Subsoil amelioration – five years on

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Key Findings

- Biomass responses to chicken litter, measured as NDVI, were evident at all sites in 2019, the fifth season after application.
- Biomass responses to fertiliser amendment, measured as NDVI, were evident at all cereal sites in 2019, but not at lentil sites.
- The application of chicken litter to the surface in 2015 as a soil amendment reduced grain yields in 2019 at four of five trial sites.
- Applying amendments to the subsoil did not improve grain yields. No cumulative benefit of subsoil amendment application has been measured over the five years of trials.
- Biomass and grain protein responses five years after amendment application indicate nitrogen inputs from amendments are still being observed as crop responses.

Why do the trial?

Subsoil constraints are known to have a large impact on grain yields in the Mid-North of SA. Trials in other regions including south western Vic have reported large yield responses (up to 60% yield increase in 1st year) from treatments of deep ripping and deep placement of high rates (up to 20 t/ha) of chicken litter. The grain yield response is thought to be coming from increasing the plant available water holding capacity of these soils by improving the structure of the subsoil. Although the cost associated with implementing these treatments is high, with these reported yield gains it is possible to pay for the treatments in the first season.

How was it done?

Seven randomised complete block design trials with three replicates of the same eight treatments (Table 1) were established in March 2015. The trials were located in three different geographic areas including two near Clare at Hill River, two at Hart and three at Bute. At each location the trials were located on different soil types which are described below.

Table 1. Treatment list for the 7 subsoil manuring sites established in 2015.

Treatment	Nutrition	Ripping	Placement
1	Nil	No	Nil
2	Nil	Yes	Nil
3	20 t/ha chicken litter	No	Surface
4	20 t/ha chicken litter	Yes	Surface
5	20 t/ha chicken litter	Yes	Subsoil
6	3 t/ha synthetic fertiliser	No	Surface
7	3 t/ha synthetic fertiliser	Yes	Surface
8	3 t/ha synthetic fertiliser	Yes	Subsoil

Plot size	2.5 m x 12.0 m
Seeding date	Hart: May 21 Bute: May 11
Main treatments applied in 2015	As per treatment list (Table 1)
2019 crop and annual fertiliser	Hart: PBA Hallmark XT lentil, 50 kg/ha MAP + 2% Zn Bute: Compass barley, 80 kg/ha DAP, 80 kg/ha urea

Sites and soil types

Hart East	Calcareous gradational clay loam Subsoil constraint: High pH and moderate to high ESP below 30 cm
Hart West	Calcareous loam Subsoil constraint: High pH, Boron and ESP below 30 cm
Bute Northwest	Calcareous transitional cracking clay Subsoil constraint: High pH, Boron and ESP below 30 cm
Bute Mid	Calcareous loam Subsoil constraint: High pH, Boron and ESP below 60 cm
Bute South East	Grey cracking clay with high exchangeable sodium at depth Subsoil constraint: High pH, Boron and ESP below 30 cm
Hill River East	Black cracking clay
Hill River West	Loam over red clay Subsoil constraint: Moderate ESP below 60 cm and moderate Boron below 90 cm

The initial treatments (Table 1) were established prior to sowing in 2015. Ripping and subsoil treatments were applied with a purpose built trial machine loaned from Victoria DPI. The machine is capable of ripping to a depth of 600 mm and applying large volumes of product to a depth of 400 mm. Chicken litter was sourced from three separate chicken sheds for ease of freight, the average nutrient content is shown in Table 2. After the treatments were implemented the plots at all sites were levelled using an offset disc. Since 2015 only seed and district practice fertiliser rates have been applied to all plots.

In 2019 the Hart sites were sown with narrow points and press wheels on 250 mm spacing. The Bute sites were sown using a concord seeder on 300mm spacing with 150 mm sweep points and press wheels and at Hill River the sites were sown using parallelogram knifepoint and press wheel seeder on 250 mm spacing.

The rate of chicken litter (20 t/ha) used in these trials was based on the rate being used in south western Victoria where the large yield responses had been observed. To assess if responses to chicken litter were attributed directly to the nutrition in the chicken litter, the 3 t/ha synthetic fertiliser treatment was designed to replicate the level of nutrition that is found in an average analysis of 20 t/ha of chicken litter. This treatment was made up of 800 kg/ha mono ammonium phosphate (MAP), 704 kg/ha muriate of potash (MoP), 420 kg/ha sulphate of ammonia (SoA) and 1026 kg/ha urea.

Table 2. Average nutrient concentration from three chicken litter sources used in subsoil manuring trials established in 2015.

