Subsoil amelioration – results from year two

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Key findings

- Grain yield at Hill River was increased on two soil types by 12% and 33% through the addition of soil amendments to the surface or subsoil.
- There was no yield difference between applying amendment to the surface or subsoil in 2016, except at one of the seven sites sown to lentils.
- There was little difference between applying large rates of synthetic fertiliser or applying 20 t/ha chicken litter.

Why do the trial?

Subsoil constraints are known to have a huge impact on grain yields in the Mid-North of SA. Trials in other regions including SW 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, yield gains in the first season have covered these costs in Victoria.

How was it done?

Plot size	2.5 m x 12.0 m
Seeding date	Hill River: 18th May Hart: 17th May Bute: 12th May
Base treatments applied in 2015	Hill River: Trojan wheat, 120 kg/ha 32:10 kg/ha IBS, 160 kg/ha post emergent urea
	Hart: PBA Hurricane XT Lentil 60 kg/ha MAP IBS
	Bute: Compass barley 60 kg/ha DAP IBS, 50 kg/ha post emergent urea

Seven randomised complete block design trials with three replicates of the same eight treatments 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.

Soil types

Hart east	Calcareous gradational clay loam High pH and moderate to high ESP below 30cm
Hart west	Calcareous loam High pH, Boron and ESP below 30cm
Bute northwest	Calcareous transitional cracking clay High pH, Boron and ESP below 30cm
Bute mid	Calcareous loam High pH, Boron and ESP below 60cm
Bute southwest	Grey cracking clay with high exchangeable sodium at depth High pH, Boron and ESP below 30cm
Hill River east	Black cracking clay
Hill River west	Loam over red clay Moderate ESP below 60cm and moderate Boron below 90cm

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. No further treatments have been made to the plots since 2015.

The trials at Hill River were sown in both 2015 and 2016 using a commercial parallelogram knifepoint and press wheel seeder on 250mm spacing. In 2015 the Hart west trial was sown using a John Deere 1980 single discs on 152 mm (6") row spacing, closer wheels and press wheels and the Hart east trial was sown using narrow points on 225 mm (9") row spacing. Both sites at Hart were sown with narrow points and presswheels in 2016. In 2015 the Bute trials were re sown due to poor establishment using a 6 row plot seeder with narrow points and press wheels on 225 mm spacing. In 2016 the Bute sites were sown with a Concord seeder on 300 mm spacing with 150 mm sweep points and press wheels.

Commercial rates of seeding fertiliser, post emergent urea and pesticides were applied by the growers in their standard paddock operations over the top of all trial treatments to provide adequate nutrition and crop protection for the control treatments.

The rate of chicken litter (20 t/ha) was used in these trials based on the rate being used in south western Victoria where the large yield responses have been observed. To assess if the results are coming directly from the nutrition in the chicken litter the MAP, MoP, SoA, Urea (3 t/ha combo) treatment is designed to replicate the level of nutrition that is found in an average analysis of 20 t/ha of chicken litter. This treatment is 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 1. Treatment list for the seven 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	MAP, MoP, SoA, Urea	No	Surface
7	MAP, MoP, SoA, Urea	Yes	Surface
8	MAP, MoP, SoA, Urea	Yes	Subsoil

Table 2. Average nutrient concentration from the three sources used in Hart subsoil manuring trials 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

Assessments including segmented soil tests to 120 cm, plant establishment, Greenseeker NDVI, grain yield and grain quality were conducted in 2015 and 2016 and results analysed using Genstat ANOVA.

In 2016, the Bute Mid and SE sites were affected by hail prior to harvest which may have affected results.

Results and discussion

Hill River sites

Grain yield at the Hill River sites averaged 7.85 t/ha and 8.00 t/ha for the east and west sites, respectively (Table 3). The main treatment effect was from the addition of either the 20 t/ha of chicken litter or the '3 t/ha combo' of MAP, MoP, SoA and urea in 2016. There was no significant difference between these two amendments and the response was irrespective of the position they were placed (surface or in the subsoil). The amendments increased grain yield by 0.85 t/ha at the east site with the red loamy clay soil and 2.1 t/ha for the higher yielding west site on black cracking clay soil.

