2021 Final Report

for the

Saskatchewan Ministry of Agriculture's

Agricultural Demonstration of Practices & Technologies (ADOPT) Program

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

(Project #20200513)

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Project Identification

1. **Project Title:** Seed rates to reduce tillering and flowering duration for fusarium head blight management in wheat
2. **Project Number:** 20200513
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-2021 to March-2022
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Objectives and Rationale

7. **Project Objectives:**
The objectives of this project were:
    1. To demonstrate the potential for higher plant populations 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 plant populations 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 during this period, 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 fungicides along with the potential for development of disease resistance 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 require additional options for managing this disease.

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 through their use vary widely under field conditions. Factors such as timing/method of application, varietal susceptibility, and overall disease pressure can all affect 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).

In addition to fungicide applications, another approach for managing FHB has been utilizing higher seed rates to reduce tillering and the overall duration of flowering. In addition to shortening the window for infection, this practice can also reduce field-scale variability in crop stage and improve our ability to properly time foliar 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 seed rate from 150 to 300 seeds/m^2. In a previous ADOPT project, Holzapfel (2016) found that increasing the seed rate from 200 to 400 seeds/m^2 did not affect yield, or the 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 seed rates and fungicide application was advantageous when both yield and quality were considered. In recent, currently unpublished research, Randy Kutcher found that seed rate had variable effects from site-to-site but did not detect any fungicide by seed rate interactions and seed rate did not affect the optimal timing of fungicide application (i.e., Kutcher 2021).

We hypothesise that the combination of higher plant populations and a well-timed 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 seed rates and fungicide applications increase production costs. Higher seed rates may also result in a denser crop canopy that can retain humidity or be more susceptible to lodging, conceivably even increasing the potential for disease and/or making uniform spike coverage more difficult to achieve. In contrast, under drought conditions, higher plant populations can lead to premature senescence and potentially even lead to yield losses. 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 increased susceptibility to FHB infection.

Literature Cited

Brar, G. S., Hnatowich, G., Peng, G., Hucl, P. J., and H. R. Kutcher. 2019. The effect of Fhb1 and Fhb5 quantitative trait loci in hard red spring wheat does not depend on fungicide use for managing fusarium head blight in wheat. Plant Dis. **103:** 1850-1857.

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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 and repeated at the same three locations in 2021. 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 seed rates and two fungicide treatments. Each treatment was arranged in an RCBD and replicated four times. The seed rates were 125, 250, 375, and 500 seeds/m^2. The fungicide treatments were 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 seed rates resulted in variable crop stage or prolonged tillering, we based the application timing on the 375 seeds/m^2 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.

Table 1. Individual treatment descriptions for ADOPT fusarium head blight management demonstrations completed at Swift Current, Scott, and Indian Head in 2020 and 2021.

#	Foliar Fungicide [Z]	Seed 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

Selected agronomic information and dates of operations are provided in Table 13 of the Appendices. The seeding equipment and durum variety differed across locations. Seed 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 herbicide options. Insecticides were not required in any cases. 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 when it was fit to do so.

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 recorded and used to calculate spikes/m^2. The mean spike density values were divided by the plant densities to calculate an 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) and FHB incidence (the percentage of spikes with infection present, regardless of severity). Lodging was rated for each plot on a scale of 1-10 where a value of 1 indicated that the plants are perfectly upright and a value of 10 indicated that the plants are completely flat. 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).

All response data except for percent FDK and DON (which were not replicated) were analyzed using the generalized linear mixed model (GLIMMIX) procedure of SAS studio. For plant density, spike density, and spikes/plant, only the effects of seed rate were considered fixed while fungicide effects and any associated interactions were excluded from the model. For the rest of the response variables, the effects of fungicide treatment, seed rate, and their interaction were considered fixed. Replicate effects were always treated as random. Data were analyzed separately for each site (location x year) because of dramatically different conditions across sites and, potentially, data quality issues resulting from extreme drought. Orthogonal contrasts were used to test whether responses to seeding rate were linear, quadratic (curvilinear), or not significant. 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 conditions*</u>

Mean temperatures and total precipitation amounts for May through August at each site are presented alongside the long-term averages in Tables 2 and 3, respectively. Over the four-month period, growing season temperatures were near average all three locations in 2020 but warmer than average in 2021. Initial soil moisture amounts were not specifically measured but were estimated to be relatively high in 2020 for all three locations but extremely low in 2021. For Swift Current in both years, Indian Head in 2020, and Scott in 2021, the May-August period was relatively dry with total precipitation amounts ranging from 46-83% of the long-term average. Scott 2020 and Indian Head 2021 received above normal growing season precipitation; however, for Indian Head 2021, much of this precipitation came relatively late in August and the FHB pressure was still well below average. For Scott in 2020, July was quite wet and this site had the highest overall disease pressure. In general, disease pressure was higher in 2020 than in 2021 but below average for all six sites. This was not ideal for the purposes of this project as disease pressure was generally too low to provide a good assessment of the treatments and their ability to improve durum yield and quality.

Table 2. Mean monthly temperatures with long-term (LT; 1981-2010) averages for the 2020 and 2021 growing season at Indian Head (IH), Scott (SC), and Swift Current (SW), Saskatchewan.

Year	May	June	July	August	May-Aug
	---------- Mean Temperature (°C) ----------				
IH-20	10.7	15.6	18.4	17.9	15.7 (101%)
IH-21	9.0	17.7	20.3	17.1	16.0 (103%)
IH-LT	10.8	15.8	18.2	17.4	15.6
SC-20	9.9	14.8	17.2	16.3	14.6 (98%)
SC-21	8.9	17.3	19.6	17.2	15.8 (107%)
SC-LT	10.8	14.8	17.3	16.3	14.8
SW-20	10.4	15.5	18.1	19.4	15.9 (100%)
SW-21	9.5	18.3	21.6	17.9	16.8 (106%)
SW-LT	11.0	15.7	18.4	17.9	15.8

Table 3. Mean monthly precipitation amounts with long-term (LT; 1981-2010) averages for the 2020 and 2021 growing season at Swift Current (SW), Scott (SC), and Indian Head (IH), Saskatchewan.

Year	May	June	July	August	May-Aug
	---------- Total Precipitation (mm) ----------				
IH-20	27.3	23.5	37.7	24.9	113 (46%)
IH-21	81.6	62.9	51.2	99.4	295 (121%)
IH-LT	51.8	77.4	63.8	51.2	244
SCT-20	51.9	55.9	123.0	27.0	258 (114%)
SC-21	43.9	43.8	10.4	51.3	149 (66%)
SCT-LT	38.9	69.7	69.4	48.7	227
SW-20	30.0	70.9	52.6	3.3	157 (83%)
SW-21	30.0	26.8	36.6	53.5	147 (78%)
SW-LT	42.1	66.1	44.0	35.4	188

<u>Overall Treatment Effects</u>

The overall tests of fixed effects for each response variable at all six sites are provided in Table 14 of the Appendices. These results provide a high level overview of whether the effects of seed rate, fungicide (where applicable), or their interaction had a statistically significant effect on each of the variables measured and will be referred to throughout the report.

