The Western Port Catchment Landcare Network Inc

Sub Soil Compost Trial

Project Report

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CONTENTS

CONTENTS

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1 Introduction

In 2013, the Western Port Catchment Landcare Network (WPCLN) received funding under the Australian Government's Community Landcare Grants program for a project trialling the use of composts applied to the pasture root zone and surface on five farms across West Gippsland in Victoria. The location and photographs of the trial sites are shown below.

Fig 1. Location of subsoil compost trial sites (source: www.land.vic.gov.au)

This method of compost application was trialled on farms including an Officer South beef (vealer) enterprise, a lifestyle farm at Nar Nar Goon North running miniature cattle and horses, a Nayook property converting from potato cropping to beef and a Neerim North dairy farm. The use of compost was also monitored on a vegetable growing enterprise at Clyde.

The project monitored pasture productivity and a range of soil indicators. These were reported on and the results from placing composts and other waste materials into the root zone of pasture grasses were compared against placing the compost on the surface. Demonstration field days were held on four of the farms showing the methods of compost application, discussion with farmers around the use of alternative fertilisers and the soil health impacts of applying the products at the root zones.

It was anticipated that the application method would improve soil health through providing an initial feed source for soil biology whilst also opening up the soil and allowing additional oxygen and water into the profile.

Fig 2. Trial sites

2 Background

2.1 Trialling compost

The use of sub surface compost in these trials was used on the basis of potentially improving productivity across a range of agricultural enterprises including dairy, beef, vegetables and lifestyle farms. Past trials by Southern Farming Systems where organic matter had been placed below or at the root zone had successfully increased soil physical properties with the potential for increased crop production (Gill, Sale, Peries, Tang, 2009). This technique has only recently been applied in limited trials on pastures. The following table shows analytical results of manures and compost utilised in other trials in the Western Port Catchment over the past several years:

Table 2.1.1 Analytical results of manures and compost utilised in other trials in the Western Port Catchment

	Poultry manure	Farm made compost	Commercially available compost
pH	6.6-7.2	6.8-8.2	5.8-8.5
Organic carbon %	32.8-39.4	13.6-20.7	14.2-29
C/N ratio %	8-11/1	9.1-13.2/1	12.1–35.9/1
Nitrogen %	3.0-4.7	1.4-1.6	0.6-1.64
Phosphorus %	1.5-2.1	0.36-0.79	0.15-0.37
Potassium %	1.89-2.14	0.89-1.20	0.33-1.31

Compost provides a pre-digested source of nutrients, increased moisture absorption, substantial organic matter/organic carbon, a supply of chelating humic acids which can assist in the mobilisation of nutrients and an inoculation of a population of microorganisms much greater than a corresponding parent soil (Termorshuizen, A.J, 2004).

The nitrogen content for example is held in the humus of the compost as well as in the protoplasm of the microorganisms, and on predation by higher trophic levels of the soil food web (protozoa, nematodes) will release this bound nitrogen. (Clarholm, M, 1985)

2.2 *Trial sites*

The trial plots were situated on four pasture sites and one vegetable site. The pasture sites were divided into sub surface compost, surface applied compost, deep ripping without compost and a control area (no compost applied). The three plots on the vegetable area used three different compost application rates with a control area in each section.

The surface applied compost on the grazing properties was trialled in order to compare the effectiveness of the sub soil compost application. This is the more accepted application approach to applying organic inputs on grazing properties.

Initial benchmarking played an important role in establishing where these enterprises were perceived to be in terms of their productive capacity. This benchmarking consisted of a comprehensive field based visual soil assessment, soil analysis, analysis of the composts used, soil biological profiling using Solvita soil health test kits and pasture yield.

Monitoring throughout the trial period was undertaken. This included benchmarking visual observations of the soil, pasture and vegetable production and at the conclusion of the trial a repeat of these observations and analysis was again undertaken.

2.3 *Southern Farming Systems Sub Soil Compost Applicator*

This prototype equipment consisted of a large double tyne ripper with a tube/shoot approximately 100 mm in diameter that allowed compost to injected into the sub soil at a depth of about 150-200mm. The operation had its difficulties with compost bridging in the hopper thus making an even application below the soil at times quite difficult. The large double tyne ripper did cause substantial surface undulation with sods inverted at the soil surface at times requiring individuals to relocate the sods and in some instances actually rolling the surface that had been disturbed.

The rolling impacted on aspects of the cultivated plots and possibly negated any beneficial aspects likely to arise from the sub soil being able to access both moisture and oxygen through ripping (both with and without the compost).

Southern Farming Systems have since redesigned the unit which should eliminate most of the issues discussed above.

3 Methods

Compost was applied into the root zone and also surface on 5 farms (1ha paddocks). Methods included monitoring of pasture together with observations taking during the trial period. Soil temperature averages were also recorded. The photographs shown below include some of the application and monitoring methods.

Sub soilcompost applicator

Tyne rip (no compost)

Surface applied compost

Monitoring activities

Fig 3. Application and monitoring activities

3.1 *Rapid Soil Assessment Test (RSAT)*

A small pit measuring 20cm wide 20 cm long and 40cm deep (spade depth) was dug. The basis of the RSAT is the observation of a number of soil characteristics across the physical, biological and chemical attributes of a soil. These included organic matter depth, root depth and development, earthworm count, leaf colour, soil compaction, aggregate stability and soil structure. Properties included in this assessment but analysed by soil analysis included percentage organic matter, soil pH, Cation Exchange Capacity (CEC) and a suite of essential plant nutrients. Pasture condition and leaf colour were assessed along a 60 metre transect taken through the soil pit.

The individual observations are qualitatively assessed and given a score out of 9 based on descriptors for each soil characteristic.

This visual soil testing methodology has been trialled extensively across the Western Port and other Catchments and found to provide good qualitative data which, with other soil testing parameters, provides a good data base on which to assess a soil's health/quality (Cavagnaro, and Damsma, 2011, Alenson, 2013).

3.2 *Solvita Soil Respiration Test*

The Solvita soil test is a technology and method that allows the soil CO2 respiration of microorganisms to be measured in the field. As biological activity increases and organic matter cycles, CO2 is released. The rate of release is regarded as an indicator of soil health.

