NORTHEAST AGRICULTURE RESEARCH FOUNDATION

2012 Seed Applied Nutrient Effects on Spring Wheat

ABSTRACT

Seed-applied nutrient products are typically marketed to help early seeded crops become established more quickly and vigorously in cool soils, potentially resulting in better root systems, more rapid crop development and earlier maturity. Variations of these products have been available for a number of years from a variety of manufacturers; however, publicly available third-party efficacy data remains somewhat limited. Field demonstrations were conducted at four locations in Saskatchewan with contrasting soils; Indian Head (Indian Head Heavy Clay, thin Black Soil Zone), Melfort (Melfort Silty Clay, Black Soil Zone), Scott (Elstow Loam , Dark Brown Soil Zone) and Swift Current (Cyprus Light Loam, Brown Soil Zone). With spring wheat as the test crop, effects on crop emergence and early season growth and development were monitored for several seed-applied nutrient products relative to treatments where untreated seed was used but, for one treatment, 12 kg $ZnSO_4$ was applied in-furrow. Plant counts were completed five separate times over the course of the emergence period at each location and no statistically significant differences between treated and untreated seed were observed. Above-ground biomass yields were determined prior to stem elongation and were not affected by any of the products demonstrated. Effects on plant development (growth stage) were measured at two locations and maturity notes were collected at three locations but no treatment effects were detected in either case. No significant differences in grain yield amongst individual treatment means were detected at any locations or when data were averaged across locations; however, a marginal increase in yield was observed with granular $ZnSO_4$ at Indian Head. Test weight and seed size of the harvested wheat was measured at two

locations and no significant treatment effects were observed. To conclude, none of the products tested had a significant effect on the variables measured for any of the four locations where this particular demonstration was conducted. While not always convenient to do so, producers investing in seed-applied fertilizer products are advised to establish check strips to allow them to evaluate for themselves whether or not they are getting the desired return on their investment.

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Project Objectives:

The objective of this project was to demonstrate the effects of commercially available seed-applied micronutrient fertilizer products and granular $ZnSO_4$ application on spring wheat emergence, development, growth and grain yield.

Project Rationale:

Grain farmers on the Prairies have access to an unprecedented quantity of new products claiming to increase profitability through either higher yields or increased efficiency. That said, slim economic margins limit how much growers can invest in their crops and still remain profitable. Furthermore, many of the products that are currently being marketed fall outside of what has been traditionally recommended or used on the Prairies. While growers are intrigued by novel products or practices, in many cases third-party data is not available to help them determine which are most likely worth investing in. For example, while seed-applied nutrient products have been available for a number of years from several different manufacturers, publicly available third-party efficacy data remains limited. Seed-applied nutrient products are typically marketed to help early seeded crops become established more quickly and vigorously in cool soils, potentially resulting in better root systems, more rapid crop development and earlier maturity. On their own, seed applied nutrients are typically not purported to result in higher yields but rather to give the crop the best possible start enabling seedlings to cope better with stresses associated with wet and/or cool soils. Actual nutrient compositions of the different products that are available vary; however, Zinc tends to be common amongst them. Zinc is an essential component of various enzyme systems associated with energy production, protein synthesis, and growth regulation. The most visible zinc deficiency symptoms are short internodes, decreased leaf size, stunted roots and delayed maturity. Zinc deficiencies are mainly found on sandy soils low in organic matter or organic soils and also tend to occur more often during cold and wet spring weather. While few would argue against the overall importance of Zinc or other micronutrients to plants, there is not a general consensus as to whether micronutrient fertilizer applications will provide economic benefits for the majority of Prairie soils and crops. While a product does not need to provide benefits under all circumstances to be of value, producers should ideally be able to predict the likelihood of response with reasonable accuracy in order to identify situations where an economic return on investment is probable.

Methodology:

Field demonstrations were conducted at four locations in Saskatchewan with contrasting soils; Indian Head (Indian Head Heavy Clay, thin Black Soil Zone), Melfort (Melfort Silty Clay, Black Soil Zone), Scott (Elstow Loam , Dark Brown Soil Zone) and Swift Current (Cyprus Light Loam, Brown Soil Zone). While plot sizes and specific seeding equipment varied, all field trials were conducted in no-till, continuous cropping systems and all fertilizers were applied at seeding with specific placement varying by location (i.e. side-band vs. mid-row band vs. seed-placed). Prior to establishing the trials, two sets of composite soil samples were collected from each site. One sample was submitted to Western Ag Laboratories who use Plant Root Simulator probes to estimate nutrient availability (Table 1) while the other was sent to A & L Canada Laboratories for more traditional extraction based analyses (Table 2). The midge tolerant hard red spring wheat variety Unity VB was seeded at a target rate of 375 seeds m^{-2} and all locations used the same seed source with all seed treatments applied by IHARF. Fertilizer rates were intended to ensure that N, P, K or S were not limiting and are provided in Table 2. Early seeding was targeted in order to increase the likelihood of encountering cool, potentially stressful conditions and actual seeding dates ranged from May 11 at Indian Head to May 21 at Swift Current. Weeds, disease and insects were controlled using registered pesticides at their recommended rates as required at each site and no insecticide / fungicide seed treatments were used.

