Project Identification

1. Project Title: Hastening maturity of oats without pre-harvest glyphosate

2. Project Number: 20160442

3. Producer Group Sponsoring the Project: IHARF

4. Project Location(s):
R.M. of Indian Head No. 156, land location NW 28-18-12 W2 – owned and managed by IHARF

5. Project start and end dates (month & year): April 2017 to February 2018

6. Project contact person & contact details:
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Objectives and Rationale

7. Project objectives:

This project will demonstrate an integrated agronomic approach to hasten maturity in oats without a pre-harvest application of glyphosate. Specifically, the objective of this project is to demonstrate the impact of seeding date, seeding rate, and fertility on oat yield, maturity, and milling quality.

8. Project Rationale:

Major oat buyers in eastern Saskatchewan have made the decision not to purchase oats which have been treated with pre-harvest glyphosate due to reductions in milling quality. It was established that pre-harvest glyphosate on oats was causing the groat to become more brittle and fall apart. Producers must now either swath the crop or wait until the crop is ripe before harvesting; however, either option increases the risk of weathering the oats. Without the use of glyphosate to hasten maturity, some growers have struggled to produce milling quality oats. Thus, producers will need to focus on other agronomic practices to hasten the maturity of oats under field conditions, particularly seeding dates, seeding rates, and fertility management. The Saskatchewan Oat Growers Association has made it a top priority to find ways to help oat growers produce milling quality oats without the option of a pre-harvest glyphosate application.

In general, crops that are seeded earlier are more likely to be harvested under ideal environmental conditions, increasing the probability of achieving milling quality oats. Increasing nitrogen rates further delays maturity; the ideal rate will depend on the seeding date. Studies have shown oats are more responsive to increasing rates of applied N when seeded in early May versus early June (May et al. 2004. Can J Plant Sci. 84:1025-1036). Ensuring adequate levels of phosphorus are present is also important in hastening maturity. Finally, an increase in seeding rate has been shown to reduce the number of tillers producing immature seed, hastening maturity and reducing green seed.

Methodology and Results

9. Methodology:

a) Experimental design

The demonstration trial was located on soybean stubble on land managed by IHARF under no-till production. The trial was conducted using a split-plot design with four replicates. The plots were 8' x 35'. The treatments were a full factorial combination, the main blocks consisting of two seeding dates (Early May and Late May), with two seeding rates (200 and 300 viable seeds per sq. metre), and three N rates (40, 65, and 90 lbs N per acre), plus an additional treatment with a lower rate of P fertilizer, fully randomized in each of the early and late seeded blocks:

Table 1. List of treatments evaluated in the demonstration trial.

Entry	Seeding date	Seeding rate (seeds/m^2)	N rate (lbs N/ac)	P rate (lbs P_2O_5/ac)
1	Early May	200	40	30
2		200	65	30
3		200	90	30
4		300	40	30
5		300	65	30
6		300	90	30
7		300	90	10
8	Late May	200	40	30
9		200	65	30
10		200	90	30
11		300	40	30
12		300	65	30
13		300	90	30
14		300	90	10

b) Plot establishment and maintenance

At Indian Head, the early-seeded treatments were seeded on May 3 and the late-seeded on May 23 using a SeedMaster plot drill on 12" row spacing and at a depth of approximately 0.75". CDC Camden (44.2 g per 1000 seeds, 90% germ) was seeded at either 97 kg per ha to achieve 200 viable seeds per m^2 or 145 kg per ha to achieve 300 viable seeds per m^2 as per protocol. MAP (11-52-0) was side-banded to target either 10 or 30 lbs P_2O_5 per acre as per protocol. Urea (46-0-0) was side-banded to target 40, 65, or 90 lbs N per acre as per protocol. The urea rate was adjusted for N in MAP.

A pre-emergent herbicide application of Startup (540 g glyphosate/L @ 0.67L/ac) was completed within 3 days of seeding on each of the early- and late-seeded blocks. Curtail M (0.81 L per ac) was applied in-crop on June 13 (early seeded blocks) and June 26 (late seeded blocks). Wild oats were hand-weeded as needed but weed pressure was minimal throughout the growing season. Disease pressure also remained low throughout the growing season and no fungicide was applied.

