Subsoil amelioration – the last year

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Key findings

- Deep ripping on soils with subsoil constraints decreased long-term grain yields at one site and had no effect at four others.
- Subsoil amendments were not able to increase long-term grain yields at any site at Bute or Hart.
- Nitrogen recovery of surface or subsoil applied amendments was poor at four of five sites, with the greatest recovery achieved at the site with the least constraints.

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 Victoria 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 come 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. Trial data was only collected from Hill River from 2016 – 2018 and has not been reported here, previous trial reports for individual years containing Hill River data can be found on the Hart website.

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

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 Southeast	Grey cracking clay with high exchangeable sodium at depth Subsoil constraint: High pH, Boron and ESP below 30 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 2020 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 300 mm spacing with 150 mm sweep points and press wheels.

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	3.80%	8%	3.50%	35.0
P	Phosphorus	1.72%		1.58%	15.8
K	Potassium	2.31%		2.13%	21.3
S	Sulphur	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

Cumulative grain yields for six seasons

Over the past six seasons no treatment in these trials has been able to increase grain yields compared to standard management (Figure 1 and 2). Main treatment effects were:

- Deep ripping (T2) decreased long-term grain yields at the Bute NW site and have had no impact at any other site (Figure 1 and 2).
- Chicken litter applied to the soil surface (20 t/ha) as an amendment in 2015 (T3) reduced grain yields compared to the untreated control at all five sites presented in this report.
- Synthetic fertiliser applied at high rates as an amendment (T6) to the soil surface produced long-term grain yields equivalent to the untreated control at four of five sites. This is in contrast with the chicken litter effect.

Subsoil application of both amendments (T5 chicken litter, T8 synthetic fertiliser) have not provided any long-term grain yield improvement at any of the three Bute sites (Figure 1). 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 six seasons, with grain yields for the NW and SE sites being lower than the Mid site. 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 have tended to reduce yield at the more constrained sites NW and SE. Therefore, these treatments have increased the yield gap between the better and poorer performing soil types.

At the Hart site subsoil application of amendments did not increase grain yields compared to the control treatment. However, they appear to have increased yields compared to surface application. The best example of this is at Hart East (Figure 2) with surface and subsoil placed chicken litter. This is due to yield loss associated with surface application of amendments in lentil in 2016 which was a high rainfall, high biomass and potentially high disease pressure season. It is thought that surface application lead to greater biomass and greater disease in this year resulting in reduced yields. Subsoil application did not produce the same level of early biomass accumulation (data not presented) and subsequent yields were greater compared to surface application.

Over the last six seasons there has been little difference between the chicken litter and synthetic amendment treatments when compared in individual seasons. However, a multi-site analysis over the lifetime of the trials shows there is an advantage of synthetic fertiliser compared to chicken litter (Table 3). The synthetic fertiliser treatments produced 1.22 t/ha and 1.07 t/ha more grain yield for surface applied application with (T7 vs T4) and without ripping (T6 vs T3), respectively. There was no difference when the amendments were placed in the subsoil (T8 vs T5).

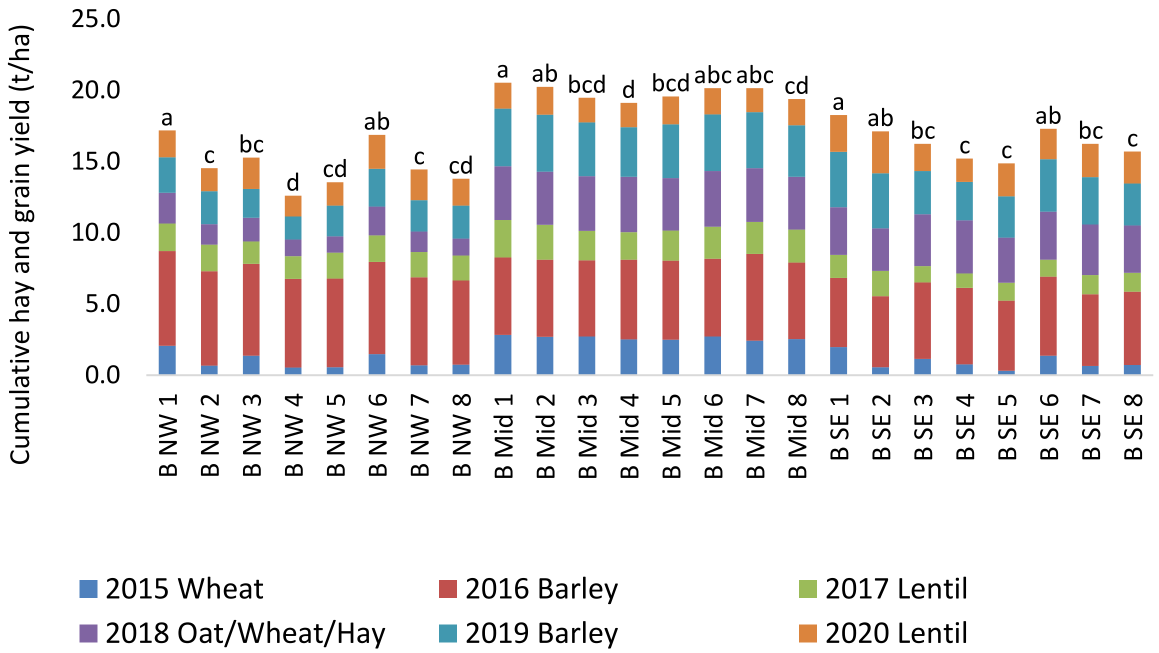

Figure 1. Cumulative hay and grain yield (t/ha) for the Bute North West (B NW), Bute Mid (B Mid) and Bute South East (B SE) sites for 2015 – 2020. Letters denote significant differences for totals at a given site. Treatment number shown in x axis label.

