Final Technical Results Report

2020 - 2022

Incorporation of organic soil ameliorants to boost productivity of sandy soils in the medium to high rainfall zones of the Wheatbelt of Western Australia

Project code: BGS1911-001SAX/9177476

Prepared by: Corrigin Farm Improvement Group (CFIG)

Joy Valle, Connor Baker (CFIG) and Veronika Crouch (formerly CFIG)

and Daniel Hester of Pedaga Investments

danielhester@pedaga.com.au

Date submitted to GRDC: 18 July 2024
(resubmitted with edits 26th September 2024)

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>

Contents

ABSTRACT

Approximately 35% of the soils in the Western Region are made up of sandy soils, including deep sands and sandy duplexes. In order to increase the productivity of these 'gutless' sandy soils, it has become relatively common practice for growers to use physical soil amelioration methods to alleviate soil constraints such as compaction and non-wetting however this does not address the constraint of low soil fertility.

The objective of this project is to evaluate a range of commonly available approaches to increasing the fertility of the 'gutless' soils in the medium and high rainfall zone of WA. This project will apply a combination of organic amendments and physical amelioration methods that are complimentary to each other in order to determine the grain yield benefit over three years. It is hoped that this approach may increase the organic matter content of the soil to increase soil nutrient supply and water holding capacity of the soil.

There were no conclusive benefits or outcomes in terms of yield or grain quality from applying organic soil ameliorants in conjunction with physical soil amelioration over and above just the physical soil amelioration. Further work is required to improve our understanding of the potential impact of these organic soil ameliorants. However, it is worth noting that from the results there was no clear yield benefit from the physical amelioration of mould board ploughing which has been well established over the past decade or longer. This result potentially demonstrates the impact of the severe wind event that was experienced just after sowing the trial in year one on the overall project results.

The cost associated with applying the organic soil ameliorants can be extremely high, with the total application costs ranging from \$135/ha to \$1040/ha for the high rate of manure (40 t/ha). It is expected these ameliorants will last in the soil for more than one season and therefore the costs can be amortised across several seasons. Improved understanding of the length of impact of the different types of organic ameliorants in these soils is required to better understand the annual cost and to determine the benefit cost analysis of applications.

EXECUTIVE SUMMARY

Approximately 35% of the soils in the Western Region are made up of sandy soils, including deep sands and sandy duplexes. The sand component of these soil profiles is inherently infertile, have low organic matter levels, low water holding capacity and generally have water repellence and compaction issues. In order to increase the productivity of these 'gutless' sandy soils, it has become relatively common practice for growers to use soil amelioration methods such as spading, plozza ploughing, mould board ploughing and deep ripping to alleviate soil constraints such as compaction and non-wetting. While this can be of benefit to physical soil constraints, the constraint of low soil fertility is currently not being addressed.

There is increasing interest in the medium to high rainfall zones (MRZ & HRZ) of the WA Wheatbelt to find ways of improving the fertility of these 'gutless' soils through the application of organic ameliorants (e.g. under-grade hay, straw or manure). It is hoped that this approach may increase the organic matter content of the soil to increase soil nutrient supply and water holding capacity of the soil. Through this approach it is hypothesized that this improvement will lead to an increase in grain yield and profitability for the growers.

There is the need to re-evaluate the approach of applying organic amendments and its integration with current physical soil amelioration methods. Many studies in the past have looked at the yield benefit of applying organic amendments but have been hampered in adoption by practical means of application and incorporation. The widespread adoption of soil amelioration methods that can incorporate organic amendments to a possible depth of 30 cm necessitates the revisiting of the practice of applying organic amendments to improve soil fertility.

The objective of this project is to evaluate a range of commonly available approaches to increasing the fertility of the 'gutless' soils in the medium and high rainfall zone of WA. This project will apply a combination of organic amendments and physical amelioration methods that are complimentary to each other in order to determine the grain yield benefit over three years. The return on investment for each approach will be evaluated to guide growers on the most profitable approach to improving poor productivity soils.

The methodology was designed to assess six different soil amelioration options available to growers across three demonstration trial sites throughout the medium or high rainfall zones of the Central Wheatbelt region of WA.

The six different soil amelioration options utilised have the potential to improve the productivity of these poor performing 'gutless' sandy soil types through a combination of organic amendment treatment options at different rates along with two physical soil amelioration strategy treatments. These options were compared to a grower practice of no organic amendment applied. The treatments for each site were implemented over three seasons to determine the long-term effects of adding organic matter on subsequent crop production.

An extreme wind event was experienced just after the first seeding of the trial in 2020 which severely impacted the three demonstration sites through soil erosion and furrow fill/damage which impacted the results across the first two seasons.

While some minor trend benefits were apparent in the results in a single season these were often reversed in the following season. There were no conclusive benefits seen from applying organic soil ameliorants in conjunction with physical soil amelioration over and above just the physical soil amelioration. However, it is worth noting that from the results there was no clear yield benefit from the physical amelioration of mould board ploughing which has been well established over the past decade or longer. This result potentially demonstrates the impact of the severe wind event on the overall trial results.

The cost associated with applying the organic soil ameliorants can be extremely high, with the total application costs ranging from $135/ha to $1040/ha for the high rate of manure (40 t/ha). It is expected these ameliorants will last in the soil for more than one season and therefore the costs can be amortised across several seasons. Improved understanding of the length of impact of the different types of organic ameliorants in these soils is required to better understand the annual cost and to determine the benefit cost analysis of applications.

Additional work that is required as a recommendation from this project is to further understand the length of time the organic soil ameliorants last in the soil and application rates curves for each of the ameliorants. Is it better to apply 40 tons/ha of manure in one application or two applications of 20 ton/ha spaced 2 years apart?

Accurate costings are also required for each of the ameliorants including purchase costs, freight and spreading costs to ensure the outcomes are relevant to all growers. Not all growers will have access to enough manure, waste hay or straw within their own operation.

In summary while the outcomes form the project were inconclusive and no clear recommendations were able to be made from the results the project did explore an important issue which is relevant to a broad range of growers throughout WA. From the project clear recommendations were established as to how to move forward with this issue to determine a strategy to increase productivity on these 'gutless' sands in the future.

BACKGROUND

Approximately 35% of the soils in the Western Region are made up of sandy soils, including deep sands and sandy duplexes. The sand component of these soil profiles is inherently infertile, have low organic matter levels, low water holding capacity and generally have water repellence and compaction issues. In order to increase the productivity of these 'gutless' sandy soils, it has become relatively common practice for growers to use soil amelioration methods such as spading, plozza ploughing, mould board ploughing and deep ripping to alleviate soil constraints such as compaction and non-wetting. While this can be of benefit to physical soil constraints, the constraint of low soil fertility is currently not being addressed.

There is increasing interest in the medium to high rainfall zones (MRZ & HRZ) of the WA Wheatbelt to find ways of improving the fertility of these 'gutless' soils through the application of organic ameliorants (e.g. under-grade hay, straw or manure). It is hoped that this approach may increase the organic matter content of the soil to increase soil nutrient supply and water holding capacity of the soil. Through this approach it is hypothesized that this improvement will lead to an increase in grain yield and profitability for the growers.

There is the need to re-evaluate the approach of applying organic amendments and its integration with current physical soil amelioration methods. Many studies in the past have looked at the yield benefit of applying organic amendments but have been hampered in adoption by practical means of application and incorporation. The widespread adoption of soil amelioration methods that can incorporate organic amendments to a possible depth of 30 cm necessitates the revisiting of the practice of applying organic amendments to improve soil fertility.