From the soil samples taken from within the quadrant for laboratory analysis a homogeneous sample was placed in the sample jars up to the fill line. An indicator probe is inserted into the soil, the lid is secured and kept at room temperature for 24 hours. The colour of the probe is compared with a supplied colour key which indicates the level of CO2 released and hence the degree of biological activity. The gradation is 1-5 with 5 being the healthiest most biologically active soil.

3.3 *Solvita soil health test illustrating coloured paddle indicating soil health*

The technology was invented by Dr. Brinton and compared with other methods in the field by Dr.John Doran's (USDA-ARS) soil quality laboratory at University of Nebraska. Based on this research, the USDA Soil Quality Institute now lists the Solvita kit as an alternative respiration testing procedure in its national soil-quality test kit program (Haney, et al Brinton, and Evans, 2008).

3.4 *Soil Analyses*

Soil samples from the initial sampling across the sites and the final sampling were analysed for a full spread of nutrients by Southern Cross Universities Environmental Analysis laboratory (EAL) based on the Albrecht Reams methodologies.

3.5 *Compost Analysis*

Green waste compost used in these trials was supplied by SITA Organics, Pinegro, Biomix Stanhope, Gibson Ground Spread (Dutson Downs), and Natural Recovery Systems assisted by Compost Victoria. The composts were analysed by Southern Cross University Environmental Analysis laboratory (EAL) for major and minor nutrients as well as importantly pH, organic carbon and carbon/nitrogen ratios. Green waste compost is generally lower in nutrients than a farm produced compost utilising animal/poultry manures and as such care has to be exercised in their use to avoid nitrogen tie-up when applied to the soil.

3.6 *Observations of pasture yield*

Pasture yield was measured using a Grass Master Pro pasture meter (www.novel.co.nz). It is a highly accurate electronic meter shaped like a wand that records the dry matter (DM) in kg/ha. It functions on the basis of a low voltage electric field that spreads out into the foliage near the probes base. Changes in the field relate to the water mass nearby and hence by difference to the dry matter of the foliage. A number of readings were taken and a mean calculated for the dry matter yield.

3.7 *Trial Site Set-up*

As shown in the following diagrams, a 1 hectare area of land was identified and photopoints were taken at each numbered letter.

Farm 1 Dairy

Site layout		**F3**		North				**D3**
						10m x		
		30m x 100m		30m x 100m		100m	30m x 100m	
		Compost	surface	Control		Sub-	Sub-Soiler	
		applied		(No Compost)		Soiler	(With Compost)	
		(belt spreader)				Ripped		
						(No		
						Compost)		
		Rate:	3.5 tonne				Rate:	3.5 tonne
	Gate							
		F2	**F1**	South		**C1**	**D2**	**D1**

Fig 4. Farm 1 Dairy trial site

Farm 2 Potatoes to Beef

Site layout		**A3**		North				**B3**
						10m x		
		30m x 100m		30m x 100m		100m	30m x 100m	
		Compost	surface	Control		Sub-	Sub-Soiler	
		applied		(No Compost)		Soiler	(With Compost)	
4in1 potash strip		(belt spreader)				Ripped		
						(No		
	gate					Compost)		
		Rate:	3.5 tonne				Rate:	3.5 tonne
	gate	**A2**	**A1**	South		**C2**	**B2**	**B1**

Fig 5. Farm 2 Potatoes to Beef trial site

Farm 3 Beef (vealers)

Site layout		**F3**		South				**A3**
						10m x		
		20m x 150m		2om x 150m		150m	20m x 150m	
		Compost	surface	Control		Sub-	Sub-Soiler	
		applied		(No Compost)		Soiler	(With Compost)	
		(belt spreader)				Ripped		
						(No		
						Compost)		
		Rate:	3.5 tonne				Rate:	3.5 tonne
	gate	**F2**	**F1**	North		**C1**	**A2**	**A1**

Fig 6. Farm 3 Beef (vealers) trial site

Farm 4 Lifestyle (miniature cattle and horses)

Site layout		**D1**						**B1**	
						10m x			
		30m x 80m		37m x 80m		80m	32m x 80m		
		Compost	surface	Control		Sub-	Sub-Soiler		
		applied		(No Compost)		Soiler	(With Compost)		
	SOUTH	(belt spreader)				Ripped			NORTH
						(No			
						Compost)			
		Rate:	3.5 tonne				Rate:	3.5 tonne	
		D3	**D2**	GATE ACCESS		**C2**	**B2**	**B3**	

