2024 Project Report

for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

and

Saskatchewan Barley Development Commission (SaskBarley)

Plant Growth Regulator Products and Mixes to Improve Crop Safety and Efficacy in Barley

(ADOPT 20230545; SaskBarley 5130)

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Agriculture Demonstration of Practices and Technologies (ADOPT)

Project Final Report

The final project report should be made available electronically (MS Word). Additional data tables and or graphs may be submitted in spreadsheet format. Due to formatting, printing and distribution requirements, final reports will not be accepted as PDF documents. Completed reports must be returned by email to Evaluation.Coordinator@gov.sk.ca.

Project Title: Plant Growth Regulator Products and Mixes to Improve Crop Safety and Efficacy in Barley

Project Number: ADOPT 20230544; SaskBarley 5130

Producer Group Sponsoring the Project: Saskatchewan Barley Development Commission

Project Location(s): *Provide the name or number of the rural municipality, nearest town or legal land location if possible. Provide the name of any cooperating landowner(s).* Indian Head (RM #156), Outlook (RM #284), Prince Albert (RM #461), and Scott (RM #380)

Project start date *(month & year):* 4/1/2024

Project end date *(month & year):* 3/31/2025

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Abstract *(maximum 200 words)*

Detail key elements from the project objectives, methodology, results and conclusions to provide a short concise summary of the project. List extension activities such as field days or workshops and include the number of people who visited the project.

Field trials with malting barley were conducted at Indian Head, Outlook, Prince Albert, and Scott. The objective was to demonstrate varietal differences in response to plant growth regulator (PGR) products and mixes. The varieties were Synergy, Fraser, and Connect and, in addition to a control, the PGR options were full and half rates of Moddus® and Manipulator®, applied alone or in combination. Moddus® reduced plant height more consistently and to a greater extent than Manipulator®. The tank-mix also effectively reduced height, especially at the full rates. Both Moddus® and the mixes greatly reduced lodging, where applicable, while Manipulator® was ineffective. Yields were only consistently improved at Indian Head, where lodging occurred, by 10% on average with Moddus®. Without lodging, no PGR options increased yield and yields were reduced by the full rate mix. Moddus® was amongst the safest options for grain quality and the mixes frequently reduced test weight and plump kernels, especially at the full rates. Overall, we recommend only applying PGR when moisture is not limiting and there is risk of lodging. Moddus® remains the preferred product

and the potential benefits of mixing with Manipulator® appear to be insufficient to justify the elevated risk of undesirable effects.

Project Objectives

Provide a short statement outlining the project objectives. Identify the key concept this project was designed to demonstrate. For example, you might use a statement such as *"This project was intended to demonstrate and compare the benefits of……" or "The objective of this project was to demonstrate the impact of…."*

The overall project objective was to demonstrate the plant health, agronomic, yield and quality responses of three important malting varieties to the registered plant growth regulator (PGR) options Manipulator® (chlormequat-chloride) and Moddus® (trinexepac-ethyl), applied both alone and in combination. We aimed to explore how three of the major malting barley varieties differ in their response with respect to plant height, lodging, yield, and grain quality and whether applying the registered PGR options in combination can improve efficacy and crop tolerance across a range Saskatchewan conditions.

Project Rationale

Briefly describe why this project is of interest to local producers. Why is it important to have this project? What are the potential beneficial outcomes? What is the perceived need?

The availability and adoption of PGRs for use on barley is recent in Western Canada. Moddus®[1] (trinexepac ethyl) was first available in 2021, and Manipulator®[2] in 2020. Manipulator® (chlormequat chloride) is flagged by the 'Keep it Clean' initiative due to some buyers restricting the use of the product on grain they purchase; however, both products are registered and widely available. Prior to 2020, only Ethrel (ethephon) was available, but it is no longer registered for use on barley in Canada[3].

Manipulator has limited efficacy on barley[4], compared to its efficacy in wheat, durum and oats. Moddus® appears to be the more effective product in barley[4]; however, the relative efficacy and benefits still vary with variety[3,4,5]. To date, there has been limited research into lodging management with PGRs on barley in Western Canada. Recently, the Strategic Field Program and SaskBarley funded "Barley MAX" showed a significant reduction in lodging at sites with high yield potential, despite generally dry conditions throughout the study period[6].

Internationally, barley growers have similar agronomic challenges as Canadian growers with respect to lodging. In the high rainfall, high fertility production areas of Europe, PGRs are a common practice for managing straw and lodging. We have recently learned that growers have adopted mixing Manipulator and Moddus® with the goal of increased efficacy while increasing crop safety. Manipulator works earlier in the gibberellin biosynthesis pathway compared with Moddus®, so some synergies can be achieved3. Anecdotal reports suggest that Moddus® causes yellowing in barley, increasing stress to the plant. Some Canadian seed growers may be adopting this practice.

Other researchers in Canada have explored this practice in wheat. Strydhorst found that a tank mix increased the frequency of a height reduction compared to using either product alone. Along with increased frequency of height reductions, Strydhorst found larger height reductions with the tank mix. Consistent with a known varietal effect in the use of PGRs, the tank mix worked better for some varieties, while a single product was better for other varieties[3].

The tank-mix is not specifically a registered option for Canadian growers currently; however, both Moddus® and Manipulator® allow for split applications at half rates for each split. Additionally, there are no anticipated risks to adjusting rates or combinations of PGRs, compared to what may occur in pesticides. The project is demonstrating a practice that is used elsewhere to explore the potential benefits for barley growers in western Canada.

Literature Cited:

1. Moddus product label
2. Manipulator 620 product label

3. **S. Stryhorst**. 2020. Investigating PGRs: Multiple modes, multiple rates and multiple species. Which combination is a winner? Top Crop Manager. Online [Available]: https://www.topcropmanager.com/investigating-pgrs/ (February 11, 2025).
4. **B.D. Tidemann, J.T. O'Donovan, M. Izydorczyk, T.K. Turkington, L. Oatway, B. Beres, R. Mohr, W.E. May, K.N. Harker, E.N. Johnson, and H. de Gooijer. 2020.** Effects of plant growth regulator applications on malting barley in western Canada. Can. J. Plant Sci. **100**:653-665.
5. **Strydhorst, S., Hall, L.M., Thompson, L. 2019.** Plant Growth Regulators for Cereal Crops. Final Report to the Alberta Funding Consortium for project RES0041117 – AF819487.
6. **M. Japp, S. Chant, M. Hall, H. Sorestad, R. Lokken, B. McInnes, J. Enns, K. Slind, B. Nybo, and A. Wall. 2023.** Barley MAX. Online [Available]: https://agriculturereports.saskatchewan.ca/ADF/ADF_Admin/Reports/20190403.pdf (February 11, 2025).

Methodology

Fully describe how the project was set up and run. You should provide enough information so that any reader can understand what you did, and where and when you did it. From that they can determine if your report has any relevance to their own operation. For example, your description should include all relevant items such as 1) the number and size of any field plots, 2) what was seeded, 3) what treatments were applied to the plots, 4) the schedule or timing of any relevant activities such as seeding, treatment application or harvest, and 5) what was measured to evaluate the success of any treatment. If your project dealt with animals, you should be sure to include 1) the number of animals in each trial group, 2) the treatment or procedure applied to each group, and 3) what was measured to evaluate the success of each treatment.

In the spring of 2024, field trials with malting barley were established at four Saskatchewan locations with differing environments; Indian Head (thin-Black soil zone, long-season), Prince Albert (moist Black soil zone, short-season), Scott (Dark Brown soil zone), and Outlook (Brown soil zone). The Outlook location was irrigated while the other three were dryland. The treatments were a factorial combination of three malting varieties and seven plant growth regulator (PGR) treatments, for a total of 21 treatments. The varieties were AAC Synergy, CDC Fraser, and AAC Connect. The PGR treatments were rates and combinations of Manipulator® 620 (620 g chlormequat chloride/L) and Moddus® (120 g Trinexapac-ethyl/L), applied at Zadoks GS 30-32 (stem elongation up to two nodes detectible in stem). The minimum solution volume was 94 l/ha; however, higher volumes were permitted. Greater details on the PGR treatments are in Table 1. The varieties were selected primarily for their current or increasing popularity amongst growers and maltsters and are rated fair (F) to good (G) for lodging. There are no currently accepted malt varieties rated worse than F for lodging resistance. The treatments were arranged in a four replicate Randomized Complete Block Design (RCBD).

Table 1. Plant Growth Regulator (PGR) treatments for a 2024 SaskBarley-ADOPT project. Each PGR treatment was evaluated for three varieties (AAC Synergy, CDC Fraser, and AAC Connect), for a total of 21 treatments.

#	Name	Litres product/ha	Treatment Details
1	1x Moddus®	1030 ml Moddus/ha	124 g trinexapac-ethyl/ha
2	1x Manipulator®	2301 ml Manipulator/ha	1426 g chlormequat chloride/ha
3	0.5x Moddus®	514 ml Moddus/ha	62 g trinexapac-ethyl/ha
4	0.5x Manipulator®	1149 ml Manipulator/ha	713 g chlormequat chloride/ac
5	0.5x Moddus® + 0.5x Manipulator®	514 ml Moddus/ha + 1149 ml Manipulator/ha	62 g trinexapac-ethyl/ha + 713 g chlormequat/ha
6	1x Moddus® + 1x Manipulator®	1030 ml Moddus/ha + 2301 ml Manipulator/ha	124 g Trinexapac-ethyl/ha + 1426 g chlormequat/ha
7	UTC	Not applicable	No PGR applied

[Z] All PGR applications completed between Zadocks GS 30-32 (GS 32 is optimal and application will not be later than GS 39) in a minimum solution volume of 94 L/ha

Plot size varied by location, depending on the seeding and spraying equipment. For all locations, the barley was direct seeded into canola stubble and all factors other than lodging were intended to be as non-limiting as possible. Variety varied as per protocol and the target seeding rate was 300 viable seeds/m^2, adjusted for seed size and percent germination. All sites used a high nitrogen (N) of 185 kg N/ha (including residual soil NO_3-N) to promote lodging. This N rate was sometimes based on fall, whole site samples; however, the specific trial areas were re-sampled in the spring. Weeds, disease, and insects were controlled using registered pesticide options, at the discretion of individual site managers. No pre-harvest herbicides or desiccants were utilized, and the centre rows of each plot were harvested when it was fit to do so.

Various data were collected through the growing season and from the harvested grain samples. Emergence for each variety was estimated by counting the number of seedings in 2 x 1 m sections of crop row for the untreated control plots of each variety. The values were averaged and converted to plants/m^2. Targeting 7 days after PGR applications, phytotoxicity/leaf burn was rated for each plot on a scale of 0-5 where 0 is no injury and 5 denotes severe leaf burn or other injury. After the stems were finished elongating (i.e. late milk/early dough stages), the total height for a minimum of eight plants per plot (four front, four back) was recorded and averaged. Between physiological maturity and harvest, each plot was rated for lodging on a scale of 1-9 where 1 is no lodging and 9 indicates that the plots were severely lodged and essentially flat. Grain yields were determined from the harvested grain samples and are adjusted for dockage and to a uniform moisture content of 13.5%. Test weights are expressed in g/0.5 l and were determined using standard CGC methods, a cleaned grain subsample, and two measurements per plot. Seed weight was determined by counting a minimum of 500 whole seeds using automated seed counters, weighing the counted seeds to the nearest 0.00 g, and calculating g/1000 seeds. Percent plump kernels were determined by hand sieving a 200 g sub-sample of cleaned seed and weighing the quantity of seed that stayed on top of a No. 6 (2m38 mm 19.05 mm) slotted sieve. Percent grain protein was the average of two runs through an NIR instruments; however, the specific machine differed with location. Weather data was from the nearest ECCC weather station and mean monthly temperatures and precipitation totals are expressed relative the long-term (1981-2010) average.

All pertinent agronomic details along with dates of field operations and data collection activities are provided in Table 5 of the Appendices.

Response data were analyzed using the generalized linear mixed model (GLIMIX) procedure of SAS Studio with, unless otherwise indicated, the effects of variety (VAR), PGR, and the VAR × PGR interaction considered fixed and replicate effects considered random. The sole exception to this was for emergence, where only variety was included as a fixed effect. All means were separated using Fisher's protected LSD test. All treatment effects and differences between means were considered significant at $P \leq 0.05$; however, meaningful trends or p-values ≤ 0.10 may also be acknowledged. The data were not combined across locations for analyses due the relatively small number of sites, known differences amongst them, subjective nature of some measurements, and inconsistencies in the specific data collection and equipment used.

Results *(you must provide the following information)*

Present and discuss any project results, including any data or measurements taken to evaluate the demonstration. Include things that didn't appear to work. These results are just as important to share. List extension activities such as field days or workshops. List the activity, the date it occurred, and the number of people who attended.

Soil characteristics for each location are provided in Table 2. The soils at each location were considered representative of the growing regions with which they corresponded. The soil at Indian Head was fine/clay textured with moderate organic matter, Outlook had lower organic matter and coarser textured but was irrigated, Prince Albert had high organic matter and a loamy texture, and Scott had a coarser texture and moderate organic matter.