Grain protein was also significantly affected by the application of either of the amendments increasing protein from 9% to 10.2% at the east site and 8.8% to 10.7% at the west site. Test weight appears to have been reduced with the application of the 3 t/ha combo to the subsoil. However, it was also lower in ripping alone at the west site.

Table 3. NDVI captured 19th July, grain yield and grain quality for the Hill River subsoil manuring trials in 2016.

Treat.	Nutrition	Ripping	Placement	Hill River East NDVI 19th Jul	Grain yield (t/ha)	Protein (%)	Test weight (kg/hL)	Screenings (%)	Hill River West NDVI 19th Jul	Grain yield (t/ha)	Protein (%)	Test weight (kg/hL)	Screenings (%)
1	Nil	No	Nil	0.39	7.27	9.0	72.2	2.0	0.66	6.16	8.9	70.8	1.6
2	Nil	Yes	Nil	0.45	7.14	9.1	72.1	2.0	0.61	6.68	8.8	69.0	2.0
3	20 t/ha chicken litter	No	Surface	0.52	8.37	10.8	72.0	2.0	0.62	8.41	10.0	71.4	1.6
4	20 t/ha chicken litter	Yes	Surface	0.54	8.25	11.2	71.7	2.0	0.68	8.61	10.4	71.1	1.8
5	20 t/ha chicken litter	Yes	Subsoil	0.54	7.99	11.4	72.2	2.1	0.67	8.66	11.6	71.5	1.5
6	MAP, MoP, SoA, Urea	No	Surface	0.60	7.91	11.0	72.3	2.1	0.62	8.68	10.3	70.6	1.7
7	MAP, MoP, SoA, Urea	Yes	Surface	0.56	7.69	11.7	72.4	1.9	0.60	8.56	10.3	70.2	1.8
8	MAP, MoP, SoA, Urea	Yes	Subsoil	0.52	8.17	11.3	70.7	2.3	0.63	8.22	11.8	69.3	1.9
			LSD (P≤0.05)	0.05	0.72	0.7	ns	ns	0.04	0.68	0.7	ns	ns

Hart sites

Lentil Greenseeker NDVI was reduced at the east site in the surface applied 3 t/ha combo treatment indicating reduced biomass (Table 4). At the west site the treatment NDVI was increased with the addition of 20 t/ha chicken litter to the surface. Lentil NDVI results were not reflected by grain yield at the east site where grain yield was maximised in the nil nutrition treatments and the 20 t/ha chicken litter applied to the subsoil. At this site the 3 t/ha combo treatment applied to the surface with ripping and applied to the subsoil also produced equal highest yields.

At the west site NDVI captured on the 12th August has an inverse relationship with grain yield. Where the lowest biomass treatments produced the greatest grain yield. These included the nil nutrition treatments, the 20 t/ha chicken litter applied to the subsoil and all of the 3 t/ha combo treatments. Of the two Hart sites the west site has the higher levels of subsoil constraints with high levels of boron below 30 cm.

Table 4. NDVI captured on 12th August, grain yield and grain quality for the Hart subsoil manuring trials in 2016.

Treat.	Nutrition	Ripping	Placement	Hart East NDVI 12th Aug	Hart East Grain yield (t/ha)	Hart West NDVI 12th Aug	Hart West Grain yield (t/ha)
1	Nil	No	Nil	0.55	2.64	0.41	3.43
2	Nil	Yes	Nil	0.53	2.71	0.48	3.35
3	20 t/ha chicken litter	No	Surface	0.53	1.82	0.63	2.53
4	20 t/ha chicken litter	Yes	Surface	0.62	1.83	0.62	2.39
5	20 t/ha chicken litter	Yes	Subsoil	0.53	2.76	0.47	3.36
6	MAP, MoP, SoA, Urea	No	Surface	0.45	1.88	0.44	3.55
7	MAP, MoP, SoA, Urea	Yes	Surface	0.46	2.38	0.42	3.16
8	MAP, MoP, SoA, Urea	Yes	Subsoil	0.56	2.49	0.48	3.30
		LSD (P≤0.05)	*Fpr = 0.053	0.10*	0.53	0.06	0.44

Bute sites

The middle (M) and south east (SE) sites were affected by hail prior to harvest in 2016. There was also minor hail damage observed in the north west (NW) site.