There are limitations to the use of organic amendments in agricultural production systems though. From a practical level, large applications of organic amendments that are merely spread on the soil surface are near impossible to seed through and can result in poor crop establishment and grain yield. Some incorporation methods cannot handle the incorporation of high rates of organic amendments into the soil as the operation was not designed for this purpose. There is the need to evaluate a range of combinations of organic amendments and incorporation methods that can provide an economic benefit and are practical so that they can be adopted by growers.

PROJECT OBJECTIVES

The objective of this project is to evaluate a range of commonly available approaches to increasing the fertility of the 'gutless' soils in the medium and high rainfall zone of WA. This project will apply a combination of organic amendments and physical amelioration methods that are complimentary to each other in order to determine the grain yield benefit over three years. The return on investment for each approach will be evaluated to guide growers on the most profitable approach to improving poor productivity soils.

METHODOLOGY

Site selection and establishment of demonstration trial sites:

The methodology has been designed to assess six different soil amelioration options available to growers to potentially improve the productive capacity of their poor performing 'gutless' soil types. Three demonstration trial sites have been established across the medium or high rainfall zones of the Central Wheatbelt region of WA. The following groups have been responsible for the implementation of a grower scale demonstration trial site:

Medium rainfall zone:

- Corrigin Farm Improvement Group – 1 site.
- Facey Group – 1 site.

High rainfall zone:

- West Midlands Group – 1 site.

The methodology of the demonstration sites has been designed to mimic the processes that growers undertake when identifying paddocks or areas of paddocks on-farm that are underperforming.

Site management and treatments:

The six different soil amelioration options available to growers to potentially improve the productive capacity of their poor performing 'gutless' sandy soil types involved a combination of organic amendment treatment options at different rates along with two physical soil amelioration strategy treatments. These options will be compared to a grower practice of no organic amendment applied.

The treatments for each site will be implemented over three seasons to determine the long-term effects of adding organic matter has on subsequent crop production. It is important for the project to operate for several seasons on the same site as the benefits of changes in organic matter and associated soil health can take several seasons to flow through into increased production and may not be seen immediately or in the first season.

The soil amendments include:

1) Straw (high and low rates)
2) Waste Hay (high and low rates)
3) Manure (high and low rates)

The physical soil amelioration treatments are:

1) Speed Tiller
2) Mould Board Plough

Corrigin Trial Design

Treatment	Treatment
Tmt 1	Grower control - standing stubble No amendment, No incorporation
Tmt 2	Stubble / Straw (annual production = low rate 3t/ha) Speed tiller incorporation (annually)
Tmt 3	Straw 3t/ha (low rate) + Manure 5t/ha (low rate) Deep incorporation (once off)
Tmt 4	Straw 6t/ha (high rate) + Manure 10t/ha (high rate) Deep incorporation (once off)
Tmt 5	Straw 6t/ha (high rate) Deep incorporation (once off)
Tmt 6	Waste Hay 3t/ha (low rate) Deep incorporation (once off)
Tmt 7	Waste Hay 6t/ha (high rate) Deep incorporation (once off)
Tmt 8	No amendment Deep incorporation (once off)
Tmt 9	Manure 10t/ha (high rate) Deep incorporation (once off)
Tmt 10	Manure 5t/ha (low rate) Speed tiller incorporation (once off)
Tmt 11	Manure 40t/ha (Very high rate) Speed tiller incorporation (once off)
Tmt 12	Grower control - standing stubble No amendment, No incorporation

Badgingarra Trial design

Treatment	Treatment name
Tmt 1	Waste Hay 3t/ha (low rate)
	Deep incorporation (once off)
Tmt 2	Waste Hay 6t/ha (high rate)
	Deep incorporation (once off)
Tmt 3	Straw High rate 6t/ha (high rate)
	Deep incorporation (once off)
Tmt 4	Grower control
	Deep incorporation (once off)
Tmt 5	Manure 5t/ha (low rate)
	Speed tiller incorporation (once off)
Tmt 6	Manure 10t/ha (high rate)
	Deep incorporation (once off)
Tmt 7	Straw low rate (annual production)
	Speed tiller incorporation (annually)
Tmt 8	Manure 30t/ha (high rate)
	Deep incorporation (once off)

P PO Box 5367 Kingston, ACT 2604 Australia
T +61 2 6166 4500 **F** +61 2 6166 4599 **E** grdc@grdc.com.au

GRAINS RESEARCH & DEVELOPMENT CORPORATION ABN 55 611 223 291

Wickepin Trial Design

Treatment	Treatment name
Treatment 1	Chicken manure high rate 10t/ha (MBP) Mouldboard Polughed
Treatment 2	Chicken manure low rate 5t/ha (ST) Speed Tiller
Treatment 3	Straw high rate 6t/ha (MBP) Mouldboard Polughed
Treatment 4	Straw low rate 3t/ha (ST) Speed Tiller
Treatment 5	Hay high rate 6t/h a(MBP) Mouldboard Polughed
Treatment 6	Hay low rate 3t/ha (MBP) Mouldboard Polughed
Treatment 7	Grower practice MBP Mouldboard Polughed
Treatment 8	Control
Treatment 9	Claying

The below measurements were recorded for each trial site throughout the season:

• Pre-season comprehensive, total organic carbon and water repellence soil testing (0-50cm soil depth; 0-10cm, 10-30cm, and 30-50cm increments).

• Nutritional analysis of organic amendments

• Plant establishment GS.14

• Weed emergence counts

• NDVI at GS.14 and GS.31 using a handheld Greenseeker

• Plant tissue tests at peak biomass

• Grain yield and grain quality via hand harvest cuts

• Monthly rainfall at site each season

• In season observations on weed and disease across the treatments.

LOCATION

Where field trials have been conducted, provide the following location details in the table below: latitude and longitude, or nearest town. (Add additional rows as required.)

Site #	Latitude (decimal degrees)	Longitude (decimal degrees)	Nearest town
Trial Site #1	S32.39796	E117.57976	Corrigin
Trial Site #2	S30.351799	E115.551247	Badgingarra
Trial Site #3	32°41'28.3"S	117°38'07.6"E	Wickepin

If the research results are applicable to a specific GRDC region/s (e.g. North/South/West) or GRDC agro-ecological zone/s, indicate which in the table below:

Research	Benefiting GRDC region (select up to three)	Benefitting GRDC agro-ecological zone	
Organic Soil Ameliorants	Western Region Choose an item. Choose an item.	☐ Qld Central ☐ NSW NE/Qld SE ☐ NSW Vic Slopes ☐ Tas Grain ☐ SA Mid North-Lower Yorke Eyre ☒ WA Northern ☐ WA Eastern ☐ WA Mallee	☐ NSW Central ☐ NSW NW/Qld SW ☐ Vic High Rainfall ☐ SA Vic Mallee ☐ SA Vic Bordertown-Wimmera ☒ WA Central ☒ WA Sandplain

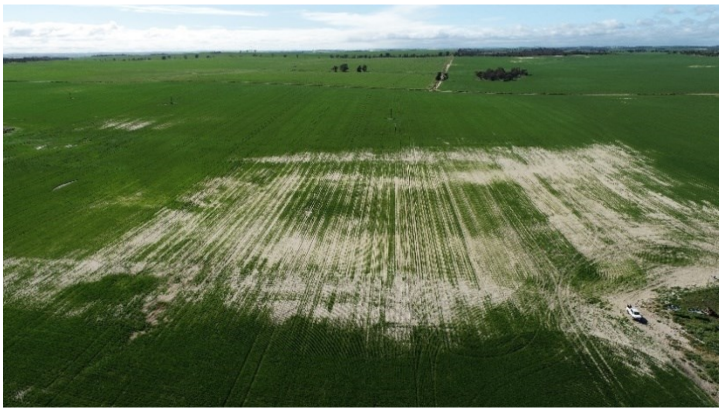
RESULTS 2022

Corrigin 2022 Results

The Corrigin site in the final year of the project was sown to Devil wheat on the 11th of May 2022. Plant establishment was measured on the 21st of June with the very high rate of manure (40 t/ha) recording the highest plant number at 134/m2. A frost event during flowering severely impacted the yields across the trial as can be seen from the very low yields across the treatments.

