Wheatland Conservation Area Inc.
Swift Current, SK.

Canola Seed Safety and Yield Response to Novel P Sources in Saskatchewan Soils
ADOPT (20200517)
Final Report

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Abstract

In 2021 a trial was established in Swift Current, Saskatchewan titled, "Canola Seed Safety and Yield Response to Novel P Sources in Saskatchewan Soils" to demonstrate canola response to increasing rates of struvite (i.e. Crystal Green), alone or in a blend, relative to other common P fertilizer formulations with a focus on stand establishment and seed yield. All of the products we propose to evaluate are commercially available and have, to varying degrees, been assessed under western Canadian field conditions. When it comes to P fertilizer forms, most research has shown that the fate of different forms along with the potential crop response is similar, regardless of initial differences. Of the growers who apply P fertilizer to canola, monoammonium phosphate (11-52-0) holds 73% of the market by volume (Stratus Ag Research, 2015). While not exclusively a P product, MES15 is a multi-nutrient fertilizer which is often perceived as having the benefits of improved seed-safety (relative to MAP/AS blends) and providing season long sulphur with the S consisting of equal parts SO_4-S and elemental forms. Promotional material and internal research on MES15 from Mosaic showed significantly higher plant populations and a 2.6 bu/ac advantage (average of 24 trials over a three-year period) over MAP plus ammonium sulphate (AS) blends. Independent University of Manitoba research (Grenkow et al. 2013) showed improved seed safety over MAP/AS but also warned that MES15 may not be as effective at providing plant available S as conventional products (i.e. MAP/AS blends). That aside, the claim specific to P is that the combination of nutrients in MES15 creates a more acidic environment which helps keep the P in plant available, soluble forms for a longer period of time leading to better overall uptake. A previous ADOPT project conducted at Indian Head in 2018 showed a 1 bu/ac yield advantage to MES15 (over MAP) when averaged across application rates; however, the response was not significant at the desired probability level (P = 0.063; Holzapfel 2019).

Struvite is marketed under the brand name Crystal Green® (5-28-0 plus 10% Mg) and, according to promotional material, boasts superior crop safety with a salt index of 7.7 (compared to 27 in MAP and 21 in MES15) along with improved season long availability relative to more traditional products (crystalgreen.com/nutrient-recovery). While it does not appear in the scientific literature or regional field trials to the same extent as MAP or diammonium phosphate, relevant peer-reviewed research on struvite as a P fertilizer source does exist. Early work at the University of Manitoba found that, at the applied rates, struvite (whether derived from liquid manure or chemically pure) increased dry matter yields and P recovery over the control but not to the same extent as MAP. The authors suggested that this may have been due to the lower initial solubility of struvite in the high pH Manitoba soils (Ackerman et al. 2013). In later evaluations with wheat and canola, Katanda et al (2016) saw similar early season dry matter yield and uptake efficiency with struvite compared to MAP and, at higher rates, greater biomass yields and P recovery with struvite during the later crop phases. They concluded that struvite can supply sufficient P to sustain yields and overall P used efficiencies matching or exceeding those for MAP. Citing Ag Quest trials with canola, the company boasts 16% higher plant populations and an 11% yield advantage to struvite compared to 111 kg/ha (total product) of MES15 (crystalgreen.com/agriculture/canola). While there is solid evidence that struvite is effective as a P fertilizer source, independent evaluations under Saskatchewan field

conditions will help increase producer awareness and of this product and help them understand if and when it may have a fit in their operations. Canola is known to respond well to P applications in low P soils but is also relatively sensitive to seed placement and, as such, is an excellent test crop for this project.

Project Objectives

The objectives of the project are to demonstrate canola response to increasing rates of struvite (i.e. Crystal Green), alone or in a blend, relative to other common P fertilizer formulations with a focus on stand establishment and seed yield.

Project Rationale

As of 2015, 81% of soil samples evaluated from Saskatchewan had phosphorus levels that were considered to be below the critical levels and the average pH was 7.4. Higher pH soils, common throughout much of eastern Saskatchewan, also lead to reduced P fertilizer use-efficiency. While Saskatchewan farmers are becoming increasingly aware of the long-term importance of P fertilization and many would like to maintain or build P levels over the long-term, P fertilizer use-efficiency in the year of application is notoriously low (generally below 30%). Consequently, many growers are seeking means of improving this efficiency and premium formulations (i.e. MES15, Alpine P, and Crystal Green) are seen as possible solutions to this challenge. Due to equipment limitations, only granular P fertilizer products can be included in the proposed demonstration therefore the forms are limited to MAP, MES15®, and Crystal Green® (struvite). Canola is known to be a large user of P and, compared to many crops, responsive to fertilizer applications. It is also well documented that high rates of seed-placed P fertilizer can reduce seedling survival and establishment in sensitive crops such as canola; however, many growers and agronomists prefer to place at least some P in the seed-row to ensure it is not limiting early in the season. While P fertilization will typically result in higher canola seed yields when residual levels of this nutrient are low, the response is often most evident early in the season when more vigorous growth is frequently observed with P fertilization. This is commonly referred to as a 'pop-up' effect and is primarily attributed to seed-placed P fertilizer but can also be observed with side-banded P[1]. The greatest advantages to seed-placed P compared to other placement options are often observed under dry conditions (due to reduced mobility of P in solution) but, unfortunately, this is also when the risk of seedling injury is highest. While side-banding is widely recognized as a viable, safe application method, the majority of P applied during seeding is placed in seed-row (51% by volume compared to 36% for side-banding, Stratus Ag Research 2015).
The proposed project will demonstrate (in the year of application and in deficient soils) the potential seed safety and yield benefits (or lack thereof) of novel P fertilizer formulations relative to the industry standard, monoammonium phosphate (11-52-0).

