Final Technical Results Report

2023

Measuring Harvest Losses in the Western Region 2022/23 Season

Project code:	GGA2211-001SAX
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REPORT SENSITIVITY

Does the report have any of the following sensitivities?

Intended for journal publication	YES ☐ NO ☒
Results are incomplete	YES ☐ NO ☒
Commercial/IP concerns	YES ☐ NO ☒
Embargo date	YES ☐ NO ☒ If Yes, Date: <Choose date>

ABSTRACT

The aim of this project was to work with growers to maximise harvester throughput capacity with acceptable losses in the Western region. While there are a number of variables that can influence harvest losses, this project demonstrated where most losses occur and how they can be reduced. These results support data generated from the 2021/22 harvest where over $300M of grain was potentially lost during the harvest process in Western Australia.

The project was co-ordinated and led by the Grower Group Alliance with the research component managed by harvest expert Ben White. The project was also supported by Peter Broley of Primary Sales who provide Bushel Plus drop trays and training in their use. The on-ground measurements were conducted by three grower groups (Liebe Group, Corrigin Farm Improvement Group and Stirlings to Coast Farmers) and a private consultant in Esperance who measured harvest losses in 65 paddocks for 8 crop species.

Harvest losses in the 2022/23 season were generally in excess of acceptable thresholds for all crop species except wheat but closely reflected the results achieved in 2021/22 with an estimated $320m of grain losses estimated for the Western Region. Front losses exceeded machine losses for all crop species except barley and oats and losses from stripper fronts were often far higher than for other front styles. Harvest losses for grain legumes, particularly lupins, continue to exceed those of cereals and canola.

Growers that used drop trays for quantification of grain losses, calibration of loss sensors and iterative investigation to address the source of losses had significantly lower losses. There may be a strong business case for the use of Vario/Varicut/Varifeed fronts as canola throughput and harvest losses were significantly reduced where they were utilised. There also appears to be merit in the use of aftermarket accessories to optimise the threshing system but further work would be recommended to validate this work more widely.

This research demonstrates where harvest losses occur and potential improvements and modifications to harvester set up that can improve grain yield retention. However, the data indicates that there remains significant variation in harvest losses at a regional and grower level so continued education in harvester setup would be highly beneficial for the industry. Caution should be taken in extrapolating this data to the southern and eastern regions of Australia as yield potentials, residue management, harvester types and configurations within and across states vary considerably. This represents a potential future investment by GRDC.

REPORT

2022
Harvester loss testing: data analysis

GRDC Western Region

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Fifth draft: 11/5/23: Style check and terminology consistency, added data sheet appendix
Sixth draft 15/5/23: DK comments, BW response notes and additions
Seventh draft 16/5/23: National loss figures via ABARES
Eighth version: Final

Executive summary

Quantifying harvest losses can assist in determining the source of the loss during the harvesting operation and optimising harvester setup and machine settings to improve field efficiency. Minimising losses should always be balanced with harvester operating cost and throughput.

Losses are unlikely to be eliminated due to the capacity balance that must be required. As per industry guidelines (Society of Agricultural Engineers, Prairie Agricultural Machinery Institute and Kondinin Group), a <1% of yield loss in cereals should be achievable with <2-3% in canola pending the conditions. 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.

Losses measured by the Grower Group Alliance exceeded these guideline benchmarks for all winter crop grain types except wheat in 2022. Note this analysis does not extend to summer crops including corn and sorghum as produced in the Ord.

Front losses were also surprisingly high, exceeding measured machine losses in all crops except for barley and oats. In particular, the centre 2m of the front contributed significantly to these figures.

Of note, while offering significantly higher throughput in wheat and barley, stripper front losses were higher than other front styles.

Vario/Varicut/Varifeed fronts also demonstrated improvement in throughput in canola crops but with a significant reduction in front losses, making a strong business case for their use.

There is an opportunity to recoup a considerable portion of harvest losses which, when tallied, exceed a value of $320m in Western Australia alone. With additional vigilance and education, halving these losses should be possible. While extrapolation of these Western region loss figures to other GRDC regions is discouraged due to likely harvest and production system variables, it has been included as a project requirement and estimates harvest losses at almost $750m nationally.

Steps to reducing these losses start with harvester operator loss quantification and subsequent loss sensor calibration. Growers that measured losses with drop trays had lower loss figures for high value crops.

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 years of experience and skill sets beyond those available at a grower group staff level. As a result, before and after adjustment testing rarely delivered any significant improvement in performance throughput or loss minimisation.

There appears to be merit in threshing system optimisation with aftermarket accessories. Loss reductions and capacity increases have been demonstrated in third-party preliminary research[1] but an investment in further work in this space would look to validate this work more widely.

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[1] https://tinyurl.com/KGFeb23RR

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Survey metrics

Table 1: Measurements taken by crop type

	Number of tests	2022 GIWA Final production est. (tonnes)
Barley	30	6,300,000
Canola	44	4,300,000
Chickpeas	11	Pulses 72,000
Faba beans	3	
Field peas	2	
Lupins	24	895,000
Oats	12	565,000
Wheat	30	13,930,000
Total	**156**	**26,062,000**

Table 1 identifies tests conducted by crop type with 2022 GIWA crop type production figures included for reference.

Commensurate with production volume and value, wheat (highest production crop) and canola (highest value crop) together accounted for around half of the tests undertaken.

Due to the timing of harvest and the limited production areas available, lentils were omitted from the 2022 analysis as growers harvested these crops several weeks earlier than they would normally.

Table 2: Measurements taken by harvester brand

	Number of tests	% of tests (2022)	2021 comparison
Case IH	49	31%	31%
Claas	12	8%	10%
Gleaner	1	1%	0.5%
John Deere	77	49%	29.5%
New Holland	17	11%	26.5%
Grand Total	**156**	**100%**	**100%**

Table 2 identifies tests conducted by make of harvester, indicating tests conducted for losses represented major brands used in Western Australia although was slightly skewed toward John Deere manufactured harvesters with potential underrepresentation for New Holland and Claas machines. 2021 data had more representation from New Holland and Claas.

Table 3: Measurements taken by front style

	Number of tests	% of tests
Conventional (tin)	5	3.2%
Draper	129	82.7%
Stripper	7	4.5%
Vario/Varicut/Varifeed	12	7.7%
Pickup	3	1.9%
Grand Total	156	100%

Table 3 lists the front style used by growers, with draper fronts featuring most prominently in the data collected.

While there is alignment with Kondinin Group member machinery inventory data, there is an increasing shift to alternative front styles, for example, Vario/Varicut/Varifeed adjustable table style fronts. Draper fronts can limit capacity in difficult to harvest crops including canola, so it is likely adjustable table fronts will increase in popularity because they offer superior feeding and crop flow for direct harvesting.

Table 4: Testing port zone coverage

Port Zone	TOTAL	GIWA Production est. 2022 (t)
Albany	23	5,480,000
Esperance	18	4,240,000
Geraldton	45	4,317,000
Kwinana East	31	Kwinana 12,025,000
Kwinana West	39	
TOTAL	**156**	**26,062,000**

Table 4 illustrates the spread of testing across port zones and alignment with 2022 production figures from GIWA. Due to the timing of harvest, the Geraldton port zone could be overrepresented in the dataset, while Albany and Esperance port zones are arguably underrepresented.

