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2020
Annual Results Report
Ripper Gauge Demonstration Sites
Esperance Port Zone

Project code:	9176166
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Date submitted to GRDC:	[11th May 2020]

REPORT SENSITIVITY

Does the report have any of the following sensitivities?

Intended for journal publication	NO	
Results are incomplete	Yes (this report covers year 2 of a 3 year project)	
Commercial/IP concerns	NO	
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KEY MESSAGES

- Tillage treatments applied in 2018 to alleviate compaction and allow better water absorption (ranging in ripping depth from 100mm to 600mm) did not significantly affect crop yield when compared to site controls, regardless of the predominant soil type present at the site or the ripping equipment used. This is likely due to the much dryer than average rainfall conditions that prevailed at all sites in 2019 and the impact of severe frost at two of the demonstration sites (Salmon Gums and Cascade).

- Although the ripping treatments did not significantly improve or reduce crop yield at any of the Ripper Gauge demonstration sites in 2019, gross margin analysis did indicate tillage to 600mm depth plus use of a Topdown slightly improved operating profit at the Neridup site, when compared to the site control. Ripping to 540mm depth also improved financial performance at the Salmon Gums site when compared to the control.

- Ripping to 300mm and 600m depth reduced financial performance at the Coomalbidgup and Cascade Demonstration Sites, compared to the site controls. Two of the tillage treatments also reduced operating profit at the Neridup site compared to the site control.

SUMMARY

The practices of soil tillage and controlled traffic farming can be confusing for some growers due to soil variability and varying options for treatment. There is indecision as to what tillage treatments suit what soil types, and what their economic benefits are (if any) in the short, medium and long term. Also, combined approaches to alleviate more than one constraint can be worthwhile, but there are still some soil types that growers are nervous about touching due to associated risks, such as bringing hostile subsoils to the surface and erosion concerns.

In addition, strategic tillage practices have been found to compact again over time following ripping, often to greater levels than prior to treatment. Currently, the solution is to repeat the deep ripping process every few years, with the period in between deep ripping dependent on the soil type and amount of wheeled traffic on the paddock. This is a costly, repetitive process that may become unsustainable in the long term if soils become compacted to greater depths with successive tillage treatments.

This project aims to demonstrate and evaluate the benefit, or not, of soil tillaqge across a range of soil types in the Esperance Port Zone. Five demonstration sites were established in locations, and on soil types, that helped to fill gaps in knowledge regarding the economic return from soil tillage approaches over time. A variety of tillage treatments at each trial location were implemented in 2018, based on the availability of machinery, geographical location and predominant site soil type.

2019 harvest yield results showed that deep ripping in 2018 did not significantly affect yields at the four demonstration sites cropped in 2019. This is likely due to the much dryer than average rainfall conditions that prevailed at all sites in 2019 and the impact of severe frost at two of the demonstration sites (Salmon Gums and Cascade).

1.0 BACKGROUND

The presence of soil constraints including compaction, water repellence, top soil acidity and subsurface acidity across the agricultural region of WA limits the opportunities for grain growers to increase crop production.

These soil constraints can be effectively dealt with through the numerous strategic soil amelioration practices that have been developed as part of previous and current projects (eg. DAW00242, CSA00033, DAW00236). A number of strategic tillage practices have been adopted by many growers

to ameliorate soils, with mouldboard ploughing and spading being used to bury the non-wetting surface layer, or to thoroughly dilute the water repellent soil into the subsurface soil profile. Deep ripping can be used to break up sub-soil compaction that is formed through trafficking paddocks with heavy agricultural equipment and/or stock.

While deep ripping has been shown to improve crop yields and decrease soil strength, the lifespan of soil tillage practices is often determined by the time it takes to recompact the soil in the years following amelioration. Coarse sandy soils, which are common in WA, naturally compact over time but the most severe soil compaction comes from random wheel traffic from paddock operations. This can compact the soil to greater levels than previously recorded before amelioration.

The adoption of controlled traffic practices by growers is one solution to extend the benefits of soil tillage over a greater length of time. Controlled traffic practices mean the establishment of permanent wheel tracks across the paddock to carry all the heavy wheel traffic during paddock operations, so that the total amount of wheeled area in the paddock is less than 20%. This is considerably less than a random wheeled system, where at least 35-70% of the paddock can be wheeled in any given season.

The benefit of combining deep ripping and controlled traffic practices has been extrapolated by Wayne Parker as part of DAW00242 project. It is considered that the benefit of deep ripping to ameliorate soil compaction may last for only 3 years under random wheel traffic, but these benefits may last at least 5 years under controlled traffic practices. However, the potential for controlled traffic practices to increase the longevity of amelioration treatments has only been evaluated on a narrow range of soil types.

2.0 OBJECTIVES

This project aims to establish at least 4 demonstration sites in the Esperance Port Zone that are used by growers to increase their knowledge and adoption of deep ripping and controlled traffic farming to alleviate non-wetting soils, compaction and waterlogging on different soil types in the port zone to improve crop production.

To do so the project will measure the grain yield and gross margin outcome of each tillage treatment at each site.

3.0 METHODS

In 2018 demonstration sites were established in each of the following five locations:

- Dunn Rock (Ravensthorpe)
- Cascade
- Coomalbidgup
- Salmon Gums
- Neridup

A side by side demonstration strip design was used at each of the 5 sites to compare at least 2 ripping depth treatments to an untreated control. The ripping depth treatments were tillage to 30cm and tillage to as close to 60cm as possible. A “local solution/combination of method” treatment was applied at 3 locations (Dunn Rock, Coomalbidgup and Neridup) where equipment was available and the soil type lent itself to another amelioration question, beyond depth to rip to. Additional soil tillage treatments were not applied at the Salmon Gums and Cascade sites for two reasons. Firstly, access to additional soil tillage equipment was limited in these locations. Secondly, the primary question that needed to be addressed at these locations was whether ripping would impede crop performance or not.

Each site was established in February-March 2018 with treatments implemented by trial site host growers. During the 2019 winter cropping season 4 of the 5 sites established in 2018 were sown, sprayed, fertilised and harvested under the management of host growers with the soil amelioration treatment being the only difference between plots. A Controlled Traffic Farming system was in place at each of the 4 locations. The Dunn Rock site was not cropped in 2019 as conditions were too dry for the host grower to be prepared to invest in a crop in this paddock.

Prior to seeding in 2019 a bulked soil sample for the following depth increments 0-10cm, 10-20cm, 20-30cm, 30-40cm and 40-50cm was submitted for comprehensive analysis by CSBP. Plant establishment counts were taken either 4 weeks after seeding or close to. During the season plant growth was measured using a Trimble® Greenseeker®.

Soil strength, quantified using a data-logging penetrometer at field capacity, was not measured in 2019 as rainfall was insufficient at all locations to achieve field capacity.

Grain yield was measured at the Coomalbidgup, Cascade, Salmon Gums and Neridup sites using yield monitor data from the host grower's header and the statistical analysis program Genstat was used to generate ANOVAs on the data.

Gross Margin was calculated for each treatment per demonstration site based on grower data for inputs and costs for the 2019 cropping season.

The communication and extension activities undertaken to support this project during 2019 are listed in Appendix 1.

4.0 LOCATION

	Latitude (decimal degrees)	Longitude (decimal degrees)
Trial Site #1 - Dunn Rock	-33.465942	119.735612
Nearest Town	Ravensthorpe	
Trial Site #2 - Cascade	-33.382425	120.943011
Nearest Town	Cascade	
Trial Site #3 - Coomalbidgup	-33.570733	121.421373
Nearest Town	Coomalbidgup	
Trial Site #4 – Salmon Gums	-33.039886	121.736452
Nearest Town	Salmon Gums	
Trial Site #5 - Neridup	-33.634446	122.053783
Nearest Town	Neridup	

If the research results are applicable to a specific GRDC region/s (e.g. North/South/West) or GRDC Agro-Ecological Zone/s please indicate which in the table below:

Research	Benefiting GRDC Region (can select up to three regions)	Benefiting GRDC Agro-Ecological Zone (see link: http://www.grdc.com.au/About-Us/GRDC-Agroecological-Zones) for guidance about AE-Zone locations	
Experiment Title	Western Region Western Region Western Region	☐ Qld Central ☐ NSW NE/Qld SE ☐ NSW Vic Slopes ☐ Tas Grain	☐ NSW Central ☐ NSW NW/Qld SW ☐ Vic High Rainfall ☐ SA Vic Mallee

		☐ SA Midnorth-Lower Yorke Eyre ☐ WA Northern ☐ WA Eastern ☒ WA Mallee	☐ SA Vic Bordertown-Wimmera ☐ WA Central ☒ WA Sandplain

5.0 RESULTS

5.1 Dunn Rock (Ravensthorpe) Demonstration Site

5.1.1 Soil Amelioration Treatment Regime

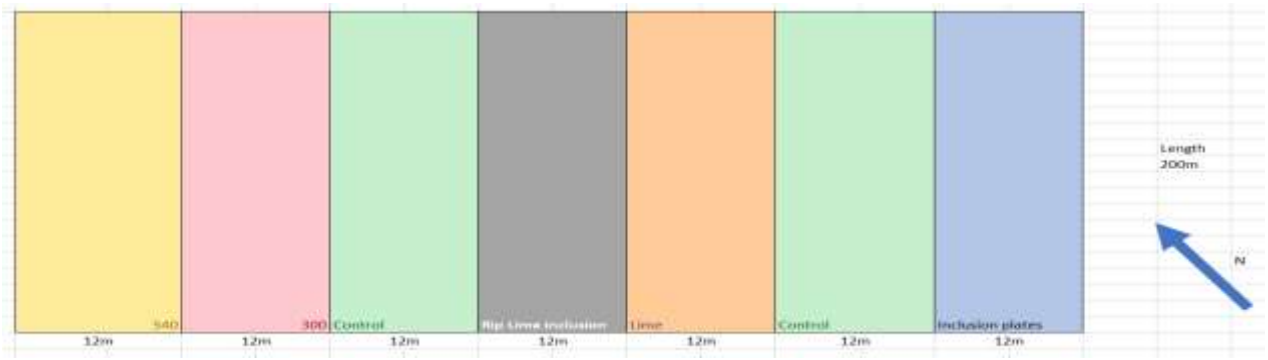

Figure 1: Dunn Rock Ripper Gauge Demonstration Site Treatment Strip Design

The Dunn Rock site had the following treatments applied in 2018 using a Nufab ripper in the order illustrated in Figure 1:

- Ripped to 540mm depth, spacing 300mm
- Ripped to 300mm depth, spacing 300mm
- Untreated control
- Lime 2t/ha and inclusion plates, spacing 600mm, rip depth 300mm
- Lime 2t/ha
- Control
- Inclusion plates, spacing 600mm, rip depth 300mm

The paddock was sown to barley in 2018. Dry conditions in that year, and there persistence in to early 2019 led to the host grower deciding not to sow a crop in 2019.

5.1.2 Soil Type

Figure 2: Dunn Rock Ripper Gauge Demonstration Representative Soil Core

Soil at the Dunn Rock site was a sandy gravel over yellow/orange clay (Figure 2). Full soil analysis results can be found for each treatment strip in Appendix 2. Soil pH ($CaCl_2$) was acidic in all treatment strips from 0 to 20cm depth. Soil was acidic to 30cm in all treatment strips except for the 2 strips that were ripped to 300m depth and had topsoil incorporated by inclusion plates in 2018 (Table 1). Soil pH

was higher in both of these treatment strips when compared to the other strips from 20cm depth but only one of these treatment strips had lime applied in 2018.

Table 1: Soil pH (CaCl) for cores taken from each of the treatment strips established in 2018 at Dunn Rock Ripper Gauge Demonstration Site, April 2019.