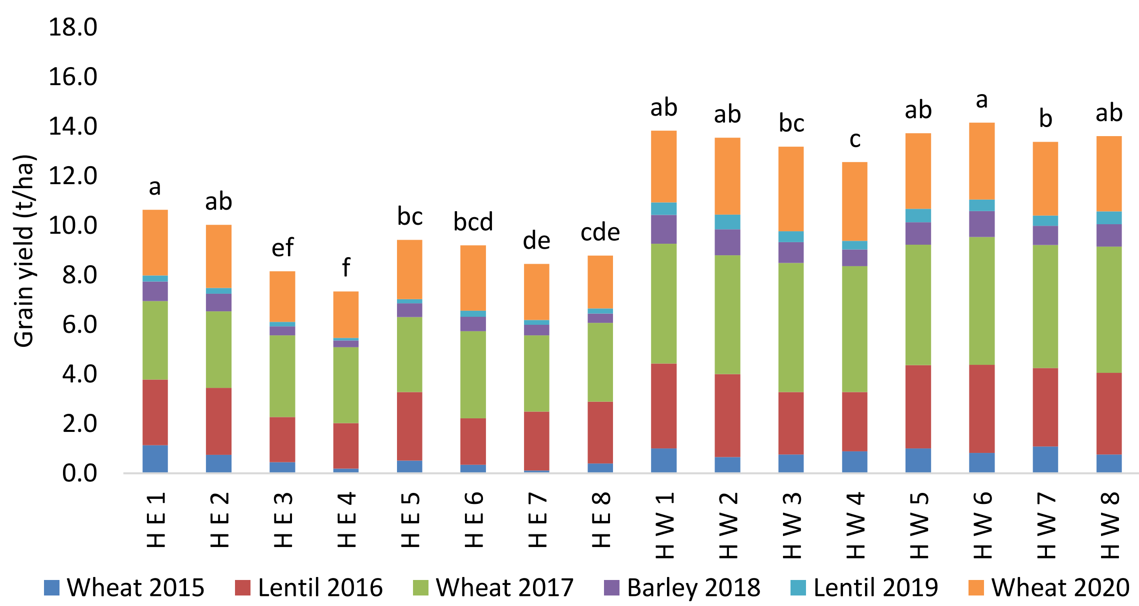

Figure 2. Cumulative grain yield (t/ha) for the Hart East (H E) and Hart West (H W) sites for 2015 – 2020. Letters denote significant differences for totals at a given site. Treatment number shown in x axis label.

Table 3. Total grain production (t/ha) averaged across five sites from 2015 – 2020 at subsoil trials Hart and Bute.

Treatment	Nutrition	Ripping	Placement	Total grain production (t/ha)
1	Nil	No	Nil	16.1 [a]
2	Nil	Yes	Nil	15.2 [bc]
3	20 t/ha chicken litter	No	Surface	14.5 [d]
4	20 t/ha chicken litter	Yes	Surface	13.4 [e]
5	20 t/ha chicken litter	Yes	Subsoil	14.3 [d]
6	3 t/ha synthetic fertiliser	No	Surface	15.6 [ab]
7	3 t/ha synthetic fertiliser	Yes	Surface	14.6 [cd]
8	3 t/ha synthetic fertiliser	Yes	Subsoil	14.3 [d]
LSD (P≤0.05)				*0.7*

Nitrogen (N) removal was calculated using grain yield and protein data for the last six seasons (Figures 3 and 4). At the Bute NW site and Hart East site greater amounts of nitrogen were removed from the surface applied synthetic fertiliser followed by ripping (T7) treatments compared with chicken litter (T4). Low long-term grain yields indicate that the subsoil constraints are greatest at these sites in each paddock. At other sites and treatments (T3 vs T6 and T5 vs T8) the differences were not significant but there was still a general trend of more N being removed from the synthetic amendment treatments.

Of the 700 kg N/ha that was applied in 2015 only a small proportion has been recovered. On average, just 0.8% of chicken litter applied N was recovered compared to 5.2% of synthetic amendment applied N. These poor recovery rates are a reflection of adequate N fertiliser application in the standard fertiliser programs being applied to these paddocks. The highest yielding site (Bute Mid) was the site with the least subsoil constraints and was the only site to consistently remove more N from treatments where the amendments were applied compared to the non-amendment treatments (T1 and T2). For this site 18% of N that was applied in 2015 was recovered over the six years, showing that with less subsoil constraints and higher yield potential a greater level of N was be extracted from the soil. More testing needs to be conducted to establish where the N that has not been recovered has gone.

