Yield Busters: Farmer directed research of products and practices

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Background and Introduction

Grain farmers on the Prairies currently have access to an unprecedented quantity of new products and practices claiming to increase profitability through either higher yields or increased efficiency. That said, relatively slim economic margins limit how much growers can invest into their crops and still remain profitable. Furthermore, many products which are currently being marketed fall outside of what has been traditionally recommended or used on the Prairies and, while growers are often intrigued by novel products or practices, in many cases, third-party data is not available to help them determine which may actually be worth investing in. In response to this realization along with a desire to become more active in determining research priorities, IHARF Director's conceived a project in February 2011 which was eventually named 'Yield-Busters'. The idea was simply to initiate a few trials each year to evaluate specific products or practices, with the topics chosen by participating producers and agronomists. The process involved canvassing individuals within the agricultural community & challenging them to present their top few agronomic questions. All ideas put forward were considered with the final selections based on what was: important to growers (ie: number of votes), practical and relatively straight-forward to evaluate and has not already been extensively tested in Western Canada. The first two Yield-Busters trials were established in 2010 to investigate 1) the effects of micronutrient seed dressings on crop establishment and seed yield of various crops and 2) the effects of fungicide application on flax yield. Both of these trials were continued in 2011 with a third trial initiated to evaluate the effects of fungicide applications on canola yield at various locations. Moving forward, we plan on continuing to initiate new trials each year while phasing out older trials after two to three years, depending on the quantity of data that has been acquired and the conclusiveness of the results. While it is understood that Yield-Buster's cannot possibly address every question put forward by farmers, it is one small step intended to get farmers more actively involved in agricultural research and to initiate timely and practical third-party field trials which may not otherwise be funded.

Crop inputs include all of the resources that are used in crop production, including land, chemicals, equipment, seed and energy. While inputs that might be considered 'specialty products' could fall into any of these categories, the term is generally reserved for products that have distinctive properties or characteristics which are unique to that specific product or brand. In contrast, many important crop inputs are treated more as commodities in that their performance or overall characteristics are not generally tied to a specific brand. One important example of a crop input that is often treated as a commodity is standard, commercial grade urea (46-0-0). While some variability in product qualities and characteristics may be expected depending on the supplier, retailers and farmers will generally purchase urea from the most economical source available, taking both the actual purchase price along with the cost of transporting and storing the product into consideration. Diesel fuel and gasoline would be treated in a similar manner. While companies frequently differentiate their products to a certain extent with additives and/or grades, the pricing of fuel, while volatile, is highly competitive amongst suppliers and growers will generally not hesitate to switch suppliers if the product becomes available at a lower cost somewhere else. Specialty products, on the other hand, tend to be less price sensitive because they have specific characteristics that are unique to a particular brand; thus, growers cannot simply source the product somewhere else if they find a lower price. Consequently, we can expect higher retail profit margins for specialty products relative to more generic crop inputs, which may partly explain why so many have appeared on the market over the past several years.

Examples of inputs that might be considered specialty products are abundant in agriculture. Some of the earlier and better known of these include the slow release nitrogen products such as polymer coated urea (ie: ESN®) or urease and/or nitrification inhibitors (ie: Agrotain® PLUS). Other specialty fertilizer products could include unique blends which contain multiple nutrients in every granule (ie: MicroEssentials® phosphorus fertilizers and the Tiger Micronutrient® products), micronutrient fertilizer coatings (ie: Woftrax DDP® Fertilizer Coating) and nutrient availability enhancers (ie: Avail® and TPA). Similarly, a variety of organic and inorganic seed treatments / dressings exist which are intended to either add nutrients directly to the seed (ie: Wolf Trax Protinus™ and Omex Primer®) or to enhance availability of nutrients already present in the soil (ie: Jumpstart®). Foliar nutrition has become somewhat of a buzzword in the industry over the past few years and products from numerous manufacturers are available to cover a wide array of nutrients (ie: Omex P3®/C3®, Alpine® Foliar, Black Label® Zn, etc.). Perhaps more common in the turf industry than in dry land agriculture, microbial based soil enhancement products which are sprayed directly onto the soil have been introduced and are available to Prairie farmers (ie: Best Environmental Technologies™ Custom Formula Fertilizers). While not related to nutrition, pod sealants designed and marketed to reduce losses in shatter prone crop species have also appeared on the Canadian market within the past few years (ie: Pod-Stik™, Desikote®Max) and might be considered specialty products. Pesticides applied as seed treatments or foliar fungicides would not necessarily be considered specialty products as they have been available for many years and have established value for specific crops and geographic areas where disease or insect pressure is the norm. On the other hand, there are still questions regarding if, when and where these products are like to provide a return on investment for many western Canadian producers. Naming every potential specialty product in agriculture is not the intent of and well beyond the scope of this paper; however, one can see how growers might become overwhelmed by the sheer range and volume of products that are at their disposal.

It is also important to recognize that there are also many questions from producers about agronomic practices which are not necessarily tied in with any specific product or piece of equipment. One example which has received recent attention is whether or growers can increase wider row spacing beyond 30 cm spacing without suffering yield loss or other agronomic pitfalls (ie: reduced weed competition). While certain equipment manufacturers could benefit from a shift toward wider row spacing, the interest in this topic has primarily been driven by producers who want to upgrade to larger drills with a minimal increase in horsepower requirements. Another example of a practice which many producers have at least tried but often question is applying fungicides at the time of herbicide application, sometimes at rates below the label recommendations. While not a new subject by any means, questions surrounding the best approaches to variable rate fertilization and the long term economic benefits of adopting this practice still have many producers and soil fertility experts alike scratching their heads. The benefits of other aspects of precision agriculture, like auto-steer and automatic sectional boom activation have been easier to quantify and, as such, these practices have seen tremendous uptake amongst producers. The list of questions that producers have on specific practices goes on and is continually changing. What are the potential benefits of growing two crops together, or intercropping? Do I still need to apply fungicide if using a sclerotinia resistant canola variety?

While the Yield-Busters project cannot address every question put forward, it does provide some important insights regarding the questions that farmers asking while also generating some third-party data which they can essentially take ownership of. Again, the final selections for projects were based on three main factors. First, the topic had to be important to a relatively broad spectrum of producers, a requirement which was gauged by the number of times a particular question or topic was raised by respondents. Second, the question(s) had to relatively straight-forward to address through simple experiments which could be replicated at multiple locations and, ideally, produce results in a single growing season. While certainly important, studies looking at things like tillage practices or crop rotations can take several years to start producing meaningful data and, as such, are not the best candidates for these relatively short-term trials. Finally, we wanted to focus on topics or products that had not already been extensively tested in western Canada. In many cases, the answers to producers' questions already exist and it is more a matter of making the published research accessible and understandable for producers as opposed to initiating new field trials. That said, producers should not be refrain from bringing forward an idea because they think it may not be a good fit for the project as the information still provides valuable guidance to researchers. The following is a brief overview of the Yield-Busters trials that are currently underway.