Fig 7. Farm 4 Lifestyle (miniature cattle and horses) trial site

Farm 5 Vegetables

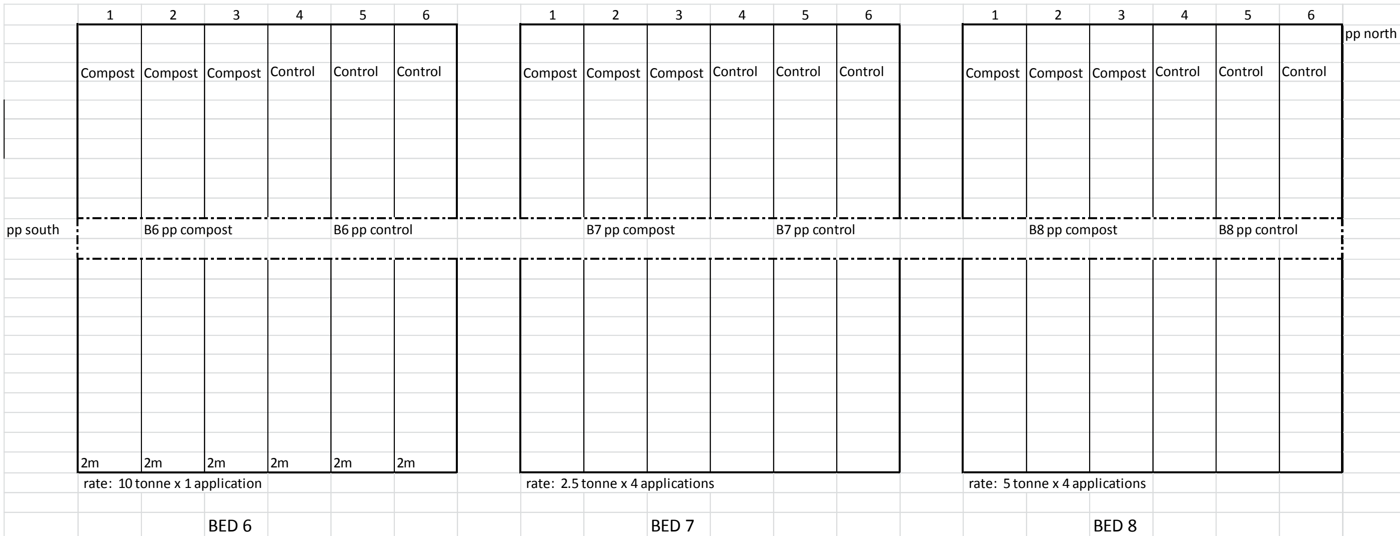

Fig 8. Farm 5 Vegetables trial site

4 Results and Discussion

4.1 Farm 1 Dairy enterprise

The Bransgrove property is a 260ha dairy property at Neerim North. The cows are rotationally grazed. The soils in these areas are described as red Ferrosols derived from older Volcanics. Texturally they would be described as a clay loam soil with well defined structure and good fertility. pH is strongly acidic with a high iron content. The site received the following treatments:

Treatment 1 Sub surface compost (10t/ha)
Treatment 2 Deep ripping no compost
Treatment 3 Control
Treatment 4 Surface applied compost (10t/ha)

The following table indicates results:

Table 4.1.1 Results Farm 1 Dairy

	BENCHMARK	Sub Soil Compost	Sub soil no compost	Control (nothing)	Surface
Total Pasture Yield kg/ha		**6,451**	**7, 097**	**9,701**	**11, 255**
RSAT (1-9)	**8.4**	**6.5**	**6.8**	**6.5**	**7.3**
pH (water)	**5.32**	**5.47**	**5.51**	**5.52**	**5.46**
Nitrate Nitrogen (ppm)	**4.8**	**9.8**	**7.3**	**13.4**	**11.8**
Ammonium Nitrogen (ppm)	**36.9**	**7.4**	**7.9**	**13.2**	**17.3**
Phosphorus (ppm)	**119**	**124**	**121**	**144**	**132**
Carbon (%)	**6.42**	**6.57**	**6.79**	**6.98**	**6.61**
Organic matter (%)	**11.2**	**11.5**	**11.9**	**12.2**	**11.6**
CEC (%)	**11.72**	**11.49**	**11.18**	**11.79**	**10.77**
Solvita (1-5)	**3.5-4**	**2**	**3**	**5**	**5**

Analysis of results

Rapid Soil Assessment Test

The average score across the observations was 6.9 (out of 9) indicating a soil of good quality with most prominent constraint being seen as varying pasture composition. End of trial observations were similar indicating no great change.

Worms and fungal activity were seen in both the sub soil compost strip which supported good clover growth and the surface applied compost strip. Dung beetles were also observed across the site. In the sub surface compost strip new roots were seen penetrating the fractured soil sods while in the rip only strip, longer feeder roots were observed. The compost appears to be cycling and releasing nutrients to plant roots.

Soil analysis

The benchmark pH of 5.3 (soil water) is slightly acid which indicates reasonably high levels of hydrogen in the soil complex. There was no significant change in pH over the time of the trial.

Available phosphorus of 119 ppm (Colwell extraction) indicate that phosphorus levels are more than adequate and did not change greatly over the time of the trial (120-130 ppm). Available nitrogen initially was (4.8 ppm November) with ammonia nitrogen registering 36.9 ppm, a level indicative of a block in the nitrogen cycle. Nitrate had risen to 9.8ppm in the sub surface compost strip, 7.3ppm in the ripped strip, 13.4ppm in the control and 11.8ppm in the surface applied strip.

Organic matter initially analysed at 11.2% with end of trial analysis indicating no great change. The surface applied compost did not show any great change.

Solvita

An initial reading of 3.5-4 (out of 5) indicated medium to good levels of microbial soil activity. There was an increase to 4 on the surface applied strip indicating the increased microbial activity in the compost. The sub surface compost strip remained the same.

Observations of pasture yield

Patchy growth over the entire trial strips with yellowing observed in August. Red legged earth mites on clover across the strips but less on the surface applied strips. At end of trial pasture was observed to be of poor quality across all strips. The highest pasture yield was recorded on the surface applied strips followed by the control with significantly less yield on the subsoil compost and ripped strips.

The following table compares the pasture growth for the four trial strips:

Table 4.1.2 Farm 1 pasture growth comparison

	Sub Soil	Rip	Control	Surface
5/12/2013	717 kg/ha	891 kg/ha	2299 kg/ha	2331 kg/ha
7/1/2014	1099 kg/ha	888kg/ha	1453kg/ha	1532 kg/ha
28/1/2014	38 kg/ha	153 kg/ha	369 kg/ha	382 kg/ha
3/6/2014	278 kg/ha	491 kg/ha	556 kg/ha	542 kg/ha
21/7/2014	305 kg/ha	275 kg/ha	218 kg/ha	544 kg/ha
11/8/2014	346 kg/ha	408 kg/ha	384 kg/ha	517 kg/ha
7/9/2014	280 kg/ha	421 kg/ha	416 kg/ha	516 kg/ha
15/10/2014	821 kg/ha	1030 kg/ha	1247 kg/ha	1792 kg/ha
12/12/2014	2267 kg/ha	2540 kg/ha	2759 kg/ha	3099 kg/ha
Total	**6,451kg/ha**	**7, 097kg/ha**	**9,701kg/ha**	**11, 255kg/ha**

Fig 9. Dairy pasture comparison

Farm 1 Summary

The benchmark visual assessment indicated that the soil was of good quality with varying pasture composition being the most noticeable constraint. Soil analyses indicated availability of all major nutrient elements and only the pH being in need of attention. This may be impacting on the soil microorganisms involved in nutrient cycling and nitrogen fixation.

