"Subsoil Manuring Project" 2014/15

Subsoil placement of Soil Ameliorants to Improve Sodic Soils Trial
- Background, Experimental Protocols and Timeline

Background

The amelioration of soil constraints when they occur in the upper soil layers is relatively straightforward. As such applications of a range of fertilisers, lime, gypsum etc. can readily be applied to overcome constraints and/or correct deficiencies. Conditions in the soil further down the soil profile (ie deeper than ~ 200 mm) can also significantly limit crop and pasture production but are much more difficult to manage. These constraints can be physical and or chemical in nature. Deep soil acidity giving rise to aluminium toxicity is a straighforward example of a chemical constraint – and often occurs in soils with a productive history but inadequate use of lime. Structural problems such as sodicity and hard soils (hard pans, high bulk density) may also impose significant limitations to root growth, hydraulic conductivity and trafficability - all having considerable impacts on crop/pasture production. Past attempts to improve soil structure at depth (deep placement of gypsum, deep ripping) have not achieved lasting or consistent results.

Recent experiments on sodic soils in southern Victoria have demonstrated that large increases in crop yield are achievable when organic amendments are added at very high rates (20 t/ha) to the sub soil of crops grown on raised beds (for an overview see Sale *et al*. 2011). For instance Gill *et al.* (2008) found that wheat yield increased by up to 1.7 times that of untreated plots when organic amendments were placed at 40 cm depth and also reported that inorganic amendments (gypsum and MAP) had minor or insignificant effects. For the most part, increases in crop yield have been achieved through changes in soil structure and not through greater nutrient availability. In more detailed analysis of the experiment reported above, Gill *et al.* (2009) found that incorporation of organic matter at depth increased macroporosity and saturated hydraulic conductivity, reduced bulk density and resulted in root proliferation in the treated zone (see also Clark *et al.* 2007; 2009). As a result crops extracted more water from the sub soil and was a major factor contributing to increased yield. More recently Gill *et al.* (2012) reported that soils treated with organic amendments also captured and stored more water in deeper soil layers and this also contributed to higher yields.

Trials carried out since the original experiment referred to above have achieved similar results – depending on the prevailing seasonal conditions (Peries 2013). A simple economic analyses suggested that even with very high upfront costs ($1244-1345/ha) the return on investment was considerable. Using actual grain yields from four years at one site in Victoria, Peries (2013) calculated a return on investment of greater than $500 over 4 years on top of an investment earning 8% per annum. For another site the annuity was lower due to crop failure in one year. Indeed, sub-surface manuring is now carried out on a small commercial scale in Victoria. However, before wide scale adoption, a greater understanding of how long the improvement persists for will be required.

None of the work cited above was carried out on the sodic soils of inland NSW – found over large areas of the cropping zone from high to low rainfall. Even where soils cannot be strictly classified as sodic (ie > 6% exchangeable sodium), but have sodic-like behavior (eg. low permeability, poor root exploration), improvement in soil structure could be achieved through sub surface manuring. This trial addresses the potential to use sub surface manuring on the sodic-like soils of the Billabong creek near Holbrook in the higher rainfall zone cropping country of southern NSW.

Trial Design

The trial will be located on Tony and Vicki Geddes' "Billa" property (35° 39' 38.17" S, 147° 15' 52.8" E) near Holbrook in southern NSW. The soil type is a yellow sodosol that can commonly be waterlogged and rarely achieved 70% of potential yield (based on growing season rainfall). Results of a preliminary soil analysis of the trial site can be found in table 1.

Table 1 Conductivity, pH (in H_20 and $CaCl_2$), exchangeable catione, total cation exchange capacity (CEC), Al and Na as a proportion of CEC and Ca:Mg ratio of soil sampled as 0-10, 10-20, 20-40 and 40-60 cm depth sampled on 18/2/2014.

Depth	Conductivity	pH	pH	Exchangeable cations (meq/100g)					CEC	Al	Na	Ca:Mg
	(dS/m)	*(Ca)*	*(H2O)*	*Al*	*Ca*	*Mg*	*Kl*	*Na*		%CEC	%CEC	
0-10	0.083	4.1	4.5	0.79	1.79	0.20	0.47	0.020	3.27	24.25	0.61	8.95
10-20	0.035	4.1	4.6	0.72	0.95	0.16	0.3	0.020	2.15	33.43	0.93	5.94
20-40	0.024	4.6	5.2	0.18	2.53	0.73	0.48	0.030	3.95	4.58	0.76	3.47
40-60	0.016	5.6	6	0.15	4.66	2.13	0.53	0.020	7.49	2.00	0.27	2.19

These results revealed that the soil was highly acidic in the surface layers, trending to higher pH with depth. While not strictly sodic (ie not greater than 6% exchangeable sodium, Ca:Mg ratio < 2), this soil displays some of the structural characteristics that are consistent with sodicity – poor structural stability. At depth this may be due to the a low Ca:Mg ratio although not < 2. Moreover, crop performance on this and similar soils that have been adequately limed have been poor compared to what would be expected on the basis of water limited crop yield calculations (according to the owner).