Site Descriptions

Trials were conducted over the 2010 and 2011 growing seasons in cooperation with the East Central Research Foundation (Canora, SK), Western Applied Research Corporation (Scott, SK) and Wheatland Conservation Area (Swift Current, SK). Weather / climate and soil fertility information are provided to help with interpretation and to explain any potential differences in results amongst sites.

For each site, monthly temperatures and precipitation levels from April to September were estimated using the nearest Environment Canada weather station and these parameters are presented along with the long-term averages in Tables 1 and 2, respectively. While the last two growing seasons tended to be wetter than normal overall at all each the locations, the multiple sites helped to provide a range of weather and climate conditions.

Table 1. Mean monthly temperatures at Canora, Indian Head, Scott and Swift Current in 2010 and 2011 relative to long-term averages (1971-2000; Environment Canada 2011).

		Month					
Location	**Year**	**April**	**May**	**June**	**July**	**August**	**September**
		---- Temperature (ºC) ----					
Canora[1]	**2010**	**6.9**[2]	**9.5**	**15.5**	**18.5**	**16.8**	**10.5**
	2011	**1.7**	**10.3**	**15.8**	**19.5**	**18.6**	**13.9**
	LT	**3.0**	**10.9**	**15.6**	**17.8**	**16.8**	**10.8**
Indian Head	**2010**	**6.3**	**9.6**	**15.6**	**17.4**	**16.3**	**11.0**
	2011	**1.8**	**9.5**	**15.1**	**18.8**	**17.8**	**13.9**
	LT	**4.0**	**11.4**	**16.1**	**18.4**	**17.5**	**11.4**
Scott	**2010**	**5.1**	**8.8**	**14.9**	**16.5**	**15.2**	**9.5**
	2011	**2.2**	**10.1**	**14.4**	**17.0**	**16.3**	**13.7**
	LT	**3.6**	**10.9**	**15.2**	**17.0**	**16.3**	**10.4**
Swift Current	**2010**	**6.1**	**8.2**	**15.5**	**17.1**	**16.6**	**10.9**
	2011	**2.5**	**9.5**	**14.3**	**18.2**	**18.2**	**15.1**
	LT	**4.9**	**11.1**	**15.6**	**18.1**	**17.9**	**11.8**

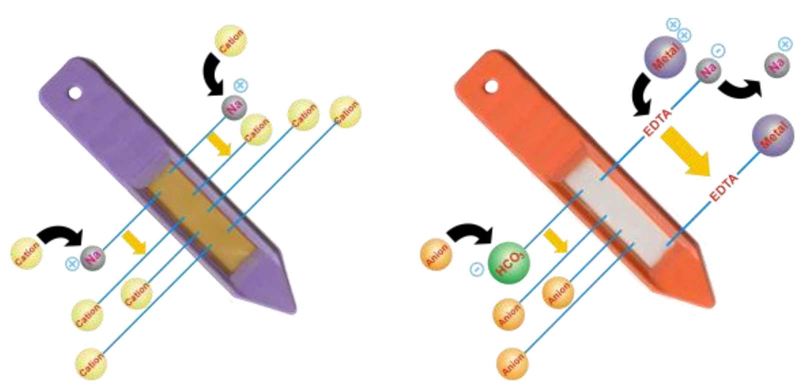
[1]Weather data for Canora estimated from nearest Environment Canada station at Yorkton, SK
[2]Red values are ≥ 1ºC higher than normal while blue values are ≥ 1ºC lower than normal

Table 2. Total monthly precipitation at Canora, Indian Head, Scott and Swift Current in 2010 and 2011 relative to long-term averages (1971-2000).

Location	Year	Month April	May	June	July	August	September
		---- Precipitation (mm) ----					
Canora[1]	2010	84.0[2]	70.0	118.5	112.5	98.5	51.0
	2011	17.5	88.0	90.5	52.0	51.0	13.0
	LT	22.5	48.2	79.4	74.2	62.1	50.1
Indian Head	2010	46.3	63.2	122.4	27.6	92.8	65.0
	2011	8.3	71.3	133.2	42.3	44.2	15.7
	LT	24.6	55.7	78.9	67.1	52.7	41.3
Scott	2010	107.3	121.4	147.2	122.4	61.8	44.2
	2011	10.4	30.8	190.2	76.2	51.8	3.8
	LT	23.6	35.9	62.5	70.9	43.1	31.4
Swift Current	2010	40.0	145.7	112.8	68.0	85.2	86.8
	2011	25.4	56.9	117.3	68.0	30.4	10.6
	LT	22.3	49.5	66.0	52.0	39.9	30.2

[1]Weather data for Canora estimated from nearest Environment Canada station at Yorkton, SK
[2]Red values are ≥ 125% of normal while blue values are ≤ 75% of normal

Soil nutrient availability was estimated for each of the participating sites using plant root simulator (PRS™) probes and the Western Ag Labs nutrient forecaster (Western Ag Labs 2011). These probes are an alternative soil analysis tool that utilize chemically charged ion exchange membranes (one for cations and one for anions) that, when buried in the soil, exhibit nutrient sorption and surface characteristics that closely resemble those of a plant root surface (Figure 1). PRS™-probes measure the bioavailable nutrients in the soil solution over their burial period, including all nutrient ions adjacent to the PRS™-probe already in the available form and also any nutrients that are converted to the available form during the incubation. Soil samples for the top 10 cm depth were collected from each site with a separate composite prepared for each replicate and the samples were analyzed for all available macro- and micro-nutrients. For each site, long-term average temperatures (May through August) and precipitation levels (May through July) along with the actual pH and EC values were used in the forecasts. Results of these analyses are presented in Table 3 with spring wheat used as an example crop. Note that the nutrient requirements presented are the total crop requirements at the estimated yield potentials assuming 50 mm of spring soil moisture at each site and average (1971-2000) weather conditions. The differences between the total crop requirements and the estimated available nutrients should not be taken as the recommended fertilizer rates as they do not take into account crop response curves for each nutrient or fertilizer and grain prices.



(Western Ag Labs 2011)

Figure 1. Schematic illustration of Plant Root Simulater (PRS) probe activity in the soil solution.

Table 3. Estimated nutrient supply and total crop requirements for sites at Canora, Indian Head, Scott and Swift Current in 2010 and 2011 using spring wheat as an example. Estimated total crop requirements for each nutrient are enclosed in brackets.