Organic matter benchmark did not vary greatly over the trial period. The initial low nitrate nitrogen indicates that the organic matter is not cycling as the ammonium nitrogen is quite high. Conditions such as compacted soil, low pH, lack of moisture and temperature at the time of sampling all combine to restrict the activity of the required nutrient cycling microorganisms.

Interestingly the surface compost strip with a higher ammonium nitrogen level appeared to still be undergoing decomposition indicating that nitrate nitrogen may be on the increase.

The sub surface applied compost strips and the deep ripped without compost strip delivered the lowest pasture yield while the surface compost strip had the highest yield. Given that both the rip lines with and without compost were rolled due to surface displacement of the turf, any possible benefits would probably have been negated and may have restricted nitrogen cycling.

It was observed that plant roots are accessing the sub surface compost strips with both worm and fungal activity widespread. It would be expected that as the compost cycles the plant roots will access this supply of nutrients and deliver an increased dry matter yield. The surface applied compost is already yielding increased dry matter and that is expected to continue.

4.2 Farm 2 Potatoes to Beef enterprise

The Harington-Hawes property is a 68 ha property on the Powelltown Road Nayook. The property carries beef cattle which are rotationally grazed. The soils in these areas are described as red Ferrosols derived from Older Volcanics. Texturally they would be described as a clay loam soil with well defined structure and good fertility. pH is strongly acidic with a high iron content.

The trial site had previously been cropped for potatoes and was considered to be less productive than other areas on the farm. Prior to the trial the paddock received 300kg of 4 in 1 (super potash) in March, 100kg ha urea in June and, 150 kg of Grass Booster in September. Hay was cut in November. The site received the following treatments:

Treatment 1 Sub surface compost (10t/ha)
Treatment 2 Deep ripping no compost
Treatment 3 Control
Treatment 4 Surface applied compost (10t/ha)

The following table indicates results:

Table 4.2.1 Results Farm 2 Potatoes to Beef

	BENCHMARK	Sub Soil Compost	Sub soil no compost	Control (nothing)	Surface
Total Pasture Yield kg/ha		**9,278**	**9,251**	**10,632**	**12,501**
RSAT (1-9)	**6.9**	**6.8**	**6.6**	**7.1**	**7.6**
pH (water)	**5.53**	**5.64**	**5.92**	**5.95**	**5.73**
Nitrate Nitrogen (ppm)	**10.6**	**28.1**	**29.5**	**29.8**	**91.0**
Ammonium Nitrogen (ppm)	**33.9**	**5.8**	**6.9**	**11.2**	**14.4**
Phosphorus (ppm)	**147**	**175**	**139**	**161**	**177**
Organic matter (%)	**10.8**	**11.3**	**11.1**	**11.5**	**12.8**
Carbon (%)	**6.16**	**6.47**	**6.37**	**6.59**	**7.33**
CEC (%)	**13.28**	**13.62**	**15.5**	**15.99**	**16.66**
Solvita (1-5)	**3-3.5**	**3**	**3**	**4**	**4**

Analysis of results

Rapid Soil Assessment Test

The benchmark score across the observations was 6.9 (out of 9) indicating a soil of medium to good quality with most prominent soil constraints seen as soil structure where some compaction was indicated by both penetrometer and water infiltration. Pasture was considered fair. End of trial observations were similar indicating no great change.

Many new roots had managed to access the sub soil compost with good worm and fungal activity. It is apparent that the compost is starting to decompose and release nutrients to plant roots and stimulate soil biology.

Soil analysis

The pH of 5.53 (soil water) is slightly acid which indicates reasonably high levels of hydrogen in the soil complex. There was no significant change in pH over the time of the trial.

Available phosphorus levels of 147 ppm (Colwell extraction) indicate that phosphorus levels are more than adequate and did not change greatly over the time of the trial. Available nitrogen initially was 10.6 ppm and rose to an average of 29.0 ppm by the end of the trial. The surface compost strip had risen to 91.0ppm. It is considered that earlier lower levels in November may be due to lower soil temperatures where nutrient cycling microorganisms were not functioning to their optimum.

Organic matter initially analysed at 10.8 % with end of trial analysis indicating no great change except for the surface applied compost which registered levels at 12.8%.

Rapid soil assessment

Chris, Bruce & Del

Peter , Chris & Bruce

Trial site sub soiling demonstration field day

Fig 10. Rapid soil assessment and sub soiling

Solvita

An initial reading of 3-3.5 (out of 5) indicated that the soil was moderately low to medium in microbial soil activity although the reading was taken in October with lower soil temperatures affecting microbial activity. There was an increase to 4 on the surface applied strip indicating the increased microbial activity in the compost. The sub surface compost strip remained the same.

Observations of pasture yield

Early in the trial pasture growth was patchy over the subsoil and rip strips but improved in August where good growth was seen over the sub surface compost and surface applied strips. Growth in the control strips was also good. Red legged earth mite was seen over the whole site but less damage across the surface applied strips. Cows initially avoided the pasture of the surface compost applied strips. The surface applied strips had significantly greater yield than all other strips with the control also registering higher yields than the other strips.

The following table compares the pasture growth for the four trial strips:

Table 4.2.2 Farm 2 pasture growth comparison

	Sub Soil	Rip	Control	Surface
23/12/13	2528 kg/ha	2738 kg/ha	3185 kg/ha	3272 kg/ha
28/3/14	460 kg/ha	280kg/ha	546kg/ha	922 kg/ha
7/5/2014	1239 kg/ha	1357 kg/ha	1230 kg/ha	1465 kg/ha
5/8/2014	1491 kg/ha	1436 kg/ha	1468 kg/ha	1541 kg/ha
22/10/2014	1748 kg/ha	1708 kg/ha	2179 kg/ha	2786 kg/ha
12/12/2014	1812 kg/ha	1732 kg/ha	2024 kg/ha	2515 kg/ha
Total	**9,278kg/ha**	**9,251 kg/ha**	**10,632kg/ha**	**12,501kg/ha**

Soil fracture and root penetration in subsoil compost strip

Root & worm activity in sub soil compost

View of surface applied compost strip

View of sub soil compost strip

Fig 11. Potatoes to Beef pasture comparison

Farm 2 Summary

As the benchmark analyses indicated the pasture site chosen for this trial was less productive and seen as a lower performing paddock. Its soil base indicated some structural physical constraints with some compaction evident perhaps emanating from its past history as a paddock that cropped potatoes. The organic matter benchmark did not change greatly over the period of the trial although the surface applied compost strip increased slightly. High benchmark ammonium nitrogen indicated that nitrate nitrogen was not as yet being mobilised through microbial activity. Conditions such as compacted soil, low pH, lack of moisture and temperature at the time of sampling all combine to restrict the activity of the required nutrient cycling microorganisms.