Nutrient		Nutrient concentration dry weight	Moisture content	Nutrient concentration fresh weight	Kg nutrient per tonne fresh weight
N	Nitrogen	3.8 %	8%	3.50 %	35.0
P	Phosphorus	1.72 %		1.58 %	15.8
K	Potassium	2.31 %		2.13 %	21.3
S	Sulfur	0.55 %		0.51 %	5.1
Zn	Zinc	0.46 g/kg	8%	0.42 g/kg	0.4
Mn	Manganese	0.51 g/kg		0.47 g/kg	0.5
Cu	Copper	0.13 g/kg		0.12 g/kg	0.1

Measurements in 2019 include Green Seeker NDVI, grain yield and quality at the Bute site and Green Seeker NDVI and grain yield at the Hart site. No measurements were taken at the Hill River sites as the paddock was grazed with sheep and cut for hay in 2019.

2019 Results

Bute sites

Green Seeker NDVI measurements conducted on July 22 at the Bute sites indicated that both chicken litter and fertiliser amendments were generating a growth response over the untreated control (Tables 3-5). This is despite NDVI values approaching 'saturation', reducing the sensitivity of this measurement to treatment differences. At the Bute SE and Mid sites, the response to chicken litter was greater than for fertiliser amendment, whereas the responses were equivalent at the Bute NW site. At the Mid and North West sites there was also an increase in NDVI as a result of the deep ripping conducted in 2015, this was in the absence of additional nutrition.

Grain yield was reduced through the application of chicken litter by 26% at the South East site. The fertiliser application had less of an impact but still reduced yield when placed in the subsoil. Grain protein at the site was high, with the nil nutrition treatments averaging 11.3%. Where fertiliser or chicken litter was applied grain protein increased to between 14.9% (fertiliser + no ripping) and 17.9% (chicken litter + deep ripping). This result highlights a large amount of the nitrogen applied in 2015 is still available. As expected, grain size and test weight were inverse to the protein values.

There was no significant grain yield response to treatments at the Bute Mid site with the average yield of 3.83 t/ha. However, when nutrient source is analysed on its own (e.g. synthetic fertiliser versus chicken litter), chicken litter was reducing grain yield on average by 8.4%. Grain yield was correlated with NDVI, where by grain yield was reduced as NDVI in July increased. This suggests the crop may have produced too much biomass and used too much water early, then was unable to fill all of the grains before running out of water. Grain quality parameters were as expected where there is a negative relationship between NDVI and grain yield. Treatments that had lower biomass (measured as NDVI) led to lower protein and increased grain size. The protein of the nil nutrition treatments averaged 11.3% where the chicken litter and fertiliser treatments ranged from 13.9% to 17.5%. The protein response to the placement of the amendment was not consistent between treatments. Chicken litter placed in the subsoil had lower protein than when applied to the surface and fertiliser was the opposite. As for the South East site, grain size, measured as retention and screenings had the inverse relationship to protein.

The Bute North West site was the lowest yielding trial in this paddock, in part due to frost at this site, averaging 2.22 t/ha. Following a similar trend to the previous two sites, chicken litter reduced grain yield by 20% compared to the nil nutrition treatments. Fertiliser however did not have a negative impact on yield whether it was placed on the surface or in the subsoil. Ripping at this site did not affect grain yield. Grain quality at this site was poor, with retention averaging only 9% and with no significant

treatment effects. Grain screenings were increased through the application of either nutrition treatment. Protein values were all high at this site, ranging from an average of 15.2% for the nil nutrition treatments up to an average of 18.7% for the chicken litter treatments and fertiliser applied to the surface with ripping.

Table 3. Green Seeker NDVI 22nd July, grain yield (t/ha) and grain quality parameters for the Bute South East subsoil manuring trial 2019.

Treatment	NDVI 22nd July	Grain yield (t/ha)	Protein (%)	Test Weight (kg/hL)	Retention (%)	Screenings (%)
1	0.857	3.88	11.2	70.5	93.6	1.1
2	0.853	3.88	11.5	69.7	91.4	1.5
3	0.889	3.04	16.5	68.0	75.1	3.9
4	0.886	2.70	17.9	66.7	70.2	5.5
5	0.869	2.89	16.8	67.1	69.0	5.1
6	0.873	3.69	14.9	68.5	81.8	2.7
7	0.868	3.32	16.3	68.1	76.8	3.8
8	0.868	2.95	16.9	67.5	76.1	4.1
LSD (0.05)	0.016	0.59	1.1	0.7	8.7	1.9

Table 4. Green Seeker NDVI 22nd July, grain yield (t/ha) and grain quality parameters for the Bute Mid subsoil manuring trial 2019.

