375 seeds/m^2 seeding rate. The fungicide treatments were applied using regular, 110° flat fan nozzles and a minimum solution volume of 187 l/ha (20 U.S. gallons/ac) but slower application speeds than most high-clearance sprayers would utilize (i.e., < 5 km/hr). Treatment information is provided in Table 1.

Selected agronomic information and dates of operations are provided in Table A-1 of the Appendices. The seeding equipment and durum variety differed across locations. Seeding rates varied as per protocol and were adjusted for both seed size and percent germination. The target seeding depth was approximately 2.5-4 cm, depending on the location. Weeds were controlled using registered pre-emergent and in-crop herbicides. Insecticides were not required at any locations. Fungicide applications at the flag leaf stage were not permitted while those at early heading were applied as per protocol. Pre-harvest herbicides were utilized at the discretion of site-managers and the centre rows of each plot were straight-combined.

Various data were collected during the growing season and from the harvested grain. Spring plant densities were assessed by counting seedlings in 2 x 1 m sections of crop row after emergence was complete and converting the averaged values to plants/m^2. Once head emergence was complete, the number of spikes in 2 x 1 m sections of crop row were determined and used to calculate spikes/m^2. The mean head density values were divided by the plant densities to calculate the average number of spikes per plant for each plot. At the late milk/early dough stage, 40 spikes were collected from each plot and rated for percent spike area affected by FHB. The ratings for individual spikes were then used to calculate FHB index (the overall average infection level, considering both infected and uninfected heads). Prior to harvest, lodging was rated for each plot on a scale of 1-10 where a value of 1 indicates that the plants are perfectly upright and a value of 10 indicates that the plants are completely flat. Lodging was always negligible; therefore, these data were not statistically analyzed or reported. Seed yields were determined from the mass of harvested grain and are corrected for dockage and to a uniform seed moisture content of 14.5%. Test weight was determined from cleaned grain sub-samples using standard CGC methods. A composite sample was prepared for each treatment and forwarded to Seed Solutions Laboratory (Swift Current, SK) for determination of percent FDK (by mass) and deoxynivalenol (DON) content (ppm).

Table 1. Individual treatment descriptions for ADOPT fusarium head blight management demonstrations completed at Swift Current, Scott, and Indian Head in 2020.

#	Foliar Fungicide [Z]	Seeding Rate [Y]
1	No foliar fungicide applied	125 seeds/m^2
2	No foliar fungicide applied	250 seeds/m^2
3	No fungicide applied	375 seeds/m^2
4	No fungicide applied	500 seeds/m^2
5	0.803 ml Prosaro XTR/ha	125 seeds/m^2
6	0.803 ml Prosaro XTR/ha	250 seeds/m^2
7	0.803 ml Prosaro XTR/ha	375 seeds/m^2
8	0.803 ml Prosaro XTR/ha	500 seeds/m^2

[Z] Applied at 50% anthesis in at least 187 l/ha solution; [Y] Adjusted for seed size and germination

All response data except for percent FDK and DON (which were not replicated) were analyzed using the Mixed procedure of SAS with the effects of fungicide treatment, seeding rate, and their interaction considered fixed and replicate effects treated as random. Data were analyzed separately for each location. Orthogonal contrasts were used to test whether responses to seeding rate were linear, quadratic (curvilinear), or not significant for individual fungicide treatments and on average. Tukey's range test was used to separate individual treatment means and all treatment effects and differences between means were considered significant at $P \leq 0.05$.

10. Results:

<u>*Growing season weather and residual soil nutrients*</u>

Mean temperatures and total precipitation amounts for May through August at each location are presented with the long-term averages in Tables 2 and 3. Over the four-month period, growing season temperatures were near average all three locations (Table 2). Swift Current and, especially Indian Head, were drier than normal (Table 3). Swift Current received 157 mm of precipitation from May through August, 83% of the long-term average. Indian Head received only 113 mm of precipitation from May-August, 46% of the long-term average. Scott was the exception, having received 118% of the long-term average precipitation over the four-month period, or 258 mm. July was the wettest month at Scott with 123 mm of precipitation during that month alone while August was the driest with approximately 25 mm, slightly below half of their long-term average. Overall, the risk of FHB is highest when temperatures and moisture conditions are high in late-June through mid-July as the wheat heads are emerging and going into anthesis. As such, the expected overall risk of disease was low at Swift Current and Indian Head but considerably higher at Scott.

Table 2. Mean monthly temperatures with long-term (LT; 1981-2010) averages for the 2020 growing season at Swift Current (SW), Scott (SCT), and Indian Head (IH), Saskatchewan.