Depth	Ripped to 540mm	Ripped to 300mm	Un-Treated Control	Lime (2t/ha) + Ripped to 300mm + Inclusion Plates	Lime (2t/ha)	Ripped to 300mm + Inclusion Plates
0-10cm	4.9	4.9	5	5.6	5.1	5
10-20cm	6.4	5.7	5.5	6.1	6	6.2
20-30cm	6	6.5	6	7.2	6.3	7.1
30-40cm	7	7	6.9	7.5	6.9	7.6
40-50cm	7.6	7.7	7.3	7.7	7.5	7.9
50-70cm	8.1	7.8	7.8	7.8	7.5	8.1

Note: Those values highlighted indicate acidic values

Potassium levels were marginal in 4 of the treatment strips. Potassium was acceptable in the strip ripped to 540mm and the strip to which 2t/ha lime was applied (see Appendix 2).

5.1.3 2019 Rainfall

Rainfall was below average in 2019 at Dunn Rock (Figure 3). Annual rainfal was 183.8mm compared to the Mt Madden annual average of 350.6mm (from 1931 to present) and the Ravemsthrope average of 429.6mm (from 1907 to present).

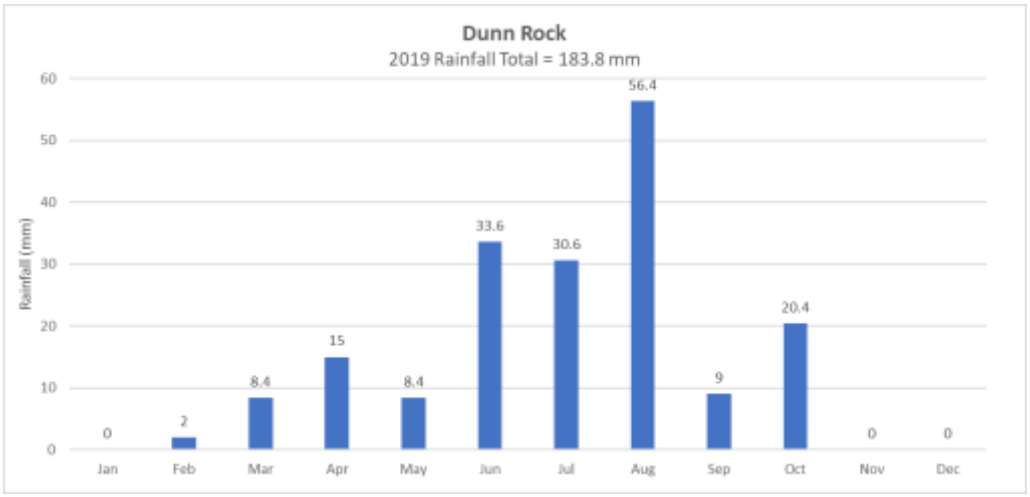

Figure 3: 2019 Annual Rainfall at Dunn Rock

5.2 Cascade Demonstration Site

5.2.1 Soil Amelioration Treatment Regime

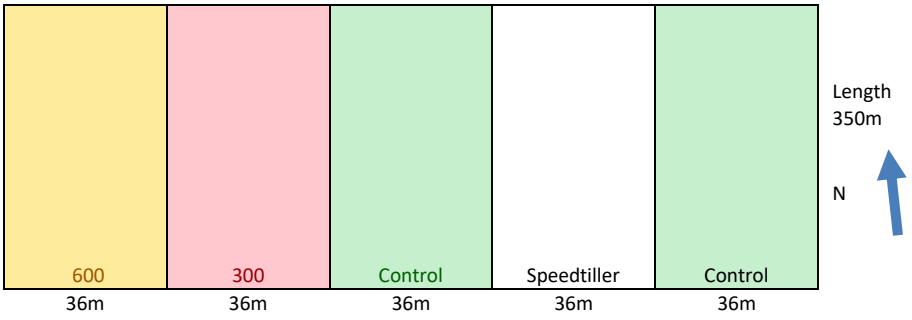

Figure 4: Cascade Ripper Gauge Demonstration Site Treatment Strip Design

The Cascade demonstration site had three tillage treatments applied in 2018 (Figure 4). The 2 ripping depth treatments (300 mm and 600mm) were undertaken using a straight shank NuFab ripper with a crumble roller. The Speedtiller treatment cultivated soil to a depth of 100mm. The site was later sown to wheat. In 2019 the paddock was sown to barley.

5.2.2 Soil Type

Heavy sodic clay soils were prevalent at the Cascade demonstration site (Figure 5 & Table 2).

Figure 5: Cascade Ripper Gauge Demonstration Representative Soil Core

Soil pH (CaCl) was acidic at 0-10cm in both the 'Ripped to 300mm' and 'Ripped to 600mm' treatments and close to neutral in the 'Control' treatment. From 10cm depth soil was alkaline throughout the profile with the levels seen at 10cm and below getting in to the range that may affect nutrient availability (ie above pH 7.5 CaCl). Conductivity levels recorded from 20cm depth were in the semi saline category and boron levels were within the problematic to high category in all treatment strips from 10-20cm depth. The levels of sulphur recorded in the 0-10cm layer was high, reflecting the gypsum application history of the paddock (2t/ha spread 4 years ago).

Table 2: Soil Core Analysis for ripping treatment strips, Cascade Demonstration Site, April 2019.

Treatment	Rip to 600	Rip to 600	Rip to 600	Rip to 600	Rip to 600	Rip to 600	Rip to 300	Rip to 300	Rip to 300	Rip to 300	Rip to 300	Rip to 300	C	C	C	C	C	C
Depth	0-10	10-20	20-30	30-40	40-50	50-70	0-10	10-20	20-30	30-40	40-50	50-70	0-10	10-20	20-30	30-40	40-50	50-70
Colour	GR	GR	GRYW	GRYW	GRWH	GRYW	GRBR	BRGR	GRYW	GRYW	BRWH	YWGR	GR	BRGR	BRGR	GRBR	GRYW	GRYW
Gravel	5	5	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
Texture	1.5	3.5	3	3	3	3	1.5	3	3	3	3	3	1.5	3	3	3	3	3
Ammonium Nitrogen	13	1	<1	<1	<1	<1	4	<1	<1	<1	<1	<1	3	<1	<1	<1	<1	<1
Nitrate Nitrogen	22	6	2	1	1	1	17	3	2	<1	3	2	30	5	4	4	2	3
Phosphorus Colwell	16	3	<2	<2	<2	<2	9	<2	<2	<2	6	<2	18	4	3	4	<2	<2
Potassium Colwell	216	471	565	557	497	570	61	331	460	433	439	566	438	460	533	614	696	676
Sulfur	21.3	29.5	76.8	120.5	88	121.8	28.2	8.5	20.4	31.6	40.5	102.7	33.9	9.5	20.2	25.8	44	85.3
Organic Carbon	1.23	0.31	0.26	0.1	0.26	0.06	0.8	0.45	0.22	0.15	0.34	0.08	1.38	0.47	0.45	0.38	0.09	0.08
Cond.	0.125	0.28	0.449	0.685	0.49	0.602	0.13	0.126	0.358	0.438	0.454	0.531	0.171	0.183	0.279	0.36	0.52	0.594
pH Level (CaCl2)	5.6	8.3	8.7	8.9	8.8	8.8	5.3	7.7	8.4	8.7	8.8	8.8	6.9	8.1	8.4	8.6	8.9	9
pH Level (H2O)	6.4	9.3	9.8	10	10	9.9	6.1	9.1	9.6	9.8	10	9.9	7.5	9	9.4	9.6	10	10.1
DTPA Copper	0.82	0.44	1.18	1.2	1.45	0.96	0.37	0.38	0.51	0.57	0.83	1.02	0.76	0.51	0.66	0.65	0.65	0.66
DTPA Iron	30.85	19.3	12.29	10.19	13.51	11.51	38.76	29.31	26.04	22.48	25.84	18.15	11.38	18.55	19.31	15.03	20.46	25.24
DTPA Manganese	5.12	0.36	0.27	0.4	0.55	0.41	1.07	0.22	0.32	0.4	1.13	0.31	2.17	0.3	0.24	0.31	0.33	0.62
DTPA Zinc	0.7	0.19	0.15	0.18	0.08	0.19	0.29	0.09	0.13	0.02	0.34	0.26	1.37	0.11	0.13	0.12	0.04	0.03
Exc. Aluminium	0.054	0.152	0.16	0.135	0.061	0.158	0.086	0.191	0.131	0.16	0.169	0.163	0.054	0.075	0.094	0.114	0.097	0.067
Exc. Calcium	4.41	9.3	8.8	3.9	7.36	1.35	2.85	5.86	6.3	6.16	8.45	3.39	10.78	17.56	15.05	10.63	5.51	4.07
Exc. Magnesium	1.02	9.17	11.2	10.55	9.74	9.17	0.5	6.49	10.27	9.48	7.37	9.46	1.65	8.15	10.12	10.36	10.67	8.7
Exc. Potassium	0.47	1.28	1.32	1.33	1.15	1.29	0.11	0.83	1.14	1.22	1.11	1.53	1.03	1.36	1.46	1.59	1.75	1.71
Exc. Sodium	0.41	2.9	5.47	9.5	6.72	10.49	0.44	2.56	5.26	6.51	6.03	11.51	0.21	1.46	2.57	3.83	7.91	10.62
Boron Hot CaCl2	1.32	13.42	18.87	26.11	20.06	28.64	0.84	6.54	16.74	22.23	19.21	30.3	2.2	8.4	13.76	21.71	33.98	34.62

5.2.3 2019 Rainfall

Rainfall was below average in 2019 at Cascade (Figure 6). Annual rainfal was 172.4mm compared to the annual average of 386.0mm (from 1983 to present). A significant frost event occurred at this site on Friday 6th September 2019.

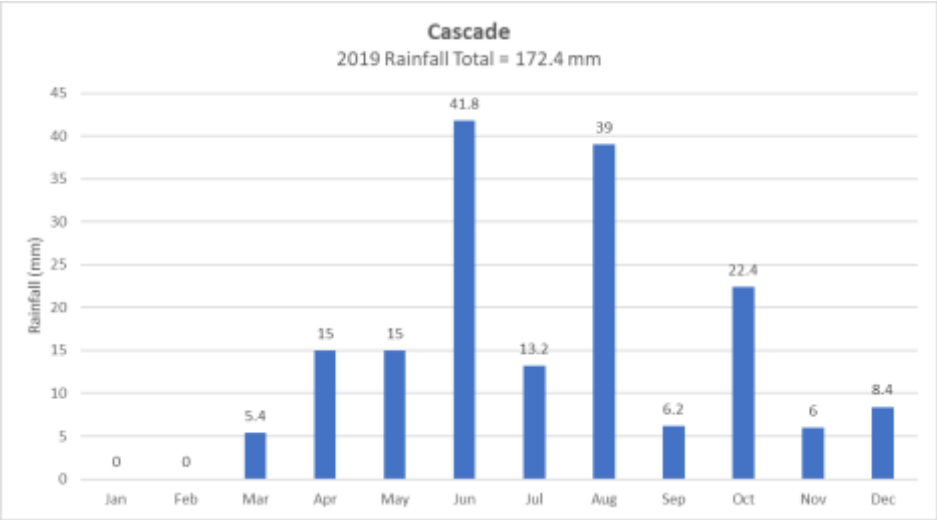

Figure 6: 2019 Annual Rainfall at Cascade

5.2.4 Harvest Yield

Low summer rainfall meant that conditions were relatively dry at seeding, as such germination was patchy and uneven. This did not, however, influence harvest yield (Figure 7). There was no significant difference between the yields recorded in 2019 from the control and the treatment strips applied in 2018. Grain quality was feed grade in all treatment strips.

