

Final Technical Results Report

2023

Measuring Harvester Losses in Western Australia

Project code: GGA2110-001SAX

Prepared by: Mark Holland
mholland@gga.org.au
Grower Group Alliance Inc.
Jo Wheeler
Jo.Wheeler@grdc.com.au

Date submitted to GRDC: 16 May 2023

REPORT SENSITIVITY

Does the report have any of the following sensitivities?

Intended for journal publication	YES <input checked="" type="checkbox"/> NO <input type="checkbox"/>
Results are incomplete	YES <input type="checkbox"/> NO <input checked="" type="checkbox"/>
Commercial/IP concerns	YES <input type="checkbox"/> NO <input checked="" type="checkbox"/>
Embargo date	YES <input type="checkbox"/> NO <input checked="" type="checkbox"/> Nil

Contents

Final Technical Results Report	1
ABSTRACT	4
Losses through the harvester directly impact grower profit. This project identified the extent of losses during harvest by growers in the Western Region.	4
The project team assessed harvester losses for wheat, barley, oats, narrowleaf lupin, lentils, field peas, chickpeas and faba bean crops across 75 sites from all port zones in the 2021 season.	4
Losses the Grower Group Alliance measured exceeded these benchmarks for all species assessed.	4
When extrapolated to the WA crop area and multiplied by average prices, the Grower Group Alliance found WA growers left grain worth \$300m on the ground in the 2021 season. Half the loss could be recovered with measurement, header setting adjustment, machinery sensor calibration and optimal equipment and modifications.	4
There is merit in threshing system optimisation with aftermarket accessories.	4
Growers should continue to be encouraged to measure losses, calibrate machinery sensors and improve their skills in adjusting harvester settings. Error!	
Bookmark not defined.	
An immediate outcome of the project has been increased awareness of the issue. It has resulted in more growers attending harvester setup workshops to improve their ability to adjust the header settings and to understand the benefits of specialist equipment.	4
EXECUTIVE SUMMARY	5
BACKGROUND	7
METHODOLOGY	9
LOCATION	14
RESULTS	15
PART A: Testing Protocol	15
PART B: Data analysis	25
DISCUSSION OF RESULTS	45
EXTENSION OF RESULTS	49

CONCLUSION	51
IMPLICATIONS	53
RECOMMENDATIONS	54
APPENDIX A: Machine loss calculations	55
GLOSSARY AND ACRONYMS	57

The data demonstrates significant variation in harvest losses between regions for cereals and canola. This may be driven by a lack of depth of data available for analysis or, variations in operating parameters including varietal, cropping practice or typical ambient operating conditions over the 2022 harvest.

ABSTRACT

Losses through the harvester directly impact grower profit. This project identified the extent of losses during harvest by growers in the Western Region.

The project team assessed harvester losses across 75 sites for wheat, barley, oats, narrowleaf lupin, lentils, field peas, chickpeas and faba bean crops from all port zones in the 2021 season.

Losses measured by the Grower Group Alliance exceeded benchmarks for all species assessed.

When extrapolated to the WA crop area and multiplied by average prices, the Grower Group Alliance found WA growers left grain worth \$300m on the ground in the 2021 season at an average of \$80,000 per grower.

The project team estimate half the loss could be recovered with measurement, header setting adjustment, machinery sensor calibration and optimal equipment and modifications. The project also found there is merit in threshing system optimisation with aftermarket accessories.

This project facilitated an impressive flow of information from reputable consultants armed with justifiable results to capture growers' and advisors' attention and provide confidence to invest time measuring losses.

An immediate outcome of the project has been increased awareness of the issue. It has resulted in more growers attending harvester setup workshops to improve their ability to adjust the header settings and to understand the benefits of specialist equipment.

EXECUTIVE SUMMARY

This project identified the extent of losses during harvest by growers in the Western Region (tonnes and cost) for the major grain crops in Western Australia and provides information to GRDC so it can target further investment.

Harvester losses for wheat, barley, oats, narrowleaf lupin, lentils, field peas, chickpeas and faba bean crops were assessed across 75 sites (200 samples) from all port zones in the 2021 season.

Growers understand losses from the harvester but many growers do not routinely measure losses, even though the losses directly impacts the profit of the enterprise.

Benchmark losses exist for each grain crop, representing the optimum balance between grain loss and harvest efficiency (speed, logistics, etc.). Losses measured by the Grower Group Alliance exceeded these benchmarks for all crop species assessed.

When extrapolated to the WA crop area and multiplied by average nominal price the Grower Group Alliance found grain worth \$300m was spilt onto the ground. It is estimated half the grain lost could be recovered with measurement, adjustment of header settings, calibration of sensors and the application of specialist equipment.

While extrapolating these Western region loss data to other GRDC regions is not directly comparable, the harvest losses nationally could be almost \$750m nationally.

The results show there is a need to encourage growers to measure losses regularly and improve their skills to adjust machinery. This project facilitated an impressive flow of information from reputable consultants armed with justifiable results to capture growers' and advisors' attention and provide confidence to invest time in measuring losses.

An immediate outcome of the project has been increased awareness of the issue resulting in more growers attending harvester setup workshops to improve their skills to adjust the header and to understand the benefits of specialist equipment.

Recommendations for machinery settings

When optimising harvester performance, the best practice is to change one machine setting or make one adjustment in isolation before retesting to evaluate the impact of that change. Determining what component, or adjustment should be made, requires significant experience. Consequently, in this study adjustment before and after testing rarely significantly improved performance throughput or loss minimisation.

There appears to be merit in threshing system optimisation with aftermarket accessories but investment in further work is required to validate these findings.

While arguably offering additional throughput and increased field efficiency, average losses measured with stripper fronts are significantly higher than draper fronts in cereals, which growers should consider when calculating the benefits and costs of using a stripper front, for example in a strip and disc system.

Cereal growers should also set the reel to penetrate the crop only enough to lay cut material onto the draper belt. This prevents the reel from knocking grain out of the head and onto the ground.

Pulses can be particularly problematic for front losses with options for knife, reel and air adaptations employed to minimise these pending the economics of doing so. While lentils are an emerging crop in WA, measured losses indicate a strong case for the use of an air reel to minimise losses.

When direct-harvesting canola, tests showed losses from an adjustable table front were one per cent compared to 1.7 per cent with a standard draper front. When you put that in context, with the canola price, the capacity to minimise losses with an adjustable table front in a direct harvesting scenario will pay for itself relatively quickly.

Investment in an adjustable table front to improve field efficiency may also offer growers significant reductions in losses with canola. Reductions in average losses with an adjustable table front were also observed in barley.

BACKGROUND

Anecdotal evidence and farmer-collected data encouraged the GRDC to seek an objective assessment of grain losses occurring during harvesting operations because they directly impact the growers' profit.

There are acceptable losses and guideline benchmarks for each grain crop, representing the optimum balance between grain loss and harvest efficiency (speed, logistics etc.). Optimising this balance ensures growers can minimise losses while maximising efficiency.

This investment is a pilot study to quantify the losses in each significant grain crop in the Western Region and create the baseline. The data captured will focus on the total machine with an analysis to summarise the findings and help guide further investment to minimise harvest loss.

PROJECT OBJECTIVES

The goal of the project was for grain growers in the Western Region to understand the current level of grain losses (tonnes and cost) from harvesters, for all of the major grain crops in Western Australia and understand where these losses occur. Growers will be able to calculate acceptable losses irrespective of varying yield levels.

Output 1

By June 30th 2022, the project will measure and provide an analysis and report on the grain losses incurred by growers during harvest. The information should contain a breakdown of losses incurred at the harvester's front and back across all port zones in the Western Region. Project staff will capture measurements using a drop tray and apply the existing Harvest Loss Calculator for wheat, barley, canola, lupins, oats, lentils, field peas, chickpeas and faba beans. Measurements also need to include additional information such as harvest conditions (e.g. moisture), crop structure & density, front losses (including front type, set up and any additions such as knife guards or air reels) and the back losses (with consideration to travel speed, rotor clearances, fan speed and sieve settings). The analysis will identify the efficacy of some existing solutions to reduce harvest losses.

There should also be consideration of any weed seed control strategies and if these have an impact on front or back losses. Where possible, each site will measure a 'before' and 'after' if the grower makes any adjustments to their header set-up due to the losses estimated.

The measurements captured in this investment will be communicated to grain growers in the Western Region to set current loss benchmarks, the measurements are also expected to help guide further investment in minimising harvest loss.

Output 2

The data captured will be loaded onto the Online Farm Trials database and provided to the industry for analysis and extension purposes. This analysis should include the data captured on grower practice change, if they altered anything about their harvest practices as a result of the losses measured. Extension is also expected, either through Grains Research Updates, field days, online communication or otherwise, as required.

Limitations of the research

The number of crops assessed through this study is relatively small. Only general findings can be made with the limitations of the data set.

When optimising harvester performance, best practice is to iteratively change one machine setting or make one adjustment in isolation before retesting to evaluate the impact of that change. Determining what component, or adjustment should be made, requires significant experience. As a result, before and after adjustment testing will be limited to the skills available on site and this may prevent significant improvement in performance throughput or loss minimisation.

METHODOLOGY

The American Society of Agricultural and Biological Engineers (ASABE) define an acceptable loss as 1% for any harvest process. However, this will vary significantly by crop, conditions and machine setup (canola might be double that or more in some circumstances). Undoubtedly, harvester setup has a significant impact on performance and productivity. The ultimate aim is to maximise harvester throughput capacity with acceptable losses. However, there are many adjustments and configurations farmers need to consider. Rotor speed, concave type and settings, sieve sizes and fan speed are just some of the components that impact performance, as do changing environmental conditions and front type. Tractor capacity also plays a role. For example, in higher-powered harvesters, the limiting factor will likely be increasing losses as harvest productivity increases. Optimised setup and settings for these machines will deliver fuel efficiency at maximum throughput for the given crop conditions.

Agricultural consultancy Planfarm reports an astounding \$90 million worth of canola is estimated to be lost from the back of harvesters every year in Western Australia. Visual assessment of grain on the ground does not provide the accuracy needed to make informed decisions about machine setup and setting changes. The importance of using drop trays to determine losses and calibrate loss sensors existing on newer harvesters is critical, and growers still need to consistently implement this as they race to harvest crops.