Seed Rate Effects on Durum Establishment and Tillering

The observed plant densities achieved at each seed rate are presented along with the orthogonal contrast results for this variable in Table 4. As expected, the overall F-test for seed rate was significant ($P < 0.001$) at all sites (Table 14). In all cases, each incremental increase in seed rate led to a significant increase in plant density (Table 4). Overall, establishment was best at Indian Head (both years), followed by Swift Current in 2020, and then Scott in both years and Swift Current in 2021. The poorer establishment at some sites was attributed to either less favourable conditions during seeding or spring drought. The plant density response to seed rate was linear and/or quadratic in all cases and there was a tendency for higher mortality at the highest seed rates. For example, at Indian Head, percent establishment averaged 74% at 125 seeds/m^2 and 69% at 500 seeds/m^2. At Scott, these averages were 68% and 42% for 125 seeds/m^2 and 500 seeds/m^2, respectively while, at Swift Current, the averages were 62% and 52%. Higher seedling mortality at higher seed rates is commonly observed and mainly attributed to increased competition between seedlings. Traditionally, minimum final plant densities of at least 200 plants/m^2 have been recommended for wheat; however, from a disease management perspective, targets of closer to 300 plants/m^2 are not uncommon. According to the Saskatchewan Ministry of Agriculture, 215-275 plants/m^2 are optimal with the higher end of this range recommended in wetter areas of the province.

Table 4. Treatment means and orthogonal contrast results for seed rate effects on durum plant densities. Means within a column followed by the same letter do not significantly differ ($P \leq 0.05$). For orthogonal contrasts, p-values ≤ 0.05 are generally considered significant; however, values of ≤ 0.10 are also worth noting. The locations were Indian Head (IH), Scott (SC), and Swift Current (SW).

Main Effect	IH-20	IH-21	SC-20	SC-21	SW-20	SW-21
Seed Rate	------------------------------------ Plant Density (plants/m^2) ------------------------------------					
125 seeds/m^2	97.0 D	88.4 D	85.5 D	81.7 C	86.2 D	68.2 D
250 seeds/m^2	172.7 C	189.0 C	137.7 C	145.9 B	161.0 C	124.3 C
375 seeds/m^2	200.7 B	267.4 B	178.3 B	174.6 B	212.8 B	163.7 B
500 seeds/m^2	345.5 A	344.7 A	204.6 A	210.1 A	310.5 A	206.5 A
S.E.M.	7.29	11.54	4.10	7.70	7.18	10.0
Contrast	--- Pr > *F* (p-values) ---					
SR – linear	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SR – quadratic	<0.001	0.360	0.008	0.074	0.082	0.454

Mean spike (head) densities are presented for each seed rate in Table 5. Spike densities were not reported for Scott-2020 due to an error in the measurement methods, but were affected by seed rate in all other cases ($P < 0.001$; Table 14). Spike densities were highest overall at Indian Head in 2020, followed by Indian Head 2021, Swift Current 2020, Swift Current 2021 and, finally Scott 2021 (Table 5). As expected, these values were consistently higher than the initial plant densities at Indian Head and this was was attributed to tillering (i.e. each plant produced, on average, more than one spike). This was not always the case at the other sites, however, especially at high seed rates. In cases where the number of spikes was similar to or smaller than the number of initially observed plants, we speculate that either tillering was negligible or, particularly at the more drought affected sites, some seedlings died off between the spring plant counts and spike emergence. Spatial variability or missed tillers during counting spikes could have also contributed in such cases. Due to the ability of individual plants to compensate for extra space through tillering, we expected to see less variation in spike densities across seed rates than in plant densities, provided that moisture was not too limiting. This was, in fact, observed at all sites; albeit to varying degrees. For example, at Indian Head in 2020, the observed spike densities were statistically similar for seed rates ranging from 250-500 seeds/m^2, despite significant differences in plant densities for each individual seed rate. This was also the case at Scott 2021 and Swift Current 2020 while, at Indian Head 2021 and Swift Current 2021, spike densities did not level off until 375 seeds/m^2 according to the multiple comparisons tests. Despite the tendency for less variation across seed rates for spike densities than plant densities, for 4/5 sites the response was still linear ($P < 0.001$) but not quadratic ($P = 0.133$-0.496). The trend was always for spike densities to increase right to the highest seed rates, regardless of whether individual treatment means differed significantly. The sole quadratic response at Indian Head 2021 was due to there being a much sharper increase in spike density going from 125 seeds/m^2 to 250 seeds/m^2 compared to what was achieved with subsequent increases in seed rate.

Table 5. Treatment means and orthogonal contrast results for seed rate effects on durum spike densities. Means within a column followed by the same letter do not significantly differ ($P \leq 0.05$). For orthogonal contrasts, p-values ≤ 0.05 are generally considered significant; however, values of ≤ 0.10 are also worth noting. The locations were Indian Head (IH), Scott (SC), and Swift Current (SW).

Main Effect	IH-20	IH-21	SC-20	SC-21	SW-20	SW-21
Seed Rate			Spike Density (spikes/m^2)			
125 seeds/m^2	391. 5 B	209.8 C	–	122.6 B	210.1 B	136.5 C
250 seeds/m^2	428. 8 AB	316.6 B	–	164.5 A	256.9 A	176.5 B
375 seeds/m^2	442.3 A	365.0 A	–	171.1 A	262.3 A	215.5 A
500 seeds/m^2	463.6 A	404.2 A	–	190.9 A	282.4 A	239.0 A
S.E.M.	17.24	14.15	–	7.68	7.77	13.96
Contrast			Pr > *F* (p-values)			
SR – linear	<0.001	<0.001	–	<0.001	<0.001	<0.001
SR – quadratic	0.496	0.010	–	0.185	0.133	0.356

The average number of spikes per plant was estimated by dividing 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, most notably seedling mortality that occurred between the plant and spike counts. Nonetheless, the seed rate effect was always significant ($P < 0.001$; Table 14) and the relative treatment effects were as expected with reduced tillering as the seed rate was increased in all possible cases (Table 6). The response was always quadratic ($P = 0.003$-0.042) due to the reduction in tillering being consistently greatest as the seed rate was increased from 125 seeds/m^2 to 250 seeds/m^2 compared to what was achieved with further increases in seed rate. At the lowest seed rate, tillering ranged from as high as 4.1 spikes/plant at Indian Head 2020 to 1.5 spikes/plant at Scott 2021 while, at the highest, values ranged from 0.9-1.4 spikes/plant. We hypothesized that the reduction in tillering at higher seed rates would simultaneously shorten the window where the plants would be susceptible to FHB infection while also making fungicide applications easier to stage. Depending on the specific environmental conditions leading up to and during anthesis, however, the shorter window for infection would not, in itself, guarantee less FHB or subsequent impacts on grain quality (i.e., FDK, DON). For example, if conditions were humid and hot at the onset of head emergence but became subsequently drier over time, yield and quality losses from FHB could conceivably be less at low plant populations due to a greater percentage of the spikes emerging under relatively low disease pressure. That said, under most conditions, a longer window for infection would have potential to lead to higher FHB damage and much of the rationale for increasing seed rates to manage disease is due to the tendency for higher plant populations to reduce spatial variability and make fungicide applications easier to time.