A total of seven treatments were evaluated at each location. These included two treatments where no seed-applied fertilizer products were applied but, in one of these, granular

$ZnSO_4$ was applied in the seed row at a rate of 12 kg ha^{-1} to supply 2.4 kg Zn ha^{-1}. The seed treatments were all applied in the same manner using a handheld spray bottle and a cement mixer. Distilled water was used as a sticking agent where required or for bulking up the fertilizer products to ensure even and adequate coverage. Untreated seed went through the same physical process, but were solely treated with distilled water. A total of 10 kg of seed was prepared for each treatment and distributed to the participating sites. The treatments are described in greater detail in Table 3.

Table 1. Estimated nutrient release and total crop requirements for spring wheat at Indian Head, Melfort, Scott and Swift Current (2012). Estimated total crop requirements for each nutrient are enclosed in brackets.

	Indian Head	Melfort	Scott	Swift Current
Max. Potential Yield (kg/ha)[Z]	5342	4099	2802	3306
Nutrient	**Nutrient Release (Total Crop Requirements)[1]**			
	---------- kg / ha ----------			
Nitrogen-N	7 (187)[Y]	18 (143)	8 (99)	82 (115)
Phosphorus-P_2O_5	13 (61)	22 (46)	8 (32)	4 (38)
Potassium-K_2O	29 (143)	78 (109)	193 (75)	43 (88)
Sulphur-S	4 (23)	9 (18)	16 (13)	8 (14)
Calcium-Ca	1304 (16)	626 (12)	193 (8)	362 (10)
Magnesium-Mg	113 (22)	122 (17)	48 (12)	67 (14)
Copper-Cu	0.14 (0.13)	0.03 (0.10)	0.03 (0.07)	0.22 (0.08)
Zinc-Zn	0.08 (0.44)	0.53 (0.34)	0.26 (0.24)	0.17 (0.28)
Manganese-Mn	0.44 (0.54)	2.18 (0.41)	5.47 (0.28)	13.44 (0.34)
Iron-Fe	1.23 (0.44)	4.54 (0.34)	2.36 (0.24)	1.38 (0.28)
Boron-B	0.45 (0.06)	0.31 (0.04)	0.35 (0.03)	0.09 (0.03)

[Z]Yield potential, nutrient release and maximum total crop requirements based on Western Ag Labs PRS probe analyses and Nutrient Forecaster© and long-term average temperature and precipitation values

[Y]Nutrient release and total crop requirement data are presented at face-value – for economic optimal fertilizer rate recommendations consultation with a Western Ag Labs Field Services Representative is required

Data collection was primarily focussed on early season growth and development; however, all plots were taken to yield with the exception of those at Scott where hail caused extensive damage to the plots before they could be harvested. Prior to emergence, two separate 1 m sections of crop row were marked in each plot and plant counts in the marked rows were repeated five times over the emergence period. The emergence counts were timed to correspond to approximately 1, 3, 5, 8 and 14 days after emergence was initially observed. When the wheat was at the 3-5 leaf stage (prior to stem elongation), above-ground biomass samples were harvested from two separate 1 m sections of crop row and dried to assess treatment effects on above-ground biomass yields early in the season. We did not attempt to measure root biomass because of the high labor requirements of these measurements and perceived difficulties in collecting and cleaning the roots at locations with fine-textured soils. At Indian Head and Scott, early season plant development was rated using the Haun scale for 25 and 4 plants per plot at the two sites, respectively. As an additional measure of early season biomass production, the NDVI of each plot was determined at Indian Head using a handheld GreenSeeker™. Significant lodging was observed at Indian Head early in July; therefore the extent and severity of lodging was rated for each plot prior to harvest at this location. Days to physiological maturity was recorded for each plot at all locations except Melfort. With the exception of Scott, grain yields were determined by mechanically straight-harvesting the centre rows of each plot and are reported as kg ha^{-1} clean seed at 14.5% seed moisture content. Test weight and seed size were determined for each plot at Indian Head and Swift Current while grain protein concentrations were also determined at Swift Current. All response data was statistically analyzed using the mixed procedure of SAS with the effects of both site and treatment considered fixed. Tukey's studentized range test was used to further investigate site and treatment effects with differences between means declared significant at $P \leq 0.05$.

Table 2. Selected soil qualities, residual nutrient levels (ppm) and actual fertilizer application rates.