Treatment	NDVI 22nd July	Grain yield (t/ha)	Protein (%)	Test Weight (kg/hL)	Retention (%)	Screenings (%)
1	0.744	4.05	11.1	69.6	88.3	1.9
2	0.790	3.99	11.4	69.7	87.2	2.1
3	0.867	3.77	17.0	65.3	49.1	7.4
4	0.887	3.48	17.4	64.6	42.2	9.6
5	0.859	3.79	15.7	67.4	63.5	5.1
6	0.803	3.98	13.9	67.0	73.8	3.7
7	0.839	3.93	15.3	66.9	65.7	4.8
8	0.860	3.63	17.5	64.6	45.2	8.8
LSD (0.05)	0.037	ns	1.4	2.1	10.7	2.8

Table 5. Green Seeker NDVI 22nd July, grain yield (t/ha) and grain quality parameters for the Bute North West subsoil manuring trial 2019.

Treatment	NDVI 22nd July	Grain yield (t/ha)	Protein (%)	Test Weight (kg/hL)	Retention (%)	Screenings (%)
1	0.850	2.48	14.4	58.3	10.2	5.8
2	0.864	2.33	16.0	66.3	8.8	6.6
3	0.873	2.01	19.2	58.7	12.0	9.5
4	0.873	1.62	19.1	63.0	8.4	8.8
5	0.875	2.16	17.5	61.9	6.7	7.4
6	0.870	2.63	15.5	60.1	7.5	6.1
7	0.872	2.21	19.1	59.5	10.1	8.9
8	0.878	2.30	16.7	60.4	8.1	7.0
LSD (0.05)	0.011	0.46	2.4	ns	ns	1.5

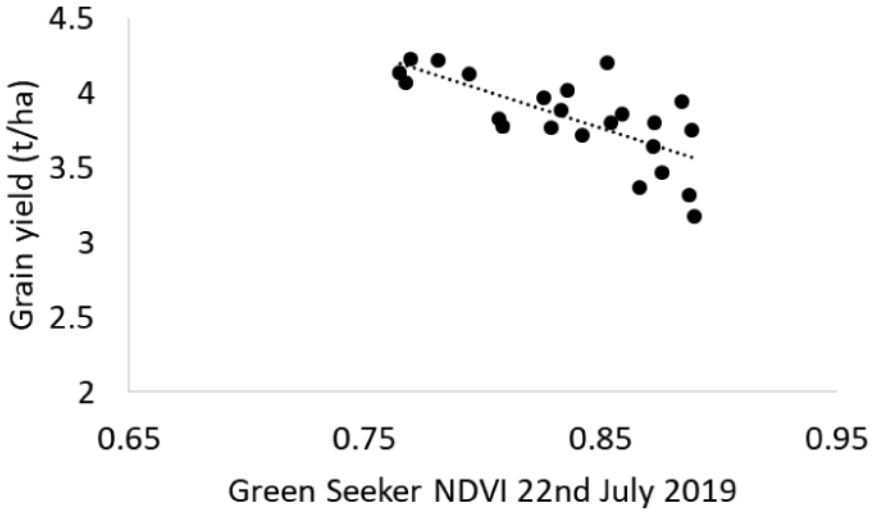

*Figure 1. Green Seeker NDVI recorded 22nd July 2019 and grain yield (t/ha) for the Bute Mid subsoil manuring trial 2019. Grain yield = -5.0317*NDVI + 8.0423, R2 = 0.5106*

Hart Sites

Lentil NDVI results for the two Hart sites were similar in 2019. At the West and East sites, the application of chicken litter to the surface increased NDVI by 25% and 16%, respectively. This has also been observed in previous lentil crops following application of chicken litter over the past 4 years. However, when chicken litter was applied into the subsoil this increase in NDVI did not occur. Also, as in previous seasons, the fertiliser treatment did not have the same effect as the chicken litter when applied to lentil.

In previous seasons where these trials have been sown to lentil there has been a yield reduction from the surface application of chicken litter. Unfortunately, at Hart this season lentil grain yield was severely affected by drought at the West site and drought plus frost at the East site. Average grain yields for these two sites were 0.48 t/ha and 0.20 t/ha for the West and East sites, respectively.

At the West site grain yield was highest in the nil nutrition treatments, or in treatments where the chicken litter or fertiliser was placed in the subsoil. This is similar to what has been found in previous seasons when sown to lentil. There was no significant difference between treatments at the East site.

Table 6. Green Seeker NDVI, 22nd August, and grain yield (t/ha) for the Hart West and East subsoil manuring trials 2019.