	Canora		**Indian Head**		**Scott**		**Swift Current**	
	2010	**2011**	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**
pH	7.37	6.80	6.67	6.53	4.55	4.87	5.67	5.98
EC (mS/cm)	0.118	0.290	0.083	0.056	0.068	0.056	0.058	0.057
Pot. Yield (kg/ha)[1]	3918	3985	5342	5342	2560	2943	3273	3320
Nutrient	**Nutrient Availability (Total Crop Requirements)[1]**							
	---------- kg / ha ----------							
N	8.5 (137.1)	144.7 (139.4)	16.5 (186.9)	37.6 (186.9)	29.3 (89.6)	32.3 (102.9)	11.2 (114.5)	42.9 (116.1)
P2O5	6.3 (44.4)	5.8 (45.1)	34.5 (60.5)	21.1 (60.5)	14.8 (29.0)	5.7 (33.4)	8.5 (37.1)	13.9 (37.6)
K2O	25.2 (104.5)	36.4 (106.2)	61.4 (142.5)	61.4 (142.5)	197.0 (68.3)	119.1 (78.4)	54.5 (87.2)	66.5 (88.5)
S	1.0 (17.0)	11.4 (17.2)	0.8 (23.2)	0.8 (23.2)	12.5 (11.1)	2.9 (12.8)	1.3 (14.2)	3.7 (14.3)
Ca	542.8 (11.8)	690.7 (12.0)	1056.4 (16.0)	820.8 (16.0)	206.1 (7.7)	335.9 (8.8)	388.1 (9.9)	550.5 (10.0)
Mg	70.2 (16.4)	109.4 (16.6)	115.6 (22.3)	87.7 (22.3)	39.0 (10.6)	68.8 (12.2)	81.8 (13.7)	108.9 (13.8)
Cu	0.06 (0.10)	0.16 (0.10)	0.11 (0.13)	0.08 (0.13)	0.09 (0.07)	0.06 (0.08)	0.04 (0.08)	0.15 (0.08)
Zn	0.12 (0.32)	0.34 (0.32)	0.11 (0.45)	0.18 (0.45)	0.25 (0.21)	0.20 (0.25)	0.08 (0.27)	0.19 (0.28)
Mn	0.27 (0.39)	3.57 (0.40)	0.41 (0.54)	0.22 (0.54)	10.56 (0.26)	3.76 (0.29)	0.17 (0.32)	5.45 (0.34)
Fe	0.55 (0.32)	1.70 (0.34)	1.59 (0.45)	0.91 (0.45)	3.16 (0.21)	3.39 (0.25)	1.75 (0.27)	3.21 (0.28)
B	0.24 (0.03)	0.34 (0.04)	0.36 (0.06)	0.36 (0.06)	0.19 (0.02)	0.31 (0.03)	0.25 (0.03)	0.34 (0.03)

[1]Yield potential, nutrient availability and total crop requirements are based on Western Ag Labs PRS Nutrient Forecaster© (Western Ag Labs 2011) and long-term average temperature and precipitation for each location.

Micronutrient Seed Dressing Effects on Various Crops

Objectives: To evaluate the effects of micronutrient seed dressings on the establishment and seed yield of various spring crops.

Locations: 1) Indian Head 2) Canora 3) Swift Current 4) Scott

Years: 2010-2011

Experimental Design / Plot layout: Factorial RBCD replicated four times

Treatments: Four crop types and two seed dressing treatments
Crops: 1) CWRS wheat, 2) canola, 3) lentil and 4) field pea
Seed treatments: 1) untreated and 2) seed dressing applied[1]

Data Collection:
1) Emergence
2) Clean seed yield

Data Analyses:
Final plant densities and grain yields were analyzed separately for each crop in a combined Mixed model analysis that included all eight site-years. The effects of site, treatment and site by treatment were considered fixed while the effects of replicate (within each site) were considered random. The rational for considering the effects of site-year and treatment by site-year fixed was to allow us to identify and quantify any differences amongst sites in the observed results. For the sites where emergence data were collected throughout the emergence period, plant densities for each measurement data were analyzed separately for each crop at each site and plotted to determine whether there was any effect on the rate of emergence.

Results:
To assess whether the seed dressing treatments had an impact on crop establishment, two separate meter rows were marked out in each plot after seeding and plant counts were completed on the marked rows repeatedly over the emergence period. At Canora, Scott and Swift Current in 2010, the first measurements were completed too late to assess the actual rate of emergence. Plant counts were not completed at Canora in 2011.

The effects of site and seed treatment were on the total number of plants established are presented in Table 4. The site by treatment interaction was not significant for any crops (P = 0.150-0.987), indicating that the effects of seed treatment on plant density were similar across sites; therefore least squares means for the interactions are not presented. Due to differences in seeding rates and environmental conditions at seeding and during crop emergence, plant densities were affected by site for all four crops ($P < 0.001$). The effect of seed treatment on plant density was significant for spring wheat ($P = 0.046$) but not for canola ($P = 0.704$), lentil ($P = 0.746$) or field pea ($P = 0.110$). In the case of spring wheat, average plant densities were actually 14 plants m^{-2}, or 6%, lower for the treated seed than for the untreated seed. The reasons for the observed reduction in spring wheat plants are unclear; however, measures were taken to ensure that the physical process of treating the seed or changes in the flow of seed through the drill's metering system would not affect plant densities. Untreated seed went through the same physical process as the treated seed; however Primer® was substituted with distilled water for the untreated seed. All seed was treated a minimum of one week before planting and treated and untreated seed were calibrated separately for each drill when not seeded through a cone. For canola, lentil and field pea, the total number of plants established was not affected by the seed dressing treatment when averaged across site-years.

[1] The specific products used in this experiment were: Omex Zn Primer® (0-22-3.5 + 6.7% Zn) for spring wheat (3 ml / kg seed) and canola (6 ml / kg seed) and Omex Pulse Primer® (10% Ca) for lentil and field pea (3 ml / kg seed)

Table 4. Type 3 tests of fixed effects and least squares means for the effects of site and micronutrient seed dressing on crop establishment of CWRS wheat, canola, lentil and field pea.

	Crop Type			
	CWRS Wheat	Canola	Lentil	Field Pea
	Type 3 Tests of Fixed Effects			
Effect	*p-values*			
Site	<0.001	<0.001	<0.001	<0.001
Treatment	0.046	0.704	0.746	0.110
Site x Treatment	0.201	0.987	0.480	0.150
	Least Squares Means			
Site	*plants m^{-2}*			
Canora 2010	193.3 c	31.8 c	74.7 d	40.3 d
Canora 2011	n/a	n/a	n/a	n/a
Indian Head 2010	297.9 a	95.1 a	155.8 a	n/a
Indian Head 2011	233.2 b	58.5 b	94.0 cd	67.7 b
Scott 2010	264.0 ab	86.4 a	85.6 cd	48.9 cd
Scott 2011	144.2 d	28.3 c	130.2 b	59.6 bc
Swift Current 2010	178.0 cd	76.7 ab	152.0 a	88.0 a
Swift Current 2011	181.5 cd	88.6 a	105.1 c	83.1 a
LSD ($P \leq 0.05$)	39.5	23.1	21.1	11.3
Treatment				
Untreated Check	220.2 a	67.4 a	113.0 a	66.7 a
Seed Dressing Applied	206.1 b	65.5 a	114.8 a	62.4 a
LSD ($P \leq 0.05$)	13.8	10.4	11.3	5.3

[1]Values the same column for site and treatment which are followed by different letters are significantly different from one another (Fisher's LSD test, $P \leq 0.05$)
n/a – data not available

Separate analyses of the emergence data were used to assess any potential impacts of seed dressings on the rate of emergence where possible. In these cases, emergence data from each measurement date were analyzed for each crop with a separate analysis completed for each site-year. In 2010 at Indian Head, plant densities were measured at 6, 11, 14, 18 and 25 days from planting. At 25 days after planting, the overall average plant densities were 298, 95 and 156 plants m^{-2} for wheat, canola and lentils, respectively (Fig. 2). No significant differences in the number of plants m^{-2} were observed between the untreated seed and seed that had been treated with a seed dressing at this time or any other point during the measurement period.