Year	May	June	July	August	May-Aug
	------------------------------------- Mean Temperature (°C) -------------------------------------				
SW-20	10.4	15.5	18.1	19.4	15.9 (100%)
SW-LT	11.0	15.7	18.4	17.9	15.8
SCT-20	9.9	14.8	17.2	16.3	14.6 (98%)
SCT-LT	10.8	14.8	17.3	16.3	14.8
IH-20	10.7	15.6	18.4	17.9	15.7 (101%)
IH-LT	10.8	15.8	18.2	17.4	15.6

Table 3. Mean monthly precipitation amounts with long-term (LT; 1981-2010) averages for the 2020 growing season at Swift Current (SW), Scott (SCT), and Indian Head (IH), Saskatchewan.

Year	May	June	July	August	May-Aug
	------------------------------------- Total Precipitation (mm) -------------------------------------				
SW-20	30.0	70.9	52.6	3.3	157 (83%)
SW-LT	42.1	66.1	44.0	35.4	188
SCT-20	51.9	55.9	123.0	27.0	258 (114%)
SCT-LT	38.9	69.7	69.4	48.7	227
IH-20	27.3	23.5	37.7	24.9	113 (46%)
IH-LT	51.8	77.4	63.8	51.2	244

Seeding Rate Effects on Durum Establishment and Tillering

While the same statistical analyses were completed for all variables, only the main effect means for seeding rate are presented for plant density, head density, and tillering; however, complete results from the overall tests of fixed effects are presented in Table A-2 of the Appendices. At Scott, head density data was discarded due to an error in how these measurements were completed; therefore, spikes per plant could not be calculated at this location.

Mean plant densities for the seeding rates are presented with the overall orthogonal contrast results in Table 4. As expected, the overall F-test for seeding rate effects on plant density was highly significant ($P < 0.001$) at all three locations (Table A-2). At Swift Current, plant densities increased linearly ($P < 0.001$) from 86-311 plants/m^2 for seeding rates ranging from 125-500 seeds/m^2. At Scott, the response was more quadratic ($P = 0.010$) with increasing mortality at the highest seeding rates and actual populations ranging from 86-205 plants/m^2. At Indian Head, the populations ranged from 97-346 plants/m^2 for seeding rates ranging from 125-500 seeds/m^2 and, although both orthogonal contrasts were highly significant ($P < 0.001$), the increase appeared to be mostly linear. According to the Saskatchewan Ministry of Agriculture, 215-275 plants/m^2 are optimal with the higher end of this range usually recommended in wetter areas of the province.

Table 4. Seeding rate effects on durum plant densities. Means within a column followed by the same letter do not significantly differ (*P* ≤ 0.05).

Main Effect	Swift Current	Scott	Indian Head
<u>Seeding Rate</u>		Plant Density (plants/m^2)	
125 seeds/m^2	86.2 D	85.5 D	97.0 D
250 seeds/m^2	161.0 C	137.7 C	172.7 C
375 seeds/m^2	212.8 B	178.3 B	200.7 B
500 seeds/m^2	310.5 A	204.6 A	345.5 A
S.E.M.	7.24	4.48	7.26
<u>Orthogonal Contrast</u>		Pr > *F* (p-values)	
SR – linear	<0.001	<0.001	<0.001
SR – quadratic	0.088	0.010	<0.001

Mean head densities, or spikes/m^2, are presented for each seeding rate in Table 5. Again, these data were not reported for Scott, but were affected by seeding rate at Swift Current and Indian Head (Table A-2; *P* < 0.001-0.004). At both locations, head densities increased linearly with seeding rate (*P* < 0.001); however, at all seeding rate levels, the values were much higher at Indian Head. At Swift Current, head densities ranged from 210-282 spikes/m^2 for seeding rates ranging from 125-500 seeds/m^2. At Indian Head, the range was 392-464 spikes/m^2. At the highest seeding rate at Swift Current, the number of spikes/m^2 was less than the corresponding plants/m^2. This may have been attributed to spatial variability, missed tillers during counting, or seedlings dying between the two measurement periods.

Table 5. Seeding rate effects on durum head densities. Means within a column followed by the same letter do not significantly differ (*P* ≤ 0.05).

