Amelioration of sandy soils - opportunities for long term improvement

Sam Trengove[1] and Stuart Sherriff[1],

[1]*Trengove Consulting*

GRDC project code: TRE00002

Keywords

- deep ripping, chicken litter, spading, amelioration

Take home messages

- Treatments combining deep ripping with surface applied nutrition (synthetic fertiliser or chicken litter) delivered the highest marginal returns, ranging from $934 - $1249/ha over three years.
- Depending on treatment cost these delivered return on investment ranging from 142 – 521%, over three years.
- Placement of high rates of chicken litter (20t/ha) or matched synthetic fertiliser in the subsoil did not provide any yield increase over surface application.

Background

Sandy dune soils are an important feature of the dune swale landscape of the northern Yorke Peninsula. Common characteristics of these sands include low water holding capacity, low organic matter, low nutrient availability, compaction, non wetting and high risk for wind erosion. In 2015 a trial site was established on a sand hill near Bute, SA, to investigate options for amelioration of these constraints. This paper will report on the results of these trials.

Method

Two trials were established on a sand hill near Bute in 2015 investigating treatments including deep ripping, spading, clay, chicken litter (rate and placement) and fertiliser. The soil at the site is described as a siliceous sand and the initial soil test results for the site are shown in Table 1. Treatment responses were measured in three consecutive cropping seasons of Grenade CL Plus wheat in 2015, Spartacus CL barley in 2016 and PBA Jumbo2 lentils in 2017. Fertiliser treatments were applied in each season, with all other treatments applied once only at trial initiation in 2015. The trials were randomized complete block designs with three replicates. Plots were 10m * 2m and were sown with knife points and press wheels on 250mm row spacing.

Table 1: Initial trial site soil test results, March 2015.

Soil depth	Available N	Colwell P	PBI	Colwell K	Available S	Organic Carbon	pH (CaCl2)	pH (H2O)	Cation Exchange Capacity
cm	kg/ha	mg/Kg		mg/Kg	kg/ha	%			
0-10	16	48	15	112	4.0	0.46	5.2	5.9	2.8
0-30	33	35	19	117	8.0	0.30	6.6	7.2	3.8
30-60	10	17	19	132	5.5	0.10	7.2	7.9	5.2
60-90	10	7	33	138	4.7	0.16	7.4	8.3	7.1
90-120	10	4	99	87	5.5	0.10	7.8	8.6	9.1

Treatment details

All income and costs quoted in this paper exclude GST.

Deep ripping: ripping was conducted with the Peries-Wightman subsoiler, with 2 tynes spaced 800mm apart and working to a depth of 450-500mm. This machine has 125mm diameter pipe behind each tyne for delivery of bulk products to near the bottom of the rip line. This had the effect of allowing some topsoil to flow back into the furrow behind the tyne, providing some 'topsoil inclusion'. This same machine was also used for subsoil manure application in Trial 2. Commercial application for deep ripping was costed at $60/ha.

Spading: Farmax spader working to 300mm deep. Commercial application for this was costed at $200/ha.

Clay: sourced from the 0-40cm layer from the adjacent swale, approximately 35% clay content. At 130t/ha commercial application for this was costed at $400/ha.

Chicken litter: Supplied from a broiler shed on the Wakefield plains. Nutrient analysis shown below (Table 2). At 5 and 20t/ha, commercial application costs were costed at $180 and $700/ha, respectively, including product, freight and spreading costs.

Fertiliser: P (MAP) and K (MoP) were applied to the soil at seeding in each season (Table 3) and Zn, Cu and Mn were applied as sulphates post emergent as a foliar application. N (urea and SoA) and S (SoA) were applied post emergent to the cereals in year 1 and 2 and for lentils in 2017 S was applied as gypsum prior to seeding. An additional trial assessing response to K, S and micronutrients found no response to these inputs from 2015-17 (data not presented). Therefore, the economic analysis has only costed the N, P & S as the applications of these more closely reflect farmer practice in the district. Commercial application for this was costed at $430/ha over the three years, including application costs for post emergent applications.

Table 2: Nutrient concentration of applied chicken litter.