Mean monthly temperatures and precipitation totals for the four-month (May through August) growing season are presented in Tables 3 and 4, respectively. For all locations, temperatures were slightly below average in May and particularly cool in June, followed by a remarkably hot July and slightly above average temperatures in August. The precipitation patterns were such that cumulative rainfall in May and June were above average at all locations but well below average in July. August participation varied with conditions being below average to about average at all locations except Indian Head where frequent August storms resulted in above average rainfall totals. Over the four-month period, all locations had close to average temperatures and precipitation totals except Scott, which reported a cumulative amount of 113% of average growing season rainfall. The Outlook site received an additional 146 mm as irrigation in June through August, making this the wettest location when all precipitation sources were accounted for. Overall, it was a season of extremes characterized by both cool periods with excess moisture and saturated soils followed by periods of prolonged heat and drought.

Table 2. Selected soil test analyses results for ADOPT (20230544) barley PGR mixing demonstration conducted at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Unless otherwise indicated, all measurements are representative of the 0-15 cm soil profile.

Parameter	IH-24	OL-24	PA-24	SC-24
pH	7.4	7.8	5.8	6.5
Organic Matter (%)	4.9	3.1	7.1	4.0
CEC (meq)	45.4	21.7	28.5	14.1
NO_3-N (kg/ha) [Z]	28.0	33.6	89.0	37.0
Olsen-P (ppm)	11	6	10	12
K (ppm)	621	450	267	294
kg S/ha (kg/ha) [Z]	76.2	269+	79.0	78.4

[Z] Values for residual NO_3-N and S are for the 0-60 cm soil profile

Table 3. Mean monthly temperatures along with long-term (LT; 1981-2010) averages for the 2024 growing season at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC), Saskatchewan.

Year	May	June	July	August	May-Aug
	Mean Temperature (°C)				
IH-24	10.6	13.6	19.5	17.9	15.4 (+0.2)
IH-LT	10.8	15.8	18.2	17.4	15.6
OL-24	11.0	14.2	20.4	18.3	16.0 (-0.1)
OL-LT	11.5	16.1	18.9	18.0	16.1
PA-24	10.1	12.9	20.0	17.0	15.0 (-0.1)
PA-LT	10.4	15.3	18.0	16.7	15.1
SC-24	9.8	13.3	18.9	17.4	14.9 (+0.1)
SC-LT	10.8	14.8	17.3	16.3	14.8

Table 4. Total monthly precipitation amounts along with long-term (LT; 1981-2010) averages for the 2024 growing season at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC), Saskatchewan.

Year	May	June	July	August	May-Aug
	Total Precipitation (mm)				
IH-24	63.7	74.9	37.4	71.2	248 (102%)
IH-LT	51.7	77.4	63.8	51.2	244
OL-24	62.6	122.0 (38)	19.1 (76)	3.8 (32)	208 (101%)
OL-LT	42.6	63.9	56.1	42.8	205
PA-24	66.9	123.1	27.0	37.6	255 (101%)
PA-LT	44.7	68.6	76.6	61.6	252
SC-24	74.2	112.0	26.7	42.8	256 (113%)
SC-LT	38.9	69.7	69.4	48.7	227

To facilitate easy comparisons of treatment effects and interactions for across locations for each variable, overall F-test results are presented for each variable and location in Table 6 of the Appendices; however, these results are also provided in subsequent tables with the specific treatment means they correspond to. The discussion will generally focus more on PGR effects and their interactions with varieties than the main effects of variety on their own.

Overall establishment was excellent at Indian Head with an overall site average 307 plants/m^2, fair at Outlook and Scott (223-229 plants/m^2), and poorer at Prince Albert (173 plants/m^2). Despite being adjusted for seed size and germination, plant populations were affected by variety at Indian Head (P = 0.005), being lower on average for AAC Connect (273 plants/m^2) than AAC Synergy and CDC Fraser (316-331 plants/m^2). Plant populations were consistent across varieties for the remaining three locations (P = 0.497-0.761). The potential for lodging can sometimes be greater at higher plant densities; however, this is not always so with variety and environment generally being more important.

Phytotoxicity was low in all cases, with no injury whatsoever reported at Outlook or Prince Albert, essentially no injury and no treatment effects at Scott, and very minor leaf burn at Indian Head. Detailed results are not presented; however, at Indian Head, we saw the greatest amount of injury when the full rate of both products was applied in a tank-mix (1x_MIX; 0.6/5). The full rates of Moddus® (1x_TE) and Manipulator® (1x_CC) applied alone along with the half rate tank-mix (½x_MIX) received overall average ratings of 0.2-0.3/5. Essentially no phytotoxicity was observed with the half rate applications of either product alone (½x_TE and ½x_CC) or, as expected, the untreated control (UTC).

Plant height was affected by variety at Indian Head, Scott, and Outlook (P < 0.001-0.027), but not Prince Albert (P = 0.199) and, for the responsive sites, the trends were consistent with AAC Synergy being the tallest, CDC Fraser being the shortest, and AAC Connect being more intermediate (Table 8). The overall F-tests for PGR were significant at all locations and the responses were quite consistent (Fig 1; Table 9). The 1x_TE treatment always resulted in shorter plants than UTC and 1x_CC. Manipulator® effects on height were less consistent, with 1x_CC reducing height relative to UTC at Indian Head and Scott, but no other locations. Relative to UTC, ½x_TE reduced height at Indian Head, Outlook, and Scott, but not Prince Albert, while ½x_CC never significantly reduced height. The 1x_MIX treatment produced shorter plants than all other treatments everywhere except Prince Albert, where it performed similarly to the full rate of Moddus®. The ½x_MIX performed slightly better than 1x_TE at Indian Head, slightly worse than 1x_TE at Outlook, and like ½x_TE at Prince Albert and Scott. The sole significant VAR × PGR interaction (P = 0.005) for plant height occurred at Outlook (Fig. 2; Table 10). This interaction appeared to be primarily due to AAC Connect, where only the 1x_MIX treatment significantly reduced height, being generally less responsive to PGR than AAC Synergy or CDC Fraser.

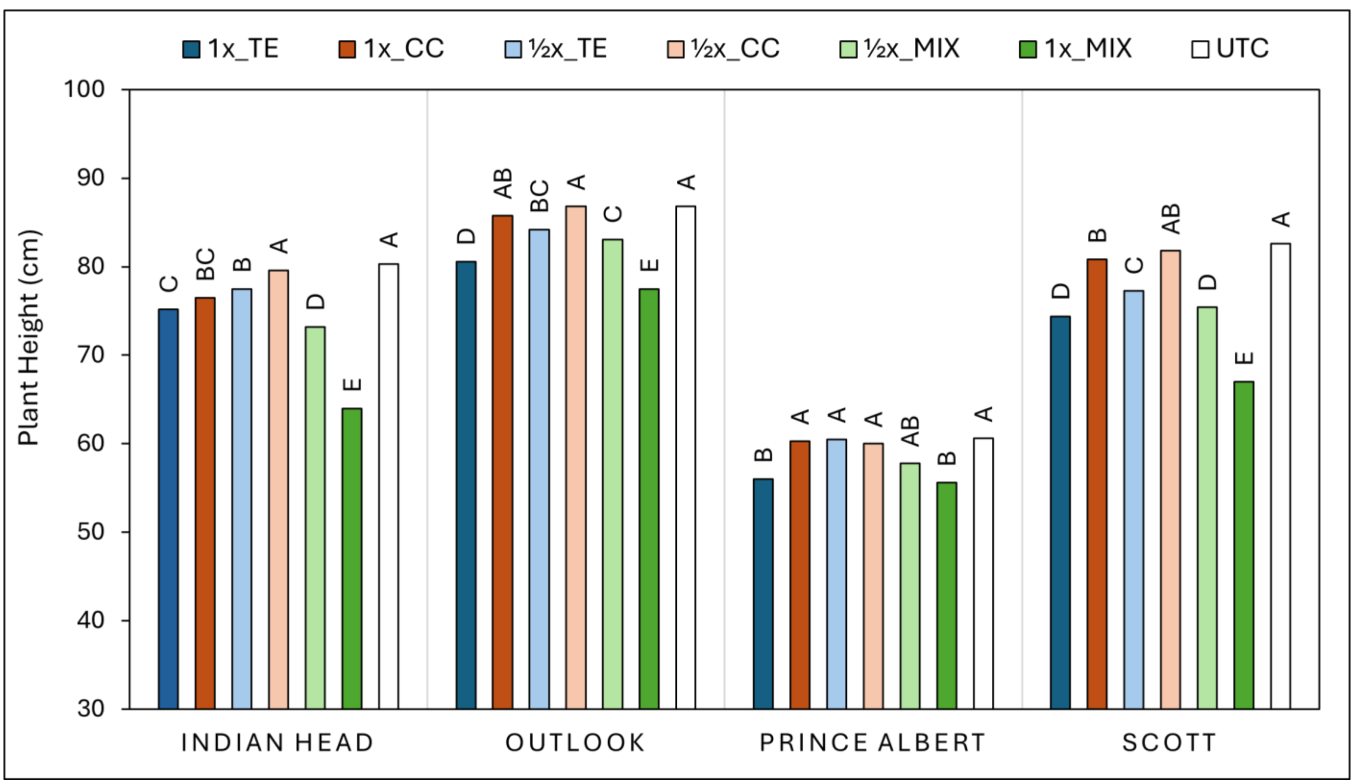

Figure 1. Plant Growth Regulator (PGR) effects on barley height at Indian Head, Outlook, Prince Albert, and Scott in 2024. Means within a location labelled with the same letter do not significantly differ (Fisher's Protected LSD test; $P \leq 0.05$).

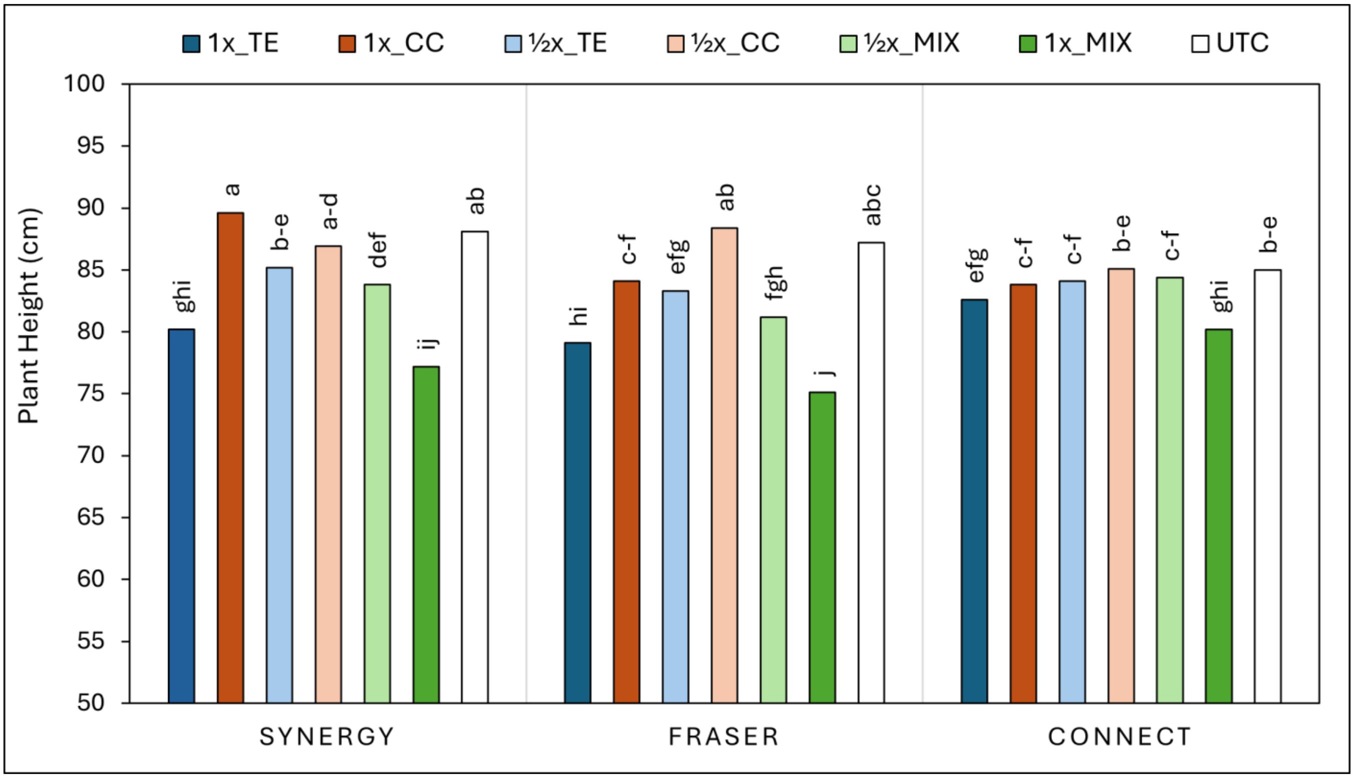

Figure 2. Individual variety by plant growth regulator (PGR) on barley height at Outlook, SK, in 2024. Means labelled with the same letter do not significantly differ (Fisher's Protected LSD test; *P* ≤ 0.05).