Main Effect	Swift Current	Scott	Indian Head
<u>Seeding Rate</u>		Head Density (spikes/m^2)	
125 seeds/m^2	210.1 B	–	391.5 B
250 seeds/m^2	256.9 A	–	428.8 AB
375 seeds/m^2	262.3 A	–	442.3 A
500 seeds/m^2	282.4 A	–	463.6 A
S.E.M.	7.80	–	17.6
<u>Orthogonal Contrast</u>		Pr > *F* (p-values)	
SR – linear	<0.001	–	<0.001
SR – quadratic	0.101	–	0.521

The average number of spikes per plant was estimated by dividing the values for spikes/m^2 by plants/m^2 for each plot – values of 1 indicate that there were no tillers and only a single main stem. Values below 1 are theoretically impossible but, as previously alluded to, could be attributed to a variety of factors. Nonetheless, the observed treatment effects were as expected with reductions in spikes/plant, or tillering, as the seeding rate was increased. At Swift Current, the values declined linearly from 2.5 spikes/plant at the lowest seeding rate to 0.9 spikes/plant at the highest. At Indian Head, the values ranged from 4.1 spikes/plant at 125 seeds/m^2 to 1.4 spikes/plant at 500 seeds/m^2. The response at Indian Head was somewhat curvilinear (*P* = 0.002) with the greatest reduction in tillering occurring when the seeding rate was increased from 125 seeds/m^2 to 250 seeds/m^2. Overall, the premise was that tillering would be reduced as we increased seeding rates; thus, narrowing the window for FHB infection and potentially reducing overall disease levels while make fungicide applications easier to time.

Table 6. Seeding rate effects on tillering in durum (spikes per plant). Means within a column followed by the same letter do not significantly differ (*P* ≤ 0.05).

Main Effect	Swift Current	Scott	Indian Head
Seeding Rate	---------------------------------- Tillering (spikes/plant) ----------------------------------		
125 seeds/m^2	2.48 A	–	4.05 A
250 seeds/m^2	1.60 B	–	2.50 B
375 seeds/m^2	1.24 C	–	2.21 B
500 seeds/m^2	0.91 C	–	1.35 C
S.E.M.	0.083	–	0.105
Orthogonal Contrast	-------------------------------------- Pr > *F* (p-values) --------------------------------------		
SR – linear	<0.001	–	<0.001
SR – quadratic	0.287	–	0.002

Fungicide and Seeding Rate Effects on Fusarium Head Blight (FHB), Yield, and Grain Quality in Durum
Fusarium head blight (FHB) index is an indicator of the overall infection level for each plot and was calculated from the visual assessments of individual spikes. Main effect means for FHB incidence are presented in Table 7 while individual treatment means appear in Table A-3 of the Appendices. Overall infection levels were lowest at Swift Current, higher but still low at Indian Head, and highest at Scott. These differences can be largely explained by the weather conditions whereby Swift Current and, especially Indian Head, were drier than normal and Scott had above-average precipitation, especially in with July when the crop was susceptible to infection.

At Swift Current, FHB index values were affected by seeding rate ($P < 0.001$) but not fungicide ($P = 0.337$) and there was no interaction between the two factors ($P = 0.638$). The seeding rate effects were not as expected, with values increasing from 1.4% to 3.2% as the seeding rate increased from 125-500 seeds/m^2. Such a response might reasonably occur if the weather became increasingly dry as heading progressed, with the wettest conditions and highest disease pressure specifically coinciding with emergence of the main stems. It is also plausible that visual ratings of FHB infection could be confounded with maturity to a certain extent. In any case, the values were too low for FHB to be of much concern, regardless of seeding rate. This is further supported by the lack of a fungicide effect. The lack of an interaction indicates that seeding rate effects were consistent, regardless of whether a fungicide was applied.

At Indian Head, where disease pressure was also low but higher than at Swift Current, neither the fungicide nor seeding rate effects were significant ($P = 0.389$-0.460) and nor was the interaction between these two factors (Table A-2; $P = 0.478$). Despite the lack of statistical significance, the trends at Indian Head were as expected with slightly higher FHB index values in the control (4.2%) relative to the treated plots (3.5%) and lower values at the highest seeding rate (2.7%) relative to the lower rates (4.0-4.7%). Neither the linear nor quadratic contrasts for seeding rate effects of FHB index were significant at this location when averaged across fungicide treatments ($P = 0.209$-0.312) or for each fungicide treatment individually (Table A-3; $P = 0.221$-0.571).

At Scott, where conditions were more favourable for disease, FHB index was affected by fungicide ($P = 0.010$) but not seeding rate ($P = 0.569$); however, a significant interaction ($P = 0.039$) warranted closer inspection of individual treatment means. When averaged across seeding rates, fungicide reduced FHB index values from 14.2% to 8.3% (Table 7). When averaged across fungicide treatments, there were no trends observed for seeding rate and no orthogonal contrasts were significant (*P* = 0.260-0.544). Focussing on individual treatments (Table A-3), differences between seeding rates within a fungicide treatment were never significant and the trends were inconsistent. For untreated durum (i.e., no fungicide applied), the least infection was observed at 125 seeds/m^2 (10.5%) while values at 250-500 seeds/m^2 rates were similar (15.0-16.2). This resulted in a significant linear response (*P* = 0.038) and a marginally significant quadratic response (*P* = 0.057). In contrast, when fungicide was applied, the highest infection occurred at the lowest seed rate (10.2%) while values at the higher seeding rates trended lower (6.9-8.6%). Although the data were quite variable, it appeared that the fungicide was relatively ineffective at the lowest seeding rate (presumably due to extensive tillering and variable staging) but did a better job at reducing visible infection at the higher seeding rates.

