Project No. A19108W
Date: February 2021

Final Report

Benchmark Testing in Wheat using a John Deere X9 1100 with HD50R and a CLAAS Lexion 8800 with MacDon FD145

For:

John Deere Harvester Works
East Moline, Illinois

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1. Executive Summary

Combine benchmark testing was conducted by the Prairie Agricultural Machinery Institute (PAMI) and only permits this report to be reproduced in its entirety. No summary data or excerpts of this report may be disseminated.

John Deere Harvester Works (the Client) contracted Prairie Agricultural Machinery Institute (PAMI), to provide combine benchmark testing between John Deere's Class 10 combine (X9) and a Class 10 CLAAS Lexion 8800 series combine.

The testing was conducted between September 19 and October 2, 2020, in a test field near Marsden, Saskatchewan, Canada. The test field consisted of a half section seeded to AAC Viewfield, a Canada Western Red Spring Wheat (CWRS) variety, in the direction of east to west. The field consisted of mostly large, flat, uniform areas that were ideal for testing.

The three focus areas of the benchmark testing for this project were loss curve testing, fuel consumption, and residue management.

The results from the loss curve testing showed that the John Deere X9 reached a throughput of 115 tonnes/h (254,000 lb/h) at a 1% total loss threshold; the CLAAS 8800 throughput was less than that at 90 tonnes/h (198,000 lb/h) at the same loss threshold percentage. When comparing relative combine capacity, the John Deere X9 had 28% higher capacity to that of the CLAAS 8800 at a 1% total loss threshold. Both combines were tested to approximately 150 tonnes/h (330,000 lb/h) where both combines became power limited at this throughput level.

Both combines were found to be separator-loss limited in the conditions tested. The CLAAS separator losses increased at a higher rate than that of the John Deere, and cleaning shoe losses remained below 1.0% on the CLAAS and at or below 0.5% on the John Deere throughout the entire range of feed rates tested.

Results of fuel consumption testing showed significant differences between combines when considering certain metrics. It should be noted that the header sizes as tested were not the same width for both combines. Fuel usage with respect to time showed that the John Deere used 19% more fuel per hour than the CLAAS. However, when considering grain throughput, the John Deere was tested at a 20% higher throughput and 17% higher field capacity than that of the CLAAS. In terms of specific fuel consumption, both combines were shown to be very similar (no statistical difference), where the combines averaged 2.00 and 2.01 L/tonne (1.44 and 1.45 gal/100 bu) for the John Deere and CLAAS, respectively. To make comparisons easier, this metric normalizes factors such as throughput and fuel usage.

After residue management testing was completed, the results showed statistically significant differences in the ability of each combine to distribute crop residues evenly over the full width of the harvest. The John Deere combine was found to have an advantage when distributing residues, depositing material more uniformly across the width of the header than that of the CLAAS combine, which is shown by a lower CV value of 33.3 in comparison to 73.0 for the CLAAS.

When averaged over the entire header width, the overall chop quality results did not indicate a significant difference between combines. The John Deere was found to have slightly more fine-class material than middle- and coarse-quality classes relative to that of the CLAAS combine; however, these variances are not considered to be statistically significant.

Some differences were noted when evaluating crop residue sizing distribution between combines. The CLAAS combine deposited less coarse material on the outer section and more on the inner, where all other sections were found to be relatively even. The John Deere was shown to deposit more fine material over the two center sections, where the remaining areas had a relatively uniform distribution of the quality classes.

Combine configuration, setting, and operation was led by PAMI; however, John Deere representatives were present to assist with optimization of the John Deere combine. Experienced PAMI personnel was responsible for optimizing the CLAAS combine, as no manufacturer representatives were present at any point during optimization or testing.

2. Introduction

John Deere Harvester Works (the Client) of East Moline, Illinois, contracted the Prairie Agricultural Machinery Institute (PAMI) of Humboldt, Saskatchewan, to conduct combine benchmark testing between John Deere's latest Class 10 combine (X9) and a Class 10 CLAAS Lexion 8800 series combine.

The goal of this testing was to directly compare performance results from the two combines in typical harvesting conditions in wheat in Western Canada. Data was collected and analysed to calculate the following harvesting performance parameters:

- Combine capacity (loss testing)
- Fuel consumption
- Residue management

Benchmark testing occurred between September 19 and October 2, 2020, in a test field near Marsden, Saskatchewan, which consisted of a half section seeded to AAC Viewfield, a Canada Western Red Spring Wheat (CWRS) variety. The field consisted of mostly large, flat, uniform areas that were ideal for testing.

PAMI has forty-five years of experience testing harvesting equipment in various locations worldwide with a specialty in Western Canadian crops and conditions. PAMI has developed a specific procedure for benchmarking combines and has the specialized equipment, expertise, and third-party impartiality to provide accurate, meaningful data to the Client.

Although this project was funded by the Client, PAMI conducted the tests as an independent agency with full control of the testing and data. Combine configuration, setting, and operation, was led by PAMI; however, Client representatives were present to assist with optimization of John Deere combine performance. Experienced PAMI personnel were responsible for optimizing the CLAAS combine, as no manufacturer representatives were present at any point during optimization or testing. It is also important to note that for this project, the field testing was conducted in one field condition per crop; therefore, the test results may not represent performance in all crops and/or conditions.

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3. Test Procedure

The following subsections detail the test procedure used for combine benchmark testing in wheat between September 19 and October 2, 2020.

3.1 Equipment

The following equipment was used in the combine benchmark tests:

- The test combines used are shown in **Figure 1**.
  - John Deere X9 1100 with 15.2 m (50 ft) John Deere HD50R Flex Draper Header
  - CLAAS LEXION 8800 with 13.7 m (45 ft) MacDon FD145 Flex Draper Header
- PAMI combine test equipment
  - Processor
  - Collector
  - Moisture Meter
  - Aluminum drop pans
  - Remote drop pans
  - Forage separator

Figure 1. John Deere X9 (top) and CLAAS Lexion 8800 (bottom) towing collector during loss curve testing.

3.2 Combine Settings Optimization Procedure

Prior to optimizing settings, both combines were configured for harvesting wheat as per the combine manufacturer's recommendations (operator's manual). The combines were then fully optimized for typical producer throughput at the target total loss rate of 1% using PAMI equipment and methods. As well, each combine was started and allowed to run for a period of time to clean internal surfaces of rust, excess paint, or anything else that may impede smooth operation. The engine and threshing hours of each machine prior to testing were recorded and are shown in **Table 1**.

Table 1. Threshing hours of each machine prior to testing.

Combine	Engine hours	Threshing Hours
John Deere X9	40	9
CLAAS LEXION 8800	61	6

The procedure to optimize each combine began by using the manufacturer recommended settings as stated in the operator's manual. If settings were given as a range, the value that would result in the least amount of loss was initially selected (i.e., widest sieve opening and smallest concave gap).

Loss data was then collected using the combine loss testing equipment (collector and processor) to quantify the grain loss associated with the test combine's separator and cleaning shoe. The grain tank sample quality (amount of material other than grain [MOG] and grain damage in sample) was also monitored to ensure each combine had a similar and acceptable sample. If grain loss was found to be higher than acceptable on either the separator or cleaning shoe, settings were changed on each system accordingly. This included making changes to concave gap or rotor speed to reduce separation loss and changes to both the chaffer and bottom sieve openings as well as fan speed to reduce grain loss on the cleaning shoe. It is important to note that all automatic combine setting features were turned off during the optimization procedure and during testing.

Residue management and fuel consumption testing were conducted prior to loss curve testing and therefore the combines were optimized by using drop pans rather than the combine test equipment, all other above steps were similar.

The optimized combine settings used in loss curve testing can be found in **Table 2**, while the optimized combine settings used in fuel consumption and crop residue management testing can be found in **Table 3**. A full list of the combine configurations can also be found in **Appendix A.**

Table 2. Combine settings used for loss curve testing.

Combine Setting	**John Deere X9**	**CLAAS LEXION 8800**
Chaffer Sieve mm (in)	19 (3/4)	18 (23/32)
Lower Sieve mm (in)	8 (5/16)	7(9/32)
Fan Speed (rpm)	1060	1300
Rotor Speed (rpm)	1120	970
Threshing Cylinder Speed (rpm)	NA	700
Concave clearance mm (in)	10 (13/32)	13 (17/32)
Vane Position	Fixed	Fixed
Separator Blank Out Plates	Installed All (2/2)	2/4 Closed
Threshing Blank Out Plates	Installed	NA
Disawning Plates	NA	Closed
Concave Bar Position	NA	Engaged

* Note: chopper/spreaders were removed for loss curve testing and therefore settings are not shown.

Table 3. Combine settings used for fuel consumption and residue management tests.

Combine Setting	**John Deere X9**	**CLAAS LEXION 8800**
Chaffer Sieve mm (in)	18 (23/32)	17 (22/32)
Lower Sieve mm (in)	7 (9/32)	7 (9/32)
Fan Speed (rpm)	900	1300
Rotor Speed (rpm)	960	950
Threshing Cylinder Speed (rpm)	-	660
Concave clearance mm (in)	14 (18/32)	14 (18/32)
Vane Position	Fixed	Fixed
Separator Blank Out Plates	NA	Closed 4/4
Threshing Blank Out Plates	Installed	NA
Disawning Plates	NA	Engaged
Concave Bar Position	NA	Disengaged
Chopper Speed	High	High
Spreader Speed	Max	Max
Crop Deflector Position	50% Width	Max Width
Spreading Wind Compensation	*Adjusted 1 Position Off Center	Auto Compensated
Friction Plate	NA	Disengaged
Knife engagement Position	Full	Full

* Adjusted into the wind one position out of five.

3.3 Loss Curve

The purpose of this test was to directly compare the capacity performance of a John Deere X9 1100 combine to a CLAAS Lexion 8800. Loss curve testing was conducted using PAMI's unique combine test equipment including a collector, processor, and tandem grain truck equipped with scales. Testing was conducted in wheat near Marsden, Saskatchewan, Canada.