Soil Parameter / Residual Nutrient / Fertilizer Application	Indian Head	Melfort	Scott	Swift Current
Soil Properties				
Soil Organic Matter (%)	3.8	10.7	4.3	2.8
Soil pH	7.9	6.0	5.6	6.9
CEC (meq/100g)	42.8	41.7	16.2	23.8
Soil Residual Nutrients[Z]	------------------------------------- ppm -------------------------------------			
Nitrate-N	4 (VL[Y])	8 (L)	23 (H)	26 (H)
Phosphorus-P (Bray-P1)	15 (M)	32 (H)	27 (M)	18 (L)
Phosphorus-P (Bicarb)	19 (M)	55 (H)	49 (M)	32 (L)
Potassium-K	502 (VH)	615 (VH)	247 (VH)	303 (VH)
Sulphur-S	15 (VL)	21 (VL)	16 (VL)	14 (VL)
Magnesium-Mg	960 (H)	1015 (H)	265 (M)	440 (H)
Calcium-Ca	6690 (H)	4880 (M)	1470 (L)	3620 (H)
Zinc-Zn	1.4 (L)	5.7 (H)	2.7 (L)	1.8 (L)
Manganese-Mn	110 (VH)	54 (VH)	54 (VH)	107 (VH)
Iron	41 (H)	109 (VH)	77 (VH)	46 (H)
Copper	4.0 (VH)	1.8 (H)	1.2 (H)	1.6 (H)
Boron	1.9 (H)	1.7 (H)	0.8 (M)	0.9 (M)
Fertilizer Application Rates	------------------------- kg N-P_2O_5-K_2O-S ha^{-1} -------------------------			
Banded macro-nutrients	120-30-15-15	70-20-10-10	77-30-15-15	78-34-0-16

[Z]Soil nutrient levels based on a 0-15 cm composite soil sample for each site and analyses completed by A & L Canada Laboratories. Letters in brackets are nutrient availability ratings (VL – very low, L – low, M = medium, H – high, VH – very high)

Table 3. Description of treatments in seed applied fertilizer demonstration.

Trt.	Trade Name[Z]	Description / Rate / Nutrient Analyses[Y]
1	Untreated check	N/A
2	EZ20 Essential Zn®	$ZnSO_4$ (2-0-0-14 + 20% Zn) applied in-furrow at 12 kg/ha
3	Awaken ST®	Seed-applied at 325 mL 100 kg $seed^{-1}$; 6-0-1-0 + 5% Zn + 0.8% B, Cu, Fe, Mn & Mo
4	Alpine Seed Nutrition®	Seed applied at 510 ml 100 kg $seed^{-1}$; 6-22-2-0 + Zn
5	Protinus®	Seed applied at 323 g 100 kg $seed^{-1}$; 40% Zn, 10% Mn + Fe

6	Undisclosed - Zn[X]	Seed-applied; commercial product containing Zn
7	Undisclosed - Cu	Seed-applied; commercial product containing Cu

[Z]Disclosure of trade names does not imply any endorsement or disapproval of any specific products and is only intended to differentiate treatments and allow producers to identify the specific technologies being demonstrated in the marketplace
[Y]Macro and micro-nutrient concentrations are provided wherever possible; however, each product may or may not contain additional proprietary materials and the concentrations do not reflect potential differences in nutrient solubility and availability
[X]Two additional treatments were evaluated that were not part of the ADOPT project but are included in this report for informative purposes. Both products were commercially available formulations with major components of the products including Zn and Cu in Treatments 6 and 7, respectively

Results

Weather Conditions

Mean monthly temperatures and precipitation levels for the 2012 growing season at each location are provided in Tables 4 and 5 along with the long-term normals (1971-2000). Temperatures in May, when the plots were established, were below normal at all four locations while summer temperatures were normal to slightly above average. Over the four month period, precipitation levels were well above normal at all locations; however the distribution of the precipitation events varied. For example, at Indian Head precipitation levels were 99% of normal for May and June but 185% in July and only 58% of normal in August. In contrast, May and June at Swift Current were wetter than average with 178% of normal precipitation amounts but July and August were very dry with only 28% of normal rainfall received over the two month period. At all of the locations, soil moisture was considered excessive at one point or another during the growing season.

Table 4. Mean monthly temperatures and long-term (1971-2000) normals for the 2012 growing season at Indian Head, Melfort, Scott and Swift Current, Saskatchewan.

Location	Year	May	June	July	August	Avg. / Total
		Mean Temperature (°C)				
Indian Head	2012	9.9	16.5	19.2	17.1	15.7
	Long-term[Z]	11.4	16.1	18.4	17.5	15.9
Melfort	2012	9.6	15.2	18.9	17.1	15.2
	Long-term	10.8	15.7	17.4	16.4	15.1
Scott	2012	9.7	15.1	18.6	17.0	15.1
	Long-term	10.9	15.2	17.0	16.3	14.9
Swift Current	2012	9.4	15.5	20.0	19.0	16.0
	Long-term	11.1	15.6	18.1	17.9	15.7

[Z]Long-term normals (1971-2000)

Table 5. Total monthly precipitation amounts and long-term (1971-2000) normals for the 2012 growing season at Indian Head, Melfort, Scott and Swift Current, Saskatchewan.