Table 7. Fungicide treatment and seeding rate effects on fusarium head blight (FHB) index in durum. FHB index is the overall average infected spike area, including spikes where no infection was observed. Main effect means within a column followed by the same letter do not significantly differ (*P* ≤ 0.05).

Main Effect	Swift Current	Scott [Y]	Indian Head
Fungicide [Z]		FHB Index (%)	
Untreated	2.3 A	14.2 A	4.2 A
Treated	2.3 A	8.3 B	3.5 A
S.E.M.	0.22	1.08	0.58
Seeding Rate			
125 seeds/m^2	1.4 B	10.3 A	4.0 A
250 seeds/m^2	1.3 B	11.3 A	4.2 A
375 seeds/m^2	2.7 A	12.4 A	4.6 A
500 seeds/m^2	3.2 A	10.9 A	2.7 A
S.E.M.	0.31	1.30	1.49
Orthogonal Contrast		Pr > *F* (p-values)	
SR – linear	<0.001	0.544	0.312
SR – quadratic	0.287	0.260	0.209

[Z] The fungicide was Prosaro XTR applied at 50% anthesis
[Y] Fung x Seed interaction was significant for FHB index at Scott

On average, durum yields were lowest at Swift Current (3189 kg/ha), intermediate at Indian Head (4758 kg/ha), and highest at Scott (4943 kg/ha). Main effect means for yield are presented in Table 8 while individual treatment means are deferred to Table A-4 of the Appendices.

At Swift Current, the overall F-test was significant for seeding rate effects on yield (*P* = 0.048) but not fungicide (*P* = 0.529) and there was no interaction between these factors (Table A-2; *P* = 0.764). Yields increased linearly with seeding rate, from 3035 kg/ha at 125 seeds/m^2 to 3310 kg/ha at 500 seeds/m^2. While we did not necessarily expect to see yield increases up to the highest rate, the observed increases were modest with statistically similar mean yields for seeding rates in the range of 250-500 seeds/m^2. The lack of a fungicide response was not unexpected given the dry weather and low levels of disease. The lack of a fungicide by seeding rate interaction indicates that the seeding rate effects were reasonably consistent for both fungicide treatments and vise versa.

The yield responses at Scott were like Swift Current with significant responses to seeding rate (P = 0.001) but not fungicide (P = 0.564) and no interaction between these factors (P = 0.774). The lack of a fungicide response was unexpected given the wetter weather, high yields, and relatively high disease pressure according to the visual FHB ratings. The linear orthogonal contrast for seeding rate at Scott (averaged across fungicide treatments) was also significant (P < 0.001); however, the quadratic response was also marginally significant (P = 0.076). Further supporting the quadratic response, the greatest yield gains, by far, occurred when the seeding rate was increased from 125 seeds/m^2 to 250 seeds/m^2. Statistically, yields were similar at seeding rates ranging from 250-500 seeds/m^2.

At Indian Head, there was no grain yield response to either fungicide application (P = 0.123) or seeding rate (P = 0.122) according to the overall F-tests (Table A-2) and there was no interaction between these factors (P = 0.458). Yields trended higher with fungicides by 133 kg/ha, or 3%, when averaged across seeding rates. Focussing on seeding rates, the trend was for lower yields at the lowest seeding rate and more similar yields for 250-500 seeds/m^2 seeding rates; however, even the overall quadratic orthogonal contrast was only marginally significant (P = 0.099).

Table 8. Fungicide treatment and seeding rate effects on durum grain yield. Main effect means within a column followed by the same letter indicate that the values did not significantly differ ($P \le 0.05$).

Main Effect	Swift Current	Scott	Indian Head
Fungicide [Z]	----------	Grain Yield (kg/ha)	----------
Untreated	3167 A	5041 A	4679 A
Treated	3211 A	4845 A	4812 A
S.E.M.	79.8	214.5	100.1
Seeding Rate			
125 seeds/m^2	3035 B	4551 B	4592 A
250 seeds/m^2	3162 AB	4997 A	4888 A
375 seeds/m^2	3248 AB	5068 A	4745 A
500 seeds/m^2	3310 A	5157 A	4757 A
S.E.M.	93.0	172.5	115.8
Orthogonal Contrast	----------	Pr > F (p-values)	----------
SR – linear	0.007	<0.001	0.350
SR – quadratic	0.636	0.076	0.099