3.3.1 Combine Loss Collection Procedure

PAMI's grain loss testing equipment consists of a collector and processor, which when used together, collect the discharged material from the rear of the combine over a set distance and separate the grain loss from the MOG. A typical collection point can be seen in **Figure 2** where the test combine has come to a stop; the collector hitch has extended and the processor is beginning to process the material from the collector belts.

Figure 2. Loss curve testing collection point.

The collector is towed behind the test combine and collects all material discharged from the rear of the combine. The combine harvests for at least 30 seconds to reach a steady state at a given feed rate. During this time, material from the combine's separator is conveyed on the top "straw belt", while material from the cleaning shoe is conveyed on the lower "chaff belt" of the collector. It should be noted that the choppers and spreaders are removed to facilitate the collection of straw and free grain.

When the test combine operator believes the combine has reached a steady state, the "start test" button on the collector controller is pressed and the test process begins. The collector travels a distance equivalent to one half rotation of its belts (9.0 m [29.5 ft]) before the belts stop and the hitch extends away from the discharge area of the combine. The operator then stops the test combine and the material on each collection belt is weighed. The material on each belt consists of MOG and grain loss. These weights, the time it took for a collection, belt length, and belt speed-to-ground speed ratio are recorded on the loss spreadsheet along with known values of crop yield and header width.

Crop yield was calculated by weighing the harvested grain at each collection point. With the known header width, distance travelled, and grain weight, the yield was calculated for each collection point rather than an average over the field. The weight was taken by unloading the test combine into the tandem grain truck outfitted with load cells after each point.

Once the belt gross weights were recorded, the chaff belt was unloaded into the processor, which recleans and, as necessary, rethreshes the crop material from the belt. Through a pneumatic retrieval system, the free grain and previously unthreshed grain were delivered separately to the processor cab. The grain loss was then weighed and recorded as free grain and as unthreshed grain loss. The reclean procedure was then repeated for the straw belt. Once both belts were empty, a tare weight was taken to get a net MOG (and grain loss) weight for the collection.

This process was repeated six to eight times at varying feed rates to create a grain loss curve. Note, the order in which the combines were tested was switched between test days to reduce the effect of changing crop condition on the results. The process to determine the target feed rates that would most effectively build a loss curve was similar for each combine. The first four collection points were used to fill in the majority of the curve by targeting feed rates of approximately 40, 60, 90, and 120 tonnes/h (88,000, 132,000, 198,000, and 265,000 lb/h). Another collection point was collected at the combine’s approximate maximum throughput (100% engine load or other harvest limitations) to achieve a high loss/high throughput point. The remaining collection points targeted specific ground speeds to achieve better resolution in areas of the curve where the rate of grain loss was changing rapidly.

To maintain optimum processor performance, settings were adjusted to the specific crop and field conditions. To verify the performance once the processor was set for wheat, a 1,000 g sample of free grain was allowed to run through the processor, and the retrieved grain was weighed. Multiple repetitions were conducted and resulted in a grain retrieval rate of approximately 96%.

Grain moisture samples were also collected throughout testing to obtain an average grain moisture content during each test day.

The above loss collection procedures were completed in reference to the ANSI/ASEA standard (S396.3 – Combine Capacity and Performance Test Procedure).

3.3.2 Loss Curve Creation

The data from the loss collection procedure was used to create loss curves, which allows head-to-head comparisons between combines. Data from each collection point was plotted on a graph that compared grain loss to feed rate. Typically, six to nine points are collected to create a curve. The grain loss is presented as a percentage of grain yield to reduce the effect of a variable yield. The feed rate can be presented as either MOG, grain, or total feed rate dependent on the crop, conditions, and results.

Once the points are plotted for each test combine, a line of best fit is laid out, typically an exponential or second-order polynomial. From there, a loss limit is set at which the capacity of the combines can be compared. The limit is dependent on the grain being harvested; in this case in wheat, the loss limit was compared at 1% total loss, as per the ANSI/ASAE standard (S343.4 – Terminology for Combines and Grain Harvesting).

MOG-to-grain ratios, MOG yield versus grain yield, and yield variations through the field, are metrics used to verify the quality of the data. Loss points that deviate significantly from the curve can be removed if they are deemed to be outliers. Outliers can occur due to machine malfunction, test equipment malfunction, significant crop condition changes, or a number of other reasons. If the points are removed, reasons for removal are provided.

3.4 Fuel Consumption

The objective of this testing was to directly compare the fuel consumption performance of a John Deere X9 combine to a CLAAS LEXION 8800 combine. All testing was conducted using test equipment from PAMI, including auxiliary fuel tanks, fuel plumbing systems and a grain truck equipped with load cells. Tests were conducted near Marsden, Saskatchewan, Canada, in wheat.

3.4.1 Test Procedure

Fuel consumption tests were conducted on both test combines, where three repetitions were conducted per combine in wheat.

The test procedure included operating each combine at near full engine load (90% to 100%), while harvesting a full header width for the entire test distance. To reduce any change in conditions between tests, the combines were tested side by side, in the same direction, and immediately after one another. The fuel consumption test included the fuel used to thresh the grain (unloading of the grain and headland turning were not taken into account).

To determine fuel use, an auxiliary fuel supply tank was weighed before and after each test. To utilize the auxiliary tank for measuring fuel use during the test, a valve was plumbed into the fuel line between the main tank and the engine. This valve switched the fuel supply from either the main fuel tank or the auxiliary tank. Similarly, a selector valve was plumbed into the return fuel line to direct return flow to either the main or auxiliary tank.

The auxiliary fuel tanks used were fuel tanks (**Figure 3**) equipped with quick couplers for easy attachment to the fuel supply and return lines.

Figure 3. Marine auxiliary tank on John Deere X9 1100 combine.

At the beginning of each test, the combine was positioned directly in front of the crop and a new GPS heading was created. The fuel line valves were then switched to the auxiliary tank. The combine thresher and header were engaged and the test start time was recoded using a stopwatch. The time spent idling before entering the crop (time for operator to engage the header, thresher, etc.) was also recorded, which was kept as consistent as possible between combines. This idle time was determined to be insignificant relative to the test length.

To ensure there was no residual grain or MOG in the combines, each combine exited the crop by approximately 3 m (10 ft) at the end of the run, while the separator remained engaged for ten seconds after the combine came to a complete stop. The operator then disengaged the separator, idled the engine down and switched the selector valves back to the combine tank. At this point, the fuel lines to the auxiliary tank were uncoupled and the fuel tank was weighed using a length of square tubing and a load cell. Once the fuel usage was determined at the end of each test, the harvested grain was unloaded into a tandem grain truck outfitted with weigh scales so the grain yield could be determined.

Prior to testing, variables that could have a significant effect on fuel consumption between combines were noted and were set similarly across both combines including chop quality, grain tank sample, grain loss, and grain damage.

Chopping quality was set similarly between both combines by adjusting the knife bank setting on the chopper. Crop residue samples were collected at this knife bank setting and processed through the forage separator to get chop quality results for each combine. It was determined that a fully engaged knife bank on both combines resulted in very similar chop quality; therefore, this position was used during testing.

To verify similar grain loss between combines, loss was measured for each by discharging straw and chaff into windrows and dropping loss pans (**Figure 4**). Both combines were tested at approximately 90% engine load (with chopper/spreaders engaged), which resulted in ground speeds of 3.7 and 3.8 mph (6.0 and 6.1 km/h) for the CLAAS and John Deere, respectively. The total feed rate can be approximated from loss curve testing conducted in the same field on September 27, 2020 (**Section 4.1**), at 90 and 115 tonnes/h (198,000 and 254,000 lb/h).

Figure 4. Collected loss in a drop pan.

3.5 Residue Management

The crop residue management results were effectively broken down into two sections: 1) chop quality, and 2) residue distribution; however, some comparisons were made to sizing distribution as well, which considers both sections. To determine if the crop residue management results were significantly different between combines, an analysis of variance (ANOVA) was used as well as the Tukey means separation test at a confidence level of 90%.

Prior to testing, all combine settings were optimized using remote drop pans to measure and reduce total losses. In addition, chopper and spreader settings were adjusted to obtain the best chop quality and residue distribution attainable. This included setting the stationary knife position to fully engaged, chopper speed to high, as well as optimally setting the spreader speed and residue deflectors to obtain the most uniform distribution.

3.5.1 Residue Distribution and Chop Quality Test Procedures

Crop residue management testing involved evaluating two main components of the combine crop residue system:

1. Residue distribution performance.
2. Chop quality performance.

To perform these evaluations, each combine was set to achieve the finest chop size and the most uniform distribution attainable (see **Section 3.2** for full combine settings).

To verify similar grain loss between combines, loss was again measured by dropping loss pans while discharging straw and chaff into windrows.
A test area was marked approximately 100 meters (330 ft) into the crop to allow the combines to reach steady state prior to collecting the residue samples. Each combine was tested side by side and immediately after the other to reduce the effect of crop variation during testing. Once the combines reached the test area, residue pans were physically placed behind the header as the combine moved past; in the center sections, remote drop pans were used to capture the residue samples. Finally, to ensure there was no overlap from one combine to another, approximately two rows of unharvested crop was left between each combine.

Ten sections for the John Deere (50 ft header) and nine sections for the CLAAS (45 ft header) were marked on each test area across the entire header width. All sections widths were measured at 1.5 x .50 m (5.0 x 1.5 ft) except for the center sections for both combines (two for the John Deere and one for the CLAAS); these sections were .25 x 1.5 m (.83 x 5.0 ft) and were simply multiplied by a factor for the analysis and comparisons to the other sections. The crop residue within each section was bagged and labeled. The crop residue from each section was then separated into three sizes using a forage separator (**Figure 5**):

- Long – 2.9 cm (1.1 in) round holes.
- Medium – 1.2 cm (.5 in) square holes.
- Short – all other material smaller than medium size.