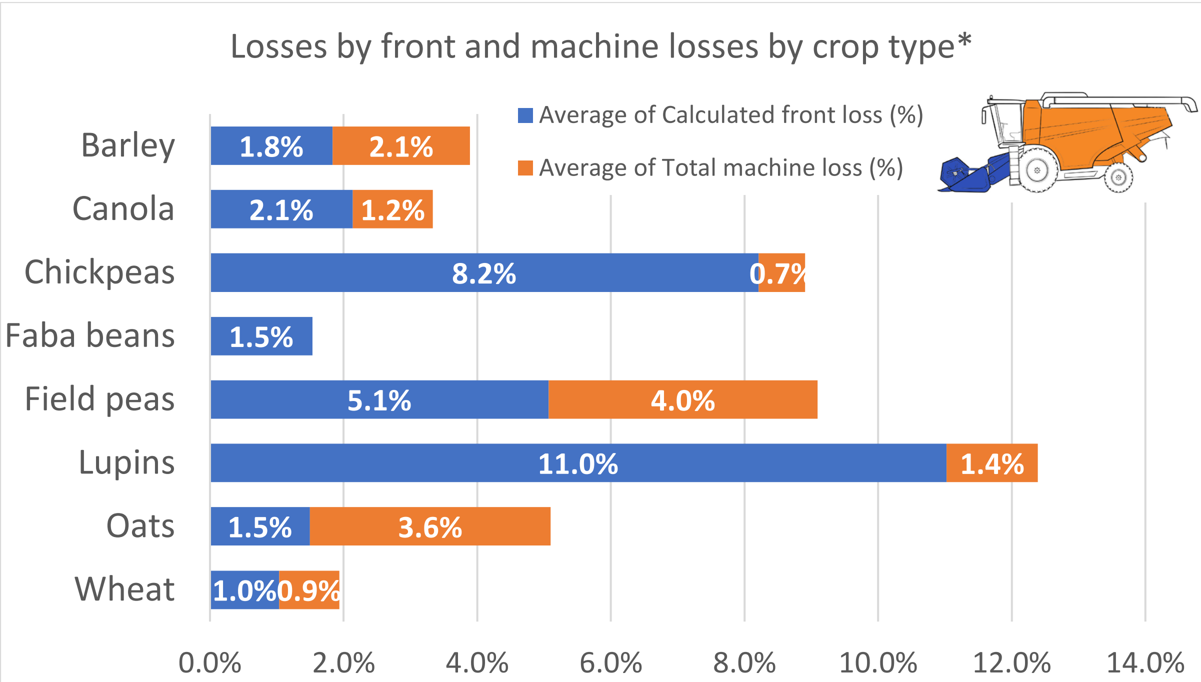
Loss measurements

Loss measurements are calculated using direct Bushel Plus tray measurements through a customised Excel spreadsheet template. The Bushel Plus app was referred to in the field for immediate operator feedback but not utilised for the calculation of results due to some ambiguity in the calculation method it employs.

Losses measured are typically reported as a fraction of the true yield, defined as the grain captured by the harvester plus any losses left in the paddock.

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.

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



*Note low sample sizes for faba beans and field peas (n=3 and 2 respectively)

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

Focussing on cereals, barley losses are double that of wheat for both machine and front losses. Higher machine losses in barley and oats could be due to the relatively high biomass and material other than grain (MOG) levels in these crops. This makes it more difficult to separate through the rotor, or potentially overloading of the sieves. Higher front losses in barley can often be attributed to whole head drops and, if so, could require attention and adjustment of the reel or finger timing.

Four of the 30 barley growers exceeded ten per cent losses, contributing to the elevated loss figures for this grain type.

Similarly, four of the twelve oat loss measurements were 10 per cent or higher, three of these were for the same grower who only made fan speed settings which in turn reduced machine losses from 10 per cent to 6.5 per cent. Additional data and testing may provide further insight here.

Legumes are traditionally more difficult to harvest with low levels of losses. Front losses through pod shattering which can be reduced by ensuring the knife and guards are in good operating condition. Accessory sweeps over the knife or guard adaptations or extensions can also pull material into the front over the knife. Solutions can vary in their effectiveness by season, ambient conditions and by crop variety.

Table 5: Losses by comparison with 2021 data (front and machine)

	Measurements taken	Average total Losses (%) 2022	Average total Losses (%) 2021	YoY Variation
Barley	30	3.9%	4.6%	-0.7%
Canola	44	3.3%	3.2%	0.1%
Chick Peas	11	8.9%	7.2%	1.7%
Faba Beans*	3	1.5%	2.8%	-1.3%
Field Peas*	2	9.1%	4.3%	4.8%
Lupins	24	12.4%	11.2%	1.2%
Oats	12	5.1%	7.3%	-2.2%
Wheat	30	1.9%	2.0%	-0.1%

*Low (<10) sample size

Table 5 compares total harvest losses for the 2022 season against the data collected in 2021. Year on year analyses of harvest losses should be referenced with caution because they encompass a wide gamut of harvest variables. Variety selection, seasonal conditions, paddock history, operator experience, crop conditions, harvester specifications, adaptations, modifications and settings will all influence performance and losses measured.

Generally, there was little significant year on year variation for canola and wheat, with some reduction in harvest losses for barley and oats which saw harvest losses reduced by 0.7 per cent and 2.2 per cent respectively.

In barley, machine losses remained consistent at around 2% for both years while front losses reduced from 2.4% in 2021 to 1.8% in 2022.

The reduction in total losses in oats came largely through a reduction in machine losses, dropping from 6.5% in 2021 to 3.6% in 2022.

The ability to draw firm conclusions from this data should be viewed in the context of the number of measurements made for each crop. Further extrapolation of this data for South Australian and eastern states analysis is discouraged as harvest variables including varieties and farming systems in other regions will influence results. Rather, a separate analysis is recommended to verify or define variations in these regions. However as this was a specific request as a project output, this analysis has been conducted utilising forecast data from ABARES March 2023 crop report[2] and can be found in Appendix D.

It could be argued that the investment made by GRDC to date has impacted loss numbers in Western Australia with barley and wheat seeing modest reductions in measured losses. A small (0.1%) increase in measured losses in canola would not appear significant but could be attributed to the sheer volume of the crop in 2022 which yielded 11 per cent higher than the average crop yields in the 2021 analysis.

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	5.03	295	3.9%	$57.35
Canola	2.64	755	3.3%	$66.07
Chick Peas	1.06	520	8.8%	$48.89
Faba Beans*	3.00	470	1.5%	$21.61
Field Peas*	2.10	450	9.0%	$85.23
Lupins	2.66	345	12.3%	$112.90
Oats	4.58	305	5.0%	$70.08
Wheat	3.90	353	1.9%	$26.50

*Low (<10) sample size

[2] https://daff.ent.sirsidynix.net.au/client/en_AU/search/asset/1034481/3

Table 6 identifies the average value of total losses on a per hectare basis applying a nominal CBH-sourced bid-sheet pricing from December 20, 2022 for wheat (ASW), barley (BFD1), oats (OAT1), canola (av. CAN1 and CAG1) and lupins (LUP1). Other pulses were valued using grower nominated average pricing ($/t for the given grade and quality) at harvest.