Nutrient		Nutrient conc. dry weight	Moisture content	Nutrient conc. fresh weight	Kg nutrient per tonne fresh weight	Kg nutrient per 5 tonne fresh weight	Kg nutrient per 20 tonne fresh weight
N	Nitrogen	3.8%	8%	3.50%	35.0	175	699
P	Phosphorus	1.72%		1.58%	15.8	79	316
K	Potassium	2.31		2.13%	21.3	106	425
S	Sulfur	0.55%		0.51%	5.1	25	101
Ca	Calcium	3.48%		3.20%	32.0	160	640
Mg	Magnesium	0.73%		0.67%	6.7	34	134
Zn	Zinc	0.46g/kg	8%	0.42g/kg	0.4	2.1	8.5
Mn	Manganese	0.51g/kg		0.47g/kg	0.5	2.3	9.4
Cu	Copper	0.13g/kg		0.12g/kg	0.1	0.6	2.4
B	Boron	0.05g/kg		0.05g/kg	0.05	0.2	0.9
Fe	Iron	4.33g/kg		3.98g/kg	4.0	19.9	79.6

Table 3: Nutrient (kg/ha) applied in each season to fertiliser treatment.

Nutrient (kg/ha)	2015	2016	2017
N	99	76	9
P	20	20	20
S	21	21	60
K	50	50	50
Zn	0.26	0.26	0.26
Cu	0.09	0.09	0.09
Mn	0.77	0.77	0.77

Trial 1: this was a factorial trial, assessing four inputs

- Deep ripping - yes or no
- Annual fertiliser - yes (Table 3) or no
- Clay - yes (130t/ha) or no
- Chicken litter - 0, 5 or 20t/ha

The factorial of these gives 24 treatments (Table 5). Deep ripping, clay and chicken litter were applied once only in 2015, fertiliser treatments were applied each year.

Trial 2: this trial assessed

- placement of chicken litter or fertiliser: surface placement vs subsoil (300-400mm deep)
- spading
- matching nutrition of chicken litter with synthetic fertiliser: 20t/ha chicken litter vs matched NPKS from fertiliser. That is 1026kg/ha urea, 800kg/ha MAP, 420kg/ha SoA and 704kg/ha MoP. This synthetic fertiliser nutrition is actually marginally less than that supplied by 20t/ha chicken litter, however rates were applied before final chicken litter analysis was available.

For a complete list of treatments see table 6.

Table 4: Rainfall received in seasons 2015-17 and trial seeding dates.

	2015	**2016**	**2017**
GSR	204 (decile 1)	441 (decile 9)	209 (decile 1)
Annual rainfall	309 (decile 2)	696 (decile 10)	369 (decile 4)
Sowing date	May 20th	May 20th	May 17th

Results and discussion

Soil penetrometer resistance

Penetrometer resistance was measured prior to sowing in April 2016, one year after treatments were imposed (Figure 1). These measurements indicate much higher resistance in the control treatment compared with treatments that were ripped or spaded. Ripping was to a depth of approx 500mm, whereas spading was to a depth of 300mm. These working depths explain differences observed in penetrometer resistance between these treatments, where below 300mm resistance is greater in the spaded treatment, with the difference narrowing with increasing depth until there is no difference below ripping depth of 500mm. In general, crop root growth restriction starts when penetration resistance exceeds 1500kPa and severe restriction when resistance exceeds 2500kPa (Blackwell et al, 2016). Even with deep ripping, penetration resistance exceeds 2500kPa below 300mm, this may indicate an opportunity for further improvement.

Note: Industry standard for measurements to be taken at field capacity when comparing between sites and soil types. This site received 110mm rainfall in 6 weeks prior to measurements in March and April 2016, therefore it is assumed the soil was close to field capacity.

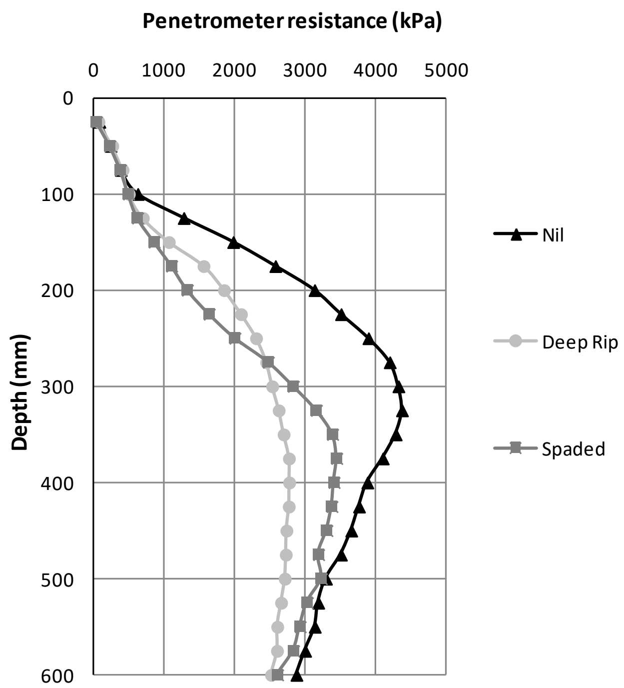

Figure 1: Penetrometer resistance measured in March 2016, 12 months after treatment application.