Weed counts and NDVI measurements were also recorded on the 21st of June. NDVI was measured at GS.14 with all treatments measuring between 0.8 – 0.12 and control north recording the highest level at 0.12. The weed count in the low rate of stubble, incorporated annually recorded the highest weed number at 36/m2, well above the next highest at 9/m2, the very high rate of manure (40 t/ha) incorporated treatment. The weeds were predominantly ryegrass and brome grass.

Yields were very poor with the low rate of waste hay (3 t/ha) deep incorporated yielding the highest @ 0.27 t/ha. The second highest yielding treatment was the low rate of stubble (3t/ha) incorporated annually @ 0.25 t/ha. All yields were contained in a narrow band between 0.02 – 0.27 t/ha. The trial was harvested with farmer equipment using a weigh trailer which didn't allow individual replicates to be harvested separately and therefore no statistical analysis can be completed on yield data.



Here we can see the site at Bulyee in 2020, through the growing season and at harvest. Showing the heavier rates of straw and manure leading to greater results with crop establishment and vigour.

P PO Box 5367 Kingston, ACT 2604 Australia
T +61 2 6166 4500 **F** +61 2 6166 4599 **E** grdc@grdc.com.au

Table 1: *2022 Corrigin wheat trial results summary*

Treatment	Plants/m2	Weeds/m2	NDVI @ GS.14	Yield (t/ha)	Yield P value	Grade
Grower control - standing stubble	116	1	0.12			
Stubble / Straw (annual production = low rate 3t/ha) Speed tiller incorporation (annually)	112	36	0.10	0.25		SEC 1
Straw 3t/ha (low rate) + Manure 5t/ha (low rate) Deep incorporation (once off)	85	1	0.08	0.02		AUN 1
Straw 6t/ha (high rate) + Manure 10t/ha (high rate) Deep incorporation (once off)	104	0	0.09	0.03		AUN 1
Straw 6t/ha (high rate) Deep incorporation (once off)	107	1	0.09	0.07		AUN 1
Waste Hay 3t/ha (low rate) Deep incorporation (once off)	104	2	0.08	0.27		AUN 1
Waste Hay 6t/ha (high rate) Deep incorporation (once off)	107	5	0.09	0.13		AUN 1
No amendment Deep incorporation (once off)	92	0	0.09	0.16		AUN 1
Manure 10t/ha (high rate) Deep incorporation (once off)	111	1	0.09	0.06		ANW 2
Manure 5t/ha (low rate) Speed tiller incorporation (once off)	104	2	0.10	0.20		ANW 2
Manure 40t/ha (v/high rate) Speed tiller incorporation (once off)	134	9	0.11	0.21		AUN 1
Control - standing stubble	108	1	0.10	0.16		SEC 1

Badgingarra 2022 Results

The Badgingarra site was left to pasture in the final season of the project and therefore no results are available for the final season. Extremely poor yields and economic returns from the previous two seasons influenced the producer to pull the paddock out of the cropping rotation.

Wickepin 2022 Results

The Wickepin site was sown to Jurien Lupins 2nd of May at 90 kg/ha with 50 kg/ha of MAP/Mn and then spread with 70 kg/ha of MOP on the 19th of May. Total annual rainfall received was 391 mm and growing season rainfall (Apr – Oct) was 343 mm.

The site recovered from the significant wind erosion experienced in 2020 to see a good plant establishment in 2022 which was measured on the 10th of June 2022. The claying treatment experienced the highest establishment, similar to 2021 at 119 plants/m2, with plant establishment in all treatments ranging from 87 – 119 plants/m2 above the recommended rates of 45 – 70 plants/m2.

NDVI readings were taken on the 10th of June (GS.14) and the 11th of August (GS.31). The Claying treatment was the equal highest reading at 0.13 for GS.14 timing and the highest reading at 0.47 at the GS.31 timing.

Table 2: 2022 Wickepin lupin trial results summary

Treatment	Plants/ m2	Weeds/ m2	NDVI @ GS.14	NDVI @ GS.31	Yield (t/ha)	Yield P value
Chicken manure high rate 10t/ha (MBP)	92	6	0.11	0.31	2.50	ab
Chicken manure low rate 5t/ha (ST)	110	7	0.11	0.35	2.03	ab
Straw high rate 6t/ha (MBP)	87	1	0.13	0.39	2.13	a
Straw low rate 3t/ha (ST)	102	6	0.11	0.37	1.89	a
Hay high rate 6t/h a(MBP)	98	10	0.12	0.40	2.61	ab
Hay low rate 3t/ha (MBP)	106	3	0.11	0.31	2.25	ab
Grower practice (MBP)	97	1	0.13	0.45	3.27	b
Control	104	4	0.13	0.44	2.25	ab
Claying (ST)	119	6	0.13	0.47	2.03	a

ST = Speed Tiller, MBP = Mould board plough

Grain yields were measured through hand harvest cuts taken in December 2022. The highest yielding treatment we the Grower Practice at 3.27 t/ha followed by the high rate of hay (6 t/ha) and mould boarded at 2.61 t/ha. The Grower Practice treatment yielded significantly higher than the claying treatment at 2.03 t/ha and the high-rate straw (6 t/ha) treatment plus mould boarded at 2.13 t/ha and the low-rate straw treatment plus speed tillering at 1.89 t/ha.

3 YEAR YIELD RESULTS SUMMARY

Corrigin Yield Results Summary

A summary of the yield results across the 3 years for the Corrigin trial site are presented below. The highest yielding plot for the first two seasons was the northern control treatment, this plot was not harvested in the final season of the trial.(Was not harvested due to not being a good control, as the soil structure was better than the rest of the site. Farmer recommended that control should have been setup in the middle of the site.) The highest yielding treatments not including the controls was the high rate of manure (10t/ha) deep incorporated in 2020 and the very high rate of manure (40 t/ha) speed tillered in 2021.

In 2022 the highest yielding treatment was the low rate of waste hay (3 t/ha) deep incorporated @ 0.27 t/ha followed by stubble/straw low rate (3 t/ha) speed tillered at 0.25 t/ha.