The centre five rows of each plot was combined on August 29 (early seeded blocks) and August 31 (late seeded blocks) using a Wintersteiger plot combine, and the entire grain sample was retained for yield and quality determination.

c) Data collection

Plant density was measured in early-seeded plots on May 30. The number of plants in two 1-m sections of crop row was counted in each plot, and the counts were converted to plants per sq metre. Spring plant density was not completed on late-seeded plots. There was no significant lodging observed in any plot or treatments, so lodging assessments were not completed for individual plots. The Julian calendar date that the crop reached medium dough stage was recorded, and the number of days from seeding to maturity was calculated for each plot individually. Fall tiller counts were added to the protocol as the late-seeded spring plant density counts were missed. The number of tillers in two 0.5-m sections of crop row was counted in each plot, and the counts were converted to tillers per sq metre. Harvest samples were weighed and seed moisture content determined using a Labtronics Model 919 seed moisture tester for each plot individually. Dockage was determined by cleaning a 1 kg subsample according to Canadian Grain Commission guidelines, using a Carter Day dockage tester. The net weight per area was calculated and corrected to 13.5% moisture content. Clean subsamples were combined into treatment composites and submitted to Intertek for milling quality analyses (test weight, thins, protein, fat, beta-glucans).

d) Statistical analysis

The demonstration trial was also conducted at Melfort and Yorkton in 2017. The data from all three sites was combined for a multi-site analysis, to compare the results at Indian Head to the results under multiple environments. Quality data was only analysed as multi-site as the samples from each site were composites with no replication.

Two subsets of data were pulled out of the full data set, to test for i) interactions between seeding date, seeding rate, and N rate using the full factorial set of treatments (entries 1-6 and 8-13), and ii) the effect of P rate on maturity and yield (entries 6-7 and 13-14):

i. For the factorial analysis, mixed-effect models were fitted for each response variable individually (tiller density, days to maturity, and yield at Indian Head, spring plant density, days to maturity, and yield for multi-site analysis), with seeding date, seeding rate, N rate, and all two-way and three-way interactions as fixed effects, and seeding date (main block) within rep, within site for multi-site, as a random effects. Mixed-effects models were also fitted for each of the quality data response variables (test weight, thins, protein, fat, beta-glucans), with the same fixed effects as above, and seeding date within site as random effects. N rate was considered a continuous variable rather than discrete/categorical, resulting in regression-type models. The quadratic term for N rate was not included as a fixed effect in the models due to the already complex three-way factorial analysis.

ii. To assess the effect of P rate, mixed-effects models were fitted for the relevant response variables (days to maturity and yield), with seeding date, P rate, and their interaction as fixed effects, and seeding date within rep, within site for multi-site, as random effects. P rate was considered a continuous variable.

Data were analyzed with the R statistical program, version 3.4.2, using the *lme4* and *lmerTest* packages for fitting mixed-effects models. A model simplification approach was utilized, where non-significant interactions and variables are removed from the model one at a time until all remaining terms are significant, as long as the reduced model does not result in a significant reduction in model fit compared to the full model (P<0.05).

10. Results

a) Effect of seeding date, seeding rate, and N rate on crop response variables

i. Spring plant density

With all sites combined, spring plant density was significantly lower at the low seeding rate (P<0.0001), and decreased significantly with N rate (P=0.0003), but there was no interaction between the two variables (Figure 1). Seeding date did not have a significant effect on spring plant density.