[Z] The fungicide was Prosaro XTR applied at 50% anthesis

The observed test weights followed a similar pattern to yield in that they were lowest at Swift Current (375 g/0.5 L), intermediate at Indian Head (389 g/0.5 L), and highest at Scott (397 g/0.5 L). The overall F-tests for test weight (Table A-2) were significant for seeding rate at all three locations (P < 0.001-0.028), for fungicide at Indian Head only (P = 0.033), and the interaction between these factors was never significant (P = 0.183-0.959). At Swift Current, test weights increased linearly with seeding rate (P < 0.001) from 370.6 g/0.5 L at 125 seeds/m^2 to 379.0 g/0.5 L at 500 seeds/m^2 (Table 9). Increasing seeding rate also had a positive effect on test weight at Scott but the response was more quadratic (P = 0.006), levelling off at modest seeding rates of 250-375 seeds/m^2. At Indian Head, the response was strictly quadratic (P = 0.010), with the highest test weight values observed at 250 seeds/m^2 and the lowest at 500 seeds/m^2. In terms of fungicide effects, the trend was always for higher test weight with fungicide, but the difference was only significant at Indian Head where mean values increased from 388.1 g/0.5 L to 389.6 g/0.5 L with the fungicide application. This increase was much smaller than the observed location-to-location variation. Individual treatment means for test weight are presented in Table A-5 of the Appendices.

Table 9. Fungicide treatment and seeding rate effects on durum test weight. Main effect means within a column followed by the same letter indicate that the values did not significantly differ (*P* ≤ 0.05).

Main Effect	Swift Current	Scott	Indian Head
Fungicide [Z]	Test Weight (g/0.5 L)		
Untreated	374.5 A	396.7 A	388.1 B
Treated	375.2 A	397.7 A	389.6 A
S.E.M.	1.15	1.81	0.64
Seeding Rate			
125 seeds/m^2	370.6 B	391.5 B	388.3 AB
250 seeds/m^2	374.1 AB	397.7 A	390.4 A
375 seeds/m^2	375.7 AB	399.4 A	389.1 AB
500 seeds/m^2	379.0 A	400.4 A	387.5 B
S.E.M.	1.50	1.56	0.78
Orthogonal Contrast	Pr > *F* (p-values)		
SR – linear	<0.001	<0.002	0.209
SR – quadratic	0.975	0.006	0.010

[Z] The fungicide was Prosaro XTR applied at 50% anthesis

Although we did not complete these measurements for every plot due the high costs, one of the key reasons for combining fungicide applications with higher seeding rates is to reduce fusarium damaged kernels (FDK) and deoxynivalenol (DON) accumulation in the harvested grain. These are important quality parameters that can greatly reduce the value of the harvested grain when too high. Furthermore, FDK and DON are largely independent of yield which is the variable we tend to focus on the most in agronomic research and demonstration projects. The results from these assessments are provided in Table 10 below. For context, the Canadian Grain Commission states that, to achieve grades of No. 2 CWAD or better, FDK can not exceed 0.5%. Fusarium damaged kernels must not exceed 2% for No. 3 or No. 4 CWAD.

Table 10. Percent fusarium damaged kernels (FDK; % by mass) and deoxynivalenol (DON; ppm) for individual fungicide by seeding rate treatments. These analyses were completed for composite samples for each treatment and, therefore, were not statistically analyzed.

Treatment [Z]	Swift Current		Scott [Y]		Indian Head	
	FDK	DON	FDK	DON	FDK	DON
Untr – 125 seeds/m^2	0.10	0.12	–	3.2	1.01	1.57
Untr – 250 seeds/m^2	0.06	0.08	–	3.0	0.77	1.30
Untr – 375 seeds/m^2	0.05	0.09	–	1.3	0.46	1.42
Untr – 500 seeds/m^2	0.03	0.14	–	1.3	0.45	0.84
Fung – 125 seeds/m^2	0.01	0.03	–	2.1	0.96	1.19
Fung – 250 seeds/m^2	0.02	0.02	–	0.8	0.47	1.01
Fung – 375 seeds/m^2	0.01	0.00	–	1.3	0.55	0.96
Fung – 500 seeds/m^2	0.00	0.02	–	0.7	0.14	0.43