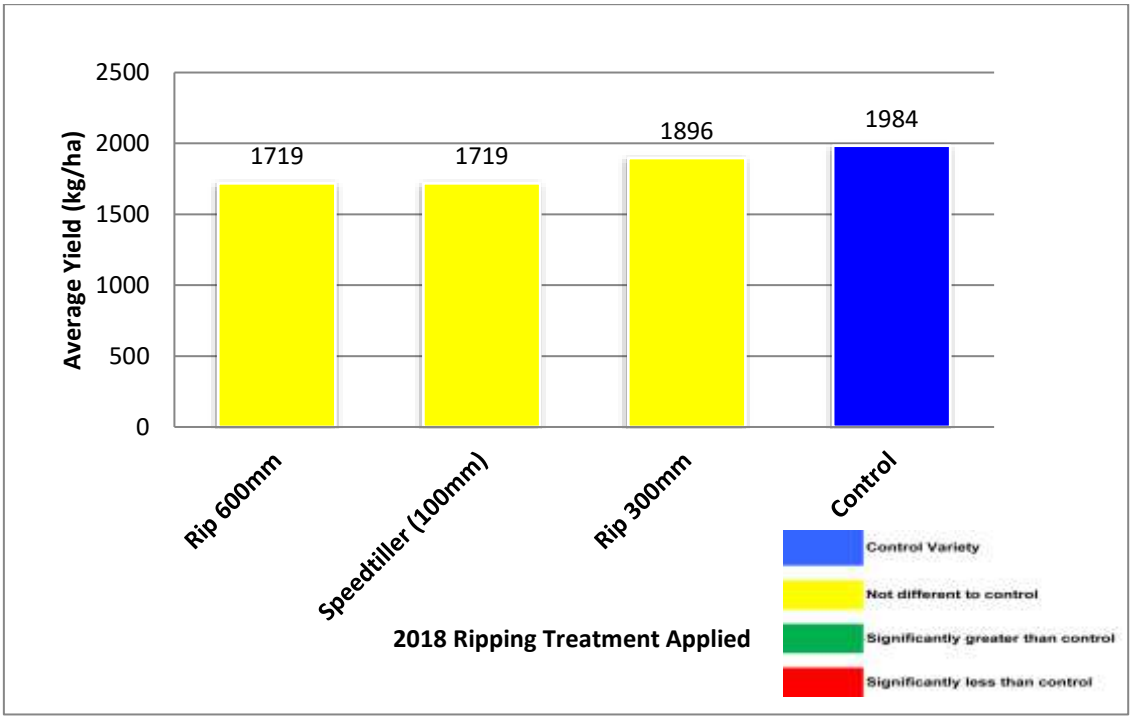

Figure 7: 2019 relative average barley harvest yields from treatment strips applied in 2018. Least significant difference (5%) = 301.1kg/ha, p = 0.185.

5.2.5 Gross Margin

Table 3: Cascade Ripper Gauge Demonstration Site 2019 Barley Crop Gross Margin per Ripping Treatment Applied in 2018.

Trial Treatment		Control		Rip 600mm		Rip 300mm	
Yield	t/ha	1.98		1.72		1.89	
Average Grain Price (FIS)	$/t	$277		$277		$277	
Income	**$/ha**	**$548**		**$476**		**$524**	
Variable Operating Costs	**$/ha**		Extra treat cost		Extra treat cost		Extra treat cost
Seed, Treatment & EPR's	$26	$26	$ -	$26	$ -	$26	$ -
Grain Freight (Up Country)		$2		$2		$2	
Grain Handling Charges		$17		$15		$17	
Crop Contract	$36	$36	$ -	$36	$ -	$36	$ -
Other Crop Costs & Crop Ins	$18	$18	$ -	$18	$ -	$18	$ -
Wages Gross	$24	$24	$ -	$24	$ -	$24	$ -
R&M Mach./Plant/Vehicle	$38	$38	$ -	$38	$ -	$38	$ -
Fuel & Oil	$35	$35	$ -	$35	$ -	$35	$ -
Fertiliser, Lime & Gypsum	$100	$100	$ -	$100	$ -	$100	$ -
Pesticide	$75	$75	$ -	$75	$ -	$75	$ -
Variable Operating Costs	$	**$372**	**$ -**	**$369**	**$ -**	**$371**	**$ -**
Operating Gross Margin	$	$177		$107		$153	
Fixed Operating Costs	92	$92		$92		$92	
Total Operating Costs	**$/ha**	**$464**		**$461**		**$463**	
Operating Profit (BIT)	**$/ha**	**$85**		**$15**		**$61**	

Total Grain Sold	**t**	2		2		2	
Up Country Freight	$/t	$1.14		$1.14		$1.14	
Handling Fees	$/t	$8.80		$8.80		$8.80	
	$	$20		$17		$19	

In 2019, the most profitable of the soil tillage treatments applied to the heavy sodic clay soils present at the Cascade site was the control, to which nothing was done. This was also the case in 2018. The 'Rip to 300mm' treatment was next in terms of profitability, as was the case in 2018, although the difference in profit between the control and the shallow rip was less in 2018 than it was in 2019. The 'Rip to 600mm' strip was the least profitable treatment in both 2019 and 2018.

5.3 Coomalbidgup Demonstration Site

5.3.1 Soil Amelioration Treatment Regime

In 2018 the Coolmalbidgup demonstration site had the following treatments applied using a 4.5m Gessner 'C' shank ripper with a crumble roller and a Vaderstad Topdown and was sown to wheat (Figure 8). In 2019 the paddock was sown to lupins.

- Ripped to 600mm depth & Spade
- Ripped to 600mm depth
- Vaderstad Topdown – tillage to 300mm
- Untreated control
- Spade – tillage to 300mm

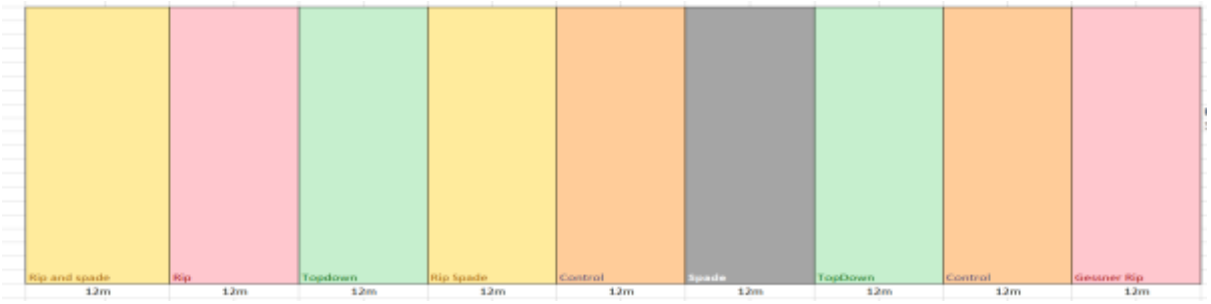

Figure 8: Coomalbidgup Ripper Gauge Demonstration Site Treatment Strip Design

5.3.2 Soil Type

Soil at this location was a gravelly sand over an orange clay (see Figure 9 and Tables 4&5) and prone to waterlogging.

Figure 9: Coomalbidgup Ripper Gauge Demonstration Representative Soil Core

Potassium levels at 0-20cm depth were higher in the 'Rip to 600mm' and 'Rip to 600mm and Spade' treatment strips when compared to the Control (Table 4), while sulphur was lower in these ripping treatment strips when compared to the control at 0-30cm depth. Conductivity was slightly lower at 0-30cm depth in these deeper ripping treatment strips when compared to the Control.

Table 4: Soil Core Analysis for Ripped, Control and Ripped and Spaded treatment strips, Coomalbidgup Ripper Gauge Demonstration Site, April 2019.

Treatment	Rip	Rip	Rip	Rip	Rip	Rip	C	C	C	C	C	C	Rip Spade	Rip Spade	Rip Spade	Rip Spade	Rip Spade	Rip Spade
Depth	0-10	10-20	20-30	30-40	40-50	50-70	0-10	10-20	20-30	30-40	40-50	50-70	0-10	10-20	20-30	30-40	40-50	50-70
Colour	GR	GR	BRGR	BRGR	YWGR	YWGR	GR	GRBR	GRBR	LTGR	BRYW	GRYW	LTGR	LTGR	GRYW	BRGR	GRYW	YW
Gravel	5	0	0	0	0	0	5	0	5	5	0	0	5	0	0	0	0	0
Texture	1.5	3	2.5	3	3	3	1	3	2	2.5	3	3	1	3	3	3	3	3
Ammonium Nitrogen	1	<1	<1	<1	<1	<1	2	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1
Nitrate Nitrogen	7	3	2	2	2	<1	10	2	2	2	2	3	2	<1	<1	<1	<1	<1
Phosphorus Colwell	32	7	6	4	3	<2	43	6	9	7	2	2	22	4	3	<2	<2	<2
Potassium Colwell	108	536	583	532	501	567	34	450	413	362	488	476	168	659	670	743	643	692
Sulfur	7	3.3	7.6	16.1	38	39.6	11.3	10.9	11.5	9.3	9.2	9.1	4.1	3.5	5.8	8.7	10.8	19
Organic Carbon	1.07	0.41	0.28	0.21	0.26	0.17	1.33	0.18	0.29	0.26	0.11	0.13	0.7	0.12	0.14	0.22	0.2	0.18
Conductivity	0.098	0.141	0.247	0.34	0.531	0.549	0.107	0.313	0.334	0.331	0.416	0.388	0.091	0.166	0.239	0.313	0.357	0.423
pH Level (CaCl2)	6.8	7.6	7.9	8.2	8.3	8.5	6.3	8.3	8.5	8.6	8.7	8.7	6.8	7.7	8.2	8.4	8.2	8.5
pH Level (H2O)	7.4	8.5	8.8	9.1	9.3	9.6	6.8	9.5	9.7	9.8	9.9	9.9	7.3	8.6	9	9.3	9.5	9.7
DTPA Copper	0.56	0.51	0.56	0.84	1.14	1.02	0.57	0.63	0.75	0.71	0.72	0.69	0.62	0.47	0.61	0.97	0.92	0.76
DTPA Iron	47.63	23.79	21.53	28.02	18.28	18.49	66.67	21.56	24.14	30.7	16.88	19.5	38.02	23.38	18.63	28.58	16.29	15.8
DTPA Manganese	1.83	0.58	0.37	0.66	0.47	0.52	2.29	0.37	0.89	2.17	0.85	1.75	1.85	0.29	0.31	1.56	0.63	0.53
DTPA Zinc	0.72	0.24	0.15	0.19	0.07	0.07	0.7	0.15	0.13	0.21	0.13	0.07	0.48	0.08	0.06	0.06	0.19	0.05
Exc. Aluminium	0.08	0.191	0.234	0.151	0.102	0.137	0.036	0.209	0.126	0.15	0.243	0.2	0.093	0.203	0.243	0.147	0.105	0.096
Exc. Calcium	5.24	9.66	13.34	14.18	12.43	10.18	4.79	6.59	8.28	8.15	6.23	6.92	4.12	6.95	9.31	10.59	9.47	8.39
Exc. Magnesium	0.76	3.06	5.57	6.14	6.11	5.86	0.54	5.85	5.18	4.49	6.56	5.88	0.82	6.23	7.21	7.48	6.91	6.84
Exc. Potassium	0.21	1.23	1.49	1.37	1.22	1.38	0.08	1.04	0.91	0.8	1.13	1.12	0.31	1.5	1.6	1.66	1.57	1.56
Exc. Sodium	0.19	0.8	1.83	2.62	4.36	5.12	0.3	3.86	3.72	3.47	5.73	5.72	0.13	1.22	1.68	2.42	2.82	3.7
Boron Hot CaCl2	0.79	1.85	2.9	3.49	4.47	5.25	0.54	4.81	5.68	6.07	9.83	10.43	0.62	4.59	8.07	10.58	11.59	13.26

In the 'Topdown' and 'Spade' ripping treatments, which had shallower tillage (to 300mm), potassium and sulphur levels at 10-30cm depth were lower compared to the Control (Table 5).