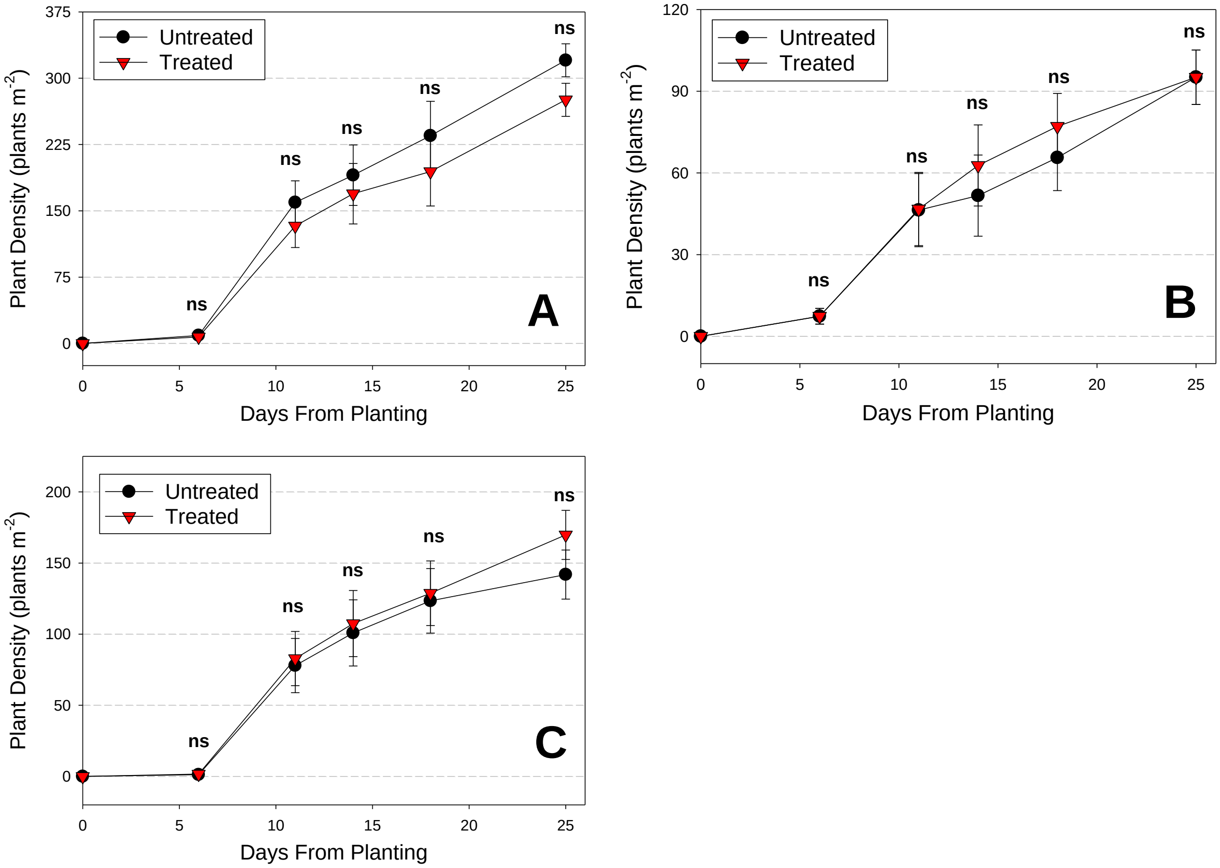


Figure 2. Plant emergence as affected by seed dressing treatment at Indian Head in 2010. Data were analyzed separately for each crop type (A - Wheat, B - Canola and C - Lentil) with differences between treatment means denoted as: ns – not significant, * – 0.05 < *P* ≤ 0.10, ** – 0.01 < *P* ≤ 0.05 and * – *P* ≤ 0.01. Error bars are the standard errors of the treatment means.**

At Indian Head in 2011, the numbers of plants established at 24 days past planting were 233, 58, 94 and 68 plants m^{-2} for wheat, canola, lentil and field pea, respectively. Similar to 2010, no differences in plant populations were observed between seed treatments for wheat, canola or lentil at the end of the emergence period; however, there was a slight tendency towards fewer plants with the treated seed for field pea (P = 0.097). For the measurements completed prior to this (9, 15 and 20 days from planting), there were no differences in plant densities observed between treated and untreated seed for wheat, canola, lentil or field pea (Fig. 3).