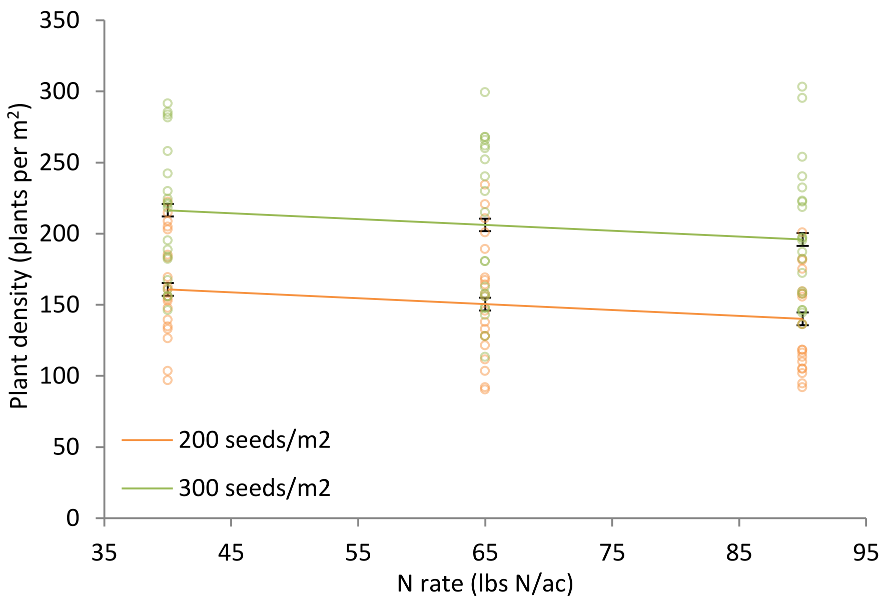

Figure 1. The effect of seeding rate and N rate on oat spring plant density at <u>all sites combined</u> (Indian Head, Melfort, and Yorkton) in 2017. Error bars indicate the standard error of seeding rate response.

ii. Tiller density

Tiller density was only assessed at Indian Head. Tiller density was significantly greater at the higher seeding rate (P=0.0174, Figure 2), but was not significantly affected by seeding date or N rate. It is likely that the number of tillers produced per plant was greater at the lower seeding rate, however, this was not assessed.

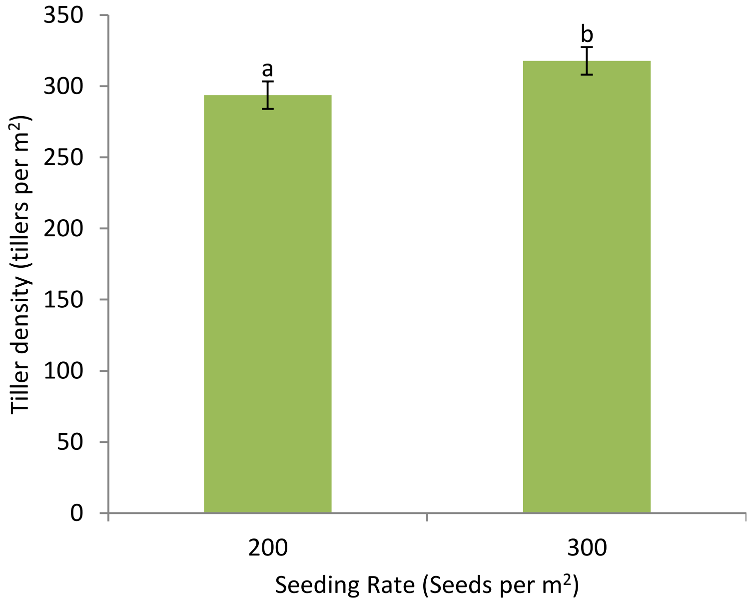

Figure 2. The effect of seeding rate on oat tiller density at Indian Head in 2017. Error bars indicate the standard error.

iii. *Days to maturity*

With all sites combined, there was a significant three-way interaction of seeding date, seeding rate, and N rate on the number of days to maturity (P=0.0002, Figure 3). Late-seeded oats matured more quickly than early-seeded oats across seeding rates and N rates (P<0.0001), though the crop was still mature at a later calendar date (data not shown). When oats were seeded early, the number of days to maturity increased with N rate (P=0.007) but did not differ significantly between seeding rates (P=0.236) (Figure 3, left). However, when oats were seeded late, the number of days to maturity increased significantly more with N rate at the low seeding rate compared to the higher seeding rate (P=0.0002) (Figure 3, right). A low seeding rate combined with a high N rate caused the greatest increase in days to maturity when oats were seeded late but still matured in fewer days than when seeded early.