Methods

A field demonstration with canola was established on wheat stubble with low residual P levels at Swift Current and managed under no-till, continuous cropping system. In addition to a control where no P fertilizer was applied, four fertilizer forms were applied at three rates. The thirteen P fertilizer treatments were replicated four times in a RCBD and described below *(Table 1)*.

The canola was seeded in mid-May, recognizing that the potential for phosphorus fertilizer response tends to be greater with early seeding (into cool soils). Canola was seeded with Fabro-built plot seeder with 8 ¼" row spacing with all P fertilizer applied in the seed-row and not blended with any other fertilizer products. Nitrogen was non-limiting and was supplied as side-banded urea with the total N of 120 lb/ac balanced across treatments. No additional Sulphur was applied as residual levels were high in soil *(Table 2)*. DKTF SC21 canola hybrid was seeded with a target seeding rate of 179 seeds/m^2 to target plant stands of roughly 50-90 plants/ m^2. All pests (weeds, disease, and insects) were kept at reasonably low levels throughout the season using registered crop protection products and sound overall agronomy. The canola was straight-

[1] https://iharf.ca/wp-content/uploads/2019/05/Seed-placed-phosphorus-fertilizer-forms-and-P-bilaii-effect-on-canola.pdf

combined and the outside rows of each plot were excluded from the harvest area to minimize potential edge effects. All response data was analyzed using basic statistical methods for assessing the overall data quality and testing the significance of treatment effects and differences between means.

Table 1. Treatment List

The following measurements were taken:

- Soil sample to determine residual nutrients and qualities
- Spring emergence (plants/m^2)
- Plant vigor ratings
- Days to maturity
- Final plant density (plants/m^2)
- Seed Yield: Corrected for dockage and to 10% seed moisture content
- Economic Analyses

2021 List of Operations

30-Apr - Soil Sampled (0-15cm; 15-60cm)
03-May- Pre-seed burn-off RT 540 @ 0.67 L/ac
19-May- Seeded canola ½ to ¾" deep
31-May- In-crop spray application of Poast Ultra @ .19 L/ac + Merge
07-June- In-crop spray application of RT 540 @ 0.67 L/ac
18-June- Spring emergence counts and vigor ratings
06-July- Irrigated ~ ¼ inch.
12-Aug- Maturity ratings
01-Sept- Harvested (7 rows)
02-Sept- Final plant densities recorded