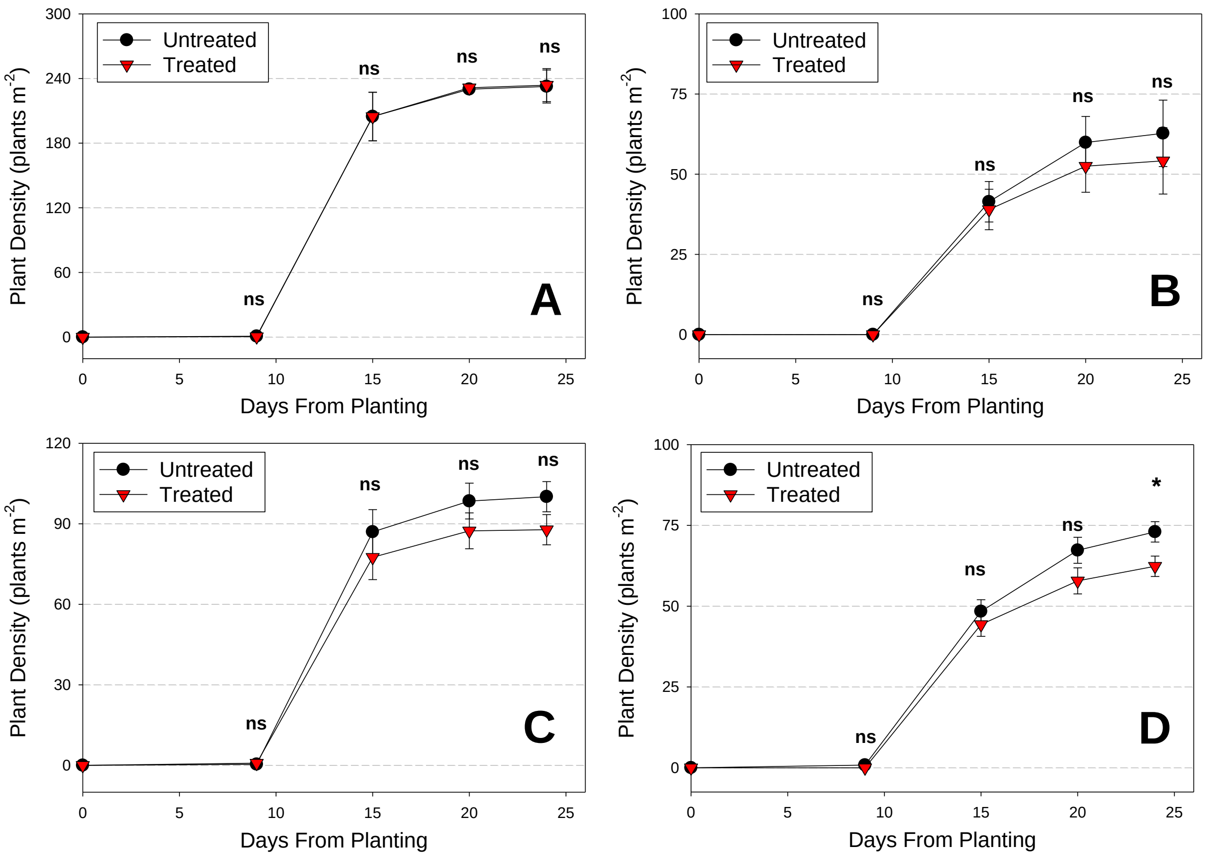


Figure 3. Plant emergence as affected by seed dressing treatment at Indian Head in 2011. Data were analyzed separately for each crop type (A - Wheat, B - Canola, C - Lentil and D - Field Pea) with differences between treatment means denoted as: ns – not significant, * – 0.05 < *P* ≤ 0.10, ** – 0.01 < *P* ≤ 0.05 and * – *P* ≤ 0.01. Error bars are the standard errors of the treatment means.**

Emergence data were collected at Scott (2011) at 8, 12, 14, 15, 18, 21 and 25 days after planting. At the end this period, the total number of plants established were 144, 28, 130 and 60 plants m^{-2} for wheat, canola, lentil and field pea, respectively, with no differences observed between seed treatments at this time (Fig. 4). For the earlier measurements, seed dressings had no impact on plant establishment at any time for field pea or lentil; however, there did appear to be a slight benefit to the Zn Primer® for spring wheat and, to a lesser extent, canola. For spring wheat, significantly higher plant densities were observed with treated seed at 15 days after planting (*P* = 0.008) and, to a lesser extent, 18 and 21 days after planting (*P* = 0.098-0.108). By the end of the emergence period, established wheat plant populations were equal for both treatments. For canola, a small but significant difference was observed at 12 days past planting with plant populations for the treated seed exceeding those of the untreated seed by 4 plants m^{-2}, or 30% (*P* = 0.017). At fewer than 30 plants m^{-2}, average canola densities at Scott in 2011 were lower than optimal; however, with the right conditions during flowering and pod filling, canola plants compensate well for reduced stands through increased size and branching. From 14 days from planting on, there was no difference in canola plant populations at Scott in 2011.

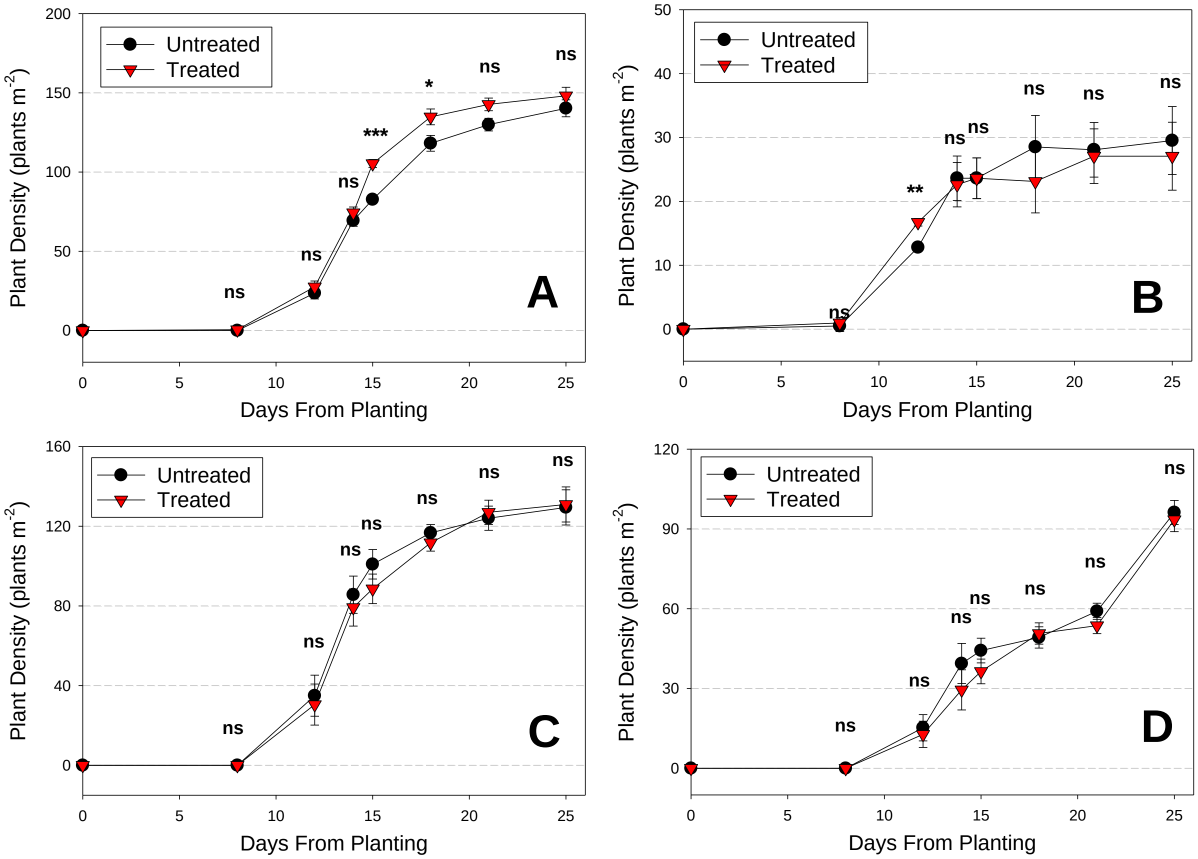


Figure 4. Plant emergence as affected by seed dressing treatment at Scott in 2011. Data were analyzed separately for each crop type (A - Wheat, B - Canola, C - Lentil and D - Field Pea) with differences between treatment means denoted as: ns – not significant, * – 0.05 < *P* ≤ 0.10, ** – 0.01 < *P* ≤ 0.05 and * – *P* ≤ 0.01. Error bars are the standard errors of the treatment means.**

Finally, at Swift Current in 2011, the total numbers of plants established at 18 days after seeding were 182, 89, 105 and 83 plants m^{-2} for wheat, canola, lentil and field pea, respectively (Fig. 5). Earlier measurements were completed at 4, 7 and 10 days after seeding. No significant differences in plant densities were observed at any of the measurement dates for any of the four crops at Swift Current in 2011.