Across all years the yields are considered to be well below district average, with no distinct pattern or trends highlighting the preferred option for the best organic soil ameliorant to be applied to these soil types. Even though those years where relatively "good years" across the regions, the impact of a severe wind event that was experienced just after sowing the trial in year one did impact the overall project results, again 2022 was a poor year due to the farmer using Terbyne ® as a (pre-emergent herbicide) on his soils; this leached into the wheat and severely reduced wheat plant numbers, before many large wind events also impacted most of the wheat plants that did establish after the poor germination. The lack of organic matter made for a difficult year then to finish; a large frost event detrimentally impacted any remaining plants.

The farmer made note that he found the manure @10T was achievable and provided the best results. He has adopted these practises into his farming system. He also noted that he has since decreased the rate of pre-emergent herbicide used and choice of pre-emergent used on his soils in an effort to build up the soil structure

Table 3: Corrigin yield results summary for the three years of the project (t/ha)

Treatment	2020 wheat yield	2021 Oat yield	2022 wheat yield
Grower control - standing stubble	1.18	1.29	
Stubble / Straw (annual production = low rate 3t/ha) Speed tiller incorporation (annually)	0.71	0.45	0.25
Straw 3t/ha (low rate) + Manure 5t/ha (low rate) Deep incorporation (once off)	0.82	0.14	0.02
Straw 6t/ha (high rate) + Manure 10t/ha (high rate) Deep incorporation (once off)	0.86	0.33	0.03
Straw 6t/ha (high rate) Deep incorporation (once off)	0.57	0.54	0.07
Waste Hay 3t/ha (low rate) Deep incorporation (once off)	0.99	0.61	0.27
Waste Hay 6t/ha (high rate) Deep incorporation (once off)	0.92	0.68	0.13
No amendment Deep incorporation (once off)	0.86	0.67	0.16
Manure 10t/ha (high rate) Deep incorporation (once off)	1.05	0.62	0.06
Manure 5t/ha (low rate) Speed tiller incorporation (once off)	0.74	0.66	0.20
Manure 40t/ha (v/high rate) Speed tiller incorporation (once off)	0.92	0.99	0.21
Control - standing stubble		0.70	0.16

Badgingarra Yield Results Summary

A summary of the yield results across the 3 years for the Badgingarra trial site are presented below. The highest yielding plot for the first season was the high rate of manure (10t/ha) speed tillered at 2.38 t/ha followed by the low straw rate speed tillered at 2.26 t/ha. The lowest yielding treatment was the high rate of water hay (6t/ha) deep incorporated @ 1.50 t/ha which was significantly lower than 1, 4, 5,6 and 7.

Extremely poor establishment of the canola crop in 2021 didn't enable to trial to be harvested and hand cut biomass weights were recorded to generate a measure of growth in each treatment. Individual plots weights were not recorded and therefore no statistics could be completed. The highest biomass yielding treatment in 2021 was the low rate of manure (5t/ha) speed tillered at 8.96 t/ha followed by low rate of straw speed tillered at 7.08 t/ha.

In the final year of the trial the grower pulled the paddock out of rotation and therefore no results were recorded for 2022. This happened due to many large wind events and the grower noticing the poor amount of organic matter, hence tried to take it back to pasture to reestablish some form of cover.

Across the trial there were no distinct trends or patterns to the preferred organic soil ameliorant that out-performed the grower control. It is worth noting that the limited available data has impacted the conclusions that can be drawn from the Badgingarra trial.

Table 4: Badgingarra yield results summary for the three years of the project (t/ha)

Treatment	2020 wheat yield	P value	2021 Canola biomass	P value	2022 yield	P value
Waste Hay 3t/ha (low rate) Deep Incorporation (once off)	2.12	b	3.63	n/a	not planted	n/a
Waste Hay 6t/ha (high rate) Deep Incorporation (once off)	1.50	a	2.80	n/a	not planted	n/a
Straw High rate 6t/ha (high rate) Deep Incorporation (once off)	2.24	ab	4.32	n/a	not planted	n/a
Grower Control Deep Incorporation (once off)	2.15	b	3.68	n/a	not planted	n/a
Manure 5t/ha (low rate) Speed Tiller incorporation (once off)	2.06	b	8.96	n/a	not planted	n/a
Manure 10t/ha (high rate) Speed Tiller incorporation (once off)	2.38	b	4.28	n/a	not planted	n/a

Straw low rate (annual production) Speed Tiller incorporation (annually)	2.26	b	7.08	n/a	not planted	n/a
Manure 30t/ha (high rate) Deep incorporation (once off)	2.09	ab	4.76	n/a	not planted	n/a

Wickepin Yield Results Summary

A summary of the yield results across the 3 years for the Wickepin trial site are presented below. Due to severe wind blow in 2020 the trial was not able to be harvested.

The highest yielding treatment in 2021 was the low rate of chicken manure (5t/ha) speed tillered at 2.46 t/ha, followed by claying, speed tillered in at 2.37 t/ha. There were no significant differences in yield between any of the treatments.

In the final season of the project the Wickepin site was planted to lupins. The highest yielding treatment was the grower practice, mould board ploughing at 3.27 t/ha, followed by high rate of hay (6t/ha) mould board ploughed at 2.61 t/ha. The grower practice treatment yielded significantly better than the high and low rate of straw and the claying treatment.

Overall, no organic soil ameliorant demonstrated a clear benefit in terms of yield. However, the high rates of straw and hay both outyielded the low rates of hay and straw in both 2021 and 2022 seasons.

Table 5: Wickepin yield results summary for the three years of the project (t/ha)

Treatment	2020 barley yield	P value	2021 barley yield	P value	2022 Lupins yield	P value
Chicken manure high rate 10t/ha (MBP)	N/A <0.3 t/ha	a	1.41	a	2.50	ab
Chicken manure low rate 5t/ha (ST)	N/A <0.3 t/ha	a	2.46	a	2.03	ab
Straw high rate 6t/ha (MBP)	N/A <0.3 t/ha	a	2.18	a	2.13	a
Straw low rate 3t/ha (ST)	N/A <0.3 t/ha	a	1.56	a	1.89	a
Hay high rate 6t/ha (MBP)	N/A <0.3 t/ha	a	2.15	a	2.61	ab
Hay low rate 3t/ha (MBP)	N/A<0.3 t/ha	a	2.09	a	2.25	ab
Grower practice (MBP)	N/A <0.3 t/ha	a	1.43	a	3.27	b
Control	N/A	a	1.56	a	2.25	ab

	<0.3 t/ha					
Claying (ST)	N/A <0.3 t/ha	a	2.37	a	2.03	a

ST = Speed Tiller, MBP = Mould board plough

3 YEAR GRAIN QUALITY RESULTS SUMMARY

Grain quality (protein and screening) results for five of the individual trails have been examined below. Both qualities are hypothesised to be potentially impacted by the addition of organic soil ameliorants by influencing either nutrient availability or water holding capacity.

The high rate of manure had the equal highest protein in year 1 of the Corrigin trail (if Nth nil treatment is removed), then the highest in year 2 and was mid-range by year 3, potentially indicating how many years the manure will impact production. The increase in protein for the high rate of manure lifted the treatment into the H1 grade commanding a grade premium.

Protein for treatments with both straw and manure were lower than treatments with straight manure for the first two seasons. However, there was no direct treatment rate curve against protein, which is the higher the ameliorant application rates the higher the protein.

Screenings were also measured as part of the results. The lowest rate of screening in 2020 was recorded in the high rate of straw plus the mid-rate of manure, mould board ploughed at 3.83% and the highest was recorded in the nil treatment south at 8.57% followed by the high rate of hay mould board ploughed at 7.42%.