[Z] Untr – no fungicide applied; Fung – Prosaro XTR applied at 50% anthesis

Consistent with the observed FHB index results, both FDK (% by mass) and DON (ppm) were extremely low at Swift Current; however, there were a few trends observed. In the absence of a fungicide application, FDK appeared to decline as seeding rate was increased. The seeding rate effect was less apparent when a fungicide was applied, but FDK was lower overall for these treatments, averaging 0.1% (with fungicide) compared to 0.06% without fungicide. For DON at Swift Current, seeding rate did not appear to have much impact; however, the values were noticeably lower with a fungicide (0.02 ppm) compared to where none was applied (0.11 ppm). At Scott, FDK was not determined but the DON analyses showed benefits to both fungicide and higher seeding rates. When no fungicide was applied at Scott, DON was 3.0-3.2 ppm for seeding rates of 125-250 seeds/m^2 but fell to 1.3 ppm with seeding rates of 375 seeds/m^2 or higher. The trend was mostly similar when fungicide was applied with the highest DON levels at 125 seeds/m^2 and generally lower values at as seeding rate increased. When averaged across seeding rates, DON at Scott was 2.2 ppm with no fungicide and 1.2 ppm with fungicide. At Indian Head, both fungicide and higher seeding rates appeared to reduce FDK. Without fungicide, FDK fell from 1.01% to 0.45% as the seeding rate was increased from 125 seeds/m^2 to 500 seeds/m^2. The values fell from 0.96% to 0.14% when combined with a fungicide. Averaged across seeding rates, fungicide at Indian Head reduced FDK from 0.67% to 0.53%. This reduction was smaller than what was achieved by increasing the seeding rate, but the lowest FDK were achieved with a combination of high seeding rates and fungicide. Focussing on DON at Indian Head, the results were generally like what was observed for FDK. Without fungicide, DON fell from 1.57 ppm to 0.84 ppm as the seeding rate was increased from 125 seeds/m^2 to 500 seeds/m^2. With fungicide, the values fell from 1.19 ppm to 0.43 ppm. When averaged across seeding rates, the observed DON values were 1.28 ppm without fungicide and 0.90 ppm with fungicide.

Extension Activities
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 at Indian Head; however, highlights of this work will be shared where feasible going forward. Technical reports and extension materials will be available online through IHARF and/or Agri-ARM websites. Extension activities for the other locations are reported in separate individual site reports.

11. Conclusions and Recommendations

Despite the dry weather and low disease pressure, particularly at Swift Current and Indian Head, this project has demonstrated modest benefits to both higher seeding rates and foliar fungicide applications for minimizing the occurrence and subsequent impact of FHB in durum. While the results from this demonstration can be applied to other classes of wheat, they also show the importance of environment as a determinant of how great of a concern FHB is. Yield gains associated with a fungicide application were always small and never statistically significant. This was a reasonable response to expect at Swift Current and, to a lesser extent, Indian Head given the lack of disease but was somewhat unexpected and more difficult to explain at Scott. Higher seeding rates were more beneficial for improving yield at Swift Current and Scott than they were at Indian Head, but these locations also had higher seedling mortality (i.e., at Scott) and/or less tillering (i.e., at Swift Current). Seeding rate effects on test weight were like those observed for yield. Fungicide generally had a positive effect on test weight, although not always significantly so. Higher seeding rates combined with fungicide application provided the most consistent benefits when we looked at fusarium damaged kernels (FDK) and DON, even though these values were low overall. We cannot say so with certainty since the results were not statistically analyzed; however, higher seeding rates appeared to have a greater impact on FDK and DON than fungicide. This was observed in a previous durum demonstration at Indian Head where fungicide had a larger effect on yield, but higher seeding rates were more impactful for improving grain quality. Importantly, the 125-250 seeds/m^2 rates in this demonstration are lower than what producers would generally target, regardless of anticipated disease pressure. The combination of both higher seeding rates and fungicide resulted in the least visible disease, FDK, and DON in the harvested grain and this would likely be even more apparent under heavier disease pressure. Consequently, implementing these practices can be an effective strategy for managing FHB in wheat production; however, producers should consider expected seedling mortality and disease pressure (i.e., weather and experience) when choosing seeding rates and deciding whether to invest in a fungicide application. There would be value in conducting these demonstrations under heavier disease pressure to build confidence in the results.

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 used at Indian Head were provided in-kind by Corteva Agriscience and Bayer CropScience. IHARF provided the land, equipment, and infrastructure required to complete this project at Indian Head 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. Selected agronomic information and dates of operations for durum fusarium head blight (FHB) management demonstrations completed at Swift Current, Scott, and Indian Head, Saskatchewan in 2020.