A considerable number of samples would have to be taken to get an accurate measure of typical losses, significantly more than have been proposed for this project. The causes of loss are so broad due to harvesting variables that a benchmark figure will not be statistically justifiable. Further, this project cannot achieve the minimum number of samples within the given budget. This is because a process needs to be followed, which can take considerable time. The team measured the baseline, made an adjustment, considering capacity and machine running costs, and then settled on what is considered an acceptable loss in that scenario; growers may need to make subsequent adjustments. These adjustments should be made in series, with new measures taken after each change. Nevertheless, this response delivers the outputs sought within reasonable expenditure by testing as many sites as possible while extending the information.

This project:

- Sampled and measured harvest losses from 75 sites (200 tests) across all WA grain belt port zones covering major species (wheat, barley, lupins and canola) and minor crops (oats, lentil, field pea, faba bean and chickpea) and recorded harvest losses before and after adjustments from the front and rear of the harvester.
- Equipped sampling teams with drop pans and train them to safely take measurements in a consistent manner across the State, and used the BushelPlus App or a custom-built spreadsheets to record data.
- Analysed the data collected and establish indicative baseline harvest loss parameters for each crop across port zones.

- Extended the findings widely and to good effect.

Training methodology

Primary Sales (PSAPL) conducted training in drop pan use. Throughout its history, PSAPL has been at the leading edge of farm practice and research (no-till farming, precision farming, harvester loss and harvester weed seed control, working jointly with universities, GRDC, agronomy organisations and growing groups. The PSAPL team has been undertaking harvester loss measurements with growers in the field using the Bushel Plus drop pan system for more than three years and understands the importance of implementing a consistent approach to undertaking the measurement and capture of the data for the project. PSAPL has a local (WA) footprint enabled it to provide hands-on support for grower groups executing the project. Training covered:

- Safety
- Drop pan application for front and rear loss measurement
- Sample separation, measurement and data capture using BushelPlus app or custom reporting tool
- Mechanical changes to front as defined by the protocol

Engagement

Grower group staff taking samples reported being welcomed by growers, who appreciated the objective check of their losses. Grower Groups also supported being involved in the project because it increased engagement with their members and while providing a valuable service.

Records methodology

The following list is a base requirement for each site.

Crop conditions

- Farmer name
- Location (latitude and longitude)
- Time of day
- Grain moisture content
- Crop type and variety
- Frosted?
- Any lodging?
- Yield variation across the paddock

Front

- Make / Model / cut width
- Knife guards: eg: Double/triple
- Knife type: Schumacher/conventional
- Knife condition and position (do the knife sections sit onto the ledger plates?)
- Reel finger/bat
- Duck feet, belt, brush or corflute used on reel? Details___

- Crop divider description
- Vertical knife used?
- Crop lifters used?
- Air reel used?
- Belt condition
- Brush/rubber seal kits used to minimise leakage? Description_____
- Turbodrums/Typhoon used?
- Top cross auger used? Modified in any way?
- Any other modifications? Detail_____

Front operation

- Reel speed (auto/manual)
- Finger reel crop penetration and angle
- Knife speed
- Cut height
- Retractable finger full retraction point eg: 7 o'clock
- Front deck angle to horizontal

Machine

- A checklist for each machine make developed as part of the protocol
- Concaves used: Position and description noting any modifications
- Rasp-bars used: Style and number by position
- Baffle fitted?
- Positive straw discharge (New Holland)

Machine operation

- Machine telemetry sourced
 - Engine load (%)
 - Fuel use
 - Rotor speed
 - Concave setting
 - Top sieve setting
 - Bottom sieve setting
 - Fan speed
 - Forward ground speed
 - Average yield *Ask the operator if the yield monitor is calibrated and correct!
- Residue management and HWSC
 - Straw handling
 - Chop and spread (eg Redekop maximum air velocity/Opti-Spread/Powercast)
 - Windrow for burning/baling
 - Baled
 - Chaff handling
 - Chaff-lining
 - Chaff-decks

- Chaff-mill (iHSD/Seed Terminator/Redekop seed control unit/WeedHOG)
- Chaff cart

Grain sample observations

- Note admixture / whitecaps levels
- Note any grain cracking
- Note repeats content (presence of grain)

Loss measurements – using BushelPlus or a custom tool developed by the project

- Pre-harvest loss notes: Visual count with quadrant

Front

- Centre narrow tray (carefully placed in canola)
- Outer trays (use visual observation to estimate placement avoiding wheels)

Sieve

- No mill
 - Minimum Left/Centre/Right 1metre pan drops (two reps with a third potentially required pending variation limits)
- With mill
 - Full protocol will need to be developed for each mill/harvester combination to ensure consistency

All results entered and stored/saved with BushelPlus app or custom tool or custom spreadsheet and collated and analysed by Ben White.

Protocol for calculating harvest losses

A program of measuring harvest losses (75 sites) targeting major and emerging crop species was undertaken following direct targeting of individual farmers by grower groups and nomination by expert consultants within identified regions and sectors. A sampling protocol was developed and training provided to guide grower group staff and ensure consistent methodology. Protocols were developed for measuring losses at the back and front of harvesters. They addressed:

- Where losses occur
- Assessing losses
- Sampling with a drop pan
- Accounting for pre-harvest loss
- Measuring front loss
- Measuring machine loss
- Cleaning and weighing the sample
- Total harvest loss
- Consideration of acceptable losses

Equipment disposal

At the conclusion of the drop pans were transferred to the grower groups conducting the study. This has resulted in a loan system being set up by the groups to make pans available for growers. Grower groups report solid uptake of the equipment by members.

Project structure and management arrangements

The Grower Group Alliance was the sole contractor for this project. The GGA Board and Chief Executive Officer oversaw the project which was managed by Mr Mark Holland. The GGA formally sub-contracted other parties to provide technical input and regional sampling teams.

All staff reported to Mr Mark Holland.

Project Team

The expertise available to this project is extensive, with a depth of capabilities that ensures delivery, with arguably WA's current leaders for harvester setups and managing harvester losses. The project developed a new capacity to support measurement practice by training grower groups in the use of equipment. While the team worked together, however, areas of focus were White (analysis), White, Riethmuller & Broley (protocols) and Broley (drop pan training and equipment supply). The staff of the participating grower groups (Facey, Stirlings to Coast Farmers and Liebe Group) are experienced in harvesting equipment and peer-to-peer learning. Grower Group Alliance provided Project Lead Mark Holland, and Kallista Bolton (marketing and communications) to round out the team.

Steps to Deliver the Outcome

1. The project team technical leads developed a protocol to measure front harvest losses and modify existing protocols for measuring rear losses.
2. Primary Sales trained grower group staff in the use of drop pans and Ben White train staff in use of the protocols and decision support tool.
3. Project staff recorded harvester loss assessments using the BushelPlus app. The team employed an economic lens to assess business risk, opportunities associated with regular harvest loss assessment, and trade-offs in throughput and acceptable losses.
4. Grower group staff engaged with their membership to identify influential growers willing to spend the time required and obtain value from participating in the assessment.
5. Grower group staff, in turn, work collaboratively with volunteer growers to develop their knowledge across crop species and ultimately create advocates within the grower groups capable of influencing peer-to-peer learning.
6. Ben White analysed the results.
7. Ongoing engagement of broader grower group membership with the trained growers, supported by documentation from the project, met other growers' needs and create opportunities for behavioural change. Options for this broader engagement included harvest review events and local forums.

Target audience

The target audience is the grain growing community of WA and the company and private agronomy consultants who help them to make decisions, and the GRDC investment panel.

LOCATION

The number of samples per port zone was determined by the GRDC. Consultation with technical leads and participating grower groups selected the crop distribution across the five port zones. The key factor in determining the distribution was the overall proportion of dominant and minor crops as specified in the tender documentation and the relative presence of the crop in each port zone.

Table 1 Minimum target sites per port zone

	Esperance	Albany	Geraldton	Kwinana West	Kwinana East	TOTAL
Wheat	1	2	3	2	3	11
Barley	1	2	2	2	4	11
Canola	2	2	2	2	3	11
Lupins	1	2	5	2	1	11
Oats				5	1	6
Lentils	4	2				6
Field peas	3	2		1	1	7
Chickpeas			3	1	2	6
Faba beans	3	3				6
	15	15	15	15	15	75

[GRDC agro-ecological zone/s](#), indicate which in the table below:

Research	Benefiting GRDC region (select up to three)	Benefiting GRDC agro-ecological zone	
Measuring Harvester Losses in Western Australia	Western Region	<input checked="" type="checkbox"/> WA Northern	<input checked="" type="checkbox"/> WA Central
	Western Region	<input checked="" type="checkbox"/> WA Eastern	<input checked="" type="checkbox"/> WA Sandplain
	Western Region	<input checked="" type="checkbox"/> WA Mallee	

RESULTS

PART A: Testing Protocol

The following harvest protocol has been developed by the project.



Harvester loss testing protocol

GRDC Western Region

Ben White: 0407941923
ben@bmwhite.com.au



Purpose

To measure and quantify grain harvester losses in Western Australia in a range of cereal, oilseed and pulse crops under harvester configurations typical to the state.

Methodology

Harvester losses will be quantified using drop trays to capture both front losses and machine losses comprising of sieve and rotor losses.

Equipment

The use of the Bushel Plus 1m wide harvester loss evaluation trays separator and scales has been assumed for the purposes of this protocol.

Variables

Variables to be measured or noted for each test.

To ensure a representative analysis, test location and timing should be varied where possible to provide a spread of variables marked with a *

Variables should be noted including:

Operational variables

- Location*
- Time of day*
- Ambient conditions (Temperature and humidity) *
- Time after maturity*
- Crop and variety if known*
- Crop conditions (note any lodging), damp straw from any rain or green straw*
- Crop average yield*
- Grain moisture content*
- Harvester operating ground speed
- Crop cut height and average crop height
- Has drop tray analysis/adjustment already been used?*
- Note if the operator has already adjusted settings or setup to minimise losses?
- Note any significant frost affected areas or variation across the paddock

Equipment variables

Collect machine specification notes including the following. (Photographs of as many of these as possible will be useful references)

- Harvester make and model*
 - Rotor configuration (if known)
- Harvester front make and model* noting cut width, knife guards, knife condition, crop divider any reel adaptations (duck feet/corflute), air reel make and model eg AWS or vertical end knife/roto-shear.
- Harvest weed seed control* (ViHSD/Seed Terminator/SCU or chaff cart or chaff-lining etc.)