Treatments and Application

To mimic earlier work completed in Victoria and to cover a range of organic amendments available, six treatments were identified. They were:

1. Control – no amendment
2. Deep Ripping with no amendment
3. Deep ripping with Lime at 1.4 t/ha
4. Deep ripping + Garden compost
5. Deep ripping + chicken manure
6. Deep ripping + Pig manure

Plots were ripped to 50 cm in depth and treatments applied on 28/4/2014. The pig and compost treatments were applied using approximately 20 t/ha of product (including moisture). The less dense (and drier) chicken manure was applied at a rate of 10 t/ha. The variation in moisture content between the products is being determined and will be used to calculate rates based on an air dry weight basis.

Attempts to use a machine developed to place low volumes (1-5 t/ha) of lime and gypsum at depth were not successful. Instead, each of the treatments that required the placement of a product at depth were applied in the following manner. An implement with 3 tynes spaced 80 cm apart was used. Funnels were adapted to allow large volumes of amendment to fall behind the tyne when tipped from a height of 100 cm above the base of the tyne (See Fig. 1). To achieve as even an application as possible over the 20 m length of plot, the amendment was weighed into four even portions for each tyne for each run (2 runs per plot) in each plot. Marking at 5 m intervals were used to help the applicators (one person for each tyne) to ensure that each portion was applied over the correct distance.

Figure 1. Deep ripping implement used to place organic amendment at depth.

In addition to all the treatments above, lime was spread on the surface of the experimental site at 2 t/ha before sowing. The site will be sown to wheat (cv. EGA Wedgetail) on 30/4/2014.

Design

A randomized complete block with six treatments and four blocks was used for the experiment. A treatment diagram can be found below. Plots were set out in two row each consisting of two replicate blocks. Plots were 4.8 m wide (ie 6 rip lines at 80 cm spacing) x 20 m long. A 20 m buffer was placed between the two rows of plots to allow enough room to operate equipment.

NW NE

	Rep	Plot		Treat	20 m	Treat		Plot	Rep
	1	1	5	COMPOST		RIPPING + LIME	3	13	3
	1	2	2	RIPPING		RIPPING	2	14	3
	1	3	1	CONTROL		COMPOST	5	15	3
	1	4	3	RIPPING + LIME		CONTROL	1	16	3
	1	5	6	PIG POO		CHOOK POO	4	17	3
5 m	1	6	4	CHOOK POO		PIG POO	6	18	3
				20 m		*20 m*			
	2	7	6	PIG POO		CHOOK POO	4	19	4
	2	8	3	RIPPING + LIME		CONTROL	1	20	4
	2	9	4	CHOOK POO		PIGPOO	6	21	4
	2	10	5	COMPOST		COMPOST	5	22	4
	2	11	2	RIPPING		RIPPING + LIME	3	23	4
	2	12	1	CONTROL		RIPPING	2	24	4

Sampling Protocols

Soils

Soils were sampled (using a corer of 5 cm in diameter) to a depth of 60 cm and separated into 6 x 10 cm horizons. These samples have been stored at Charles Sturt University (CSU) and will be analysed depending on yield results. Jason Condon (CSU) will be responsible for all soil analyses.

Crop

The crop will be grown and managed under normal commercial conditions. Dry matter at anthesis will be measured by cutting 4 x 0.25 m^2 quads randomly placed in the plot. Dry matter will be obtained by drying samples at 80°C for 48 hours and then weighing. Yield will be obtained by whole plot measurements using a plot header. Sub samples will be collected at harvest for protein analysis. In addition, dry matter at harvest will be determined in the same way as for anthesis (above). Further analysis of grain yield components will take place if there is a yield response.

Timeline for operations

DATE	OPERATION/TASK	PERSONNEL
PRE APRIL 2014	Initial soil sampling (Table 1), purchase of organic amendments, assessment of deep soil placement machine.	Tony Geddes, Jim Virgona
9/4/2013	Meeting with Holbrook Landcare to consider treatments, administration and logistics	Tony Geddes, Michael Gooden, Claire Hockley, Jim Virgona & Jason Condon
14/4/2013	Trial designed and pegged out. Sub soil machine found to be inadequate.	Jim Virgona, Tony Geddes
24/4/2014	Soil sampled to 60 cm in each plot	Jim Virgona
28/4/2014	Treatments applied – using modified machine	Tony Geddes, Michael Gooden, Jim Virgona and helpers!
30/4/2014	Site limed and sown	Tony Geddes
MAY	Site monitoring – establishment counts	Jim Virgona
JUNE-SEPT	Site monitoring – no specific activities, site to be grazed	Tony Geddes, Jim Virgona
OCTOBER	Anthesis cuts	Jim Virgona
DECEMBER	Harvest and yield analysis	Jim Virgona

References

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