Interestingly the surface compost strip had risen indicating the mobilisation of nitrogen from the compost.

The increase in the CEC of the surface applied strip perhaps indicates humus formation and the release of plant nutrients.

The sub surface applied compost strips and the deep ripped without compost strip delivered the lowest pasture yield while the surface compost strip had the highest yield. The increased soil nitrate nitrogen would be a major factor in the increased dry matter yield.

It was evident on exposing the compost rip lines that roots were starting to access this compost with worms and fungal activity observed and in time this strip may deliver significantly higher pasture yields.

The deep ripped strip without compost was instigated to test the hypothesis that opening up the soil to oxygen and moisture might encourage deeper rooting of pasture species thus improving nutrient cycling and enhancing biological activity. This hypothesis may still require more time to be fully tested.

Over the coming seasons it is suggested that the sub surface compost with its inoculation of microorganisms will cycle more efficiently and provide plant roots with a nutrient source at a depth previously not realised. The surface applied compost will also be more readily absorbed into the soil profile and should continue to provide increased pasture growth.

4.3 Farm 3 Beef (vealers) enterprise

The Beard property is a 100ha property on Cardinia Road, Officer. The property carries beef cattle which are rotationally grazed. The soils in these areas are described as red Chromosols derived from Sediments. Texturally they would be described as a silty loam soils with moderate structure. pH is acidic.

In 2013 the site received urea (80kg/ha), gypsum (1.5t/ha) and poultry manure (4t/ha). Pasture had been cut for hay. The site received the following treatments:

Treatment 1 Sub surface compost (10t/ha)
Treatment 2 Deep ripping no compost
Treatment 3 Control
Treatment 4 Surface applied compost (10t/ha)

The following table indicates results:

Table 4.3.1 Results Farm 3 Beef (vealers)

	BENCHMARK	Sub Soil Compost	Sub soil no compost	Control (nothing)	Surface
Total Pasture Yield kg/ha		**14,847**	**12,679**	**11,948**	**13,649**
RSAT (1-9)	**5.1**	**4.6**	**4.8**	**4.6**	**4.6**
pH (water)	**5.68**	**5.91**	**5.90**	**5.95**	**5.93**
Nitrate Nitrogen (ppm)	**16.9**	**6.8**	**7.0**	**7.0**	**3.8**
Ammonium Nitrogen (ppm)	**13.2**	**4.6**	**5.9**	**5.0**	**4.6**
Phosphorus (ppm)	**110**	**123**	**110**	**144**	**115**
Organic matter (%)	**7.6**	**7.0**	**7.6**	**6.5**	**7.7**
Carbon (%)	**4.32**	**4.01**	**4.35**	**3.69**	**4.41**
CEC (%)	**11.96**	**10.35**	**11.28**	**9.96**	**10.77**
Solvita (1-5)	**2.5-3**	**4**	**3.5**	**3.5**	**3.5**

Analysis of Results

Rapid Soil Assessment Test

The average score across the observations was 5.1 (out of 9) indicating a soil of medium quality quality with most prominent constraints being seen as compaction with only a medium soil structure, medium water infiltration and evidence of water logging. End of trial observations were similar, indicating no great change.

Worms were seen in the sub soil compost strip with new fine feeder roots evident. Dung beetle activity was observed in both the sub soil compost and surface applied strips. Thicker pasture growth was seen on the sub soil compost strip and cattle appeared to be preferentially grazing the sub soil compost and the rip strips. Pasture in the surface applied strip however appeared to be healthier.

Soil analysis

The pH of 5.68 (soil water) is slightly acid which indicates reasonably high levels of hydrogen in the soil complex. There was no significant change in pH over the time of the trial.

Available phosphorus levels of 110 ppm (Colwell extraction) indicate that phosphorus levels are more than adequate and did not change greatly over the time of the trial although the control strip did register slightly higher levels.

Available nitrogen initially was (16.9 ppm November), which is adequate for production but decreased by the end of the trial to 6.8ppm in the sub surface compost strip, 7.0ppm in the ripped strip, 7.0ppm in the control strip and 3.8ppm in the surface compost strip. Given the previous inputs to this site prior to the trial (urea, super potash and poultry manure) the nitrate nitrogen appears to be below what should be required for production. It should be considered whether soil temperatures, lack of moisture or compacted soils are factors that are limiting the action of nutrient cycling microorganisms.

Organic matter initially analysed at 7.6 % with end of trial analysis indicating no great change. The surface applied compost at 7.7% was slightly higher than the other trial strips.

Solvita

An initial reading of 2.5-3 (out of 5) indicated only medium levels of microbial soil activity. There was an increase to 4 on the surface applied strip indicating increased microbial activity in the compost. The sub surface compost strip registered 3.5 indicating medium to ideal in biological quality.

Observations of pasture yield

Patchy growth was observed over the entire trial strips with yellowing observed in August. Red legged earth mites were to be seen on clover across the strips but less on the surface applied strips. At end of trial, pasture was observed to be of poor quality across all strips. The highest pasture yield was recorded on the sub soil compost strip and the surface applied strip and less on the ripped strip and the control.