High value by area losses ($/ha) are typically a reflection of high commodity price (e.g. canola) and/or high levels of harvester losses (e.g. grain legumes).

On a loss by area basis, lupins had the highest loss value at $112.90/ha while wheat at $26.50/ha was the lowest loss value of significance.

In comparison with 2021 data, wheat, oats, canola and chickpea figures are similar while the higher yields in barley and remaining pulses saw these financial losses increase year-on-year on a per hectare basis.

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

	Nominal av. Commodity price ($/t)	2022 WA production (t)	Average of Total Losses (%)	Total production Losses (t)	Total extrapolated value of harvest losses
Barley	$295	6,300,000	3.9%	245,700	$71,893,467
Canola	$755	4,300,000	3.3%	141,900	$107,642,448
Lupins	$345	895,000	12.3%	110,085	$37,926,702
Oats	$305	565,000	5.0%	28,250	$8,638,391
Wheat	$353	13,930,000	1.9%	264,670	$94,725,524
Total		**25,990,000**		**790,605**	**$320,826,531**

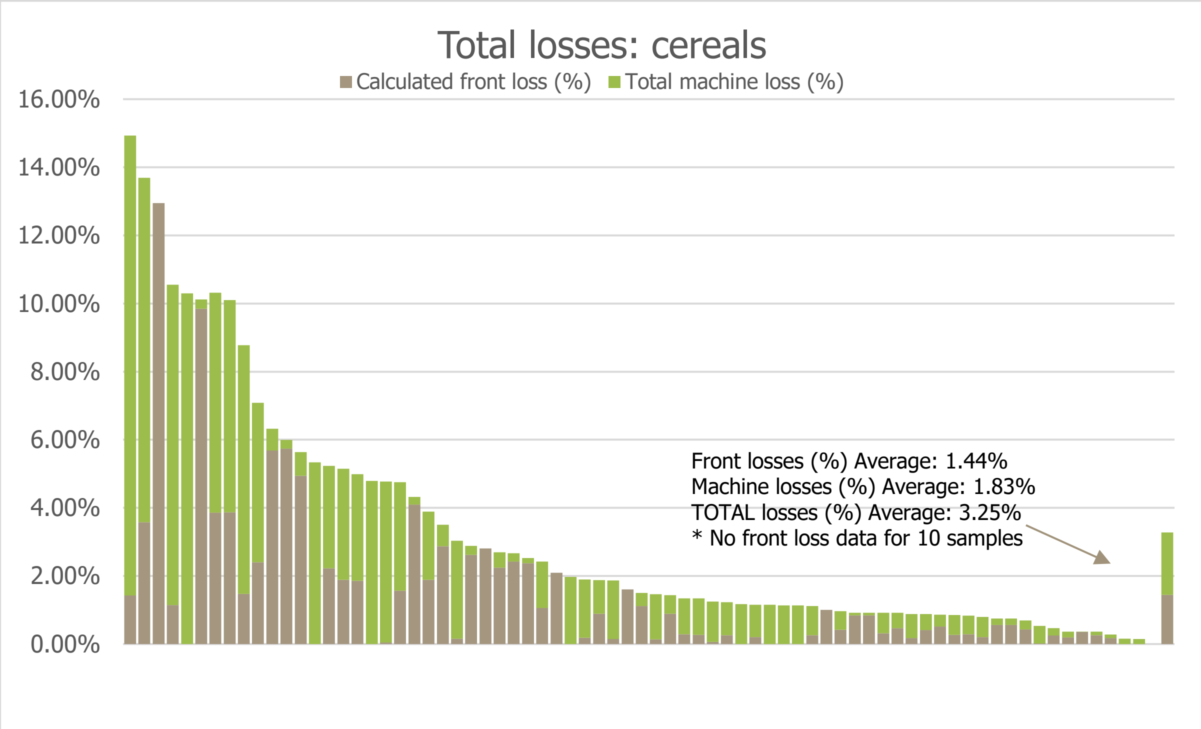
Table 7 extrapolates the value of measured losses for a selection of grains across the entire WA production area as estimated by GIWA. Grain legume data (chickpeas, faba beans and field peas) is not presented because GIWA does not separate state production data for these commodities.

It could be argued that sheep grazing on stubbles and unharvested grain may see some of the lost grain utilised.

But with a continuing reduction in sheep numbers in WA, expected to accelerate with the phasing out of the live export market, the value of grain lost at harvest and unutilised is expected to increase.

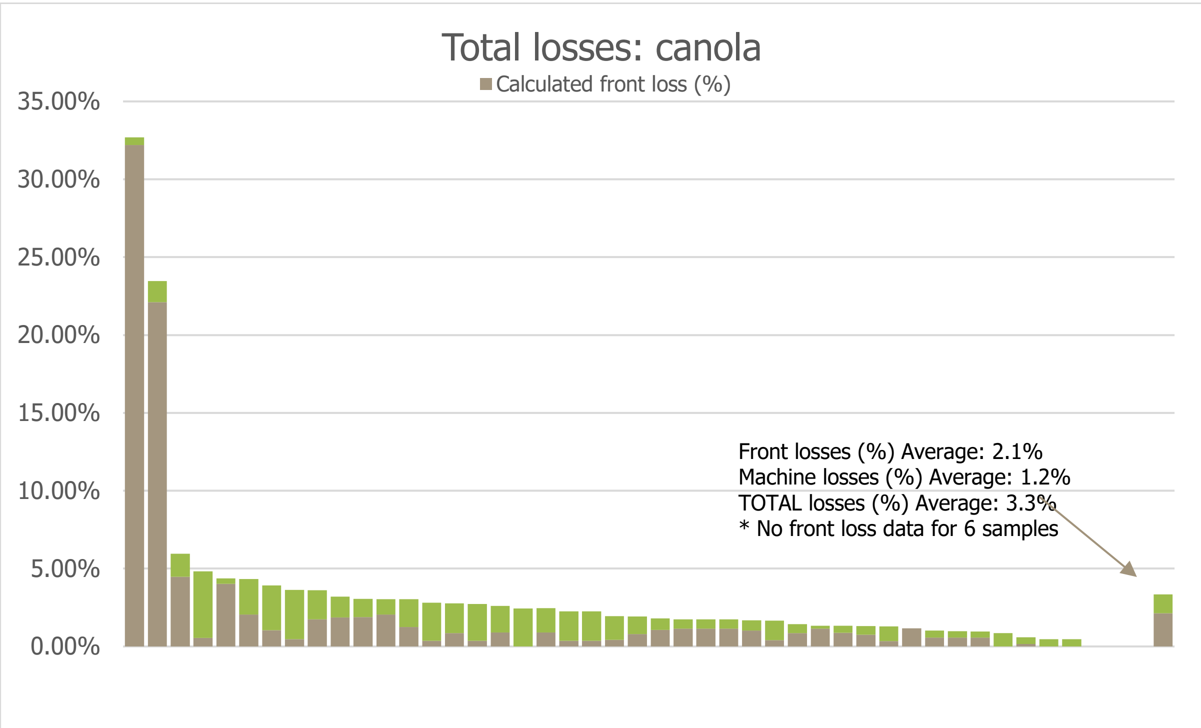
In addition to significant harvest losses, other factors including mice are likely to become increasingly prevalent.