Front losses

Where direct harvesting, front losses will be measured by placing trays in the standing crop prior to the harvester passing over. Care should be taken to minimise crop disturbance in the process of placing trays.

Three trays will be used to evaluate front losses with placement of the long side of the tray orthogonal to the direction of harvest (see figure 1).



Figure 1: Front loss evaluation tray placement

D (Divider) Centred under the crop divider on the side in full crop.



- Centre (C) Slightly offset of the feeder house centre to capture any centre and belt transition losses or leaks on draper fronts
(Note: if the harvester doesn't have autosteer consider only placing this in the centre to avoid tray damage)



- Side (S) A section to the left or right of the feeder house in a position representative of the majority of the width of the front, but specifically clear of the gauge wheels to avoid tray damage.



Placement of the trays in the crop can be made easier using a length of rope or strap equal to the width of the front. Laying the rope out in front of the front when the machine is stationary should allow for markers or knots to be tied where optimal tray centre placement would be when in operation. (See figure 2)



Figure 2: Using rope or strap to determine optimal tray placement for the front.

Once the harvester front has passed, the harvester should stop and allow the collection of trays prior to crop residue from the harvester being spread over them.

Any material other than grain captured in the trays should be removed using the blower separator with full heads or pods captured in the trays hand-threshed to release any grain into the tray or separator prior to separation. A note describing the number of whole heads captured in the trays should be made to help identify the source of the loss.

The mass of grain in each tray should then be weighed, taking care to cover the scales with a transparent box if weighing in the field. This will minimise the impact of air movement over the highly sensitive scales.

Repetitions

Two repetitions should be taken in uniform and representative areas of the paddock. If any of the successive grain mass measures at the respective position varies significantly (nominally >15%) between the first and second tests, a third test should be conducted to provide a more precise data set.

Windrowed crop

Where crop has been windrowed, it is very difficult to place trays in under the windrow without significant disturbance.

In this instance it may be better to use a small flat low-lip tray that can sit low on the ground and not be picked up by the front but still capable of capturing any lost grain. Ensure the tray is made from a material stiff enough to pick up and retrieve grain from, but unlikely to cause any machine damage if ingested by the harvester. An ice-cream bucket lid could be an option or a plastic tray with a slight edge. The

area of these low-profile trays would need to be accurately measured for calculating losses.

Calculation of front losses

Front losses can then be calculated utilising a weighting applied for each tray weight collected representative of the proportional width of each of the three sections.

As an example, where a 12m cut width front is used, losses are assumed to be spread over 12.5m (allowing for an additional 0.5m of potential losses captured at the crop divider).

Weighted average front losses (FL) in kg/ha for a front measured with common 1m width trays of a given capture area (T) could be calculated as follows:

$$FL = \frac{D + 2C + ((W - 2.5) \times S)}{W + 0.5} \times \frac{10}{T}$$

Where:

Divider tray at the end grain mass (D) in grams,

Centre grain mass (C) in grams,

Side grain mass (S) in grams,

Front width (W) in metres and

1m wide tray area (T) is expressed in m²

Notes: Standard Bushel Plus 1m tray area is 0.254m², narrow trays are 0.1 m².

Calculations assume a full cut is being taken with the front. If not, substitute the actual cut width for "W" in the below calculation.

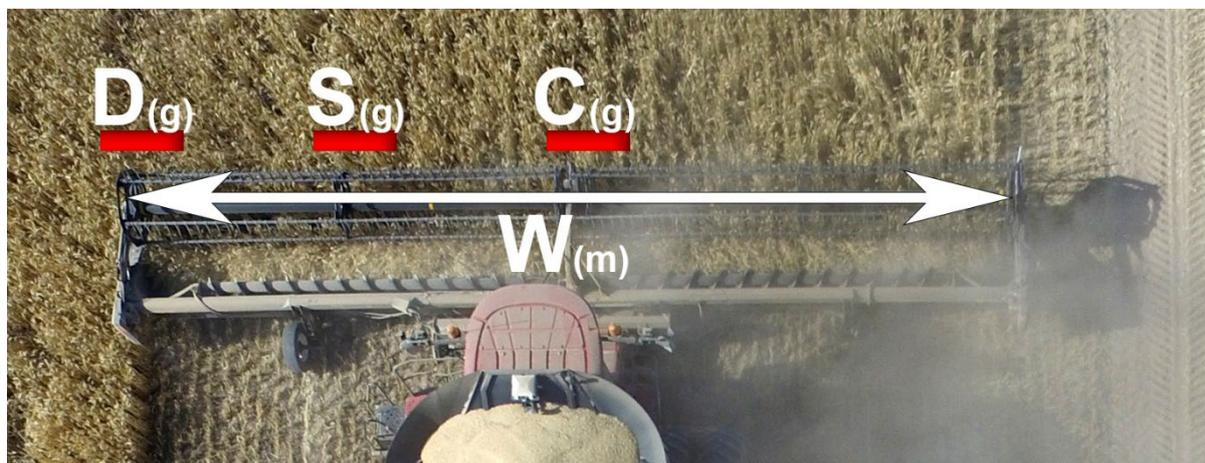


Figure 3: Measures used to determine weighted average front losses.

Under swath loss calculation

For example: under swath losses with a 1.5m swath width from a 12m swather cut and say 1.0g of seed is collected in a container of area 0.1m² then the loss would be:

$$\text{Loss (kg/ha)} = \frac{\text{grain weight (g)}}{1000} \div \frac{\text{area (m}^2\text{)}}{10000} \times \text{swath width (m)} \div \text{swather width (m)}$$

$$1.0/1000/0.1*10000*1.5/12 = 12.5 \text{ kg/ha}$$

Notes: A square 2L ice cream container is about 0.022m².

Rotor and sieve losses

While it is possible to separately evaluate rotor and sieve losses, machine losses will be separately gathered and measured where possible, but will be combined for the purposes of this analysis.

It is important that loss measurements are taken in the mode of harvest operation. That is, if the standard mode of harvest is spreading both the chaff and straw fractions, then this is the mode by which loss measurements are taken.

If the straw fraction is spread but the chaff is windrowed, this is the mode by which losses should be evaluated. The only exception to this rule is when a harvest weed seed impact mill is employed.

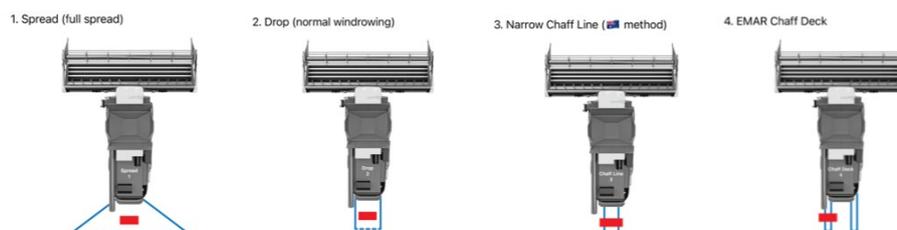
The Bushel plus app v4.01 or later should be used to select both the sieve (chaff fraction) and rotor (straw fraction) operating environment and steps through the process and measures required.

The app will firstly ask for the mode of chaff residue spread, then straw residue spread.

A filename should be entered reflecting the name of the farm, date and 24h time. Cut width should be measured from divider to divider on the front assuming a full cut is being taken with the front. If not, substitute the actual cut width in the app calculator.

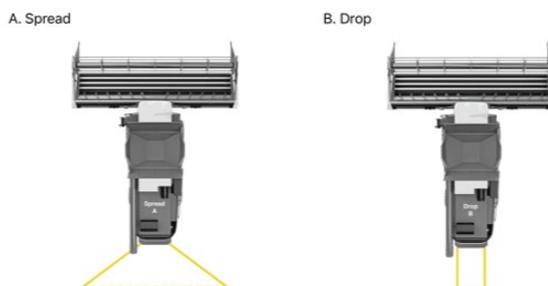
Depending on the selected mode of spread, an estimate of the spread pattern may be required. This can be tricky to estimate but is important in determining losses so a quick run with a tape measure at the position of tray drop is recommended.

Chaff residue spread modes (from sieves)





Straw residue spread modes (from rotor)



Side drops of the pan to gather spread residue should be inside the spread zone but be mindful of the main drive wheel position, particularly if the harvester is running duals.

Pans can be mounted to the front in the desired position to catch the spread residue and dropped around the same time as the pan mounted to the rear axle.

The standard 1m wide pans are recommended for measuring sieve and rotor losses.



Because many machines will favour one side with residue spread, or can be influenced by cross-winds, it is important to gather losses on both the left and right-hand side of the machine in addition to the centre tray drop from the rear axle. It is suggested that if the pan was dropped off the front on the left for the first test is dropped off the right in the second test.

Ensure the correct pan size is selected in the app when calculating losses.

Machine performance metrics to gather

It is important to be in touch with the operator just prior to the time of pan drop to gather some essential harvester performance metrics including:

- Yield (t/Ha)*
- Throughput (t/hr)*

If possible, it would be useful, but not essential to gather: (a photograph of the operator terminal may provide a quick way of recording these settings)

- Ground speed (km/h)
- Drum speed on relevant hybrid Claas/Fendt/Massey machines
- Rotor speed (rpm)
- Concave setting (mm) or setting number
- Pre-sieve if available
- Top sieve setting
- Bottom sieve setting
- Fan speed (rpm)
- Engine load (%)
- Fuel use (L/hr)
- Cut height (mm)

*Important note – ask the harvester operator to confirm the accuracy of the on-board yield monitor and whether it has been calibrated. If not apply a correction factor to the yield and throughput figures quoted from the cab prior to calculating losses.

Impact mills

For harvesters fitted with a weed seed impact mill, rotor and sieve losses are usually gathered separately.

Note that where a chaff impact mill is used, handling of the chaff fraction may need to deviate from the mode of harvest operation. But operating speed and settings should remain the same with the only change made being the diversion of the chaff material off the sieves for capture.

Chaff off the sieves which may contain machine losses will need to be diverted prior to entering the mills by disengaging and/or diverting the material flow off the sieves for capture in the trays. Note that some mills may take a while to get material to flow out after diversion so run until the flow is consistent for an accurate measure.