Soil nutrition

Chicken litter applied at 20t/ha in 2015 increased deep soil nitrogen (N) and sulphur (S) measured prior to seeding in 2016 and 2017 (Table 5). However, annual fertiliser and 5t/ha chicken litter were the same as the unfertilised control. Nitrogen recovery also indicates that only 18% of the N applied in 20t/ha chicken litter has been recovered in harvested grain. In addition to the measured deep soil N, the remaining 82% (573kg/ha) may remain in chicken litter (not yet mineralised), be in crop residues or soil organic matter or may have been lost through ammonia losses or leaching. Unless large losses have occurred this indicates there should still be considerable N in the system to support ongoing crop responses where chicken litter has been applied at 20t/ha. Soil testing will be conducted to measure further changes in soil organic matter this year.

Table 5: Nitrogen balance and deep soil N and S (0-1.2m) measured prior to seeding in the stated season for selected treatments.

	Total applied and removed, 2015-16 (kg/ha)				**2015**		**2016**		**2017**	
Treatment	N applied	N removed	NUE (% recovery)	S applied	N (kg/ha)	S (kg/ha)	N (kg/ha)	S (kg/ha)	N (kg/ha)	S (kg/ha)
Nil	0	63		0			68	20	43	74
Annual Fertiliser	175	128	37%	48	63	24	73	34	43	66
Chicken litter @ 5t/ha	175	103	23%	25			68	28	44	81
Chicken litter @ 20t/ha	699	190	18%	101			291	140	88	111
Lsd (0.05)							*70*	*40*	*28*	29

Trial 1: Crop growth and grain yield responses

Wheat 2015

Large growth responses occurred in year 1 (2015) in response to chicken litter, fertiliser and deep ripping. However, with low growing season rainfall (table 4) and hot conditions during grain fill in that season, the relationship between in season crop growth and yield was not linear (Figure 2). There was an optimum level of canopy production, approximately NDVI 0.5-0.65 at GS31, for optimising yield. Beyond this, the larger canopy produced used too much moisture pre anthesis and yields declined. Below this the crop was constrained by insufficient nutrition and lack of green leaf area. Therefore yields were highest for deep ripping and chicken litter at 5t/ha (Table 6). Combinations of these also produced high yields, but not significantly more than each individually. However, deep ripping in combination with standard fertiliser practice increased yield significantly compared with fertiliser alone. Treatments receiving chicken litter at 20t/ha had lower yields, due to the excessive biomass production. However, yields for these were not significantly less than standard practice, but not better than nil either. Grain quality for these treatments also declined, with high screenings, low test weight and high protein, many of these were graded as AUW1 (data not shown).

Similar results were observed in trial 2 (Table 7). The combination of applying chicken litter at 20t/ha, clay, deep ripping, spading and applying a normal fertiliser practice (treatment 5) produced the most spectacular failure in the trial. This treatment produced the greatest growth response. The spading process thoroughly mixed in the chicken litter and provided conditions conducive for increased mineralisation of nutrients in the litter, promoting increased biomass production. There was insufficient moisture to support this extra growth and the treatment hayed off severely, producing the lowest yields in the trial in that year (Table 7).

In 2015 safest way to apply chicken litter at 20t/ha was to place it in the subsoil, with no additional nutrition applied to the surface (treatment 10, table 7). Canopy biomass production was slow early, limited by low nutrition in the topsoil. However, the crop responded when the roots reached the chicken litter banded in the subsoil, approximately 6-8 weeks after sowing. The delayed biomass response appears to have reduced early moisture use and saved more for the grain filling period. This effect was negated where standard fertiliser was applied to the surface in combination with subsoil manure.