Lodging measurements were not completed at Outlook and no lodging whatsoever was observed at Prince Albert; however, lodging was severe for some treatments and minor, but with significant treatment effects, at Scott. At Indian Head, lodging was much more severe for AAC Synergy (4.3/9) than CDC Fraser or AAC Connect (1.9-2.0/9) while, at Scott, lodging was slightly but significantly worse for AAC Synergy and AAC Connect (1.4-1.5/9) than CDC Fraser (1.2/9; Table 11). The overall PGR effects on lodging for both locations are presented in Fig. 3 and Table 12. At Indian Head, all PGR treatments except ½x_CC reduced lodging relative to the control. Moddus® (TE) consistently outperformed Manipulator® (CC) for reducing lodging, and the tank mix (MIX) trended slightly better than TE alone; however, the advantage was never significant. With overall means of 1.1-1.6/9 compared to 4.4/9 in the control, the 1x_TE and 1X_MIX treatments were extremely effective for reducing lodging. In contrast, the CC treatments performed relatively poorly for reducing lodging, despite the observed reductions in height. The interaction at Indian Head (Fig. 4; Table 13) was mostly due higher lodging severity with AAC Synergy resulting in substantially more separation between PGR treatments relative to CDC Fraser and AAC Connect; however, the overall trends were mostly similar. For CDC Fraser, we unexpectedly saw worse lodging with ½x_CC than in the UTC; however, this result was largely due to chance as, in addition to the treatment differences, random spatial variability was also high for lodging. While the ½x_CC treatment clearly did not improve lodging even slightly, it is unlikely that it made it worse. At Scott, lodging was minor overall; however, we did see significant reductions relative to UTC with both Moddus® alone (TE) and the tank-mix (MIX), regardless of rate. Manipulator® (CC) did not reduce lodging, regardless of rate, and there was no advantage to the tank-mix over Moddus® alone.

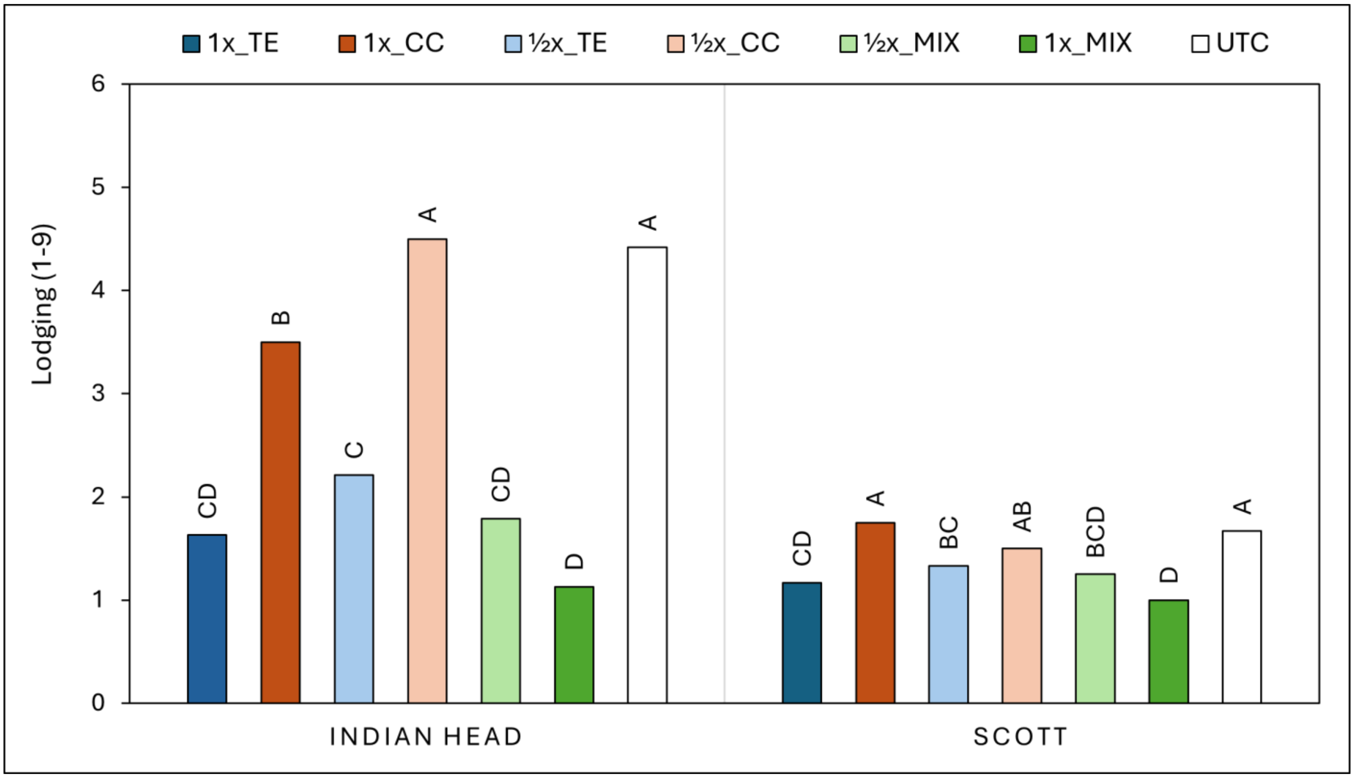

Figure 3. Plant Growth Regulator (PGR) effects on barley height at Indian Head and Scott in 2024. No lodging was observed at Prince Albert and rating were not completed at Outlook. Means within a location labelled with the same letter do not significantly differ (Fisher's Protected LSD test; *P* ≤ 0.05).

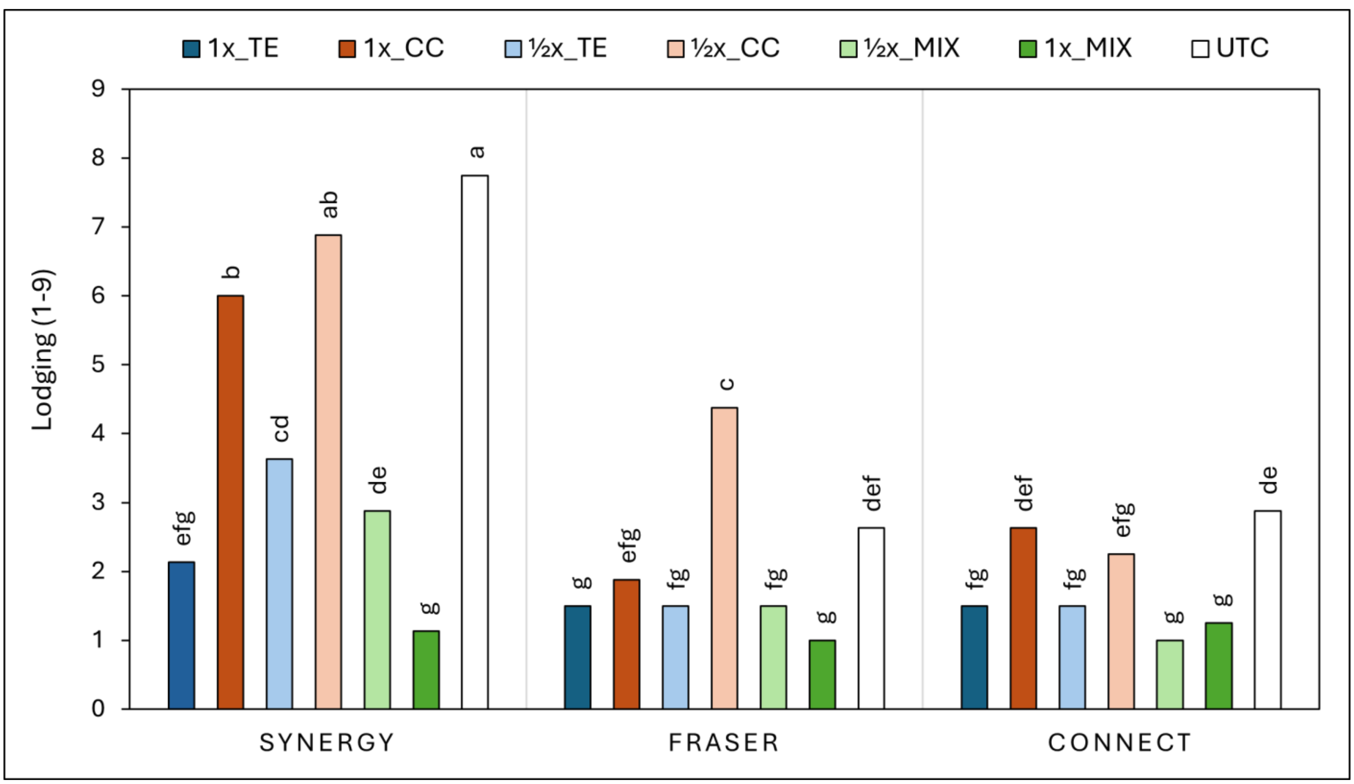

Figure 4. Individual variety by plant growth regulator (PGR) on barley lodging at Indian Head, SK, in 2024. Means labelled with the same letter do not significantly differ (Fisher's Protected LSD test; *P* ≤ 0.05).

Grain yields were affected by variety at all locations (P < 0.001-0.026); however, the relative performance varied to a certain extent. AAC Synergy always yielded amongst the highest while CDC Fraser yielded lower than AAC Synergy at three of four locations (all except Outlook) and AAC Connect yielded lower than AAC Synergy at Outlook, like AAC Synergy at Indian Head and Prince Albert, and intermediate between AAC Synergy and CDC Fraser at Scott (Table 14). Significant PGR effects were detected at all locations except Outlook (P <0.001-0.037) where the VAR × PGR was significant (P = 0.050), but the main effect of PGR was not (P = 0.318). There was no VAR × PGR interaction for grain yield detected at Indian Head, Prince Albert, or Scott (P = 0.413-0.752); thus, indicating that the observed PGR effects were consistent across varieties. At Indian Head, both the 1x_TE and ½x_TE treatments yielded higher than UTC while yields with ½x_MIX were more intermediate were intermediate and those with CC (regardless of rate) and the 1X_MIX treatments were like the control (Fig. 5; Table 15). While high yield variability made it that relatively large treatment differences were required to be significant, the 1x_TE stood out as noticeably above the rest at Indian Head, presumably due to the combination of high efficacy and crop safety of this product under the conditions encountered. At Prince Albert and Scott, where lodging was negligible, the only treatment that significantly differed from UTC was the 1x_MIX, and the response was negative. The observed yield reduction in the 1x_MIX treatment relative to the control was 306-504 kg/ha, or approximately 6-10%. At Outlook, yields were high, but variable, and certain aspects of the PGR responses were difficult to explain (Fig. 6; Table 16). Overall, the interaction was due to there being relatively little yield response to PGR with AAC Synergy, lower yields with Manipulator® (regardless of rate) for CDC Fraser, and equally strong and significant positive responses to all PGR treatments for AAC Connect. For AAC Connect at Outlook, the magnitude of the yield benefit to PGR over the control was 869 kg/ha, or 15%, when averaged across PGR treatments.

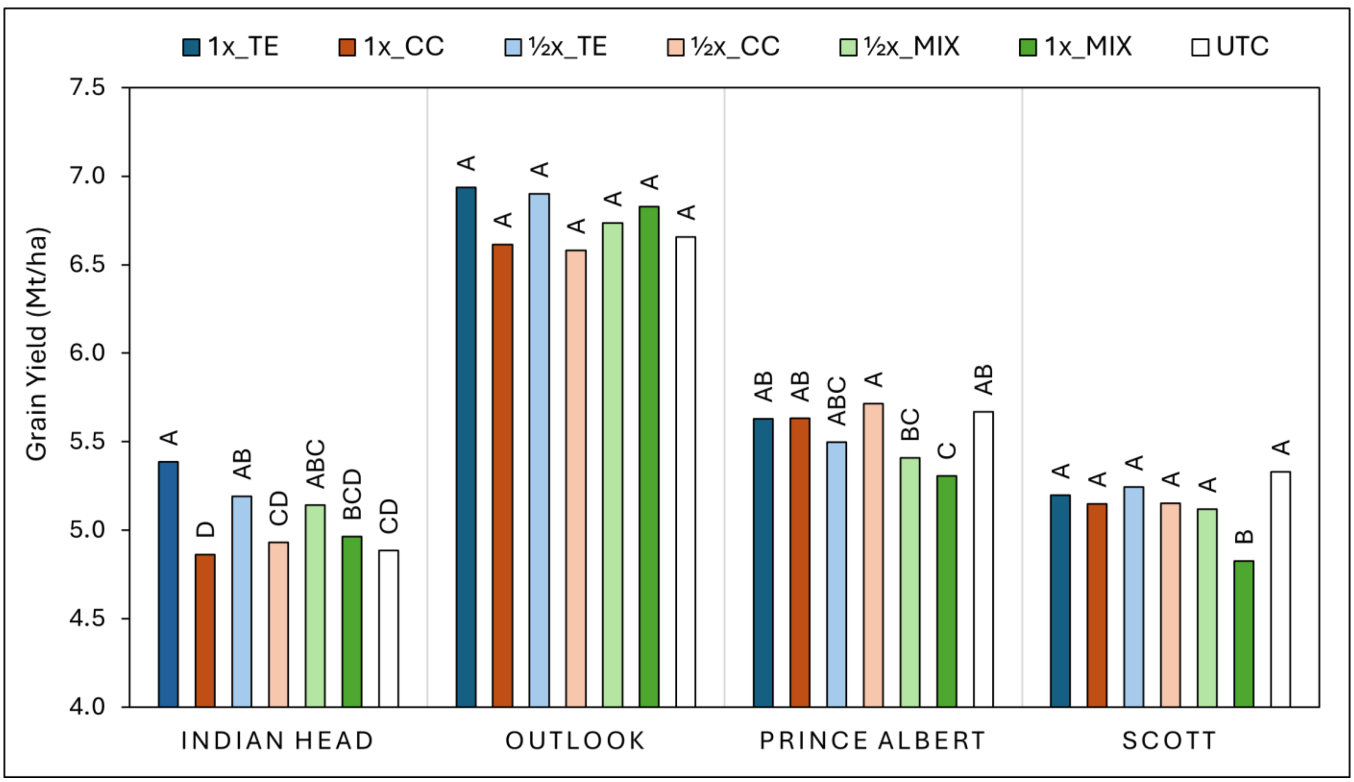

Figure 5. Plant Growth Regulator (PGR) effects on barley grain yield at Indian Head, Outlook, Prince Albert, and Scott in 2024. Means within a location labelled with the same letter do not significantly differ (Fisher's Protected LSD test; $P \leq 0.05$).