Note that standard commercial rates of fertiliser have been applied to these trials each year in addition to the amendment rate, total approximate N applied for Bute and Hart was 185 and 168 kg N/ha respectively. Also note that of the six seasons two were legumes where nitrogen fixation would have occurred.

The long-term results from these trials suggest that the greatest gains from high rates of chicken litter or synthetic fertiliser applied as an amendment will come from the best parts of the paddock with higher levels of grain yield and protein being produced in these areas. The process of subsoil amelioration through addition of chicken litter or synthetic fertiliser into the subsoil has not been successful at these sites and if anything, grain yields have declined as a result.

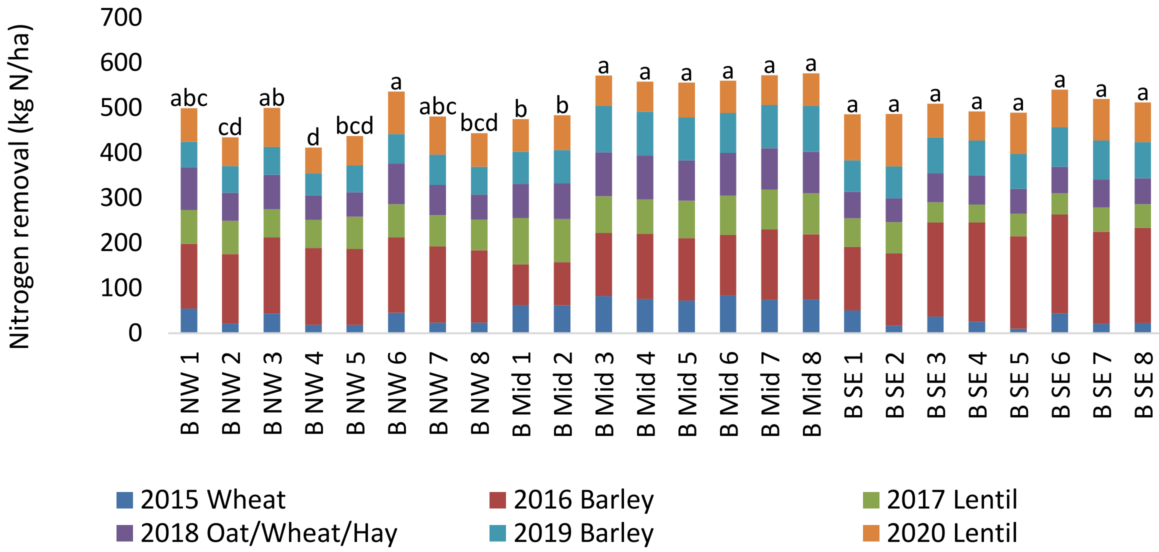

Figure 3. Cumulative N removal for the Bute North West (B NW), Bute Mid (B Mid) and Bute South East (B SE) sites for 2015 – 2020. Letters denote significant differences for totals at a given site.

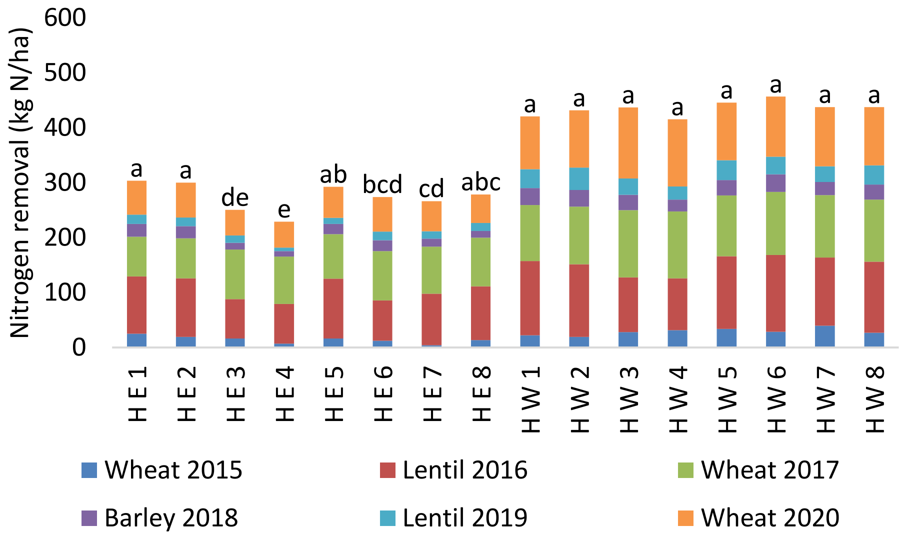

Figure 4. Cumulative N removal for the Hart East (H E) and Hart West (H W) sites for 2015 – 2020. Letters denote significant differences for totals at a given site.

Acknowledgements

Trial co-operators Bill Trengove, Matt Dare, Vic DPI for loan of the subsoil manuring machine, Jim Maitland for providing chicken litter at the Hart site and the Hart Field-Site Group and SARDI Clare for providing facilities for grain quality analysis.