Table 6. Treatment means and orthogonal contrast results for seed rate effects on durum tillering. Means within a column followed by the same letter do not significantly differ ($P \leq 0.05$). For orthogonal contrasts, p-values ≤ 0.05 are generally considered significant; however, values of ≤ 0.10 are also worth noting. The locations were Indian Head (IH), Scott (SC), and Swift Current (SW).

Main Effect	IH-20	IH-21	SC-20	SC-21	SW-20	SW-21
Seed Rate	Tillering (spikes/plant)					
125 seeds/m^2	4.05 A	2.39 A	–	1.52 A	2.47 A	2.01 A
250 seeds/m^2	2.50 B	1.71 B	–	1.13 B	1.61 B	1.46 B
375 seeds/m^2	2.21 B	1.41 BC	–	1.00 B	1.24 C	1.34 B
500 seeds/m^2	1.35 C	1.18 C	–	0.93 B	0.92 C	1.18 B
S.E.M.	0.108	0.123	–	0.073	0.078	0.153
Contrast	Pr > *F* (p-values)					
SR – linear	<0.001	<0.001	–	<0.001	<0.001	<0.001
SR – quadratic	0.003	0.038	–	0.042	0.005	0.015

Fungicide and Seed 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 and was calculated for each plot from the visual assessments of individual spikes. Average FHB index values in the absence of fungicide ranged widely, from as low as 0.02% at Scott 2021 to as high as 14% at Scott in 2020. Fusarium index values at the remaining sites were intermediate to these, but still low overall from a practical perspective. In general, disease pressure was lower in 2021 than in 2020. According to the overall tests of fixed effects, FHB index was not affected by any treatments at Indian Head in either year or Scott in 2021 (Table 14). The fungicide effect was significant at Scott 2020 and Swift Current 2021 ($P < 0.001$), the seed rate effect was significant at Swift Current 2020 ($P < 0.001$), and the interaction was significant at Scott 2020 ($P = 0.035$). Main effect means for FHB incidence are presented in Table 7 while individual treatment means are deferred to Table 15 of the Appendices.

At Scott 2020, when averaged across seed rates, FHB index was 14.2% with no fungicide and 8.3% with fungicide. At Swift Current 2021, FHB index was reduced from 2.5% to 0.7% with fungicide. The seed rate effect on FHB index at Swift Current, however, was the opposite of what was expected, increasing linearly ($P < 0.001$) from 1.4% to 3.2% when the seed rate was increased from 125 seeds/m^2 to 500 seeds/m^2. While not consistent with what was expected, the observed seed rate responses 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 have been confounded with maturity or other factors to some extent. The interaction at Scott in 2020 was due to seed rate having a greater effect in the absence of fungicide but, here too, the response was not as expected with FHB index increasing with seed rate. When combined with a fungicide, the trend at Scott 2021 was as expected but not statistically significant. At Indian Head in 2020, there was a tendency for lower FHB index both with fungicide application and at the highest seed rate; however, the effects were too small and inconsistent to be considered significant.

Table 7. Treatment means and orthogonal contrast results for fungicide and seed 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). For orthogonal contrasts, p-values ≤ 0.05 are generally considered significant; however, values of ≤ 0.10 are also worth noting. The locations were Indian Head (IH), Scott (SC), and Swift Current (SW).

Main Effect	IH-20	IH-21	SC-20[Y]	SC-21	SW-20	SW-21
Fungicide [Z]			FHB Index (%)			
Untreated	4.19 A	0.08 A	14.20 A	0.016 A	2.31 A	2.49 A
Treated	3.57 A	0.05 A	8.25 B	0.010 A	2.00 A	0.69 B
S.E.M.	0.54	0.016	1.082	0.012	0.187	0.33
Seed Rate						
125 seeds/m^2	4.03 A	0.03 A	10.35 A	0.00 A	1.43 C	1.83 A
250 seeds/m^2	4.25 A	0.08 A	11.28 A	0.05 A	1.32 BC	1.48 A
375 seeds/m^2	4.57 A	0.08 A	12.36 A	0.00 A	2.65 AB	1.42 A
500 seeds/m^2	2.66 A	0.08 A	10.93 A	0.00 A	3.21 A	1.63 A
S.E.M.	0.802	0.026	1.299	0.018	0.293	0.411
Contrast			Pr > *F* (p-values)			
SR – linear	0.321	0.224	0.542	0.552	<0.001	0.671
SR – quadratic	0.217	0.415	0.258	0.191	0.307	0.434

[Z] The fungicide was Prosaro XTR applied at 50% anthesis
[Y] Fung x Seed interaction was significant at SC-20

Treatment effects on percent FHB incidence were generally similar to what was observed for FHB index (Table 14). The values were consistently much higher; however, this measurement does not take into account the severity of infection for individual heads as FHB index does. The main effect means for FHB incidence are presented in Table 8 below while individual treatment means are in Table 16 of the Appendices. Due to the similarity to the results for FHB index, these results will not be discussed in detail. At Indian Head 2020, one trend that did appear more prominently with FHB incidence relative to FHB index was the tendency for values to decline linearly with seed rate specifically when combined with a foliar fungicide application (Table 16; $P = 0.066$). The effect was subtle, with the percentage of infected heads declining from 12.5% to 7.5% as the seed rate was increased from 125 seeds/m^2 to 500 seeds/m^2. In the absence of fungicide, the percent FHB incidence at Indian Head 2020 ranged from 10.0-14.4% with no specific trends observed. The effects were similar for FHB index but, again, these values were smaller and no treatment differences were significant.

Table 8. Treatment means and orthogonal contrast results for fungicide and seed rate effects on fusarium head blight (FHB) incidence in durum. FHB incidence is the percentage of individual spikes where infection was observed, regardless of severity. Main effect means within a column followed by the same letter do not significantly differ (*P* ≤ 0.05). For orthogonal contrasts, p-values ≤ 0.05 are generally considered significant; however, values of ≤ 0.10 are also worth noting. The locations were Indian Head (IH), Scott (SC), and Swift Current (SW).