In 2021 the high rate of straw plus the mid-rate of manure, mould board ploughed, had the highest rate of screenings at 37.38 grams and the highest rate of manure speed tillered had the lowest rate at 13.43 grams.

Screening was high in the final year despite the soft finish to the season. The highest rate of manure again had the lowest screenings at 8.29% followed by the mid-rate of manure at 9.54%. All three manure treatments recorded screenings below 10%.

Table 6: Corrigin 3-year grain protein and screenings summary
(Grd = Grade, Prtn = Protein, Scrng = Screenings)

	2020 (wheat)			2021 (Oats)		2022 (Wheat)		
Treatment Name	**Grd**	**Prtn**	**Scrng (%)**	**Prtn**	**Scrng (g)**	**Grd**	**Prtn**	**Scrng (%)**
Nil treatment North	**H1**	13.7	4.60	9.2	17.04			
Stubble 3t/ha (ST)	**FED1**	12.8	5.19	8.8	30.05	**SEC 1**	8.6	16.79
Straw 3t/ha + Manure 5t/ha (MB)	**AGP1**	11.3	6.05			**AUN 1**	8.9	14.96
Straw 6t/ha + Manure 10t/ha (MB)	**APW1**	10.6	3.83	9.0	37.38	**AUN 1**	8.7	12.20
Straw 6t/ha (MB)	**AUH2**	10.6	5.01	9.1	30.98	**AUN 1**	8.9	13.99
Hay 3t/ha (MB)	**FED1**	11.9	5.58	9.5	18.21	**AUN 1**	8.8	14.43
Hay 6t/ha (MB)	**FED1**	11.5	7.42	10	16.38	**AUN 1**	8.8	15.65
Control - (MB)	**AUH2**	11.8	5.91	10.1	15.01	**AUN 1**	8.5	16.59
Manure 10t/ha (MB)	**H2**	11.6	5.74	10	14.42	**ANW 2**	8.2	9.54
Manure 5t/ha (ST)	**AUH2**	12.6	5.26	9.5	16.16	**ANW 2**	8.1	9.78
Manure 40t/ha (ST)	**H1**	13.6	6.30	10.4	13.43	**AUN 1**	8.5	8.29
Nil treatment South	**AUH2**	13.6	8.57	9.6	16.12	**SEC 1**	8.6	17.82

The table over the page details the grain quality results from the Wickepin demonstration for 2021 and 2022. In 2021 the highest protein was the high rate of hay mould board ploughed followed by the low rate of hay mould board ploughed and the grower practice of just mouldboard ploughed. In 2022 the lupin protein between all treatments was contained in a very tight band between 32.2% to 33.9%. The claying treatment had the highest protein at 33.9% and the low rate of straw had the lowest protein at 32.2%.

In 2021 at the Wickepin site the low rate of chicken manure, speed tillered had the lowest screenings at 11.09 grams with the grower practice having the highest screenings at 27.31 grams. In 2022 the claying treatment had the lowest shrivelled grain % at 0.23% followed by the high rate of straw mould board ploughed at 0.40%. The low rate of hay mould board ploughed at 2.00%.

P PO Box 5367 Kingston, ACT 2604 Australia
T +61 2 6166 4500 **F** +61 2 6166 4599 **E** grdc@grdc.com.au

Table 7: Wickepin 2-year grain protein and screenings summary

Treatment	2021 (Barley)		2022 (lupins)	
	Protein (%)	Screenings (g)	Protein (%)	Shriveled (%)
Chicken manure high rate 10 t/ha (MBP)	6.9	13.43	33.1	0.75
Chicken manure low rate 5 t/ha (ST)	7.4	11.09	33.0	0.80
Straw high rate 6t/ha (MBP)	7.6	19.78	33.1	0.40
Straw low rate 3t/ha (ST)			32.9	0.55
Hay high rate 6t/ha (MBP)	8.9	23.67	32.4	0.50
Hay low rate 3t/ha (MBP)	8.4	17.89	32.2	2.10
Grower practice (MBP)	8.4	27.31	32.8	1.05
Control	7.2	17.39	32.3	2.00
Claying (ST)	6.1	11.24	33.9	0.23

BENEFIT COST ANALYSIS

The benefit cost analysis (BCA) for this project only examines the two factors that influence the outcomes for the trial, being the cost of the organic soil ameliorant and the change in revenue generated by yield. As the project is a demonstration style trial using grower equipment and all plots are treated equally for seeding, spraying, fertiliser and harvest, these factors have not been accounted for in the BCA.

Therefore, the BCA in this project doesn't examine the gross profit but rather the change in returns for each treatment before adjusting for the normal production costs. No quality adjustments have been made in the value of wheat to simplify the BCA calculations.

Organic Soil Ameliorant Cost Structure

The application cost for each type of treatment, each ameliorants expected benefit in years (amortisation) and the annual cost per hectare is shown in table 8. The costs have been assigned to each of the three demonstration sites for the benefit cost analysis.

Table 8: Application and amortised annual cost for each organic soil ameliorant.

Treatment	$/ton delivered	$/Ha delivered	application cost ($/ha)?	Total Cost $/ha	Amortisation (years)	Annual cost $/ha
Speed tillering	$0	$0	$40	$40	1	$40
Deep Incorporation	$0	$0	$80	$80	5	$16
Mould Board Ploughing	$0	$0	$125	$125	5	$25
Manure low rate - 5 t/ha	$25	$125	$10	$135	5	$27
Manure high rate - 10 t/ha	$25	$250	$20	$270	5	$54
Manure very high rate - 40 t/ha	$25	$1,000	$40	$1,040	5	$208
Straw low rate - 3 t/ha	$80	$240	$15	$255	5	$51
Straw high rate - 6 t/ha	$80	$480	$30	$510	5	$102
Waste hay low rate - 3 t/ha	$40	$120	$15	$135	5	$27
Waste hay high rate - 6 t/ha	$40	$240	$30	$270	5	$54
Claying (ST) (100 t/ha)	$0	$0	$250	$250	10	$25

Corrigin Site Benefit Cost Analysis

Table 9 below demonstrates the combined cost of each treatment including the cost of each ameliorant delivered and spread and the tillage to incorporate each of the products. Each combined cost is amortised over the expected life of each of the treatments.

There is a high cost for each of the treatments / organic ameliorants which need to be amortised over several seasons to recover the costs of the spend. The highest cost treatment was the very high rate of manure (40 t/ha) costing $216/ha annually.

Table 9: Corrigin organic ameliorant cost amortised for each treatment ($/ha).