2021 General Site Conditions

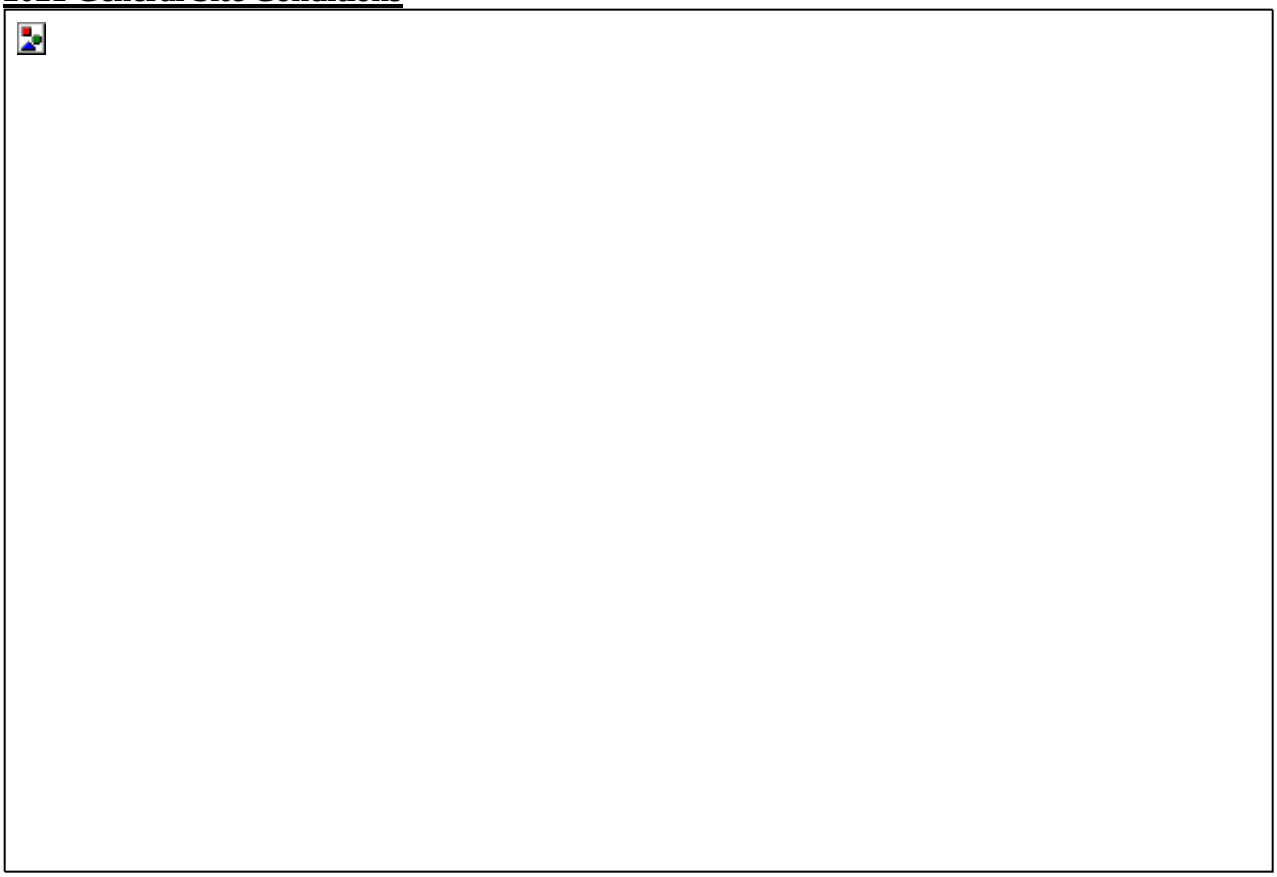

Figure 1. Accumulative weekly precipitation for years 2010 (record high), and 2017-2021 (Agriculture and Agri-Food Canada)

In 2021 according to the Saskatchewan Crop Report[2], Swift Current went into spring seeding with below adequate moisture levels *(Figure 1)*. Swift Current received very little rain throughout seeding followed by cool and dry conditions. Canola emergence was delayed and soil moisture diminished very quickly. By the middle of June, soil conditions were deteriorating rapidly with the onset of higher than normal temperatures. Dry and windy weather caused crops to advance faster than usual, resulting in estimated yields to be well below average.

Results

Table 2. Spring Soil Test Results

Attribute/Nutrient	*0-15cm*	*15-60cm*	*0-60cm*
pH	*6.5*	*7.9*	
Sol. Salts	*0.3 mmho/cm*	*0.33 mmho/cm*	
Nitrate	*14 lb/ac*	*39 lb/ac*	*53 lb/ac*
Phosphorus (Olsen-P)	*16 ppm*		

[2] https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/market-and-trade-statistics/crops-statistics/crop-report/previous-crop-reports

Sulphur	*42 lb/ac*	*48 lb/ac*	*90 lb/ac*
Potassium	*282 ppm*		
Zinc	*0.49 ppm*		
Organic Matter	*2.4%*		

The highest overall spring emergence counts of (100 plants/m^2) were attained by seed placing 25 kg P_2O_5/ha of the MAP/Crystal Green blend and (98.75 plants/m^2) from the 25 kg rate of MAP, both significantly higher than using the same rates of 100% Crystal Green (89 plants/m^2), MES15 (82 plants/m^2) and the Control (83.75 plants/m^2) *(Figure 2).*

The data shows all 25 kg P_2O_5/ha formulations used in the trial as safe to use in the canola seed row. When increasing to 45 and 65 kg/ha P_2O_5 only Crystal Green with resulting emergence counts of 94.5 plants/m^2 and 88.25 plants/m^2 showed higher emergence in the seed row when compared to the Control (83.75 plants/m^2). MAP/Crystal Green blend at the 45 kg/ha rate (82 plants/m^2) was statistically the same as the Control.

A negative impact on emergence was observed when using both MAP and MES15 at the higher rates and MAP/Crystal Green blend at the 65 kg/ha rate. The 45 kg and 65 kg/ha P_2O_5 rates of MAP resulted in plant emergence reduction of 13.7% and 25.6% when compared to the Control. Using MES15 at the same rates resulted in the highest overall reduction in plant stands. Compared to the Control (83.75 plants/m^2) using MES15 in the seed row at 45 kg P_2O_5/ha resulted in a 41.2% reduction with MES15 at 65 kg P_2O_5/ha showing a 37% reduction. MAP/Crystal Green at 65 kg P_2O_5/ha saw the smallest reduction of 12.2% compared to the Control.