Location	Year	May	June	July	August	Avg. / Total
		Precipitation (mm)				
Indian Head	2012	79.4	51.0	124.6	30.4	285.4
	Long-term[Z]	52.5	78.9	67.1	52.7	251.2
Melfort	2012	55.2	112.3	97.8	68.1	333.4

	Long-term	45.6	65.8	75.7	56.8	243.9
Scott	2012	50.6	164.6	56.4	51.4	323.0
	Long-term	35.9	62.5	70.9	43.1	212.4
Swift Current	2012	98.3	107.0	17.2	8.2	230.7
	Long-term	49.5	66.0	52.0	39.9	207.4

[z]Long-term normals (1971-2000)

<u>Crop Emergence and Establishment</u>

Treatment effects on spring plant populations for each of the measurement dates are presented in Table 6 while the actual treatment means for each location appear in the appendices (Tables 13-16). The dates of the counts were based on when the wheat actually emerged; however, the precise numbers of days from planting for each measurement date are also provided in the appendices to reflect differences amongst sites. The first counts were completed 9-14 days after planting while the final counts took place 25-27 days after planting, at which point it was assumed that all viable seedlings had become established. At the time when these measurements were initiated, the percentage of seedlings emerged ranged from 8-50%; therefore, at least one set of counts was completed during the peak emergence period at all locations. The effects of site were significant in all cases (Table 6; $P < 0.001$) and are a function of the different environmental conditions along with variation in the actual measurement dates. A significant treatment effect was observed at the final count date ($P = 0.022$). In addition, treatment effects were marginally significant ($P = 0.089$) at approximately 3 days after the start of emergence and the site X treatment interaction was marginally significant at the final date ($P = 0.094$).

Table 6.Type 3 tests of fixed effects on wheat emergence at Indian Head, Melfort, Scott and Swift Current.

	Days after emergence[z]				
Effect	**1**	**3**	**5**	**8**	**14**
	---- p-value ----				
Site (location)	<0.001	<0.001	<0.001	<0.001	<0.001
Treatment	0.285	0.089	0.339	0.330	0.022
Site X Treatment	0.299	0.648	0.862	0.277	0.094

[z]Timing of spring plant counts were relative to date where emergence was first noted and actual dates of measurements varied with location

Averaged treatment effects are illustrated graphically in Fig. 1. While a marginally significant treatment effect was observed three days after emergence, plant populations for the untreated check (Trt. 1) did not significantly differ from those observed for any other individual treatments. At the end of the emergence period, while there was a significant treatment effect, observed plant populations in the check (Trt. 1) were intermediate and not significantly different from final plant populations in any other individual treatments. The marginally significant site by treatment interaction on the final plant density count was due to the observed treatment effects being more prominent at Melfort than they were at Indian Head, Scott or Swift Current (Table 7).

The final plant densities were 374, 337, 327 and 249 plants m^{-2} at Indian Head, Melfort, Scott and Swift Current, respectively and site and treatment means for this variable are presented in Table 7.