Officer trial site and dung beetle activity

View of surface applied compost strip

View of sub soil compost strip

Control strip

Fig 12. Observations at Officer trial site

The following table compares the pasture growth for the four trial strips:

Table 4.3.2 Farm 3 pasture growth comparison

	Sub Soil	**Rip**	**Control**	**Surface**
10/12/2013	2458 kg/ha	3038 kg/ha	3129 kg/ha	3100 kg/ha
14/4/2014	1151 kg/ha	1188kg/ha	1010kg/ha	1491 kg/ha
30/5//2014	1817 kg/ha	1285 kg/ha	1212 kg/ha	1287 kg/ha
21/7/2014	2677 kg/ha	1972 kg/ha	1908 kg/ha	1909 kg/ha
26/8/2014	2179 kg/ha	1427 kg/ha	1547 kg/ha	1652 kg/ha
15/10/2014	2294 kg/ha	1810 kg/ha	1428 kg/ha	1976 kg/ha
28/11/2014	2271 kg/ha	1959 kg/ha	1714 kg/ha	2234 kg/ha
Total	**14,847kg/ha**	**12,679kg/ha**	**11,948kg/ha**	**13,649kg/ha**

Farm 3 Summary

The benchmark visual assessment indicated that the soil was only of medium quality with soil structure, water infiltration, compaction, water logging and a lack of earthworms being the major characteristics indicating potential restraints to production.

Soil analyses indicated availability of all major nutrient elements and only the pH requiring adjustment.

The organic matter benchmark was at a good level with the nitrate nitrogen being in the desirable range. Nitrate nitrogen decreased in the sub surface compost strip, the ripped strip, the control and the surface compost strip. It is considered that the visual soil assessment characteristics of compacted soil, water infiltration, poor soil structure and low biological activity as evidenced by earthworm numbers and the soil Solvita test, maybe restricting the mobilisation of nitrogen.

In the latter half of the trial the sub surface compost strip out yielded the other strips with the surface applied compost registering the second highest pasture yield by the end of the trial. New root growth was observed accessing the sub surface compost strips with worms breeding in the compost. This was occurring relatively early in the trial leading perhaps being responsible for the increased pasture growth in the latter half of the trial.

Solvita soil tests indicated a slightly higher reading by the end of the trial. Surface applied compost registered the second highest pasture yield.

Observation of the soil visual characteristics towards the end of the trail still indicated that soil compaction could still be an issue to increased root growth and higher pasture production.

4.4 Farm 4 Lifestyle (miniature cattle and horses) enterprise

The Livermore property is an 11 ha property on Bessie Creek Road at Nar Nar Goon. The property carries both horses and cattle which are rotationally grazed. The soils in these areas are described as grey to brown duplex soils with a sandy to gravelly texture derived from Devonian granites. Texturally they would be described as a sandy to gravelly loam soil. They tend to have weakly developed structure with poor fertility. pH is generally acidic with major, minor and trace element deficiencies. The site received the following treatments:

Treatment 1 Sub surface compost (10t/ha)
Treatment 2 Deep ripping no compost
Treatment 3 Control
Treatment 4 Surface applied compost (10t/ha)

The following table indicates results:

Table 4.4.1 Results Farm 4 Lifestyle (miniature cattle and horses)

	BENCHMARK	Sub Soil Compost	Sub soil no compost	Control (nothing)	Surface
Total Pasture Yield kg/ha		3,335	3,426	3,162	2,690
RSAT (1-9)	5.0	4.5	4.3	4.6	4.6
pH (water)	5.68	5.88	5.98	6.00	6.10
Nitrate Nitrogen (ppm)	3	14.8	12.0	14.0	12.6
Ammonium Nitrogen (ppm)	20.5	14.9	10.0	10.3	17.7
Phosphorus (ppm)	18	23	18	22	23
Organic matter (%)	9.8	5.1	6.7	9.1	12.0
Carbon (%)	5.6	4.63	3.81	5.17	6.86
CEC (%)	8.73	7.82	7.01	8.89	11.89
Solvita (1-5)	3	2.5	3	3	3.5

Analysis of Results

Rapid Soil Assessment Test

The Benchmark RSAT score across the observations was 5 (out of 9) with most prominent soil constraints being seen as a lack of soil structure, few water stable aggregates, compaction, areas of apparent water logging, poor root penetration and worm numbers low. As to be expected this poor quality soil supported a varied and low quality pasture. There was no significant variation in the RSAT results between strips at the conclusion of the trial.

Potentially improved conditions could be seen where roots had just managed to access the sub soil compost. It is anticipated that as roots access nutrients from this compost improved pasture yields may be realised. Other characteristics such as soil structural changes would not be anticipated to be seen at this stage. It is considered that biological indicators such as worms and root penetration may be more noticeable as the season's progress. Similar observations were made with the RSAT for both the surface applied compost and the control strip.

The compost evident in the rip line has been slow to break down possibly due to a microbial environment not conducive to nutrient cycling, i.e. soil compaction, oxygen depletion and insufficient moisture.

Alison & Chris

Sub soil demonstration field day

Sub soil depth

Rip strip (no compost) Mar 2014

Rip strip (no compost) Jul 2014

Fig 13. Trial site field day

Soil analysis

The pH of 5.68 (soil water) is slightly acid which indicates reasonably high levels of hydrogen in the soil complex. There was a slight increase in pH over the time of the trial.

Benchmark phosphorus levels (Colwell P) 18ppm didn't change significantly between strips.

Available nitrogen is at a low level (3.0ppm) whereas the desirable level should be about 10ppm. The final analysis across the strips indicated nitrate nitrogen had increased to between 12-14 ppm.

Organic matter at 9.8% with end of trial analysis indicating 5.1% for sub surface compost, 6.7% for the deep ripped section, 9.1% for the control and 12.0% for the surface applied compost. The higher value for the surface applied compost is to be expected with this surface application.

The Cation Exchange Capacity (CEC) benchmark was at 8.73%. There was no great change in the CEC across the strips except for the surface applied compost which rose to 11.89% indicating the conversion of organic matter to humus.

Solvita

A benchmark reading of 3 indicated that the soil was moderately low to medium in microbial soil activity. This supported observational data from the visual soil assessment (RSAT). A Solvita test taken from in the Sub surface compost strip indicated a similar reading.

Observations of pasture yield

Flatweed and herbs were evident in the surface applied compost strip and less in the sub soil compost. Scattered clover and pasture growth was evident across the site.