The lower emergence from the two higher rates of MES15 may be related to the higher applied nitrogen and sulphur in the seed row in combination with the very dry soil conditions observed in May and early June, perhaps increasing the salt toxicity due to the lower water content in the soil. The extremely dry conditions may have also been a factor in the reduced emergence when using the high rates of MAP although not as severe as when using MES15. Nutrients of 15.8 and 22.8 lbs of N/ac and 18.2 and 26.3 lbs S/ac were applied in the seed row from the 45 kg/ha and 65 kg/ha P_2O_5 using MES15 fertilizer compared to only 8.4 and 12.2 lb of N/ac (no sulfur) when applying the MAP at the same two rates of P_2O_5.

With a salt index of 27 for MAP and 7.7 for Crystal Green the overall salt index rating is reduced when combining the two products compared to MAP alone. Both the 25 kg and 45 kg P_2O_5/ha MAP/Crystal Green blend saw increased emergence counts when compared to MAP at the same rates. The 12.2% reduction in plant stand compared to the Control when applying the blend at the 65 kg P_2O_5/ha was likely being caused by the higher salt index in the MAP portion of the blend in combination with the extremely dry soil conditions observed in 2021.

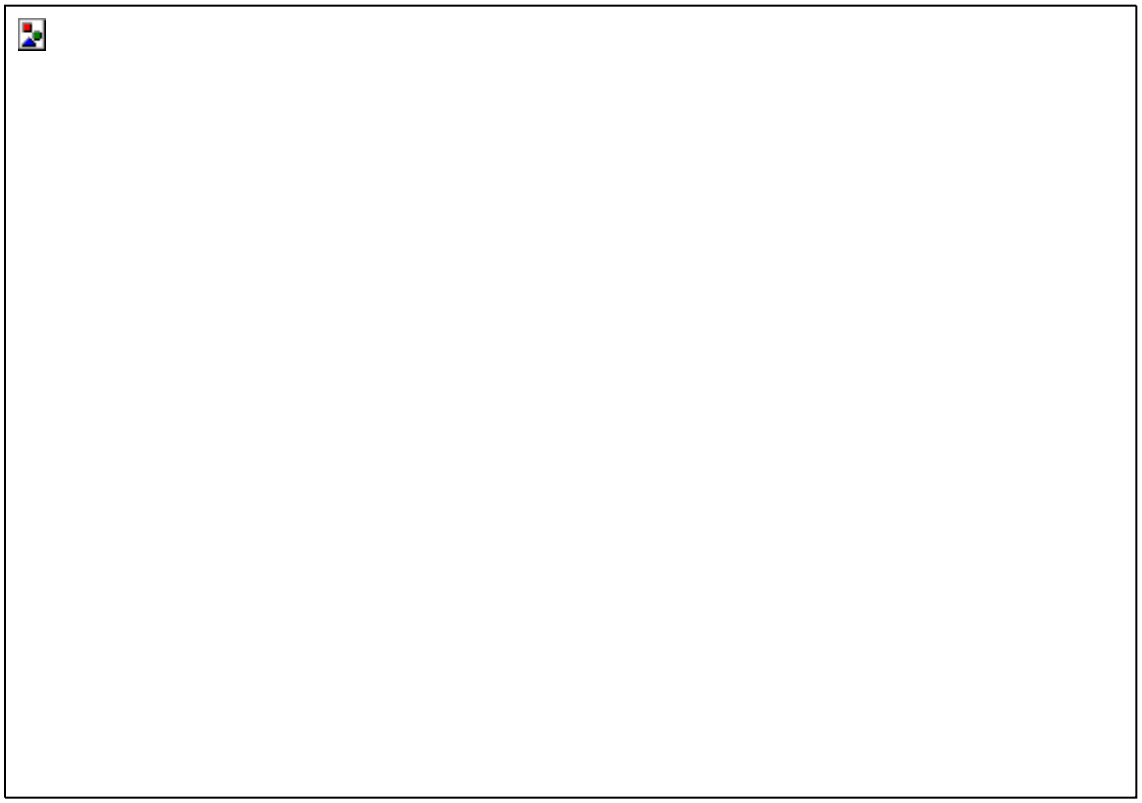

Figure 2. Seed Placed Novel P Sources Effect on Spring Emergence in Canola

P fertilization will typically result in higher canola seed yields when residual levels of this nutrient are low. The response is often most evident early in the season when more vigorous growth is frequently observed with P fertilization, which is commonly referred to as a 'pop-up' effect and is primarily attributed to seed-placed P fertilizer[3]. Canola plants were rated for vigor four weeks after seeding *(Figure 3).* showing Crystal Green, MAP, and MAP/Crystal Green at the 45 kg rate as having the best vigor of 10.0 followed by the 25 kg P_2O_5/ha rates of the same products with a 9.75 vigor rating compared to the Control (9.25 vigor rating). The 65 kg P_2O_5/ha of Crystal Green, MAP, and MAP/Crystal Green and low rate of MES15 had similar or better vigor than the Control. MES15 at 45 kg and 65 kg P_2O_5/ha had vigor ratings of 8.75 and 8.5, both below the Control.