NDVI values at all Bute sites were measured on 20th July and by this time all treatments produced values greater than 0.71 and results were not significantly different. However, the results for the mid site indicate that biomass was slightly lower in the nil nutrition treatments (Tables 5 a, b and c).

At the NW site grain yield was maximised in the two nil nutrition treatments averaging 6.65 t/ha indicating that the farmer practice of 60 kg/ha of DAP at sowing and 50 kg/ha post emergent urea was enough to produce maximum yield at this site (in March 2015 153 kg of available soil N was measured to a depth of 120 cm). Chicken litter and the 3 t/ha combo treatments applied to either the surface or subsoil with ripping produced the lowest grain yields averaging 6.22 t/ha. Grain yield was lower at the SE site and there was a significant positive response to addition of either amendment when applied to the surface without ripping. Chicken litter applied to the surface with ripping also performed well at the SE site. Grain yield at the Mid site averaged 5.54 t/ha and was not significantly affected by treatment.

Grain protein was lowest in the nil nutrition treatments at all sites. Ripping in these nil treatments increased protein by 1% at all three Bute sites. This may be attributed to the soil disturbance during ripping and therefore increased N mineralisation. Poor establishment and low grain yields in 2015 in these treatments could also explain the difference at the NW and SE sites as grain N removal was lower in these treatments (Table 6). When comparing among the other treatments 3 – 8, deep ripping produced higher protein (approximately 1%) compared to the same nutrition treatments applied to the surface. This response occurred for all sites and amendments accept for the mid site with chicken litter.

Other grain quality parameters performed as expected with higher nutrition treatments producing generally lower test weight, lower retention and higher screenings. The inclusion of ripping in the nil nutrition treatment in 2015 had a slight negative impact on these attributes at all three sites.

Table 5. NDVI captured on 20th July, grain yield and grain quality for the Bute subsoil manuring trials a) north west, b) south east and c) middle in 2016.

a)

Treat.	Nutrition	Ripping	Placement	Bute NW NDVI 20th Jul	Grain yield (t/ha)	Protein (%)	Test Weight (kg/hL)	Retention (%)	Screenings (%)
1	Nil	No	Nil	0.86	6.65	13.4	63.9	85.8	4.4
2	Nil	Yes	Nil	0.86	6.64	14.6	64.6	82.2	6.2
3	20 t/ha chicken litter	No	Surface	0.86	6.44	16.5	60.0	72.2	11.4
4	20 t/ha chicken litter	Yes	Surface	0.87	6.22	17.2	61.3	72.7	11.3
5	20 t/ha chicken litter	Yes	Subsoil	0.86	6.22	17.0	61.7	74.0	10.8
6	MAP, MoP, SoA, Urea	No	Surface	0.85	6.46	16.2	62.2	76.5	8.9
7	MAP, MoP, SoA, Urea	Yes	Surface	0.87	6.17	17.2	62.1	74.7	9.9
8	MAP, MoP, SoA, Urea	Yes	Subsoil	0.87	6.19	17.0	61.9	73.2	10.9
			LSD (P≤0.05)	ns	0.32	1.0	2.4	3.5	2.0

b)

