Research Report

Summary

Optimizing Combine Efficiency While Harvesting Soybeans in Manitoba

For:
Manitoba Agriculture, Manitoba
Final Report

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Optimizing Combine Efficiency While Harvesting Soybeans in Manitoba

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Acknowledgement

This project was funded by the Canada and Manitoba governments through Growing Forward 2, a federal-provincial-territorial initiative.

Thank you to our cooperating producer for allowing us to work with them during their soybean harvest operations.
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1. Executive Summary

The vast majority (80%) of losses during soybean harvest occur at the header, indicating that significant savings may be realized if harvest is optimized to reduce losses at the header. Two variables which may significantly affect header losses are the choice of the header and the ground speed of the combine during harvest. The aim of this project was to understand how these two variables affect header losses and by how much.

The trials took place near East Selkirk, MB with Dekalb 2410 soybeans. Headers chosen for this comparison were both auger headers: one equipped with an air reel and one without. Ground speeds at harvest were 2, 3, 4, and 5 miles per hour (mph). This resulted in a total of eight treatments. Four replications of each treatment were performed for a total of thirty-two field-scale plots.

Pre-harvest loss samples were taken to distinguish losses specifically due to harvest activities and quantify plant density. Pre-harvest loss samples showed average losses of 0.0375 bu/ac¹ and 3.73 plants per square foot (162,479 plants/ac). Plots were harvested on October 15. A minimum of forty loss samples were taken randomly in each plot with 4 seeds/ft² representing a loss of 1 bu/ac. A total of 1344 samples were taken.

Speed was found to have a significant effect on losses only once 4 mph was surpassed. Optimal speed for reducing losses with an auger header was 2 mph (1.36 bu/ac loss), though there was no statistical difference in losses between 2, 3, and 4 mph. When speed increased to 5 mph, header losses increased exponentially, nearly doubling to 2.18 bu/ac. This is a difference of 0.82 bu/ac or $8.20/ac (assuming a price of $10/bu) compared to the slowest speed tested in this trial.

An air reel was found to have a significant effect on decreasing header losses under the harvest conditions in this study. An auger header equipped with an air reel resulted in just over half the losses (1.02 bu/ac) when compared with an auger header with no air reel (2.27 bu/ac) with a difference of 1.25 bu/ac. At a price of $10/bu, this resulted in the air reel providing a savings of approximately $12.50/ac when compared with an auger header without an air reel. This indicates that an auger header equipped with an air reel can provide substantial benefit in reducing losses and increasing profitability.

From the insights gained from this project, producers can evaluate the value of an air reel for their operations, and optimal travel speed, based on the return per acre of soybeans grown.

¹ All harvest losses described in this report have been adjusted to account for pre-harvest losses.
2. Introduction

Soybeans are generally a heat-loving crop, but genetic advances in recent years have made soybeans a popular and viable choice in the Manitoba climate. Soybean acres in Manitoba have more than doubled from 587,000 acres in 2010 to 1.35 million acres in 2015. This is partially due to more available varieties that can be successfully grown in our climate. An increase in excess moisture in certain areas of the province, and the resilience of soybeans under these conditions is likely to have also accelerated the uptake of soybeans.

The majority of soybean loss during harvest (estimated at 80%) occurs at the header. Soybeans are much lower on the stem than most other agricultural crops in Manitoba, and slow speeds and a floating or flexible cutter bar with automatic header height control are essential for reducing losses. Cutting should be done as low to the ground as possible while avoiding mechanical damage, as the best beans are often the lowest on the stem.

Harvest losses in soybeans remain relatively high at an average of 10%, sometimes reaching as high as 15-20%. This represents a significant profit loss and creates a larger volunteer seed bed and additional management costs the following year. Any effort to decrease the number of beans left behind in the field can make a substantial difference on the economic gain of the operation. Two harvest factors that can have a large effect on losses are the type of header used, and the ground speed of the combine at harvest.