Treatment	Hart West		Hart East	
	NDVI 22nd August	Grain yield (t/ha)	NDVI 22nd August	Grain yield (t/ha)
1	0.528	0.51	0.633	0.24
2	0.499	0.60	0.623	0.23
3	0.640	0.44	0.717	0.19
4	0.650	0.35	0.740	0.10
5	0.510	0.53	0.617	0.17
6	0.557	0.47	0.613	0.23
7	0.526	0.42	0.583	0.20
8	0.516	0.51	0.673	0.21
LSD	(0.05) 0.049	(0.1) 0.11	(0.05) 0.083	ns

Cumulative grain yields for the five seasons

Over the past five seasons it is evident that subsoil amelioration treatments implemented in 2015 have not been able to increase grain yields in areas of the paddocks with shallow subsoil constraints. In the Bute paddock, the NW and SE site have more severe subsoil constraints at shallower depths (from 300 mm), compared with the Mid site (from 600 mm), as described in the soil descriptions. This is also reflected in the site yields over the past five seasons (Figure 2). With the subsoil machinery used placing amendments at ~400 mm, the subsoil amendment application was placed into the constrained subsoil at the NW and SE sites, whereas it was placed ~200 mm above the constrained subsoil at the Mid site. Long term grain yield results indicate that the subsoil treatments (treatments 5 and 8) have actually tended to reduce yield at the more constrained sites (NW and SE), whereas these treatments have had little impact at the less constrained Mid site (Figure 2). Therefore, these treatments have actually increased the yield gap between the better and poorer performing soil types.

Hart and Hill River long term results have not been presented as there was little change from the previous season, see previous report for more detail.

The greatest positive response observed over the past five years has come from large yield gains in 2016 which was a high rainfall and high yield potential season. In this year, standard fertiliser applications were not enough to achieve maximum grain yields, therefore the additional nutrition that came from either the chicken litter or the synthetic fertiliser was able to produce higher grain yields. However, in subsequent years where rainfall has been limiting the application of either nutrition treatment, but particularly chicken litter, to these soil types in 2015 has generally resulted in a decrease in grain yields. Further to that the disturbance caused by the ripping process, or deep placement of the nutrition treatment has also reduced yields at some sites.

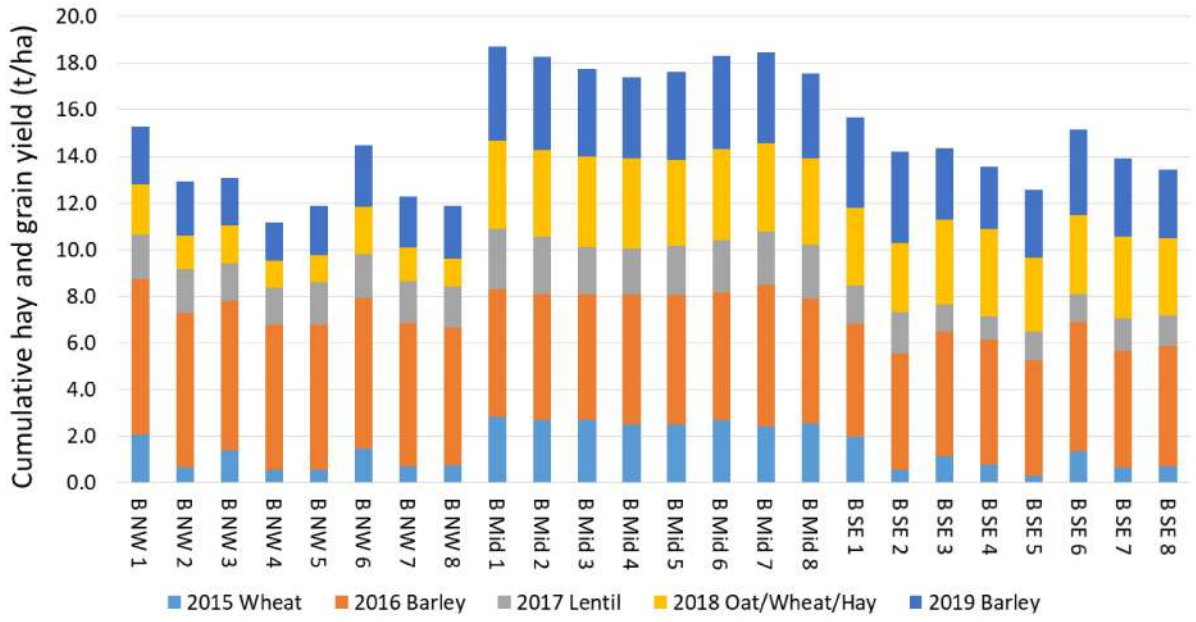

Figure 2. Cumulative hay and grain yield (t/ha) for the Bute North West (B NW), Bute Mid (B Mid) and Bute South East (B SE) sites for 2015 – 2019.

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