Treat.	Nutrition	Ripping	Placement	Bute SE NDVI 20th Jul	Grain yield (t/ha)	Protein (%)	Test weight (kg/hL)	Retention (%)	Screenings (%)
1	Nil	No	Nil	0.86	4.85	12.1	65.6	88.6	3.2
2	Nil	Yes	Nil	0.86	4.99	13.4	63.9	86.8	4.0
3	20 t/ha chicken litter	No	Surface	0.86	5.38	16.2	61.5	71.9	10.5
4	20 t/ha chicken litter	Yes	Surface	0.87	5.37	17.1	60.9	71.0	11.4
5	20 t/ha chicken litter	Yes	Subsoil	0.86	4.92	17.4	61.6	75.1	9.1
6	MAP, MoP, SoA, Urea	No	Surface	0.86	5.55	16.5	62.7	76.2	8.3
7	MAP, MoP, SoA, Urea	Yes	Surface	0.86	5.02	17.0	61.7	72.5	10.1
8	MAP, MoP, SoA, Urea	Yes	Subsoil	0.86	5.14	17.1	61.6	75.4	8.9
			LSD (P≤0.05)	ns	0.33	1.2	1.6	3.2	1.5

c)

Treat.	Nutrition	Ripping	Placement	Bute Mid NDVI 20th Jul	Grain yield (t/ha)	Protein (%)	Test weight (kg/hL)	Retention (%)	Screenings (%)
1	Nil	No	Nil	0.71	5.45	10.3	68.2	95.1	1.4
2	Nil	Yes	Nil	0.77	5.42	11.1	68.0	91.4	2.4
3	20 t/ha chicken litter	No	Surface	0.87	5.35	16.4	62.4	79.4	7.5
4	20 t/ha chicken litter	Yes	Surface	0.87	5.59	16.1	61.3	76.4	9.0
5	20 t/ha chicken litter	Yes	Subsoil	0.86	5.56	15.6	62.8	77.2	8.3
6	MAP, MoP, SoA, Urea	No	Surface	0.86	5.48	15.3	61.8	78.5	7.2
7	MAP, MoP, SoA, Urea	Yes	Surface	0.86	6.07	16.0	62.0	77.3	7.8
8	MAP, MoP, SoA, Urea	Yes	Subsoil	0.85	5.38	16.9	61.8	77.7	7.7
			LSD (P≤0.05)	ns	ns	1.2	1.6	4.7	2.1

Table 6. Wheat grain N removal for the NW, SE and Mid site at Bute, 2015.

Treat.	Nutrition	Ripping	Placement	2015 grain N removal Bute NW	Bute SE	Bute Mid
1	Nil	No	Nil	55	51	63
2	Nil	Yes	Nil	21	18	62
3	20 t/ha chicken litter	No	Surface	43	37	83
4	20 t/ha chicken litter	Yes	Surface	19	25	76
5	20 t/ha chicken litter	Yes	Subsoil	19	*	72
6	MAP, MoP, SoA, Urea	No	Surface	46	44	84
7	MAP, MoP, SoA, Urea	Yes	Surface	23	24	74
8	MAP, MoP, SoA, Urea	Yes	Subsoil	24	27	75

Summary / implications

There have been large yield responses reported from subsoil manuring in high rainfall environments, particularly south western Victoria. However in recent seasons with lower rainfall these yield responses have declined. The results from the first season of the Hart and Bute trials (2015) were negative with the high nutrition treatments and deep ripping producing lower grain yields than the nil. Responses at all seven sites in 2016 were better than the first year due to better crop establishment and the wetter and cooler Spring.

Deep ripping alone did not have any significant impact on grain yield at any of the seven sites. However, at Bute there was a significant protein response indicating more access to nutrients. The response to either amendment at any given site was similar, with a few exceptions, indicating that after two seasons there is little difference between the two products. This suggests that the main response to the application of chicken litter is nutritional as the levels of nitrogen, phosphorus, potassium and sulphur are matched in each treatment.

The placement of the product, either chicken litter or the matched synthetic fertiliser (3 t/ha combo) did not have any impact at five of the seven sites. At the Hart west site placing chicken litter in the subsoil compared to the surface reduced Greenseeker NDVI (19th July) which in turn prevented a yield reduction from the application of the chicken litter. At the Bute SE site screenings were reduced by placing either amendment in the subsoil compared with the surface. It is likely that both of these responses are a result of delayed access to the nutrition in the amendment.