Ripping and subsoil placement of chicken litter and fertiliser

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Key findings

- The nil treatment produced the highest grain yield at all sites.
- Deep ripping treatments reduced early crop vigour and grain yield at all sites, however at the Clare sites the effect on crop vigour was less.
- Subsoil manuring produced higher grain yields than surface manuring at 4 of 5 harvested sites.

Why do the trial?

Subsoil constraints are known to reduce 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 the 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 attributed to the improvement in sub soil structure which increases the plant available water holding capacity of these soils.

Currently there is limited adoption of subsoil manuring due to access to chicken litter and specialised equipment to deep rip and place the litter. Although the cost associated with implementing these treatments is high, if significant yield gains can be made it has been possible to pay for the treatment in the first season at many of the Victorian sites.

How was it done?

Plot size	2.5 m x 12.0 m	**Base fertiliser**	Clare: 80 kg/ha 32:10 kg/ha IBS, 160 kg/ha post emergent urea Hart: 110 kg/ha 22:14 kg/ha IBS Bute: 80 kg/ha DAP IBS NW & SE 70 kg/ha post emergent urea Mid 140 kg/ha Post emergent urea
Seeding date	Clare: 6th May Hart: 3rd June Bute: 3rd June		

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 at Clare, 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 exchangeable sodium percentage (ESP) below 30 cm
Hart west	Calcareous loam High pH, Boron and ESP below 30 cm
Bute northwest	Calcareous transitional cracking clay High pH, Boron and ESP below 30 cm
Bute mid	Calcareous loam High pH, Boron and ESP below 60 cm
Bute southwest	Grey cracking clay with high exchangeable sodium at depth High pH, Boron and ESP below 30 cm
Clare east	Black cracking clay
Clare west	Loam over red clay Moderate ESP below 60 cm and moderate Boron below 90cm
Bute sand hill	Sand over sandy clay loam Low exchangeable cation capacity

The 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 3 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. The trials at Clare were sown using a commercial parallelogram knifepoint and press wheel seeder on 250 mm spacing. The Hart west trial was sown using a John Deere 1980 single disc at 152 mm (6") row spacing, closer wheels and press wheels. The Hart east trial was sown using narrow points at 225 mm (9") row spacing. The Bute trials were initially sown using a Concord on 300 mm spacing with 150 mm sweep points and press wheels, however due to poor establishment in deep ripped treatments these trials were re-sown using a 6 row plot seeder with narrow points and press wheels on 225 mm spacing.

Commercial rates of seeding fertiliser, post emergent urea and pesticides were applied by the growers in their standard paddock operations 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 trials from south western Victoria. To assess if the results are coming directly from the nutrition in the chicken litter the fertiliser treatment was added at rates to match the nutrition (N, P, K, S) in the average analysis of the chick 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 and will be referred to as 'matched fertiliser' throughout the article.

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	Matched fertiliser (NPKS)	No	Surface
7	Matched fertiliser (NPKS)	Yes	Surface
8	Matched fertiliser (NPKS)	Yes	Subsoil

Table 2. Average nutrient concentration from the 3 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 %		3.50 %	35.0
P	Phosphorus	1.72 %	8%	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		0.42 g/kg	0.4
Mn	Manganese	0.51 g/kg	8%	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 and results analysed using Genstat ANOVA. In selected plots at the Bute NE and Bute SE sites the plant counts were conducted in an area of the plot not affected by poor emergence, the same area of the plot was used for all other measurements including NDVI and harvest. Some plots, including all from treatment five were not harvested due to whole of plot having very poor emergence at Bute. These areas were later re-sown by hand to fill in the gaps. The Clare trials were unable to be harvested due to fire damage.

Results and discussion

Crop establishment was measured on selected treatments and the responses varied among sites. At the Hart east site the nil treatment had the best establishment (162 plants/m^2) with all other treatments being similar (average 118 plants/m^2). Fertiliser toxicity from the surface applied matched fertiliser treatment reduced emergence at the Hart west site to 82 plants/m^2. No significant difference was observed at the Bute Mid and SE treatments with average values of 164 and 141 plants/m^2 respectively. The effects at the Clare sites were only marginal with emergence values ranging from 201 and 212 plants/m^2.