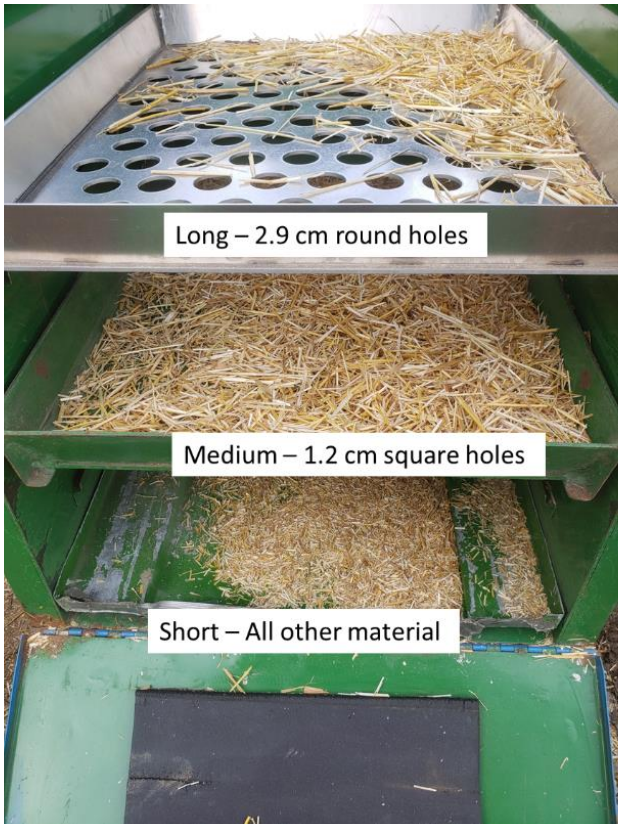

Figure 5. Forage separator showing three pan sizes.

The crop residue material in each of the three sizes was then weighed for each section so size distribution could be analysed across the entire header width (**Figure 6**). **Figure 7** shows the crop residue sorted into the three size classes.


Figure 6. Weighing crop residue material for size distribution analysis.

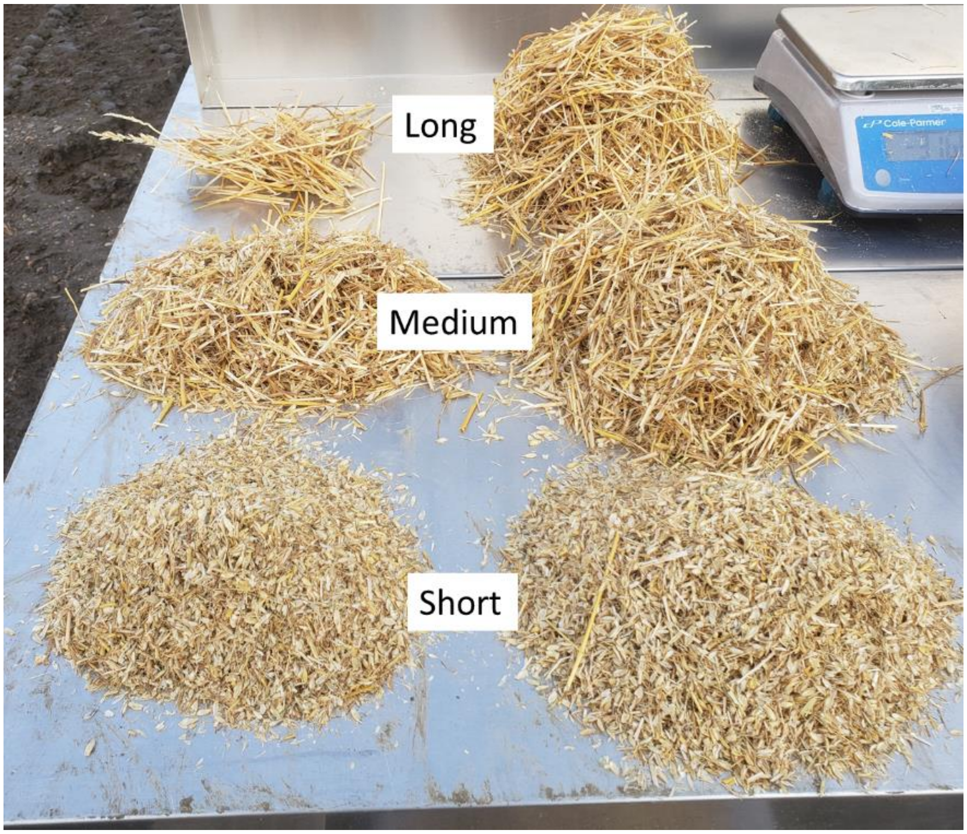

Figure 7. Residue sorted into three classes.

3.6 Limitation of Results

In general, the combines were tested in a similar crop/weather condition using the same testing procedures, such that testing could be conducted as fairly and in as controlled an environment as possible. However, there are always uncontrollable variables and uncertainties to consider. These variables are further apparent with field testing where environmental conditions cannot be controlled.

In addition, the results were collected from one crop, over one day, in one condition; therefore, the results will not represent performance in all crops or all conditions.

3.6.1 Loss Curve Testing

Combine configuration, setting, and operation was led by PAMI; however, John Deere representatives were present to assist with optimization of the John Deere combine. PAMI personnel with combine experience were responsible for optimizing the CLAAS combine, as manufacturer representatives were not present at any point during testing.

3.6.1.1 Processor Loss

To ensure optimum performance of the processor, settings were adjusted to the specific crop and field conditions. To verify the performance of the processor for wheat, a 1,000 g sample of free grain was put through the processor, and the retrieved grain was weighed. Multiple repetitions were conducted and resulted in a grain retrieval rate approximately 96%.

3.6.1.2 Collector Scales

As the collector was being used for field testing in an uncontrolled environment, there are several factors that can affect the scale readout, such as the slope of the terrain where the collector was sitting, wind, and belt positioning/tracking.

3.6.1.3 Approximations in Loss Curve Analysis

The methods used to analyse the loss curve data included using exponential or polynomial functions to approximate a best-fit curve. These functions are used to interpolate between loss points so multiple curves or combines can be compared at a specific grain loss or feed rate. As such, it is difficult to accurately predict values of loss along the curve, especially if the data points are variable and do not show a strong trend in the curve.

3.6.1.4 Field Variability

Comparing the combine's capacity at a percentage of loss rather than absolute loss helps remove some uncertainty from field variability in the analysis. Despite this, variability in grain yield and/or MOG yield over short distances can still affect the results. Since yield is measured as an average over the distance the combine travels during the point, the short actual collection time where the loss is collected may not completely represent the average yield. Since it is difficult to keep a constant feed rate into the combine, due to crop yield changes, a constant speed is the best approximation.

3.6.2 Fuel Consumption Testing

The method used to test the fuel consumption of each combine was designed to reduce the chance of human error and provide the most accurate results. Therefore, fuel usage across all combines was determined by strictly measuring for harvesting only (i.e., threshing the grain) and not accounting for the fuel required to turn at headlands or unload grain. In doing so, the results obtained can be used as a comparison across combines; however, the values do not actually represent realistic values that a producer would see, as unloading and turning at headlands are inherently part of the harvesting operation.

It should also be noted that fuel consumption tests were conducted to target an engine load between 90% and 100% as indicated by the combine display. The CLAAS combine displays engine load as a numerical value; however, the John Deere combine displays engine load on a bar graph with three zones: green, yellow, and red. To more accurately target engine load, ground speed was increased until engine speed decreased by approximately 50 rpm (upper yellow zone). However, the engine load could not be monitored as accurately, which could have an effect on test results.

Due to availability, the combine headers used during testing were not the same width (X9 was 10% wider), and although its effect on test results are considered minimal, it should be noted.

4. Testing and Results

The combine testing results are discussed in this section, where each test including loss testing, fuel consumption testing, and residue management testing was broken down into individual subsections.

Combine benchmark testing took place in two fields approximately 5 km (3 miles) northeast of Marsden, Saskatchewan (**Figure 8**), in a variety of CWSR wheat on September 27, 2020.

Figure 8. Test field shown, approximately 5 km (3 miles) northeast of Marsden, Saskatchewan.

Test field number one (Field 1) consisted of a half section (294 seeded acres) of a CWRS wheat variety, CDC Landmark VB, that was seeded east-west on May 3, 2020. The test field did have some draws and low-lying areas that needed to be avoided during testing but had many large areas that were flat and uniform. Test field number two (Field 2) was also a half section (307 seeded acres) of a CWRS wheat variety, AAC Viewfield, that was seeded north-south on May 5, 2020, and was very flat and uniform throughout. Both fields were desiccated prior to harvesting by applying 2.5 L/ha (1 Qt/acre) of 360 g/L glyphosate. The wheat test fields were desiccated on August 31, 2020, and September 2, 2020, for Fields 1 and 2, respectively.

Loss curve testing and residue management testing were conducted in Field 1, while fuel consumption testing was conducted in both Fields 1 and 2.

Overall, harvest conditions were favourable during all tests, with the wheat crop standing upright with no lodged plants, so crop feeding was not an issue when harvesting.

4.1 Loss Curve Testing

The objective of this testing was to directly compare the performance of the combines, by creating loss curves for each, allowing for measurement of their capacities at a given loss rate. Testing was conducted in wheat using combine test equipment (collector and processor) from PAMI.

4.1.1 Crops, Conditions and Test Location

Loss testing took place on the south-east corner of the test field (**Figure 9**) on September 27, 2020.

Figure 9. Satellite image showing location of wheat testing within the overall test field.

A summary of the weather conditions during crop residue management testing is detailed in **Table 4** (obtained from the airport weather station in Lloydminster, Alberta); the full weather data set can be found in **Appendix B**).

Table 4. Weather data during time of loss testing.

Test Day	Time	Temp		RH %	Wind			Condition
		°C	°F		(km/h)	(mph)	Direction	
27-Sep-20	1:00 PM	11	52	61	30	19	NNE	Overcast
	2:00 PM	12	54	62	30	19	NNE	Overcast
	3:00 PM	12	54	58	28	17	NNE	Overcast
	4:00 PM	12	54	58	28	17	NNE	Overcast
	5:00 PM	12	54	59	15	9	NNE	Overcast

All testing was conducted while harvesting from east to west, where some crop was left between each pass to ensure a full header width was obtained. Test paths were also placed between sprayer tracks (also running east to west) to reduce variations in crop yield. The average grain yield in the AAC Viewfield variety was 6.87 tonne/ha (102.1 bu/acre) and the moisture content averaged 15.9%.