Figure 2: dataset spread of losses in cereals



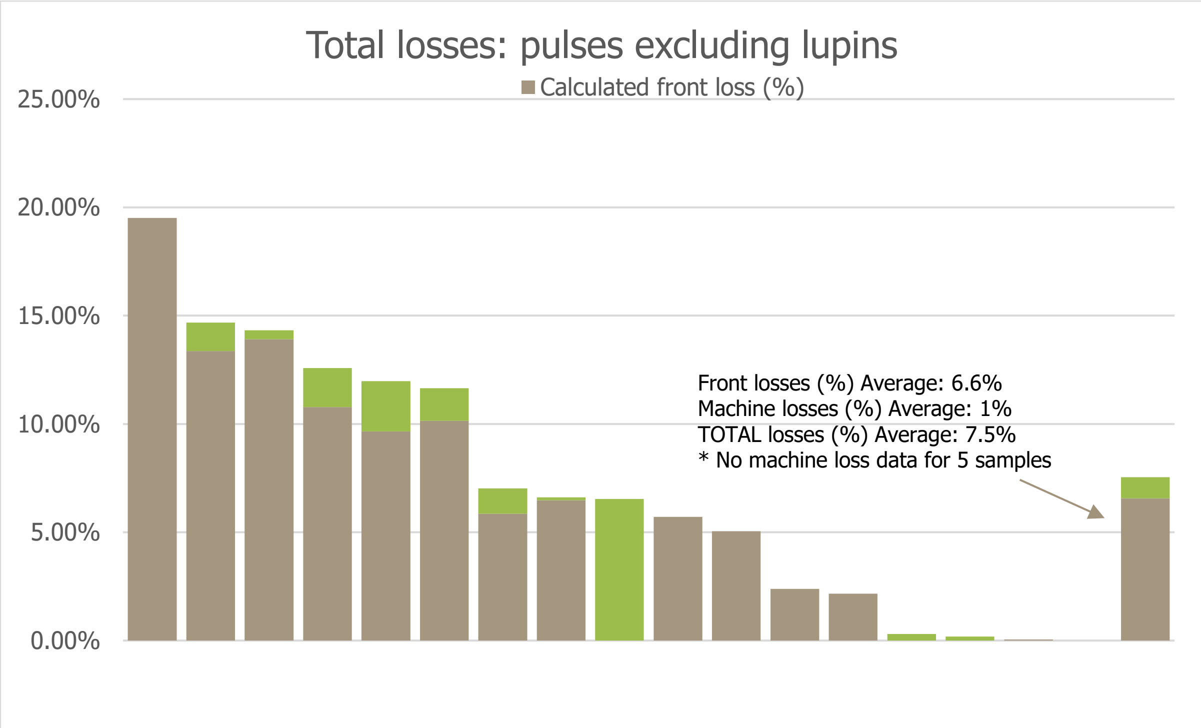
Of the eight high (>9%) total losses observed in cereals, stripper fronts contributed to two of these figures while worn knives were observed in another three instances. Identifying the source of high machine losses in this dataset would typically require an iterative approch over a dozen tests with specialist knowledge an advantage.

Figure 3: dataset spread of losses in canola



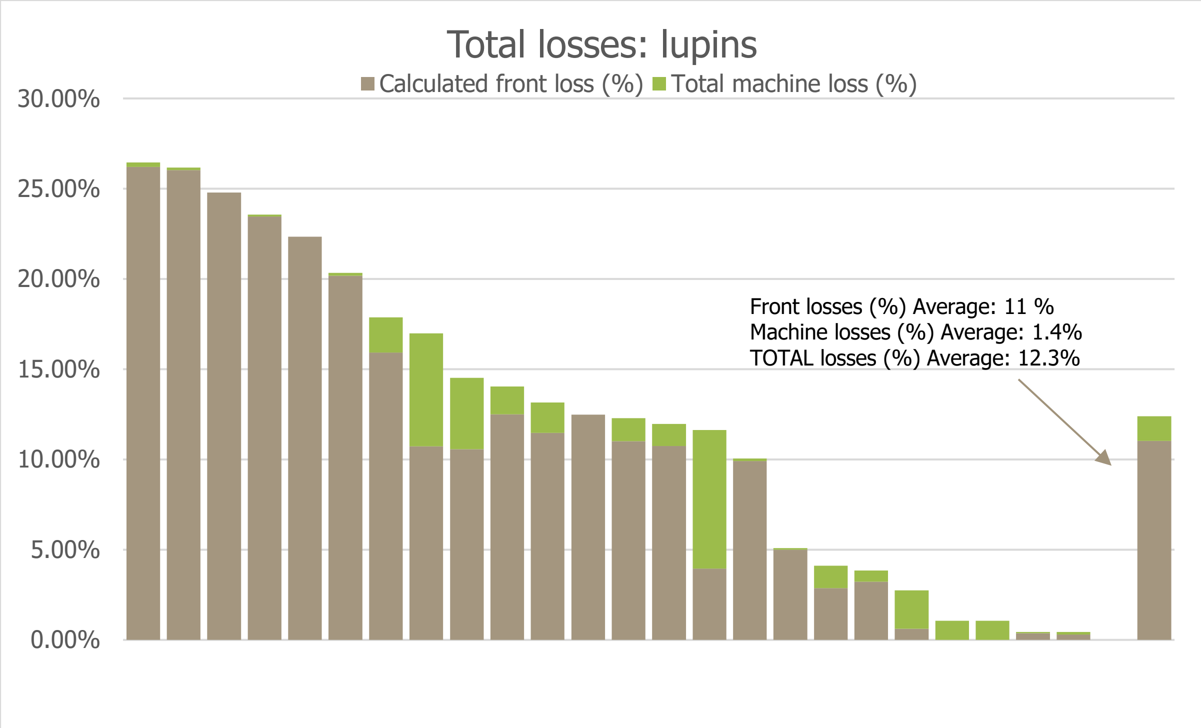
The two outliers in the canola dataset saw significant losses from the centre and side of a John Deere draper front in a Wubin crop yielding 2.4t/ha. Removing these two outliers sees canola losses across the dataset reduce from 3.3% to a markedly more acceptable 2.1%.

Figure 4: dataset spread of losses in pulses



Five of the six crops with above average losses were for chickpeas. Of those five, four were from the same farm in Latham with two different varieties of chickpeas each tested twice and accounting for high levels of front loss off the MacDon D145.

Figure 5: dataset spread of losses in lupins



Growers experiencing high (>15%) losses were all growing Jurien lupins, all were using draper fronts with knives noted to be in good condition. All but one of the growers with less than 5 per cent losses in lupins were using drop trays to measure losses.

Machine losses and modifications

Harvester modifications and alterations include the addition of threshing elements to the rotor, modifying the pinch point, or the adjustment of (for example, pulling wires from) or using aftermarket concaves.

Modifications to the rotor are designed to minimise rotor losses by extracting more grain from the crop mat as it moves along the rotor while concave modifications look to allow grain to fall out of the threshing area and onto the cleaning shoe without overloading the sieves with excessive volumes of chaff.

See figures 6 and 7 for threshing element modifications and aftermarket concave installations respectively.