[3] https://iharf.ca/wp-content/uploads/2019/05/Seed-placed-phosphorus-fertilizer-forms-and-P-bilaii-effect-on-canola.pdf

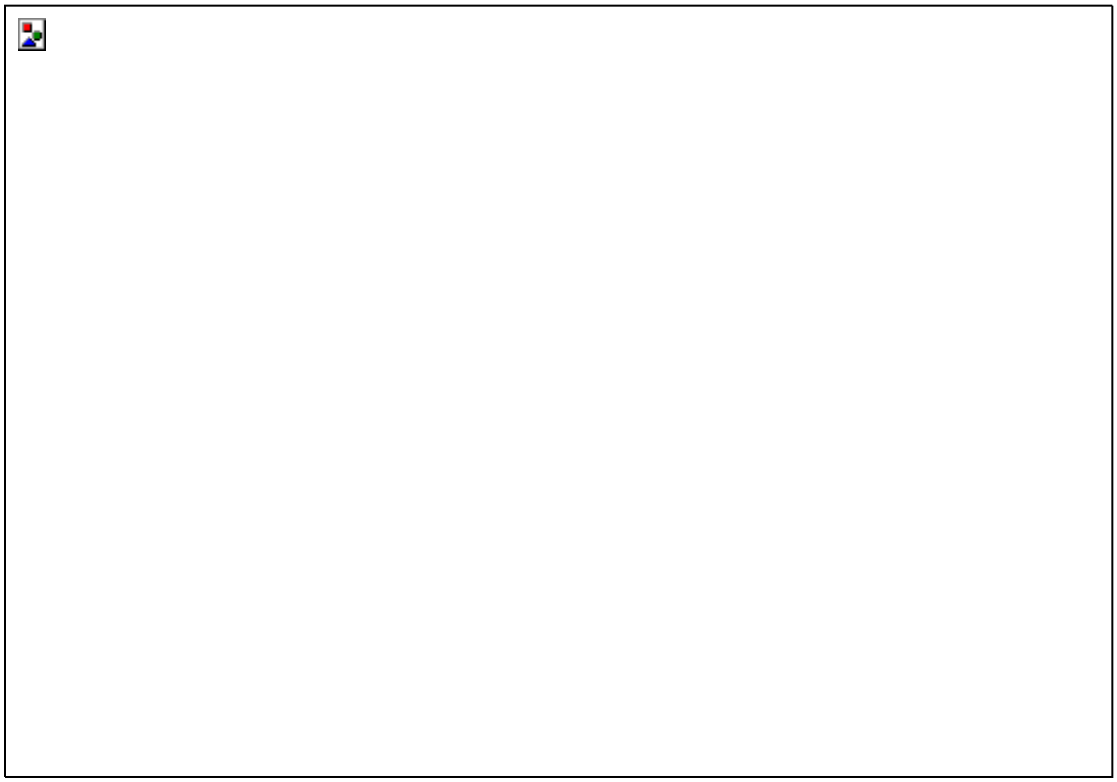

Figure 3. Seed Placed Novel P Sources Effect on Plant Vigor in Canola

Final plant densities were counted at harvest and mostly mirrored the spring emergence counts. *(Figure 4)*. Densities ranged from a high of 103.75 plants/m^2 for MAP at 25 kg P_2O_5/ha to low of 51.25 plants/ m^2 using MES at 45 kg P_2O_5/ha. Overall variations from spring emergence counts to fall plant densities were negligible and were likely pre-determined by drought conditions observed through the growing season.