To reduce the effect of changing crop conditions as much as possible, testing was conducted between 1:00 p.m. and 5:00 p.m. As can be seen in **Table 4**, weather conditions during loss curve testing were mostly overcast and windy on September 27.

4.1.2 Wheat Loss Testing Results

The CLAAS 8800 was evaluated first followed by the John Deere X9. The capacity of each combine was evaluated at a total grain loss level of 1% (obtained from ANSI/ASAE S343.4 – Terminology for Combines and Grain Harvesting).

The full set of raw data from loss testing can be found in **Appendix C**.

In addition, the combines were compared using total machine loss with respect to total feed rate, as well as a breakdown of separator and cleaning shoe performance. It should be noted that for the purposes of this report, the total machine loss consists of the separator and cleaning losses but does not include external losses such as header loss. The separator and cleaning shoe loss are discussed in terms of total feed rate.

The total grain loss for both test combines was evaluated as a function of total feed rate and this percent grain loss is plotted in **Figure 10**.

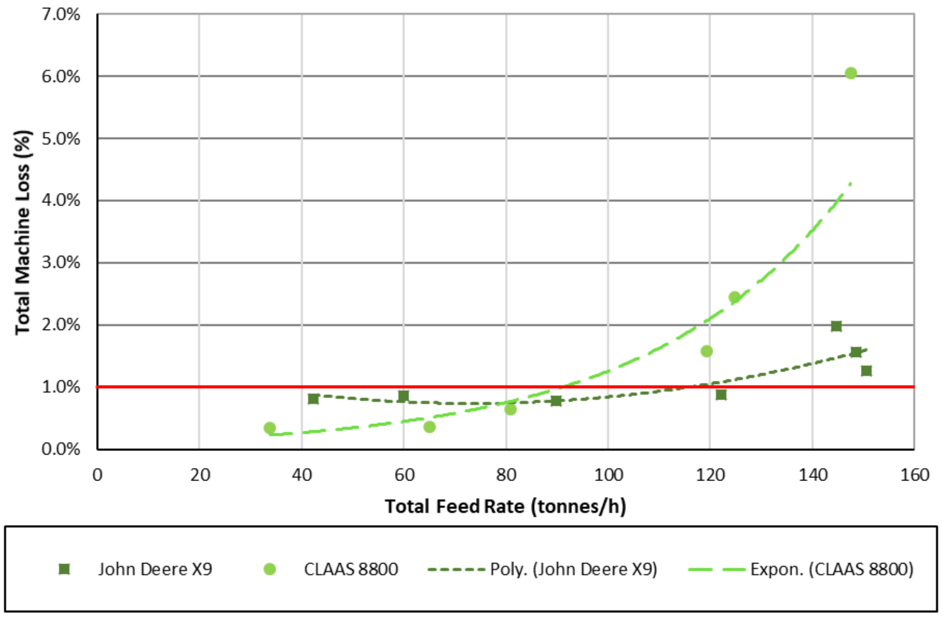

Figure 10. Total loss curves in wheat.

The results show a relatively flat curve on the John Deere that reached the 1% loss threshold at approximately 115 tonnes/h (254,000 lb/h), meanwhile the CLAAS curve reached the 1% loss threshold at approximately 90 tonnes/h (198,000 lb/h). The CLAAS curve was able to achieve lower losses in the lower range of throughputs but losses began to increase at a higher rate at the upper range of throughputs. Both combines reached a maximum throughput of approximately 150 tonnes/h (330,000 lb/h) in which both combines were power limited at this throughput level.

The grain loss associated with the separator was also graphed as a function of total feed rate as shown in **Figure 11.**

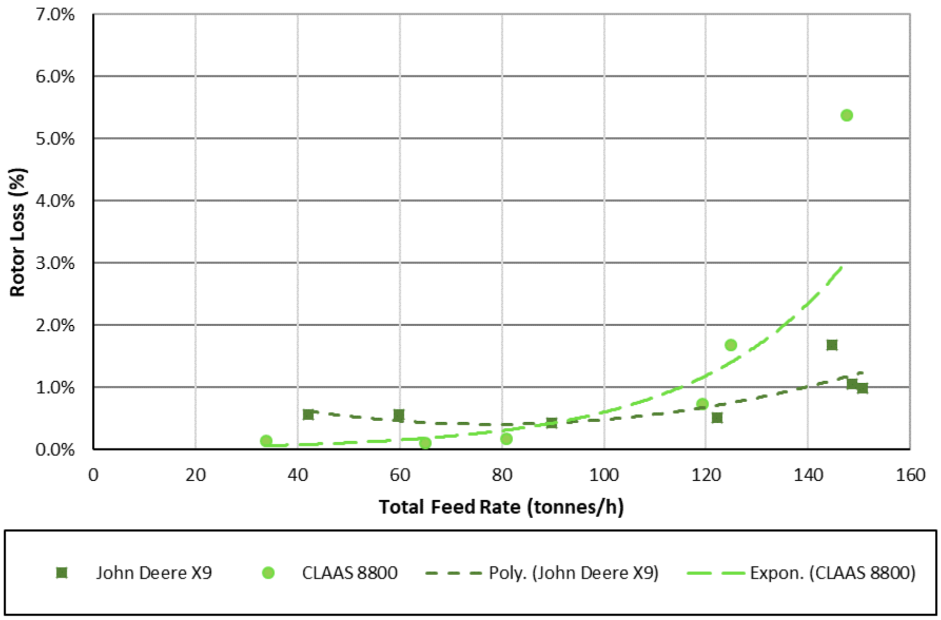

Figure 11. Separator loss curves wheat

The separator loss curves show a stable curve on the John Deere where rotor losses remained between 0.4% and 1.7% over the entire range of feed rates. The CLAAS curve showed a steady increase in losses with an increase in throughput, becoming unstable around 130 tonnes/h (287,000 lb/h) when losses begin to increase significantly. It should be noted that the CLAAS had lower loss levels than the John Deere until approximately 90 tonnes/h (198,000 lb/h).

Similarly, the cleaning losses were graphed as a function of total feed rate for both combines (**Figure 12**).

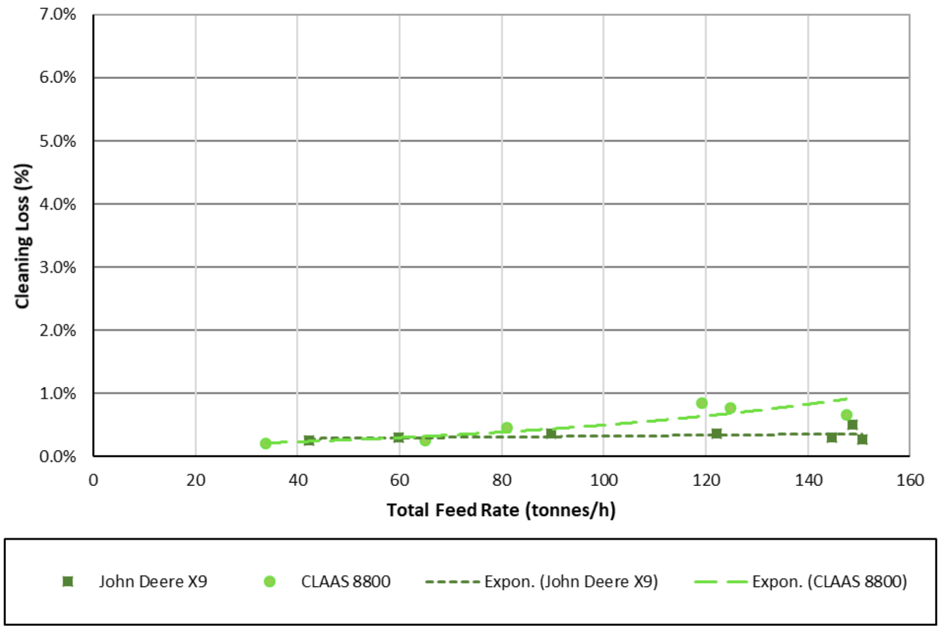

Figure 12. Cleaning loss curves wheat

The cleaning loss curves for both combines are relatively flat and remained between 0.2% and 1.0% loss throughput the entire range of feed rates. The John Deere curve does not show an increase in losses with an increase in feed rate, while the CLAAS combine had a slight increase in losses as feed rates were increased.

From the cleaning and separator loss curves it can be seen losses were dominated by separator losses at high throughputs but fairly balanced between the two systems at mid and low throughput ranges.

MOG-to-grain ratios were calculated for each test point and give an indication of variability of the test field. The John Deere MOG to grain ratios varied from 0.67 to 0.98 while the CLAAS varied from 0.60 to 0.92. Note, all of the MOG-to-grain ratios fit within the acceptable testing range for wheat according to the ANSI/ASAE Standard S343.4, which gives a range from 0.6 to 1.2. Further, crop yields were calculated over each test point and ranged from 5.79 tonnes/ha (86.1 bu/ac) to 7.54 tonnes/ha (112.1 bu/ac).

4.2 Fuel Consumption

The purpose of this testing was to directly compare fuel consumption performance of the John Deere X9 1100 to the CLAAS 8800 in wheat. All testing was conducted using test equipment from PAMI, including auxiliary fuel tanks, fuel plumbing systems, and a grain truck equipped with load cells.

4.2.1 Crops, Conditions and Test Location

Fuel consumption testing took place on the north side of Field 1 and the east side of Field 2 as shown below (**Figure 13**).

Figure 13. Satellite images of the two fuel consumption test fields located within the overall field.

To minimize the effect of changing crop conditions as much as possible, testing was conducted between 11:00 a.m. and 7:00 p.m. Weather conditions during fuel consumption testing was cool with a mix of sun and cloud.

A summary of the weather conditions during crop residue management testing is detailed in **Table 5** (obtained from the airport weather station in Lloydminster, Alberta); the full weather data set can be found in **Appendix B**).

Table 5. Weather data during time of fuel consumption testing.