Factor / Operation	Swift Current	Scott	Indian Head
Soil Climatic Zone	dry Brown	Dark Brown	thin-Black
Previous Crop	Canola	Canola	Canola
Pre-emergent herbicide	1334 g glyphosate/ha + 29 g carfentrazone-ethyl/ha (May 5)	1334 g glyphosate/ha + 21 g carfentrazone-ethyl/ha (May 9)	894 g glyphosate/ha (May 14)
Cultivar	AAC Spitfire	AAC Stronghold	AAC Spitfire
Seeding Date	May 7	May 12	May 12
Row Spacing	21 cm	25 cm	30 cm
Fertility (kg N-P_2O_5-K_2O-S/ha)	112-56-28-28	73-19-0-20	135-35-18-18
Plant Density	May 26	June 11	June 5
Spike (head) Density	July 21	July 17	July 22
FHB Ratings	July 31	August 17	August 5
In-crop Herbicides	100 g fluroxypyr/ha + 532 g 2,4-D LV ester + 55 g clodinafop-propargyl/ha (June 5)	5 g thiencarbazone-methyl/ha + 31 g pyrasulfotole/ha + 175 g bromoxynil/ha (June 16)	100 g fluroxypyr/ha + 400 g 2,4-D LV ester + 15 g pyroxsulam/ha (June 15)
Foliar Fungicide (as per protocol)	100 g prothioconazole/ha + 100 g tebuconazole/ha (July 15)	100 g prothioconazole/ha + 100 g tebuconazole/ha (July 20)	100 g prothioconazole/ha + 100 g tebuconazole/ha (July 13)
Lodging Ratings	August 20	August 21	August 21
Pre-harvest herbicide	n/a	1334 g glyphosate/ha + 50 saflufenacil/ha (August 31)	894 g glyphosate/ha (August 19)
Harvest date	August 20	September 24	August 27

Table A-2. Overall tests of fixed effects for selected response variables in durum fusarium head blight (FHB) management demonstrations at Swift Current, Scott, and Indian Head in 2020. P-values ≤ 0.05 are considered significant. Data were analyzed using the Mixed procedure of SAS.

Source	Swift Current	Scott	Indian Head
	---------------------------- Spring Plant Density (p-values) ----------------------------		
Fungicide (Fung)	0.502	0.542	0.941
Seeding Rate (Seed)	<0.001	<0.001	<0.001
Fung x Seed	0.445	0.708	0.261
	--------------------------------- Spike Density (p-values) ---------------------------------		
Fungicide (Fung)	0.901	–	0.470
Seeding Rate (Seed)	<0.001	–	0.004
Fung x Seed	0.090	–	0.855
	------------------------------------ Tillering (p-values) ------------------------------------		
Fungicide (Fung)	0.655	–	0.357
Seeding Rate (Seed)	<0.001	–	<0.001
Fung x Seed	0.540	–	0.171
	----------------------------------- FHB Index (p-values) -----------------------------------		
Fungicide (Fung)	0.337	0.010	0.460
Seeding Rate (Seed)	<0.001	0.569	0.389
Fung x Seed	0.429	0.039	0.478
	--------------------------------- Grain Yield (p-values) ---------------------------------		
Fungicide (Fung)	0.529	0.564	0.123
Seeding Rate (Seed)	0.049	0.001	0.122
Fung x Seed	0.764	0.774	0.458
	--------------------------------- Test Weight (p-values) ---------------------------------		
Fungicide (Fung)	0.609	0.699	0.033
Seeding Rate (Seed)	0.003	<0.001	0.028
Fung x Seed	0.854	0.959	0.183

Table A-3. Individual fungicide by seeding rate treatment means for fusarium head blight (FHB) index in durum at Swift Current, Scott, and Indian Head in 2020. FHB index is the overall average infected spike area, including spikes where no infection was observed. Means within a column followed by the same letter did not significantly differ ($P \leq 0.05$).

Treatment [Z]	Swift Current	Scott [Y]	Indian Head
	------ FHB Index (%) ------		
Untr – 125 seeds/m^2	1.9 ab	10.5 abc	4.82 a
Untr – 250 seeds/m^2	1.7 ab	15.2 ab	3.52 a
Untr – 375 seeds/m^2	2.5 ab	16.1 a	5.52 a
Untr – 500 seeds/m^2	3.1 a	15.0 ab	2.89 a
Fung – 125 seeds/m^2	1.0 b	10.2 abc	3.25 a
Fung – 250 seeds/m^2	1.0 b	7.4 c	4.98 a
Fung – 375 seeds/m^2	2.8 ab	8.6 bc	3.62 a
Fung – 500 seeds/m^2	3.3 a	6.9 c	2.44 a
S.E.M.	0.43	1.65	1.16
Orthogonal Contrast	------ Pr > *F* (p-values) ------		
Untr-SR – linear	0.028	0.038	0.470
Untr-SR – quadratic	0.358	0.057	0.571
Fung-SR – linear	<0.001	0.190	0.474
Fung-SR – quadratic	0.552	0.703	0.221

[Z] Untr – no fungicide applied; Fung – Prosaro XTR applied at 50% anthesis

[Y] Fung x Seed interaction was significant for FHB Index at Scott but not Swift Current or Indian Head

Table A-4. Individual fungicide by seeding rate treatment means for durum grain yield at Swift Current, Scott, and Indian Head in 2020. Means within a column followed by the same letter did not significantly differ ($P \leq 0.05$).