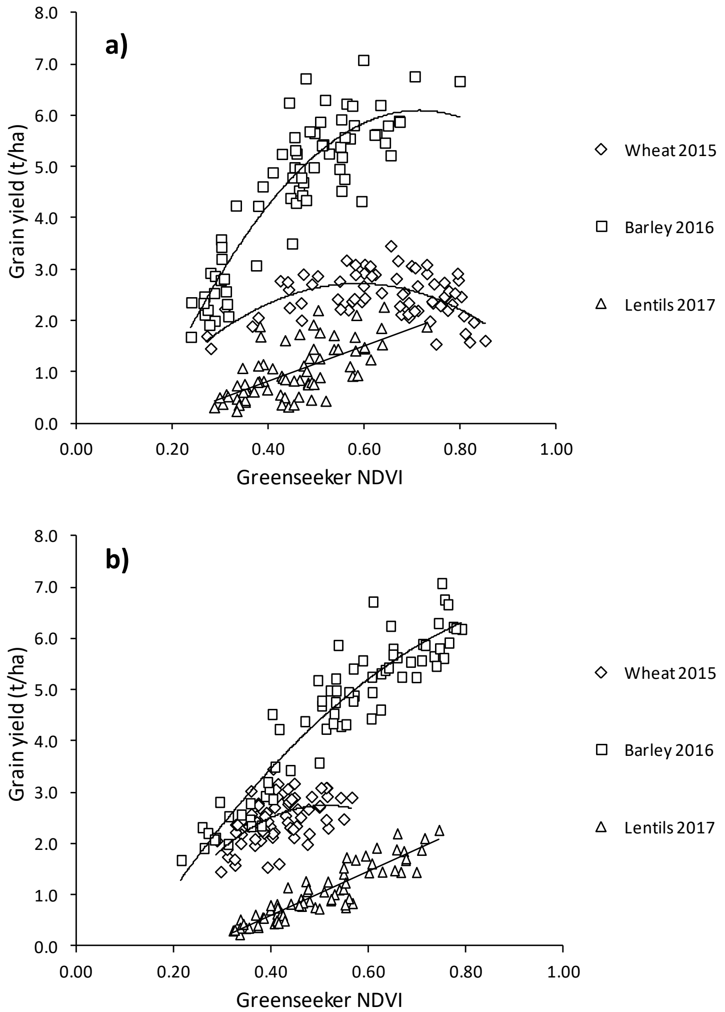

Figure 2 a) Greenseeker NDVI measured at GS31 for wheat and barley and early flower for lentil and grain yield. Wheat R^2 = 0.33, barley R^2 = 0.81, lentils R^2 = 0.41. **b)** Greenseeker NDVI measured mid-late grain fill (early Oct) and grain yield. Wheat R^2 = 0.30, barley R^2 = 0.88, lentils R^2 = 0.83.

Table 6: Trial 1 treatments, treatment costs, grain yields and economic returns.

Treatment	Chicken Litter (t/ha)	Ripping	Clay (t/ha)	Annual fertiliser	Amelioration cost ($/ha)	Grain yield (t/ha) Wheat 2015	Barley 2016	Lentil 2017	2015-2017 Summary ($/ha) Total costs incl. annual fert.	Gross income	Marginal return	ROI (%)
1	0	No	0	No	0	1.79	2.15	0.41	0	1170	0	
2				Yes	0	2.44	4.52	0.39	430	1999	399	93%
3			130	No	400	2.30	2.08	0.54	400	1336	-234	-58%
4				Yes	400	2.52	4.44	0.69	830	2181	181	22%
5		Yes	0	No	60	2.78	2.77	1.22	60	2035	805	1342%
6				Yes	60	3.11	4.83	0.97	490	2594	934	191%
7			130	No	460	2.39	2.59	1.10	460	1802	172	37%
8				Yes	460	2.54	5.16	1.00	890	2489	430	48%
9	5	No	0	No	180	2.88	2.90	0.57	180	1674	324	180%
10				Yes	180	2.89	4.98	0.57	610	2339	559	92%
11			130	No	580	2.45	2.66	0.72	580	1735	-15	-3%
12				Yes	580	2.35	4.84	0.74	1010	2206	26	3%
13		Yes	0	No	240	2.92	3.60	1.67	240	2659	1249	521%
14				Yes	240	2.55	5.85	1.23	670	2840	1000	149%
15			130	No	640	2.96	3.75	1.52	640	2549	739	116%
16				Yes	640	2.40	5.23	1.36	1070	2686	446	42%
17	20	No	0	No	700	2.50	5.66	0.97	700	2588	718	103%
18				Yes	700	2.53	5.60	0.68	1130	2405	105	9%
19			130	No	1100	1.97	5.54	1.08	1100	2496	226	21%
20				Yes	1100	2.15	5.85	0.78	1530	2436	-264	-17%
21		Yes	0	No	760	2.28	5.85	1.68	760	3007	1077	142%
22				Yes	760	2.34	6.15	1.38	1190	2914	554	47%
23			130	No	1160	2.03	5.94	1.55	1160	2890	560	48%
24				Yes	1160	2.26	6.54	1.48	1590	3054	294	18%
Lsd (0.05)						*0.58*	*0.68*	*0.30*		*406*	*406*	*96*