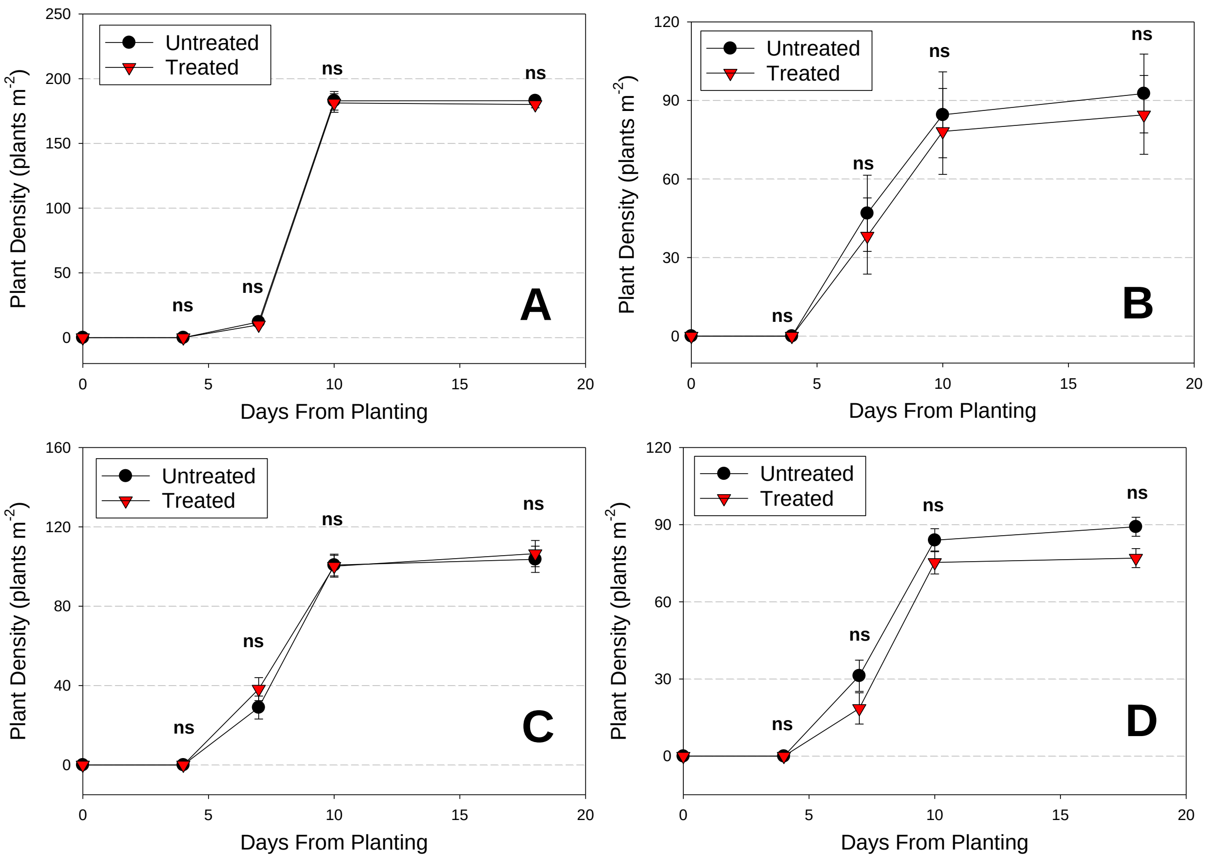


Figure 5. Plant emergence as affected by seed dressing treatment at Swift Current in 2011. Data were analyzed separately for each crop type (A - Wheat, B - Canola, C - Lentil and D - Field Pea) with differences between treatment means denoted as: ns – not significant, * – 0.05 < *P* ≤ 0.10, ** – 0.01 < *P* ≤ 0.05 and * – *P* ≤ 0.01. Error bars are the standard errors of the treatment means.**

Overall, any significant impacts of micronutrient seed dressings on crop establishment that were observed were rare and somewhat inconsistent. There did appear to be an early benefit with the Zn Primer® on spring wheat and canola at Scott in 2011; however, the observed differences were no longer evident by the end of the emergence period for either crop. When all sites were combined, average wheat populations were actually higher for the check than when a seed dressing was used, but the reasons for this effect are not known and a reduction in plant populations was not observed for the majority of individual sites. All things considered, our results indicate that the seed dressings evaluated would not be expected to result in improved emergence under the environmental conditions encountered at these sites.

Grain yields were determined by mechanically harvesting each plot and determining the mass of clean seed that was produced. Yield data from all sites were analyzed in the same manner as the final plant densities (Table 4) and results are presented in Table 5. Overall, grain yield was affected by site for all crops ($P < 0.001$) but not by seed treatment ($P = 0.161$-0.718) or site by seed treatment ($P = 0.477$-0.987), indicating similar product performance across sites. Overall, yields ranged widely across site-years for each crop and, the relative rankings of each site varied with crop type. Because neither the treatment nor the site by treatment effect was significant, separate yields for the two seed dressing treatments are not presented for individual site-years. Preliminary analyses of yield data from the individual sites confirmed the results of the combined analyses as no significant yield differences were observed for treatment in any cases (data not shown).

Table 5. Type 3 tests of fixed effects and least squares means for the effects of site and micronutrient seed dressings on seed yields of CWRS wheat, canola, lentil and field pea.

	Crop Type			
	CWRS Wheat	Canola	Lentil	Field Pea
	Type 3 Tests of Fixed Effects			
Effect	*p-values*			
Site	<0.001	<0.001	<0.001	<0.001
Treatment	0.718	0.370	0.161	0.607
Site x Treatment	0.525	0.781	0.477	0.987
	Least Squares Means			
Site	*kg ha^{-1}*			
Canora 2010	1489 d[1]	656 d	895 cd	1819 c
Canora 2011	3342b	2891 a	1098 cd	2852 b
Indian Head 2010	2488 c	1702 c	2427 a	n/a
Indian Head 2011	4224 a	2728 a	1528 bc	3132 ab
Scott 2010	3323 b	2247 b	807 d	2660 b
Scott 2011	3167 b	3020 a	1324 bcd	3777 a
Swift Current 2010	3231 b	520 d	1822 ab	2887 b
Swift Current 2011	2349 c	1618 c	1375 bcd	2546 b
LSD ($P \leq 0.05$)	442.4	441.4	660.1	713.9
Treatment				
Untreated Check	2962 a	1771 a	1367 a	2836 a
Seed Dressing Applied	2942 a	1798 a	1452 a	2785 a
LSD ($P \leq 0.05$)	111.7	135.5	120.8	204.3

[1]Values the same column for site and treatment which are followed by different letters are significantly different from one another (Fisher's LSD test, $P \leq 0.05$)

Concluding Remarks:

Micronutrient seed dressings are generally marketed as having the greatest benefit when crops are emerging under stressful conditions (ie: cold and wet soils). With this in mind, early seeding was targeted but, with the wet springs, was not generally possible and the trial was never planted during the first week of May. Seeding was mostly completed during the second (Indian Head 2010 and 2011 and Scott in 2011) or third week of May (Canora, Scott and Swift Current in 2010) but was later at Swift Current (May 26) and Canora in 2011 (June 7). Nonetheless, for the years and locations that this trial was conducted, cool and wet conditions after planting were frequently encountered with six of eight site-years having average May temperatures at least 1 ºC cooler than normal (Table 1) and five of eight site-years receiving at least 125% of the long-term average May precipitation (Table 2). While temperatures were generally close to average in June, precipitation was at least 125% of average at seven of eight sites. At Scott in 2011 where there did appear to be a slight benefit to the seed dressings for wheat and canola early on in the season, May temperatures were close to normal and precipitation was actually lower than normal when both April and May were taken into consideration. Focussing on soil fertility at each of the sites (Table 3), estimated Zn supplies were less than half of the maximum potential crop requirements (for spring wheat) at four sites (Canora 2010, Indian Head 2010, Indian Head 2011 and Swift Current 2010), between 50% and 100% of the maximum estimated crop requirements at two sites (Scott 2011 and Swift Current 2011) and above the estimated requirements at the remaining two sites (Canora 2011 and Scott 2010). For Ca, which was the sole nutrient provided in the seed dressing applied to lentil and field pea, supply rates always greatly exceeded estimated crop requirements (Table 3). When interpreting the results of these soil test analyses, one would generally not even consider a micronutrient fertilizer application unless supply rates are below half of the estimated maximum crop requirements. Even in these cases, crop responses to micronutrient fertilizer applications are not well understood and, with all of the other factors that can potentially limit seed yield, a response to micronutrient fertilizer would still not be guaranteed or even necessarily expected. The product that was applied to wheat and canola in this study also contained 22% P_2O_5 and 3.5% K_2O. It makes some sense that the likelihood of a crop response to nutrient based seed dressings would be higher when soil test levels or seed concentrations of the relevant nutrients are low; however, one should recognize that the actual quantities of nutrients that can be supplied with a seed applied product are limited. For example, if we assume that the product has a similar density as water (1 kg l^{-1}) and a 134 kg ha^{-1} wheat seeding rate, the Zn Primer® used in this trial would have supplied a total of 0.09 kg P_2O_5 ha^{-1}, 0.01 kg K_2O ha^{-1} and 0.026 kg Zn ha^{-1} at its recommended rate of 3 ml product kg $seed^{-1}$. When these trials were initiated, the retail price of a 10 l jug of the products tested was \$300, thus the estimated costs on a per hectare basis were \$12.16 ha^{-1} for spring wheat (134 kg ha^{-1} seeding rate), \$1.31 ha^{-1} for canola (7.3 kg ha^{-1} seeding rate), \$10.13 ha^{-1} for lentil (56 kg ha^{-1} seeding rate) and \$19.76 ha^{-1} for field pea (218 kg ha^{-1} seeding rate). While relatively inexpensive compared with many crop inputs, the results of this study on their own would not justify a recommendation to use micronutrient seed dressings, even in cases where soil tests show potential for the applicable nutrients to be limiting. Nonetheless, many different products are available, formulations change and the eight site-years of this study cannot be representative of every field so it is possible that benefits to such products could exist under the right circumstances. In cases where severe micronutrient deficiencies exist, while it is possible that the odds of seeing a benefit to seed dressings may be improved, it is unlikely that they could supply enough of the nutrients in question to correct a severe deficiency and they would have to be supplemented with either a soil placed or foliar fertilizer application.

Field Trials: Evaluating Fungicide Applications on Flax
Objectives: To evaluate the effects of fungicide applications on flax yield

Locations: 1) Indian Head 2) Canora 3) Swift Current

Years: 2010-2011

Experimental Design: RBCD replicated four times

Treatments: 1) no fungicide applied and 2) Headline applied mid-flower (0.16 l ac^{-1})

Data Collection:
1) Clean seed yield

Data Analyses:
Yield data were analyzed for each site individually using a generalized linear model (GLM) with treatment means compared using Fishers Protected LSD test. In addition, combined data from all six sites were analyzed using a mixed model with the effects of site, treatment and site by treatment considered fixed and the effects of replicate (within each site) considered random.

Results:

For the combined analysis where all six site-years were included, flax yield was significantly affected by site (*P* < 0.001) and treatment (*P* < 0.001) and the site by treatment interaction was also significant (*P* = 0.010). Indian Head in 2011 was the highest yielding site, followed by Indian Head in 2010 and Swift Current in 2011 and then Canora in both years and Swift Current in 2010. Averaged across sites, the average treated yield of 1450 kg ha^{-1} was significantly higher than the untreated check which yielded 1303 kg ha^{-1}. The significant site by treatment interaction justifies looking at each site individually, which revealed a response to fungicide at Indian Head in both 2010 (*P* < 0.001) and 2011 (*P* = 0.027) but nowhere else (*P* = 066-0.986).

Table 6. Effects of fungicide application on the seed yield of flax over 6 sites.

	Canora		Indian Head		Swift Current		All Sites
	2010	2011	2010	2011	2010	2011	–
Effect	**F-Test / Type 3 Tests of Fixed Effects**						
	---------- Pr > F ----------						
Site (S)	–	–	–	–	–	–	<0.001
Treatment (T)	0.066	0.986	<0.001	0.027	0.384	0.571	<0.001
S X T	–	–	–	–	–	–	0.010
CV (%)	19.3	23.7	3.5	1.8	4.7	11.7	–
	Least Squares Means						
	---------- Clean Seed Yield (kg ha^{-1}) ----------						
Site	958 c	1154 c	1777 b	2098 a	639 d	1635 b	–
Untreated	833 a	1147 a	1563 b	2044 b	631 a	1599 a	1303 b
Headliine	1083 a	1175 a	1991 a	2152 a	648 a	1686 a	1450 a
Std. Error	75.4	155.8	25.7	18.8	12.2	98.9	34.5

[1]Values in the same row for site and the same column for fungicide treatment followed by different letters are significantly different from one another (Fisher's LSD test, *P* ≤ 0.05)

Figure 6. Flax plants from the untreated check (left) and treatment that received 0.16 l ac-1 of Headline 27 days earlier at Indian Head in 2010. Note the brown bands on the stem and wilted leaves (the few that remain) on the untreated check, typical late season symptoms of Pasmo.