Harvesting soybeans can be done with either an auger or draper header. Air reels are sometimes fitted onto these headers to further reduce losses. An air reel uses a high velocity air stream to push the crop to the augur, or onto the draper belt, to avoid bunching and decrease the number of beans dropping to the ground. Air reel manufacturers claim to increase yields by 1-4 bu/ac. The purpose of this project is to quantify the difference in yield between an auger header with and without an air reel.

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2 Michigan State University Extension
3 North Carolina Cooperative Extension Service
4 Crary Air Reel Brochure
3. Project Description

Dekalb 2410 soybeans were seeded in the spring by the cooperating producer near East Selkirk. Crop production was carried out as per the cooperating producer’s normal soybean management strategy. Near harvest time, the field was assessed for a uniform area to perform the harvest trial. The quality of the plan stand was variable due to drown out and excess moisture. An area of 20 acres was selected for the trial.

Treatments consisted of combinations of four harvest speeds and two headers, for a total of 8 treatments. Speeds used were 2, 3, 4, and 5 miles per hour, and headers included an auger header with no air reel (Auger NA) and an auger header equipped with an air reel (Auger A). The headers are shown in Figure 1 and Figure 2. Both auger headers were 35’ in width.

Figure 1. Auger header equipped with an air reel
Prior to harvest, 958 loss samples were taken throughout the field to determine seed losses unrelated to harvest activities. These samples were taken by randomly placing one half of a sample square on the ground, and completing the square with the other half to avoid damaging plants and knocking off any seeds or pods (Figure 3). Together, the two halves created a square foot of area. The number of seeds, pods, and seeds in dropped pods were recorded for each square. The number of stems in each square was also recorded, in order to determine the density of the plant stand (Figure 4).
Figure 4. Counting stems in this pre-harvest loss sample

Plots were marked out in a randomized block pattern to ensure variability was constant throughout the trial. Four replications of each plot were marked. Each replication was 50’ wide to allow for excess crop on either side of the header after cutting. Trial layout is depicted in Appendix A. Thirty-two samples were also taken of the height of the lowest pod on the stalk from the ground.

Harvest took place on October 15 with a John Deere S690. Each pass was marked out with colour-coded flags to clearly identify which treatment had been completed. The speed was varied throughout each treatment to correspond with the plot map to achieve all 8 plot treatments.

A minimum of forty loss samples were taken per plot. Loss samples were taken with metal squares that were manufactured to be exactly one square foot. Four seeds per square foot were considered to represent 1 bu/ac loss\(^5\). The square was thrown randomly throughout the plot in an attempt to gain a representation of losses throughout the plot. Ten feet at the beginning and end of the plot were not sampled in order to avoid areas where the combine may have been changing speed between plots. Losses counted included any seeds that were in the square, whether loose, in dropped pods, on lodged stalks, or remaining on cut stubble. Seed losses were separated into the following categories:

- Loose seeds
- Dropped pods, and seeds in dropped pods
- Lodged stalks, pods on lodged stalks, and seeds in pods on lodged stalks

\(^5\) Manitoba Pulse and Soybean Growers
- Pods on cut stubble, and seeds in pods on cut stubble
- Total seeds in sample square

These categories were used to understand if certain types of loss were more prevalent with certain harvest methods, or certain speeds. Cut stubble, dropped pods, a lodged stalk, and loose seed losses are depicted in Figure 5. The straw chopper was not used in order to avoid counting threshing losses in with header losses.

![Figure 5. Loose seed, cut stubble, lodged stalk, and dropped pod losses](image)

Collected data was put through an ANOVA program to ensure sufficient samples had been collected for meaningful conclusions. Though loss sampling was random, areas of obviously low plant density due to moisture, or of excessively high loss due to combine plugging or operator error were avoided for sampling.
4. Results

Pre-harvest loss observations showed that throughout the field, average seed loss was 0.15 seeds/ft$^2$ (0.0375 bu/ac) with an average plant density of 3.73 plants/ft$^2$ (162,479 plants/ac). The average height of the lowest pod was 3.34". All results presented in this section as bu/ac have been adjusted to account for pre-harvest losses. Four replications of each Auger A and Auger NA treatment were included in the data analyzed. Variability within replications on this project was high, but due to a high number of samples taken, an ANOVA analysis shows that results are valid.