Treatment	Ameliorant 1(Manure) cost + app	Ameliorant 2(Straw, waste hay)cost + app	Tillage Cost	Total cost	Amort-isation	Annual cost
Grower control - standing stubble	$0	$0	$0	$0	1	$0
Stubble / Straw (annual production = low rate 3t/ha) Speed tiller incorporation (annually)	$0	$0	$40	$40	1	$40
Straw 3t/ha (low rate) + Manure 5t/ha (low rate) Deep incorporation (once off)	$255	$135	$80	$470	5	$94
Straw 6t/ha (high rate) + Manure 10t/ha (high rate) Deep incorporation (once off)	$510	$270	$80	$860	5	$172
Straw 6t/ha (high rate) Deep incorporation (once off)	$0	$540	$80	$620	5	$124
Waste Hay 3t/ha (low rate) Deep incorporation (once off)	$0	$135	$80	$215	5	$43
Waste Hay 6t/ha (high rate) Deep incorporation (once off)	$0	$270	$80	$350	5	$70
No amendment Deep incorporation (once off)	$0	$0	$80	$80	5	$16
Manure 10t/ha (high rate) Deep incorporation (once off)	$270	$0	$80	$350	5	$70
Manure 5t/ha (low rate) Speed tiller incorporation (once off)	$135	$0	$40	$175	5	$35
Manure 40t/ha (v/high rate) Speed tiller incorporation (once off)	$1,080	$0	$40	$1120	5	$224
Control - standing stubble	$0	$0	$0	$0	1	$0

Table 10 shows the BCA for the Corrigin site in 2020. The highest returning treatment was the grower control at $448/ha which was the highest yielding treatment and did not have any costs associated with amelioration. The second highest returning treatment was the high rate of manure (10 t/ha) deep incorporation at $329/ha. The treatment with the lowest BCA was the high rate of straw with deep incorporation at $99/ha.

Table 10: Corrigin benefit cost analysis for 2020.

Treatment	2020 wheat yield t/ha	$/ton FIS	revenue $/ha	ameliorant cost $/ha	BCA $/ha
Grower control - standing stubble	1.18	$380	$448	$0	$448
Stubble / Straw (annual production = low rate 3t/ha) Speed tiller incorporation (annually)	0.71	$380	$270	$40	$230
Straw 3t/ha (low rate) + Manure 5t/ha (low rate) Deep incorporation (once off)	0.82	$380	$312	$94	$218
Straw 6t/ha (high rate) + Manure 10t/ha (high rate) Deep incorporation (once off)	0.86	$380	$327	$172	$155
Straw 6t/ha (high rate) Deep incorporation (once off)	0.57	$380	$217	$118	$99
Waste Hay 3t/ha (low rate) Deep incorporation (once off)	0.99	$380	$376	$43	$333
Waste Hay 6t/ha (high rate) Deep incorporation (once off)	0.92	$380	$350	$70	$280
No amendment Deep incorporation (once off)	0.86	$380	$327	$16	$311
Manure 10t/ha (high rate) Deep incorporation (once off)	1.05	$380	$399	$70	$329
Manure 5t/ha (low rate) Speed tiller incorporation (once off)	0.74	$380	$281	$35	$246
Manure 40t/ha (v/high rate) Speed tiller incorporation (once off)	0.92	$380	$350	$216	$134
Control - standing stubble		$380	$0	$0	$0

Table 11 shows the BCA for the Corrigin site in 2021 and 2022. The highest returning treatment for 2021 was the northern grower control returning a BCA of $439/ha. The next highest treatment was the southern control plot at $238/ha followed by no amendment with deep incorporation at $211/ha.

For 2022 the highest returning BCA was the southern grower control at $63/ha followed by low rate of waste hay (3 t/ha) with deep incorporation at $60/ha. Due to the very poor yields produced in 2022 the lowest returning BCA was the high rate of straw (6 t/ha) plus high rate of manure (10 t/ha) with deep incorporation at -$159/ha, followed by the very high rate of manure (40 t/ha) with deep incorporation at -$138/ha.

Table 11: Corrigin benefit cost analysis for 2021 and 2022.

	Oats $/ton	$340		Wheat $/ton	$380	
Treatment	**2021 oats yield t/ha**	**revenue $/ha**	**BCA $/ha**	**2022 wheat yield t/ha**	**revenue $/ha**	**BCA $/ha**
Grower control - standing stubble	1.29	$439	$439			
Stubble / Straw (annual production = low rate 3t/ha) Speed tiller incorporation (annually)	0.45	$154	$114	0.25	$94	$54
Straw 3t/ha (low rate) + Manure 5t/ha (low rate) Deep incorporation (once off)	0.14	$49	-$45	0.02	$9	-$85
Straw 6t/ha (high rate) + Manure 10t/ha (high rate) Deep incorporation (once off)	0.33	$111	-$61	0.03	$13	-$159
Straw 6t/ha (high rate) Deep incorporation (once off)	0.54	$184	$66	0.07	$25	-$93
Waste Hay 3t/ha (low rate) Deep incorporation (once off)	0.61	$206	$163	0.27	$103	$60
Waste Hay 6t/ha (high rate) Deep incorporation (once off)	0.68	$230	$160	0.13	$50	-$20
No amendment Deep incorporation (once off)	0.67	$227	$211	0.16	$63	$47
Manure 10t/ha (high rate) Deep incorporation (once off)	0.62	$211	$141	0.06	$22	-$48
Manure 5t/ha (low rate) Speed tiller incorporation (once off)	0.66	$225	$190	0.20	$75	$40
Manure 40t/ha (v/high rate) Speed tiller incorporation (once off)	0.99	$336	$120	0.21	$78	-$138
Control - standing stubble	0.70	$238	$238	0.16	$63	$63

Badgingarra Site Benefit Cost Analysis

Table 12 below details the combined cost of each organic ameliorant treatment at the Badgingarra site. Each combined cost is the amortised over the expected life of each of the treatments.

The highest cost treatment is the high rate of manure (30t/ha) costing $172/ha annually followed by the high rate of straw (6 t/ha) at $118/ha.

Table 12: Badgingarra organic ameliorant cost amortised for each treatment ($/ha).

	Ameliorant cost + app	tillage cost	total cost	Amortisation (yrs)	Annual cost
Waste Hay 3t/ha (low rate) Deep Incorporation (once off)	$135	$80	$215	5	$43
Waste Hay 6t/ha (high rate) Deep Incorporation (once off)	$270	$80	$350	5	$70
Straw High rate 6t/ha (high rate) Deep Incorporation (once off)	$510	$80	$590	5	$118
Grower Control Deep Incorporation (once off)	$0	$80	$80	5	$16
Manure 5t/ha (low rate) Speed Tiller incorporation (once off)	$135	$40	$175	5	$35
Manure 10t/ha (high rate) Speed Tiller incorporation (once off)	$270	$40	$310	5	$62
Straw low rate (annual production) Speed Tiller incorporation (annually)	$0	$40	$40	5	$8
Manure 30t/ha (high rate) Deep incorporation (once off)	$780	$80	$860	5	$172

Table 13 shows the BCA for the Badgingarra site in 2020. The treatment with the highest BCA was the was the high rate of manure (10 t/ha) speed tillered treatment at $841/ha. The second highest BCA was the low rate of straw speed tillered at $818/ha. The treatment with the lowest BCA was the high rate of waste hay (6 t/ha) with deep incorporation at $501/ha.

Table 13: Badgingarra benefit cost analysis for 2020.

Treatment	2020 wheat yield t/ha	$/ton FIS	Revenue $/ha	Ameliorant cost $/ha	BCA $/ha
Waste Hay 3t/ha (low rate) Deep Incorporation (once off)	2.12	$380	$807	$0	$807
Waste Hay 6t/ha (high rate) Deep Incorporation (once off)	1.50	$380	$571	$70	$501
Straw High rate 6t/ha (high rate) Deep Incorporation (once off)	2.24	$380	$851	$118	$733
Grower Control Deep Incorporation (once off)	2.15	$380	$819	$16	$803
Manure 5t/ha (low rate) Speed Tiller incorporation (once off)	2.06	$380	$783	$35	$748

Manure 10t/ha (high rate) Speed Tiller incorporation (once off)	2.38	$380	$903	$62	$841
Straw low rate (annual production) Speed Tiller incorporation (annually)	2.26	$380	$858	$40	$818
Manure 30t/ha (high rate) Deep incorporation (once off)	2.09	$380	$794	$172	$622

Wickepin Site Benefit Cost Analysis

Table 14 below details the combined cost of each organic ameliorant treatment at the Wickepin site. Each combined cost is the amortised over the expected life of each of the treatments.