Treatment [Z]	Swift Current	Scott	Indian Head
	------ Grain Yield (kg/ha) ------		
Untr – 125 seeds/m^2	2965 a	4713 ab	4566 a
Untr – 250 seeds/m^2	3177 a	5085 ab	4715 a
Untr – 375 seeds/m^2	3260 a	5186 ab	4750 a
Untr – 500 seeds/m^2	3267 a	5181 ab	4686 a
Fung – 125 seeds/m^2	3106 a	4389 b	4618 a
Fung – 250 seeds/m^2	3147 a	4909 ab	5062 a
Fung – 375 seeds/m^2	3236 a	4951 ab	4740 a
Fung – 500 seeds/m^2	3353 a	5133 a	4828 a
S.E.M.	115.1	244.0	142.1
Orthogonal Contrast	------ Pr > *F* (p-values) ------		
Untr-SR – linear	0.031	0.022	0.456
Untr-SR – quadratic	0.296	0.178	0.371
Fung-SR – linear	0.066	0.001	0.559
Fung-SR – quadratic	0.698	0.234	0.142

[Z] Untr – no fungicide applied; Fung – Prosaro XTR applied at 50% anthesis

Table A-5. Individual fungicide by seeding rate treatment means for durum test weight at Swift Current, Scott, and Indian Head in 2020. Means within a column followed by the same letter did not significantly differ (*P* ≤ 0.05).

Treatment [Z]	Swift Current	Scott	Indian Head
	Test Weight (g/0.5 L)		
Untr – 125 seeds/m^2	370.0 b	391.1 bd	387.7 b
Untr – 250 seeds/m^2	374.4 ab	397.5 ac	388.7 ab
Untr – 375 seeds/m^2	375.8 ab	398.5 ac	389.4 ab
Untr – 500 seeds/m^2	377.9 ab	399.9 ac	386.7 b
Fung – 125 seeds/m^2	371.3 ab	392.0 cd	389.0 ab
Fung – 250 seeds/m^2	373.8 ab	397.9 ab	392.2 a
Fung – 375 seeds/m^2	375.6 ab	400.2 ab	388.8 ab
Fung – 500 seeds/m^2	380.2 a	400.8 a	388.4 ab
S.E.M.	2.03	2.07	1.01
Orthogonal Contrast	Pr > *F* (p-values)		
Untr-SR – linear	0.008	<0.001	0.594
Untr-SR – quadratic	0.548	0.047	0.055
Fung-SR – linear	0.003	<0.001	0.210
Fung-SR – quadratic	0.578	0.035	0.061

[Z] Untr – no fungicide applied; Fung – Prosaro XTR applied at 50% anthesis

Abstract

14. Abstract/Summary

Field trials were conducted with durum wheat at Swift Current, Scott, and Indian Head to demonstrate the potential for higher seeding rates combined with fungicides to reduce fusarium head blight (FHB) and subsequent yield and quality losses. The treatments were four seeding rates (125, 250, 375, or 500 seeds/m^2) and two fungicide treatments (untreated versus fungicide applied at 50% anthesis). Data collection included assessments of plant and head density, tillering, visible FHB infection, yield, test weight, fusarium damaged kernels (FDK), and deoxynivalenol (DON). The weather was drier than normal at Swift Current and Indian Head but wetter than normal at Scott, especially in July. As expected, higher seeding rates resulted in higher plant and head densities, but reduced tillering for individual plants. With the dry weather, there was relatively little visible FHB infection at Swift Current and Indian Head, but these values were higher at Scott and were reduced by fungicide. The fungicide application at Scott appeared to be less effective at reducing visible FHB infection at the lowest seeding rate, presumably due to increasing tillering and more variable crop stage. Yield gains with the fungicide application were always small and never statistically significant. This was a reasonable response at Swift Current and Indian Head given the lack of disease but was somewhat unexpected at Scott. Higher seeding rates were more beneficial for improving yield at Swift Current and Scott than they were at Indian Head, but these locations also had higher seedling mortality and/or less tillering. Seeding rate effects on test weight were like those observed for yield. Fungicide tended to have a positive effect on test weight, although not always significantly so. Higher seeding rates appeared to have a greater impact on FDK and DON than fungicide. The combination of higher seeding rates and fungicide resulted in the least visible disease, FDK, and DON. This would likely be more apparent under heavier disease pressure. Consequently, implementing these practices can be an effective strategy for managing FHB in wheat; however, producers should consider expected seedling mortality and disease pressure when choosing seeding rates and deciding whether to invest in a fungicide application.