[a] Grain prices used to calculate gross income depended on grade. Wheat: AUH2 = $260/t, ASW1 = $245/t, AGP1 = $235/t, AUW1 = $235/t, FED1 = $215/t. Barley: Malt = $250/t, Feed = $225/t. Lentils = $600/t.

* Marginal return = gross income - amelioration and fertiliser costs - gross income of nil ($1170/ha).

Table 7: Trial 2 treatments, treatment costs, grain yields and economic returns.

Treatment	Ameliorant	Placement	Ripping	Spading	Clay (t/ha)	Annual fertiliser	Amelioration and fertiliser costs ($/ha)	Grain yield (t/ha)			Sum 2015 - 2017 ($/ha)		
								Wheat 2015	Barley 2016	Lentil 2017	Gross Income [a]	Marginal Return *	ROI (%)
1	None	-	No	No	0	No	0	1.87	2.30	0.69	1434		
2	20t Chicken Litter	Surface	Yes	No	130	Yes	1590	2.02	5.82	2.20	3133	109	7%
3	20t Chicken Litter	Subsoil	Yes	No	130	Yes	1730	2.50	5.67	1.57	2847	-317	-18%
4	None	-	No	Yes	0	No	200	2.64	2.44	1.64	2240	605	303%
5	20t Chicken Litter	Surface	Yes	Yes	130	Yes	1790	1.44	5.39	1.81	2650	-574	-32%
6	3t Synthetic Fert	Surface	Yes	No	130	No	2270	2.68	6.28	1.34	2860	-844	-37%
7	3t Synthetic Fert	Subsoil	Yes	No	130	No	2300	2.33	5.62	1.33	2682	-1052	-46%
8	3t Synthetic Fert	Subsoil	Yes	No	0	No	1900	2.37	5.08	1.03	2330	-1005	-53%
9	20t Chicken Litter	Subsoil	Yes	No	0	Yes	1330	2.49	5.73	1.08	2535	-230	-17%
10	20t Chicken Litter	Subsoil	Yes	No	0	No	900	3.12	5.28	1.76	3158	824	92%
Lsd (0.05)								*0.67*	*0.66*	*0.33*	*620*	*-814*	*136*

[a] Grain prices used to calculate gross income depended on grade. Wheat: AUH2 = $260/t, ASW1 = $245/t, AGP1 = $235/t, AUW1 = $235/t, FED1 = $215/t.

Barley: Malt = $250/t, Feed = $225/t. Lentils = $600/t.

* Marginal return = gross income - amelioration and fertiliser costs - gross income of nil ($1434/ha).

Table 8: nutrient analysis of lentil whole tops for selected treatments in Trial 1, sampled 30/7/17.

Treatment		Phosphorus %	Potassium %	Calcium %	Magnesium %	Sulfur %	Boron mg/kg	Copper mg/kg	Zinc mg/kg	Manganese mg/kg	Molybdenum mg/kg
Nil	1	0.37	2.1	1.08	0.36	0.25	28	5.1	85	147	0.40
Annual fertiliser	2	0.38	2.2	1.15	0.36	0.41	27	10.5	143	330	0.40
Clay	3	0.34	2.0	1.15	0.37	0.25	29	6.6	84	106	0.40
Ripping	5	0.40	2.5	1.21	0.38	0.27	29	5.4	81	127	0.43
5t/ha chicken litter	9	0.40	2.3	1.04	0.35	0.24	27	4.5	75	110	0.40
20t/ha chicken litter	17	0.48	2.7	1.12	0.48	0.28	29	3.5	75	100	0.87
Fert, clay, rip, 20t/ha CL	24	0.53	2.8	1.12	0.37	0.37	26	8.8	107	200	0.61
Lsd (0.05)		*0.03*	*0.3*	*ns*	*0.05*	*0.03*	*ns*	*1.9*	*13*	*43*	*0.19*

Barley 2016

Crop nutrition was the biggest factor influencing yield in 2016, a decile 9 growing season (Table 4), where response to chicken litter at 20t/ha > annual fertiliser > chicken litter at 5t/ha (Table 9). The yield response to chicken litter at 20t/ha could not be matched by combinations of annual fertiliser and chicken litter at 5t/ha. The addition of fertiliser to 20t/ha chicken litter generated an NDVI growth response (data not shown) over that of chicken litter alone but the yield response was not significant. In contrast to 2015, the relationship between in season growth and grain yield was positive (Figure 2). The highest nutrition treatments had high grain protein (data not shown) that reduced grain quality from malt to feed.