Table 5: Soil Core Analysis for Spaded and Topdown treatment strips, Coomalbidgup Ripper Gauge Demonstration Site, April 2019.

Treatment	Spade	Spade	Spade	Spade	Spade	Spade	Topdown	Topdown	Topdown	Topdown	Topdown	Topdown
Depth	0-10	10-20	20-30	30-40	40-50	50-70	0-10	10-20	20-30	30-40	40-50	50-70
Colour	GR	BRGR	BRGR	BRYW	YWGR	YWGR	GR	LTGR	LTBR	BRYW	YWGR	BRWH
Gravel	5	5	75-80	75-80	0	0	0	75-80	75-80	0	0	0
Texture	1	1	1	1	3	3	1.5	1.5	1.5	3	3	3
Ammonium Nitrogen	2	1	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1
Nitrate Nitrogen	5	3	3	2	1	< 1	9	2	1	3	4	3
Phosphorus Colwell	53	28	7	2	< 2	< 2	45	17	7	< 2	< 2	< 2
Potassium Colwell	49	65	112	105	435	646	44	157	114	544	682	518
Sulfur	6.6	4.1	14.8	13.4	5.1	6	6.5	7.9	1.2	2.6	3.2	4.7
Organic Carbon	0.92	0.62	0.22	0.11	0.15	0.06	0.98	0.28	0.18	0.14	0.13	0.17
Conductivity	0.059	0.032	0.05	0.053	0.126	0.15	0.074	0.056	0.029	0.106	0.162	0.146
pH Level (CaCl2)	5.5	5.5	6.2	6.8	7.2	7.9	7.1	7.1	6.9	7.6	8.1	8.3
pH Level (H2O)	6.3	6.4	6.9	7.6	8.9	9.3	8.1	7.9	8.2	8.7	9.1	9.3
DTPA Copper	0.62	0.48	0.4	0.28	0.33	0.49	0.52	0.59	0.39	0.4	0.4	0.38
DTPA Iron	86.07	116.1	121.3	121.1	26.44	15.2	38.48	103.89	23.54	22.85	15.44	21.87
DTPA Manganese	1.68	1.11	1.99	1.66	0.3	0.41	1.44	2.7	0.19	0.28	0.3	0.83
DTPA Zinc	0.49	0.49	0.34	0.25	0.17	0.12	0.61	0.4	0.21	0.1	0.07	0.12
Exc. Aluminium	0.07	0.072	0.067	0.038	0.165	0.224	0.032	0.033	0.107	0.199	0.247	0.101
Exc. Calcium	2.65	1.35	1.09	1.04	3.12	5	4.76	2.13	1.7	6.36	9.03	10.18
Exc. Magnesium	0.38	0.25	0.37	0.43	5.66	8.96	0.45	0.39	0.82	5.62	7.71	5.28
Exc. Potassium	0.11	0.13	0.25	0.23	1.01	1.52	0.11	0.31	0.24	1.27	1.59	1.17
Exc. Sodium	0.12	0.09	0.25	0.53	3.83	5.71	0.14	0.1	0.17	1.17	1.77	1.51
Boron Hot CaCl2	0.35	0.31	0.47	0.75	7.14	12.57	0.52	0.4	0.79	5.5	8.21	7.21

5.3.3 2019 Rainfall

Rainfall was below average in 2019 at Coomalbidgup (Figure 10). Annual rainfal was 325.1mm compared to the annual average of 494.3mm (from 1974 to present). A significant frost event occurred in the Esperance Port Zone on Friday 6th September 2019 that did affect some parts of the Coomalbidgup area but this paddock did not sustain widespread, extensive damage.

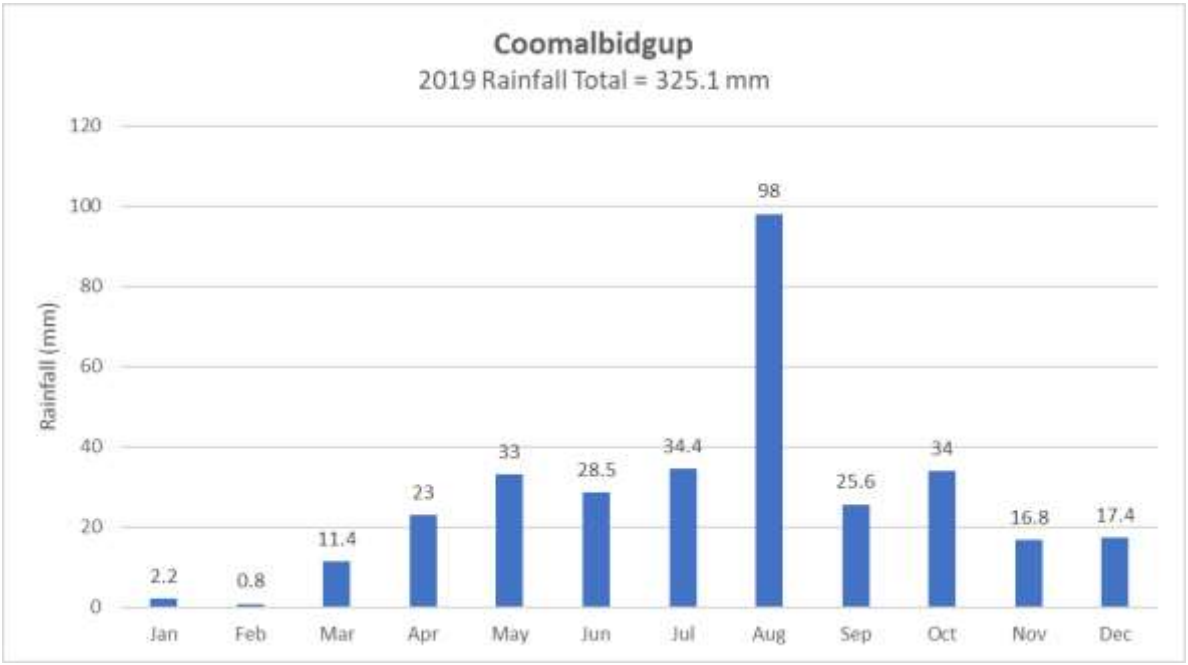

Figure 10: 2019 Annual Rainfall at Coomalbidgup

5.3.4 Harvest Yield

Germination was variable between treatments at this demonstration site but this did not influence lupin crop harvest yield (Figure 11). There was no significant difference between the yields recorded in 2019 from the control and the treatment strips applied in 2018.

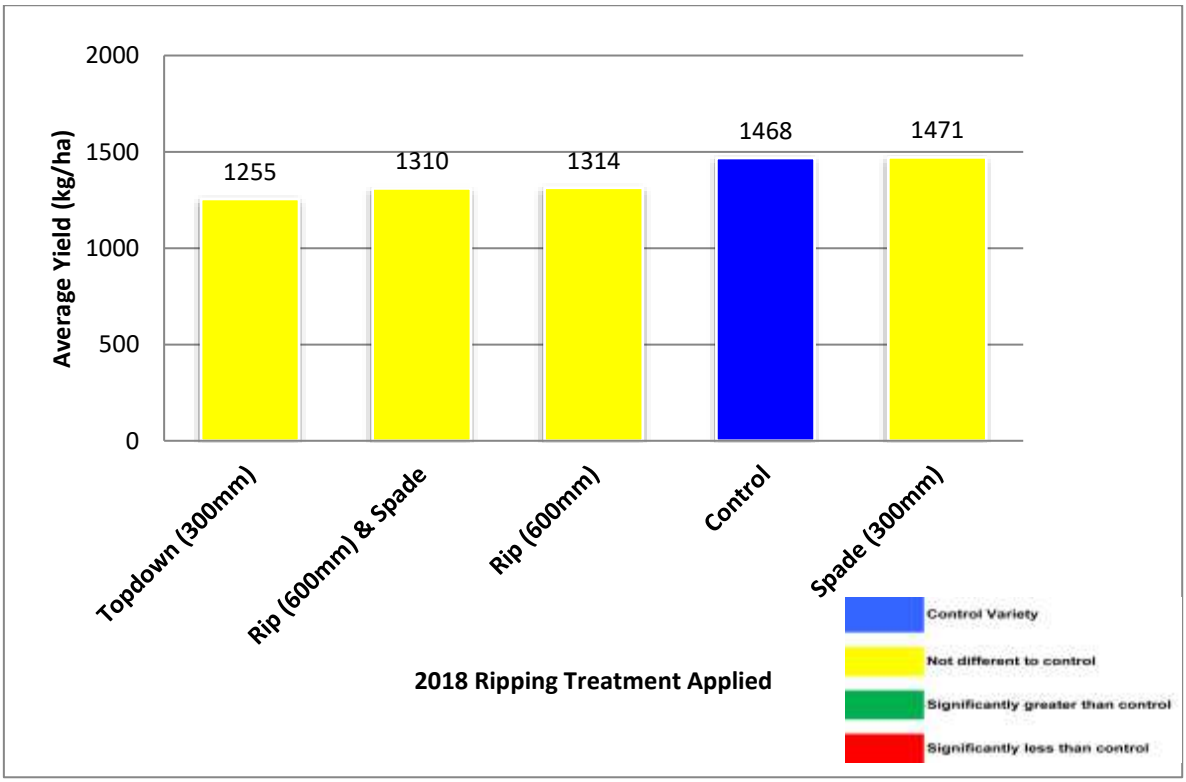

Figure 11: 2019 relative average lupin harvest yields from treatment strips applied in 2018. Least significant difference (5%) = 429.7kg/ha, p = 0.524.

5.3.5 Gross Margin

Gross margin data (Table 6) indicated that, in 2019, the lupin crop at the Coomalbidgup demonstration site performed at an operating loss in all treatment strips. The loss was highest in the Topdown treatment strip and lowest in the Control and Spaded strips.

Table 6: Coomalbidgup Ripper Gauge Demonstration Site 2019 Lupin Crop Gross Margin per Ripping Treatment Applied in 2018.