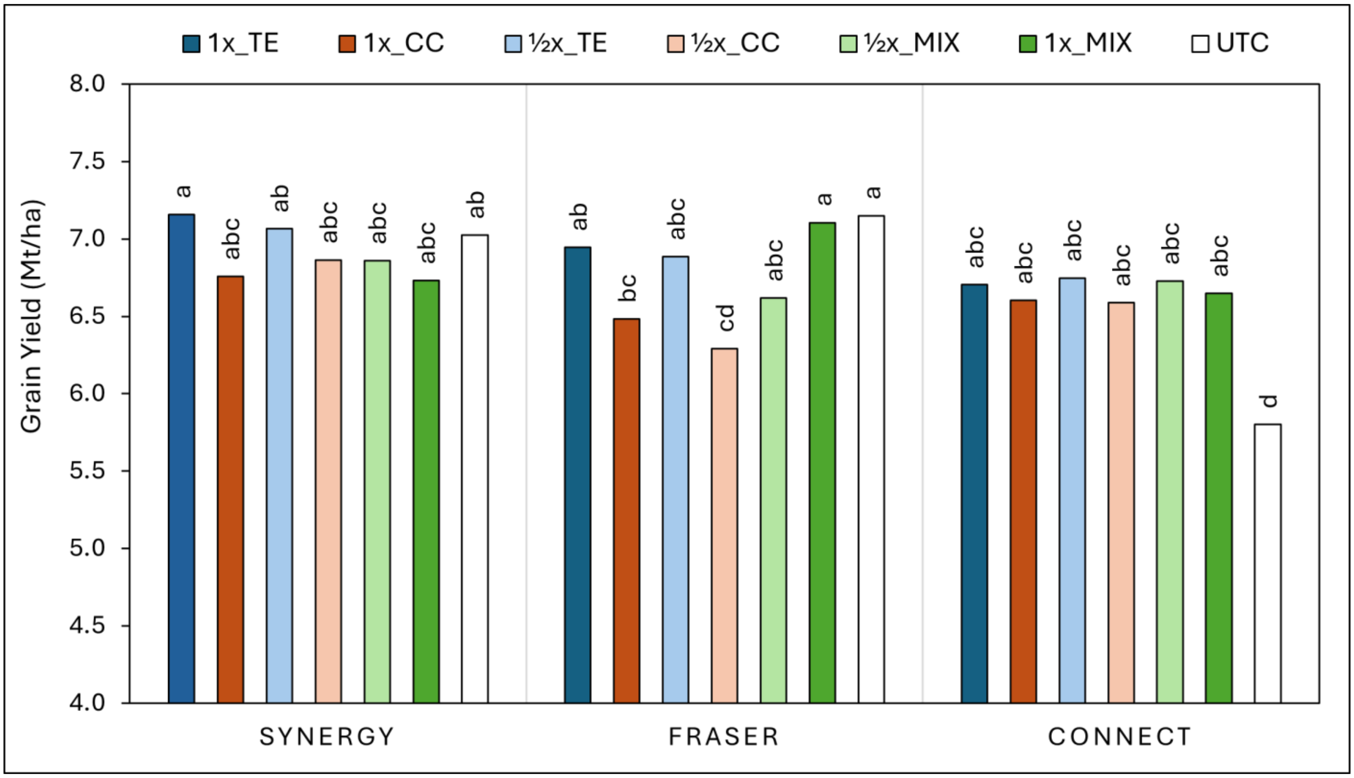

Figure 6. Individual variety by plant growth regulator (PGR) on barley grain yield at Outlook, SK, in 2024. Means labelled with the same letter do not significantly differ (Fisher's Protected LSD test; *P* ≤ 0.05).

Variety effects on test weight were significant at Indian Head and Outlook ($P < 0.001$), marginally significant at Prince Albert ($P = 0.063$), and not significant at Scott ($P = 0.411$). Where significant, the variety effects were inconsistent (Table 17). AAC Connect had the highest test weight at Indian Head (284 g/0.5 l), followed by AAC Synergy (279 g/0.5 l), and then CDC Fraser (269 g/0.5 l). At Outlook, AAC Synergy (325 g/0.5 l) had higher test weight than both other varieties (319 g/0.5 l) and, at Prince Albert, AAC Synergy (310 g/0.5 l) had higher test weight than CDC Fraser (303 g/0.5 l) and the values were intermediate for Connect (308 g/0.5 l). The PGR treatment effects on test weight were only significant at Indian Head and Outlook (P < 0.001-0.046) and the VAR × PGR interaction was also significant at Indian Head ($P = 0.003$). Averaged across varieties at Indian Head, only 1x_TE resulted in significantly higher than the control (Fig. 7; Table 18). The interaction at Indian Head showed the previously mentioned positive response to 1x_TE being strongest with AAC Synergy and CDC Fraser along with a tendency for lower test weights with 1x_CC in these varieties (Fig. 8; Table 19). In contrast, AAC Connect test weights were unaffected by both Moddus® and Manipulator® applied alone, regardless of rate, but a significant negative response occurred when both products were applied in a tank-mix.

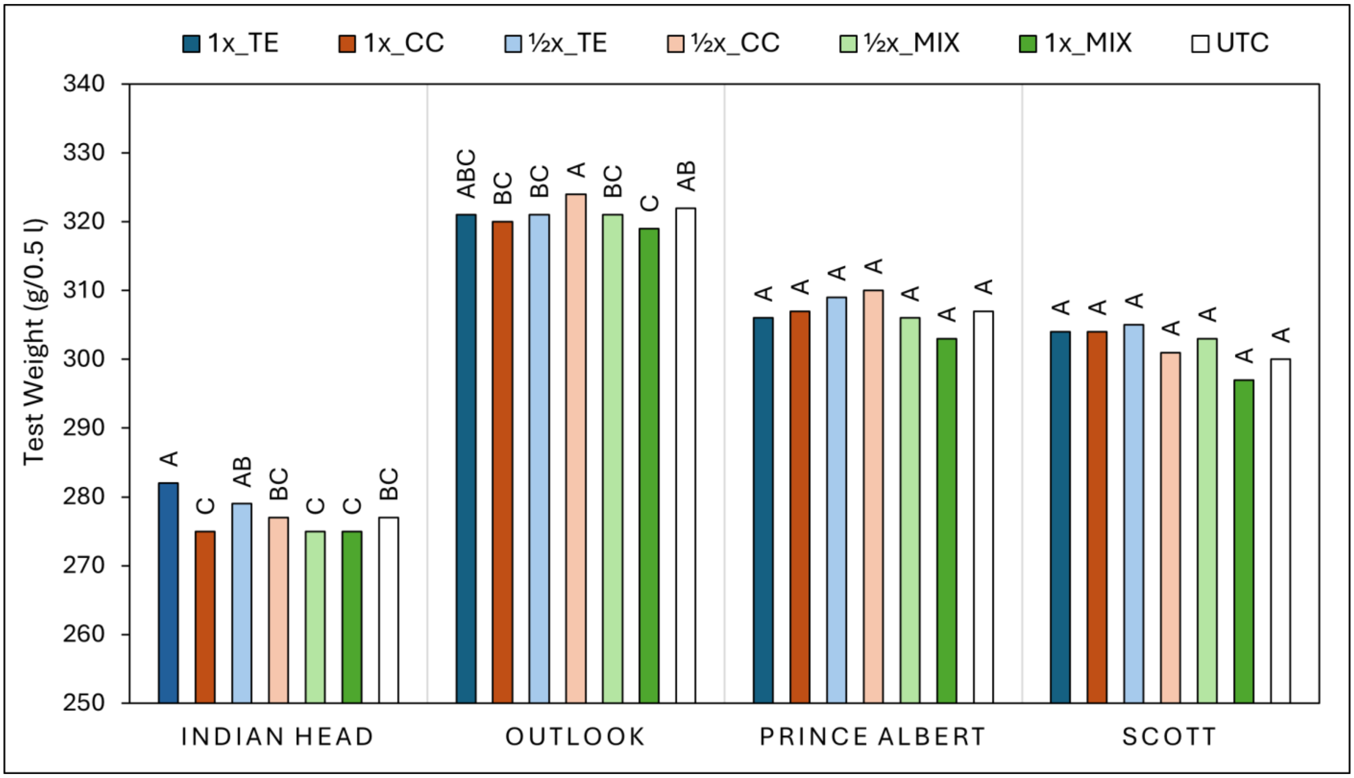

Figure 7. Plant Growth Regulator (PGR) effects on barley test weight at Indian Head, Outlook, and Scott in 2024. Means within a location labelled with the same letter do not significantly differ (Fisher's Protected LSD test; *P* ≤ 0.05).

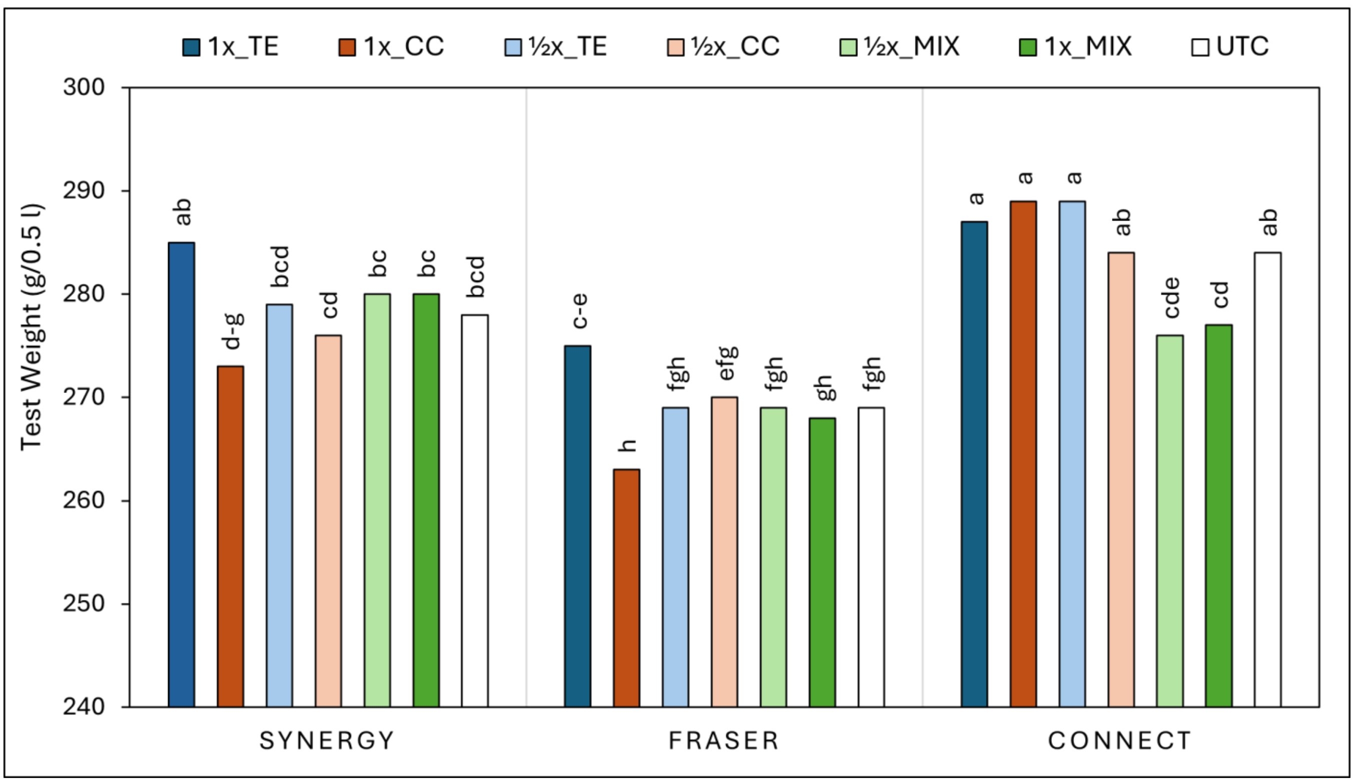

Figure 8. Individual variety by plant growth regulator (PGR) on barley test weight at Indian Head, SK, in 2024. Means labelled with the same letter do not significantly differ (Fisher's Protected LSD test; *P* ≤ 0.05).