Test Day	Time	Temp		RH %	Wind			Condition
		°C	°F		(km/h)	(mph)	Direction	
19-Sep-20	3:00 PM	19	66	59	8	5	NNE	Partly Cloudy
	4:00 PM	18	64	65	11	7	NNE	Partly Cloudy
	5:00 PM	17	63	68	4	2	NNE	Partly Cloudy
	6:00 PM	16	61	76	5	3	NNE	Partly Cloudy
	7:00 PM	14	57	83	9	6	NNE	Partly Cloudy
2-Oct-20	2:00 PM	17	63	35	24	15	NNE	Partly Cloudy
	3:00 PM	17	63	41	18	11	NE	Partly Cloudy

All testing was conducted while harvesting from east to west in Field 1 and north to south in Field 2, where some crop was left between each pass to ensure a full header width was obtained. Test paths were also placed between sprayer tracks to reduce variations in crop yield. The average grain yield in the AAC Viewfield variety was 6.0 tonne/ha (90 bu/acre) and the moisture content averaged 15.9%. The average grain yield in the CDC Landmark VB variety was 6.5 tonne/ha (95.9 bu/ac) and the moisture content averaged 14.5%.

4.2.2 Fuel Consumption Test Results

Fuel consumption testing was conducted on September 19, 2020, and October 2, 2020, in two varieties of CWSR wheat. Three repetitions per combine where collected between both varieties.

The fuel consumption data is presented in this section using tables and graphs; the raw data is available in **Appendix D**. Where appropriate, an analysis of variance (ANOVA) was used to determine if the differences found in the data were significant. For all statistical analyses, a 90% confidence level was used. In addition, a Grubb's outlier test was performed on the data collected to determine if any outliers existed; none were found.

The average specific fuel consumption results were graphed for each combine and shown in **Figure 14**.

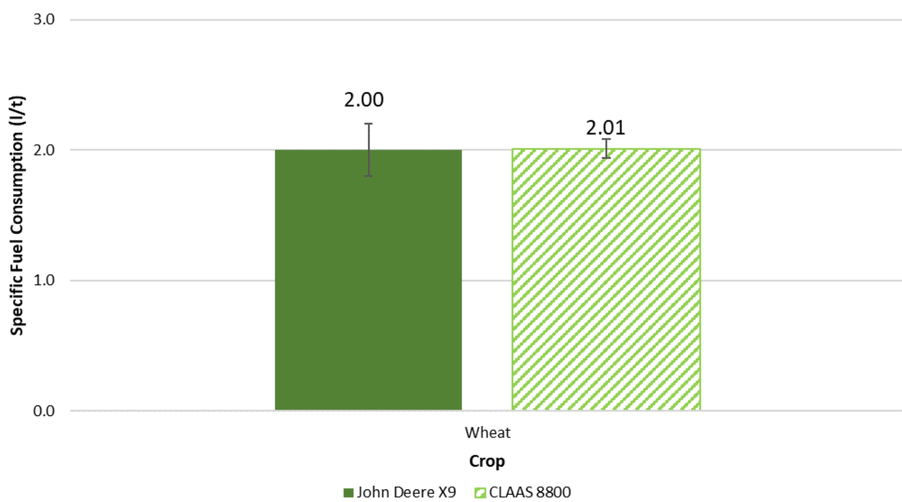

Figure 14. Average specific fuel consumption results.

The average specific fuel consumption rate was found to be very similar between combines where the John Deere and CLAAS averaged 2.00 and 2.01 L/t (1.44 and 1.45 US gal/100 bu), respectively.

The average fuel consumption rate with respect to time (litres per hour [L/h]) was also graphed for each combine as shown in **Figure 15**.

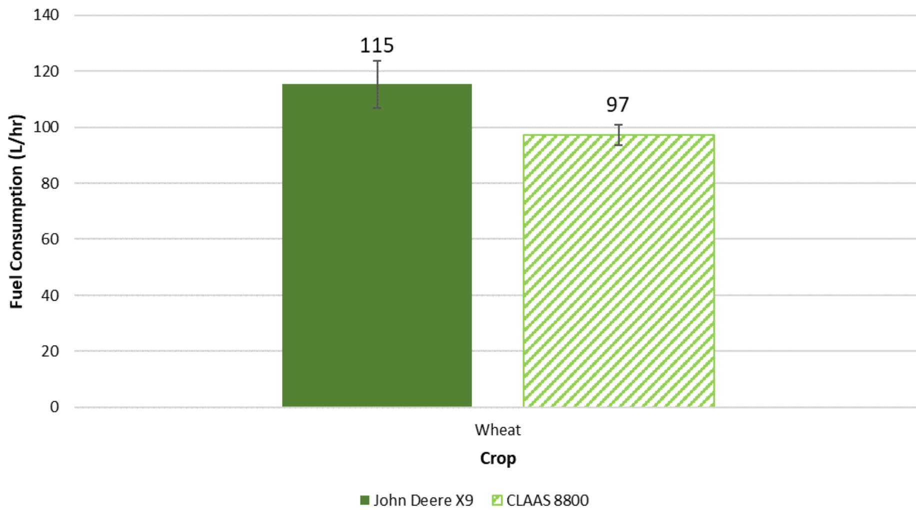

Figure 15. Average fuel consumption rates in L/h.

The average fuel consumption rate was found to be 115 and 97 L/h (30.5 and 25.7 US gal/h) for the John Deere and CLAAS, respectively. The results show a statistically significant difference between combines where the John Deere used 19% more fuel per hour than the CLAAS. It should be noted, that although the John Deere had a higher fuel consumption rate it also had a higher throughput and field capacity **(Table 6)**, which is why when compared using specific fuel consumption rate, the combines are very similar.

Table 6. Grain throughput and field capacity data.

	Grain Throughput		**Field Capacity**	
	t/h	bu/h	ha/h	ac/h
John Deere X9	57.9	2127	9.3	22.9
CLAAS 8800	48.4	1778	7.9	19.6
John Deere X9 compared to CLAAS 8800	120%[1]		117%[1]	

[1] Statistically significant at a 90% confidence level

The grain throughput results show the John Deere had a 20% higher throughput and a 17% higher field capacity than the CLAAS. Upon completing an ANOVA and Tukey test, it was determined that both differences between the John Deere combine and CLAAS combine showed a statistically significant difference.

Finally, the average fuel consumption rate with respect to area harvested (per hectare) was also determined for each combine as shown in **Figure 16** (L/ha).

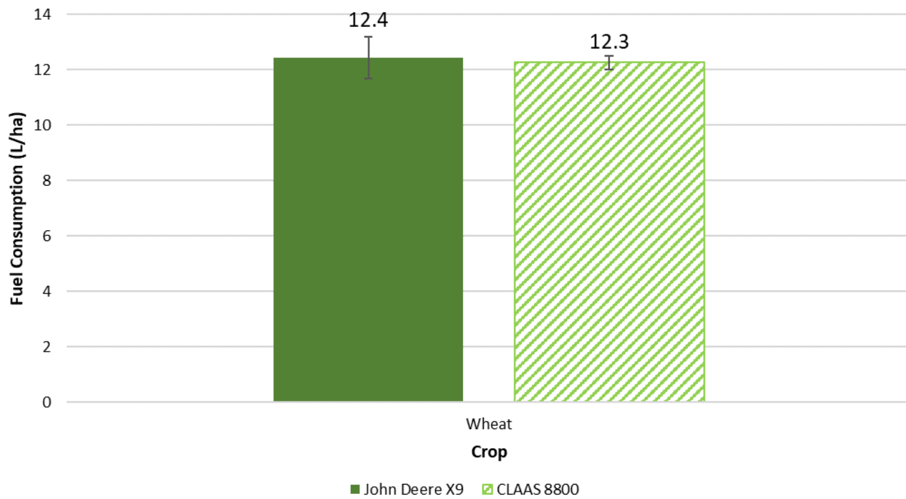

Figure 16. Average fuel consumption rate in L/ha.

The average fuel consumption rate was found to be 12.4 and 12.3 L/ha (1.3 and 1.3 gal/ac) for the John Deere and CLAAS combines, respectively. No statistical difference was found between combines.

A summary of the fuel consumption results discussed in the above section was tabulated and is shown in **Table 7**.

Table 7. Fuel consumption results summary.

Average Fuel Use in Wheat										
	Specific Fuel Consumption		Fuel Consumption Rate				Grain Throughput		Field Capacity	
	L/t	US gal/100 bu	L/h	gal/h	L/ha	gal/ac	t/h	bu/h	ha/h	ac/h
John Deere X9	2.00	1.44	115	30.5	12.4	1.3	57.9	2,127	9.3	22.9
CLAAS 8800	2.01	1.45	97	25.7	12.3	1.3	48.4	1,778	7.9	19.6
John Deere X9 compared to CLAAS 8800	99%[2]		119%[1]		101%[2]		120%[1]		117%[1]	
P-Value	0.954		0.009		0.721		0.026		0.001	

[1] Statistically significant at a 90% confidence level
[2] Not statistically significant at a 90% confidence level

4.3 Residue Management

Residue management testing was conducted to directly compare the chopping and spreading performance of the John Deere X9 against the CLAAS 8800. This testing was conducted using drop pans and a forage separator to collect and size the residue.

4.3.1 Crops, Conditions, and Test Locations

A summary of the weather conditions during crop residue management testing can be seen in **Table 8** (obtained from the airport weather station in Lloydminster, Alberta); the full weather data set can be found in **Appendix B**). This weather range covers the time from combine loss checks until crop residue management testing:

Table 8. Weather data during time of residue management testing.

Test Day	Time	Temp		RH %	Wind			Condition
		°C	°F		(km/h)	(mph)	Direction	
19-Sep-20	3:00 PM	19	66	60	7	4	NW	Mainly Clear
	4:00 PM	18	64	65	12	8	N	Mainly Clear
	5:00 PM	17	63	68	3	2	N	Cloudy
	6:00 PM	16	61	76	7	4	NNE	Not available
	7:00 PM	14	57	83	9	6	NNE	Not available

All testing was conducted while harvesting east to west, where some crop was left between each pass to ensure a full header width was obtained. Test paths were also placed between sprayer tracks (also running east to west) to reduce variations in crop yield. The average grain yield in the AAC Viewfield variety was 6.0 tonne/ha (89.8 bu/acre) and the moisture content averaged 15.9%.