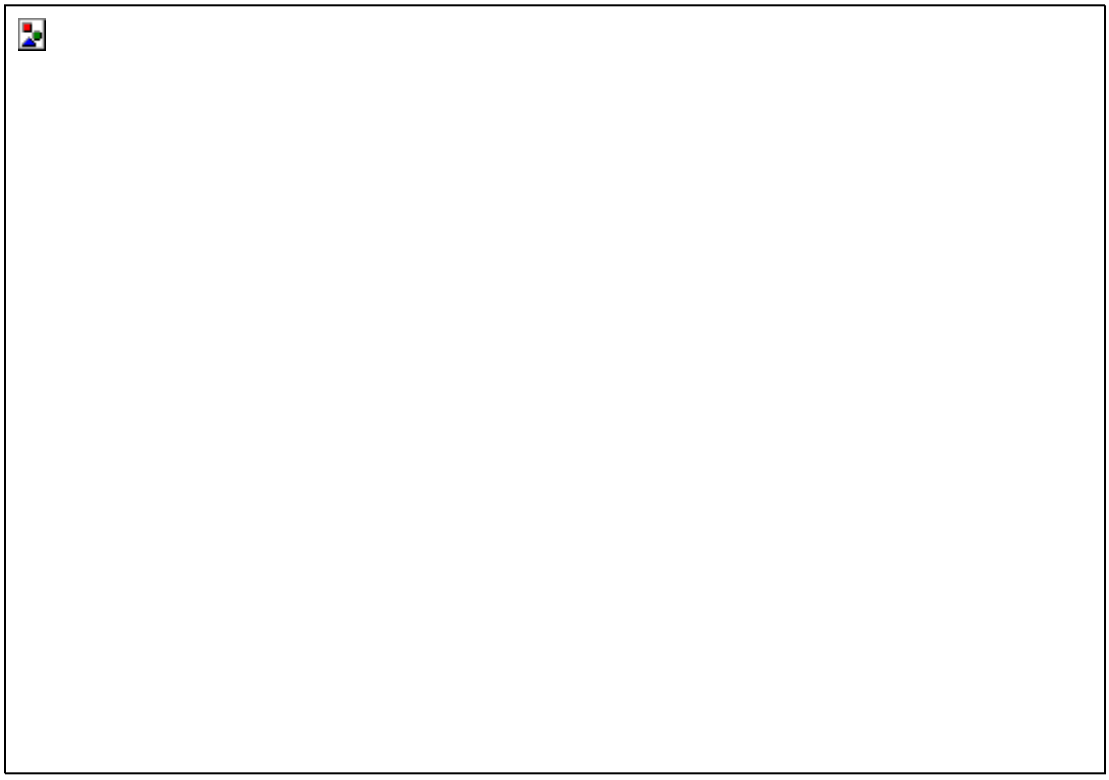

Figure 4. Seed Placed Novel P Sources Effect on Final Plant Density in Canola

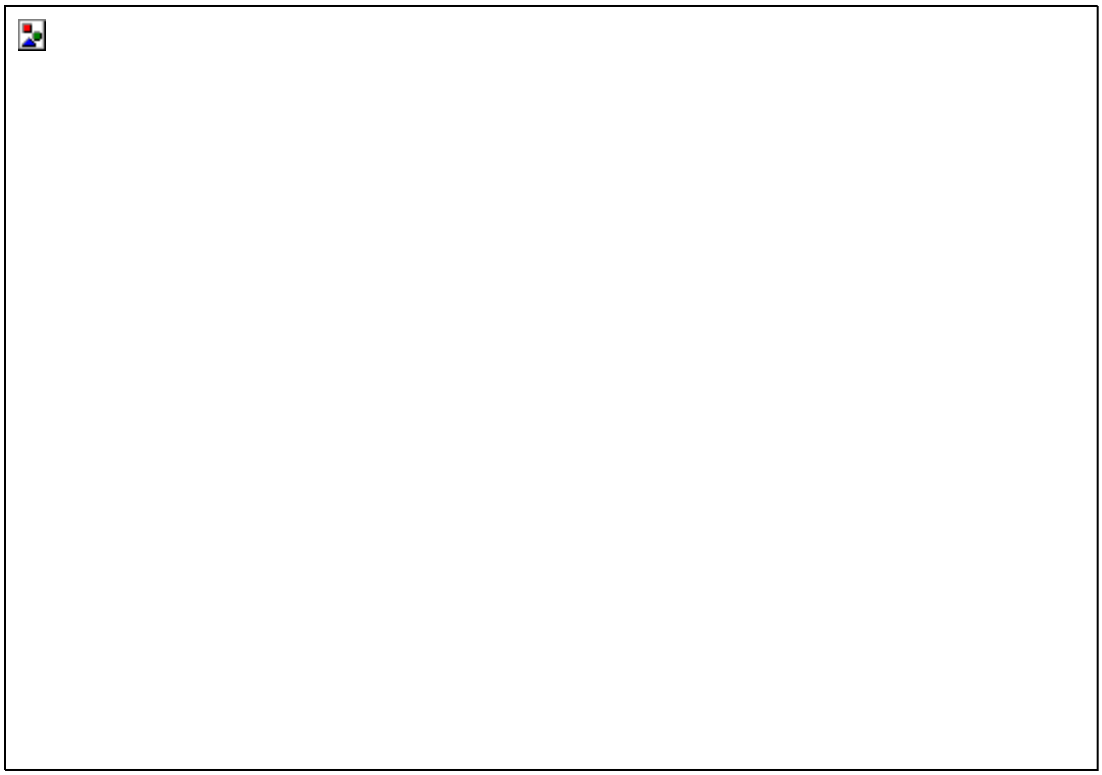

Figure 5. Yield Response to Seed Placed Novel P Sources in Canola
CV= 11.08; LSD= 49.05; $P \leq 0.05$

Comparing yields, 50/50 MAP/Crystal Green rate of 65 kg P_2O_5/ha provided the highest yield of ***(1495.5 kg/ha)*** statistically similar to 100% Crystal Green 65 kg P_2O_5/ha yield of ***(1447.5 kg/ha)***, both significantly higher yielding than the three MES15 rates of 25 kg P_2O_5/ha ***(1395 kg/ha),*** 45 kg P_2O_5/ha ***(1380.75 kg/ha)***, and 65 kg P_2O_5/ha ***(1382.75 kg/ha)***. Applying no phosphorous resulted in a yield of ***(1297.25 kg/ha)***. *(Figure 5).*