Seed weight, or thousand kernel weight (TKW), varied with variety at Indian Head and Scott ($P < 0.001$), but not Outlook or Prince Albert ($P = 0.421$-0.811). For both response locations, the responses were similar with AAC Connect having the largest TKW at both locations and CDC Fraser having the lowest (Table 20). The only location where PGR had a significant impact on TKW was Indian Head (Fig. 9; Table 21), and VAR × PGR interactions were not significant at any locations (Table 22). At Indian Head, the highest TKW was with 1x_TE (38.2 g/1000 seeds) while the lowest was with ½x_MIX (34.9 g/1000 seeds); however, only the ½x_MIX treatment significantly differed from the control (36.8 g/1000 seeds). While not significant due to high variability, the trends at Scott were like Indian Head while, at Prince Albert, there was a tendency for higher TKW with 1x_TE, relative to all other treatments.

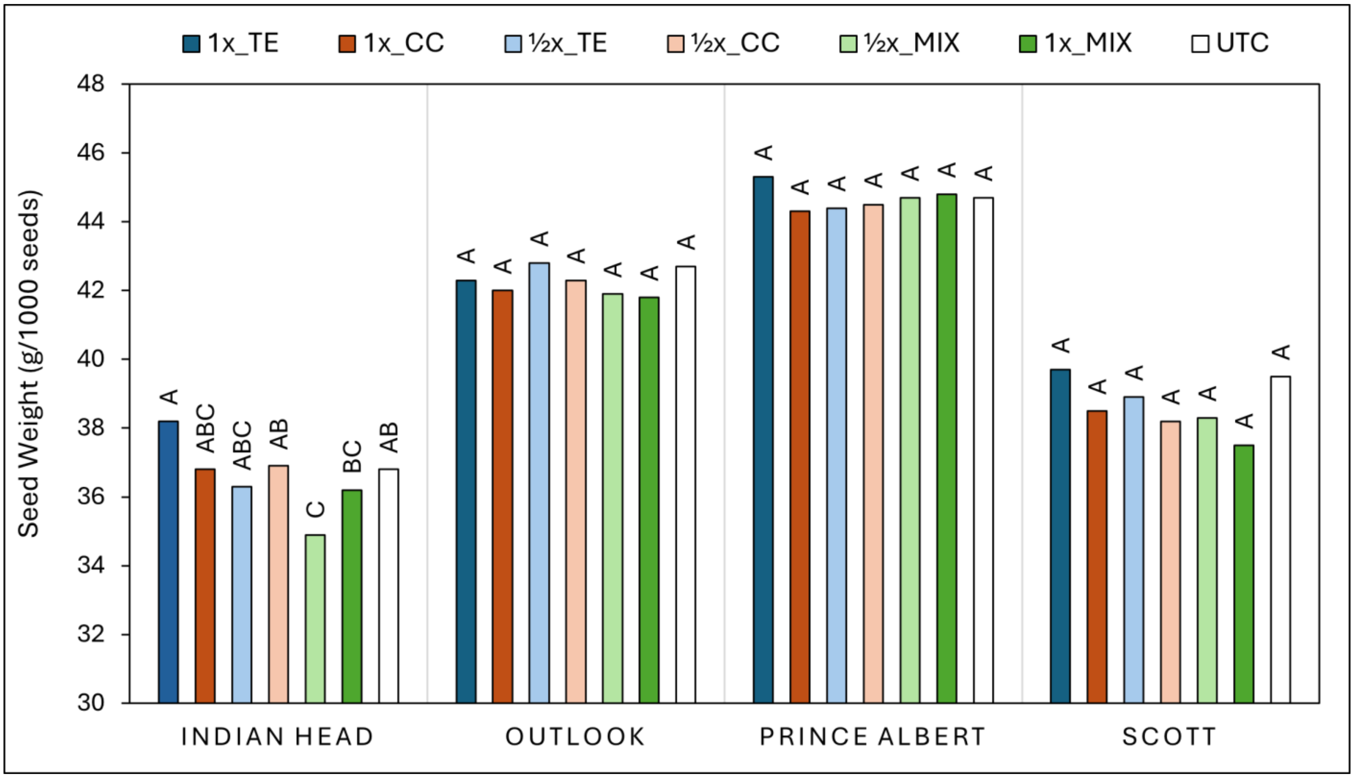

Figure 9. Plant Growth Regulator (PGR) effects on barley seed weight (TKW) at Indian Head, Outlook, and Scott in 2024. Means within a location labelled with the same letter do not significantly differ (Fisher's Protected LSD test; $P \leq 0.05$).

The proportion of plump kernels was affected by variety at Prince Albert ($P < 0.001$), but not Indian Head or Scott ($P = 0.144$-0.241). This measurement was not completed at Outlook (Table 23). The variety effect at Prince Albert showed the highest values with CDC Fraser (87.8%), intermediate values with AAC Synergy (84.5%), and the lowest values with AAC Connect (80.2%). The PGR treatments affected plump kernels at all locations where the measurement was completed ($P < 0.001$) and the VAR × PGR interaction was also significant at Indian Head ($P = 0.050$). Overall, these data were variable at Indian Head and the main PGR effects were difficult to explain (Fig. 10; Table 24). However, the interaction (Fig. 11; Table 25) showed consistently high values for 1x_TE and UTC along with fewer or smaller negative responses with AAC Connect relative to AAC Synergy or CDC Fraser. The 1x_CC treatment reduced kernel plumpness with CDC Fraser only, and the 1x_MIX treatment reduced plumpness in both AAC Synergy and CDC Fraser, but not AAC Connect. At Prince Albert, the effects were relatively small, but we saw reduced plump kernels relative to the control with 1x_TE, ½x_MIX, and 1x_MIX. The response was similar at Scott, with 1x_TE, ½x_MIX, and 1x_MIX being the only treatments with significantly fewer plump kernels than the control; however, in this case, was sawed a notably worse reduction with the 1x_MIX.

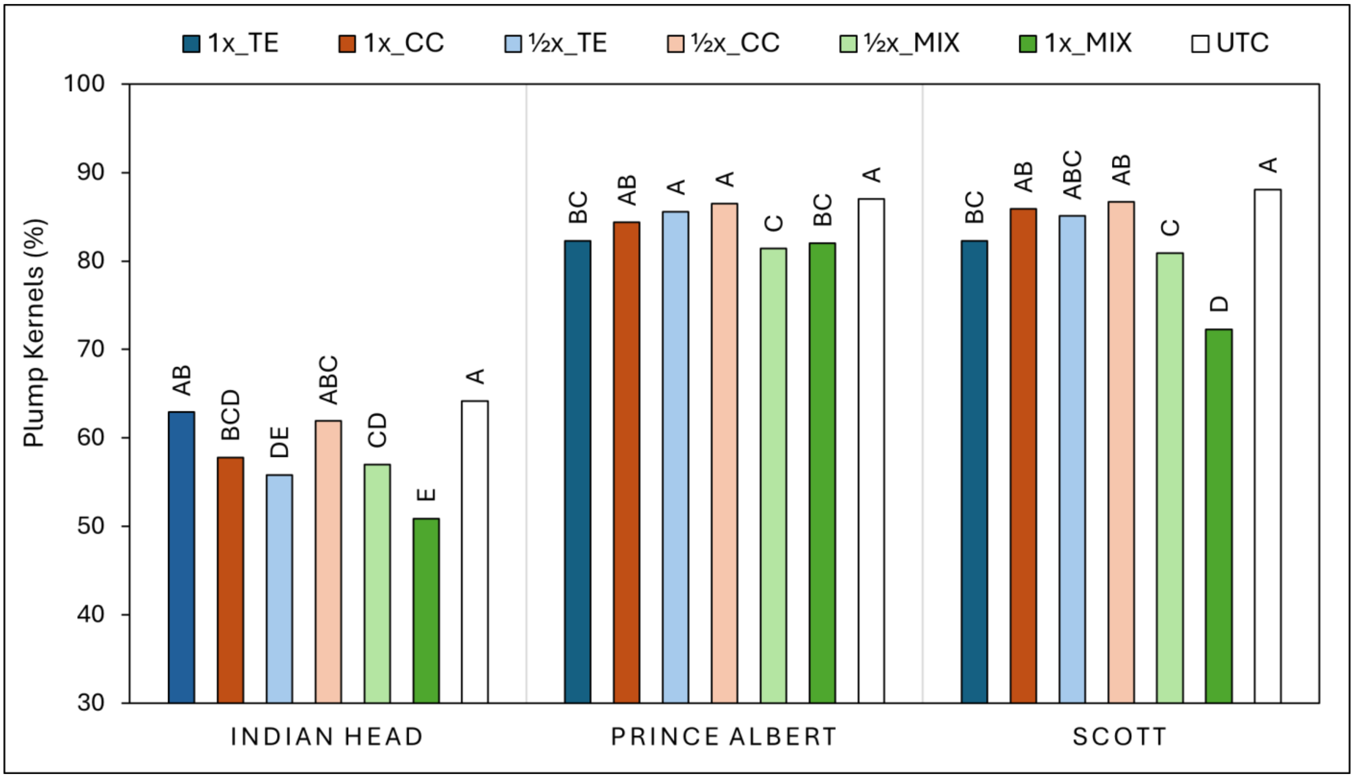

Figure 10. Plant Growth Regulator (PGR) effects on percent plump kernels in barley at Indian Head, Prince Albert, and Scott in 2024. Means within a location labelled with the same letter do not significantly differ (Fisher's Protected LSD test; *P* ≤ 0.05).

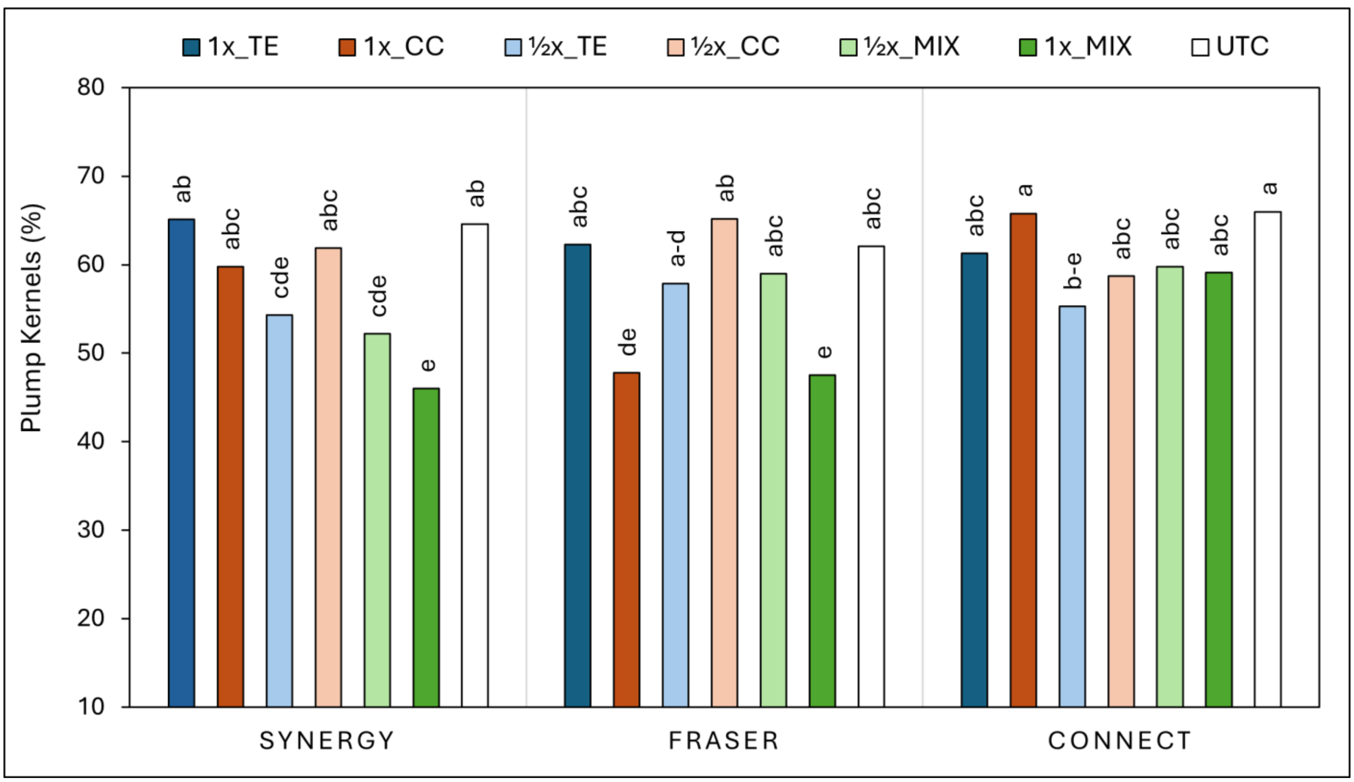

Figure 11. Individual variety by plant growth regulator (PGR) on percent plump kernels in barley at Indian Head, SK, in 2024. Means labelled with the same letter do not significantly differ (Fisher's Protected LSD test; *P* ≤ 0.05).