Deep ripping produced an average response of 0.59 t/ha (14%) increase across all other treatments (Table 10). The highest yielding treatments in the trial combined high nutrition and deep ripping and exceeded 6t/ha (Table 6).

Table 9: Chicken litter and annual fertiliser application effect on 2016 barley grain yields.

Chicken Litter (t/ha)	**Annual fertiliser**	**Grain yield (t/ha)**
0	No	2.40
5		3.23
20		5.75
0	Yes	4.74
5		5.23
20		6.04
Lsd (0.05)		*0.34*

Table 10: Deep ripping effect on 2016 barley grain yields.

Ripping	**Grain yield (t/ha)**
No	4.27
Yes	4.86
Lsd (0.05)	*0.21*

Lentils 2017

Lentils were highly responsive to deep ripping, with yields doubling (Table 11). Interestingly the actual yield increase in response to deep ripping is similar for each year, 0.65t/ha for wheat in 2015 (treatment 6 vs treatment 2, table 6), 0.59t/ha for barley in 2016 (Table 10) and 0.69t/ha for lentils in 2017 (Table 11). Lentils were also rate responsive to chicken litter (Table 12), but surprisingly there was a small negative yield response to annual fertiliser (Table 13). As a result, the highest treatment yields of up to 1.68t/ha were achieved by deep ripping in combination with either 5 or 20t/ha chicken litter (Table 6). District practice annual fertiliser application achieved the lowest yields in the trial of 0.39t/ha (treatment 2, Table 6) although this was not significantly lower than the nil treatment. Lentil grain yield had a positive linear correlation with in season NDVI (Figure 2).

Nutrient analysis of lentil whole tops indicates that the annual fertiliser treatment has the same phosphorous (P) and potassium (K) concentration as the unfertilised control, despite three annual applications since 2015 (Table 8). The fertilised treatment was higher for sulphur (S), copper (Cu), zinc (Zn) and manganese (Mn), these too have been applied as fertiliser. Chicken litter at 20t/ha has higher levels of P and K than the annual fertiliser treatment and 5t/ha chicken litter. It was also higher in magnesium (Mg) and molybdenum (Mo) (Table 8). In year 1 of the trial (2015) wheat leaf nutrient analysis showed that the 20t/ha chicken litter treatment had the highest levels for all nutrients measured (data not shown), but this has not been maintained two years later with calcium, boron, S, Cu, Zn and Mn having the same nutrient concentration as the unfertilised control.

Soil moisture measurements indicate a drained upper limit (DUL) at the site of 114mm to a depth of 1.2m (Figure 3). The unfertilised control has a crop lower limit (CLL) in lentils of 69mm, giving plant available water capacity (PAWC) of 45mm. CLL is reduced by deep ripping and the application of chicken litter at 20t/ha, increasing the PAWC. The combination of deep ripping and chicken litter application lowers the CLL further, to 46mm, increasing the PAWC to 68mm. That is a 23mm (51%) increase in PAWC. The treatment induced change in PAWC is highly correlated with lentil grain yield (Figure 4). Lentil yield increases at 67kg/ha/mm of increase in PAWC. Extrapolating the line indicates that lentil yield is zero when PAWC is reduced to 40mm. Treatments that lower the CLL and increase PAWC will likely help in seep management too, increasing the moisture required to refill the soil profile after harvest before deep drainage can occur.

Table 11: Deep ripping effect on 2017 lentil grain yields.

Ripping	Grain yield (t/ha)
No	0.67
Yes	1.36
Lsd (0.05)	*0.09*

Table 12: Chicken litter effect on 2017 lentil grain yields.

Chicken litter	Grain yield (t/ha)
0	0.78
5	1.05
20	1.21
Lsd (0.05)	*0.11*

Table 13: Annual fertiliser effect on 2017 lentil grain yields.