The highest cost treatment is the high rate of straw (6 t/ha) mould board ploughed costing $127/ha annually followed by the high rate of waste hay (6 t/ha) mould board ploughed at $79/ha.

Table 14: Wickepin organic ameliorant cost amortised for each treatment ($/ha).

Treatment	Ameliorant cost + app	Tillage cost	Total cost	Amortisation (yrs)	Annual cost
Chicken manure high rate 10t/ha (MBP)	$270	$125	$395	5	$0
Chicken manure low rate 5t/ha (ST)	$135	$40	$175	5	$35
Straw high rate 6t/ha (MBP)	$510	$125	$635	5	$127
Straw low rate 3t/ha (ST)	$255	$40	$295	5	$59
Hay high rate 6t/h a(MBP)	$270	$125	$395	5	$79
Hay low rate 3t/ha (MBP)	$135	$125	$260	5	$52
Grower practice (MBP)	$0	$125	$125	5	$25
Control	$0	$0	$0	5	$0
Claying (ST)	$250	$40	$290	10	$29

Table 15 shows the BCA for the Wickepin site in 2021 and 2022. The treatment with the highest BCA in 2021 claying treatment at $729/ha. The second highest BCA was the low rate of chicken manure (5 t/ha) speed tillered at $752/ha. The treatment with the lowest BCA was the high rate of chicken manure (10t/ha) mould board ploughed at $372/ha.

The treatment with the highest BCA in 2022 was the grower practice, mould board ploughing at $1,346/ha followed by the hay rate of hay (6 t/ha) mould board ploughed treatment at $1,019/ha. The treatment with the lowest BCA was the low rate of straw (3 t/ha) speed tillered at $734/ha.

Table 15: Wickepin benefit cost analysis for 2021 and 2022.

	Barley $/ton	$320		Lupins $/ton	$420	
Treatment	**2021 oats yield t/ha**	**revenue $/ha**	**BCA $/ha**	**2022 wheat yield t/ha**	**revenue $/ha**	**BCA $/ha**
Chicken manure high rate 10t/ha (MBP)	1.41	$451	$372	2.50	$1,052	$973
Chicken manure low rate 5t/ha (ST)	2.46	$787	$752	2.03	$852	$817
Straw high rate 6t/ha (MBP)	2.18	$698	$571	2.13	$893	$766
Straw low rate 3t/ha (ST)	1.56	$499	$440	1.89	$793	$734
Hay high rate 6t/ha (MBP)	2.15	$688	$609	2.61	$1,098	$1,019
Hay low rate 3t/ha (MBP)	2.09	$669	$617	2.25	$946	$894
Grower practice (MBP)	1.43	$458	$433	3.27	$1,371	$1,346
Control	1.56	$499	$499	2.25	$944	$944
Claying (ST)	2.37	$758	$729	2.03	$851	$822

DISCUSSION OF RESULTS

The project was designed to examine strategies to increase the productivity of the 'gutless' sandy soils typical in WA, on top of the common practice soil amelioration methods such as spading, plozza ploughing, mould board ploughing and deep ripping.

The project examines the use of organic soil ameliorants in combination with the soil ameliorant methods to increase the organic matter content of the soil to increase soil nutrient supply and water holding capacity of the soil and in turn increase in grain yield and profitability for the growers.

It was also hypothesised, that the organic soil ameliorants could work to improve grain quality through increasing protein or reduced screenings via better water holding capacity and controlled release of nutrients through the season.

An extreme wind event was experienced just after the first seeding of the trial in 2020 which severely impacted the three demonstration sites through soil erosion and furrow fill/damage. This extreme event impacted the sites for the first two seasons.

The seasonal conditions across the 3 years of the project were some of the bests ever experienced in Western Australia, with record crops grown in 2021 and 2022. La Nina weather patterns were experienced during the last 6 months of 2020 and over 2021 and 2022 generating high rainfall seasons.

For the Corrigin demonstration the highest yielding plot for the first two seasons was the northern control treatment, this plot was not harvested in the final season of the trial . It is expected this treatment was the highest yielding due to an improvement in soil type over the balance of the site. For this reason, the plot was removed from the trial for the final season. The highest yielding treatments not including the controls was the high rate of manure (10 t/ha) deep incorporated in 2020 and the very high rate of manure (40 t/ha) speed tillered in 2021. In 2022 the highest yielding treatment was the low rate of waste hay (3 t/ha) deep incorporated @ 0.27.

Across all years the yields were well below district average, with no distinct pattern or trends highlighting the preferred option for the best organic soil ameliorant to be applied to these soil types.

The cost associated with applying the organic soil ameliorants can be extremely high, with the total application costs ranging from $175/ha to $1040/ha for the high rate of manure (40 t/ha). It is expected these ameliorants will last in the soil for more than one season and therefore the costs can be amortised across several seasons (further work in required the determine how many seasons).

Assuming an amortisation period of five years the annual cost of application is for the ameliorants is between $27 - $208/ha. Due to the high costs associated with the organic soil ameliorants the application would be applied to targeted areas rather than being applied on an entire paddock basis. Targeting the light 'gutless' sands areas in paddocks.

However, from the results seen in Corrigin there are no conclusive benefits seen from applying organic soil ameliorants in conjunction with physical soil ameliorants over and above just the physical soil ameliorant.

For the Badgingarra site only one year's results with yields were completed as the second years canola crop poor establishment meant it was not good enough to harvest and for the final season the demonstration site was left sown to pasture.

The yield results for the Badgingarra site were similar to the Corrigin site in that there was no discernible pattern between treatments to give a clear recommendation for applying an organic soil ameliorant. The yields across the demonstration were held in a tight band between 2.06 – 2.38 t/ha except for the treatment with the high rate of waste hay (6 t/ha) with deep incorporation at 1.50 t/ha.

The restrictive factor of only generating one year's worth of data also limited the demonstration's ability to give a clear conclusion of whether there were benefits in either grain yield or quality to the inclusion of organic soil ameliorants over these soil types.

In terms of benefit cost analysis only two treatments gave a better return than the grower practice of just mould board ploughing, the two speed tillered sites (high rate of manure and low rate of straw, which indicates the driver behind the difference is the type of physical amelioration rather than the organic ameliorant.

The mould board ploughed sites are more exposed to damage from a strong wind event than a speed tillered treatment as some cover remains and this is potentially the driver for better yields seen in the two highest yielding treatments.

The Wickepin site suffered extreme damage in the first year of the project from the strong wind event and as a result was not able to be harvested. The impacts of the damage extended to the second year of the demonstration and although the yields improved considerably the large variation in yield between replicates within each treatment didn't give any statistical differences despite quite large variations in average yields.

The grower practice of mould board ploughing was the second lowest yielding treatment in 2021 and then the highest yielding treatment in 2022. Similarly to the other two sites there was no discernible pattern between the treatments to generate a conclusive recommendation to add a certain organic soil ameliorant in front of the physical amelioration process which will improve yields and generate a positive return.