Grain protein concentrations were affected by variety at Indian Head and Outlook (*P* = 0.002-0.005), marginally affected at Prince Albert (*P* = 0.086), and not affected at Scott (*P* = 0.479). These effects varied (Table 26), with CDC Fraser having higher protein than the other two varieties at Indian Head (15.8% versus 14.7-14.8%) and AAC Connect having higher protein the other two varieties at Outlook (12.0% versus 11.7%). These variety effects were related to yield, with the lower yielding varieties at each location exhibiting higher protein. Unlike most crops, high protein is not a desirable trait in malting barley. The PGR effects on protein (Fig. 12; Table 27) were significant at Prince Albert (*P* < 0.001), marginally significant at Indian Head (*P* = 0.086), and not significant at Outlook or Scott (*P* = 0.300-0.479). At Indian Head, the trends were consistent with the yield responses, whereby the highest yielding treatments tended to have the lowest protein and vise versa. At Prince Albert, the lowest yielding treatments (½x_MIX and 1x_MIX) had the highest protein; however, protein values amongst the highest yielding treatments were more variable. For example, the UTC and 1x_TE treatments had similar yields (5670 kg/ha and 5631 kg/ha), but the protein values were 15.2% and 16.3%, respectively. Based on experience with spring wheat, we might expect lower protein with PGR in cases where substantial yield gains are realized; however, again, lower protein is not a concern in malting barley like it is with wheat, so this potential effect is actually a positive. The VAR × PGR interaction was never significant at the desired probability level (*P* = 0.086-0.823).

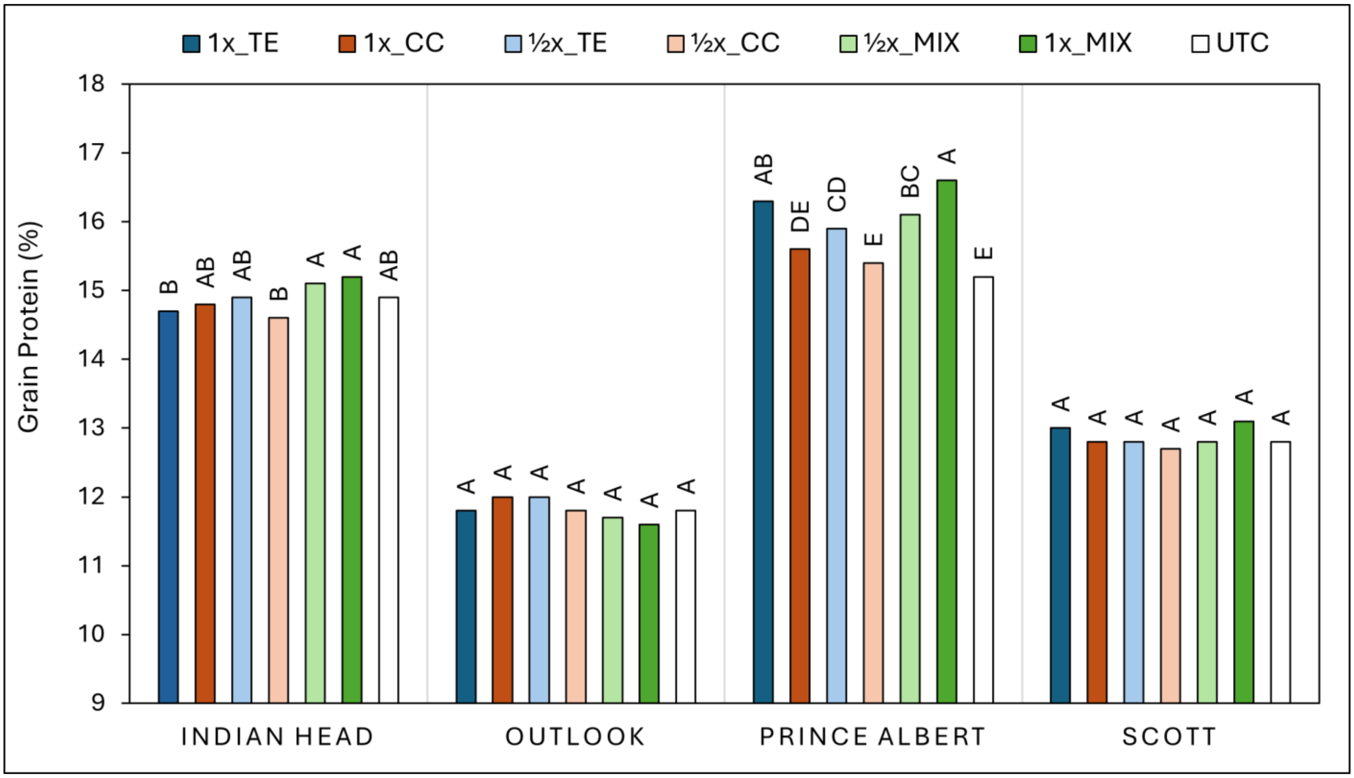

Figure 12. Plant Growth Regulator (PGR) effects on grain protein concentrations in barley at Indian Head, Prince Albert, and Scott in 2024. Means within a location labelled with the same letter do not significantly differ (Fisher's Protected LSD test; *P* ≤ 0.05).

Conclusions and Recommendations

Describe what was learned from the demonstration. Highlight any significant conclusions and provide recommendations for the application and adoption of the project results. Be sure that you have presented the relevant data to support your conclusions. Identify any further research, development and communication needs, if applicable.

In conclusion, this project demonstrated potential for substantial benefits to plant growth regulator (PGR) applications when lodging pressure was high, but relatively little benefit or occasional negative impacts in the absence of lodging. Of the two products, Moddus® provided more consistent and larger reductions in height relative to Manipulator® and, when lodging occurred (i.e.,. Indian Head), Moddus was also much more effective in reducing it. The tank-mix generally also performed well with respect to height and lodging reductions, especially when both products were applied at the full rate; however, despite being effective, the half-rate tank-mix was generally not advantage over simply applying a full rate of Moddus®. Yield increases with PGR only occurred at Indian Head, when lodging pressure was also high and Moddus® (full rate) resulted in the highest yields under such circumstances. The half rate of Moddus® also significantly improved yields over the control, but not to the same extent, and the half rate tank mix resulted in intermediate yields that did not significantly differ from either the highest or lowest values. Manipulator® and the full rate tank mix did not yield higher than the control and yielded significantly less than the full rate of Moddus®. For the remaining locations, with minor or no lodging, yields were mostly unaffected by PGR but the full rate tank significantly reduced yields relative to the control at both Prince Albert and Scott. The PGR effects on quality varied, but at Indian Head the full rate of Moddus® had amongst the highest quality for all values measured. It appeared that some PGR treatments did have potential to have negative impacts, especially the full rate tank-mix, but so did severe lodging. In the absence of lodging, test weights were sometimes reduced with the full rate tank mix, but the other treatments were relatively safe. Kernel plumpness was reduced by both Moddus® and the tank-mix treatments when applied in the absence of lodging, especially at the higher rates. Manipulator® generally had less effect on grain quality but was also the least effective option for reducing height, managing lodging, and protecting yield.

Based on the results from this demonstration along with previous work, the recommendation is to reserve PGR applications in barley to fields where early season conditions and management have resulted in a lush crop that is at a higher risk of lodging. These are the conditions where improvements in yield and harvestability are most likely and the risks of negative impacts on either yield or grain quality are lowest. In this case, our results were reasonably consistent across the varieties which were evaluated, despite differences in lodging at Indian Head in particular. As far as product recommendations, Moddus® was the clear frontrunner, with responses to Manipulator® being inconsistent at best. Fortunately, Moddus® is also the preferred option from a marketability perspective as some malt buyers have flagged chlormequat chloride as a potential concern. Although the half-rate tank-mix performed well overall, it was rarely an improvement over Moddus® applied alone at a full rate and the potential for undesirable responses did appear to be higher with the tank-mix. When both products were applied at a full rate, we saw remarkable height reductions and protection against lodging; however, this treatment is expensive and comes with an unacceptably high risk of yield and/or quality loss.

A similar project will be conducted in the 2025 growing season and these recommendations will be updated as necessary upon its completion.

Sustainable Canadian Agricultural Partnership (Sustainable CAP) Performance Indicators

a) List of performance indicators

Sustainable CAP Indicator	Total Number
Scientific publications from this project (List the publications under section b)	
• Published	None
• Accepted for publication	None
Highly Qualified Personnel (HQPs) trained during this project	
• Master's students	None
• PhD students	None
• Post docs	None

Knowledge transfer products developed based on this project (presentations, brochures, factsheets, flyers, guides, extension articles, podcasts, videos)[1]. List the knowledge transfer products under section (c)	11+

[1] Please only include the number of unique knowledge transfer products.

b) List of scientific journal articles published/accepted for publication from this project. Please ensure that each line includes the following: **Title, Author(s), Journal, Date Published or Accepted for Publication and Link to Article (if available).** *Add additional lines as needed*.

1. Not applicable

c) List of knowledge transfer products/activities developed from this project.

Knowledge Transfer Product or Activity	Event/Location Where Knowledge Transfer Was Conducted	Estimated Number of Participants	Link (if available)
M. Japp (SBDC) and C. Holzapfel (IHARF), Plot Tour	Crop Management Field Day, Indian Head, SK (Jul-16-2024)	145	https://iharf.ca/indian-head-crop-management-field-day/
Z. Galbraith (CLC), Plot Tour	CLC Annual Field Day, Prince Albert (Jul-23-2024)	67	https://saskclc.ca/
D. Petty (IHARF) Plot Tour	NCIAF – IHARF Plot Tour, Indian Head, SK (Aug-7-2024)	40	https://nciaf.ca/
C. Holzapfel (IHARF) Oral Presentation	BarleyBin Live, Nipawan, SK/Online (Dec-5-2024)	48 live, ~150 recording views	https://saskbarley.com/events/
C. Holzapfel (IHARF) Oral Presentation	Agronomy Research Update, Saskatoon, SK/Online (Dec-11-2024)	433	https://prairiecca.ca/events/
M. Japp (SBDC) Oral Presentation	Top Notch Farming, Hudson Bay, SK (Feb-4-2025)	14	https://www.saskcanola.com/events
C. Holzapfel (IHARF) Oral Presentation	IHARF Soil and Crop Mgt Seminar & AGM, Melville, SK (Feb-5-2025)	100	https://iharf.ca/iharf-soil-and-crop-management-seminar-agm
M. Japp (SBDC) Oral Presentation	Top Notch Farming, Melfort, SK (Feb-5-2025)	42	https://www.saskcanola.com/events
M. Japp (SBDC) Oral Presentation	Top Notch Farming, Weyburn, SK (Feb-11-2025)	25	https://www.saskcanola.com/events
M. Japp (SBDC) Oral Presentation	Top Notch Farming, Moosomin, SK (Feb-12-2025)	15	https://www.saskcanola.com/events
C. Holzapfel (IHARF) Oral Presentation	Home Grown Research Webinar / Online through SaskAg (Mar-27-2025)	105 (live online)	https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/sask-ag-now/crops/crops-blog-posts/crops-winter-webinars-2025
Final Project Report – Online	IHARF Website	unknown	https://iharf.ca/full-reports/

Acknowledgements

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Financial support for this demonstration was provided under the Sustainable Canadian Agricultural Partnership, a federal-provincial-territorial initiative. Co-funding was provided by the Saskatchewan Barley Development Commission (SaskBarley). Signs were in-place for any plot tours to acknowledge the funding sources and appropriate acknowledgements will be made in all written communications, oral presentations, or other printed materials pertaining to the project. We would like to acknowledge the Boards of Directors for the participating organizations in addition to the many technical and support staff who worked on the project. Several of the crop protection products that were utilized were provided as in-kind donations. IHARF, ISask, and WARC have strong working relationships and memorandum of understanding with Agriculture and Agri-Food Canada and all participating organizations have received funding for infrastructure and basic operating expenses from the Saskatchewan Ministry of Agriculture and several other producer/commodity groups, all of which has helped to make work like this possible.

Appendices

Identify any changes expected to industry contributions, in-kind support, collaborations or other resources.

Table 5. Selected agronomic information and dates of operations for the ADOPT-SaskBarley plant growth regulator (PGR) mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024.

Activity	IH-24	OL-24	PA-24	SC-23
Previous Crop	Canola	Canola	Canola	Canola
Pre-Emergent Herbicide	May-12-2024 (glyphosate) May-21-2024 (glyphosate)	None	Jun-3-2024 (glyphosate)	May-9-2024 (glyphosate + AIM)
Seeding Date	May-16-2024	May-13-2024	Jun-3-2024	May-15-2024
Row Spacing	30 cm	25 cm	25 cm	25 cm
kg N-P_2O_5-K_2O-S/ha [Z]	175-40-20-20	151-x-x-x [Z]	140-33-0-0	168-32-12-16
Emergence Counts	Jun-6-2024	Jun-7-2024	Jun-26-2024	Jun-6-2024
In-crop Herbicide	Jun-14-2024 (Prestige + Axial)	Jun-18-2024 (Thumper + Cirray)	Jul-5-2024 (Infinity)	Jun-18-2024 (Buctril M) Jun-18-2024 (Axial)
PGR Applications	Jun-18-2024 (as per protocol)	Not Known	Jul-15-2024	Jun-22-2024
Phyto Ratings	Jun-25-2024	Jun-26-2024 (no injury noted)	Jul-17-2024 (no injury noted)	Jun-26-2024
Foliar Fungicide	Jul-7-2024 (Trivepro) Jul-22-2024 (Prosaro XTR)	Jun-26-2024 (Prosaro XTR)	Jul-16-2024 (Prosaro XTR) Jul-30-2024 (Caramba)	Jul-5-2024 (Nexicor)
Plant Height	Jul-29-2024	Aug-1-2024	Aug-15-2024	Not Known
Lodging Ratings	Aug-9-2024	Not Completed	Sep-10-2024 (no lodging noted)	Aug-20-2024
Harvest Date	Aug-21-2024 (R4) Aug-25-2024 (R1-3)	Sep-10-2024	Sep-10-2024	Aug-23-2024

[Z] Rates of P, K, and S fertilizer applied at Outlook are not known

Table 6. Selected agronomic information and dates of operations for the variables in the ADOPT-SaskBarley plant growth regulator (PGR) mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024.

