The economics of subsoil manuring: the numbers are out

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Take home messages

- Subsoil manuring is expensive; it involves the incorporation of high rates (up to 20t/ha) of organic manures into clay subsoil and is estimated to cost in excess of $1100/ha depending on the location of the farm.
- Our field trials across the HRZ, using small, hand-harvested plots, found that large increases in grain yields continue to occur, over a four year period, with subsoil manuring.
- The large, continuing, and consistent increases in grain yield with consecutive crops mean that subsoil manuring is highly profitable.
- Research into the use of processed crop residues as subsoil amendments is now required to reduce subsoil manuring costs and the reliance on animal manures.

Background

The first objective of this project was to determine whether subsoil manuring would deliver grain yield increases at a range of sites across the Victorian high rainfall zone (HRZ). The practice involves the incorporation of high rates of organic manure such as poultry litter (up to 20 t/ha fresh weight) in rip-lines 80 cm apart, in the upper layers of dense clay subsoils at depths of around 30-40 cm. The practice has been developed to overcome the constraints to crop growth that result from the dense, sodic clay in the subsoil, which is widespread in cropping soils across the Victorian HRZ. The second objective was to determine whether the practice was profitable. There was considerable doubt as to the profitability of the practice, and that it would be too costly to ameliorate subsoils, so the question of profitability was crucial for this new practice.

At this gathering in Ballarat in 2012, we reported that significant grain yield increases occurred at field sites across the HRZ in 2009, 2010 and 2011. The story was the same for the 2012 crop where the grain yield increases exceeded all expectations. This was the year of the 'dry finish' which suited subsoil manuring. This is because subsoil manuring 'opens up' the clay subsoil, enabling the crop to use the deep subsoil water late in the growing season, and then to 'replenish' the subsoil water with summer, autumn, or in-crop rainfall that can readily infiltrate into the subsoil. The yield increases in the subsoil-manured crops in 2012 were around 2 t/ha of canola at one site, more than 4 t/ha of wheat at each of the 3 wheat sites, and 2.7 t/ha at the faba bean site. Over the 8 years of subsoil manuring research, we calculated that the average yields for wheat crops, for 12 site x season combinations, was 5.8 t/ha for the commercial crop and 9.3 t/ha for the subsoil-manured crop, which represented an average yield increase of 60%. Would these yield increases make the practice profitable?

This paper will focus on the costs of subsoil manuring, and whether the practice is profitable. These objectives will be determined for two field sites at Penshurst and at Derrinallum, where 4 consecutive grain crops were grown from 2009 to 2012.

Methodology

The approach taken for this economic analysis was to carefully analyse the inputs and outputs, and hence the costs and returns that were associated with the crop sequences at Penshurst and Derrinallum. The analysis used the actual grain yields and grain prices that occurred at the sites, over the four consecutive crops, and the costs of inputs for the crops. We employed a partial budgeting approach to compare the extra costs and the extra returns for the subsoil-manured crops, compared to the nil-intervention commercial crops, which grew side-by-side in replicated small plots in the paddocks.

Simply put, the analysis was all about "….what happened over 4 years of cropping on these HRZ cropping farms, when subsoil manuring was undertaken in 2009, compared to what happened with normal cropping practices over the same time".

Central to the analysis were the assumptions that were made to calculate the cost of incorporating the poultry litter into the subsoil. Here we were guided by discussions with grain producers and industry specialists about the costs associated with owning and operating a 300 HP tractor, and a custom-built subsoil-manuring implement, that would incorporate a high rate of 18-20 t/ha of poultry litter at the rate of 0.5 ha/hour into the subsoil. We assumed that the tractor would operate for 1500 hours per year, and this increased to 2000 hours per year to undertake subsoil manuring on 125 ha on the home farm, and a further 125 ha on a contract basis on neighbouring farms. The cost of the poultry litter (at $18/ t) and the freight ($0.083 /t/km) were based on prices ex-Bendigo in 2009-2010. In addition there was a handling cost of $80/ha to screen the litter and a further $20/ha to load the manure into the implement. Two labour units costing $100/ha were required for the intervention. There were extra harvesting and handling costs for the higher grain yields. We also assumed that there would be savings in fertiliser costs for three years, given the high rates of added nutrients in the litter. These savings lasted for three crops, based on the higher grain protein concentrations in wheat crops that persisted for three years. These savings were determined using prices from local suppliers that were quoted for urea, MAP and muriate of potash in 2009, 2010 and 2011.