Concluding Remarks:
Overall, flax responded well Headline to applications with a significant yield increase of 147 kg ha^{-1} or 11% over the check, when averaged across sites. However, the fact that the site by location interaction is significant tells us that this response would not be expected at every location or in every year. In actuality, a significant response was only observed at one-third of the individual sites, half if Canora in 2010 is included where the response was not significant at the 5% probability level but was worth noting and economically significant. With the drier overall climatic conditions and, presumably lower levels of disease inoculum, flax yields were never increased with Headline application at Swift Current. Even at Indian Head, it should be acknowledged that 2010 and 2011 were both exceptionally wet years where overall conditions were conducive to higher disease pressure and the repeatability of these results over the long-term at this location is uncertain. While 2011 became relatively dry later in the season at Indian Head compared to 2010, the yield response was also smaller in 2011 (5% versus 27%). Pasmo symptoms were observed in both years, and were especially prevalent in 2010 (Figure 6). Canora in 2010 was also wet and the response to Headline was not statistically significant (P = 0.066); however, the CV values for this site were 19% which greatly inhibited our ability to detect treatment differences at this site and the actually numerical difference between the untreated and treated yields was economically significant. The fact that flax yields were not affected by Headline application at Swift Current in either year or at Canora in 2011 suggests that the responses observed in this study were likely a result of disease suppression as opposed to any potential general plant health benefits associated with the fungicide application. While flax does appear to respond well to fungicide applications, this data suggests that growers should still inspect the crop closely for Pasmo at the early flowering stage and base the decision to spray on whether or not the disease is present.

Field Trials: Evaluating Fungicide Applications on Canola
Objectives: To evaluate the effects of fungicide applications on canola yield

Locations: 1) Indian Head 2) Canora 3) Swift Current

Years: 2011

Experimental Design: RBCD replicated four times

Treatments: 1) no fungicide applied 2) Headline (0.16 l ac^{-1}) 3) Lance (142 g ac^{-1}) 4) Lance (142 g ac^{-1}) plus Headline (0.12 l ac^{-1}) 5) Proline (0.15 l ac^{-1}) 6) Astound (390 g ac^{-1})

Data Collection:
1) Clean seed yield

Data Analyses:
Yield data were analyzed for each site individually using a generalized linear model (GLM) with treatment means compared using Fishers Protected LSD test. In addition, combined data from all three sites were analyzed using a mixed model with the effects of site, treatment and site by treatment considered fixed and the effects of replicate (within each site) considered random.

Results:
Averaged across the three trials, seed yield was affected by site (P = 0.004) but not fungicide treatment (P = 0.186) and the site by treatment interaction was not significant (P = 0.529). The overall yields were highest at Indian Head and Swift Current (2653 kg ha^{-1} on average) and lower at Canora (1897 kg ha^{-1}). While the non-significant F-test for the effect of treatment in the combined analysis indicates that no individual treatments were significantly different from any other individual treatments, the untreated versus treated comparison (P = 0.075) did indicate a

slight, albeit not statistically significant, overall response to fungicides (Table 6). Inspection of individual site analyses revealed a response at Indian Head where the untreated versus treated contrast was significant at $P < 0.01$ and the check yielded significantly lower than every other treatment except one. The overall average yield of the treated plots (fungicide applied) at Indian Head was 2727 kg ha^{-1}, over 13% higher than the check yield of 2406 kg ha^{-1}, while the highest yielding treatment, Lance, yielded 17% higher than the check. No response to fungicide was observed at either Canora ($P = 0.570$) or Swift Current in 2011 ($P = 0.957$); however, CV values at Canora were 18% which, again, limits our ability to detect a response at that site.

Table 7. Effects of fungicide application on the seed yield of canola over 3 sites.

	Canora	**Indian Head**	**Swift Current**	**All Sites**
	2011	2011	2011	–
Effect	**F-Test / Type 3 Tests of Fixed Effects / Contrasts**			
	---------- Pr > F ----------			
Site (S)	–	–	–	0.004
Treatment (T)	0.602	0.022	0.918	0.186
S X T	–	–	–	0.529
Check vs Rest	0.570	0.004	0.957	0.075
CV (%)	17.9	6.4	8.1	–
	Least Squares Means			
	---------- Clean Seed Yield (kg ha^{-1}) ----------			
Site	1897 b[1]	2674 a	2631 a	–
Untreated	1800 a[1]	2406 c	2637 a	2281 a
Headline[1]	1738 a	2781 ab	2653 a	2390 a
Lance	1782 a	2815 a	2622 a	2406 a
Headline + Lance	2103 a	2808 ab	2706 a	2540 a
Proline	1858 a	2554 bc	2534 a	2324 a
Astound	2072 a	2678 ab	2636 a	2462 a
Std. Error	152.7	85.8	106.2	100.8

[1]Values in the same row for site and the same column for fungicide treatment followed by different letters are significantly different from one another (Fisher's LSD test, $P \leq 0.05$).

Figure 7. Close-up of canola plants just prior to swathing (left) and whole crop canopy on the same date (right) for an untreated check (no fungicide applied; right) at Indian Head in 2011.

Concluding Remarks:
This study needs to be continued in order required to draw conclusions on the response of canola to fungicide applications at these locations; however the response at Indian Head was of interest and somewhat unexpected. Fungicides have not traditionally been applied to canola on a regular basis at Indian Head; however, with tightening rotations, recent wet growing conditions and high canola prices many growers are looking at this practice more closely. The response to Headline (Treatment 2) is also interesting as the targeted application date for this treatment was during the second herbicide application (4-6 leaf stage), which is the recommended application stage for controlling Blackleg. In actuality, the Headline application at Indian Head in 2011 was delayed by wet weather and was not applied until the bolting stage, but still considerably earlier than the rest of the treatments which were applied at close to 50% bloom at this site. While disease levels were not formally measured, sclerotina symptoms were not observed at Indian Head either at the time application or prior to swathing. There were symptoms of alternaria black spot late in the season, with some spots occurring on the stems and pods, but they did not appear to be severe enough to have a significant impact on yield (Figure 7). With respect to Swift Current, similar to flax, the drier climate at this location will likely make the economics of fungicide applications in this region questionable and the data from 2011 showed no advantage to any of the products. Even though we did not observe sclerotina at Indian Head, these results do not justify spraying in the absence of disease. Again, disease was not objectively measured so its presence may have been overlooked and the repeatability of these results at this location has not been established. Past field-scale fungicide trials with canola at Indian Head have rarely shown a benefit. Nonetheless, growers in the thin Black and Black soil zones who are not applying fungicide on their canola may be wise to at least consider applying a few passes on their canola fields and measuring the response, especially if rotations are tight or the weather is conducive to disease. As always, growers who are routinely applying fungicides to canola will benefit from leaving untreated checks on a few of their fields to be confident that their money would not be better invested elsewhere.

Final Comments
Again, the Yield-Busters project cannot address all of the questions put forward by growers and agronomists, but does help to engage them in the research process and is a mechanism to initiate field trials which might not otherwise be funded. By its nature, for the project to be successful, it is critical for those in the agricultural community to provide feedback and input on new ideas for upcoming trials. The project does tend to be a good fit for product testing as, in

most cases, results can be expected in a single growing season and product testing is rarely a focus of more traditional research programs for a variety of reasons. Nonetheless, any and all ideas are welcome as they can help guide future projects and demonstrations that fall outside of this specific project. Ideas can be passed on to Chris Holzapfel (cholzapfel.iharf@sasktel.net) or Danny Petty (dpetty.iharf@sasktel.net) and future research results along with upcoming events and other information can be found online at www.iharf.ca.

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