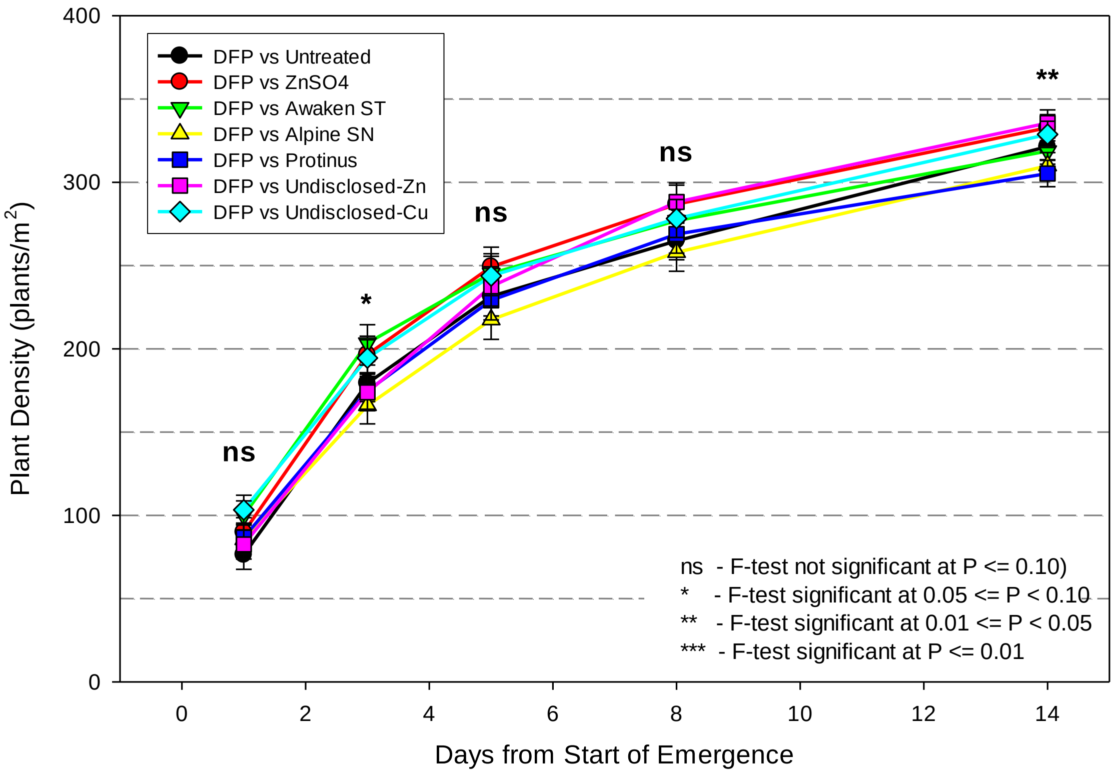

Figure 1. Treatment effects on spring wheat emergence (averaged across four locations in 2012).

Table 7. Treatment effects on final plant density of spring wheat. Interactions and main effect means followed by the same letter do not significantly differ (Tukey's test; $P \leq 0.05$).

Effect	**Site**	**Treatment**	**Site X Treatment**
	Final Plant Densities		
	---------- p-value ----------		
Tests of Fixed Effects	<0.001	0.022	0.094

Treatment	**Indian Head**	**Melfort**	**Scott**	**Swift Current**	**All Sites (main effect)**
	---------- plants / m^2 ----------				
All Treatments (site main effect)	**374 a**	**337 ab**	**327 b**	**249 c**	**—**
1 Untreated check	375 a	325 abcdef	337 abcd	249 efg	**321 ab**
2 Granular $ZnSO_4$	382 a	368 a	338 abc	243 fg	**333 ab**
3 Awaken ST®	376 a	336 abcd	315 abcdefg	249 efg	**319 ab**
4 Alpine Seed Nutrition®	350 ab	328 abcdef	312 abcdefg	250 defg	**310 ab**
5 Protinus®	366 a	278 bcdefg	315 abcdefg	262 cdefg	**305 b**

6	Undisclosed - Zn	385 a	377 a	342 abc	238 g	**336 a**
7	Undisclosed - Cu	386 a	348 ab	330 abcde	251 defg	**329 ab**

Crop Development and Growth

Above-ground biomass yields were measured at each location at the early vegetative stages, prior to stem elongation (Table 8). The overall mean biomass yields were 870, 337, 478 and 142 kg ha^{-1} at Indian Head, Melfort, Scott and Swift Current. In addition to different environmental conditions, the effect of site ($P < 0.001$) was attributed primarily to the measurements being completed at slightly different growth stages depending on the location. Averaged across sites, treatment means ranged from 400-491 kg ha^{-1} and treatment did not affect early season, above-ground biomass yield ($P = 0.104$). No treatment differences were significant within individual sites which is consistent with the non-significant site by treatment interaction ($P = 0.389$). Again, it should be emphasized these measurements do not take into account potential effects on root growth and we did not look at the roots in this demonstration. While we would expect larger roots to translate into enhanced above-ground growth under certain circumstances, this will not always be the case particularly in years where plant growth is not limited by dry conditions.

As an indirect indicator of early season biomass accumulation and crop growth, the normalized difference vegetation index (NDVI) of each plot at Indian Head was measured on June 22, when the wheat was at approximately the 5.5 leaf stage. For natural surfaces (i.e. soil and plant material), NDVI values theoretically range from 0-1.0, with higher numbers indicating more vegetation and a denser crop canopy. Consistent with the above-ground biomass measurements completed at the same time at Indian Head, no differences in NDVI were observed amongst the treatments (Table 9). The growth stage of the wheat was also measured at both Indian Head and Scott using the Haun scale. These measurements were completed at the 2.5-3.5 leaf stage and growth stage was not affected by treatment ($P = 0.832$) nor was the site by treatment interaction significant ($P = 0.609$; Table 9).

Relatively severe lodging occurred at Indian Head during early heading / flowering and, while the plants generally stood back up reasonably well as the season progressed, ratings were completed prior to harvest. The severity of lodging was not affected by any of the treatments ($P = 0.963$; Table 9).