The hypothesis for benefits to the grain quality from the organic soil ameliorants were that the manure would act like a slow-release fertiliser and by giving a release of nitrogen during grain fill the protein could be increased. The additional of straw and/or hay is thought to function to increase soil carbon, especially while breaking down and increasing soil microbial activity which can act the water holding capacity and reduce screenings as the plant has access to further moisture to finish grain fill.

However, the addition of hay and straw could work to reduce protein as the available nitrogen is tied up by the microbes as they break down the high carbon content straw and reducing the available nitrogen to the plant.

The 2020 results for the Corrigin site showed the manure treatments (average 12.6%) had higher protein in general than the straw and hay treatments (average 11.3%) which were higher than the straw + manure treatments (average 10.95%). However contrary to these results the stubble speed tillered treatment averaged 12.8% and the south nil treatment averaged 13.6%.

While there were trends in the results to support the hypothesis there were no conclusive outcomes from the results. The protein trends were more in line with expectation for 2021 in oats as the 40 ton/manure had the highest protein at 10.4%. The manure treatments averaged 9.97% compared to the hay/straw treatments which averaged 9.53%. By the final year the straw treatments were producing higher proteins than the manure treatments which could indicate that the manure had completely broken down and the hay/straw treatments had a nitrogen boost from the microbes being broken down. However, it is worth noting the impact of the frost on the final year may have been the over riding factor and not the treatments.

Similar to the protein results there was no clear trend in the screenings results for the Corrigin site. The high rate of straw + mid-rate of manure had the lowest screenings in 2020 and then the highest in 2021. There are trends in the data to support the hypothesis however overall, the results are inconclusive. The screenings results are similar for the Wickepin site overall being inconclusive in their support of the hypothesis.

The results at the Wickepin site were inverse to expectation. The protein in barley in 2021 the hay treatments had the highest protein followed by the straw treatment and the chicken manure treatments had the lowest. This trend was reversed in the final year of the project in the lupins. The clayed treatment had the lowest protein in 2021 and then the highest in 2022. Overall, the results for the Wickepin site did not support the hypothesis.

CONCLUSION

Finding to solutions to increase productivity on 'gutless' sand in WA's wheatbelt has wide implications due to the large areas these soils make up.

Physical soil amelioration methods such as spading, plozza ploughing, mould board ploughing, and deep ripping are common practice methods to improve productivity and generally result in considerable yield uplifts.

These soils are typically very low in fertility, organic matter and have very poor water holding capacity and the addition of organic soil ameliorant to improve production by addressing these shortfalls is a compelling hypothesis.

The extreme wind event experienced just after the first seeding of the trial in 2020 which severely impacted the three demonstration sites through soil erosion and furrow fill/damage is always a risk associated with trial work and impacted the results across the first two seasons.

Across the three years and in light of the very good seasons experienced, the yields were well below district average, with no distinct pattern or trends highlighting the preferred option for the best organic soil ameliorant to be applied to these soil types.

While some minor trend benefits were apparent in the results in a single season these were often reversed in the following season.

There are no conclusive benefits seen from applying organic soil ameliorants in conjunction with physical soil ameliorants over and above just the physical soil ameliorant. However, it is worth noting that from the results there was no clear yield benefit from the physical amelioration of mould board ploughing which has been well established over the past decade or longer. This result potentially demonstrates the impact of the severe wind event on the overall trial results.

The cost associated with applying the organic soil ameliorants can be extremely high, with the total application costs ranging from $135/ha to $1040/ha for the high rate of manure (40 t/ha). It is expected these ameliorants will last in the soil for more than one season and therefore the costs can be amortised across several seasons. Improved understanding of the length of impact of the different types of organic ameliorants in these soils is required to better understand the annual cost and the determine the benefit cost analysis of applications.

For producers examining the impacts on production and the BCA of which physical soil amelioration method to use and then assess the addition of an organic soil ameliorant and at what rate and then incorporating this into there production system is a reality they face every season, which makes this demonstration align to decisions growers need to make.

However, for experimental methodology having so many variables will often make deciphering the outcomes of a trial difficult, without giving a clear outcome. Assessing which factor gave an outcome is unknown and therefore the overall complexity of the demonstration was part of the reason for the outcome.

IMPLICATIONS

Improving production on the 'gutless' sands across the Western Australian wheatbelt is important work with wide applications through out the state. The inconclusive result from the demonstration means there are limited outcomes on industry in Australia directly from the demonstration however the demonstration was impacted from a severe wind event just after seeding in the first year which impacted the results for the first two seasons.

The implication from the project is the requirement for further work to improve our understanding around the potential impact of organic soil ameliorants on grain production and quality.

Future work should be simplified in the design to examine one or two elements and then build a knowledge framework to understand the best methodology of organic soil ameliorant, type and rate, to be used in combination with physical soil amelioration.

Application costs for the organic soil ameliorant ranged from $175 - $1080 per ha, per treatment, which can then be amortised over several years. The BCA results were inconclusive, with a large driver for these results being the number of years the costs can be spread over, which requires further work. It is worth noting however the organic ameliorants, when applied, are expected to only be targeted at certain areas (soils) within a paddock rather than the entire paddock.

RECOMMENDATIONS

The outcomes from the project were inclusive and unable to determine any clear recommendations. However, the hypothesis being examined in the project remains valid that incorporating organic soil ameliorants onto gutless sands ahead of physical soil amelioration to improve grain yields and quality.

Further work is required to better understand the impact on production, grain quality and benefit cost analysis for each of the organic soil ameliorants, waste hay, straw and chicken manure and then the best method of incorporating each of the ameliorants, mould board ploughing, speed tillering, spading, plozza ploughing or deep ripping.

Due to the considerable number of variables that need to be examined the methodologies need to be simplified to only examine one or two variables and then build a knowledge base to determine the final best outcome or strategy.

Additional work that is required as a recommendation from this project is the further understand the length of time the organic soil ameliorants last in the soil and application rates curves for each of the ameliorants. Is it better to apply 40 t/ha of manure in one application or two applications of 20 t/ha spaced 2 years apart.

Accurate costings are also required for each of the ameliorants including purchase costs, freight and spreading costs to ensure the outcomes are relevant to all growers. Not all growers will have access to enough manure, waste hay or straw to source these inputs from within their own operation.

In summary while the outcomes form the project were inconclusive and no clear recommendations were able to be made from the results the project did explore an important issue which is relevant to a broad range of growers through out WA. From the project clear recommendations were established as to how to move forward with this issue to determine a strategy to increase productivity on these 'gutless' sands in the future.

Further studies should see growers be less harsh with chemicals due to no organic matter to protect crop establishment. Carry out tillage towards the end of the seeding program to miss large wind events. Consider what they are planting and why? Grass types such as wheat and rye corn could establish better than canola in low organic matter environments.

For more information there has been a podcast regarding the organic soil amelioration please see link: https://grdc.com.au/news-and-media/audio/podcast/measuring-the-impact-of-organic-soil-ameliorants

Video Link: https://www.youtube.com/watch?v=qmvKYA3sjCQ

P PO Box 5367 Kingston, ACT 2604 Australia
T +61 2 6166 4500 **F** +61 2 6166 4599 **E** grdc@grdc.com.au