For harvesters fitted with a Seed Terminator, firstly measure rotor losses by dropping side trays from the front. Then do a second test, dropping the chaff diverter door down on the Seed Terminator to measure sieve losses. The rotor and sieve data can be individually run through the Bushel Plus app and added to derive total machine losses.

For machines fitted with iHSD, firstly measure rotor losses by dropping side trays from the front. To measure sieve losses, disconnect the belt to the mill and remove the rear access door to allow the chaff to come out on the ground in a line. Drop the tray from the rear axle to collect material off the sieves. The rotor and sieve data can be individually run through the Bushel Plus app and added to derive total machine losses.

For machines fitted with a Redekop SCU, firstly measure rotor losses by dropping side trays from the front. To measure sieve losses, disengage the dog-clutch to the mills, retract the SCU up out of the chaff stream and drop the chaff directly down, capturing material in a tray dropped off the rear axle.

While it is acknowledged that variation in chaff flow will arguably alter airflow through the harvester, it is argued that a measure of losses via this method is better than not gathering this data. (It is noted that grain losses over the sieves will also increase the wear rate of mill components.)

Repetitions

Two repetitions should be taken in uniform and representative areas of the paddock. If any of the successive grain mass measures at the respective position varies significantly (nominally >15%) between the first and second tests, a third test should be conducted to provide confidence in the data set.

Calculation of rotor and sieve losses

Given losses are being captured using Bushel Plus trays, the app should be used to calculate rotor and sieve losses.

Ensure all data entered into the Bushel plus app is accurate and entered in the required format and measurement unit.

Legume grain sampling

Collect a representative sample of pulse grains (around 2kg) from the harvester box via the sample chute near the cab entry. Be sure the sample is kept in calico bags supplied and treated carefully, kept in a cool space without excessive disturbance.

A small Esky is good to store samples in the field as the insulation stops temperature variations – although there is no need for the samples to be chilled. Package calico bags in a padded mailing envelope and forward to the DPIRD seed testing station. Samples will be tested for germination level.

PART B: Data analysis



Harvester loss testing: data analysis
GRDC Western Region

Ben White: 0407941923

ben@bmwhite.com.au



Version history:

First draft: 2/04/2022

Second draft: 14/04/22: Updated with additional missing data
Third draft: 26/5/22: Additional data included; peak capacity benchmark machines identified

Fourth draft: 1/6/22: Narrative for figures added. Additional data analysis exploring state production and loss values added

Final version: 7/6/22: Machine loss recalculated, and relevant graphics redrawn where individual tray collection data available

Survey metrics

Table 1: Measurements taken by crop type

	Number of tests	2021 GIWA Final production est. (tonnes)
Barley	26	6,370,000
Canola	44	3,130,000
Chick Peas	10	Pulses 104,000
Faba Beans	18	
Field Peas	12	
Lentils	10	
Lupins	26	780,000
Oats	20	735,000
Wheat	34	12,890,000
Total	200	

Table 1 identifies tests conducted by crop type with 2021 GIWA crop type production figures included for reference. Commensurate with production volume and value, wheat (highest production crop) and canola (highest value crop) were included in more tests than other crops.

Table 2: Measurements taken by harvester brand

	Number of tests	% of tests
Case IH	62	31.00%
Cat	3	1.50%
Claas	20	10.00%
Fendt	2	1.00%
Gleaner	1	0.50%
John Deere	59	29.50%

New Holland	53	26.50%
Total	200	100.00%

Table 2 identifies tests conducted by make of harvester, indicating tests conducted for losses was representative of the three makes dominating the harvesting equipment landscape in Western Australia. These figures align with Kondinin Group member machinery inventory data.

Table 3: Measurements taken by front style

	Number of tests	% of tests
Adjustable table	23	11.50%
Conventional	2	1.00%
Draper	122	61.00%
n/a	24	12.00%
Pickup	18	9.00%
Stripper	11	5.50%
Total	200	100.00%

Table 3 lists the front style used by growers with draper fronts featuring most prominently in the data collected. While this aligns with *Kondinin Group member machinery inventory data*, shifts to alternative front styles, for example adjustable table fronts, are beginning to emerge more prominently for difficult to harvest crops including canola as they offer superior feeding and crop flow for direct harvesting.

Table 4: Testing port zone coverage

Port Zone	Full dataset	Excluding front losses	TOTAL	GIWA Production est. 2021 (t)
Albany	30	9	39	5,320,000
Esperance	19	23	42	4,180,000
Geraldton	38	2	40	4,097,000

Kwinana East	19	9	28	Kwinana
Kwinana West	50	1	51	10,412,000
TOTAL	156	44	200	

Table 4 illustrates the spread of test across port zones illustrating the whole of state dataset collected has some level of proportionate representation by region and alignment with 2021 production figures from GIWA.

Loss measurements

Loss measurements are calculated using tray data where possible with reliance on data coming from the Bushel Plus app where tray data was unavailable.

Loss measurements were broken down by source where possible with further distillation by crop type and equipment used where sufficient depth of data was recorded.

This project also identified an anomaly in the way some losses are traditionally reported, with losses measured typically reported as a fraction of the “yield” with yield typically defined as the mass of grain captured by the harvester.

In reality, the true yield is the grain captured by the harvester plus any losses left in the paddock. For the purposes of analysis, loss results have been reported using the latter approach.

Figure 1: Losses by front and machine losses by crop type

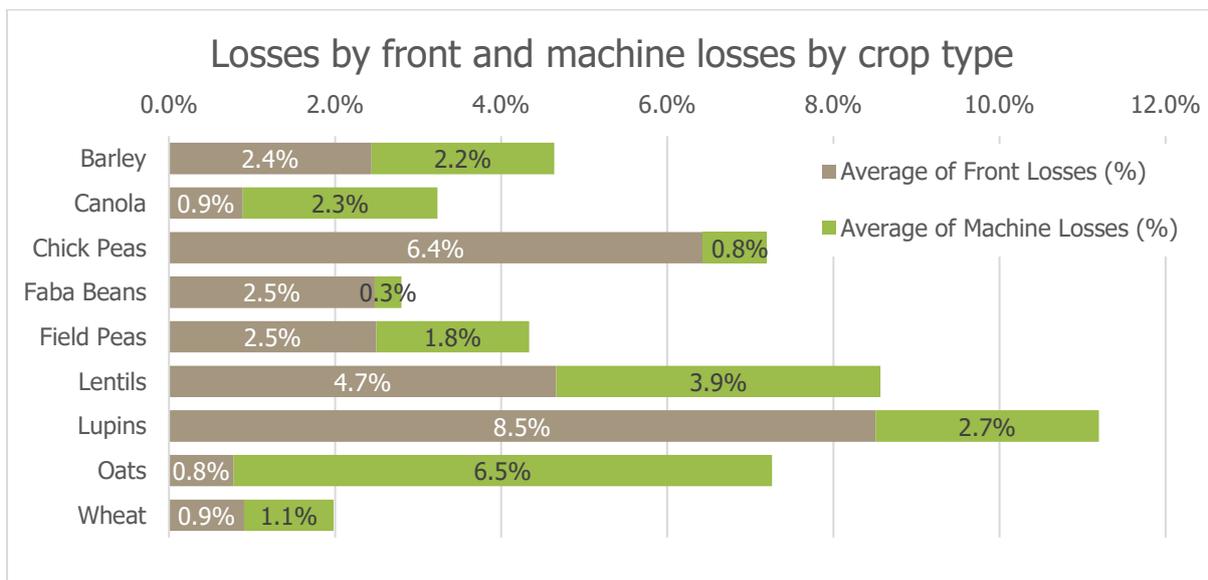


Figure 1 identifies heavy front losses for pulse grains with loss measurements in cereals also significant for both front and machine measurements.

Table 5: Losses by crop type (front and machine)

	Average of Front Losses (%)	Average of Machine Losses (%)
Barley	2.4%	2.2%
Canola	0.9%	2.3%
Chick Peas	6.4%	0.8%
Faba Beans	2.5%	0.3%
Field Peas	2.5%	1.8%
Lentils	4.7%	3.9%
Lupins	8.5%	2.7%
Oats	0.8%	6.5%
Wheat	0.9%	1.1%

Table 5 lists losses by front and machine loss fractions. By way of a benchmark, machine losses should be less than 1% of the total yield in cereals and pulses and under 2-3% for canola.

Average front and machine harvester loss figures captured in this project identify losses in all crop types exceeding these benchmark levels by a significant margin.

Table 6: Average total loss in value terms by crop type

	Yield averages as measured t/ha	Nominal average harvest commodity price (\$/t)	Average front + machine losses (%)	Average value measured lost (\$/ha)
Barley	4.23	\$296.48	4.64%	\$58.24
Canola	2.39	\$886.30	3.23%	\$68.59
Chick Peas	1.32	\$460.00	7.19%	\$43.66
Faba Beans	2.50	\$440.89	2.80%	\$30.84
Field Peas	2.13	\$466.58	4.34%	\$43.00
Lentils	1.19	\$800.00	8.57%	\$81.57

Lupins	2.37	\$305.00	11.20%	\$80.92
Oats	3.80	\$279.15	7.26%	\$77.07
Wheat	4.27	\$335.00	1.98%	\$28.37

Table 6 identifies the average value of total losses on a per hectare basis applying a nominal average price for each commodity at harvest. Higher priced commodities like canola have higher area-based loss figures although due to the high losses in lupins and oats, some of these per area cost figures are also high.

Table 7: Extrapolated total loss value - WA production for a selection of grains

	Nominal ave. Commodity price (\$/t)	Average of Total Losses (%)	2021 WA production (t)	Total extrapolated value of harvest losses
Barley	\$296.48	4.6%	6,370,000	\$87,606,341
Canola	\$886.30	3.2%	3,130,000	\$89,687,330
Lupins	\$305.00	11.2%	780,000	\$26,640,329
Oats	\$279.15	7.3%	735,000	\$14,899,545
Wheat	\$335.00	2.0%	12,890,000	\$85,624,204
Total			23,905,000	\$304,457,749

Table 7 extrapolates the value of measured losses for a selection of grains across the entire WA production area as estimated by GIWA. While sheep grazing on stubbles and unharvested grain may see some of these losses reduced, a reduction in sheep numbers in WA will see the value of grain not harvested as a loss to farm production systems.