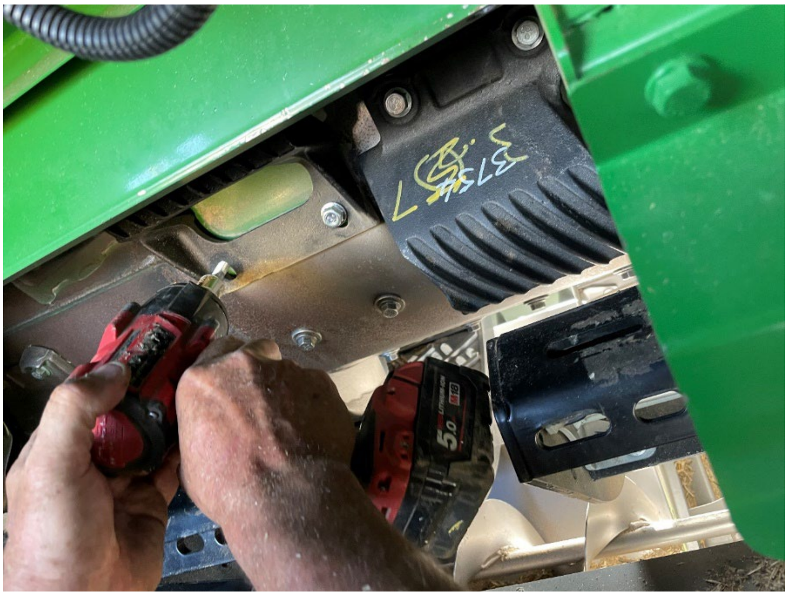


Figure 6: **Threshing elements**

Adding threshing elements (known as a dense pack) to the unfilled rotor positions in a John Deere S780 harvester.

Figure 7: **Aftermarket concaves**

Aftermarket concaves fitted to a Case IH 8230 harvester. Alternative concave modifications include pulling wires from the concave segments and increasing the open area.

Table 8: Concave modifications by brand

	Number tested	Those with concave modifications	% of brand with threshing modifications
Case IH	40	9	18%
Claas	12	0	0%
Gleaner	1	0	0%
John Deere	52	25	32%
New Holland	16	1	6%

Table 8 specifies harvesters with modifications to the concave as recorded by field personnel. Aftermarket concaves to suit both Case IH and John Deere are widely available as reflected in the uptake numbers.

Table 9: Rotor modifications by brand

	Number tested	Those with rotor modifications	% of brand with threshing modifications
Case IH	40	11	22%
Claas	12	0	0%
Gleaner	1	0	0%
John Deere	52	19	25%
New Holland	16	0	0%

Table 9 specifies harvesters with modifications to the rotor as recorded by field personnel. Aftermarket rotor elements to suit both Case IH and John Deere are widely available and most commonly modified.

Table 10: Machine losses in harvesters with modified threshing components

Harvester brand	Standard concave machine losses	Modified concave machine losses	Variation	Standard rotor machine losses	Modified rotor machine losses	Variation
Case IH	2.3%	1.3%	**-0.9%**	2.6%	1.0%	**-1.6%**
Claas	0.4%	0.0%	**-0.4%**	0.4%	0.0%	**-0.4%**

John Deere	1.6%	1.4%	**-0.3%**	0.8%	1.5%	**0.7%**

Table 10 lists average machine losses for rotor and concave modified machines in cereals against those in unmodified machines.

Results suggest losses can be minimised significantly (0.4-1.6% improvement) by undertaking adjustments to the standard threshing components.

Modifications identified included pulling concave wires, installation of aftermarket concaves, rotor and threshing element adjustment including additional and more aggressively profiled rasp bars.

Front losses and modifications

Table 11: Front make used – All crops

Make	Number	% of tests
Case IH	26	17%
Claas	11	7%
John Deere	66	42%
MacDon	33	21%
Midwest	6	4%
New Holland	4	3%
Phillips	3	2%
Shelbourne	7	4%
Total	**156**	**100%**

Table 11 lists harvester fronts used by make. John Deere draper fronts dominate the dataset when compared with other reference industry inventories (Kondinin Group members) suggests some underrepresentation of MacDon harvester fronts in Western Australia.

Crop losses are identified by front style for a given crop in table 12.

Significant additional throughput and increased field efficiency was observed when using stripper fronts in cereals (69% increase in wheat and 100% increase in barley) although average losses measured are several times higher than losses from draper fronts. Growers should consider this and the other agronomic implications (for example stubble handling) when calculating the benefits and costs of using a stripper front, for example in a strip and disc system.

Depending on cropped area, it could be argued that the investment in a Vario/Varicut/Varifeed 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 wheat but not in barley.

Table 12: Front style, capacity and losses by crop

Crop type	Barley				Canola				Lupins				Wheat			
Front losses by front style	Count	% of growers	Av. losses (%)	Av. throughput (t/h)	Count	% of growers	Av. losses (%)	Av. throughput (t/h)	Count	% of growers	Av. losses (%)	Av. throughput (t/h)	Count	% of growers	Av. losses (%)	Av. throughput (t/h)
Conventional									2	8.3	7.4		2	6.7	0.1	
Draper	25	83	1.0	29	36	82	2.4	13	20	83	13	22	23	77	0.9	26
Stripper	3	10	9.2	59									4	13	2.6	44
Vario style	2	7	1.9	35	8	18	0.7	15					1	3.3	0.3	34
Pickup									2	8.3	N/A*					
Total	**30**	**100**			**44**	**100**			**22**	**100**			**30**	**100**		

Table 13: Losses by measurement drop trays

	Number of growers	% of growers	Average of measured machine Losses (%)
No trays	72	62%	5.4%
Yes - own trays	44	38%	4.6%
Total	116	100%	

Loss measurement tray ownership in the 2022 dataset matched that of the 2021 dataset. Unfortunately, the proportion of growers using drop trays are in the minority in Western Australia with less than four in 10 growers utilising them. Total loss figures across all crops for those that own trays was around 0.8% lower than those that did not own trays. This could be attributed to awareness, or the ability to quantify and manage losses accordingly.

Table 14: Achieved benefit using trays in canola

	Canola
Total losses – Growers not using trays	3.76%
Total losses – Growers using trays	2.40%
Benefit for those using trays (reduction in losses)	1.64%
Average yield in dataset (t/ha)	2.64
Average value at harvest ($/t)	$755
Differences in losses per hectare (kg)	43.3
Differences in losses per hectare ($)	$32.70

Table 14 demonstrates the value of growers dropping trays to measure total losses in canola crops to quantitatively evaluate losses and subsequently make adjustments to their harvester to reduce losses.

In 2022, the benefit for those using trays was over $32/ha, up from $24/ha in 2021 due to the elevated yield and slightly higher losses measured in canola in 2022.

Table 15: Achieved benefit using trays in cereals

	Cereals
Machine losses – Growers not using trays	2.0%
Machine losses – Growers using trays	1.6%
Benefit for those using trays	0.4%

Table 15 incorporates wheat, barley and oat losses and again demonstrates the value of growers using drop trays to measure machine losses to quantitatively evaluate losses and subsequently make adjustments to their harvester to reduce losses.

Table 16: Achieved benefit using trays in pulses (including lupins)

	All pulse crops inc. lupins
Total losses – Growers not using trays	12.6%
Total losses – Growers using trays	7.9%
Benefit for those using trays	4.7%

Table 16 incorporates chickpeas, faba beans, field peas and lupins with a breakdown of operators using loss measurement trays and the benefit achieved through loss quantification and subsequent reduction for those growers.