Data for this trial was not considered to have a normal distribution due to large amounts of zeros in the data (many sample squares contained no losses, or no losses of a particular kind). The quantification of seed loss was determined through an ANOVA analysis with Minitab and a chi-squared analysis confirmed the significance of these results.

4.1 Speed

When data was analyzed purely based on the ground speed of the combine, speed appeared to make little difference in overall seed losses except for the fastest speed (5 mph) when total seed losses rose significantly. There was no statistical difference between total losses due to speed at 2, 3, and 4 mph.

Examining specific loss categories, data shows that losses from lodged stalks were significantly higher at 5 mph compared to 2 mph, but there were no other significant differences. This is also true for losses due to dropped pods. There was no statistical difference between losses at different speeds for losses due to loose seed, or from seeds on uncut stubble.

Results are summarized in Table 1.

Table 1. Various losses based on combine ground speed

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<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3.15</td>
<td>1.89</td>
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<td>0.05</td>
<td>5.46</td>
<td>1.36</td>
</tr>
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<td>3</td>
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<td>2.33</td>
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<td>0.20</td>
<td>6.50</td>
<td>1.59</td>
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<td>0.44</td>
<td>0.29</td>
<td>6.12</td>
<td>1.49</td>
</tr>
<tr>
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<td>3.65</td>
<td>3.87</td>
<td>1.09</td>
<td>0.24</td>
<td>8.86</td>
<td>2.18</td>
</tr>
</tbody>
</table>

$^6$ Assuming 4 seeds/ft$^2$ is equivalent to 1 bu/ac loss (Manitoba Pulse and Soybean Growers). Adjusted to account for 0.0375 bu/ac pre-harvest losses.
4.2 Header

When data is analyzed based purely on the header type used, the Auger NA treatments sustained significantly higher seed losses compared to Auger A treatments. Losses due to loose seeds and seeds in dropped pods were significantly higher in the Auger NA treatments. There was no statistical difference between losses due to seeds on cut stubble or seeds on lodged stalks.

Overall loss data is given in **Table 2**.

**Table 2. Various losses based on harvest header**

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Auger (No Air)</td>
<td>4.67</td>
<td>3.46</td>
<td>0.85</td>
<td>0.24</td>
<td>9.23</td>
<td>2.27</td>
</tr>
<tr>
<td>Auger (With Air)</td>
<td>1.97</td>
<td>1.62</td>
<td>0.49</td>
<td>0.15</td>
<td>4.23</td>
<td>1.02</td>
</tr>
</tbody>
</table>

$^7$ Assuming 4 seeds/ft$^2$ is equivalent to 1 bu/ac loss (Manitoba Pulse and Soybean Growers). Adjusted to account for 0.0375 bu/ac pre-harvest losses.
5. Discussion

The slowest speed in this trial (2 mph) resulted in the lowest losses. However there was no statistical difference in losses between speeds 2, 3, or 4 mph. This indicates that travelling at any of these speeds will likely result in similar losses, despite the quantitative differences seen in this particular trial. Increasing speed beyond 4 mph appears to result in exponential losses. Therefore, slower speeds will minimize harvest losses, but there is a reasonable threshold of speed where losses will not differ significantly. It is likely that the trend of increasing losses at higher speeds would continue exponentially. Figure 6 shows the relationship between harvest speed and soybean losses for loss categories, and total seed loss.