The location of grain quality testing within the test field is outlined in the satellite image shown in **Figure 17**.

Figure 17. Specific test location for residue management testing within the overall test field.

4.3.2 Crop Residue Management Results

The results of the crop residue management tests conducted on September 19, 2020, are discussed in this section. The results were broken into two main areas of performance: crop residue distribution and chop quality.

Where appropriate, an analysis of variance (ANOVA) and the Tukey means separation test were used to determine if differences in the data were significant. For all statistical analyses, a 90% confidence level was used.

The residue distribution performance was evaluated by measuring how evenly each combine could distribute the crop residue over the header width, while chop quality was evaluated by sizing the crop residue and making a comparison between combines. For the full raw data set see **Appendix E**.

Crop distribution was analysed by plotting the percentage of residue weight (based on the total residue across the entire header width) in each of the sections across the entire header width for both combines. **Figure 18** shows the average crop residue distribution for both combines (across three repetitions) across each section.

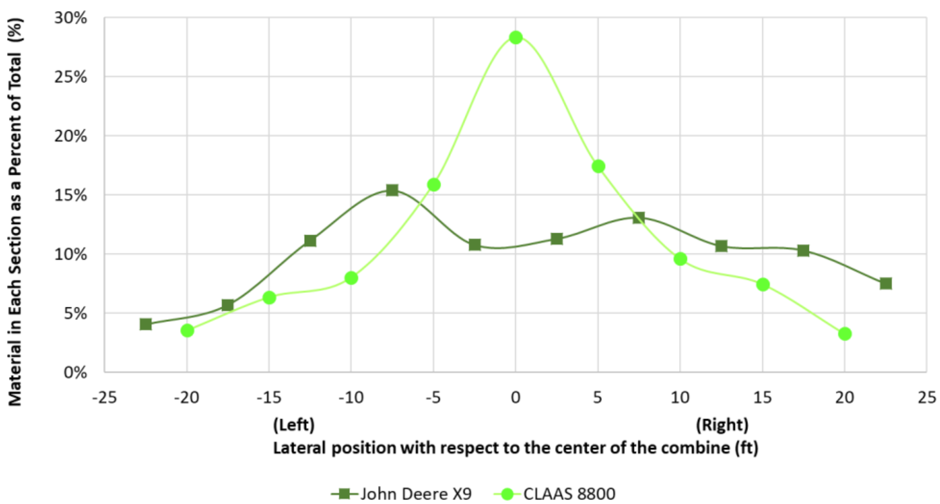

Figure 18. Average crop residue distribution by combine.

The CLAAS distribution curve can be seen to deposit more material in the center three sections and less material on the outer sections on either side of the combine. The John Deere combine deposited slightly more material on the intermediate sections and less on the outer sections. The largest percentage of crop residue in one section on the CLAAS was approximately 28% (center section) while the largest percentage of crop residue on the John Deere was approximately 15% (intermediate left section).

Coefficient of variation (CV) is used to determine the dispersion of data around a mean (value) within a data set. The formula for determining the CV is as follows:

$$CV = \frac{\sigma}{\mu}\, x\, 100$$

where: σ = standard deviation

μ = mean

Using the formula above, the CV was calculated for each combine data set; the John Deere X9 was found to have a CV of 33.3 and the CLAAS 8800 was 73.0.

Once the CV is known, uniformity within a data set can be identified; the lower the value, the more uniform the data set is considered. Therefore, when looking at the CV values for both John Deere and CLAAS, it can quickly be seen that the John Deere X9 has the more uniform distribution of the two combines.

To determine if this variance in CV values is significantly different between the two combines, a Two-Sample test method was used. This method is used to determine whether or not the means of two test samples are equal. This test applied here resulted in a p-value of 0.079, indicating there is a significant difference with a confidence level of 90%.

For comparison, the overall chop quality between combines, the three residue quality classes across all eight sections, and both repetitions were averaged and graphed for each combine (**Figure 19**).

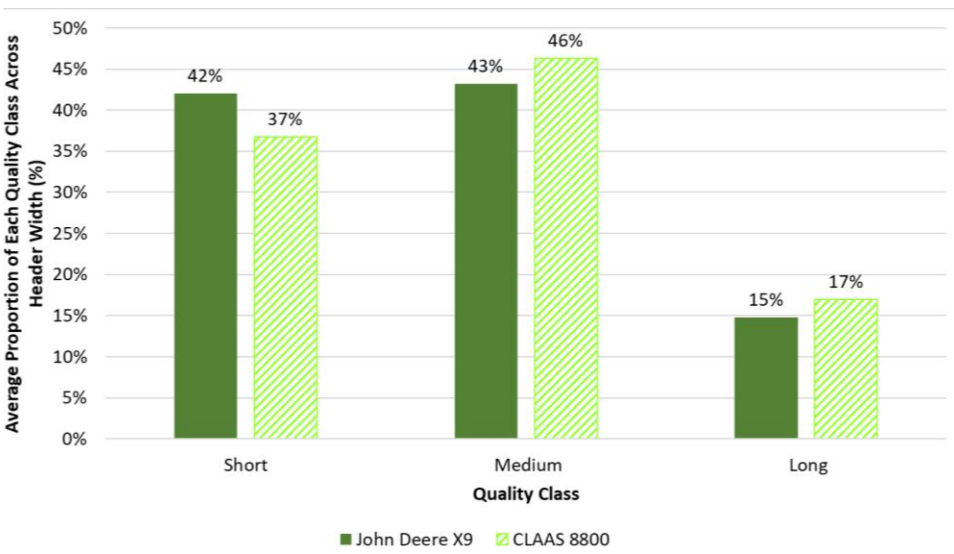

Figure 19. Average chop quality across sections and repetitions for each combine.

As shown in the figure above, the John Deere has a slightly higher percentage of short material than both medium and long material classes, where the CLAAS is shown to have a higher percentage of both medium and long classes.

Table 9 summarizes the average percentage of material in each size class as well as how these values compare in both combines. After performing an ANOVA test, no significant differences were observed.

Table 9. Average percent of material in each size class across both combines.

Combine	Short (%)	Medium (%)	Long (%)
John Deere X9	42%	43%	15%
CLAAS 8800	37%	46%	17%
John Deere X9 compared to CLAAS 8800	114%	93%	87%
Statistical P-Value	0.140[1]	0.150[1]	0.594[1]

[1]Not statistically significant at a 90% confidence level

The residue size distribution was also analysed by plotting the three size classes for each combine across the eight sections. This displays the overall residue system performance, as it presents both the chop quality and distribution profile of each combine. The associated plots for the two combines can be seen in **Figure 20**, and **Figure 21**, respectively.

In **Figure 20**, The CLAAS combine shows relative consistency in the percentage of the short and medium quality classes across each section of the harvest width. However, the long quality class, shows somewhat more variability with a higher percentage in the middle than the outer sections.

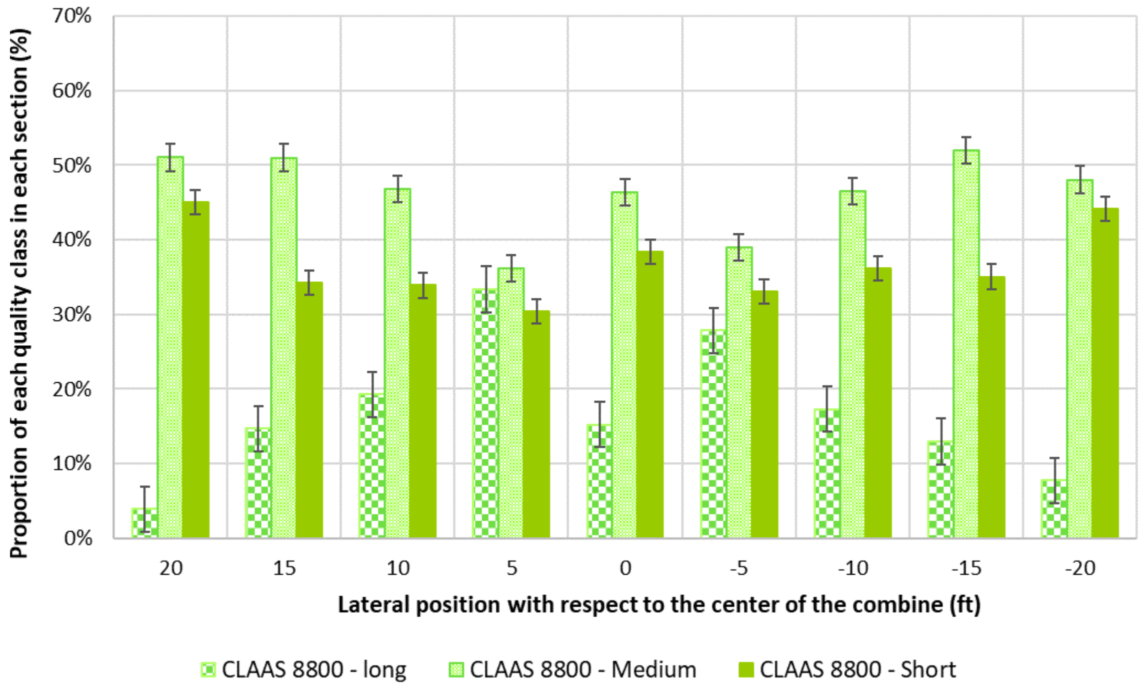

Figure 20. Overall residue system performance, CLAAS combine.

In **Figure 21**, The John Deere combine shows relatively low variability in percentage of each quality class across the harvest width except in the center two sections. These two sections show a higher percentage of the short quality class and a lower percentage of the long quality class.