Annual fertiliser	Grain yield (t/ha)
No	1.09
Yes	0.94
Lsd (0.05)	*0.09*

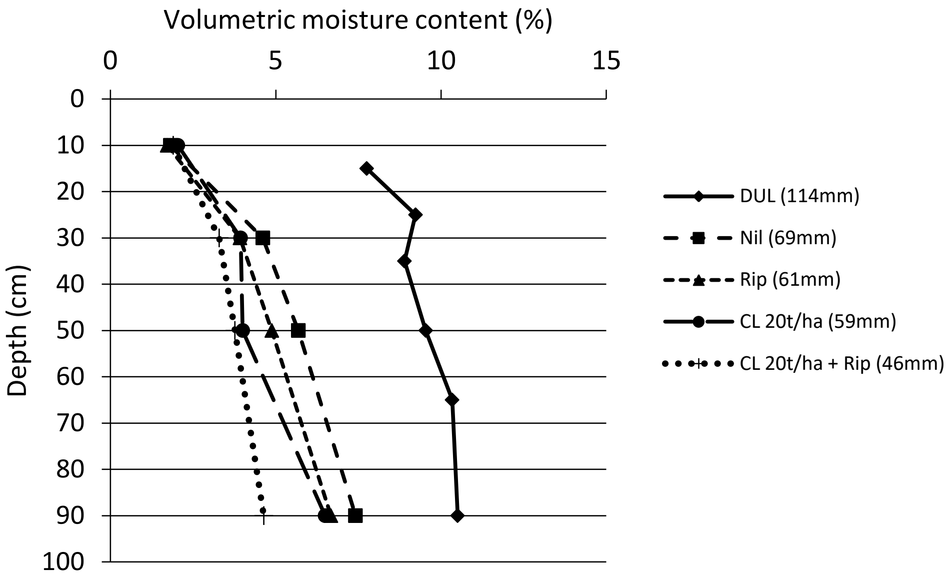

Figure 3: Trial site drained upper limit (DUL) and lentil crop lower limit (CLL) for selected treatments. Total mm of soil moisture represented by the line shown in brackets next to legend. DUL estimated from measurements at one wet up site adjacent to trial.

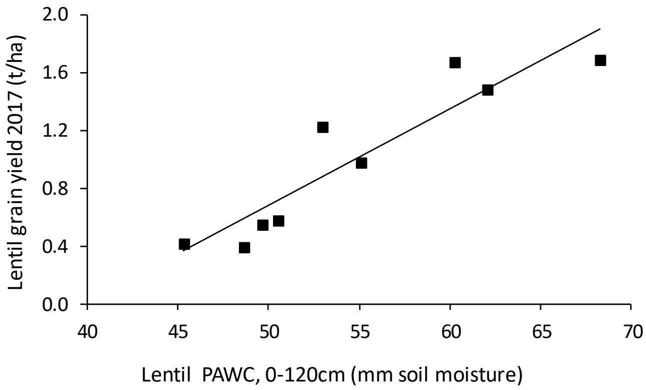

Figure 4: lentil plant available water capacity measured from 0-120cm post harvest in 2017 and grain yield, where y = -0.067x - 2.66, R^2 = 0.86.

Trial 2: Grain yield responses

Surface vs subsoil application

Grain yields for surface application of ameliorants were as good as, or better than comparative treatments with ameliorants placed in the subsoil (treatment 2 vs 3, treatment 6 vs 7, Table 7). In 4 of 6 treatment by year comparisons yields are not significantly different, and in 2 of 6, yields are higher with surface applications. However, as mentioned earlier, in 2015 with no additional nutrition applied to the surface (as opposed to treatment 3) there was an advantage for subsoil application of chicken litter (treatment 10, table 7). Delaying access to the chicken litter until the roots reached the banded rows in the subsoil, approximately 6-8 weeks after sowing, had the effect of managing the canopy, reducing early moisture use and saving more for the grain filling period.

Chicken litter at 20t/ha vs matched synthetic fertiliser (NPKS)

Grain yields for subsoil applications of chicken litter and matched synthetic fertiliser were the same in all three years (treatment 3 vs 7, Table 7). For surface applications there was no significant difference between them in cereal years, however there was a 0.86t/ha advantage in lentils for chicken litter at 20t/ha over matched synthetic fertiliser (treatment 2 vs 6, Table 7). Nutrient analysis of lentil whole tops (data not shown) shows P and K concentrations to be similar between these treatments, whereas a difference was observed in Trial 1 when comparing chicken litter at 20t/ha and commercial annual fertiliser (Table 8). However, as in Trial 1, the 20t/ha chicken litter treatments are higher in magnesium and molybdenum.