Trial Treatment		Control		Rip 600mm		Top Down 300mm		Rip and Spade 600mm		Spade 300mm	
Yield	t/ha	1.47		1.30		1.26		1.31		1.47	
Average Grain Price (FIS)	$/t	$425		$425		$425		$425		$425	
Income	**$/ha**	**$625**		**$553**		**$536**		**$557**		**$625**	
Variable Operating Costs	**$/ha**		Extra treat cost		Extra treat cost		Extra treat cost		Extra treat cost		E.T.C.
Seed, Treatment & EPR's	$30	$30	$ -	$30	$ -	$30	$ -	$30	$ -	$30	$ -
Grain Freight (Up Country)		$2		$1		$1		$1		$2	
Grain Handling Charges		$13		$11		$11		$12		$13	
Crop Contract	$51	$51	$ -	$51	$ -	$51	$ -	$51	$ -	$51	$ -
Other Crop Costs & Crop Ins	$31	$31	$ -	$31	$ -	$31	$ -	$31	$ -	$31	$ -
Wages Gross	$39	$39	$ -	$39	$ -	$39	$ -	$39	$ -	$39	$ -
R&M Mach./Plant/Vehicle	$47	$47	$ -	$47	$ -	$47	$ -	$47	$ -	$47	$ -
Fuel & Oil	$38	$38	$ -	$38	$ -	$38	$ -	$38	$ -	$38	$ -
Fertiliser, Lime & Gypsum	$145	$145	$ -	$145	$ -	$145	$ -	$145	$ -	$145	$ -
Pesticide	$110	$110	$ -	$110	$ -	$110	$ -	$110	$ -	$110	$ -
Speed Tiller year 2 (2019)	$50/ha		$50.00		$50.00		$50.00		$50.00		$50.00
Variable Operating Costs	$	**$556**	**$50.00**	**$554**	**$50.00**	**$554**	**$50.00**	**$554**	**$50.00**	**$556**	**$50.00**
Operating Gross Margin	$	$69		($1)		($18)		$3		$69	
Fixed Operating Costs	92	$92		$92		$92		$92		$92	
Total Operating Costs	**$/ha**	**$648**		**$646**		**$646**		**$646**		**$648**	
Operating Profit (BIT)	**$/ha**	**($23)**		**($93)**		**($110)**		**($89)**		**($23)**	

Total Grain Sold	**t**	1	1	1	1	1
Up Country Freight	$/t	$1.14	$1.14	$1.14	$1.14	$1.14
Handling Fees	$/t	$8.80	$8.80	$8.80	$8.80	$8.80
	$	$15	$13	$13	$13	$15

5.4 Salmon Gums Demonstration Site

5.4.1 Soil Amelioration Treatment Regime

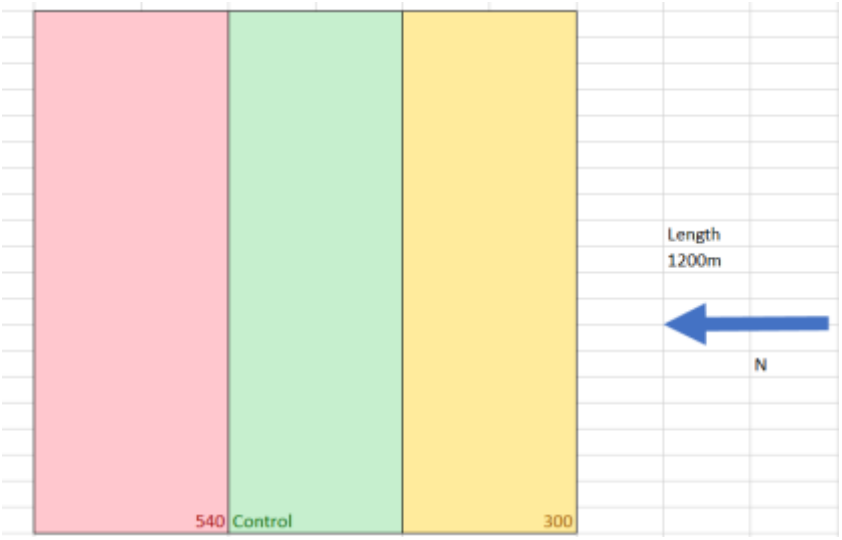

Figure 12: Salmon Gums Ripper Gauge Demonstration Site Treatment Strip Design

Figure 12 illustrates the tillage treatments applied at the Salmon Gums demonstration site in 2018 using DPIRD's modified Grizzly Ripper, with straight rather than curved tynes, and a crumble. The site was later sown to wheat. In 2019 the paddock was again sown to wheat.

5.4.2 Soil Type

Soil at this demonstration site was predominantly loamy clay to clay (Figure 13).

Figure 13: Salmon Gums Ripper Gauge Demonstration Representative Soil Core

Soil cores collected from this site indicate that soil in all treatment strips was mildly acidic (CaCl) from 0 to 50cm depth in both the 'Ripped to 540mm' and 'Control' treatment strip and from 0 to 10cm depth in the 'Ripped to 300mm' treatment strip (Table 7). Soil in this latter treatment strip was close to neutral from 10 to 50cm depth. Conductivity was not problematic in the treatment strips, which was unexpected for this soil type in this location. Potassium levels were marginal from the surface to 40cm depth.

Table 7: Soil Core Analysis for ripping treatment strips, Salmon Gums Ripper Gauge Demonstration Site, April 2019.

Treatment	Rip 540	Rip 540	Rip 540	Rip 540	Rip 540	Rip 540	C	C	C	C	C	C	Rip 300	Rip 300	Rip 300	Rip 300	Rip 300	Rip 300
Depth	0-10	10-20	20-30	30-40	40-50	50-70	0-10	10-20	20-30	30-40	40-50	50-70	0-10	10-20	20-30	30-40	40-50	50-70
Colour	LTGR	LTGR	LTGR	BRGR	BRGR	BRYW	LTGR	GR	LTGR	BRWH	GRYW	BRYW	LTGR	LTGR	LTGR	GRWH	GRWH	BRYW
Gravel	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Texture	1	1	1	2	2.5	3	1	1	1	1	3	3	1	1	1	1	2	3
Ammonium Nitrogen	11	< 1	< 1	< 1	< 1	< 1	11	10	1	< 1	< 1	< 1	20	< 1	< 1	< 1	< 1	< 1
Nitrate Nitrogen	8	5	3	2	1	< 1	12	9	3	1	2	2	7	5	3	2	1	< 1
Phosphorus Colwell	22	18	15	16	10	3	31	15	10	9	18	3	24	14	6	4	2	< 2
Potassium Colwell	66	47	51	109	150	244	44	42	44	50	156	284	52	37	31	32	59	339
Sulfur	12.9	14	11	0.9	0.9	12	18.4	18.8	5	17	2.4	2.2	22.7	2	1.9	1	1.1	2.3
Organic Carbon	0.47	0.26	0.2	0.38	0.13	0.09	0.38	0.16	0.09	0.08	0.13	0.1	0.33	0.16	0.22	0.07	0.05	0.09
Conductivity	0.055	0.027	0.023	0.054	0.048	0.1	0.07	0.075	0.03	0.021	0.046	0.11	0.075	0.057	0.065	0.028	0.046	0.189
pH Level (CaCl2)	5.6	5.2	5.8	6.8	6.8	8	5.2	6.3	6.3	6.3	6.7	7.9	6	7.2	7.7	7.2	7.6	8.4
pH Level (H2O)	6.3	6.3	6.5	7.4	7.7	8.7	6	6.7	7	6.8	7.5	8.6	6.6	7.7	8.4	8.1	8.8	9.4
DTPA Copper	0.48	0.33	0.14	0.21	0.25	0.41	0.6	0.34	0.18	0.15	0.24	0.31	0.32	0.31	0.22	0.27	0.29	0.31
DTPA Iron	26.65	52.55	35.18	17.59	17.49	12.38	29.87	22.72	18.08	12.1	12.39	10.55	29.46	18.5	11.38	9.69	7.42	11.35
DTPA Manganese	5.91	2.57	1.09	0.52	0.45	0.36	5.36	0.76	0.47	0.33	0.33	0.26	4.3	0.64	0.39	0.31	0.27	0.38
DTPA Zinc	1.2	0.33	0.16	0.14	0.1	0.1	2.59	0.63	0.24	0.15	0.15	0.12	0.79	0.3	0.17	0.12	0.35	0.18
Exc. Aluminium	0.054	0.136	0.118	0.221	0.316	0.204	0.046	0.078	0.084	0.097	0.112	0.129	0.032	0.06	0.069	0.076	0.128	0.117
Exc. Calcium	1.25	0.98	1.4	3.27	4.26	6.96	1.04	1.09	0.83	0.89	3.48	6.28	1.1	1.69	3.91	0.71	0.82	5.43
Exc. Magnesium	0.32	0.18	0.19	0.63	1.21	2.76	0.24	0.19	0.17	0.24	1.51	3.04	0.26	0.29	0.3	0.16	0.38	3.58
Exc. Potassium	0.1	0.08	0.08	0.24	0.37	0.61	0.08	0.08	0.08	0.09	0.36	0.68	0.09	0.05	0.05	0.05	0.09	0.78
Exc. Sodium	0.05	0.03	0.04	0.1	0.19	0.28	0.07	0.05	0.04	0.05	0.16	0.28	0.03	0.07	0.06	0.06	0.15	1.53
Boron Hot CaCl2	0.3	0.18	0.21	0.62	0.86	1.93	0.26	0.2	0.16	0.23	0.98	2.53	0.21	0.29	0.43	0.2	0.41	5.03

5.4.3 Rainfall

Rainfall was below average in 2019 at the Salmon Gums demonstration site (Figure 14). Annual rainfal was 169.65mm compared to the long term annual average of 321.0mm (from 1931 to present). A significant frost event occurred in the Esperance Port Zone on Friday 6th September 2019 that affected this site.