Table 17: Harvester capacity by crop

	Average of capacity t/hr 2022	Average of capacity t/hr 2021	2022 YoY capacity variation %
Barley	32.2	32.7	-2%
Canola	13.5	12.8	+5%
Lupins	20.9	19.8	+5%
Oats	25.9	27.6	-7%
Wheat	31.6	31.6	0%

A balance between harvester capacity and losses should be struck in any harvesting operation. As per industry guidelines (Society of Agricultural Engineers, Prairie Agricultural Machinery Institute and Kondinin Group), a <1% of yield loss in cereals should be achievable with <2-3% in canola pending the conditions. Harvester capacity should be maximised whilst adhering to these loss benchmarks. Table 20 demonstrates the average capacity of harvesters by crop for the 2022 harvest and figures for the same crops in the 2021 harvest.

Note that while throughput in canola and lupins increased by five per cent, losses increased by 0.1% and 1.2% respectively. Conversely, harvest throughput capacity reduced in barley by two per cent and oats by five per cent while year on year losses fell by 0.7% and 2.2%.

It could be assumed that in 2022, growers may have been "pushing" harvesters beyond acceptable loss benchmarks due to the sheer bulk of crop to get through. Lower losses could be achieved by reducing throughput, but as previously noted, the balance between operating capacity and losses must be found.

Residue management

Tables 18 and 19 illustrate residue management practices employed by growers in the 2022 dataset. Less than ten per cent of growers were windrowing from the harvester with the majority of the balance opting to chop and spread the straw. This aligns with 2021 data for straw management.

Chaff fraction management on the utilised machines for the 2022 dataset had significantly lower levels of chaff windrowing than those used in 2021, dropping from 39% to 9%. Full spread chaff management for the 2022 testing accounted for 73% of the tests conducted while in 2021, this figure was around 38%. This may reflect heaver yields in 2022 and resulting residue management requirements but further analysis of this result may be required.

Weed seed mill use at 16% aligns with Kondinin Group member machinery inventory figures in Western Australia.

Table 18: Straw management

	% adoption straw management
Chop & spread	89%
Other	3%
Windrow	8%
Total	**100%**

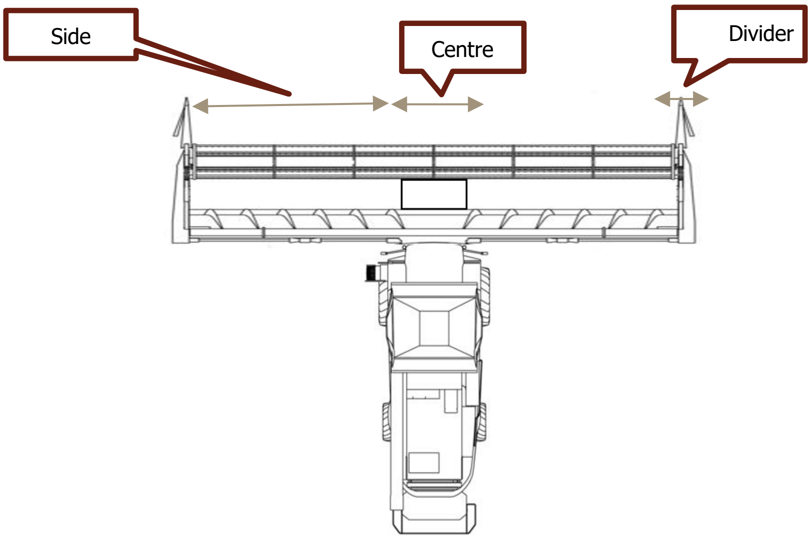
Table 19: Chaff management

	% adoption chaff management 2022	% adoption chaff management 2021
Decks/Chaff cart	2%	14%
Mill	16%	9%
Spread	73%	38%
Windrow	9%	39%
Total	**100 %**	**100 %**

Front Losses

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. See figure C

Figure 8: Front loss measurement positions



Multiplying each of these areas by their relative swath width coverage, an analysis can be made to determine which components on the harvester front is contributing most to total front losses.

Table 20: Front loss by position

Front loss sources by position (%)	Cereals	Canola	Lupins
Centre (2m)	40%	48%	37%
Outside centre	53%	49%	58%
Crop divider	7%	3%	5%
TOTAL	**100%**	**100%**	**100%**

Unsurprisingly, the losses at the three measured positions differed by crop type. Cereal grains were largely lost off the front along the front width outside the centre section although 40% of front losses could be attributed to the centre section.

Half of the front losses in canola occurred at the 2m centre section, significantly lower than found in 2021 where two thirds of canola losses were found at this position.

The main variation in the year-on-year analysis is that in 2022, around 20% of tests were done with conventional or Vario/Varicut/Varifeed style fronts which typically reduce centre losses off the front.

While the centre of the front is only considered the middle two metres, a significant portion of front losses occur here for all crops and should be an area of focus for growers.

Extrapolating the data

Table 24 illustrates the total lost value per grower by dividing GIWA production figures [3] by 3,800 growers in WA, multiplying this production by the average losses for that crop the typical harvest value in 2022.

Applying these averages across all growers in WA indicates they are each leaving behind over $80,000 worth of grain in the paddock.

Table 22: 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 (%)	Nominal commodity value ($/t)	Loss per grower (Total value of losses) Based on av. measured losses by harvest value
Barley	1,658	3.9%	$295	$18,919
Canola	1,132	3.3%	$755	$28,327
Lupins	236	12.3%	$345	$10,455
Oats	149	5.0%	$305	$2,273
Wheat	3,666	1.9%	$353	$24,654
				$84,629

Table 23: The value of losses and where they occur 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	1.8%	2.1%	$8,930	$9,990
Canola	2.1%	1.2%	$18,130	$10,196
Lupins	11.0%	1.4%	$9,353	$1,102

[3] https://www.giwa.org.au/wa-crop-reports/2023-season/giwa-crop-report-february-2023/

Oats	1.5%	3.6%	$666	$1,607
Wheat	1.0%	0.9%	$13,056	$11,598
TOTAL			**$50,135**	**$34,493**

In Table 23, an extrapolation of the collected dataset across state production figures indicates Western Australian growers are, on average, each losing over $50,000 in grain value off the harvester front and over $34,000 via sieve or rotor losses.

Table 24: Cereal losses by region

Row Labels	Cereal tests conducted	Average machine loss (%)	Average front loss (%)	Average of Total loss (%)
Albany	7	3.5%	0.2%	3.7%
Esperance	8	1.1%	1.2%	2.3%
Geraldton	17	1.4%	2.2%	3.6%
Kwinana East	11	0.3%	0.3%	0.6%
Kwinana West	29	2.4%	1.8%	4.2%
TOTAL	**72**	**1.8%**	**1.4%**	**3.2%**

Table 24 identifies large variations in cereal losses between port zones for cereals, but this could be influenced by the mix of cereals in each port zone and additional breakdown into individual grains may dilute the value of the relative data.