While total cost of harvester losses is significant, other factors including pestilence are likely to become increasingly prevalent.

Figure 2: dataset spread of losses in cereals

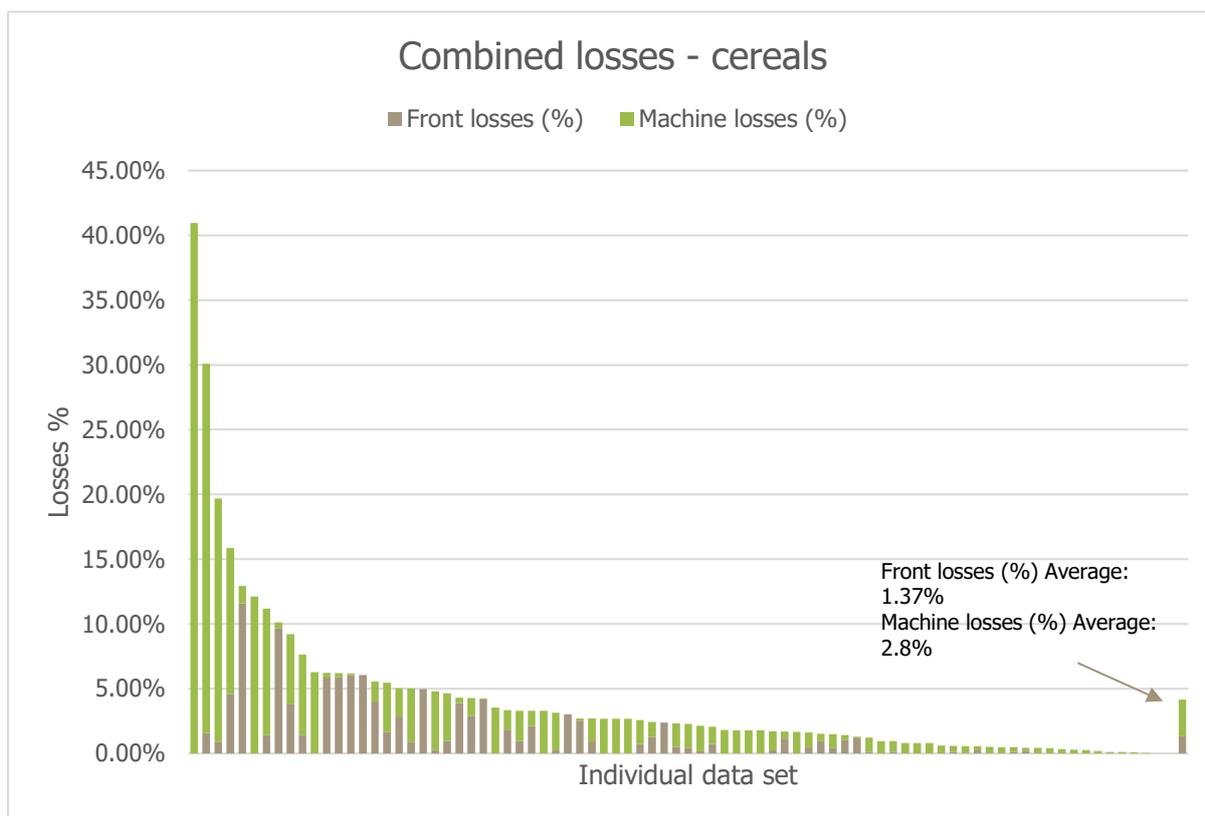


Figure 3: dataset spread of losses in canola

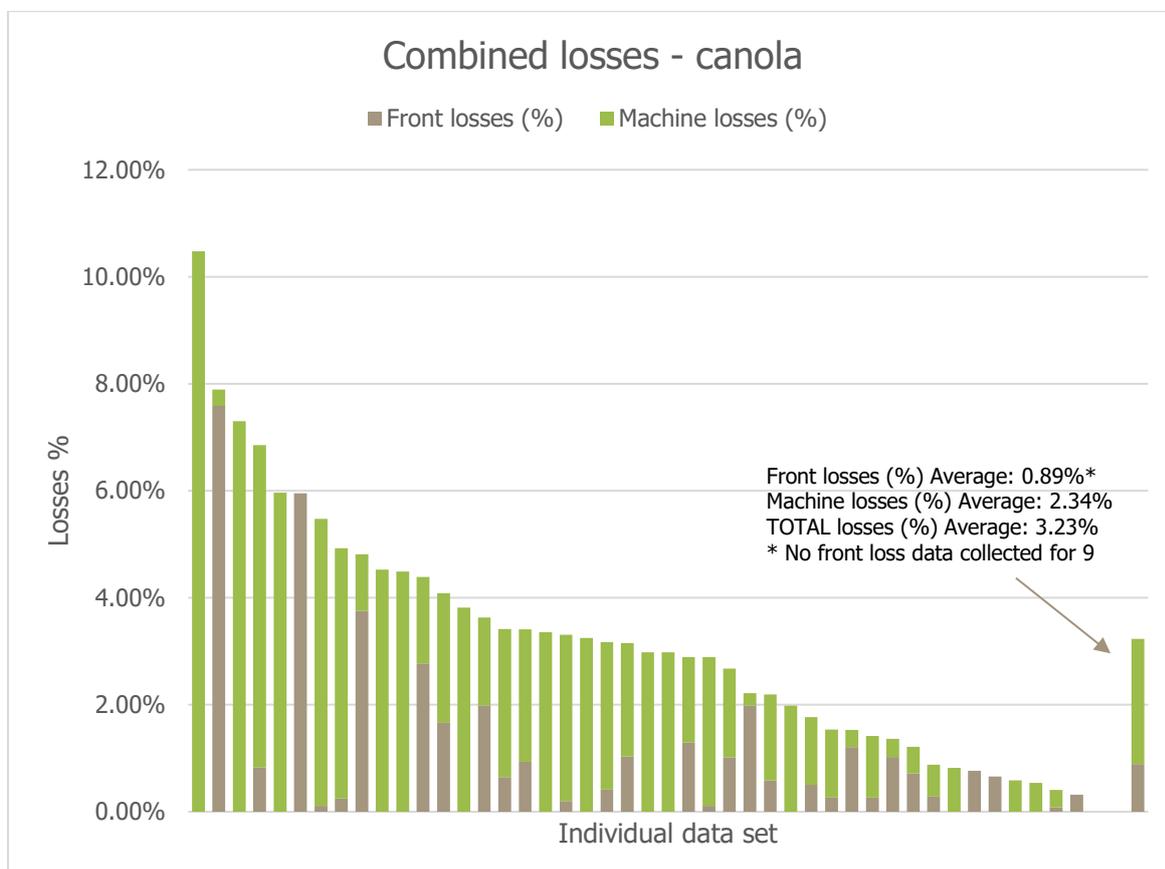


Figure 4: dataset spread of losses in pulses

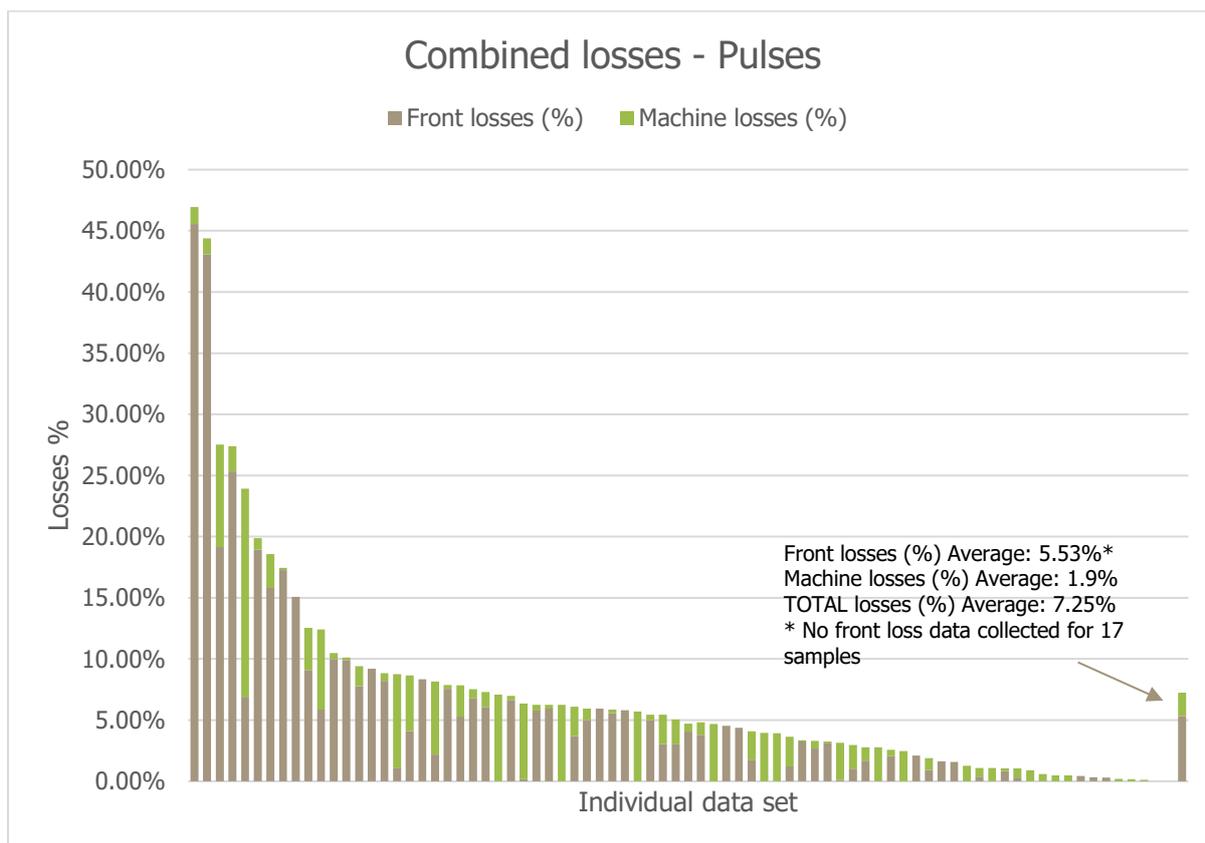
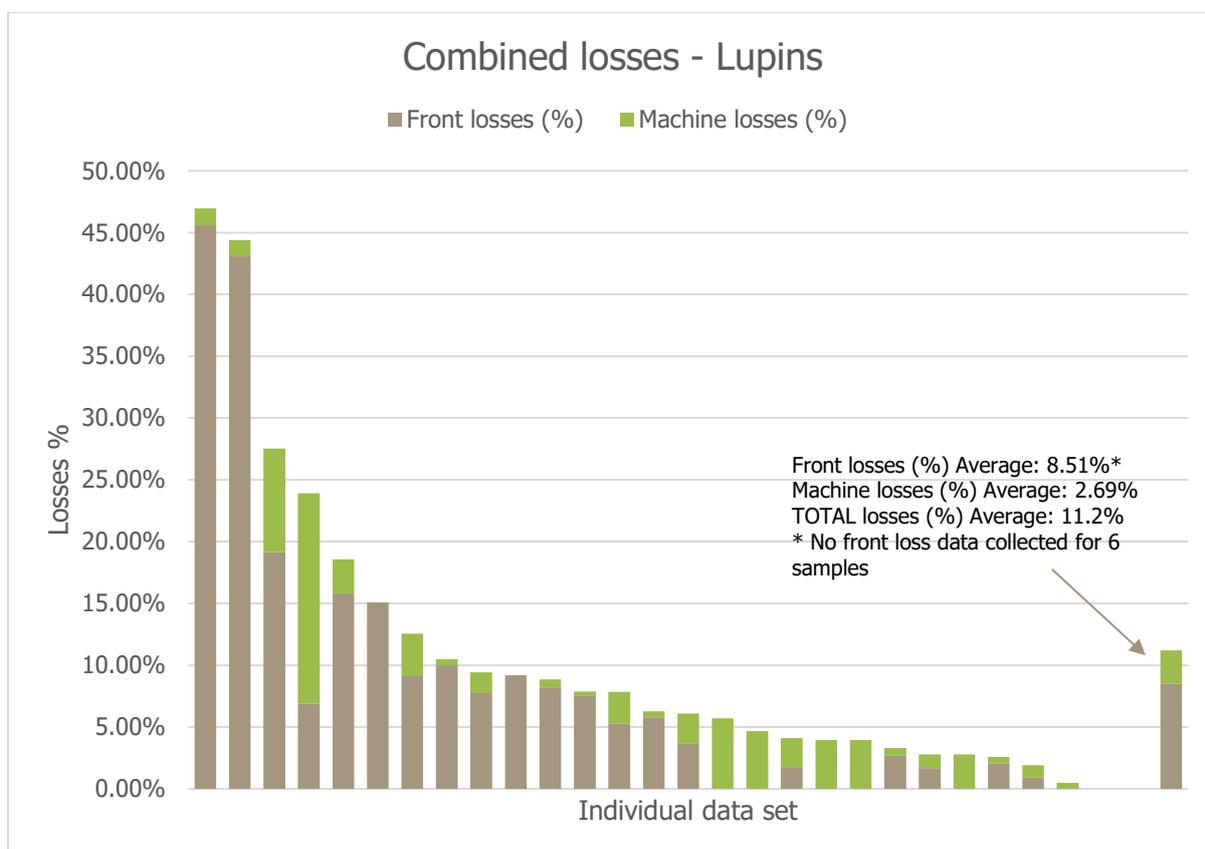