Seed applied fertilizer products are sometimes marketed to provide an initial boost to crop emergence and development that can translate into earlier maturity. The economic value of earlier maturity to producers will likely vary depending on the geographic location (i.e. regions with short growing seasons) and specific objectives of the producer. For example, a 2-3 day reduction in maturity could be quite valuable to growers where the growing season is already marginal for the crops being grown and frost damage is a serious threat. In contrast, producers growing typical crops in warmer environments will be less likely to benefit from earlier maturity and are not likely to extract much value out of small reductions in days to maturity. The actual maturity dates of each plot (where kernels were difficult to dent with a thumbnail) were recorded at Indian Head, Scott and Swift Current and these results are presented in Table 10. The average number of days from planting to maturity differed between sites and ranged from 90 at Swift

Current to 101 at Indian Head (P < 0.001). This range is attributed to a combination of environment, crop management and different individuals rating the plots at each location. Days to maturity was not affected by treatment (P = 0.241) and the site by treatment interaction was not significant (P = 0.241).

Table 8. Treatment effects on early season biomass yield of spring wheat. Interactions and main effect means followed by the same letter do not significantly differ (Tukey's test; $P \leq 0.05$).

	Early Season Above-ground Biomass Yield		
Effect	**Site**	**Treatment**	**Site X Treatment**
	p-value		
Tests of Fixed Effects	<0.001	0.104	0.389

Treatment	**Indian Head**	**Melfort**	**Scott**	**Swift Current**	**All Sites (main effect)**
	kg / ha				
All Treatments (site main effect)	**870 a**	**337 c**	**478 b**	**142 d**	**—**
1 Untreated check	898 ab	320 de	436 d	137 e	**448 a**
2 Granular $ZnSO_4$	833 ab	335 de	488 cd	134 e	**447 a**
3 Awaken ST®	861 ab	389 de	523 cd	154 e	**482 a**
4 Alpine Seed Nutrition®	1013 a	323 de	485 cd	143 e	**491 a**
5 Protinus®	751 bc	264 de	434 d	152 e	**400 a**
6 Undisclosed - Zn	910 ab	371 de	463 d	133 e	**469 a**
7 Undisclosed - Cu	824 ab	357 de	516 cd	143 e	**460 a**

Table 9. Treatment effects on NDVI, lodging and growth stage development of spring wheat. Means within a column followed by the same letter do not significantly differ.

		Indian Head			**Scott**
#	Treatment	NDVI	Lodging	Growth Stage	
			(1-9)	Haun Scale	
1	Untreated check	0.742 a	2.5 a	3.35 a	2.63 a
2	Granular $ZnSO_4$	0.690 a	2.1 a	3.28 a	2.82 a
3	Awaken ST®	0.712 a	2.5 a	3.35 a	2.67 a
4	Alpine Seed Nutrition®	0.722 a	2.1 a	3.36 a	2.73 a
5	Protinus®	0.705 a	2.3 a	3.35 a	2.47 a
6	Undisclosed - Zn	0.716 a	2.3 a	3.37 a	2.71 a
7	Undisclosed - Cu	0.725 a	2.4 a	3.24 a	2.75 a
			Type 3 Tests of Fixed Effects		
	Effect	p-value			
	Site	—	—	<0.001	

Treatment	0.548	0.963	0.832
Site X Treatment	—	—	0.609

Table 10. Treatment effects on days to maturity of spring wheat. Interactions and main effect means followed by the same letter do not significantly differ (Tukey's test; $P \leq 0.05$).

	Days to Maturity		
Effect	**Site**	**Treatment**	**Site X Treatment**
	------ p-value ------		
Tests of Fixed Effects	<0.001	0.241	0.241

Treatment	**Indian Head**	**Melfort**	**Scott**	**Swift Current**	**All Sites (main effect)**
	------ kg / ha ------				
All Treatments (main effect)	**100.8 a**	**n/a**	**93.4 b**	**89.6 c**	**—**
1 Untreated check	101.0 a	n/a	93.0 bcd	90.0 de	**94.7 a**
2 Granular $ZnSO_4$	100.6 a	n/a	93.0 bcd	89.3 e	**94.3 a**
3 Awaken ST®	101.0 a	n/a	92.0 cde	89.8 de	**94.3 a**
4 Alpine Seed Nutrition®	100.6 a	n/a	94.0 bc	89.3 e	**94.6 a**
5 Protinus®	101.0 a	n/a	95.0 b	89.8 de	**95.3 a**
6 Undisclosed - Zn	100.8 a	n/a	93.8 bc	89.8 de	**94.8 a**
7 Undisclosed - Cu	100.3 a	n/a	93.0 bcd	89.8 de	**94.3 a**

n/a – data not available

Grain Yield and Quality

To be fair, seed-applied fertilizer products are typically not marketed to improve seed or grain yields directly. However, for most growers, yield is the single most important measure of return on investment and many who are investing in novel inputs or technologies expect at least occasional yield increases. Grain yield was affected by site (P = 0.010) and mean yields at Indian Head, Melfort and Swift Current were 2716, 3260 and 2913 kg ha^{-1}, respectively (Table 11). Grain yields were not affected by treatment (P = 0.938) nor was site by treatment interaction significant (P = 0.549). There was, however, a tendency for higher yields when granular $ZnSO_4$ were applied at Indian Head. When data from Indian Head was analyzed separately (not shown) and Trt. 2 (granular $ZnSO_4$) was compared directly to Trt. 1 (untreated check), the yield increase was not significant at the desired probability level (P = 0.089); however, Trt. 2 did yield significantly higher than the treatments 3-7 combined (P = 0.026). The actual yield difference between the untreated check (Trt. 1) at Indian Head and Trt. 2, where granular Zn was applied, was 369 kg ha^{-1}. At both Melfort and Swift Current, grain yields were similar across all treatments ranging from 3119-3318 kg ha^{-1} at Melfort and 2781-2956 kg ha^{-1} at Swift Current. Averaged across locations, treatment yields ranged from 2942-3026 kg ha^{-1}.