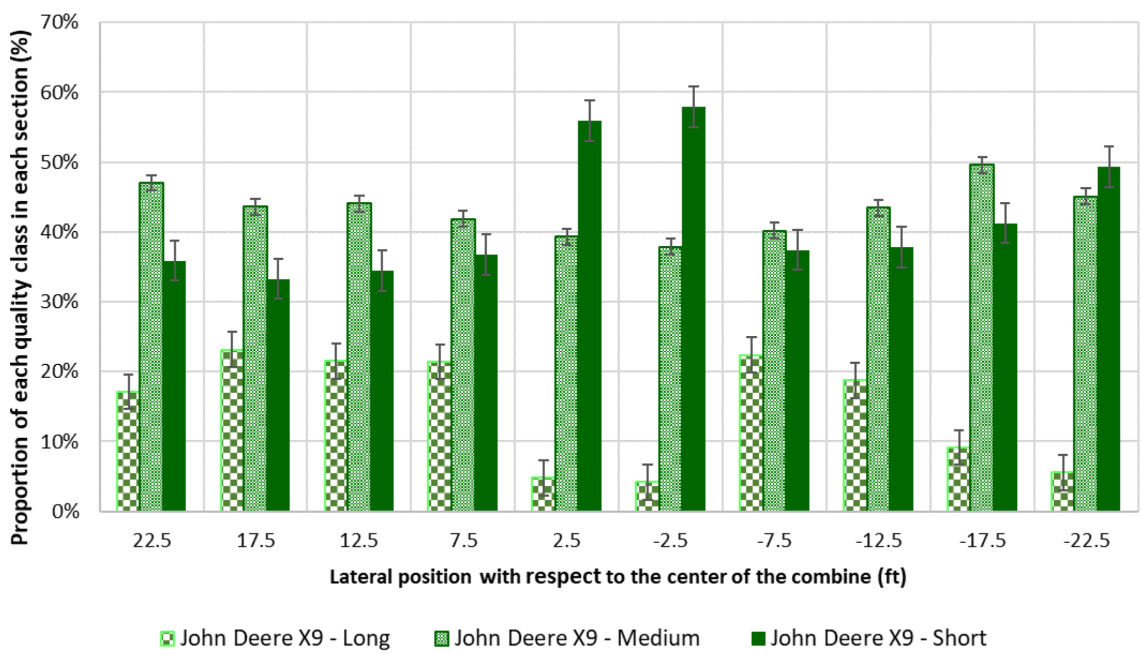

Figure 21. Results for residue size distribution testing, John Deere combine.

It should be noted that the center two sections of the John Deere are based on a smaller sample size than the rest of the sections due to issues with the remote pans dropping consistently.

5. Conclusions

Based on the combine benchmark test results in wheat some conclusions can be made on relative combine performance between the John Deere X9 and the CLAAS 8800.

Note, these results were obtained from one crop, in one condition, on one day and are therefore not representative of performance in all crops and conditions.

5.1 Loss Testing

Loss curve testing results in wheat showed some differences in combine capacity at a 1% total grain loss threshold. The John Deere showed an advantage in capacity where it had a relatively flat curve and was able to reach a throughput of 115 tonnes/h (254,000 lb/h) at the 1% loss threshold, while the CLAAS was only able to reach 90 tonnes/h at 1% total loss. When comparing relative combine capacity, the John Deere had a 28% higher capacity than that of the CLAAS.

Both combines were found to be separator loss limited in the conditions tested, where the CLAAS separator losses increased at a higher rate than that of the John Deere. The cleaning shoe losses remained below 1.0% on the CLAAS and at or below 0.5% on the John Deere throughout the entire range of feed rates tested.

5.2 Fuel Consumption

The fuel consumption results showed significant differences between combines in some of the metrics measured. In terms of the primary metric specific fuel consumption, the results showed both combines were very similar (no statistical difference) where the John Deere and CLAAS averaged 2.00 and 2.01 L/tonne (1.44 and 1.45 US gal/100 bu) respectively. It should be noted, this metric normalizes factors such as throughput and fuel usage making comparisons easier.

When fuel use was compared with respect to time the John Deere was found to use 19% more fuel per hour than the CLAAS, which was found to be statistically significant. In terms of fuel use per area harvested both combines were again very similar and no significant difference was found.

Significant differences were found between combines in the grain throughput and work rate metrics, where the John Deere had a 20% and 17% advantage, respectively.

5.3 Residue Management

The crop distribution results showed significant differences in the ability of each combine to uniformly distribute crop residue over the full harvest width. The John Deere combine showed an advantage in residue distribution, depositing material more evenly across the header width than the CLAAS combine. This is shown by a lower CV value on the John Deere of 33.3 compared to 73.0 on the CLAAS combine.

The overall chop quality results, when averaged over the entire header width, did not show a significant difference between combines. The John Deere had slightly more material in the short quality class than the medium and long quality classes when compared to the CLAAS; however, these differences were not found to be statistically significant.

When evaluating the crop residue sizing distribution between combines, some differences were noted in the evenness of distribution of each quality class. The CLAAS combine deposited less long material on the outer section and more on the inner sections where all other sections were relatively even. The John Deere showed a tendency to deposit more short material and less long material on the center two sections, where the remaining sections had a relatively even distribution of quality classes.

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Appendix A

Combine Configurations

Table A-1. Combine configurations.

	CLAAS 8800	JD X9
Engine hours	61	40
Separator hours	6	9
Header type	flex draper	Hinged draper
Header make	MacDon	John Deere
Header model	FD145	HD50R
Feeder drum position	Down	Floating
Feeder jackshaft speed	adjustable (high)	Fixed (490rpm)
Feeder chain speed	adjustable (high)	Fast (26 tooth)
Feeder face plate position	center pos.	0
Stone protection type	standard	Standard
Feed accelerator/DSP speed	synchronous to the threshing drum	Fast
Feed accelerator type	APS -Drum accelerate pre separation	Serrated wear strips
Rotor type	std. series rotor	std. dual rotor
Rasp bars	10 rasp bars (thresh cylinder)	30 grain threshing elements
Concave type	Standard (small grain)	Small wire
Concave bar	Engaged	N/A
Separator grate type	Fingerbar	Fingerbar
Separator Vanes	Fixed	Fixed
Chaffer type	Small grain - TM 6	general purpose
Sieve type	Small grain - TM 6	general purpose
Presieve type	N/A	Fixed
Tailings system concave position	N/A (conventional handling of returns)	Small grains
Spreader speed	Max	Fixed
Residue deflectors	Max width	50% width
Returns speed	Fixed	Fixed
Elevator speed	fixed	Fixed
Chopper type	Special cut (premium line)	Premium
Chopper speed	High	High

	CLAAS 8800	JD X9
Chopper knife bank position	Fully engaged	Fully engaged
Spreader type	Power spreader	Standard, Powercast Tailboard
Grain tank covers	Powered covers	Powered covers
Powered rear axle	No	No
Drive tires	Duals 580/85R42	Duals 650/85 R38
Steering tires	710/65R30	VF750/65R26
Rated power [hp = metric hp]	610 hp	603 hp
Max power [hp = metric hp]	653 hp	690 hp

Appendix B

Weather Data

The weather conditions including the temperature, relative humidity, wind speed, wind direction, and general weather condition for each test day were collected and tabulated (**Table B-1**). The weather data was collected from the nearest weather station to the test field; in this case, Lloydminster, Saskatchewan, approximately 63 km (39 miles) away. Therefore, the weather data will not be an exact summary of the weather conditions at the test field, but provides a good approximation.

Table B-1. Weather conditions during test days.

Test	Test Day	Time	Temp		RH %	Wind			Condition
			°C	°F		(km/h)	(mph)	Direction	
Loss Testing	**19-Sep-20**	3:00 PM	19	66	60	7	4	NW	Mainly Clear
		4:00 PM	18	64	65	12	8	N	Mainly Clear
		5:00 PM	17	63	68	3	2	N	Cloudy
		6:00 PM	16	61	76	7	4	NNE	Not available
		7:00 PM	14	57	83	9	6	NNE	Not available
Header Loss	**25-Sep-20**	3:00 PM	19	66	30	18	11	NNE	Sunny
		4:00 PM	18	64	32	11	7	NNE	Sunny
		5:00 PM	18	64	32	17	11	NNE	Sunny
		6:00 PM	14	57	42	9	6	NNE	Sunny
		7:00 PM	12	54	44	9	6	NNE	Partly Cloudy
Fuel Consumption	**2-Oct-20**	2:00 PM	17	63	35	24	15	NNE	Partly Cloudy
		3:00 PM	17	63	41	18	11	NE	Partly Cloudy

Appendix C

Loss Curve Raw Data

Crop: Wheat

September 27, Marsden, SK

Curve 1 – CLAAS 8800

Curve 2 – John Deere X9 1100

								Yield Calculation					Gross Weight		Tare Weight		Rotor Loss		Cleaning Loss	
Time of Day	Curve	Run	Cut Width (m)	Ground Speed	Test Dist.	Rotor Belt Ratio	Clean Belt Ratio	Dist.	Tare	Gross	Yield	Time	Rotor	Clean	Rotor	Clean	Free Grain	Unthd	Free Grain	Unthd
-	-	-		(km/h)	(m)	-	-	(m)	(kg)	(kg)	(t/ha)	(s)	(kg)	(kg)	(kg)	(kg)	(g)	(g)	(g)	(g)
13:23	1	1	13.7	3.5	9.0	1.20	1.20	66	2278	2920	7.1	9.33	37.8	40.2	-13.9	11.1	84	17	187	38
13:31	1	2	13.7	6.1	9.0	1.20	1.20	146	2930	4082	5.8	5.32	33.3	25.9	-1.6	12.2	103	25	250	79
13:47	1	3	13.7	8.7	9.0	1.20	1.20	160	4075	5630	7.5	3.74	39.3	38.4	-4.9	16.8	4893	117	583	35
14:01	1	4	13.7	6.8	9.0	1.20	1.20	150	5600	7033	7.1	4.74	38.9	31.2	-7.1	6.1	602	33	696	47
14:21	1	5	13.7	2.2	9.0	1.20	1.20	60	7045	7630	7.1	14.95	21.4	28.5	-11.2	8.4	89	29	128	57
14:40	1	6	13.7	7.7	9.0	1.20	1.20	109	1260	2272	6.9	4.21	42.8	24.6	-6.5	11.5	1382	53	621	39
15:05	1	7	15.2	5.0	9.0	1.20	1.20	84	1265	2150	7.0	6.5	32.5	42	-16.5	23.7	349	58	287	58
15:24	1	8	15.2	6.5	9.0	1.20	1.20	100	3261	4385	7.4	5.01	49.9	30.1	0.4	10.7	477	41	330	44
15:33	1	9	15.2	3.3	9.0	1.20	1.20	86	4439	5262	6.3	9.92	59	25.1	6.6	-1.4	424	68	209	49
15:43	1	10	15.2	2.3	9.0	1.20	1.20	76	5245	6073	7.2	14.24	51.6	19.3	-5.8	7.8	459	94	208	49
16:01	1	11	15.2	7.9	9.0	1.20	1.20	175	7720	9543	6.9	4.11	60.4	33.7	2.7	13.2	877	56	219	44
16:18	1	12	15.2	7.6	9.0	1.20	1.20	120	9545	10753	6.7	4.28	59.7	33.5	-2.7	14.4	1464	92	239	33
16:38	1	13	15.2	8.1	9.0	1.20	1.20	116	10850	11905	6.1	3.99	55.9	33.3	-6.2	12.5	804	69	359	62