The following table compares the pasture growth for the four trial strips:

Table 4.4.2 Farm 4 pasture growth comparison

	Sub Soil	Rip	Control	Surface
27/3/14	**1636 kg/ha**	**1940 kg/ha**	**1668 kg/ha**	**1439 kg/ha**
26/7/14	**820 kg/ha**	**718 kg/ha**	**564 kg/ha**	**604 kg/ha**
24/12/14	**879 kg/ha**	**768 kg/ha**	**934 kg/ha**	**647 kg/ha**
Total	**3335kg/ha**	**3426 kg/ha**	**3162 kg/ha**	**2690kg/ha**

Fig 14. Pasture at Nar Nar Goon Nth trial site

Farm 4 Summary

The benchmark analysis indicated the pasture was not of high quality and its soil base indicated both structural and biological constraints to production of pasture were apparent. Organic matter benchmark decreased for the sub surface compost and for the ripped strip. This perhaps may indicate that the opening up of this soil low in biological activity further oxidised top soil organic matter.

The initial benchmark of nitrate nitrogen is indicative of a soil that is not cycling its organic material. Soil conditions such as compacted soil, low pH, lack of moisture, all are factors that may restrict the activity of the required nutrient cycling microorganisms. Nitrate nitrogen did not change greatly over the trial although the high ammonium nitrogen of the surface applied compost suggested that cycling of nitrogen is taking place.

The sub surface applied compost strips along with the ripped strip with no compost demonstrated higher yields than the control and surface applied compost.

It was evident on exposing the compost rip lines that roots were only just starting to access this compost. Soil temperatures at this time (12 degrees) were well below temperatures where optimum nutrient cycling can take place. It is considered that over the coming seasons improved nutrient cycling (due to the microbial inoculation with the compost) might be reflected in increasingly higher pasture yields.

The deep ripped strip without compost was trialled to test the hypothesis that opening up the soil to oxygen and moisture might encourage deeper rooting of pasture species thus improving nutrient cycling and enhancing biological activity. Initially the rip lines did indicate higher pasture yields but decreased significantly by the end of the trial. The initial opening up of the soil may have stimulated some microbial activity resulting in increased nutrient cycling, however over time the exposure of the rip line to atmospheric conditions may have negated the activity of these organisms. The decline in organic matter is suggestive evidence to support this hypothesis.

Interestingly the surface applied compost indicated lower pasture yields from the commencement of the trial. Soil analysis indicated higher organic matter levels and hence it is also postulated that soil biology was not as active as it could be and nutrient cycling of the compost to release bound nutrients was not at its optimum and initially drew nitrogen from the surface soil. The CEC of the surface applied strip indicates that humus formation may be taking place and that pasture may soon benefit from nutrient release.

Over the coming seasons it is likely that the sub surface compost with its inoculation of microorganisms will cycle more efficiently and provide plant roots with a nutrient source at a depth previously not realised. The surface applied compost will also be more readily absorbed into the soil profile and should provide a foundation for increased pasture growth.

4.5 Farm 5 Vegetable enterprise

The Arnott property is situated on approximately 68ha at Moores Road, Clyde and is a commercial vegetable producing enterprise. The soils in these areas are described as Sodosols derived from Quaternary sands and sandy clays. Texturally they would be described as sandy loams. pH is alkaline.

Soil fertility is maintained through the use of commercially formulated NPK fertilisers with additional poultry manure and composts. Half a tonne of poultry manure was applied to each bed twice during the trial period.

The site received the following treatments:

Treatment 1 Bed 6 (plots 1-3) – One compost application of 10 tonnes
Treatment 2 Bed 6 (plots 4-6) – Control
Treatment 3 Bed 7 (plots 1-3) - Four compost applications of 2.5 tonnes
Treatment 4 Bed 7 (plots 3-6) - Control
Treatment 5 Bed 8 (plots 1-3) - Four compost applications of 5 tonnes
Treatment 6 Bed 8 (plots 3-4) – Control

The following table indicates results:

Table 4.5.1 Results Farm 5 Vegetables

	Area Bed 6 Bench mark	Bed 6 Plot 1-3 Compost	Bed 6 Plot 4-6 Control	Area Bed 7 Bench mark	Bed 7 Plot 1-3 Compost	Bed7 Plot 4-6 Control	Area Bed 8 Bench mark	Bed8 Plot 1-3 Compost	Bed 8 Plot 4-6 Control
pH (water)	**7.25**	**6.58**	**6.88**	**7.65**	**7.38**	**7.16**	**7.90**	**7.33**	**7.40**
Nitrate Nitrogen (ppm)	**36.8**	**50.0**	**41.8**	**24.0**	**43.2**	**49.2**	**15.6**	**111.4**	**77.0**
Ammonium Nitrogen (ppm)	**6.8**	**1.3**	**1.6**	**5.9**	**1.3**	**0.7**	**4.5**	**1.3**	**1.5**
Phosphorus (ppm)	**403**	**306**	**369**	**431**	**440**	**388**	**557**	**478**	**414**
Organic matter (%)	**2.8**	**2.7**	**3.2**	**3**	**2.6**	**3.6**	**3**	**2.6**	**3.1**
Carbon (%)	**1.6**	**156**	**1.81**	**1.70**	**1.46**	**2.04**	**1.71**	**1.50**	**1.77**
CEC (%)	**8.6**	**6.45**	**7.667**	**10.49**	**8.36**	**8.76**	**10.87**	**10.61**	**9.87**
Solvita (1-5)		**4**	**2**		**2**	**2**		**2.5**	**3**
Soil temp (May av)		**14.4**	**13.9**		**13.8**	**13.8**		**14**	**13.8**
Soil temp (Jul av)		**12.4**	**12.2**		**12.4**	**12.4**		**12.3**	**12.4**
Soil temp (Aug av)		**11.4**	**11.3**		**11.2**	**11.2**		**11.4**	**11.3**

Analysis of results

Rapid Soil Assessment Test

As the RSAT is designed to be used in a pasture grazing context the full assessment of soil characteristics was not relevant. However some characteristics were examined. These included water infiltration, soil life, plant root development, smell, soil crusting and organic matter.