Spading

Spading without any additional inputs produced yield increases compared with untreated in 2015 and 2017, but not in 2016 where it was severely constrained by nutrition (treatment 4 vs 1, Table 7). While not directly comparable with deep ripping in Trial 1, the yield responses are of similar order. That is 0.77t/ha, 0.14t/ha (not significant) and 0.95t/ha for spading in 2015, 2016 and 2017, respectively. For deep ripping with no nutrition in Trial 1 they were 0.99t/ha, 0.62t/ha (not significant) and 0.81t/ha for 2015, 2016 and 2017, respectively (treatment 5 vs 1, Table 6).

Spading in combination with chicken litter at 20t/ha, clay, deep ripping and applying a normal fertiliser practice (treatment 5) produced low yields in 2015 due to excess biomass production and a dry finish to the season. Whereas in 2016 it had high yields, however in neither season was it significantly different to the unspaded comparative treatment (treatment 5 vs 2, Table 7). In 2017 lentil yields were 0.39t/ha higher in the unspaded (treatment 2). Treatments combining spading with standard fertiliser practices or moderate rates of chicken litter are needed to better assess how spading would be implemented commercially.

Return on Investment (ROI)

The unfertilised control generated a gross income of $1170/ha over three years in Trial 1. Annual fertiliser produced a ROI of 93% over the three years, where the N, P and S inputs were costed at $430/ha (treatment 2, Table 6). Given that annual fertiliser treatments are not increasing leaf tissue P and there was no response to S in a third trial (data not shown), it is likely that the application rates of these nutrients are much higher than necessary to achieve optimum yields. If the rates of these were reduced to replacement levels then the cost of annual fertiliser over three years would be reduced to $308 per hectare. This would in turn increase the ROI for annual fertiliser to 163%.

Treatments achieving higher ROI were deep ripping treatments, either alone or combined with annual fertiliser or 5t/ha chicken litter (treatments 5,6 and 13). Deep ripping alone had the highest ROI (1342%), which is driven by being the lowest cost treatment, but it does not generate the highest marginal return. The greatest marginal returns are produced by combining deep ripping with 5 or 20t/ha chicken litter or annual fertiliser (treatment 6, 13, 14 and 20). Therefore, investment decisions will depend on the available budget, with investment in deep ripping being highest priority followed by chicken litter or fertiliser.

Deep ripping combined with 5t/ha chicken litter produced the highest marginal return and ROI of 521%. However, there is still scope for improvement to this treatment by responding to the season. In the decile 9 growing season, 2016, barley yield for this treatment increased by 2.25t/ha from addition of fertiliser (treatment 13 vs 14, Table 6).

Deep ripping in combination with 20t/ha chicken litter produced the highest gross income, despite lower yields and poor grain quality in wheat in year 1 (treatments 21-24), but these treatments drop down the rankings in marginal return and ROI due to their high cost. However, based on trends to date these treatments are expected to continue to deliver positive responses, and if so the ROI for these treatments may improve over the longer term.

The addition of clay didn't pay, being a high cost treatment and not providing any significant yield responses.

Conclusion

Treatments of deep ripping and chicken litter applied in 2015 generated crop growth and yield responses for three consecutive seasons, and indicate opportunities for long term improvement of sandy soils, depending on soil constraints. The question still remains as to how long some of these treatment responses will last? Treatments combining deep ripping with surface applied nutrition (fertiliser or chicken litter) delivered the highest marginal returns, ranging from $934 - $1249/ha over three years. Depending on treatment cost these delivered return on investment ranging from 142 – 521%.

References

Blackwell P, Davies S & Isbister B, 2016. Identifying soil compaction. DAFWA website, https://agric.wa.gov.au/n/95

Acknowledgements

The research undertaken as part of this project was initiated from contributions from growers through both trial cooperation and the support of the GRDC (TRE00002), the authors would like to thank them for their support. Ongoing support has been provided by Northern and Yorke Landcare Project Community Capacity Component and SAGIT (TC116) and is gratefully acknowledged. Support is also gratefully acknowledged from Nigel Wilhelm and Peter Telfer (SARDI) and Max and Bill Trengove (cooperating land owners).

Contact details

Sam Trengove

0428 262 057

samtrenny34@hotmail.com

@TrengoveSam