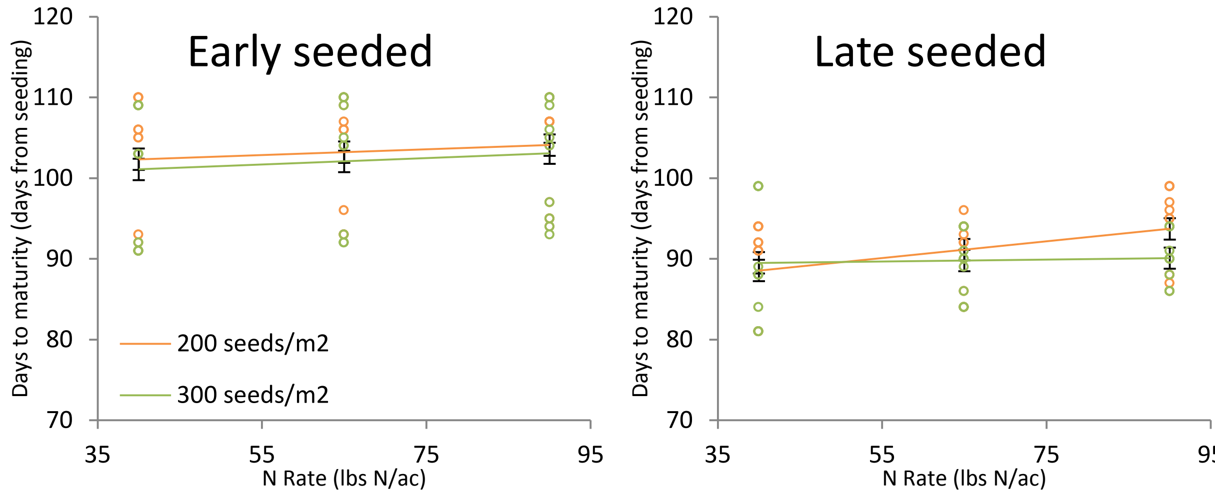

Figure 3. The effect of seeding date, seeding rate, and N rate on oat maturity at all sites combined (Indian Head, Melfort, and Yorkton) in 2017. Error bars indicate the standard error of seeding rate response.

The maturity response at Indian Head was similar to the combined sites' response. There was a significant three-way interaction of seeding date, seeding rate, and N rate on the number of days to maturity (P=0.018, Figure 4). Compared to the multi-site data, seeding rate had a greater effect on days to maturity, across seeding dates and N rates (multi-site, P=0.071 vs IH, P=0.011). The lower seeding rate significantly increased the number of days to maturity at nearly all N rates and seeding dates, with the exception of the highest N rate when seeded early.

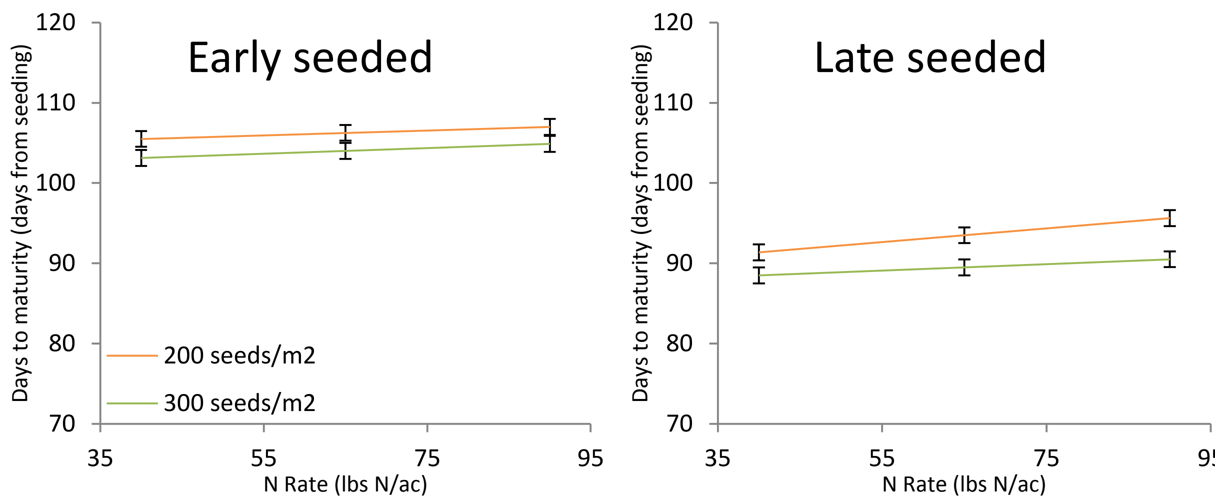

Figure 4. The effect of seeding date, seeding rate, and N rate on oat maturity at Indian Head in 2017. Error bars indicate the standard error of seeding rate response.

iv. Grain yield

With all sites combined, grain yield increased significantly with N rate (P<0.0001), but was not affected by seeding date or seeding rate (Figure 5).