45 kg P_2O_5/ha of Crystal Green ***(1238.25 kg/ha),*** 25 kg P_2O_5/ha of MAP ***(1228.25 kg/ha),*** and 25 kg P_2O_5/ha of MAP/Crystal Green blend ***(1152.25 kg/ha)*** resulted in the lowest yields, significantly lower than applying no phosphorus, the "Control" ***(1297.25 kg/ha)***. Looking back at the spring emergence counts, we found these low yielding treatments had the highest spring plant densities, whereas the higher yielding treatments had low plant densities. The severe drought of 2021 created textbook conditions for soil moisture competition, with lower plant densities being able to compensate more so than dense plant stands. This is very evident when looking at MES15 at the two high rates of P_2O_5 and their corresponding spring emergence counts. These two treatments had the lowest plant densities overall of 49.25 and 52.25 plants/m^2 and achieved the greatest yield response *(Figure 2).* Overall, the best yields came from treatments with lower plant densities.

When looking at each product individually the MES15 yields ***(1395 kg/ha***, ***1380.75 kg/ha***, *and* ***1382.75 kg/ha)***, showed no statistical yield difference when increasing P_2O_5.

The MAP/Crystal Green blend resulted in each yield being significantly higher with each increase of P_2O_5 rate as follows: ***(1152.25 kg/ha)*** from 25 kg/ha P_2O_5; ***(1309.25 kg/ha)*** from 45 kg/ha P_2O_5 and ***(1495.5 kg/ha)*** from 65 kg/ha P_2O_5.

When increasing the rates MAP, we found there was a significant difference in yield going from a fertility rate of 25 kg/ha P_2O_5 ***(1228.25 kg/ha)*** to 45 kg/ha P_2O_5 ***(1322.25 kg/ha).*** Although a higher yield ***(1345 kg/ha)*** was realized when applying MAP at 65 kg/ha P_2O_5 it was not significantly different than MAP at 45 kg/ha P_2O_5.

Applying Crystal Green at 25 kg/ha P_2O_5 yielded ***(1357 kg/ha)*** significantly higher than ***(1238.25 kg/ha)*** when applying 45 kg/ha P_2O_5. The noticeable yield reduction when using the 45 kg/ha rate is likely due to higher plant density and more competition for moisture as described earlier. The 65 kg/ha P_2O_5 yielded ***(1447.5 kg/ha)*** significantly higher than both lower Crystal Green fertility rates.

These 25 kg P_2O_5/ha rates which are within the Saskatchewan guideline for canola seed placed phosphorus[4] shows MES15 ***(1395 kg/ha)*** and 100% Crystal Green ***(1357 kg/ha)*** both yielded significantly higher than MAP ***(1228.25 kg/ha)***, and the MAP/Crystal Green treatment ***(1152.25 kg/ha)***.

Only two fertility rates showed better economical return than the No Phosphorous/Control. The highest economic return associated solely to the P_2O_5 formulations and based on a canola price of $900.00/tonne shows applying MES15 at 25 kg/ha P_2O_5/ha provided the third highest overall yield (1395 kg/ha) at a cost of $65.90/ha for a return of $1,189.60/ha. *(Table 3. Economic Return Associated with* P_2O_5 *Formulation).* MAP/Crystal Green blend at 65 kg P_2O_5/ha had the highest yield of 1495.50 kg/ha and second highest economical return of $1175.95. 100% Crystal Green at 65 kg P_2O_5/ha provided the second highest yield of 1447.5 kg/ha, but due to the higher fertilizer cost its return per hectare was third lowest economically at $1059.00.

Table 3. Economic Return Associated with P_2O_5 *Formulation*

Product	P_2O_5 kg/ha	Yield kg/ha	** Canola Sales $/ha (based on $900/tonne)	* Fertilizer Cost/ha	Return $/ha
100% MES15	25	1395	1255.50	65.9	1189.60
50/50 MAP/Crystal Green	65	1495.5	1345.95	170	1175.95
Control	0	1297.25	1167.53	0	1167.53
100% Crystal Green	25	1357	1221.3	93.74	1127.56
100% MES15	45	1380.25	1242.23	118.63	1123.60
100% MAP	45	1322.25	1190.03	66.63	1123.40
100%MAP	65	1345	1210.50	96.25	1114.25
100% MES15	65	1382.75	1244.48	171.36	1073.12
100% MAP	25	1228.25	1105.43	37.01	1068.42
50/50 MAP/Crystal Green	45	1309.25	1178.33	117.69	1060.64
100% Crystal Green	65	1447.5	1302.75	243.75	1059.00
50/50 MAP/Crystal Green	25	1152.25	1037.03	65.38	971.65
100% Crystal Green	45	1238.25	1114.43	168.74	945.69

Fertilizer Cost: Crystal Green= $1050/tonne MAP= $770/tonne MES15= $870/tonne

*Spring 2021 fertilizer cost.