Figure 5: dataset spread of losses in lupins



Machine losses and modifications

Table 9: Modifications to threshing components by brand

	Number tested	Those with threshing modifications	% with threshing modifications
Case IH	62	3	5%
Cat	3		0%
Claas	20	5	25%
Fendt	2	2	100%
Gleaner	1		0%
John Deere	59	6	10%
New Holland	53	6	11%

Table 9 specifies harvesters with modifications to the threshing components as recorded by field personnel. This could include rotor, threshing elements or concave variations to an as-delivered machine.

Table 10: Machine losses in machines with modified threshing components

Crop	Average machine losses in barley and wheat – standard threshing system only (%)	Average machine losses in barley and wheat – modified threshing system only (%)
Wheat	1.3%	0.5%
Barley	2.5%	1.4%

Table 10 lists average machine losses for modified machines in wheat and barley against those in unmodified machines.

Results would suggest losses can be minimised significantly by undertaking adjustments to the standard threshing components. Modifications identified included aftermarket concaves, rotor and threshing element adjustment including full sets of spiked rasp bars.

Front losses and modifications

Table 11: Front make used – All crops

Make	Number	% of tests
Case IH	15	8.1%
Claas	8	4.3%
Fendt	2	1.1%
Honeybee	2	1.1%
John Deere	38	20.5%
MacDon	73	39.5%
Midwest	6	3.2%
New Holland	21	11.4%
Phillips	3	1.6%
Other pickup	6	3.2%
Shelbourne	11	5.9%
Total	185	100%

Table 11 lists harvester fronts used by make. MacDon and John Deere draper fronts dominate the dataset but this is in keeping with Kondinin Group member machinery inventory data and suggests an accurate representation of currently used harvester fronts in Western Australia.

Crop losses are identified by front style in tables 12, 13 and 14. While arguably offering additional throughput and increased field efficiency, average losses measured with stripper fronts are significantly higher than draper fronts in cereals which growers should consider when calculating the benefits and costs of using a stripper front, for example in a strip and disc system.

It could be argued that the investment in an adjustable table front to improve field efficiency may also offer growers significant reductions in losses with canola. Reductions in average losses with an adjustable table front were also observed in barley.

Table 12: Front losses by front style: Barley

Crop type		Barley	
Front losses by front style			
	Number tested	Average Front Losses (%)	
Adjustable table	5	1.1%	
Draper	13	1.6%	
Stripper	5	3.7%	
Total	23	1.9%	

Table 13: Front losses by front style: Wheat

Crop type		Wheat	
Front losses by front style			
	Number tested	Average Front Losses (%)	
Draper	26	0.8%	
Stripper	6	1.8%	
Total	32	1.0%	

Table 14: Front losses by front style: Canola

Crop type		Canola	
Front losses by front style			
	% of growers	Number tested	Average front losses (%)
Adjustable table	48%	13	1.0%
Draper	52%	14	1.7%
Total	100%	27	1.3%

Table 15: Air reel use - Lentils

Crop type		Lentils
Front losses by front style		
	Number tested	Average Front Losses (%)
Air reel	5	2.5%
No mods	5	6.9%
Total	10	4.7%

While lentils are an emerging crop in Western Australia, measured losses indicate a strong case for the use of an air reel to minimise losses. Table 15 illustrates losses on 5 non-modified fronts were almost three times that of fronts that had an air reel fitted.

Assuming a yield of 1.2t/ha and average pricing of \$800/t, the payback requirement for an \$80,000 air reel is only around 1800ha based on the average losses measured in 2021.

Table 16: Air reel use – Faba beans

Crop type		Faba Beans
Front losses by front style		
	Number tested	Average Front Losses (%)
Air reel	3	4.1%
No mods	15	2.1%
Total	18	2.5%

For Faba beans, table 16 identifies higher losses when using an air reel. However a small sample size of just three datasets against a larger dataset of 15 samples raises questions around the validity of this specific result.

Table 17: Losses by measurement drop trays

	Number of growers using drop trays	% of growers	Average of measured machine Losses (%)
No trays	110	61.80%	2.9%
Yes - own trays	68	38.20%	1.3%
Total	178	100.00%	2.3%

Be it simply awareness, or the ability to quantify and manage losses accordingly, Table 17 illustrates the lower level of losses growers using drop trays were able to achieve. Unfortunately, the proportion of growers using drop trays are in the minority in Western Australia.

Table 17b: Achieved benefit using trays

	Canola	Wheat
Machine losses – Growers not using trays	2.74%	1.41%
Machine losses – Growers using trays	1.60%	0.69%
Benefit for those using trays (reduction in losses)	1.14%	0.72%
Average yield in dataset (t/ha)	2.4	4.3
Average value at harvest (\$/t)	\$886.30	\$335.00
Differences in losses per hectare (kg)	27.3	30.9
Differences in losses per hectare (\$)	\$24.18	\$10.35

Table 17b demonstrates the value of growers dropping trays to measure machine losses to quantitatively evaluate losses and subsequently make adjustments to their harvester to reduce losses.

Successive repetitions

Tables 18-20 demonstrate the importance of knowing where to look to minimise losses. These figures look at successive repetitions with growers looking to minimise losses whilst maintaining capacity. With the exception of cereals, where growers were able to reduce losses in successive repetitions, for both canola and pulses, adjustments made by the operator utilising the knowledge of a previous test were largely futile.

Results would suggest that without expert advice, growers trying to optimise both capacity and losses by making machine adjustments are likely to make little headway on either front.

Table 18: Losses by repetitions: Cereals

Crop type		Cereals
Total losses by repetition (Cereals)		
Rep number	Average Losses (%)	
1	3.2%	
2	3.2%	
3	1.8%	
4	15.9%	
Average	3.1%	

Table 19: Losses by repetitions: Pulses

Crop type		Pulses
Total losses by repetition (Pulses)		
Rep number	Average Losses (%)	
1	7.7%	
2	8.3%	
3	3.4%	
Average	7.3%	

Table 20: Losses by repetitions: Canola

Crop type	Canola
Total losses by repetition (Canola)	
Rep number	Average Losses (%)
1	2.7%
2	3.5%
3	4.1%
4	3.0%
Average	3.2%

Table 21: Harvester capacity by crop

	Average of capacity t/hr
Barley	32.7
Canola	12.8
Chick Peas	18.9
Faba Beans	15.7
Field Peas	10.1
Lentils	9.4
Lupins	19.8
Oats	27.6
Wheat	31.6

Harvester capacity and losses need to be balanced in any harvesting operation. Maximum harvester capacity should be obtained whilst adhering to losses below 1% in cereals and 2-3% in canola. Table 21 demonstrates the average capacity of harvesters by crop for the 2021 harvest.

Residue management

Tables 22 and 23 demonstrate residue management practices employed by growers in the captured dataset. Less than 10% of growers are windrowing straw from the harvester while the chaff fraction was windrowed in nearly 40% of cases.

Weed seed mill use at 9% would appear to be relatively low by industry data including Kondinin Group member machinery inventory figures.