The net benefit (in $/ha) was calculated at each site, for each of the four years, by subtracting the extra costs associated with the subsoil-manured plots, from the extra cash benefit in $/ha for the given year. This enabled the NPV (net present value) and the annual annuity for the 2009 investment in subsoil manuring, in 2009 dollars, to be determined over the four years (NPV) and on an annual basis, respectively.

Results and Discussion

Poultry litter incorporation costs

The per ha estimated costs associated with the 20 t/ha subsoil manuring intervention in 2009, at the Penshurst and Derrinallum sites, were higher than we had previously estimated (Table 1). The costs of purchasing and delivering poultry litter (the floor material used in sheds where batches of broiler chickens are grown into mature meat birds) to the implement that incorporates the litter into the subsoil, were disconcertingly high. They amounted to around 2/3 of the total cost of the subsoil manuring intervention. The estimated freight costs alone for transporting the litter 261 km from Bendigo to Penshurst amounted to $440/ha. The fact that the Derrinallum site was 61 km closer to Bendigo meant that the incorporation cost declined by around $100/ha. Then there was the estimated cost that would be required to screen the litter (to make it flow through the implement), and then load the screened litter into the implement, amounted to $150/ha. These estimated litter costs just highlight the benefits that *might* be possible if grain producers were able to somehow use their crop residues as a base material for an effective amendment that is incorporated into the subsoil. Preliminary PhD research findings at La Trobe University indicate that processed crop residues show promise as potential subsoil amendments.

Table 1. Costs for subsoil manuring (at 20t/ha) at the Penshurst and Derrinallum sites in 2009.

Costs of incorporating poultry litter	Penshurst	Derrinallum
Poultry litter – purchase ($/ha)	320	320
Poultry litter – freight ($/ha)	435	334
Poultry litter – handling ($/ha)	100	100
Poultry litter – labour ($/ha)	50	50
Poultry litter - TOTAL	905	804
Incorporation - machinery ($/ha)	168	168
Incorporation – operating ($/ha)	222	222
Incorporation – labour ($/ha)	50	50
Incorporation – TOTAL	440	440
TOTAL	$1345 /ha	$1244 /ha

The incorporation costs were based on the machinery operating at 0.5 ha/hour, due to the high rate of litter being incorporated into the subsoil. On the other hand, if the tractor and implement could travel faster and cover 1 ha/hour, then the per ha costs in labour, operating costs, and machinery overheads could be substantially reduced. Interestingly, we estimated the costs of incorporating the poultry litter at 10 t/ha, which did allow the machinery to cover 1 ha/hour. The total estimated subsoil manuring costs were reduced to $681 and $631/ha for the Penshurst and Derrinallum sites respectively. The estimated total incorporation cost component declined from $440 for 20 t/ha to $229/ha for 10 t/ha, after allowing for extra repairs and maintenance costs with the faster incorporation rate.

Partial budget analysis

The key finding from this analysis is that the payback period for the investment was surprisingly short (Table 2). In fact the large yield increases in the wheat crop at the Derrinallum site in 2009 (98% yield increase), and the high quality of the wheat from the subsoil-manured plots, meant that the investment was repaid in the first year. At Penshurst, the yield response to subsoil manuring was lower for the 2009 wheat crop, and this resulted in the payback occurring in the second year. Spring rainfall in 2010 was excessively high at Derrinallum (a decile 9 year), and this led to the failure of the canola crop in the second year. Less rain fell at Penshurst compared to Derrinallum in the spring of 2010, and this allowed a small canola crop to survive, but only on the subsoil-manured land.

Table 2. The yield increases, and extra costs and benefits resulting from the subsoil manuring at 20t/ha at the Penshurst and Derrinallum sites in 2009.

Yield increases costs and benefits	Penshurst				Derrinallum			
	2009 Wheat	2010 Canola	2011 Wheat	2012 Canola	2009 Wheat	2010 Canola	2011 Wheat	2012 Wheat
Yield increase (t/ha)	2.8	1.2	4.5	2.0	4.8	0.0	2.4	4.1
Extra costs ($/ha)	1398	27	67	39	1310	0	43	64
Extra benefits ($/ha)	830	791	1202	1100	1359	66	715	1086
NET BENEFIT ($/ha)	-568	764	1135	1061	49	66	672	1022

Having paid for the subsoil manuring at these sites with the grain yield increases from the 1st crop at Derrinallum, or from the 1st and 2nd crop at Penshurst, then any continuing increases in grain yield on subsoil-manured land with the 3rd or 4th crop would contribute to profit. Well such yield increases did continue with the 3rd and 4th crop. In fact the quite amazing responses in the 4th consecutive 2012 crop, following subsoil manuring in 2009 (discussed above), resulted in increased net benefits in excess of $1000/ha at the Penshurst and the Derrinallum sites (Table 2). Similar net benefits also occurred in 2012 at the 3-year site at Wickliffe, and at the 2-year sites at Dookie and Stewarton in north east Victoria.