Table 25: Canola losses by region

Row Labels	Cereal tests conducted	Average machine loss (%)	Average front loss (%)	Average of Total loss (%)
Albany	12	0.3%	0.6%	1.0%
Esperance	5	1.5%	1.2%	2.6%
Geraldton	12	1.8%	1.1%	2.8%
Kwinana East	11	1.1%	5.9%	6.9%
Kwinana West	4	2.2%	0.5%	2.7%
TOTAL	**44**	**1.2%**	**2.1%**	**3.3%**

Table 25 breaks down canola losses by port zone although sample sizes are relatively small and large variation between port zones can be observed. Additional data may provide more in-depth insights into relative canola losses between port zones.

Conclusion

The harvest losses measured in 2022 are largely consistent with results from 2021 over the full spectrum of results with sufficient depth of data from which conclusions can be drawn.

Front losses continue to be a significant contributing factor to losses in the harvesting process. Stripper fronts have again demonstrated significantly higher levels of loss which could be partly offset by the increased capacity of the harvester.

Table 24 and 25 demonstrate 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.

Given these measurement variations 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. The need for all growers to embrace drop trays is demonstrated in the 2021 data and reinforced in the 2022 data. 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.

Determining the best path to minimise losses whilst maintaining capacity requires continuing education of operators, trainers and in some cases, manufacturers. But this training would be more effective if supported by independent research to quantify the potential benefits of, for example, threshing component modifications.

Modifications to the machine threshing components should be investigated further and quantified for a cross-section of modifications, harvesters and crop types.

The economics of using a Vario/Varicut/Varifeed fronts pending crop type, area and value may assist growers in making decisions around the investment in a second front.

Port zone variations in yield are likely a symptom of a lack of data depth, but an ongoing investment in this work to add depth to the collected data may assist in identifying and filtering data.

With better than average crops harvested in the 2021 and 2022, 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.

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 the 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 the average of the 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

Appendix B: Data collection sheet

Grower Name		Dataset №	
Mobile phone		Nearest town	
Port zone		Crop type & variety	
Date	/ /	Average yield	t/ha ☐Calibrated
Time	AM/PM	Approx yield range	t/ha
Grower uses drop trays ☐Yes ☐No		Grain moisture	%
Conditions			
Temperature	°C	Humidity	%
Threshing condition	☐Good ☐Tough	Any lodging?	☐Yes ☐No
Equipment			
Harvester make	☐John Deere ☐Case IH ☐New Holland ☐Claas ☐Fendt/Massey ☐Other:		
Harvester model		Rotor hours (approx.)	
Rotor	☐As delivered ☐Custom (details):		
Concaves	☐As delivered ☐Custom (details):		
Front style	☐Draper ☐Adjustable table (eg Vario/Varicut/Varifeed) ☐Conventional (tin) ☐Stripper ☐Pickup		
Front make	☐Macdon ☐John Deere ☐New Holland ☐Case IH ☐Claas ☐Shelbourne ☐MidWest ☐Other:		
Front model		Cut: Width (m): Height (mm):	
Front modifications	☐Seed saver kit ☐Air reel ☐Finger sweeps / Duck feet ☐Typhoon		

	☐Crop lifters ☐Top cross auger ☐Other:
Front divider	☐Round bar ☐Vertical/roto knife ☐Nose cone ☐Other:

Process		
Straw residue	Spread Width ☐Full cut / or (m):________	☐Chop & Spread ☐Windrow ☐Other:
Chaff residue	Spread Width ☐Full cut / or (m):________	☐Spread ☐Mill - Make: ☐Windrow ☐Decks ☐Other:

Notes:

(Include knife description / condition)

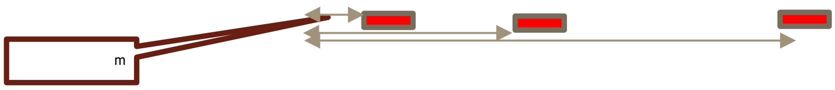
Data gathered by:

FRONT Side tray	
Test	Tray weight (g)
1	
2	
3	
Tray size: ☐Full ☐Narrow	

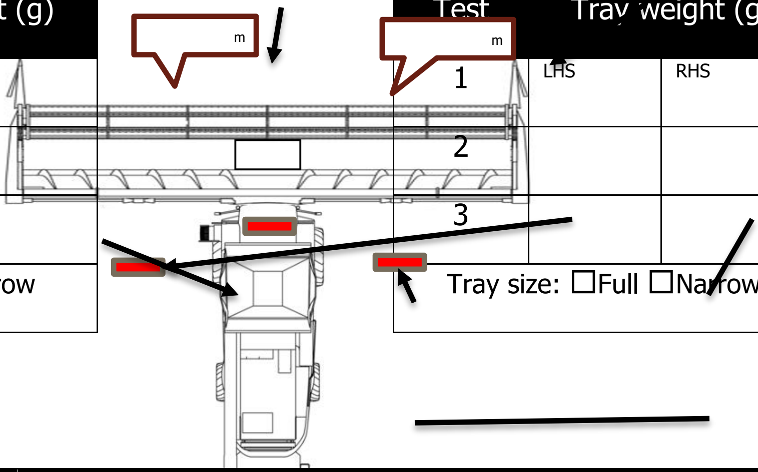
FRONT Centre tray	
Test	Tray weight (g)
1	
2	
3	
Tray size: ☐Full ☐Narrow	

FRONT Crop divider tray	
Test	Tray weight (g)
1	
2	
3	
Tray size: ☐Full ☐Narrow	

*Measure tray positions carefully



MACHINE Centre	
Test	Tray weight (g)
1	
2	
3	
Tray size: ☐Full ☐Narrow	



MACHINE L/R Side tray		
Test	Tray weight (g)	
	LHS	RHS
1		
2		
3		
Tray size: ☐Full ☐Narrow		

Machine Settings	Test 1	Test 2	Test 3
		(leave blank if no change)	
Ground speed (km/h)			
Engine load (%)			
Capacity (t/hr)			
Fuel use (l/h)			
Rotor speed (rpm)			
Drum speed (rpm) Claas / Massey / Fendt only			
Concave clearance (mm)			
Top Sieve (mm)			
Bottom sieve (mm)			
Pre sieve (mm if applicable)			
Fan speed (rpm)			

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Reel finger angle (o'clock view from RHS of driver)			
Other variation			

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Appendix C: CBH Daily contract pricing reference

All contract prices are indicative and are subject to change without notice. For live pricing refer to LoadNet www.cbh.com.au

WHEAT 2021/22	Geraldton	Kwinana	Albany	Esperance
FIXED GRADES	All 2021/22 Wheat grades are now price on application (POA). Call the Grower Services Centre to seek prices 1800 199 083			

WHEAT 2022/23	Geraldton	Kwinana	Albany	Esperance
FIXED GRADE				
H1	488.00	533.00	453.00	463.00
H2	468.00	503.00	443.00	448.00
APW1	428.00	483.00	423.00	428.00
APW2	413.00	~~423.00~~	408.00	413.00
ASW1	361.00	353.00	353.00	353.00
AGP1	343.00	~~333.00~~	343.00	348.00
ANW1	458.00	458.00	448.00	423.00
ANW2	368.00	358.00	358.00	
APWN	428.00	448.00	430.00	
ASW9	393.00	393.00	391.00	391.00

WHEAT 2022/23	Geraldton	Kwinana	Albany	Esperance
STANDARD MULTIGRADE			418.00	
SPREADS APW1 BASE	Kwinana (refer to Online Contract Writer for other zones)			
NOODLE MULTIGRADE			438.00	
SPREADS ANW1 BASE	Kwinana (refer to Online Contract Writer for other zones)			

LUPINS 2021/22	Geraldton	Kwinana	Albany	Esperance
FIXED GRADE LUP1	All 2021/22 Lupin grades are now price on application (POA). Call the Grower Services Centre to seek prices 1800 199 083			

LUPINS 2022/23	Geraldton	Kwinana	Albany	Esperance
FIXED GRADE				
LUP1	350.00	345.00		

Deferred 2022/23	STD Delivery / DEF payment	DEF Delivery / DEF payment
Wheat APW1 BASE	+3	
Canola CAN1 BASE		
Barley BFD1 BASE	+2.19	
Lupins LUP1 BASE		
Oats OAT1 BASE		

**DEFERRED CONTACT PRICES – NOTES
1. +/- Deferred values are based on commodity base grades in the Kwinana Port Zone.
2. Wheat, Barley, Canola and Lupins - prices are for fixed grade contracts. Oats - prices are for multigrade contracts. Refer to LoadNet for live pricing.