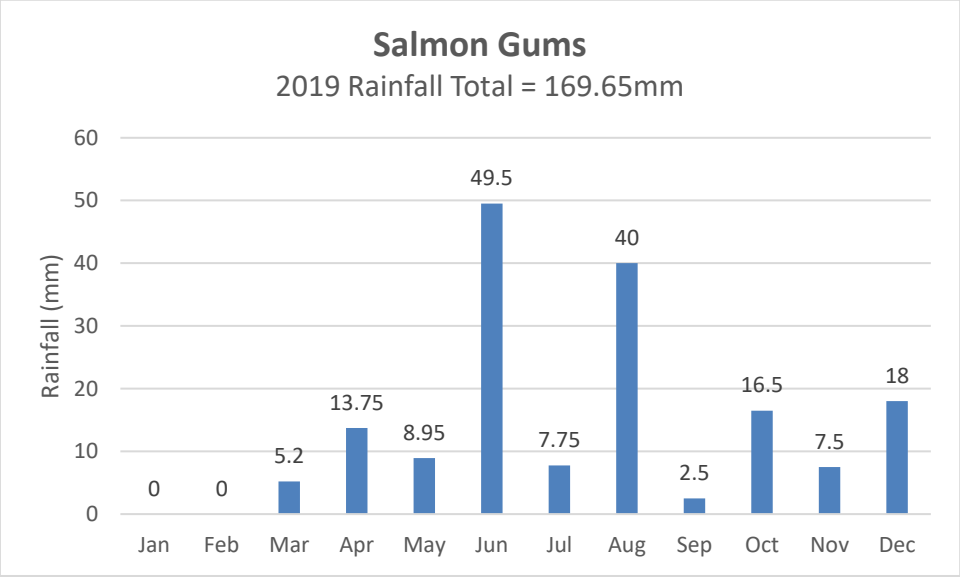

Figure 14: 2019 Annual Rainfall at Salmon Gums

5.4.4 Harvest Yield

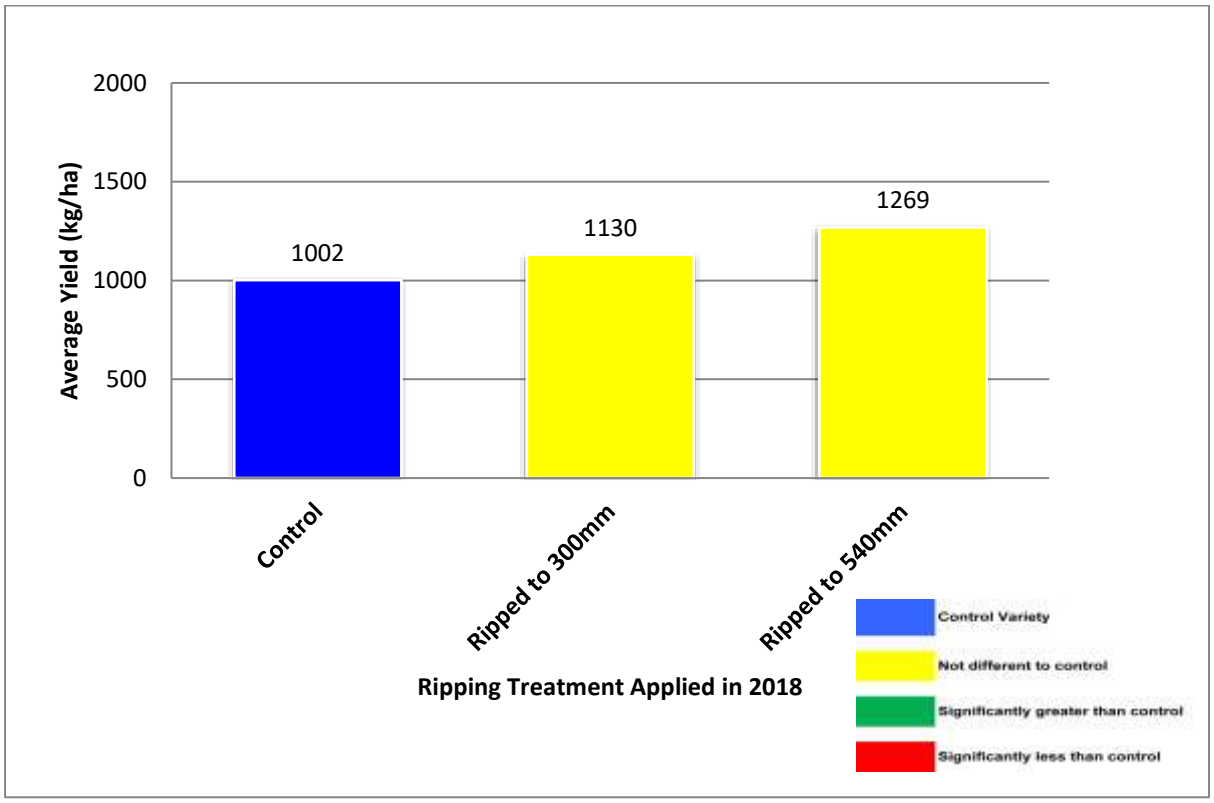

Figure 15: 2019 relative average wheat harvest yields from treatment strips applied in 2018. Least significant difference (5%) = 445.2kg/ha, p = 0.399.

Wheat crop harvest yield data is presented in Figure 15. There was no significant difference between yields recorded in 2019 from each of the treatment strips and the control whereas in 2018 tillage to 540mm did improve wheat crop yield.

5.4.5 Gross Margin

Gross margin analysis of the Salmon Gums demonstration site indicates that while there was no statistically significant increase in wheat yield between the control and ripping treatment strips in 2019, ripping to 540mm depth did improve financial performance of the wheat crop (Table 8).

Ripping to 540mm depth resulted in an increase in operating profit of $63/ha when compared to the control. This trend was also the case in 2018 when ripping to 540mm depth improved wheat crop performance by $316/ha compared to the control.

Neither the ‘Control’ or ‘Tillage to 300m’ treatments produced a profitable wheat crop in 2019 but tillage to 300mm depth increased wheat crop performance by $22/ha when compared to the control. In 2018 it reduced wheat crop performance by $22/ha compared to the control.

Table 8: Salmon Gums Ripper Gauge Demonstration Site 2019 Wheat Crop Gross Margin per Ripping Treatment Applied in 2018.

Trial Treatment		Control		Rip 540mm depth		Rip 300mm depth	
Yield	t/ha	1.00		1.27		1.13	
Average Grain Price (FIS)	$/t	$341		$320		$322	
Income	**$/ha**	**$341**		**$406**		**$364**	
Variable Operating Costs	**$/ha**		Extra treat cost $/ha		Extra treat cost $/ha		Extra treat cost $/ha
Seed, Treatment & EPR's	$20	$20	$ -	$20	$ -	$20	$ -
Grain Freight (Up Country)		$1		$1		$1	
Grain Handling Charges		$9		$11		$10	
Crop Contract	$24	$24	$ -	$24	$ -	$24	$ -
Other Crop Costs & Crop Ins	$12	$12	$ -	$12	$ -	$12	$ -
Wages Gross	$18	$18	$ -	$18	$ -	$18	$ -
R&M Mach./Plant/Vehicle	$27	$27	$ -	$27	$ -	$27	$ -
Fuel & Oil	$28	$28	$ -	$28	$ -	$28	$ -
Fertiliser, Lime & Gypsum	$90	$90	$ -	$90	$ -	$90	$ -
Pesticide	$73	$73	$ -	$73	$ -	$73	$ -
Variable Operating Costs	$	**$302**	**$ -**	**$305**	**$ -**	**$303**	**$ -**
Operating Gross Margin	$	$39		$102		$61	
Fixed Operating Costs	92	$92		$92		$92	
Total Operating Costs	**$/ha**	**$394**		**$397**		**$395**	
Operating Profit (BIT)	**$/ha**	**($53)**		**$10**		**($31)**	

Total Grain Sold	**t**	1	1	1
Up Country Freight	$/t	$1.14	$1.14	$1.14
Handling Fees	$/t	$8.80	$8.80	$8.80
	$	$10	$13	$11

5.5 Neridup Demonstration Site

5.5.1 Soil Amelioration Treatment Regime

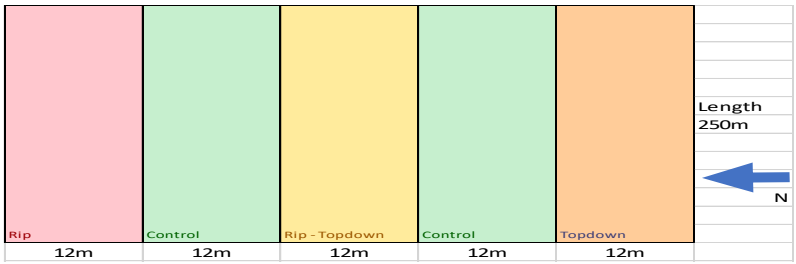

Figure 16: Neridup Ripper Gauge Demonstration Site Treatment Strip Design

The following tillage treatments were applied in 2018 at the Neridup demonstration site using a Nufab ripper and/or a Vaderstad Topdown. The site was then sown to Canola. In 2019 the site was sown to Barley:

- Ripped to 600mm
- Ripped to 600mm and Vaderstad Topdown
- Control
- Vaderstad Topdown – tillage to 300mm

5.5.2 Soil Type

Figure 17: Neridup Ripper Gauge Demonstration Representative Soil Core

The trial site was located in an area prone to waterlogging and the soil type was predominantly sandy gravel over clay. Soil pH (CaCl) was acidic in all treatment strips at all depths except for at 0-10cm depth in the 'Ripped to 600mm' treatment strip (Tables 9 & 10). Potassium was highest at 0-10cm in all treatment strips and was present at good levels (ie 80-150 mg/kg) at this depth in the 'Topdown', 'Control' and 'Rip to 600mm + Topdown' treatment strips and marginal (ie 40-80mg/kg) in the 'Ripped to 600mm' treatment strip.

Table 9: Soil Core Analysis for Ripped and Topdown treatment strips, Neridup Ripper Gauge Demonstration Site, April 2019.

Treatment	Rip	Rip	Rip	Rip	Rip	Rip	Topdown	Topdown	Topdown	Topdown	Topdown	Topdown
Depth	0-10	10-20	20-30	30-40	40-50	50-70	0-10	10-20	20-30	30-40	40-50	50-70
Colour	GR	GRWH	GRWH	BRGR	BRGR	BR	GR	LTGR	LTGR	BRGR	BRGR	BRYW
Gravel	5	0	5	75-80	75-80	0	5	75-80	75-80	75-80	75-80	0
Texture	1	1	1	1	1	3	1	1	1	1	1	3
Ammonium Nitrogen	3	< 1	< 1	< 1	< 1	< 1	3	< 1	< 1	< 1	< 1	< 1
Nitrate Nitrogen	11	1	< 1	< 1	< 1	3	17	4	1	1	< 1	2
Phosphorus Colwell	43	12	4	< 2	< 2	< 2	26	15	4	2	12	< 2
Potassium Colwell	68	27	30	103	117	175	133	51	47	34	46	85
Sulfur	10.1	1.8	2	26.3	23.7	31.4	8.4	3.7	4	4.1	6.5	27.7
Organic Carbon	0.98	0.22	0.09	0.11	0.13	0.13	1.35	0.69	0.15	0.11	0.11	0.28
Conductivity	0.13	0.021	0.018	0.05	0.046	0.095	0.114	0.037	0.018	0.018	0.021	0.095
pH Level (CaCl2)	7.1	6.7	6.5	6.5	6	6.4	6.3	6.2	6.1	6.1	6.1	6.1
pH Level (H2O)	8.1	8	7.8	7.5	6.7	7.6	6.8	7.2	6.7	6.8	6.9	7.1
DTPA Copper	0.49	0.35	0.27	0.28	0.29	0.23	0.46	0.34	0.24	0.46	0.34	0.46
DTPA Iron	60	40.97	33.14	80.93	44.01	6.55	62.15	61.13	32.75	27.58	23.39	14.19
DTPA Manganese	3.12	0.32	0.21	0.98	0.56	0.18	2.09	0.67	0.24	0.15	0.2	0.16
DTPA Zinc	0.72	0.33	0.3	0.4	0.31	0.12	0.61	0.62	0.31	0.41	0.4	0.28
Exc. Aluminium	0.027	0.058	0.13	0.091	0.097	0.206	0.072	0.062	0.044	0.062	0.116	0.306
Exc. Calcium	3.68	0.7	0.52	0.94	1.24	2.45	4.48	2.5	0.74	0.61	0.65	1.92
Exc. Magnesium	0.54	0.13	0.14	0.36	0.67	2.47	0.41	0.25	0.16	0.19	0.33	3.43
Exc. Potassium	0.17	0.04	0.05	0.23	0.25	0.39	0.27	0.08	0.11	0.06	0.07	0.2
Exc. Sodium	0.17	0.06	0.04	0.16	0.28	0.71	0.08	0.04	0.06	0.07	0.15	1.32
Boron Hot CaCl2	0.54	0.21	0.24	0.59	0.81	1.96	0.49	0.38	0.26	0.29	0.39	3.39

Table 10: Soil Core Analysis for the Control and Rip plus Topdown treatment strips, Neridup Ripper Gauge Demonstration Site, April 2019.