Table 22: Straw management

% adoption straw management	
Chop and spread	92%
Windrow	8%
Total	100%

Table 23: Chaff management

% adoption chaff management	
Chaff Cart	5.70%
Chaff decks	8.23%
Spread	37.97%
Weed seed mill	8.86%
Windrow	39.24%
Total	100 %

Table 24: Front loss position

Losses measured for the harvester front were taken at the centre draper, side (table auger or transverse draper belt) section and at the crop divider. Multiplying each of these areas by their relative swath width coverage, an analysis can be made of which components on the harvester front is contributing to total front losses.

Unsurprisingly, different crops resulted in higher losses at the three measured positions. Cereal grains were largely lost off the front along the front width outside the centre section while nearly two thirds of canola losses occurred at the centre section.

Front loss sources by position (%)	Cereals	Canola	Lupins
Centre (2m)	21%	62%	19%
Outside centre	70%	35%	72%
Crop divider	8%	3%	9%
TOTAL	100%	100%	100%

Extrapolating the data

Table 25 illustrates the total lost value per grower by dividing GIWA production figures by 3,800 growers in WA, multiplying this production by the average losses for that crop the typical harvest value in 2021. Applying these averages across all growers in WA indicates they are each leaving behind over \$80,000 worth of grain in the paddock.

Table 25: Losses by value for an "average" WA grower

Crop type	Average tonnage grown per grower based on GIWA production divided by 3800 growers	Average of Total Losses (%)	Loss per grower (Total value of losses) Based on av. measured losses by harvest value
Barley	1,676	4.6%	\$23,054
Canola	823	3.2%	\$23,602
Lupins	205	11.2%	\$7,011
Oats	193	7.3%	\$3,921
Wheat	3,392	2.0%	\$22,533
			\$80,120

Table 26: Losses by value for an “average” WA grower

	Average of Front Losses (%)	Average of Machine Losses (%)	Value of Front losses (Av. \$ per grower)	Value of Machine losses (Av. \$ per grower)
Barley	2.44%	2.20%	\$12,113	\$10,941
Canola	0.89%	2.34%	\$6,504	\$17,098
Lupins	8.51%	2.69%	\$5,327	\$1,684
Oats	0.78%	6.49%	\$419	\$3,502
Wheat	0.90%	1.08%	\$ 10,281	\$12,251
TOTAL			\$34,643.13	\$45,477.33

In Table 26, an extrapolation of the collected dataset across state production figures indicates Western Australian growers are, on average, each losing \$34,600 worth of grain off the harvester front and almost \$45,500 in sieve or rotor losses.

Benchmark performance capacity and losses

Peak operating capacity examples from collected data set whilst maintaining minimal losses

Benchmark peak capacity at minimal losses														
Dataset Number	Crop type	Average Yield	Harvester Make	Harvester Model	Harvester capacity t/hr	Front Make	Front style	Speed (km/hr)	Yield wet t/ha	Engine load (%)	Fuel use (L/h)	Front Losses (%)	Machine Losses (%)	Total Losses (%)
Sub 2% losses														
29	Barley	4	Claas	Lexion 750	33	Claas	Adjustable table	5	4.9	60%		0.00%	1.67%	1.67%
59	Chick Peas	1.2	Case IH	8250	25	MacDon	Draper	7.9	1.2			0.38%	0.02%	0.40%
47	Faba Beans	5.1	New Holland	CR9.90	27	NH	Adjustable table	4.5	5	78%		0.86%	0.43%	1.29%
19	Lupins	1.5	Case IH	7010	15	Case IH	Draper	7.7	1.6			0.92%	0.98%	1.90%
60	Oats	2.92	Case IH	8250	32		Draper	8.3	2.92			0.15%	0.02%	0.16%
35	Wheat	2.7	New Holland	CR9.90	34	Macdon	Draper	7.6	3.7			0.00%	0.08%	0.08%
Sub 3% losses														
37	Canola	4	New Holland	970	20	NH	Adjustable table	4.5	4	76%		0.11%	1.14%	1.25%
2	Lentils	1.3	John Deere	S780	15	JD	Draper	7.1	1.8			1.03%	1.41%	2.44%
Sub 5% losses														
3	Field Peas	2.1	New Holland	CR9080	18	Macdon	Draper	6	2.2			0.17%	4.30%	4.47%

DISCUSSION OF RESULTS

This project measured the scale of grain and profit lost during harvest and has found that Western Australian growers have an opportunity to reduce harvest losses which were estimated at \$300 million in 2021.

Findings from the 12-month GRDC investment have been compiled from a study conducted across 75 sites (200 tests) during the harvest of 2021.

This project found that the average losses in wheat and barley crops were around two and 4.6 per cent per hectare respectively. In canola, losses were measured at 3.2 per cent per hectare but were as high as 10 per cent at some sites. The spread of losses was considerable with outliers present.

In comparison, industry-wide loss benchmarks are less than 1 per cent per hectare for cereals and 2-3 per cent per hectare for canola. Harvest losses were found in all crop species to be greater than the industry benchmarks, indicating that WA growers have an opportunity to reclaim a portion of these.

Historically, growers often rely on visual assessment of grain on the ground to measure losses, but this method does not provide the accuracy needed for informed decisions about machine setup and setting changes.

Table 25: Losses by value for an “average” WA grower

Crop type	Average tonnage grown per grower based on GIWA production divided by 3800 growers	Average of Total Losses (%)	Loss per grower (Total value of losses) Based on av. measured losses by harvest value
Barley	1,676	4.6%	\$23,054
Canola	823	3.2%	\$23,602
Lupins	205	11.2%	\$7,011
Oats	193	7.3%	\$3,921
Wheat	3,392	2.0%	\$22,533
			\$80,120

In this study, growers using drop trays were found to have averaged 1.3 per cent machine losses across all crops, while those not using trays averaged 2.9 per cent.

This data underpins the assertion that visual assessment of grain on the ground does not provide the accuracy needed for informed decisions about machine set-up and setting changes. It also indicates that growers who invest in measurement tools are more effective at reducing losses.

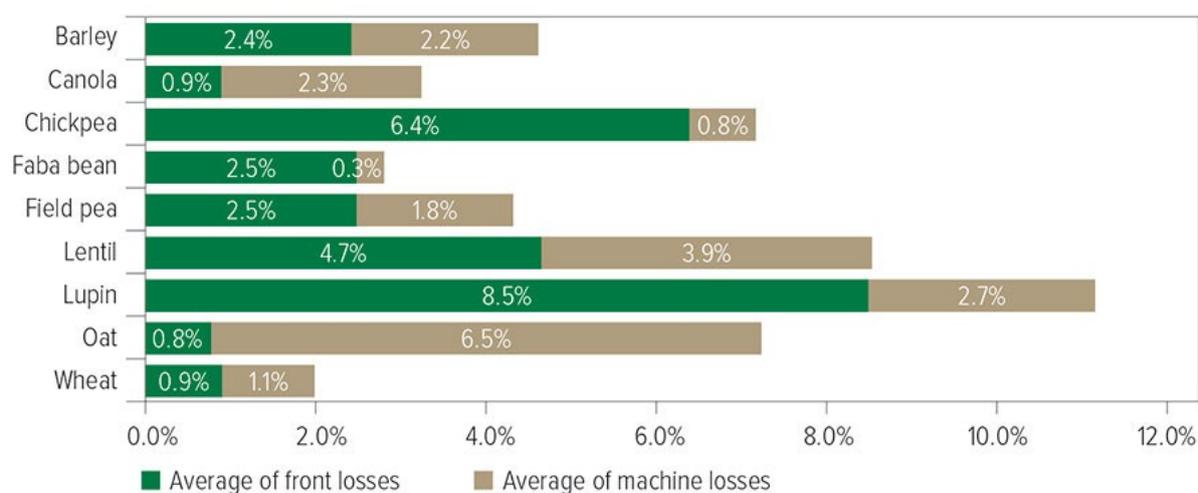
Drop trays should be regularly used each season and in every crop to assess harvest losses and assist in adjusting harvester settings and calibrating sensors in newer harvesters.



Source: Grower Group Alliance

Front and machine losses were measured for nine crop species using several different harvester brands and front types using a consistent protocol.

Figure 1: Losses by front and machine by crop types.



Source: Grower Group Alliance

Harvest losses were converted to financial losses on a per tonne basis, applying a nominal average price for each commodity for the 2021 harvest. These financial losses are shown by crop species for an average WA grower in the Table below. The data indicates an average WA grower is leaving behind \$80,000 worth of grain in the paddock.

Losses by value for an 'average' WA grower.

	Average of front losses (%)	Average of machine losses (%)	Value of front losses (Av. \$ per grower)	Value of machine losses (Av. \$ per grower)
Barley	2.44	2.20	12,113	10,941
Canola	0.89	2.34	6,504	17,098
Lupins	8.51	2.69	5,327	1,684
Oats	0.78	6.49	419	3,502
Wheat	0.90	1.08	10,281	12,251
TOTAL			34,6413	\$45,477

Source: Grower Group Alliance

The project identified several machinery trends:

- Front losses were far higher than expected. Front losses in canola averaged 1.7 per cent for growers using draper fronts, while adjustable table fronts averaged losses of one per cent.
- While arguably offering additional throughput and increased field efficiency, average losses measured with stripper fronts are significantly higher than draper fronts in cereals, which growers should consider when calculating the

benefits and costs of using a stripper front, for example in a strip and disc system.

- When harvesting cereals, it is recommended that growers set the reel to penetrate the crop only enough to lay cut material onto the draper belt. This prevents the reel from knocking grain out of the head and onto the ground.
- While lentils are an emerging crop in WA, measured losses indicate a strong case for using an air reel to minimise losses.
- When direct-harvesting canola, tests showed losses from an adjustable table front were one per cent compared to 1.7 per cent with a standard draper front. When you put that in context, with the canola price, the capacity to minimise losses with an adjustable table front in a direct harvesting scenario will pay for itself relatively quickly.
- Investment in an adjustable table front to improve field efficiency may also offer growers significant reductions in losses with canola. This project demonstrated average losses in a 2.39-tonne-per-hectare canola crop are just over three per cent, reducing profit by more than \$68/ha when canola is valued at \$886.30/tonne.
- Reductions in average losses with an adjustable table front were also observed in barley.

Results from the study have informed growers and the upcoming GRDC Western Harvester Forums and resulted in an increase in the number of growers attending the forums.