Grey shaded cells are calculations, all other data is raw data

Appendix D

Fuel Consumption Testing Raw Data

		JD X9 1100	CLAAS 8800	JD X9 1100	CLAAS 8800	JD X9 1100	CLAAS 8800	Average JD X9 1100	Average CLAAS 8800	JD compared to CLAAS	P-Value
Test Data	Date	19-Sep-20	19-Sep-20	19-Sep-20	19-Sep-20	2-Oct-20	2-Oct-20				
	Time of Day	4:02	3:32	5:55	6:30	2:30	2:30				
	Test Duration (min)	8.00	8.57	8.33	17.08	11.33	12.17				
	Time Idle at Start (min)	0.17	0.17	0.17	0.17	0.25	0.25				
	Actual Test Duration (min)	7.83	8.40	8.17	16.75	11.08	11.92				
	Test Distance (m)	829	829	829	1,658	1100	1,100				
	Test Area (m2)	12,634	12,634	12,634	22,741	16,764	16,008				
	Test Area (acres)	3.12	2.81	3.12	5.62	4.14	3.73				
	Grain Weight (kg)	*7645	*6815	7645	13775	11100	9470				
	Yield (tonnes)	7.65	6.82	7.65	13.78	11.1	9.47				
	Yield (bu)	281	250	281	506	408	348				
	Starting Fuel Weight (lb)	120.2	130.5	111.8	149.7	127.9	57.1				
	Ending Fuel Weight (lb)	90.8	104.7	81.1	98.5	92.8	41.9				
	Fuel used (lb)	29.3	25.8	30.6	51.1	35.1	33.5				
	Fuel used (US gal)	4.22	3.72	4.41	7.37	5.05	4.83				
	Fuel used (L)	16.0	14.1	16.7	27.9	19.1	18.3				
Results	Specific Fuel Consumption (L/t)	2.09	2.06	2.19	2.03	1.72	1.93	2.00	2.01	99%	
	Specific Fuel Consumption (US gal/100 bu)	1.50	1.48	1.57	1.46	1.24	1.39	1.44	1.44	100%	0.954
	Fuel Rate (L/h)	122	101	123	100	104	92	116	98	119%	
	Fuel Rate (US gal/h)	32.3	26.5	32.4	26.4	27.3	24.3	30.7	25.7	119%	0.009
	Fuel Rate (L/ha)	12.7	12.4	13.2	12.3	11.4	12.1	12.4	12.3	101%	
	Fuel Rate (US gal/acre)	1.35	1.32	1.41	1.31	1.22	1.29	1.33	1.31	102%	0.721
	Field Capacity (ha/h)	9.7	8.1	9.3	8.2	9.1	7.6	9.3	8.0	117%	
	Field Capacity (acre/h)	23.91	20.07	22.94	20.13	22.43	18.77	23.09	19.66	117%	0.001
	Throughput (t/h)	57.9	48.2	55.6	48.9	60.1	47.7	57.9	48.4	120%	
	Throughput (bu/h)	2,129	1,771	2,043	1,795	2,208	1,752	2,127	1,773	120%	0.026

	JD X9 1100	CLAAS 8800	JD X9 1100	CLAAS 8800	JD X9 1100	CLAAS 8800	Average		JD compared to CLAAS	P-Value
							JD X9 1100	CLAAS 8800		

NOTES:
1. Two reps were completed on each combine on September 19, 2020 and one rep completed on October 2, 2020.
2. Test area on JD was generally larger due to the header size difference.
3. One - Way ANOVA was performed using Minitab v18.1, P-value < 0.1 signifies statistically significant with a confidence level of 90%
4. Due to significant figures and the effects of round and conversions, values reported in the body of the report may not exactly match this table.
5. * indicates a bad weigh value on the grain weight, therefore these two values were taken as average yield (based on the previous rep)

Constants		
Wheat	60	lb/bu
Diesel	6.943	lb/gal US
CLAAS cut width	45	ft
JD cut width	50	ft

Conversions	
2.2046	lb/kg
0.3048	ft/m
4046.86	acre/m²
3.78541	L/gal US

Appendix E

Crop Residue Management Raw Data

Combine	Rep No.	Lateral Position	Short (g)	Medium (g)	Long (g)	Total (g)	Short (%)	Medium (%)	Long (%)
John Deere X9	1	22.5	58.4	83.8	34.0	176.2	33%	48%	19%
	1	17.5	71.6	98.6	49.2	219.4	33%	45%	22%
	1	12.5	72.0	102.8	49.8	224.6	32%	46%	22%
	1	7.5	102.2	118.2	46.2	266.6	38%	44%	17%
	1	2.5	144.7	108.7	14.4	267.8	54%	41%	5%
	1	-2.5	142.6	96.8	11.3	250.7	57%	39%	5%
	1	-7.5	106.6	129.2	56.8	292.6	36%	44%	19%
	1	-12.5	95.0	114.0	41.4	250.4	38%	46%	17%
	1	-17.5	56.2	65.8	13.8	135.8	41%	48%	10%
	1	-22.5	44.2	46.6	5.2	96.0	46%	49%	5%
	2	22.5	64.8	92.0	42.6	199.4	32%	46%	21%
	2	17.5	72.4	108.8	81.8	263.0	28%	41%	31%
	2	12.5	69.4	94.0	35.4	198.8	35%	47%	18%
	2	7.5	92.4	113.6	60.2	266.2	35%	43%	23%
	2	2.5	142.6	96.8	11.3	250.7	57%	39%	5%
	2	-2.5	142.6	96.8	11.3	250.7	57%	39%	5%
	2	-7.5	110.8	129.0	71.2	311.0	36%	41%	23%
	2	-12.5	120.8	127.8	116.0	364.6	33%	35%	32%
	2	-17.5	49.4	63.2	11.8	124.4	40%	51%	9%
	2	-22.5	55.0	72.8	14.0	141.8	39%	51%	10%
	3	22.5	57.6	64.8	14.6	137.0	42%	47%	11%
	3	17.5	88.2	99.2	35.4	222.8	40%	45%	16%
	3	12.5	110.6	118.8	74.8	304.2	36%	39%	25%
	3	7.5	133.8	138.4	87.4	359.6	37%	38%	24%
	3	2.5	142.6	96.8	11.3	250.7	57%	39%	5%
	3	-2.5	140.4	85.0	8.3	233.6	60%	36%	4%
	3	-7.5	179.2	155.8	110.8	445.8	40%	35%	25%
	3	-12.5	63.4	74.4	11.8	149.6	42%	50%	8%
	3	-17.5	54.6	63.4	10.0	128.0	43%	50%	8%
	3	-22.5	25.4	14.2	0.6	40.2	63%	35%	1%
Average	-	-	93.6	95.7	38.1	227.4	42%	43%	15%

Combine	Rep No.	Lateral Position	Short (g)	Medium (g)	Long (g)	Total (g)	Short (%)	Medium (%)	Long (%)
CLAAS 8800	1	20	23.4	27.4	2.4	53.2	44%	52%	5%
	1	15	79.4	128.0	59.2	266.6	30%	48%	22%
	1	10	105.0	142.4	98.0	345.4	30%	41%	28%
	1	5	181.8	191.4	285.4	658.6	28%	29%	43%
	1	0	296.3	362.0	77.4	735.7	40%	49%	11%
	1	-5	151.4	176.4	152.2	480.0	32%	37%	32%
	1	-10	85.6	114.6	66.2	266.4	32%	43%	25%
	1	-15	62.4	108.4	38.2	209.0	30%	52%	18%
	1	-20	44.2	62.6	13.6	120.4	37%	52%	11%
	2	20	34.0	29.6	1.2	64.8	52%	46%	2%
	2	15	65.2	94.0	25.4	184.6	35%	51%	14%
	2	10	91.0	126.8	49.8	267.6	34%	47%	19%
	2	5	127.8	165.6	162.0	455.4	28%	36%	36%
	2	0	358.9	401.4	252.7	1013.0	35%	40%	25%
	2	-5	179.4	189.2	188.4	557.0	32%	34%	34%
	2	-10	107.2	132.0	83.2	322.4	33%	41%	26%
	2	-15	85.6	116.0	37.8	239.4	36%	48%	16%
	2	-20	62.2	84.8	16.4	163.4	38%	52%	10%
	3	20	53.8	78.2	7.6	139.6	39%	56%	5%
	3	15	71.0	101.8	15.2	188.0	38%	54%	8%
	3	10	81.6	113.2	23.8	218.6	37%	52%	11%
	3	5	141.0	170.6	83.8	395.4	36%	43%	21%
	3	0	273.2	348.8	71.3	693.4	39%	50%	10%
	3	-5	124.0	161.4	63.0	348.4	36%	46%	18%
	3	-10	56.4	72.4	1.6	130.4	43%	56%	1%
	3	-15	45.8	64.4	5.6	115.8	40%	56%	5%
	3	-20	23.8	16.6	0.8	41.2	58%	40%	2%
Average	-	-	111.5	140.0	69.7	321.2	37%	46%	17%

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