Treatment	C	C	C	C	C	C	Rip+ Top	Rip+ Top	Rip+ Top	Rip+ Top	Rip+ Top	Rip+ Top
Depth	0-10	10-20	20-30	30-40	40-50	50-70	0-10	10-20	20-30	30-40	40-50	50-70
Colour	GR	GRWH	BRGR	BRWH	BRGR	BRGR	GR	LTGR	LTGR	BRGR	BR	BRYW
Gravel	5	5	5	75-80	75-80	75-80	5	5	75-80	75-80	75-80	0
Texture	1	1	1	1	1	3	1	1	1	1	1	3
Ammonium Nitrogen	2	< 1	< 1	< 1	1	< 1	4	1	< 1	< 1	< 1	< 1
Nitrate Nitrogen	17	< 1	< 1	1	< 1	1	12	2	1	< 1	1	2
Phosphorus Colwell	32	25	15	2	< 2	< 2	30	30	8	4	2	< 2
Potassium Colwell	126	26	59	93	91	86	86	39	48	73	90	203
Sulfur	10.9	1.9	7	8.2	8.9	14.9	10.7	3.1	5.2	8.3	20.2	71.6
Organic Carbon	1.06	0.21	0.12	0.12	0.09	0.12	1.18	0.64	0.2	0.12	0.16	0.13
Conductivity	0.085	0.02	0.017	0.019	0.019	0.048	0.119	0.027	0.016	0.017	0.037	0.148
pH Level (CaCl2)	5.7	5.7	5.9	6.1	6.3	6.1	5.7	5.7	6.1	6.1	6.2	5.8
pH Level (H2O)	6.6	6.8	6.6	6.5	6.7	6.6	6.3	6.7	6.6	6.7	6.9	6.8
DTPA Copper	0.51	0.3	0.26	0.36	0.24	0.22	0.51	0.59	0.35	0.25	0.23	0.17
DTPA Iron	88.74	53.36	31.05	17.5	15.48	7.65	88.79	103.8	52.32	34.88	52.86	9.16
DTPA Manganese	3.32	0.74	0.22	0.21	0.25	0.19	2.93	1.42	0.38	0.26	0.73	0.18
DTPA Zinc	0.97	0.45	0.61	0.46	0.51	0.33	0.87	0.82	1.17	0.81	0.38	0.02
Exc. Aluminium	0.08	0.057	0.046	0.072	0.142	0.199	0.054	0.089	0.119	0.083	0.084	0.225
Exc. Calcium	3.17	0.71	0.49	0.58	0.64	0.93	3.81	1.69	0.86	0.69	0.91	2.53
Exc. Magnesium	0.38	0.1	0.1	0.15	0.21	0.8	0.38	0.18	0.18	0.19	0.46	3.98
Exc. Potassium	0.25	0.05	0.1	0.17	0.18	0.21	0.17	0.06	0.08	0.11	0.19	0.5
Exc. Sodium	0.1	0.04	0.04	0.07	0.1	0.31	0.13	0.06	0.06	0.08	0.24	1.42
Boron Hot CaCl2	0.54	0.17	0.24	0.33	0.37	0.72	0.55	0.29	0.28	0.34	0.58	2.35

5.5.3 Rainfall

Rainfall was below average in 2019 at the Neridup demonstration site (Figure 18). Annual rainfal was 361.8mm compared to the long term annual average of 498.2mm (from 1972-2017). A significant frost event occurred in the Esperance Port Zone on Friday 6th September 2019 that did affect some parts of the Neridup area but this paddock did not sustain widespread damage.

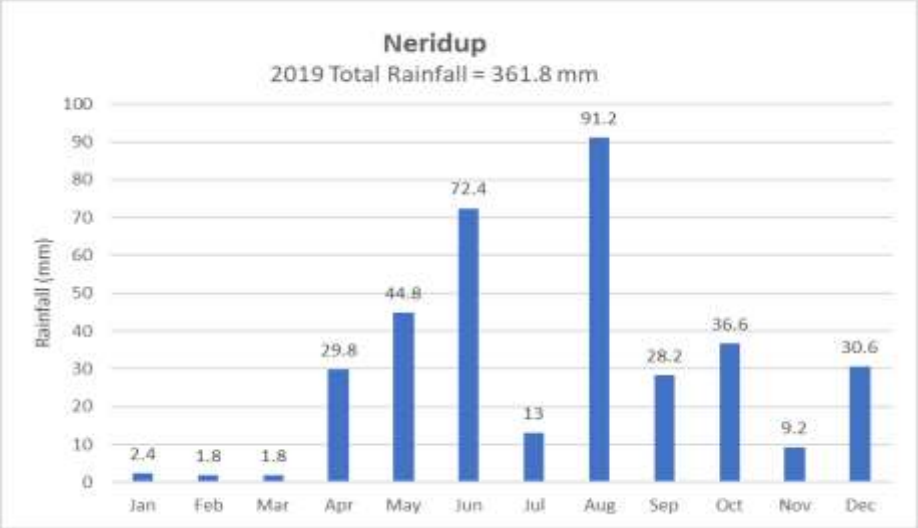

Figure 18: 2019 Annual Rainfall at Neridup

5.5.4 Harvest Yield

Barley crop harvest yield data is presented in Figure 19. There was no significant difference between yields recorded in 2019 from each of the tillage treatment strips compared to the control.

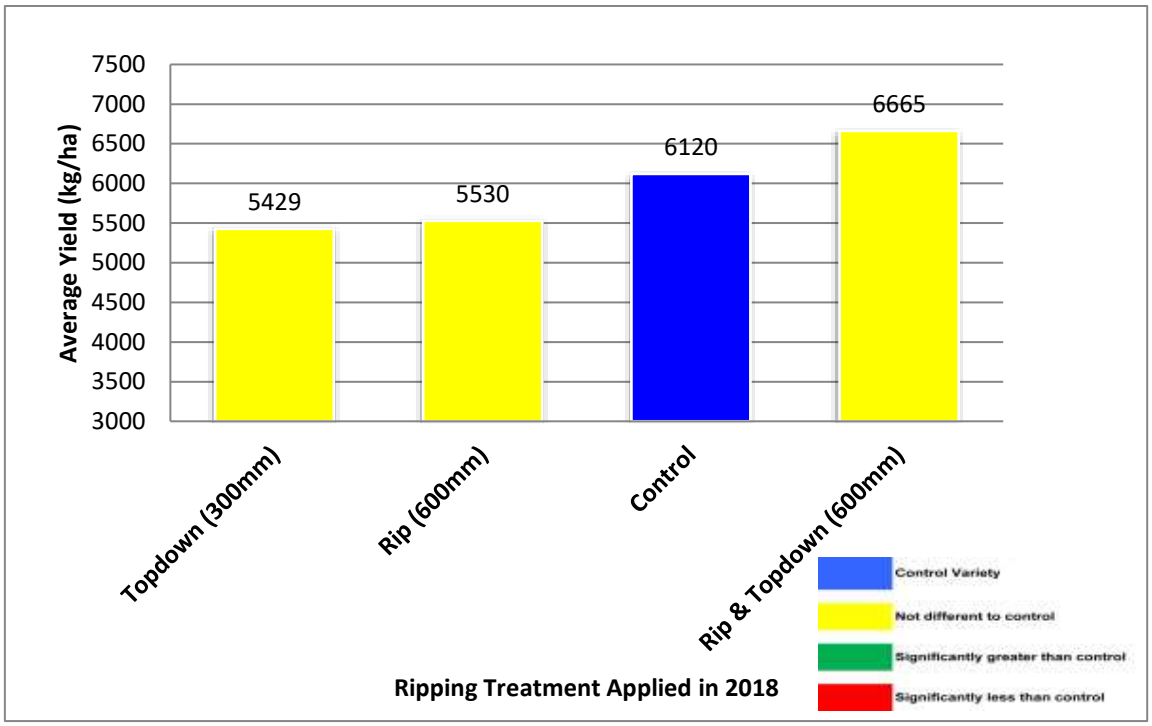

Figure 19: 2019 relative average barley harvest yields from treatment strips applied in 2018. Least significant difference (5%) = 1719.9kg/ha, p = 0.301.

The results seen in 2019 are similar to those in 2018's canola crop. In 2018 the 'Topdown' treatment had an increased yield compared to the control of 0.03t/ha, 'Rip to 600mm' showed a reduction in yield of 0.35t/ha and the 'Ripped to 600mm + Topdown' treatment strip showed a reduction in yield

of 0.9t/ha. Rainfall was not high in 2018 and 2019 and waterlogging was not extensive, the results may have been different if both were years in which waterlogging was more prevalent.

5.5.5 Gross Margin

While there was no statistically significant difference between barley yield in the tillage treatment strips compared to the control at the Neridup demonstration site in 2019, gross margin analysis of crop production indicated that the 'Rip to 600mm + Topdown' treatment strip resulted in an operating profit $18/ha higher than the control (Table 11). The 'Rip to 600mm' and 'Topdown' treatment strips saw operating profits of $214/ha and $242 respectively less than the 'Control'.

Table 11: Neridup Ripper Gauge Demonstration Site 2019 Barley Crop Gross Margin per Ripping Treatment Applied in 2018.

Trial Treatment		Control		Rip 600mm		Rip & TopDown		TopDown	
Yield	t/ha	6.12		5.53		6.67		5.43	
Average Grain Price (FIS)	$/t	$298		$290		$277		$290	
Income	**$/ha**	**$1,824**		**$1,604**		**$1,848**		**$1,575**	
Variable Operating Costs	**$/ha**		Extra treat cost		Extra treat cost		Extra treat cost		Extra treat cost
Seed, Treatment & EPR's	$30	$30	$ -	$30	$ -	$30	$ -	$30	$ -
Grain Freight (Up Country)		$7		$6		$8		$6	
Grain Handling Charges		$54		$49		$59		$48	
Crop Contract	$51	$51	$ -	$51	$ -	$51	$ -	$51	$ -
Other Crop Costs & Crop Ins	$31	$31	$ -	$31	$ -	$31	$ -	$31	$ -
Wages Gross	$39	$39	$ -	$39	$ -	$39	$ -	$39	$ -
R&M Mach./Plant/Vehicle	$47	$47	$ -	$47	$ -	$47	$ -	$47	$ -
Fuel & Oil	$38	$38	$ -	$38	$ -	$38	$ -	$38	$ -
Fertiliser, Lime & Gypsum	$145	$145	$ -	$145	$ -	$145	$ -	$145	$ -
Pesticide	$110	$110	$ -	$110	$ -	$110	$ -	$110	$ -
Variable Operating Costs	$	**$552**	**$ -**	**$546**	**$ -**	**$557**	**$ -**	**$545**	**$ -**
Operating Gross Margin	$	$1,272		$1,058		$1,290		$1,030	
Fixed Operating Costs	92	$92		$92		$92		$92	
Total Operating Costs	**$/ha**	**$644**		**$638**		**$649**		**$637**	
Operating Profit (BIT)	**$/ha**	**$1,180**		**$966**		**$1,198**		**$938**	

Total Grain Sold	**t**	6	6	7	5
Up Country Freight	$/t	$1.14	$1.14	$1.14	$1.14
Handling Fees	$/t	$8.80	$8.80	$8.80	$8.80
	$	$61	$55	$66	$54

These financial results compare with the results produced by 2018's canola crop in which the 'Topdown' treatment reduced canola crop performance by $30/ha compared to the control, the 'Rip to 600mm' treatment reduced canola crop performance by $239/ha and the 'Rip to 600mm + Topdown' treatment reduced operating profit by $582/ha.

CONCLUSIONS

While all sites will be monitored during the 2020 cropping season as part of the GRDC Ripper Gauge investment there are a few points that can be drawn from the performance of crops at the 4 demonstration sites cropped in 2019 following the application of tillage treatments in 2018:

1. Tillage treatments ranging in ripping depths from 100mm to 600mm did not significantly affect crop yield when compared to site controls, regardless of the predominant soil type present at the site or the ripping equipment used. This is likely due to the much dryer than average rainfall conditions that prevailed at all sites in 2019 and the impact of severe frost at two of the demonstration sites (Salmon Gums and Cascade).

2. Although the ripping treatments did not significantly improve or reduce crop yield at any of the Ripper Gauge demonstration sites, gross margin analysis did reveal tillage to 600mm depth plus use of a Topdown did slightly improve operating profit at the Neridup site, when compared to the site control. Ripping to 540mm depth also improved financial performance at the Salmon Gums site when compared to the control.

3. Ripping to 300mm and 600m depth reduced financial performance at the Coomalbidgup and Cascade Demonstration Sites, compared to the site controls. Two of the tillage treatments also reduced operating profit at the Neridup site compared to the site control.