Losses can usually be reduced to a certain extent by simply going slower, but this has to be done to balance the capacity and cost of harvest.

Research would suggest losses can be minimised significantly by undertaking adjustments to the standard threshing components while improving harvester capacity. Modifications identified included aftermarket concaves, rotor and threshing element adjustment including rotor offsets, and rasp bar changes.

A number of apps are available to assist in calculating harvest losses that have other functions, such as the ability to store harvester settings and crop conditions.

The WA harvest loss study indicates that further work needs to be undertaken to identify additional means of loss reduction during harvest for each crop species.

The project results also show it is important to extend this project into other grain growing regions where losses may also be excessive. However, given the variation and without access to equivalent data from other states, it would therefore be difficult to assume national consistency extrapolated from this data. In addition, there would be significant variation in yield potentials, residue management, harvester types and

configurations within and across states that would need to be quantified. This represents a potential future investment by GRDC.

Specific information, products and/or services delivered to target users

Specific information, products and services delivered to the target users include:

1. Participating growers received a free service to demonstrate the value of optimising their harvesters
2. Presentation of the project findings at GRDC Grains Research Updates
3. Presentation and informative reports at grower group forums and through their communication channels
4. Participating grower group staff were equipped and trained to use drop pans to provide an ongoing capability for the benefit of growers by retaining the drop pan equipment on completion of the project.
5. GRDC were provided with recommendations for future investments in harvest losses.

Intellectual property

No Intellectual Property was produced by this project. However, the record collection BushelPlus app was background IP.

EXTENSION OF RESULTS

This project facilitated an impressive flow of information from reputable consultants armed with justifiable results to capture growers' and advisors' attention and provide confidence to invest time measuring losses.

The project team promoted outcomes of the study through crop updates, local grower group peer-to-peer learning forums and GRDC and Grower Group Alliance (GGA) communications channels and Harvester Setup Forums.

Extension of the 2021 Harvest loss work included:

- Creation of a webpage on the Grower Group Alliance website, updated regularly with results and resources. Start of the 2021 project to the finish of the 2022 project.
- Triple M radio i/v – Rural Focus Tuesday 4th October
- GRDC Press releases with Danielle Green, Nicole Baxter (Coretext) and Sue Knights (GRDC)

- [https://groundcover.grdc.com.au/farm-business/business-management/research-finds-opportunity-to-reclaim-\\$300m-in-grain-lost-at-harvest](https://groundcover.grdc.com.au/farm-business/business-management/research-finds-opportunity-to-reclaim-$300m-in-grain-lost-at-harvest)
- <https://groundcover.grdc.com.au/farm-business/learning-and-development/find-your-harvesting-sweet-spot>
- <https://groundcover.grdc.com.au/innovation/precision-agriculture-and-machinery/how-profitable-is-your-harvester-set-up>
- <https://groundcover.grdc.com.au/farm-business/learning-and-development/phase-two-of-grdcs-harvest-losses-project-announced>
- <https://groundcover.grdc.com.au/innovation/industry-insights/new-research-to-reveal-true-cost-of-harvest-losses-to-growers>
- Twitter
 - <https://twitter.com/InnovationFarm7/status/1604909835241521152?s=20>
 - <https://twitter.com/harvestloss/status/1571031665371234307?s=20>
 - <https://twitter.com/1800weevil/status/1577880014745632768?s=20>
 - <https://twitter.com/1800weevil/status/1577881531124944896?s=20>
- Farming Ahead
 - <https://www.farmingahead.com.au/on-farm/news/1438709/research-finds-usd300-million-in-grain-losses-last-harvest>
 - Also mentioned in Research Report February 2023: pp11 ^[1]
<https://tinyurl.com/KGFeb23RR>
- Harvester workshops
 - Harden NSW 16/8/22
 - Caragabal NSW 17/8/22
 - Lockhart NSW 18/8/22
 - Tarin Rock WA 12/9/22
 - Frankland WA 13/9/22
 - Merredin WA 20/9/22
 - Dalwallinu WA 21/9/22
 - Chapman Valley WA 21/9/22
 - Dulacca Qld 27/9/22
 - Inglestone Qld 28/9/22
 - Keith SA 11/10/22
 - Millicent SA 12/10/22
 - Hamilton Vic 13/10/22

- Inverleigh Vic 14/10/22
- Cressy Tas 18/11/22
- ABC Rural radio – Rural Report – Dowerin field days late August 2022
- GRDC crop updates – Perth 2023 – Feedback on the session as follows:
 - There were 85 attendees in your session and they rated the value of your presentation as **9 out of 10** (Congrats! The highest score for an individual presentation at the Update!) with some specific comments:
 - Measure Measure Measure
 - A good first step to minimising crop losses is start using trays
 - Front header losses on Lupins were considerably higher than any other commodity, meaning more work here can be done to limit losses
 - Some great calculations surrounding harvest loss and quantified results. Making it clear that machine set up is critical to minimise losses without compromising

CONCLUSION

This project measured the scale of grain and revenue lost during harvest and found Western Australian growers left grain valued at \$300 million in the paddock in the 2021 season. Losses for all crops exceeded industry benchmarks. The project team estimate up to half of the losses could be avoided with regular measurement and adjustment of machinery and adoption of best practice modifications.

With better than average crops harvested in the 2021, it should be remembered that harvest loss figures in a lower yielding year may vary significantly in loss amount, source or geographic location to those found in this research.

Determining the best path to minimise losses whilst maintaining capacity requires continuing education of operators, trainers and in some cases, manufacturers.

There is a need to continue to support Western Australian growers to understand the benefits of measuring machine performance so they can calculate their losses and build a business case for investment in modifications.

Growers using trays had significantly lower losses simply by using trays for quantification, calibration of loss sensors and iterative investigation to address the

source of losses. The need for all growers to embrace drop trays is demonstrated in this data.

The project results also show it is important to extend this project into other grain growing areas to determine if losses there are excessive. However, given the variation in our data and without access to equivalent data from other states, it would be difficult to extrapolate this data nationally. Significant variation in yield potentials, residue management, harvester types and configurations within and across states may be problematic. This represents a potential future investment by GRDC.

Modifications to the machine threshing components should be investigated further and quantified for a cross-section of modifications, harvesters and crop types. This training would be more effective if supported by independent research to quantify the potential benefits of, for example, threshing component modifications.

IMPLICATIONS

The project has implications for:

- GRDC Investment Team: the level of investment GRDC makes in this area address losses
- Machinery Dealers and Growers: the type of modifications to harvesters required to reduce losses per species
- Growers: the process growers use to analyse and adjust machinery setup during harvest

RECOMMENDATIONS

Program findings that \$300 million of grain are being spilt on the ground in Western Australia has increased awareness of the issue, has created a benchmark and is driving change (increased attendance at harvester setup forums). These results have identified a significant issue in Western Australia that is likely to have some relevance and application to other cropping regions across Australia.

- Recommendation 1: The survey continue in Western Australia to increase awareness of the issue, to measure grower's level of adoption of closer attention to waste and to determine the extent of losses in lower yield harvests.
- Recommendation 2: Growers use a grain collection (drop) tray to measure losses and fine-tune productivity. Change one setting at a time and re-test to check the results
- Recommendation 3: Growers measure losses for each crop at the start of harvest and when conditions change markedly.
- Recommendation 4: The project be deployed to other grain growing areas to establish the extent of the issue.
- Recommendation 5: Growers consider the various elements of their harvester setup and ensure each is aligned with the findings of this report.
- Recommendation 6: The correlation of grain spilt to mouse numbers be explored.

APPENDIX A: Machine loss calculations

Pending dataset quality, each residue management style calculation was evaluated differently.

Assumptions below are made as specified for each residue management approach.

Where available, individual tray figures were used to calculate losses as follows:

Weed seed mill

Weed seed mill datasets provided both centre and side machine loss tray weights (or no tray weights and no Bushel Plus kg/ha or % machine losses).

Assumes no measurable sieve losses.

Assumes all grains caught in centre tray and spread tray are rotor losses.

Average of centre tray and spread tray weights then applies this averaged weight to the residue spread width where known (or cut width where not known).

Chop and spread (using 2 trays)

Assumes sieve and rotor losses measured are spread to the recorded “residue spread” or where this is not recorded, the full cut width is used as the residue spread.

Calculate average of centre tray and side spread tray and apply for spread width where known (or cut width where not known).

Where individual tray weights are not provided, Bushel Plus (kg/ha) loss figures from original datasets were used.

Calculate losses in kg/ha and %.

Narrow windrow

Assumes all sieve losses are confined to the 1m centre tray.

Where no tray data is provided for machine loss, Bushel Plus app calculated losses in kg/ha have been applied to calculations.

Where individual tray weights are not provided, utilises Bushel Plus (kg/ha) loss figures from original datasets.

Calculate losses in kg/ha and %.

Chaff deck

Assumes chaff deck trays were used to measure all losses (including sieve losses off the decks).

Assumes left and right deck are uniform in discharge volume of losses.

Assumes all sieve losses are confined to the trays dropped in the wheel tracks.

GLOSSARY AND ACRONYMS

Below is a sample abbreviations and acronyms list. Be sure to include all abbreviations and acronyms that appear in the report.

DPIRD	Department of Primary Industries and Regional Development
DAP	di ammonium phosphate
DArT	Diversity Arrays Technology
DAT	days after treatment
Db	bulk density

DISCLAIMER Any recommendations, suggestions or opinions contained in this publication do not necessarily represent the policy or views of the Grains Research and Development Corporation (GRDC). No person should act on the basis of the contents of this publication without first obtaining specific, independent professional advice.

The Grains Research and Development Corporation may identify products by proprietary or trade names to help readers identify particular types of products. We do not endorse or recommend the products of any manufacturer referred to. Other products may perform as well as or better than those specifically referred to. The GRDC will not be liable for any loss, damage, cost or expense incurred or arising by reason of any person using or relying on the information in this publication.

Caution: Research on Unregistered Pesticide Use

Any research with unregistered pesticides of unregistered products reported in this publication does not constitute a recommendation for that particular use by the authors or the authors' organisations.

All pesticide applications must accord with the currently registered label for that particular pesticide, crop, pest and region.

Copyright © All material published in this publication is copyright protected and may not be reproduced in any form without written permission from the GRDC.