Main Effect	IH-20	IH-21	SC-20[Y]	SC-21	SW-20	SW-21
Fungicide [Z]			FHB Incidence (%)			
Untreated	12.3 A	2.5 A	73.0 A	0.2 A	25.3 A	20.9 A
Treated	10.3 A	2.0 A	55.9 B	0.2 A	21.1 A	7.0 B
S.E.M.	1.16	0.55	2.02	0.14	2.41	2.33
Seed Rate						
125 seeds/m^2	12.8 A	1.3 A	61.9 A	0.0 A	14.7 B	17.8 A
250 seeds/m^2	10.6 A	2.5 A	65.9 A	0.6 A	15.0 B	14.1 A
375 seeds/m^2	12.2 A	2.8 A	66.6 A	0.0 A	29.4 A	10.9 A
500 seeds/m^2	9.7 A	2.5 A	63.4 A	0.0 A	33.8 A	13.1 A
S.E.M.	1.49	0.83	3.01	0.22	3.12	2.83
Contrast			Pr > *F* (p-values)			
SR – linear	0.201	0.318	0.710	0.543	<0.001	0.107
SR – quadratic	0.907	0.389	0.267	0.182	0.477	0.208

[Z] The fungicide was Prosaro XTR applied at 50% anthesis
[Y] Fung x Seed interaction was significant at SC-20

We expected that lodging could potentially increase with high seed rates and reduced lodging has also been observed with fungicide applications for certain crops and conditions. Lodging pressure was always quite low under the relatively dry conditions encountered for this project with values of 1 (no lodging) reported for either all or the vast majority of treatments at both Scott and Swift Current in both years. Lodging was slightly higher at Indian Head in both years and affected by seed rate (*P* = 0.003-0.037) but not by fungicide application, or the interaction (*P* = 0.202-0.762; Table 14). Main effect means for lodging appear in Table 9 below while individual treatment means are in Table 17. In 2019, lodging increased quadratically with seed rate (*P* = 0.043), relatively stable from from 125-375 seeds/m^2 but increasing slightly at 500 seeds/m^2. In 2021, the response was linear (*P* = 0.009) but values for seed rates of 250-500 seeds/m^2 were statistically similar, ranging from 2.3-2.8. There were no cases where lodging was severe enough to create challenges for harvest and, in 2021, the slightly higher values were mostly attributed to a wind (and hail) storm that occurred in late July.

Table 9. Treatment means and orthogonal contrast results for fungicide and seed rate effects on lodging in durum. Main effect means within a column followed by the same letter do not significantly differ ($P \leq 0.05$). For orthogonal contrasts, p-values ≤ 0.05 are generally considered significant; however, values of ≤ 0.10 are also worth noting. The locations were Indian Head (IH), Scott (SC), and Swift Current (SW).

Main Effect	IH-20	IH-21	SC-20	SC-21	SW-20	SW-21
Fungicide [z]	------ Lodging (1-10) ------					
Untreated	1.8 A	2.3 A	1.0 A	1.0	1.0	1.0
Treated	1.6 A	2.5 A	1.1 A	1.0	1.0	1.0
S.E.M.	0.08	0.24	0.05	–	–	–
Seed Rate						
125 seeds/m^2	1.5 B	1.9 B	1.0 A	1.0	1.0	1.0
250 seeds/m^2	1.5 B	2.3 AB	1.1 A	1.0	1.0	1.0
375 seeds/m^2	1.6 B	2.8 A	1.0 A	1.0	1.0	1.0
500 seeds/m^2	2.1 A	2.6 AB	1.1 A	1.0	1.0	1.0
S.E.M.	0.113	0.28	0.07	–	–	–
Contrast	------ Pr > *F* (p-values) ------					
SR – linear	<0.001	0.009	0.846	–	–	–
SR – quadratic	0.043	0.258	0.665	–	–	–

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

Durum grain yields were affected by seed rate at 5/6 sites (P = 0.001-0.049), but never by fungicide application (P = 0.123-0.747) and the seed rate by fungicide interaction was never significant (P = 0.193-0.924; Table 14). The lack of any fungicide effects indicates that, either disease pressure was too low for fungicide to be beneficial or other factors (i.e. moisture availability), were more limiting to yield than disease. Main effect means for yield appear in Table 10 below while those for the individual treatments are in Table 18 of the Appendices. Inspection of the main effect means showed that seed rate effects on durum yield varied. Indian Head 2020 was the sole non-responsive site; however, even there, a marginally significant (P = 0.099) quadratic orthogonal contrast showed a trend for slightly lower yields at 125 seeds/m^2. In 2021 at Indian Head, the response was also quadratic (P = 0.003) with a large yield gain with seed rates going from 125 seeds/m^2 to 250 seeds/m^2 but no further benefits, or even slight reductions in yield, with subsequent increases. At both Scott and Swift Current in 2020, yields increased linearly (P = 0.007-0.009) with seed rate while, under severe drought and much lower yield potential, yields actually declined with increasing seed rate at both of these locations in 2021. At Scott 2021, the decline was linear (P = 0.013), with higher yields at 125-250 seeds/m^2 (1380-1484 kg/ha) but substantially lower yields at 375-500 seeds/m^2 (1005-1099 kg/ha). At Swift Current 2021, the decline was quadratic with yields dropping sharply from 1134 kg/ha to 600 kg/ha as the seed rate was increased from 125 seeds/m^2 to 250 seeds/m^2 and further declines to 375 seeds/m^2, at which point yields appeared to level off. While these negative responses to seed rate were not specifically hypothesized, such effects have occasionally been observed in severely moisture limited environments.

Table 10. Treatment means and orthogonal contrast results for fungicide and seed rate effects on durum grain yield. Main effect means within a column followed by the same letter do not significantly differ ($P \leq 0.05$). For orthogonal contrasts, p-values ≤ 0.05 are generally considered significant; however, values of ≤ 0.10 are also worth noting. The locations were Indian Head (IH), Scott (SC), and Swift Current (SW).

Main Effect	IH-20	IH-21	SC-20	SC-21	SW-20	SW-21
Fungicide [Z]	---------- Grain Yield (kg/ha) ----------					
Untreated	4679 A	3585 A	5041 A	1262 A	3167 A	559 A
Treated	4812 A	3662 A	4845 A	1222 A	3211 A	612 A
S.E.M.	100.1	59.2	166.0	304.4	79.8	111.5
Seed Rate						
125 seeds/m^2	4592 A	3225 B	4551 B	1380 A	3035 B	1134 A
250 seeds/m^2	4888 A	3820 A	4997 AB	1484 A	3162 AB	600 B
375 seeds/m^2	4745 A	3753 A	5068 AB	1099 A	3248 AB	336 C
500 seeds/m^2	4757 A	3696 A	5157 A	1005 A	3310 A	272 C
S.E.M.	115.8	90.4	195.5	316.9	93.0	120.8
Contrast	---------- Pr > *F* (p-values) ----------					
SR – linear	0.350	0.005	0.009	0.013	0.007	<0.001
SR – quadratic	0.099	0.003	0.235	0.433	0.636	0.002