Operating Profit $/ha							
Site	**Crop**	**Rainfall Zone**	**Control**	**Rip 600mm**	**Top Down 300mm**	**Rip and Spade 600mm**	**Spade 300mm**
Coomalbidgup	Wheat	High	-$23	-$93	-$106	-$89	-$23
	Crop	**Rainfall Zone**	**Control**	**Rip 600mm**	**Rip & TopDown**	**Top Down**	
Neridup	Canola	High	$1,180	$966	$1,196	$938	
	Crop	**Rainfall Zone**	**Control**	**Rip 600mm**	**Rip 300mm**		
Cascade	Wheat	Medium	$85	$15	$61		
	Crop	**Rainfall Zone**	**Control**	**Rip 540mm**	**Rip 300mm**		
Salmon Gums	Wheat	Low	-$53	$10	-$31		

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Appendix 1

"Ripper Gauge - Esperance Port Zone" 2019/20 Communication Activities

a) 25/7/19 Farm and General Winter Field Walk (35 Attendees)

The Coomalbidgup Ripper Gauge Site was visited during this field walk. Aidan Sinnott (SEPWA) spoke at this site.

b) SEPWA Ripping Demonstration Day (planned for 19th March) – This field day was cancelled due to the requirement to cancel large gatherings in response to the spread of corona virus. Instead, Ripping Machines were filmed in action in sandy gravel soil at Munglinup and video footage was placed on SEPWA's Twitter site.

2. Speaking Events

a) 30/8/19 – SEPWA Ladies Day (110 attendees) – The Ripper Gauge Project was explained (by Michelle Handley, SEPWA) and demonstration sites were highlighted.

b) 28/2/20 – SEPWA Harvest Review (87 attendees) – 2019 data from the Ripper Gauge demonstration sites was presented (by Michelle Handley, SEPWA).

Appendix 2

Dunn Rock Soil Core Analysis Results

Table 1: Soil Core Analysis for the Ripped to 540mm and Ripped to 300mm Treatment strips, Dunn Rock Ripper Gauge Demonstration Site, April 2019.

Soil Treatment	Rip to 540mm	Rip to 540mm	Rip to 540mm	Rip to 540mm	Rip to 540mm	Rip to 540mm	Rip to 300mm	Rip to 300mm	Rip to 300mm	Rip to 300mm	Rip to 300mm	Rip to 300mm
Soil Core Depth	0-10	10-20	20-30	30-40	40-50	50-70	0-10	10-20	20-30	30-40	40-50	50-70
Colour	GR	BRGR	BRGR	GRYW	YWGR	YWGR	GR	BRGR	GRYW	YWGR	YW	YW
Gravel	5	5	5	0	0	0	5	5	0	0	0	0
Texture	1	1.5	1	1.5	3	3	1	1	3	3	3	3
Ammonium Nitrogen	5	< 1	< 1	< 1	< 1	< 1	4	< 1	< 1	< 1	< 1	< 1
Nitrate Nitrogen	7	2	5	1	1	< 1	5	2	2	1	< 1	< 1
Phosphorus Colwell	26	4	11	< 2	< 2	< 2	22	15	4	< 2	< 2	< 2
Potassium Colwell	73	247	88	460	676	703	67	59	158	409	480	533
Sulfur	5.9	1.3	1.7	1.2	1.6	2.6	4.5	1.8	1.8	4.5	8.9	10.4
Organic Carbon	0.84	0.17	0.42	0.23	0.1	0.1	1.1	0.39	0.19	0.18	0.07	0.08
Conductivity	0.046	0.037	0.028	0.071	0.072	0.152	0.043	0.022	0.054	0.085	0.085	0.098
pH Level (CaCl2)	4.9	6.4	6	7	7.6	8.1	4.9	5.7	6.5	7	7.7	7.8
pH Level (H2O)	5.9	7.4	7.4	8.5	9	9.2	5.8	6.5	8.3	8.8	9.3	9.5
DTPA Copper	0.25	0.2	0.27	0.17	0.16	0.19	0.38	0.33	0.29	0.11	0.09	0.15
DTPA Iron	47.21	32.22	58.59	27.7	10.71	10.07	38.55	43.8	33.38	17.67	10.65	11.68
DTPA Manganese	3.56	0.79	1.98	0.37	0.43	0.49	2.91	0.86	0.91	0.27	0.39	0.62
DTPA Zinc	0.37	1.08	4.62	0.55	0.37	0.67	0.68	2.03	0.89	0.12	0.1	0.08
Exc. Aluminium	0.17	0.174	0.12	0.194	0.211	0.196	0.128	0.053	0.224	0.265	0.297	0.192
Exc. Calcium	1.96	2.25	1.06	4.14	5.16	7.24	1.92	0.93	1.37	3.97	4.11	4.46
Exc. Magnesium	0.52	1.79	0.48	4.17	6.26	6.33	0.41	0.21	1.21	5.09	6.06	6.88
Exc. Potassium	0.17	0.52	0.18	1.03	1.54	1.6	0.16	0.1	0.28	0.98	1.15	1.34
Exc. Sodium	0.13	0.36	0.1	1.24	2.02	2.27	0.1	0.07	0.69	2.95	3.62	4.47
Boron Hot CaCl2	0.39	1.83	0.56	3.65	6.78	7.93	0.33	0.25	1.24	3.48	4.99	6.89

Table 2: Soil Core Analysis for the Control and Ripped to 300m + Lime treatment strips, Dunn Rock Ripper Gauge Demonstration Site, April 2019.

Soil Treatment	Control	Control	Control	Control	Control	Control	Rip Lime	Rip Lime	Rip Lime	Rip Lime	Rip Lime	Rip Lime
Soil Core Depth	0-10	10-20	20-30	30-40	40-50	50-70	0-10	10-20	20-30	30-40	40-50	50-70
Colour	GRBR	BRWH	BRGR	GRYW	YWGR	YWGR	GR	LTGR	GRYW	YWGR	YWGR	YWGR
Gravel	0	5	5	0	0	0	5	5-Oct	0	0	0	0
Texture	1	1	1	3	3	3	1	1	3	3	3	3
Ammonium Nitrogen	1	< 1	1	< 1	< 1	< 1	5	< 1	< 1	< 1	< 1	< 1
Nitrate Nitrogen	10	2	2	2	2	2	6	3	1	< 1	1	1
Phosphorus Colwell	28	18	10	< 2	< 2	< 2	18	7	3	< 2	< 2	< 2
Potassium Colwell	115	35	45	519	650	620	55	70	318	730	966	1068
Sulfur	3.5	1.7	1.6	1.1	1.5	2.7	18	4.1	2.3	2.2	2.1	2.4
Organic Carbon	0.7	0.2	0.11	0.21	0.14	0.08	0.93	0.41	0.26	0.15	0.07	0.09
Conductivity	0.038	0.016	0.019	0.066	0.075	0.11	0.062	0.026	0.061	0.062	0.079	0.086
pH Level (CaCl2)	5	5.5	6	6.9	7.3	7.8	5.6	6.1	7.2	7.5	7.7	7.8
pH Level (H2O)	6	6.4	6.8	8.4	8.9	9.2	6.3	6.9	8	8.6	8.8	8.9
DTPA Copper	0.53	0.36	0.18	0.28	0.17	0.13	0.25	0.25	0.12	0.16	0.1	0.17
DTPA Iron	48.71	31.98	29.24	22.84	11.88	9.81	38.97	14.55	14.84	10.61	8.56	9.82
DTPA Manganese	4.17	0.76	0.51	0.26	0.26	0.23	3.95	0.79	0.4	0.27	0.4	0.47
DTPA Zinc	0.89	1.11	1.38	0.7	0.52	0.16	0.5	0.26	0.14	0.15	0.02	0.07
Exc. Aluminium	0.113	0.069	0.048	0.243	0.257	0.219	0.047	0.081	0.222	0.193	0.23	0.302
Exc. Calcium	1.89	0.59	0.56	4.28	5.01	5.43	3.06	2.1	4.52	7.8	9.55	9.48
Exc. Magnesium	0.35	0.12	0.17	3.54	4.46	4.34	0.47	0.33	1.37	3.12	4.23	4.95
Exc. Potassium	0.25	0.05	0.08	1.22	1.52	1.49	0.13	0.16	0.79	1.73	2.3	2.59
Exc. Sodium	0.07	0.03	0.08	1.98	2.52	2.67	0.09	0.03	0.17	0.45	0.71	1.02
Boron Hot CaCl2	0.31	0.16	0.21	2.18	3.78	5.25	0.37	0.31	1.34	3.71	5.42	6.33

Table 3: Soil Core Analysis for the Lime and Inclusion Plates treatment strips, Dunn Rock Ripper Gauge Demonstration Site, April 2019.

Soil Treatment	Lime	Lime	Lime	Lime	Lime	Lime	Inc Plates	Inc Plates	Inc Plates	Inc Plates	Inc Plates	Inc Plates
Soil Core Depth	0-10	10-20	20-30	30-40	40-50	50-70	0-10	10-20	20-30	30-40	40-50	50-70
Colour	GR	GR	GRYW	YWGR	YWGR	YWGR	GR	GRBR	GRYW	YWGR	YWGR	YWGR
Gravel	0	5	0	0	0	0	5	5	0	0	0	0
Texture	1	1	3	3	3	3	1	1	3	3	3	3
Ammonium Nitrogen	3	< 1	< 1	< 1	< 1	< 1	4	< 1	< 1	< 1	< 1	< 1
Nitrate Nitrogen	9	3	1	< 1	< 1	< 1	6	3	1	< 1	< 1	< 1
Phosphorus Colwell	24	12	4	3	< 2	< 2	23	8	< 2	< 2	< 2	< 2
Potassium Colwell	71	125	204	675	768	802	60	98	513	695	798	842
Sulfur	9.1	2.8	1.6	2.8	1.8	1.7	6.3	1.3	1.7	2.1	2.8	3.5
Organic Carbon	0.87	0.56	0.23	0.31	0.09	0.09	1.13	0.53	0.2	0.09	0.07	0.08
Conductivity	0.049	0.02	0.035	0.068	0.073	0.074	0.042	0.033	0.075	0.081	0.088	0.107
pH Level (CaCl2)	5.1	6	6.3	6.9	7.5	7.5	5	6.2	7.1	7.6	7.9	8.1
pH Level (H2O)	6.2	6.8	6.8	7.6	8.4	8.7	6	7	8.8	9.2	9.4	9.5
DTPA Copper	0.42	0.48	0.33	0.45	0.23	0.29	0.29	0.21	0.19	0.13	0.24	0.23
DTPA Iron	44.06	21.53	15.27	19.64	8.01	7.46	39.85	28.67	20.64	9.34	9.42	10.03
DTPA Manganese	4.17	1.33	0.48	0.57	0.27	0.35	4.01	0.8	0.25	0.29	0.57	0.63
DTPA Zinc	0.52	0.77	0.58	0.29	0.1	0.1	0.54	1.02	0.14	0.19	0.15	0.06
Exc. Aluminium	0.135	0.094	0.116	0.216	0.278	0.242	0.085	0.113	0.23	0.303	0.218	0.288
Exc. Calcium	2.29	2.18	3.58	10.04	10.17	9.59	2.5	1.72	3.34	3.65	4.06	4.34
Exc. Magnesium	0.35	0.37	0.91	2.95	3.75	4.24	0.48	0.5	4.12	5.57	6.8	7.18
Exc. Potassium	0.14	0.27	0.55	1.63	1.99	2.14	0.12	0.22	1.19	1.58	1.88	2
Exc. Sodium	0.07	0.04	0.08	0.33	0.52	0.75	0.12	0.14	1.88	2.52	3.19	3.58
Boron Hot CaCl2	0.32	0.36	0.71	2.67	4.21	4.51	0.44	0.56	3.64	5.8	9.12	10.04