Variable	Effect	IH-24	OL-24	PA-24	SC-23
		Pr > F			
Plant Density	VAR	0.005	0.496	0.591	0.761
Phytotoxicity	VAR	0.041	–	–	0.855
	PGR	<0.001	–	–	0.108
	VAR × PGR	0.279	–	–	0.978
Plant Height	VAR	<0.001	0.027	0.199	<0.001
	PGR	<0.001	<0.001	0.007	<0.001
	VAR × PGR	0.135	0.005	0.983	0.746
Lodging	VAR	<0.001	–	–	0.023
	PGR	<0.001	–	–	<0.001
	VAR × PGR	<0.001	–	–	0.153
Grain Yield	VAR	<0.001	0.008	0.026	0.023
	PGR	<0.001	0.318	0.037	0.006
	VAR × PGR	0.413	0.050	0.464	0.752
Test Weight	VAR	<0.001	<0.001	0.063	0.411
	PGR	0.003	0.046	0.819	0.445
	VAR × PGR	0.003	0.419	0.578	0.807
Thousand Kernel Weight	VAR	<0.001	0.421	0.811	<0.001
	PGR	0.059	0.782	0.901	0.175
	VAR × PGR	0.064	0.982	0.493	0.995
Plump Kernels	VAR	0.144	–	<0.001	0.241
	PGR	<0.001	–	<0.001	<0.001
	VAR × PGR	0.050	–	0.572	0.990
Grain Protein Concentration	VAR	0.002	0.005	0.086	0.479
	PGR	0.088	0.302	<0.001	0.479
	VAR × PGR	0.075	0.696	0.658	0.823

Table 7. Least squares means for variety effects on emerge in plant growth regulator (PGR) mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Variety	IH-24	OL-24	PA-24	SC-23
	Emergence (plants/m^2)			
AAC Synergy	316 A	218 A	170 A	229 A
CDC Fraser	331 A	230 A	171 A	231 A
AAC Connect	273 B	222 A	177 A	228 A
S.E.M.	7.8	8.3	9.5	3.6
Pr > F	0.005	0.497	0.591	0.761

Table 8. Least squares means for variety effects on plant height in plant growth regulator (PGR) mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Variety	IH-24	OL-24	PA-24	SC-23
	--------------------------------------- Plant Height (cm)			---------------------------------------
AAC Synergy	77.5 A	84.4 A	59.8 A	78.2 A
CDC Fraser	71.9 C	82.6 B	58.5 A	76.0 B
AAC Connect	76.2 B	83.6 AB	57.7 A	77.0 B
S.E.M.	1.46	2.00	1.08	0.58
Pr > F	<0.001	0.027	0.199	<0.001

Table 9. Least squares means for plant growth regulator (PGR) effects on plant height in PGR mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

PGR [Z]	IH-24	OL-24	PA-24	SC-23
	--------------------------------------- Plant Height (cm)			---------------------------------------
1x TE	75.2 C	80.6 D	56.0 B	74.4 D
1x CC	76.5 BC	85.8 AB	60.3 A	80.8 B
½x TE	77.5 B	84.2 BC	60.5 A	77.3 C
½x CC	79.6 A	86.8 A	60.0 A	81.8 AB
½x MIX	73.2 D	83.1 C	57.8 AB	75.4 D
1x MIX	64.0 E	77.5 E	55.6 B	67.0 E
UTC	80.3 A	86.8 A	60.6 A	82.6 A
S.E.M.	1.52	2.07	1.41	0.73
Pr > F	<0.001	<0.001	0.007	<0.001

[Z] TE – Trinexepac-ethyl; CC – chormequat chloride; MIX – TE + CC; UTC – untreated control; 1x – full label rate; ½x – half label rate

Table 10. Individual treatment means for plant height in plant growth regulator (PGR) mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Variety-PGR	IH-24	OL-24	PA-24	SC-23
	--------------------------------------- Plant Height (cm)			---------------------------------------
Synergy – 1x TE	78.2	80.2 ghi	57.8	75.4
Synergy – 1x CC	78.7	89.6 a	61.7	82.0
Synergy – ½x TE	78.3	85.2 b-e	62.3	78.1
Synergy – ½x CC	81.3	86.9 a-d	60.1	82.3
Synergy – ½x MIX	77.0	83.8 def	59.2	76.0
Synergy – 1x MIX	67.3	77.2 ij	57.0	69.8
Synergy – UTC	81.6	88.1 ab	60.2	83.7
Fraser – 1x TE	71.0	79.1 hi	56.3	73.2
Fraser – 1x CC	73.3	84.1 c-f	58.2	79.6
Fraser – ½x TE	75.3	83.3 efg	59.6	76.8
Fraser – ½x CC	77.9	88.4 ab	60.6	81.2
Fraser – ½x MIX	69.9	81.2 fgh	57.4	75.0
Fraser – 1x MIX	59.0	75.1 j	56.0	64.1
Fraser – UTC	77.1	87.2 abc	61.7	82.1
Connect – 1x TE	76.4	82.6 efg	53.7	74.5
Connect – 1x CC	77.7	83.8 c-f	61.0	80.7
Connect – ½x TE	79.1	84.1 c-f	59.5	77.2
Connect – ½x CC	79.7	85.1 b-e	59.2	81.8
Connect – ½x MIX	72.8	84.4 c-f	57.0	75.3
Connect – 1x MIX	65.8	80.2 ghi	53.9	67.2
Connect – UTC	82.2	85.0 b-e	60.1	82.2
S.E.M.	1.74	2.29	2.21 a	1.11
Pr > F	0.135	0.005	0.983	0.746

[Z] TE – Trinexepac-ethyl; CC – chormequat chloride; MIX – TE + CC; UTC – untreated control; 1x – full label rate; ½x – half label rate

Table 11. Least squares means for variety effects on lodging in plant growth regulator (PGR) mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Variety	IH-24	OL-24	PA-24	SC-23
	---------- Lodging (1-9) ----------			
AAC Synergy	4.34 A	–	–	1.50 A
CDC Fraser	2.02 B	–	–	1.21 B
AAC Connect	1.86 B	–	–	1.43 A
S.E.M.	0.432	–	–	0.093
Pr > F	<0.001	–	–	0.023

Table 12. Least squares means for plant growth regulator (PGR) effects on lodging in PGR mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

PGR [Z]	IH-24	OL-24	PA-24	SC-23
	---------- Lodging (1-9) ----------			
1x TE	1.63 CD	–	–	1.17 CD
1x CC	3.50 B	–	–	1.75 A
½x TE	2.21 C	–	–	1.33 BC
½x CC	4.50 A	–	–	1.50 AB
½x MIX	1.79 CD	–	–	1.25 BCD
1x MIX	1.13 D	–	–	1.00 D
UTC	4.42 A	–	–	1.67 A
S.E.M.	0.476	–	–	0.126
Pr > F	<0.001	–	–	<0.001

[Z] TE – Trinexepac-ethyl; CC – chormequat chloride; MIX – TE + CC; UTC – untreated control; 1x – full label rate; ½x – half label rate

Table 13. Individual treatment means for lodging in plant growth regulator (PGR) mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Variety-PGR	IH-24	OL-24	PA-24	SC-23
	---------- Lodging (1-9) ----------			
Synergy – 1x TE	2.13 efg	–	–	1.25
Synergy – 1x CC	6.00 b	–	–	1.75
Synergy – ½x TE	3.63 cd	–	–	1.75
Synergy – ½x CC	6.88 ab	–	–	1.75
Synergy – ½x MIX	2.88 de	–	–	1.25
Synergy – 1x MIX	1.13 g	–	–	1.00
Synergy – UTC	7.75 a	–	–	1.75
Fraser – 1x TE	1.25 g	–	–	1.00
Fraser – 1x CC	1.88 efg	–	–	2.00
–Fraser – ½x TE	1.50 fg	–	–	1.00
F–raser – ½x CC	4.38 c	–	–	1.00
Fraser – ½x MIX	1.50 fg	–	–	1.00
Fraser – 1x MIX	1.00 g	–	–	1.00
Fraser – UTC	2.63 def	–	–	1.50
Connect – 1x TE	1.50 fg	–	–	1.25
Connect – 1x CC	2.63 def	–	–	1.50
Connect – ½x TE	1.50 fg	–	–	1.25
Connect – ½x CC	2.25 efg	–	–	1.75
Connect – ½x MIX	1.00 g	–	–	1.50
Connect – 1x MIX	1.25 g	–	–	1.00
Connect – UTC	2.88 de	–	–	1.75
S.E.M.	0.605	–	–	0.204
Pr > F	<0.001	–	–	0.153

[Z] TE – Trinexepac-ethyl; CC – chormequat chloride; MIX – TE + CC; UTC – untreated control; 1x – full label rate; ½x – half label rate

Table 14. Least squares means for variety effects on grain yield in plant growth regulator (PGR) mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, $P \leq 0.05$).

Variety	IH-24	OL-24	PA-24	SC-23
	Grain Yield (kg/ha)			
AAC Synergy	5157 A	6923 A	5632 A	5243 A
CDC Fraser	4691 B	6783 A	5407 B	5022 B
AAC Connect	5306 A	6545 B	5615 A	5170 AB
S.E.M.	292.5	227.2	146.6	129.4
Pr > F	<0.001	0.008	0.026	0.023

Table 15. Least squares means for plant growth regulator (PGR) effects on grain yield in PGR mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, $P \leq 0.05$).

PGR [Z]	IH-24	OL-24	PA-24	SC-23
	Grain Yield (kg/ha)			
1x TE	5385 A	6936 A	5631 AB	5197 A
1x CC	4862 D	6615 A	5632 AB	5150 A
½x TE	5193 AB	6900 A	5497 ABC	5243 A
½x CC	4930 CD	6581 A	5714 A	5151 A
½x MIX	5142 ABC	6735 A	5408 BC	5119 A
1x MIX	4963 BCD	6829 A	5306 C	4826 B
UTC	4885 CD	6658 A	5670 AB	5330 A
S.E.M.	300.5	246.7	164.0	144.6
Pr > F	<0.001	0.318	0.037	0.006

[Z] TE – Trinexepac-ethyl; CC – chormequat chloride; MIX – TE + CC; UTC – untreated control; 1x – full label rate; ½x – half label rate

Table 16. Individual treatment means for grain yield in plant growth regulator (PGR) mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, $P \leq 0.05$).

Variety-PGR	IH-24	OL-24	PA-24	SC-23
	Grain Yield (kg/ha)			
Synergy – 1x TE	5577	7157 a	5822	5167
Synergy – 1x CC	4874	6758 abc	5817	5365
Synergy – ½x TE	5195	7065 ab	5558	5265
Synergy – ½x CC	4978	6865 abc	5642	5211
Synergy – ½x MIX	5346	6860 abc	5571	5219
Synergy – 1x MIX	5164	6732 abc	5483	5070
Synergy – UTC	4966	7024 ab	5532	5403
Fraser – 1x TE	4987	6946 ab	5411	5055
Fraser – 1x CC	4264	6484 bc	5587	5005
Fraser – ½x TE	4822	6886 abc	5360	5212
Fraser – ½x CC	4716	6293 cd	5606	5051
Fraser – ½x MIX	4834	6619 abc	5125	5126
Fraser – 1x MIX	4566	7106 a	4957	4495
Fraser – UTC	4646	7149 a	5800	5211
Connect – 1x TE	5591	6704 abc	5660	5367
Connect – 1x CC	5448	6603 abc	5491	5080
Connect – ½x TE	5561	6748 abc	5572	5252
Connect – ½x CC	5095	6587 abc	5894	5193
Connect – ½x MIX	5246	6728 abc	5528	5012
Connect – 1x MIX	5160	6648 abc	5479	4912
Connect – UTC	5042	5801 d	5678	5377
S.E.M.	327.1	305.3	214.0	188.4
Pr > F	0.413	0.050	0.464	0.752

[Z] TE – Trinexepac-ethyl; CC – chormequat chloride; MIX – TE + CC; UTC – untreated control; 1x – full label rate; ½x – half label rate

Table 17. Least squares means for variety effects on test weight in plant growth regulator (PGR) mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Variety	IH-24	OL-24	PA-24	SC-23
	-------------------------------------- Test Weight (g/0.5 l) --------------------------------------			
AAC Synergy	279 B	325 A	310 A	304 A
CDC Fraser	269 C	319 B	303 B	300 A
AAC Connect	284 A	319 B	308 AB	302 A
S.E.M.	4.4	1.9	2.5	1.97
Pr > F	<0.001	<0.001	0.063	0.411