No significant NDVI response was measured at the Hart east site. At the Hart west site the NDVI of plots treated with 20 t/ha chicken litter placed on the surface had the highest values (average 0.57), 190% of the nil and all other treatments were similar (Table 3). At the three Bute sites, treatments that received either 20 t/ha of chicken litter on the surface or the matched fertiliser treatment applied to the surface and not ripped produced the highest NDVI at the time of measurement. This indicates that although deep ripping did not reduce plant numbers it did reduce early vigour, which supports visual observations that were made throughout the season. The 20 t/ha of chicken litter on the surface and the matched fertiliser treatments also produced high values at the Clare sites, however, at Clare the impact of ripping was not as great.

Table 3. NDVI values from Greenseeker measurements at Hart and Bute (15th August 2015) and Clare (29th July 2015) subsoil manuring trials.

Treatment	Nutrition	Ripping	Placement	Greenseeker NDVI						
				Hart East	Hart West	Bute NW	Bute Mid	Bute SE	Clare East	Clare West
1	Nil	No	Nil	0.59	0.30	0.74	0.69	0.66	0.75	0.85
2	Nil	Yes	Nil	0.64	0.31	0.62	0.69	0.34	0.74	0.81
3	20 t/ha chicken litter	No	Surface	0.58	0.54	0.86	0.87	0.80	0.88	0.89
4	20 t/ha chicken litter	Yes	Surface	0.57	0.60	0.70	0.85	0.59	0.85	0.88
5	20 t/ha chicken litter	Yes	Subsoil	0.66	0.30	0.55	0.67	0.24	0.73	0.81
6	MAP, MoP, SoA, Urea	No	Surface	0.54	0.25	0.86	0.86	0.85	0.86	0.88
7	MAP, MoP, SoA, Urea	Yes	Surface	0.54	0.30	0.70	0.76	0.30	0.82	0.85
8	MAP, MoP, SoA, Urea	Yes	Subsoil	0.69	0.32	0.57	0.74	0.36	0.76	0.83
LSD (P≤0.05)				ns	0.09	0.08	0.09	0.16	0.05	0.02

The nil treatment produced the highest grain yields at all of the Hart and Bute sites ranging from 1.14 t/ha at Hart east to 2.82 t/ha at the Bute mid site (Table 4). The second highest yielding treatments at four sites were 20 t/ha chicken litter or matched fertiliser applied to the surface with no ripping.

Ripping had a strong negative impact on grain yield. At all five sites it reduced grain yield when comparing against the same levels of nutrition. In the nil, 20 t/ha chicken litter and the matched fertiliser treatment grain yield was reduced by of 42%, 55% and 42% respectively across the five sites by including ripping.

By comparing the same level of nutrition placed in the subsoil to that on the surface, the data shows that grain yield for the subsoil treatments is always greater or equal to that for the surface applied treatments. The average yield gain across the five sites is 0.14 t/ha for putting nutrition into the subsoil. Grain yield was similar at each site for chicken litter and the matched fertiliser treatments. There was no consistent difference between the chicken litter and matched fertiliser when comparing within the same level of placement. The average across all sites was within 0.01 t/ha for both surface and subsoil applications.

The Bute mid site produced the highest grain yields of all sites with an average of 2.62 t/ha. However, there was no significant response to treatment at this site.

Table 4. Grain yield (t/ha) from Hart and Bute subsoil manuring trials 2015. Bute SE treatment 5 not harvested due to poor establishment.

Treatment	Nutrition	Ripping	Placement	Grain yield (t/ha)				
				Hart East	Hart West	Bute NW	Bute Mid	Bute SE
1	Nil	No	Nil	1.14	1.28	2.07	2.82	1.97
2	Nil	Yes	Nil	0.74	0.86	0.66	2.70	0.61
3	20 t/ha chicken litter	No	Surface	0.45	0.94	1.38	2.72	1.13
4	20 t/ha chicken litter	Yes	Surface	0.19	0.56	0.55	2.52	0.77
5	20 t/ha chicken litter	Yes	Subsoil	0.52	0.73	0.56	2.50	*
6	MAP, MoP, SoA, Urea	No	Surface	0.35	1.20	1.49	2.71	1.36
7	MAP, MoP, SoA, Urea	Yes	Surface	0.11	0.67	0.70	2.44	0.74
8	MAP, MoP, SoA, Urea	Yes	Subsoil	0.40	0.75	0.75	2.53	0.87
LSD (P≤0.05)				0.21	0.27	0.36	ns	0.36

Grain protein varied greatly across treatments at all sites (Table 5). Not surprisingly there was generally an inverse relationship where, as grain yield increased protein was reduced. Therefore, the lowest proteins came from treatments with no chicken litter or matched fertiliser (average 13.6% for all sites). Ripping in the absence of nutrition treatments decreased yield and therefore protein increased to an average of 16.1% for all sites in the absence of chicken litter or matched fertiliser. Across all sites, subsoil applications of chicken litter or matched fertiliser compared to surface applications of the same treatment reduced protein by an average of 0.8% and 0.5% respectively (this difference was not significant when sites were analysed individually).