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

Results for test weight were mostly consistent with what was observed for grain yield. The overall tests of fixed effects showed significant fungicide effects at 2/6 sites, seed rate effects at 5/6 sites, and an interaction at 1/6 sites (Table 14). Despite the lack of a significant impact on either FHB ratings or yield, the fungicide effect on test weight was significant and positive, albeit small, in both years at Indian Head (Table 11). In 2020, test weights increased from 388 g/0.5 L (79.1 kg/hL) to 390 g/0.5 L (79.5 kg/hL) with fungicide while, in 2021, the values increased from 384 g/0.5 L (78.3 kg/hL) to 386 g/0.5 L (78.7 kg/hL). Seed rate effects were often larger, but also variable across sites. Scott 2021 was the sole location where the overall F-test for seed rate was not significant; however, there was still a slight linear increase ($P = 0.038$) in test weight with increasing seed rate whereby values increased from 384 g/0.5 L to 387 g/0.5 L (78.3-78.9 kg/hL) over the range of rates evaluated. The responses at Scott and Swift Current in 2020 were also positive, but much stronger. At Scott 2020, test weight increased quadratically ($P = 0.038$), from 392 g/1000 seeds to 398 g/1000 seeds (79.9-81.2 kg/hL) when the seed rate was increased from 125 seeds/m^2 to 250 seeds/m^2 but then levelling off. At Swift Current 2020, the response was linear ($P < 0.001$), increasing from 371 seeds/m^2 to 379 seeds/m^2 (75.7-77.3 kg/hL) as the seed rate was increased from 125 seeds/m^2 to 500 seeds/m^2. At Swift Current 2021, the seed rate effect on test weight was strong but negative, decreasing sharply from 362 g/0.5 L to 350 g/0.5 L at 500 seeds/m^2 (73.9-71.5 kg/hL) as the seed rate was increased from 125 seeds/m^2 to 500 seeds/m^2. At Indian Head in 2020, the seed rate effect was quadratic ($P = 0.010$), increasing slightly with seed rate at the lower end of the range but declining with further increases. In 2021 at Indian Head, the response was again quadratic and similar to the previous season, peaking at 250 seeds/m^2; however, the interaction was also significant at this site ($P = 0.019$). While the trends were similar regardless of whether a fungicide was applied, the interaction appeared to be due to the negative impacts of extremely high seed rates being more apparent in the absence of a foliar fungicide application (Table 19).

Table 11. Treatment means and orthogonal contrast results for fungicide and seed rate effects on durum test weight. Main effect means within a column followed by the same letter do not significantly differ (*P* ≤ 0.05). For orthogonal contrasts, p-values ≤ 0.05 are generally considered significant; however, values of ≤ 0.10 are also worth noting. The locations were Indian Head (IH), Scott (SC), and Swift Current (SW).

Main Effect	IH-20	IH-21[Y]	SC-20	SC-21	SW-20	SW-21
Fungicide [Z]			Test Weight (g/0.5 L)			
Untreated	388.1 B	383.9 B	396.7 A	386.2 A	374.5 A	355.1 A
Treated	389.6 A	385.7 A	397.7 A	385.2 A	375.2 A	355.2 A
S.E.M.	0.64	0.96	1.50	1.18	1.15	2.53
Seed Rate						
125 seeds/m^2	388.3 AB	384.5 B	391.5 B	384.4 A	370.6 B	361.8 A
250 seeds/m^2	390.4 A	388.7 A	397.7 A	385.2 A	374.1 AB	357.0 AB
375 seeds/m^2	389.1 AB	384.0 A	399.4 A	386.4 A	375.7 AB	351.9 BC
500 seeds/m^2	387.5 B	382.0 A	400.4 A	386.7 A	379.0 A	349.8 C
S.E.M.	0.78	1.10	1.71	1.32	1.50	1.88
Contrast			Pr > *F* (p-values)			
SR – linear	0.209	0.001	<0.001	0.036	<0.001	<0.001
SR – quadratic	0.010	< 0.001	0.038	0.755	0.975	0.345

[Z] The fungicide was Prosaro XTR applied at 50% anthesis
[Y] Fung x Seed interaction was significant at IH-21

Although we did not complete these measurements for every plot due the high costs, one of the key reasons for combining fungicide applications with high seed rates is to reduce fusarium damaged kernels (FDK) and deoxynivalenol (DON) accumulation in the harvested grain. These are important quality parameters that 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 12 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.

Overall, the results for these analyses were reasonably consistent with those of the visual ratings. The values were highest at Scott 2020, followed by Indian Head 2020, Swift Current 2021, and finally Swift Current 2020. That said, from a practical perspective, the values for essentially all sites except for Scott 2020 and, to a lesser extent, Indian Head 2020, were too low to be of much concern or interest. As expected, at Indian Head 2020, we saw a tendency for both FDK and DON to be lower with fungicide and also at the higher seed rates. Anecdotally, fungicide appeared to be more effective for improving grain quality at the higher seed rates. Under slightly higher disease pressure, the response was similar at Scott 2020; however, FDK was not reported at this site. At Swift Current 2021, despite the low overall values, we did see a slight improvement with fungicide. The seed rate effects were opposite of what was expected and observed at either Indian Head or Scott 2020, but consistent with the visual FHB ratings. At Swift Current 2020, FDK and DON values were also too low to be of concern or particularly informative; however, we did tend to see the lowest levels with the combination of higher seed rates and foliar fungicide. For Indian Head and Scott 2021, both FDK and DON were extremely low with no concerns whatsoever about grain quality or meaningful trends.

Table 12. Percent fusarium damaged kernels (FDK; % by mass) and deoxynivalenol (DON; ppm) in durum for both the main effects of fungicide and seed rate and the interaction (fungicide by seed rate. These analyses were completed for composite samples for each treatment and, therefore, were not statistically analyzed. The locations were Indian Head (IH), Scott (SC), and Swift Current (SW).

Trt [Z]	--- IH-20 ---		--- IH-21 ---		--- SC-20 ---		--- SC-21 ---		--- SW-20 ---		--- SW-21 ---	
	FDK	DON	FDK	DON	FDK	DON	FDK	DON	FDK	DON	FDK	DON
Fungicide												
Untr	0.67	1.28	0.02	0.00	–	2.20	0.01	0.00	0.06	0.11	0.06	0.23
Fung	0.53	0.90	0.02	0.03	–	1.23	0.01	0.00	0.01	0.02	0.02	0.05
Seed Rate												
125	0.99	1.38	0.03	0.06	–	2.65	0.01	0.00	0.06	0.08	0.00	0.09
250	0.62	1.16	0.03	0.00	–	1.90	0.00	0.00	0.04	0.05	0.03	0.12
375	0.51	1.19	0.02	0.00	–	1.30	0.01	0.00	0.03	0.05	0.05	0.14
500	0.30	0.64	0.01	0.00	–	1.00	0.01	0.00	0.02	0.08	0.09	0.22
Fungicide x Seed Rate												
Untr-125	1.01	1.57	0.02	0.00	–	3.20	0.02	0.00	0.10	0.12	0.00	0.18
Untr-250	0.77	1.30	0.05	0.00	–	3.00	0.00	0.00	0.06	0.08	0.03	0.21
Untr-375	0.46	1.42	0.01	0.00	–	1.30	0.00	0.00	0.05	0.09	0.05	0.21
Untr-500	0.45	0.84	0.01	0.00	–	1.30	0.00	0.00	0.03	0.14	0.14	0.31
Fung-125	0.96	1.19	0.04	0.12	–	2.10	0.00	0.00	0.01	0.03	0.00	0.00
Fung-250	0.47	1.01	0.01	0.00	–	0.80	0.00	0.00	0.02	0.02	0.02	0.03
Fung-375	0.55	0.96	0.02	0.00	–	1.30	0.01	0.00	0.01	0.00	0.04	0.06
Fung-500	0.14	0.43	0.01	0.00	–	0.70	0.01	0.00	0.00	0.02	0.03	0.12