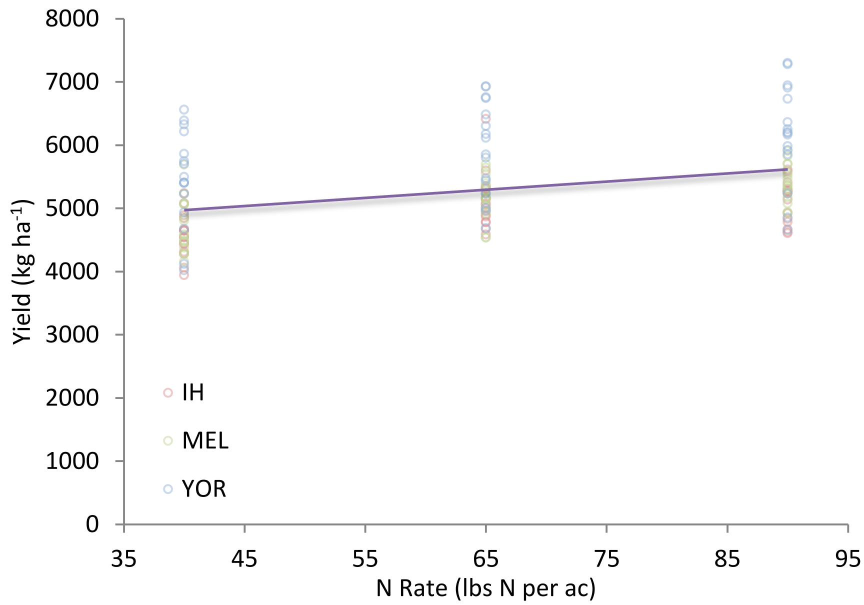

Figure 5. The effect of N rate on oat yield at <u>all sites combined</u> (Indian Head, Melfort, Yorkton) in 2017.

At Indian Head, there was a significant effect of seeding date (P=0.0034) in addition to the effect of N rate (P<0.0001), but there was no interaction between the two variables (Figure 6). Late-seeded oats yielded significantly higher than early-seeded oats.

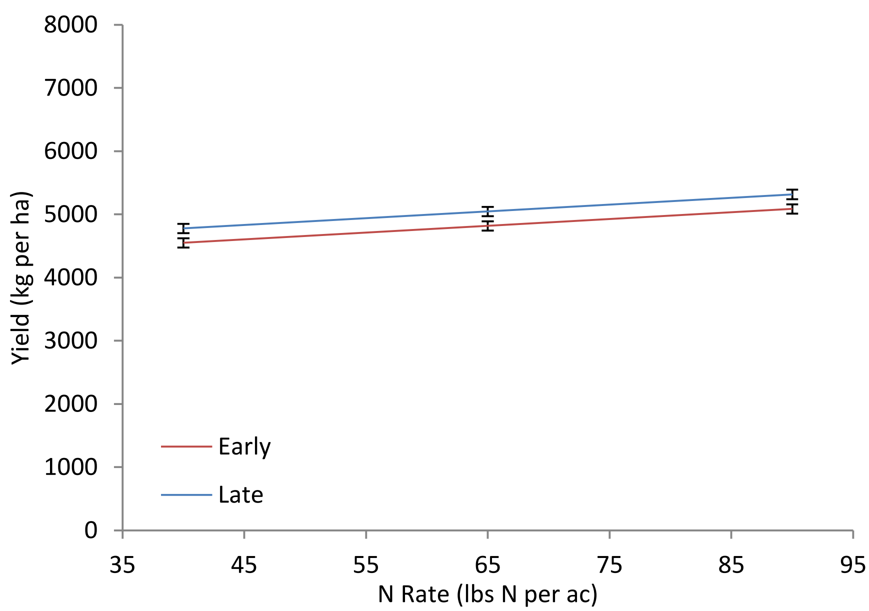

Figure 6. The effect of seeding date and N rate on oat yield at <u>Indian Head</u> in 2017. Error bars indicate the standard error of the seeding date response.