For interest sake, treatment effects on the test weight and seed size of the harvested grain at Indian Head and Swift Current were evaluated and results are presented in Table 12. To the best of our knowledge, seed-applied fertilizer products are not marketed to improve grain quality. Test weight was affected by site (*P* = 0.043) but not treatment (*P* = 0.811) and the interaction between site and treatment was not significant (*P* = 0.737). Test weights at Swift Current were slightly higher than at Indian Head, possibly a result of the unusually high fusarium head blight levels encountered at Indian Head. Neither site (*P* = 0.285) nor treatment (P = 0.874) affected seed size and the interaction between the two was not significant (*P* = 0.965). Grain protein was also analyzed at Swift Current and, with a range of 12.1-12.4%, was not significantly affected by any of the treatments (*P* = 0.432; data not shown).

Table 11. Treatment effects on grain yield of spring wheat. Interactions and main effect means followed by the same letter do not significantly differ (Tukey's test; $P \leq 0.05$).

	Grain Yield		
Effect	**Site**	**Treatment**	**Site X Treatment**
	---- p-value ----		
Tests of Fixed Effects	0.010	0.938	0.549

Treatment	Indian Head	Melfort	Scott	Swift Current	All Sites (main effect)
	---- kg / ha ----				
All Treatments (main effect)	**2716 b**	**3261 a**	**n/a**	**2913 ab**	**—**
1 Untreated check	2675 a	3282 a	n/a	2991 a	**2983 a**
2 Granular $ZnSO_4$	3044 a	3119 a	n/a	2915 a	**3026 a**
3 Awaken ST®	2687 a	3316 a	n/a	2937 a	**2980 a**
4 Alpine Seed Nutrition®	2580 a	3238 a	n/a	2878 a	**2899 a**
5 Protinus®	2756 a	3318 a	n/a	2781 a	**2951 a**
6 Undisclosed - Zn	2660 a	3290 a	n/a	2933 a	**2961 a**
7 Undisclosed - Cu	2608 a	3263 a	n/a	2956 a	**2942 a**

n/a – data not available

Conclusions and Recommendations:

With cool and wet conditions through May and early June along with potentially low Zn levels at three of the four study locations (depending on the soil test), 2012 provided a good opportunity to evaluate seed-applied fertilizer products and soil-placed granular $ZnSO_4$. While subtle treatment effects on emergence were detected at Melfort, there were no cases where the observed plant densities for the check differed from those of any other treatments. Early season above-ground biomass yield, NDVI, crop growth stage and days to maturity were not affected by treatment in any of the cases where data for these parameters was available. Grain yield was not affected by any of the seed-applied products at any locations; however, at Indian Head there was a slight yield increase observed with application of granular $ZnSO_4$ fertilizer. Grain quality (test weight, seed size or protein concentration) was not affected in any cases where data were available.

Table 12. Treatment effects on test weight and seed size of harvested spring wheat. Means within a column followed by the same letter do not significantly differ.

		Indian Head	**Swift Current**	**Indian Head**	**Swift Current**
#	Treatment	Test Weight		Seed Size	
		----------------- g / 0.5 L -----------------		------------- g / 1000 seeds -------------	
1	Untreated check	374.5 a	383.0 a	27.9 a	28.7 a
2	Granular $ZnSO_4$	381.1 a	382.9 a	27.6 a	27.8 a
3	Awaken ST®	374.9 a	384.2 a	27.5 a	28.3 a
4	Alpine Seed Nutrition®	375.0 a	382.2 a	27.7 a	28.0 a
5	Protinus®	376.1 a	382.7 a	27.3 a	28.7 a
6	Undisclosed – Zn	375.3 a	382.5 a	27.1 a	27.8 a
7	Undisclosed – Cu	374.9 a	383.6 a	27.6 a	28.2 a
		Type 3 Tests of Fixed Effects			
Effect		-- p-value --			
	Site	0.043		0.285	
	Treatment	0.811		0.874	
	Site X Treatment	0.737		0.965	