![Figure 6. Seed losses as related to combine ground speed](image)

In 2016, Manitoba producers seeded 1.6 million acres of soybeans. We can use this number to compare the difference in profit loss if harvest is completed at optimal speed compared to the speed with the highest losses in this study. Based on the data collected here, slowing harvest speeds from 5 mph to 2 mph, soybean producers in Manitoba would collectively increase annual revenue by $13,560,000 ($8.48/ac). Even decreasing speeds from 5 to 4 mph would result in savings of $10,920,000 ($6.83/ac). The relationship between harvest speed and potential loss in on-farm revenue is shown in Figure 7.
Figure 7. The effect of harvest speed on losses on foregone profit

The choice of header used at harvest appears to have a significant effect on overall harvest losses. In this trial, an auger with an air reel reduced losses by approximately 55% compared to an auger header with no air reel. This ratio remained true for most types of losses, as an air reel reduced losses due to loose seeds, dropped pods, seeds on cut stubble, and lodged stalks by approximately half. Losses related to header choice are shown in Figure 8.

Figure 8. Seed losses as related to harvest header

In 2016, Manitoba producers seeded 1.6 million acres of soybeans. We can use this number to compare the difference in profit loss based on the header chosen. Based on the results of this study, soybean producers in the province could collectively regain $20,000,000 ($12.50/ac) if all producers moved from auger headers without air reels to
auger headers with air reels\textsuperscript{8}. The relationship between header type and potential loss in on-farm revenue can be seen in Figure 9.

![Figure 9](image)

**Figure 9.** The effect of header choice on harvest losses, and therefore foregone profit

These results represent one replicated season of data on one variety of soybeans. Further replication of this study would improve the accuracy in quantifying the difference in losses between different headers and harvest speeds or locating the speed threshold where losses begin to increase exponentially. Trends are likely to remain similar (e.g. increasing losses with increasing speed) but accuracy in quantifying these trends will improve with further trials.

Much of the variability between replications and samples was due to the nature of the losses. A sample square containing one or more lodged plants significantly increased the number of total lost seeds due to the large number of pods and seeds on the plant, compared to a sample square where only loose seeds or dropped pods were found.

This study shows that simple variables such as header choice or harvest speed can have significant effects on overall harvest loss. These variables should be optimized for each operation to ensure harvest losses are minimized to avoid forfeiting potential profit. There is substantial opportunity to improve soybean harvest efficiency in the province.

\textsuperscript{8} Assuming a price of $10/bu.
6. **Conclusion**

The purpose of this project was to evaluate the effect of ground speed and header choice on header losses during harvest. Speeds of 2, 3, 4, and 5 mph were tested as well as an auger header with and without an air reel. Four replications of each treatment were performed for a total of eight treatments and thirty-two replications.

This study has shown that harvest speed and header type can have a significant effect on harvest losses. An auger header equipped with an air reel resulted in just over half the losses (1.02 bu/ac) when compared with an auger header with no air reel (2.27 bu/ac) with a difference of 1.25 bu/ac. At a price of $10/bu, this resulted in the air reel providing a savings of approximately $12.50/ac when compared with an auger header without an air reel.

Optimal speed to prevent header losses was found to be between 2-4 mph. Increasing harvest speed above 4 mph caused an exponential increase in losses. In this trial, increasing harvest speed from 2 to 5 mph resulted in increased losses of 0.85 bu/ac ($8.48/ac). Increasing speeds from 2 to 4 mph allows for doubling harvest speed without incurring significant losses from a statistical standpoint, as there was no significant difference between losses at 2, 3, or 4 mph.

Additional years of data are important in confirming quantification of losses for a more accurate cost comparison. Inclusion of a draper header, and/or a draper header with an air reel for comparison would also provide valuable information in future studies as well. There is significant opportunity to increase on-farm revenues through optimization of soybean harvest in the province.
Appendix A

Trial Layout

40 samples per plot

- Speed 1
- Speed 2
- Speed 3
- Speed 4

- Test
- Auger With Air
- Auger Without Air
For further information with regards to this report, please contact
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