v. Milling quality

Quality data was only analysed as multi-site as the samples from each site were composites with no replication. Test weight and % thins were not affected by seeding date, seeding rate, or N rate. Test weight was 268.9 ± 7.5 g/0.5 L on average and % thins were 1.503 ± 0.488% on average. Protein and beta-glucans increased significantly with N rate (P<0.0001, P=0.0001), but neither were affected by seeding date or rate. Protein was 12.75% at the lowest N rate and increased by a rate of 0.24 ± 0.02% per 10 lbs/ac increase of added N. Beta-glucans was 5.01% at the lowest N rate and increased by a rate of 0.021 ± 0.005 per 10 lbs/ac of added N. Fat content decreased significantly with seeding rate (P=0.0419) and with N rate (P=0.0011). Fat content was 6.87 ± 0.04% at the low seeding rate and 6.78% ± 0.04% at the higher seeding rate, and decreased by a rate of 0.04 ± 0.01% per 10 lbs/ac increase of added N.

b) Effect of P rate on crop maturity and yield

i. Maturity

In both the multi-site and single-site analyses, the number of days to maturity was significantly affected by seeding date (P<0.0001 for both), as seen in the factorial analysis above, but there was no significant effect of P rate (data not shown). Anecdotally, variability in the number of days to maturity appeared to be greater with the low P treatments at Indian Head.

ii. Grain yield

With all sites combined, grain yield was significantly higher when seeded late (P=0.016), and increased significantly with P rate (P<0.0001, Figure 7). In contrast, there was no difference in grain yield between the two seeding dates at Indian Head, but there was a similar increase in yield with P rate (Figure 7).

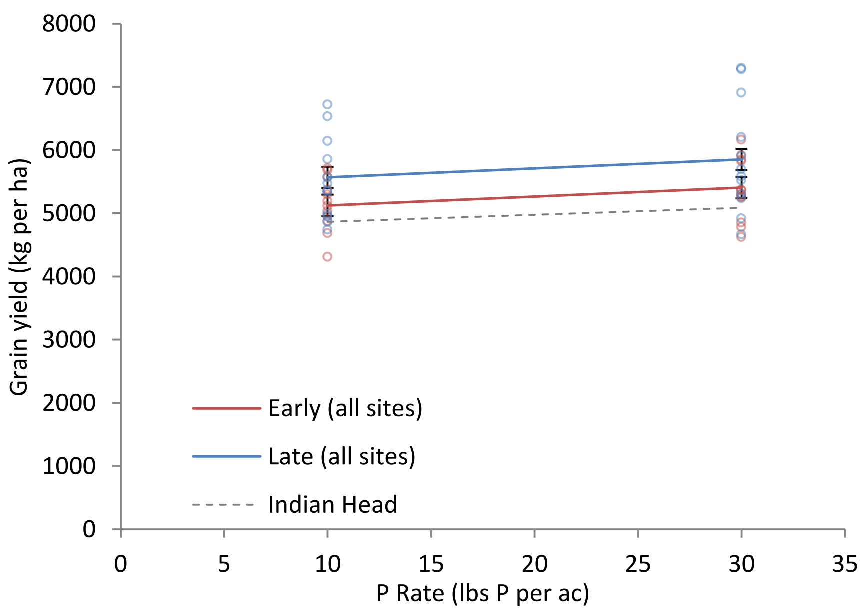

Figure 7. The effect of seeding date and P rate on oat grain yield at all sites combined (Indian Head, Melfort, Yorkton) in 2017, compared to the oat yield response at Indian Head only. Error bars indicate the standard error of the seeding date response in the multi-site analysis.

The seeding date results seen here are in contrast to the results of the factorial analysis above, where there was no difference in yield between the two seeding dates in the multi-site analysis, but there was a significant difference in yield between the two seeding dates at Indian Head. The difference may be because the four treatments included in the P rate analysis all have a high N rate (90 lbs N/ac) and a high seeding rate (300 seeds per sq. metre), and because there is likely more variability in the larger subset of data.

c) Discussion

In general, the oat maturity and yield response to the treatments was as expected. Higher rates of N delayed maturity and increased yield. Higher seeding rate hastened maturity, possibly due to a higher mature tiller density as was seen at Indian Head. Later seeding date also hastened maturity but the crop was still mature at a later calendar date. Interestingly, the delay in maturity with lower seeding rate and higher N rate was greater when the oats were seeded late than when they were seeded early. However, early seeding date was not as beneficial as was expected. With combined data, there was no yield benefit to seeding early in the full factorial analysis, and there was actually a yield benefit with late seeding when only the P-rate treatments (high N rate + higher seeding rate) were compared. At Indian Head, there was a significant yield benefit with late-seeded oats compared to early-seeded oats in the factorial analysis, and no yield difference in the P-rate analysis. This may have been a function of dry conditions at all locations in 2017, combined with the timing of significant rain events to coincide with important developmental stages at Indian Head, and the timing of high temperatures with important developmental stages at Yorkton. In Yorkton, there was a substantial amount of floral blasting recorded for the early seeded oats (Mike Hall, personal communication).