Given the magnitude of the crop yield increases with subsoil manuring, and their continuation over time, then it is not surprising that the practice was found to be highly profitable. Investing in subsoil manuring in 2009 meant that these farmers were *very much* better off in terms of financial and economic criteria. At Penshurst we estimated that the average annual increase in wealth (Table 3), above the conventional way of using the land and capital, would be $546 per ha. The amount of this annuity was less at Derrinallum due to the canola failure in the very wet spring in 2010.

Table 3. The financial results from subsoil manuring with 20 t manure/ha at the Penshurst and Derrinallum in 2009, based on the extra costs and returns from the 4 successive crops between 2009 and 2012.

Financial performance	Penshurst	Derrinallum
NPV /ha	$1810	$1387
Annuity /ha	$546	$419
MIRR	76 %	N/A

NPV is the total addition to wealth per ha (in 2009 $s) over the 4 years from subsoil manuring in 2009, over and above other uses of capital that would earn 8% p.a. The Annuity is the extra annual addition to wealth per ha (in 2009 $s) from subsoil manuring in 2009, over and above other uses of capital that would earn 8% p.a. The MIRR is percentage annual return over the 4 years on the extra capital that was invested in subsoil manuring in 2009. This could only be calculated if there was a negative benefit in year 1.

The yield responses for the lower rate of litter incorporation (10 t/ha) were still quite large for the wheat crops, but smaller for the canola crops at the Penshurst and Derrinallum sites. However the costs were significantly less (Table 4).

Table 4. The yield increases, and extra costs and benefits from subsoil manuring with 10 tonnes of poultry litter per ha, at the Penshurst and Derrinallum sites in 2009.

Yield increases costs and benefits	Penshurst				Derrinallum			
	2009 Wheat	2010 Canola	2011 Wheat	2012 Canola	2009 Wheat	2010 Canola	2011 Wheat	2012 Wheat
Yield increase (t/ha)	2.0	0.6	3.6	0.6	2.7	0.0	1.9	2.5
Extra costs ($/ha)	717	**21**	**57**	22	674	0	**37**	45
Extra benefits ($/ha)	678	398	814	330	902	66	418	662
NET BENEFIT ($/ha)	-39	377	757	308	228	66	381	617

Using the results in Table 4, we estimated that the average annual increase in wealth (the annual annuity) for this lower rate of subsoil manuring at 10 t/ha, was lower than that from the higher rate of litter incorporation, but was still in excess of $300 / ha / year (Table 5). This is encouraging for growers who are not able to incorporate the higher rate of litter at 20t/ha.

Table 5. Financial results from subsoil manuring with 10 tonnes manure/ha at the Penshurst and Derrinallum sites in 2009, using crop yield responses at these sites from 2009-2012.

Financial performance	Penshurst	Derrinallum
NPV	$1114 /ha	$1024 /ha
Annuity	$336 /ha	$309 /ha
MIRR	239 %	N/A

Conclusions

Subsoil manuring with 20 t/ha of poultry litter, or with the half rate of 10 t/ha, was profitable and financially feasible, with net benefits above alternative uses of land and capital. The intervention resulted in a reasonably prompt return to positive net cash flow. These findings are quite illuminating, given the earlier view that any attempt to modify the properties of subsoils would be exorbitantly expensive and unlikely to be profitable or financially feasible.

The costs of subsoil manuring with 20 tonnes of poultry litter per ha, are estimated to be high, relative to conventional cropping, and were in excess of $1200/ha for the farms in this analysis. However the large increases in grain yield, occurring each year over at least a four year period, plus savings on fertiliser use, meant that there were large economic and financial benefits. There is now an urgent need for industry research to determine whether processed crop residues, or other farm sources of plant material, could be used as alternative subsoil amendments to lower subsoil manuring costs and to reduce the reliance on animal manures.

The analysis shows that the farmers at these two grain farms were likely to be substantially better off, as a result of investing in subsoil manuring in their paddocks in 2009. These results will increase the interest in subsoil manuring in the HRZ and will surely lead to increased adoption in the region.

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