**September 2021 canola price.

Conclusions and Recommendations

All P_2O_5 formulations at the 25 kg/ha rate applied in the seed row resulted in no seedling injury or reduced establishment. Only the 100% Crystal Green treatment at all three fertility rates resulted in plant stands that were as good, or better than the Control (no phosphorous) and showed no signs of seedling damage. Applying MES15 at 45 kg and 65 kg P_2O_5/ha saw the highest plant reduction of 41.2% and 37% when compared to the Control. The high plant stand reduction is most likely related to the very dry soil conditions in May and early June in combination with the higher applied nitrogen in the MES15 formulation and may

[4] https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/crops-and-irrigation/soils-fertility-and-nutrients/guidelines-for-safe-rates-of-fertilizer-applied-with-the-seed

be caused by salt and/or ammonia stress delaying the spring emergence. Lower plant emergence resulting from 45 kg and 65 kg/ha P_2O_5 rates of MAP were also observed with reductions of 13.7% and 25.6% respectively, as compared to the Control.

The 50/50 MAP/Crystal Green Mix P_2O_5 rate of 65 kg/ha similarly reduced spring emergence, but not to the extent as MAP and MES15 as there was only a 12.2% reduction in emergence compared to the Control. The higher salt index in the MAP portion of this high fertility blend, in combination with the extremely dry soil conditions observed in 2021 is likely the cause of the reduced plant emergence. With a salt index of 27 for MAP and 7.7 for Crystal Green the overall salt index is theoretically reduced when combining the two products compared to MAP alone and should lessen toxicity to the seedlings.

Final plant densities were counted at harvest and mostly mirrored the spring emergence counts. Densities ranged from a high of 103.75 plants/m^2 for MAP at 25 kg P_2O_5/ha to a low of 51.25 plants/m^2 using MES15 at 45 kg P_2O_{55}/ha. Overall, variations from spring emergence counts to fall plant densities were negligible and were likely pre-determined by drought conditions observed through the growing season. Although plant densities can be negatively affected using higher fertility in the seed row, canola can be resilient and recover by the less dense population scavenging for the extra phosphorus, nitrogen, water, and other nutrients, promoting more branching, production of pods and increasing yields as seen with the lower populations from the 45 kg and 65 kg P_2O_5/ha fertility rates of MES15, MAP and the 65 kg P_2O_5/ha rate of MAP/Crystal Green blend.

Comparing yields, 50/50 MAP/Crystal Green rate of 65 kg P_2O_5/ha provided the highest yield of ***(1495.5 kg/ha)*** statistically similar to 100% Crystal Green 65 kg P_2O_5/ha yield ***(1447.5 kg/ha)***, both significantly higher yielding than the three MES15 rates of 25 kg P_2O_5/ha ***(1395 kg/ha),*** 45 kg P_2O_5/ha ***(1380.75 kg/ha)***, and 65 kg P_2O_5/ha ***(1382.75 kg/ha)***. Applying No phosphorous resulted in a yield of ***(1297.25 kg/ha)***.

Producers should also be aware that the maximum recommended rate of seed-placed P in Saskatchewan for canola is 28 kg P_2O_5/ha[5]. Data from our 25 kg P_2O_5/ha rates which are within the Saskatchewan guideline for canola seed placed phosphorus shows MES15 ***(1395 kg/ha)*** and 100% Crystal Green ***(1357 kg/ha)*** both yielding significantly higher than MAP ***(1228.25 kg/ha)***, and 50/50 MAP Crystal Green yield of ***(1152.25 kg/ha)***.

The objectives of the project were to demonstrate canola response to increasing rates of struvite (i.e. Crystal Green), alone or in a blend, relative to other common P fertilizer formulations when applied in the seed row with a focus on stand establishment and seed yield. All rates of 100% Crystal Green seed placed fertilizer row showed to be safe on the canola seedlings with good emergence and provided a good substitute to MAP or MES15 showing similar yields. However, the cost of the product negatively affected the return per acre when using over 25 kg P_2O_5 kg/ha of Crystal Green. With higher fertilizer costs associated with Crystal Green, blending it with MAP may be an option for producers to consider if still wanting to apply higher than the maximum recommended rate of seed-placed P_2O_5.

Technology Transfer Activities

Extension activities were limited in 2021 due to Covid 19 restrictions and many of these activities will be postponed until restrictions are lifted. This trial was promoted on a segment of a CKSW radio program titled, "Walk the Plots" that was broadcasted on a weekly basis throughout the summer, as well on Facebook, Twitter and the Swift Current Online Podcast. The trial was also featured on WCA's Annual field tour, presented by Sean Senko of the Canola Council. Preliminary results were also shared on January 13, 2022 by Kayla Slind (WARC) as a part of the Annual Agri-ARM Update. Results will continue to be shared locally with the Saskatchewan Ministry of Agriculture in Swift Current and a summary will be found on our website at www.wheatlandconservation.ca.

[5] https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/crops-and-irrigation/soils-fertility-and-nutrients/guidelines-for-safe-rates-of-fertilizer-applied-with-the-seed

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