Table 18. Least squares means for plant growth regulator (PGR) effects on test weight in PGR mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

PGR [Z]	IH-24	OL-24	PA-24	SC-23
	-------------------------------------- Test Weight (g/0.5 l) --------------------------------------			
1x TE	282 A	321 ABC	306 A	304 A
1x CC	275 C	320 BC	307 A	304 A
½x TE	279 AB	321 BC	309 A	305 A
½x CC	277 BC	324 A	310 A	301 A
½x MIX	275 C	321 BC	306 A	303 A
1x MIX	275 C	319 C	303 A	297 A
UTC	277 BC	322 AB	307 A	300 A
S.E.M.	4.5	2.0	3.4	3.0
Pr > F	<0.001	0.046	0.819	0.445

[Z] TE – Trinexepac-ethyl; CC – chormequat chloride; MIX – TE + CC; UTC – untreated control; 1x – full Alabel rate; ½x – half label rate

Table 19. Individual treatment means for test weight in plant growth regulator (PGR) mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Variety-PGR	IH-24	OL-24	PA-24	SC-23
	-------------------------------------- Test Weight (g/0.5 l) --------------------------------------			
Synergy – 1x TE	285 ab	325	312	309
Synergy – 1x CC	273 d-g	326	311	304
Synergy – ½x TE	279 bcd	322	313	310
Synergy – ½x CC	276 cd	328	307	306
Synergy – ½x MIX	280 bc	324	310	301
Synergy – 1x MIX	280 bc	323	313	295
Synergy – UTC	278 bcd	327	305	302
Fraser – 1x TE	275 c-e	320	305	297
Fraser – 1x CC	263 h	315	300	304
Fraser – ½x TE	269 fgh	320	306	304
Fraser – ½x CC	270 efg	321	313	294
Fraser – ½x MIX	269 fgh	320	302	306
Fraser – 1x MIX	268 gh	317	291	295
Fraser – UTC	269 fgh	319	306	302
Connect – 1x TE	287 a	320	301	304
Connect – 1x CC	289 a	319	311	304
Connect – ½x TE	289 a	320	309	301
Connect – ½x CC	284 ab	321	310	302
Connect – ½x MIX	276 cde	319	307	302
Connect – 1x MIX	277 cd	318	306	301
Connect – UTC	284 ab	319	309	297
S.E.M.	4.9	2.4	5.6	5.1
Pr > F	0.003	0.419	0.578	0.807

[Z] TE – Trinexepac-ethyl; CC – chormequat chloride; MIX – TE + CC; UTC – untreated control; 1x – full label rate; ½x – half label rate

Table 20. Least squares means for variety effects on kernel weight in plant growth regulator (PGR) mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Variety	IH-24	OL-24	PA-24	SC-23
	TKW (g/1000 seeds)			
AAC Synergy	36.5 B	42.1 A	44.7 A	38.3 B
CDC Fraser	35.2 C	42.0 A	44.8 A	37.6 B
AAC Connect	38.0 A	42.6 A	44.5 A	40.0 A
S.E.M.	1.59	0.48	0.67	0.59
Pr > F	<0.001	0.421	0.811	<0.001

Table 21. Least squares means for plant growth regulator (PGR) effects on TKW in PGR mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC), 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

PGR [Z]	IH-24	OL-24	PA-24	SC-23
	TKW (g/1000 seeds)			
1x TE	38.2 A	42.3 A	45.3 A	39.7 A
1x CC	36.8 ABC	42.0 A	44.3 A	38.5 A
½x TE	36.3 ABC	42.8 A	44.4 A	38.9 A
½x CC	36.9 AB	42.3 A	44.5 A	38.2 A
½x MIX	34.9 C	41.9 A	44.7 A	38.3 A
1x MIX	36.2 BC	41.8 A	44.8 A	37.5 A
UTC	36.8 AB	42.7 A	44.7 A	39.5 A
S.E.M.	1.67	0.62	0.79	0.75
Pr > F	0.059	0.782	0.901	0.175

[Z] TE – Trinexepac-ethyl; CC – chormequat chloride; MIX – TE + CC; UTC – untreated control; 1x – full label rate; ½x – half label rate

Table 22. Individual treatment means for kernel weight (TKW) in plant growth regulator (PGR) mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Variety-PGR	IH-24	OL-24	PA-24	SC-23
	TKW (g/1000 seeds)			
Synergy – 1x TE	38.9	42.0	47.6	39.3
Synergy – 1x CC	35.3	41.8	44.2	39.1
Synergy – ½x TE	35.5	42.3	43.9	38.2
Synergy – ½x CC	35.9	42.5	44.2	37.9
Synergy – ½x MIX	35.1	41.9	44.2	37.4
Synergy – 1x MIX	38.6	40.9	44.8	37.2
Synergy – UTC	36.5	43.1	44.0	39.2
Fraser – 1x TE	36.2	42.2	44.3	38.6
Fraser – 1x CC	34.1	41.5	44.4	36.5
Fraser – ½x TE	35.1	43.4	44.6	38.2
Fraser – ½x CC	36.4	41.5	44.5	37.8
Fraser – ½x MIX	34.9	41.8	45.3	37.7
Fraser – 1x MIX	33.5	42.0	44.8	36.4
Fraser – UTC	36.4	42.0	45.9	38.3
Connect – 1x TE	39.5	42.8	44.0	41.3
Connect – 1x CC	41.0	42.9	44.2	39.9
Connect – ½x TE	38.4	42.6	44.6	40.3
Connect – ½x CC	38.5	42.8	44.9	39.0
Connect – ½x MIX	34.7	42.0	44.7	39.8
Connect – 1x MIX	36.5	42.4	44.8	39.0
Connect – UTC	37.6	43.0	44.2	41.1
S.E.M.	1.93	0.98	1.13	1.16
Pr > F	0.064	0.982	0.493	0.995

[Z] TE – Trinexepac-ethyl; CC – chormequat chloride; MIX – TE + CC; UTC – untreated control; 1x – full label rate; ½x – half label rate

Table 23. Least squares means for variety effects on plump kernels in plant growth regulator (PGR) mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Variety	IH-24	OL-24	PA-24	SC-23
	---------- Plump Kernels (%) ----------			
AAC Synergy	57.7 A	–	84.5 B	84.6 A
CDC Fraser	57.4 A	–	87.8 A	82.1 A
AAC Connect	60.9 A	–	80.2 C	82.5 A
S.E.M.	7.20	–	0.96	2.16
Pr > F	0.144	–	<0.001	0.241

Table 24. Least squares means for plant growth regulator (PGR) effects on plump kernels in PGR mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

PGR [Z]	IH-24	OL-24	PA-24	SC-23
	---------- Plump Kernels (%) ----------			
1x TE	62.9 AB	–	82.3 BC	82.3 BC
1x CC	57.8 BCD	–	84.4 AB	85.9 AB
½x TE	55.8 DE	–	85.6 A	85.1 ABC
½x CC	61.9 ABC	–	86.5 A	86.7 AB
½x MIX	57.0 CD	–	81.4 C	80.9 C
1x MIX	50.9 E	–	82.0 BC	72.3 D
UTC	64.2 A	–	87.0 A	88.1 A
S.E.M.	7.37	–	1.20	2.50
Pr > F	<0.001	–	<0.001	<0.001

[Z] TE – Trinexepac-ethyl; CC – chormequat chloride; MIX – TE + CC; UTC – untreated control; 1x – full label rate; ½x – half label rate

Table 25. Individual treatment means for percent plump kernels in plant growth regulator (PGR) mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Variety-PGR	IH-24	OL-24	PA-24	SC-23
	---------- Plump Kernels (%) ----------			
Synergy – 1x TE	65.1 ab	–	84.5	82.2
Synergy – 1x CC	59.8 abc	–	85.9	89.1
Synergy – ½x TE	54.3 cde	–	84.1	86.1
Synergy – ½x CC	61.9 abc	–	87.1	87.8
Synergy – ½x MIX	52.2 cde	–	81.9	81.1
Synergy – 1x MIX	46.0 e	–	82.7	74.6
Synergy – UTC	64.6 ab	–	85.2	91.2
Fraser – 1x TE	62.3 abc	–	85.0	80.9
Fraser – 1x CC	47.8 de	–	88.0	83.8
Fraser – ½x TE	57.9 a-d	–	88.5	84.8
Fraser – ½x CC	65.2 ab	–	89.6	86.5
Fraser – ½x MIX	59.0 abc	–	84.7	81.7
Fraser – 1x MIX	47.5 e	–	86.5	69.6
Fraser – UTC	62.1 abc	–	92.1	87.4
Connect – 1x TE	61.3 abc	–	77.4	83.8
Connect – 1x CC	65.8 a	–	79.1	84.8
Connect – ½x TE	55.3 b-e	–	84.2	84.4
Connect – ½x CC	58.7 abc	–	82.8	85.7
Connect – ½x MIX	59.8 abc	–	77.6	79.9
Connect – 1x MIX	59.1 abc	–	76.9	72.9
Connect – UTC	66.0 a	–	83.8	85.8
S.E.M.	7.93	–	1.81	3.45
Pr > F	0.050	–	0.572	0.990

[Z] TE – Trinexepac-ethyl; CC – chormequat chloride; MIX – TE + CC; UTC – untreated control; 1x – full label rate; ½x – half label rate

Table 26. Least squares means for variety effects on grain protein in plant growth regulator (PGR) mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Variety	IH-24	OL-24	PA-24	SC-23
	---------- Grain Protein (%) ----------			
AAC Synergy	14.7 B	11.7 B	15.7 B	12.8 A
CDC Fraser	15.8 A	11.7 B	15.9 AB	12.9 A
AAC Connect	14.8 B	12.0 A	16.0 A	12.9 A
S.E.M.	0.61	0.18	0.13	0.17
Pr > F	0.002	0.005	0.086	0.479

Table 27. Least squares means for plant growth regulator (PGR) effects on grain protein in PGR mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

PGR [Z]	IH-24	OL-24	PA-24	SC-23
	---------- Grain Protein (%) ----------			
1x TE	14.7 B	11.8 A	16.3 AB	13.0 A
1x CC	14.8 AB	12.0 A	15.6 DE	12.8 A
½x TE	14.9 AB	12.0 A	15.9 CD	12.8 A
½x CC	14.6 B	11.8 A	15.4 E	12.7 A
½x MIX	15.1 A	11.7 A	16.1 BC	12.8 A
1x MIX	15.2 A	11.6 A	16.6 A	13.1 A
UTC	14.9 AB	11.8 A	15.2 E	12.8 A
S.E.M.	0.62	0.18	0.17	0.19
Pr > F	0.088	0.302	<0.001	0.479

[Z] TE – Trinexepac-ethyl; CC – chormequat chloride; MIX – TE + CC; UTC – untreated control; 1x – full label rate; ½x – half label rate

Table 28. Individual treatment means for percent grain protein in plant growth regulator (PGR) mixing demonstrations at Indian Head (IH), Outlook (OL), Prince Albert (PA), and Scott (SC) in 2024. Values within a column do not significantly differ (Fisher's protected LSD test, *P* ≤ 0.05).

Variety-PGR	IH-24	OL-24	PA-24	SC-23
	---------- Grain Protein (%) ----------			
Synergy – 1x TE	14.4	11.9	16.0	13.1
Synergy – 1x CC	14.9	11.8	15.2	12.8
Synergy – ½x TE	15.0	11.9	15.9	12.8
Synergy – ½x CC	14.7	11.5	15.3	12.7
Synergy – ½x MIX	14.5	11.6	16.0	12.7
Synergy – 1x MIX	15.0	11.4	16.3	12.9
Synergy – UTC	14.6	12.0	15.3	12.6
Fraser – 1x TE	15.0	11.5	16.6	13.0
Fraser – 1x CC	15.4	12.1	15.5	12.9
Fraser – ½x TE	15.3	11.7	16.1	12.7
Fraser – ½x CC	14.7	11.7	15.3	12.7
Fraser – ½x MIX	15.2	11.5	16.1	12.8
Fraser – 1x MIX	15.6	11.6	16.6	13.4
Fraser – UTC	15.2	11.6	14.9	13.1
Connect – 1x TE	14.6	12.0	16.4	12.9
Connect – 1x CC	14.1	12.0	16.0	12.6
Connect – ½x TE	14.5	12.4	15.8	13.1
Connect – ½x CC	14.5	12.2	15.4	12.8
Connect – ½x MIX	15.6	12.0	16.2	12.8
Connect – 1x MIX	15.0	11.7	16.8	13.0
Connect – UTC	14. 9	11.9	15.4	12.9
S.E.M.	0.66	0.26	0.26	0.27
Pr > F	0.075	0.696	0.658	0.823

[Z] TE – Trinexepac-ethyl; CC – chormequat chloride; MIX – TE + CC; UTC – untreated control; 1x – full label rate; ½x – half label rate

Expenditure Statement

You must provide an expenditure statement showing how ADOPT funds were used. Expenditures must be reported using the budget categories shown in Appendix B of your contract. We recommend that you report your expenditures using the Excel spreadsheet we have developed for this purpose (ADOPT Expenditure Statement.xls). That spreadsheet is available from the research branch project manager or the evaluation coordinator.

Note that the ADOPT contract requires you to retain all receipts and financial records relating to the project for at least six years after the project is completed.

Expenditure statements are available in a separate Excel workbook upon request.