In conclusion, there were no measureable benefits observed for any of the seed-applied fertilizer products in these particular demonstrations. As with many crop inputs, including traditional fertilizers and crop protection products, the challenge will be to reasonably predict when, where, and to what extent a response to seed-applied fertilizer products is likely to occur. The first recommended steps for producers hoping to improve crop establishment would be to 1) ensure that they are managing crop residues sufficiently (i.e. adequate chaff and straw spreading, heavy harrowing if necessary), 2) confirm that they are using high quality seed, 3) ensure that seed is being placed at an appropriate depth, 4) follow provincial guidelines for seed-placed fertilizer and 5) make sure that overall fertility levels are adequate. Growers who are considering investing in this technology are encouraged to establish check strips to objectively evaluate whether or not they are getting the desired results. While not always convenient to establish, properly placed and replicated check strips (in every field) are the only way to properly evaluate whether a product or practice has value and is providing a return on investment. While it can be tempting to simply judge a growing crop against neighboring fields or past performance, such comparisons have relatively little value and cannot be used to detect subtle treatment effects such as those that may be expected with a seed-applied fertilizer application.

Technology Transfer Activities:

Field demonstrations were showcased at the IHARF Crop Management Field Day on July 24, 2012 at Indian Head, Saskatchewan. A total of 173 guests came out for the event of which it is estimated that 46% were producers and 54% were from industry and potentially farming as well. The trial was also shown at the NARF Field Day on July 17, 2012 at Melfort Saskatchewan where approximately 80 guests were in attendance.

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Appendices:

Table 13. Spring wheat emergence treatment means for Indian Head (2012). Means within a specific column followed by the same letter do not significantly differ (Tukey's studentized range test; $P \leq 0.05$).

	Wheat Emergence (Indian Head 2012)				
Days from planting	**9**	**11**	**13**	**15**	**25**
Treatment	plants / m^2				
1 Untreated check	63 a	198 a	227 a	259 a	375 a
2 Granular $ZnSO_4$	69 a	233 a	276 a	299 a	382 a
3 Awaken ST®	96 a	228 a	251 a	282 a	376 a
4 Alpine Seed Nutrition®	94 a	181 a	217 a	247 a	350 a
5 Protinus®	80 a	208 a	244 a	283 a	366 a
6 Undisclosed - Zn	91 a	210 a	246 a	278 a	385 a
7 Undisclosed - Cu	60 a	212 a	263 a	303 a	386 a

Table 14. Spring wheat emergence treatment means for Melfort (2012). Means within a specific column followed by the same letter do not significantly differ (Tukey's studentized range test; $P \leq 0.05$).

	Wheat Emergence (Melfort 2012)				
Days from planting	**13**	**15**	**17**	**20**	**26**
Treatment	plants / m^2				
1 Untreated check	25 a	89 a	187 a	232 ab	325 ab
2 Granular $ZnSO_4$	10 a	73 a	201 a	279 ab	368 a
3 Awaken ST®	38 a	106 a	208 a	263 ab	336 ab
4 Alpine Seed Nutrition®	36 a	103 a	177 a	232 ab	328 ab
5 Protinus®	19 a	71 a	151 a	207 b	278 b

6 Undisclosed - Zn	14 a	70 a	199 a	322 a	377 a
7 Undisclosed - Cu	41 a	108 a	196 a	246 ab	348 ab

Table 15. Spring wheat emergence treatment means for Scott (2012). Means within a specific column followed by the same letter do not significantly differ (Tukey's studentized range test; *P* ≤ 0.05).

	Wheat Emergence (Scott 2012)				
Days from planting	**14**	**16**	**18**	**21**	**27**
Treatment	plants / m^2				
1 Untreated check	132 a	269 a	325 a	332 a	337 a
2 Granular $ZnSO_4$	192 a	324 a	340 a	348 a	338 a
3 Awaken ST®	186 a	289 a	315 a	329 a	315 a
4 Alpine Seed Nutrition®	131 a	235 a	280 a	311 a	312 a
5 Protinus®	159 a	254 a	321 a	342 a	315 a
6 Undisclosed - Zn	164 a	282 a	330 a	336 a	342 a
7 Undisclosed - Cu	191 a	305 a	332 a	331 a	330 a

Table 16. Spring wheat emergence treatment means for Swift Current (2012). Means within a specific column followed by the same letter do not significantly differ (Tukey's studentized range test; *P* ≤ 0.05).

	Wheat Emergence (Swift Current 2012)				
Days from planting	**11**	**14**	**16**	**18**	**25**
Treatment	plants / m^2				
1 Untreated check	85 a	162 a	188 a	237 a	249 a
2 Granular $ZnSO_4$	87 a	157 a	181 a	221 a	243 a
3 Awaken ST®	80 a	191 a	208 a	235 a	249 a
4 Alpine Seed Nutrition®	81 a	145 a	198 a	242 a	250 a
5 Protinus®	89 a	166 a	201 a	243 a	262 a
6 Undisclosed - Zn	62 a	135 a	175 a	217 a	238 a
7 Undisclosed – Cu	122 a	154 a	184 a	233 a	251 a