[Z] Untr – no fungicide applied; Fung – Prosaro XTR applied at 50% anthesis; Seed rates are viable seeds/m^2

Extension Activities

Due to COVID-19 restrictions, we were not able to show these field trials on any summer field tours or workshops during the 2020 season; however, a 2020 interim report covering results from all three locations was made available online through the IHARF website (www.iharf.ca). In 2021, the project was highlighted during the Indian Head Crop Management Field Day which was attended by approximately 75 participants, not including staff or directors. The discussion focussed on results from the previous season and preceding projects, in addition to other ongoing studies addressing FHB management and modelling. At Swift Current, the trial was promoted on a segment of a CKSW radio program titled "Walk the Plots" that was broadcast on a weekly basis through the summer and also on WCA's social medial accounts and the Swift Current online podcast. Technical reports and any other extension materials derived from this work will be available online through IHARF and/or Agri-ARM websites.

11. Conclusions and Recommendations

Despite the dry weather and low disease pressure encountered through much of Saskatchewan over the past two seasons, this project occasionally demonstrated subtle benefits to both higher seed rates and foliar fungicide applications to reduce fusarium head blight (FHB) in durum. In contrast, the quality benefits were not always consistent and there were also occasions where, under severe drought, high seed rates negatively impacted grain yield and test weight. While the low fusarium pressure was not ideal for the purposes of this project, these results illustrate the importance of environment in determining the extent to which FHB can occur and what measures might be appropriate to manage it. Yield gains associated with fungicide applications were always small and never statistically significant. Given the lack of disease, this was a reasonable response to expect at all locations in 2021 along with Swift Current and, to a lesser extent, Indian Head in 2020, but was more difficult to explain at Scott in 2020 where disease pressure was relatively high. The yield responses to seed rate varied, with intermediate rates being optimal both years at Indian Head, high seeding rates performing well at Scott and Swift Current in 2020, but negative responses to seed rates greater than 125-250 seeds/m^2 at Scott and Swift Current 2021 under severe drought conditions. Seed rate effects on test weight were similar to those observed for yield. Fungicide application increased test weight at Indian Head in both years but not at any other sites. Where disease pressure was high enough to make meaningful observations, higher seed rates combined with a foliar fungicide application provided the most consistent benefits with respect to fusarium damaged kernels (FDK) and DON; however, these values were rarely high enough to be a concern, regardless of the treatment. At the two sites with the highest levels of disease (Indian Head and Scott 2020), higher seed rates appeared to have a greater impact on FDK and DON than fungicide; however, both were beneficial.

While wetter conditions and higher disease pressure would have been preferred for this project, our results demonstrate some of the risks of using high seed rates and fungicides to manage FHB under drought conditions. Not only do these practices increase input costs, but the higher seeding rates also had a substantial negative impacts in severely moisture limited environments (i.e. Scott and Swift Current 2021). In conclusion, implementing these strategies for managing FHB in wheat production may be beneficial in wetter environments where disease pressure is sufficiently high, but can actually be detrimental under drought conditions. Producers in the Brown and, to a lesser extent, Dark Brown soil zone should be cautious about utilizing seeding rates greater than 300 seeds/m^2, especially if initial soil moisture reserves are low. In regions less likely to be greatly limited by drought (i.e. Black soil zone), the potential risks associated with higher seed rates are less, especially if growing a variety with good lodging resistance. That said, the chosen rates should still consider expected mortality and final plant populations of 250-300 plants/m^2 are likely more than sufficient for optimizing both yield and grain quality. Regardless of location, decisions surrounding fungicide applications should be based on actual leaf disease pressure in addition to the potential for FHB to develop. While foliar fungicides do not come with the same agronomic risks as high seeding rates under drought conditions, they do increase production costs and are unlikely to provide a return on investment if disease pressure is not sufficiently high.

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 all three of the organizations who collaborated on this project have a strong working relationships and memorandums of understanding with Agriculture & Agri-Food Canada which help to make work like this a possibility.

13. Appendices:

Table 13. Selected agronomic information and dates of operations for durum fusarium head blight (FHB) management demonstrations completed at Indian Head (IH), Scott (SC), and Swift Current (SW), Saskatchewan in 2020 and 2021.

Factor / Operation	IH-20	IH-21	SC-20	SC-21	SW-20	SW-21
Soil Climatic Zone	thin Black		Dark Brown		dry Brown	
Previous Crop	Canola	Canola	Canola	Canola	Canola	Barley
Cultivar	AAC Spitfire	AAC Spitfire	AAC Stronghold	AAC Stronghold	AAC Spitfire	AAC Spitfire
Seeding Date	May-12	May-8	May 12	May-17	May-7	May-12
Row Spacing	30 cm	30 cm	25 cm	25	21 cm	21
Fertility (kg N-P_2O_5-K_2O-S/ha)	135-35-18-18	135-35-18-18	73-19-0-20	112-42-0-8	112-56-28-28	112-56-0-22
Plant Density	Jun-5	Jun-8	Jun-11	Jun-14	May-26	Jun-2
Spike (head) Density	Jul-22	Jul-22	Jul-17	Jul-19	Jul-21	Jul-19
FHB Ratings	Aug-5	Jul-30	Aug-17	Aug-4	Jul-31	Jul-30
Foliar Fungicide (as per protocol)	Jul-13	Jul-12	Jul-20	Jul-15	Jul-15	Jul-13
Lodging Ratings	Aug-21	Aug-6	Aug-21	Aug-9	Aug-20	Aug-29
Harvest date	Aug-27	Sep-1	Sep-24	Aug-31	Aug-20	Aug-30

Table 14. Overall tests of fixed effects for selected response variables in durum fusarium head blight (FHB) management demonstrations at Indian Head (IH), Scott (SC), and Swift Current (SW) in 2020 and 2021. P-values ≤ 0.05 are considered significant.