DISCLAIMER
This price sheet may contain general advice, which was prepared without taking account of your objectives, financial situation or needs. You should, before acting on the advice, consider the appropriateness of the advice having regard to your objectives, financial situation and needs.

BARLEY 2021/22	Geraldton	Kwinana	Albany	Esperance
FIXED GRADES	All 2021/22 Barley grades are now price on application (POA). Call the Grower Services Centre to seek prices 1800 199 083			

BARLEY 2022/23	Geraldton	Kwinana	Albany	Esperance
FIXED GRADE				
BAS1		387.00		
FLI1			332.00	
LAT1				312.00
SPA1		387.00	382.00	372.00
PLA1		387.00	382.00	372.00
MAX1		330.00	335.00	327.00
MULTIGRADE				
BFD1	280.00	295.00	300.00	302.00

OATS 2021/22	Geraldton	Kwinana	Albany	Esperance
MULTIGRADE OAT1 WAN1	All 2021/22 Oat grades are now price on application (POA). Call the Grower Services Centre to seek prices 1800 199 083			

OATS 2022/23	Geraldton	Kwinana	Albany	Esperance
MULTIGRADE				
OAT1		305.00	300.00	
OAT1 BASE		OAT2 -15		
WAN1		310.00		
WAN1 BASE		OAT2 -20		

CANOLA 2021/22	Geraldton	Kwinana	Albany	Esperance
FIXED GRADE *CAN1 / CAN2 *CAG1 / CAG2	All 2021/22 Canola grades are now price on application (POA). Call the Grower Services Centre to seek prices 1800 199 083			

CANOLA 2022/23	Geraldton	Kwinana	Albany	Esperance
MULTIGRADE				
*CAN1 / CAN2	740.00	780.00	780.00	780.00
*CAG1 / CAG2	740.00	730.00	730.00	740.00

*All Canola prices displayed above are inclusive of ISCC. A $25/tonne price discount will apply to Canola contracts entered by a non ISCC participant. For more details on the scheme, please see the ISCC section on www.cbh.com.au

CASH CONTRACT PRICES - NOTES
1. All wheat prices displayed are flat priced with no quality rewards to apply for protein, screenings and moisture. Wheat Grade spreads will be locked in on the day of contracting.
2. Should you wish to receive this information by email or SMS, please notify us by email to CBHMarketingWA@cbh.com.au or by freecall on 1800 199 083 and we will update your preferences.
3. Prices are quoted GST exclusive and on a Free In Store (FIS) basis.
4. All contract prices are indicative and are subject to change without notice.
5. CBH Grain PTY LTD (ABN. 39 089 394 883) Level 6, 240 St Georges Terrace, Perth WA 6000

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Appendix D: Extrapolation of western GRDC region measured losses across northern and southern regions using ABARES production data

	ABARES SA prod_n 2022 (t)	ABARES Vic prod_n 2022 (t)	ABARES NSW prod_n 2022 (t)	ABARES Qld prod_n 2022 (t)	ABARES Tas prod_n 2022 (t)	ABARES WA prod_n 2022 (t)	GIWA WA prod_n 2022 (t)	ABARES vs GIWA var (%)	Nom. pricing ($/t)	GRDC South (SA+VIC+Tas +50% NSW) Production (t)	GRDC North (Qld+50% NSW) Production (t)	WA meas losses	GRDC south loss estimate using WA loss figures (t)	GRDC north loss estimate using WA loss figures (t)	GRDC west loss estimate using WA loss figures (t)	GRDC south loss estimate using WA loss figures and nominal pricing ($)	GRDC north loss estimate using WA loss figures and nominal pricing ($)	GRDC west loss estimate using WA loss figures and nominal pricing ($)	Total value of losses using ABARES production figures
Barley	2,900,000	2,896,000	2,278,000	403,000	60,500	5,600,000	6,300,000	-11%	$295	6,995,500	1,542,000	3.9%	270,611	59,650	216,628	79,830,277	17,596,782	63,905,304	161,332,362
Canola	770,000	1,383,000	1,800,000	10,000	10,000	4,300,000	4,300,000	0%	$755	3,063,000	910,000	3.3%	101,558	30,172	142,573	76,676,469	22,780,146	107,642,448	207,099,063
Chickpeas	10,000	40,000	192,000	292,000	-	7,000			$520	146,000	388,000	8.8%	12,905	34,296	619	6,710,787	17,834,145	321,750	24,866,682
Faba beans	300,000	150,000	81,000	35,000	-	19,000	155,000	n/a	$470	490,500	75,500	1.5%	7,519	1,157	291	3,533,751	543,931	136,883	4,214,565
Field peas	120,000	76,600	47,300	-	-	70,000			$450	220,250	23,650	9.0%	19,864	2,133	6,313	8,938,749	959,825	2,840,919	12,739,492
Lupins	55,000	48,000	70,000	-	-	925,000	895,000	3%	$345	138,000	35,000	12.9%	17,757	4,503	119,021	6,126,046	1,553,707	41,062,266	48,742,020
Oats	200,000	240,000	324,000	19,000	4,500	800,000	565,000	42%	$305	606,500	181,000	5.0%	30,403	9,073	40,103	9,272,892	2,767,343	12,231,350	24,271,585
Wheat	7,350,000	5,393,000	10,260,000	2,305,000	82,500	13,800,000	13,930,000	-1%	$353	17,955,500	7,435,000	1.9%	342,088	141,651	262,917	120,757,013	50,002,973	92,809,823	263,569,809
TOTAL	**11,705,000**	**10,226,600**	**15,052,300**	**3,064,000**	**157,500**	**25,521,000**	**26,145,000**			**29,615,250**	**10,590,150**		**802,705**	**282,637**	**788,465**	**$311,845,983**	**$114,038,853**	**$320,950,743**	**$746,835,579**

It should be noted that ABARES and GIWA figures vary significantly for barley and oats. GIWA figures for chickpeas, faba beans and field peas are bulked under "pulses" and are not included in the breakdown of values in the body of this report.

While this report largely relies on GIWA production figures which include on-farm seed and feed requirements as well as trade outside the CBH network, for the purposes of a comparative ABARES-sourced figures analysis, ABARES figures have been used for production numbers and carried through to lost grain value estimates. Some variation in values of lost grain between GIWA and ABARES figures are noted for the GRDC western region.