Table 5. Grain protein (%) from Hart and Bute subsoil manuring trials 2015. Bute SE treatment 5 not harvested due to poor establishment. Hart east treatments 4 and 7 did not produce a sufficient sample for quality testing.

Treatment	Nutrition	Ripping	Placement	Grain protein (%)				
				Hart East	Hart West	Bute NW	Bute Mid	Bute SE
1	Nil	No	Nil	12.6	12.9	15.2	12.7	14.7
2	Nil	Yes	Nil	15.3	17.0	18.3	13.1	17.0
3	20 t/ha chicken litter	No	Surface	20.5	21.2	18.0	17.4	18.6
4	20 t/ha chicken litter	Yes	Surface	*	20.2	19.4	17.3	19.0
5	20 t/ha chicken litter	Yes	Subsoil	18.2	19.0	19.1	16.6	*
6	MAP, MoP, SoA, Urea	No	Surface	20.5	20.0	17.8	17.7	18.4
7	MAP, MoP, SoA, Urea	Yes	Surface	*	20.8	19.0	17.4	18.2
8	MAP, MoP, SoA, Urea	Yes	Subsoil	19.0	19.9	18.7	16.9	18.0
LSD ($P \leq 0.05$)				3.0	2.0	1.0	1.0	1.3

All test weight values were greater than 71 kg/hL. The highest values came from the higher yielding Bute mid site with an average of 80.4 kg/hL.

Screenings values were generally high, with the nil treatments producing values from 5.5% at Bute SE to 8.2% at Bute mid (Table 6). The highest values were recorded at the Hart west site with surface applied applications of 20 t/ha chicken litter with an average of 33.3%. Of the three grain quality parameters the screenings value is what determined the receival grade for each treatment, AUH2 was the maximum grade achieved for all treatment and site combinations.

Table 6. Grain screenings (% < 2.0mm) from Hart and Bute subsoil manuring trials 2015. Bute SE treatment 5 not harvested due to poor establishment. Hart east treatments 4 and 7 did not produce a sufficient sample for quality testing.

Treatment	Nutrition	Ripping	Placement	Grain screenings (%<2.0mm)				
				Hart East	Hart West	Bute NW	Bute Mid	Bute SE
1	Nil	No	Nil	6.2	7.0	7.9	8.2	5.5
2	Nil	Yes	Nil	11.6	14.0	15.9	6.9	16.8
3	20 t/ha chicken litter	No	Surface	20.3	31.9	9.1	13.0	11.9
4	20 t/ha chicken litter	Yes	Surface	*	34.7	16.8	7.4	17.7
5	20 t/ha chicken litter	Yes	Subsoil	26.0	16.2	15.9	9.0	*
6	MAP, MoP, SoA, Urea	No	Surface	19.6	13.2	12.4	16.5	12.2
7	MAP, MoP, SoA, Urea	Yes	Surface	*	20.6	16.2	13.8	13.2
8	MAP, MoP, SoA, Urea	Yes	Subsoil	26.7	20.2	13.4	7.9	23.3
LSD ($P \leq 0.05$)				2.9	6.9	4.3	4.3	8.9

Summary / implications

Subsoil manuring has led to significant yield gains in high rainfall areas, particularly south western Victoria. These results were not replicated in the first year of trials in the Mid North and growers should be cautious before implementing such strategies in this region. The results from the Hart and Bute sites are partly due to poor establishment from dry conditions at the time of sowing in combination with the difficulty of producing a suitable seedbed with good seed to soil contact in deep ripped treatments.

The results highlight the importance of timely sowing and good establishment, particularly in seasons with a dry and hot finish. Trials where sowing was delayed were lower yielding than the adjacent commercial crop sown earlier.

Issues related to cloddy soil and crop establishment in deep ripped treatments are not expected to be on-going as the large clods are broken down overtime. All treatments in the seven trials are expected to continue to influence grain yield and quality for a number of years and will continue to be monitored and harvested in the coming seasons.

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These photos (above) were taken at the trial on Matt Dare's property on March 23rd 2015.