Source	IH-20	IH-21	SC-20	SC-21	SW-20	SW-21
	------------ Spring Plant Density (p-values) ------------					
Seed Rate (Seed)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	------------ Spike Density (p-values) ------------					
Seed Rate (Seed)	0.002	<0.001	–	<0.001	<0.001	<0.001
	------------ Tillering (p-values) ------------					
Seed Rate (Seed)	<0.001	<0.001	–	<0.001	<0.001	<0.001
	------------ FHB Index (p-values) ------------					
Fungicide (Fung)	0.468	0.251	<0.001	0.770	0.357	<0.001
Seed Rate (Seed)	0.406	0.521	0.568	0.173	<0.001	0.843
Fung x Seed	0.494	0.588	0.035	0.966	0.464	0.169
	------------ FHB Incidence (p-values) ------------					
Fungicide (Fung)	0.140	0.603	<0.001	1.000	0.147	<0.001
Seed Rate (Seed)	0.347	0.616	0.698	0.159	<0.001	0.225
Fung x Seed	0.361	0.616	0.046	1.000	0.638	0.056
	------------ Lodging (p-values) ------------					
Fungicide (Fung)	0.293	0.258	0.202	–	–	–
Seed Rate (Seed)	0.003	0.037	0.559	–	–	–
Fung x Seed	0.762	0.360	0.559	–	–	–
	------------ Grain Yield (p-values) ------------					
Fungicide (Fung)	0.123	0.437	0.194	0.747	0.529	0.424
Seed Rate (Seed)	0.122	0.001	0.036	0.039	0.049	<0.001
Fung x Seed	0.458	0.916	0.924	0.355	0.764	0.193
	------------ Test Weight (p-values) ------------					
Fungicide (Fung)	0.033	0.020	0.405	0.223	0.609	0.919
Seed Rate (Seed)	0.028	<0.001	<0.001	0.188	0.003	<0.001
Fung x Seed	0.183	0.019	0.985	0.922	0.854	0.860

Table 15. Individual fungicide by seed rate treatment means for fusarium head blight (FHB) index in durum at Indian Head (IH), Scott (SC), and Swift Current (SW) in 2020 and 2021. 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]	IH-20	IH-21	SC-20[Y]	SC-21	SW-20	SW-21
	FHB Index (%)					
Untr – 125 seeds/m^2	4.82 a	0.02 a	10.5 abc	0.00 a	1.88 ab	2.96 ab
Untr – 250 seeds/m^2	3.52 a	0.09 a	15.2 ab	0.06 a	1.69 ab	1.76 abc
Untr – 375 seeds/m^2	5.52 a	0.12 a	16.1 a	0.00 a	2.51 ab	2.20 abc
Untr – 500 seeds/m^2	2.89 a	0.11 a	15.0 ab	0.00 a	3.14 a	3.02 a
Fung – 125 seeds/m^2	3.25 a	0.04 a	10.2 abc	0.00 a	0.98 b	0.70 abc
Fung – 250 seeds/m^2	4.98 a	0.06 a	7.4 c	0.04 a	0.96 b	1.20 abc
Fung – 375 seeds/m^2	3.62 a	0.04 a	8.6 bc	0.00 a	2.79 ab	0.63 bc
Fung – 500 seeds/m^2	2.44 a	0.05 a	6.9 c	0.00 a	3.29 a	0.23 c
S.E.M.	1.16	0.038	1.64	0.026	0.434	0.541
Orthogonal Contrast	Pr > *F* (p-values)					
Untr-SR – linear	0.478	0.093	0.036	0.607	0.034	0.785
Untr-SR – quadratic	0.579	0.319	0.055	0.257	0.378	0.056
Fung-SR – linear	0.482	0.989	0.187	0.742	<0.001	0.385
Fung-SR – quadratic	0.230	0.879	0.702	0.464	0.568	0.381

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

[Y] Fung x Seed interaction was significant at SC-20 but no other sites

Table 16. Individual fungicide by seed rate treatment means for fusarium head blight (FHB) incidence in durum at Indian Head (IH), Scott (SC), and Swift Current (SW) in 2020 and 2021. FHB incidence is the percentage of individual spikes where infection was observed, regardless of severity. Means within a column followed by the same letter did not significantly differ (*P* ≤ 0.05).

Treatment [Z]	IH-20	IH-21	SC-20[Y]	SC-21	SW-20	SW-21
	FHB Incidence (%)					
Untr – 125 seeds/m^2	13.1 a	0.6 a	62.5 abcd	0.0 a	18.1 ab	27.5 a
Untr – 250 seeds/m^2	10.0 a	2.5 a	74.4 abc	0.6 a	19.4 ab	16.3 abc
Untr – 375 seeds/m^2	14.4 a	3.8 a	78.8 a	0.0 a	29.4 ab	16.3 abc
Untr – 500 seeds/m^2	11.9 a	3.1 a	76.3 ab	0.0 a	34.4 a	23.8 ab
Fung – 125 seeds/m^2	12.5 a	1.9 a	61.3 abcd	0.0 a	11.3 b	8.1 c
Fung – 250 seeds/m^2	11.3 a	2.5 a	57.5 bcd	0.6 a	10.6 b	11.9 bc
Fung – 375 seeds/m^2	10.0 a	1.9 a	54.4 cd	0.0 a	29.4 ab	5.6 c
Fung – 500 seeds/m^2	7.5 a	1.9 a	50.6 d	0.0 a	33.1 a	2.5 c
S.E.M.	2.00	1.22	4.35	0.31	4.19	3.64
<u>Orthogonal Contrast</u>	Pr > *F* (p-values)					
Untr-SR – linear	0.941	0.134	0.032	0.667	0.003	0.445
Untr-SR – quadratic	0.869	0.330	0.121	0.340	0.641	0.009
Fung-SR – linear	0.066	0.912	0.093	0.667	<0.001	0.124
Fung-SR – quadratic	0.742	0.806	1.000	0.340	0.587	0.299

[Z] Untr – no fungicide applied; Fung – Prosaro XTR applied at 50% anthesis
[Y] Fung x Seed interaction was significant at SC-20 but no other sites

Table 17. Individual fungicide by seed rate treatment means for lodging in durum at Indian Head (IH), Scott (SC), and Swift Current (SW) in 2020 and 2021. Means within a column followed by the same letter did not significantly differ (*P* ≤ 0.05). The fungicide x seed rate interaction was not significant in any cases.