Though there were some significant treatment effects on grain quality, all of the quality factors fell within acceptable ranges for milling quality, even at the lowest quality treatment for each factor. Test weights are of particular importance with discounts for test weights below 245 g/0.5 L and rejection if less than 230 g/0.5 L. Thins should be less than 10%. Beta-glucans should be above 4% to support the "heart-healthy" claim. Protein and fat do not have specific industry standards but higher protein is desirable.

An effect of P rate on maturity was not observed, however, it was shown that adequate P rates are necessary to achieve maximum yield.

Treatment responses at Indian Head were very similar to the overall multi-site response. Where the results differed, the difference was likely attributable to specific environmental conditions experienced at Indian Head in 2017.

d) Extension Activities

The full project report will be made available online (www.iharf.ca) and results will be summarized in the IHARF annual report. A factsheet will be produced which summarizes the results from the multi-site analysis and will be made available on the Agri-ARM website as well as IHARF, NARF, and ECRF websites. The factsheet will also be printed and distributed at various events (farm shows, meetings, conventions) at which Agri-ARM organizations will be attending. Mike Hall has created a youtube video highlighting the results of the multi-site trial.

11. Conclusions and Recommendations

Results from this trial have demonstrated that oats compensate for a later seeding date by hastening maturity, and that this does not necessarily result in a yield penalty. However, if oats are seeded late, increasing the seeding rate may be the most important consideration in order to hasten maturity while still maintaining a higher N rate to preserve yield potential, as maturity is significantly delayed when lower seeding rates are combined with higher N rates at later seeding dates. Reducing the nitrogen rate will also hasten maturity significantly, but the benefit of earlier maturity will need to be weighed against the corresponding yield loss. That being said, environmental conditions at all three sites were much drier than normal in 2017, and this may have influenced the results. It would be beneficial to observe the crop response under wetter conditions.

Supporting Information

12. Acknowledgements

This project was supported by the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canada-Saskatchewan Growing Forward 2 bi-lateral agreement. Crop protection products were provided in-kind by industry partners. IHARF staff contributed to technical aspects of the trial at Indian Head. Mike Hall from Parkland College and ECRF initiated the trial proposal and designed the protocol. All contributions will be acknowledged on future extension material.

13. Appendices

Plot photos, tabulated data, and detailed results of statistical analyses can be provided upon request.

Abstract

14. Abstract/Summary

Major oat buyers in eastern Saskatchewan have made the decision not to purchase oats which have been treated with pre-harvest glyphosate due to reductions in milling quality. Thus, producers will need to focus on other agronomic practices to hasten the maturity of oats under field conditions, particularly seeding dates, seeding rates, and fertility management. The treatments were a full factorial combination, the main blocks consisting of two seeding dates (early May and late May), with two seeding rates (200 and 300 seeds per sq. metre), and three N rates (40, 65, and 90 lbs N per acre), plus an additional treatment with a lower rate of P fertilizer, fully randomized in each of the early and late seeded blocks. The objective was to demonstrate the interacting effects of these factors on oat maturity, yield, and milling quality. A secondary objective was to demonstrate the importance of

adequate P fertilization in crop development and achieving earlier maturity. Results from this trial have demonstrated that oats compensate for a later seeding date by hastening maturity, and that this does not necessarily result in a yield penalty. However, if oats are seeded late, increasing the seeding rate may be the most important consideration in order to hasten maturity while still maintaining a higher N rate to preserve yield potential, as maturity is significantly delayed when lower seeding rates are combined with higher N rates at later seeding dates. Reducing the nitrogen rate will also hasten maturity significantly, but the benefit of earlier maturity will need to be weighed against the corresponding yield loss. The effect of P rate on maturity was not observed, however, it was shown that adequate P rates are necessary to achieve maximum yield. Though there were some significant treatment effects on grain quality, all of the quality factors fell within acceptable ranges for milling quality, even at the lowest quality treatment for each factor, but this may have been a result of environmental conditions in 2017. Environmental conditions were much drier than normal in 2017, and it would be beneficial to observe the crop response under wetter conditions.