Treatment [Z]	IH-20	IH-21	SC-20	SC-21	SW-20	SW-21
	---------- Lodging (1-10) ----------					
Untr – 125 seeds/m^2	1.6 a	1.5 b	1.0 a	1.0	1.0	1.0
Untr – 250 seeds/m^2	1.5 a	2.3 ab	1.0 a	1.0	1.0	1.0
Untr – 375 seeds/m^2	1.8 a	2.5 ab	1.0 a	1.0	1.0	1.0
Untr – 500 seeds/m^2	2.1 a	2.8 ab	1.0 a	1.0	1.0	1.0
Fung – 125 seeds/m^2	1.4 a	2.3 ab	1.0 a	1.0	1.0	1.0
Fung – 250 seeds/m^2	1.5 a	2.3 ab	1.3 a	1.0	1.0	1.0
Fung – 375 seeds/m^2	1.5 a	3.0 a	1.0 a	1.0	1.0	1.0
Fung – 500 seeds/m^2	2.1 a	2.5 ab	1.1 a	1.0	1.0	1.0
S.E.M.	0.16	0.35	0.10	–	–	–
<u>Orthogonal Contrast</u>	---------- Pr > *F* (p-values) ----------					
Untr-SR – linear	0.026	0.008	1.000	–	–	–
Untr-SR – quadratic	0.142	0.420	1.000	–	–	–
Fung-SR – linear	0.006	0.282	0.784	–	–	–
Fung-SR – quadratic	0.142	0.420	0.541	–	–	–

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

Table 18. Individual fungicide by seed rate treatment means for durum grain yield at Indian Head (IH), Scott (SC), and Swift Current (SW) in 2020 and 2021. Means within a column followed by the same letter did not significantly differ (*P* ≤ 0.05). The fungicide by seed rate interaction was not significant in any cases.

Treatment [Z]	IH-20	IH-21	SC-20	SC-21	SW-20	SW-21
	Grain Yield (kg/ha)					
Untr – 125 seeds/m^2	4566 A	3239 b	4713 a	1275 a	2965 a	980 ab
Untr – 250 seeds/m^2	4715 A	3746 ab	5085 a	1488 a	3177 a	615 bc
Untr – 375 seeds/m^2	4750 A	3689 ab	5186 a	1307 a	3260 a	367 c
Untr – 500 seeds/m^2	4686 A	3667 ab	5181 a	980 a	3267 a	274 c
Fung – 125 seeds/m^2	4618 A	3211 b	4389 a	1484 a	3106 a	1289 a
Fung – 250 seeds/m^2	5062 A	3894 a	4909 a	1481 a	3147 a	585 bc
Fung – 375 seeds/m^2	4740 A	3817 ab	4951 a	892 a	3236 a	305 c
Fung – 500 seeds/m^2	4828 A	3726 ab	5133 a	1030 a	3353 a	270 c
S.E.M.	142.1	132.2	244.0	340.4	115.1	137.4
Orthogonal Contrast	Pr > *F* (p-values)					
Untr-SR – linear	0.456	0.057	0.118	0.189	0.031	<0.001
Untr-SR – quadratic	0.371	0.066	0.373	0.140	0.296	0.157
Fung-SR – linear	0.559	0.026	0.023	0.023	0.066	<0.001
Fung-SR – quadratic	0.142	0.010	0.422	0.691	0.698	0.002

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

Table 19. Individual fungicide by seed rate treatment means for durum test weight at Indian Head (IH), Scott (SC), and Swift Current (SW) in 2020 and 2021. Means within a column followed by the same letter did not significantly differ (*P* ≤ 0.05).

Treatment [Z]	IH-20	IH-21[Y]	SC-20	SC-21	SW-20	SW-21
	------------ Test Weight (g/0.5 L) ------------					
Untr – 125 seeds/m^2	387.7 b	385.2 abc	391.1 b	384.8 a	370.0 b	360.9 ab
Untr – 250 seeds/m^2	388.7 ab	388.4 ab	397.5 ab	386.2 a	374.4 ab	357.8 abc
Untr – 375 seeds/m^2	389.4 ab	382.6 cd	398.5 ab	386.6 a	375.8 ab	352.0 bc
Untr – 500 seeds/m^2	386.7 b	379.2 d	399.9 a	387.2 a	377.9 ab	349.7 c
Fung – 125 seeds/m^2	389.0 ab	383.8 bcd	392.0 b	384.0 a	371.3 ab	362.7 a
Fung – 250 seeds/m^2	392.2 a	389.0 a	397.9 ab	384.2 a	373.8 ab	356.3 abc
Fung – 375 seeds/m^2	388.8 ab	385.4 abc	400.2 a	386.2 a	375.6 ab	351.9 c
Fung – 500 seeds/m^2	388.4 ab	384.8 abc	400.8 a	386.3 a	380.2 a	349.9 c
S.E.M.	1.01	1.32	2.07	1.55	2.03	3.01
<u>Orthogonal Contrast</u>	------------ Pr > *F* (p-values) ------------					
Untr-SR – linear	0.594	<0.001	0.001	0.155	0.008	<0.001
Untr-SR – quadratic	0.055	0.005	0.145	0.707	0.548	0.834
Fung-SR – linear	0.210	0.866	<0.001	0.105	0.003	<0.001
Fung-SR – quadratic	0.061	0.012	0.120	0.949	0.578	0.262

[Z] Untr – no fungicide applied; Fung – Prosaro XTR applied at 50% anthesis
[Y] Fung x Seed interaction was significant at IH-21 but no other sites

Abstract

14. Abstract/Summary

Field trials with durum were conducted over two seasons at Swift Current, Scott, and Indian Head. The objective was to demonstrate the potential for higher plant populations combined with fungicides to reduce fusarium head blight (FHB) infection and subsequent yield and quality losses. The treatments were four seed rates (125, 250, 375, or 500 seeds/m^2) and two fungicide treatments (untreated versus fungicide at 50% anthesis). Data collection included assessments of plant and spike density, tillering, visible FHB infection, yield, test weight, fusarium damaged kernels (FDK), and deoxynivalenol (DON). For most sites, disease pressure was lower than normal with the greatest exceptions being Scott and, to a lesser extent, Indian Head in 2020. As expected, higher seed rates increased plant and spike densities, but reduced tillering for individual plants. The expectation was that this would shorten the FHB infection window while making fungicide applications easier to stage. Treatment effects on the visible FHB ratings were somewhat inconsistent; however, at the sites with the highest pressure, values tended to be lowest with the combination of fungicide and higher seed rates. Yield gains with fungicide were never significant. This was a reasonable response for most sites given the lack of disease but somewhat unexpected at Scott 2020. Higher seed rates were more beneficial for improving yield at Swift Current and Scott in 2020 than at Indian Head (both years) but these locations also had higher seedling mortality and/or less tillering. In contrast, under severe drought, higher seed rates resulted in substantial yield reductions. Seed rate effects on test weight were similar to those observed for yield. Higher seed rates appeared to have more impact on FDK and DON than fungicide; however, these values were too low to allow for meaningful conclusions at most sites. Consistent with the in-season assessments, where disease was sufficiently high, FDK and DON were lowest with the combination of higher seed rates and fungicide. Consequently, implementing these practices can be beneficial for managing FHB; however, high seed rates are risky under drought conditions. Producers should consider overall moisture conditions, expected seedling mortality, and actual disease when choosing seed rates and deciding whether to apply fungicide.