Craig Arnott is well aware of the strengths and weaknesses of these soils. The sandy loam with its commercial fertiliser and organic inputs provides a soil environment that is conducive to the good penetration and growth of plant roots and quick turnaround in the crops planted. Its major physical and chemical limitation is the inability to hold onto plant nutrients and moisture hence the addition of organic inputs.

The above soil characteristics were examined at the end of the trial and very little change could be seen.

Soil analysis

The pH across the beds averaged 7.60 (soil water). There was not a great change in pH across the beds over the time of the trial.

Available phosphorus levels between Beds 6, 7, 8 were between 403 ppm - 557 ppm (Colwell extraction) indicating that phosphorus levels are more than adequate. At the end of the trial there was only slight variation in the phosphorus values (300-480 ppm).

Available nitrogen initially varied between 15.6 ppm and 36.8 ppm (February 2014). At the conclusion of the trial nitrate nitrogen registered between 41.8 ppm -111.4 ppm. Organic matter benchmark analysed between 1.6% -1.71% with end of trial analysis indicating no great change. Bed 8 with the heaviest application of compost still only analysed between 1.50% -1.77%.

Effective Cation Exchange Capacity did not register any significant changes.

Observations of crop growth

The commercial reality of having to ensure productive efficiency across the cropping area meant that a range of commercial fertilisers have been applied as well as the various application rates of compost. This made it virtually impossible to correlate crop yield and quality with compost applications when other inputs affected the outcomes. It was noticeable however that in Beds 8 with the heavier compost application (5 tonnes x 4) reduced root growth was apparent. This could be due to some phytoxic affects generated from the compost, or perhaps the heavy application meant the compost was still undergoing decomposition and hence nitrate nitrogen may have been a limiting factor.

Coriander control crop roots have numerous branching roots.

In November spring onions were harvested and bed 7 yielded heavier crops than bed 8.

Photographs taken of crops are shown below:

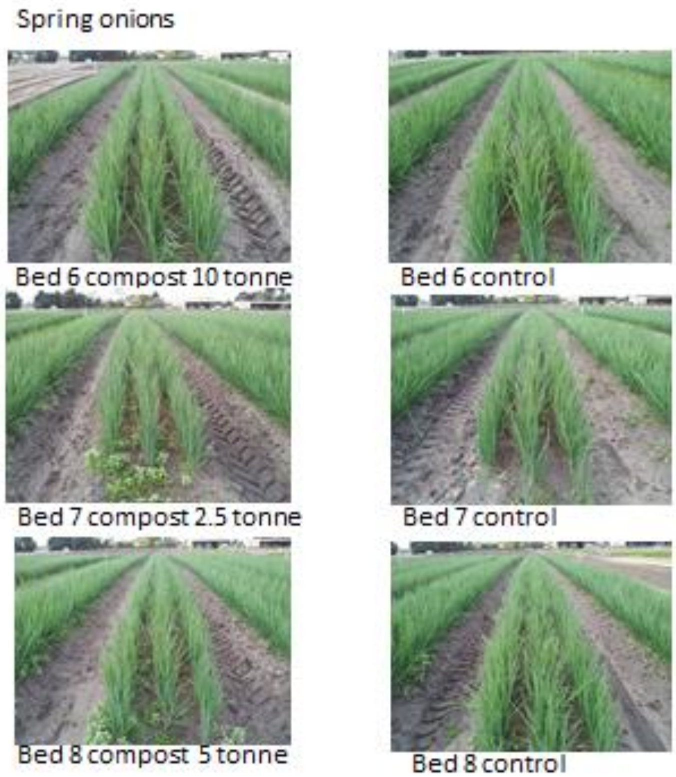

Fig 15. Spring onion crop May 2014

Fig 16. Radish crop Sep 2014

Fig 17. Coriander crop

Farm 5 Summary

The Clyde area is an important horticultural area producing a range of flower and vegetable crops on sandy clay soils. The soils contain low levels of fertility meaning organic matter is low with little storage ability to hold nutrient elements (colloidal cation mechanisms). The majority of producers recognise this and utilise compost and poultry manures as an organic input to assist in water and nutrient storage as well as its ability to stimulate biological processes and minimise pathogenic soil borne diseases (Hoitink and Fahy, 1986)

This trial examined the use of different application rates of green waste compost. As has been mentioned the application of a number of commercial formulations of synthetic fertiliser made it difficult to assess positive or negative outcomes form the compost application. Compost additions to a soil rely on microbial processes to supply nutrients from humus compounds and microorganisms that are contained in the compost. This may occur quickly when soil temperatures and moisture levels are adequate for the microorganisms responsible for nutrient cycling. This soil without any organic amendments would be very low in these organisms so it is possible in these soils that nutrient cycling may be inhibited.

The Arnott enterprise relies on soil analysis and the advice of an agronomist to ensure optimum nutrient supply for the range of crops grown. Initial soil analysis does suggest that the sodic soils indicated by the ESP sodium percentage in the bases saturation cations requires on going monitoring. The end of trial soil analysis indicated that slight changes in the Effective Cation Exchange Capacity (ECEC) occurred and substantial increases were seen in the nitrate nitrogen levels. This may be more a result of synthetic fertiliser additions than an actual increase in nitrogen cycling from the compost inputs.

Australia is widely recognised as having a ‘clean and green’ image with quality assurance schemes supporting its horticulture industry. Although the grower believed trialling the use of compost was beneficial, the longer term benefit of the compost may be lost in that it may be too costly an input for vegetable growers. He suggested instead that it could be more economical to apply compost only once per year, growing green crops to turn into the soil and, to avoid nutrient runoff, being careful not to overwater crops. Computerisation of watering systems to reduce overwatering and the treatment of some seedlings prior to planting has reduced pest control measures for the grower in the field and are some of the improvements for his enterprise. The grower also pointed out that whilst consumers continued to want cheap vegetables all year unfair pressure had been placed on Australian growers to be able to compete with imported products.

6 Summary and Conclusion

These trials investigated the placement of compost below the root zone in four pasture enterprises plus the incorporation of compost with a rotary hoe on a vegetable farm. This was a new approach to the enhancement of pasture production on the above grazing properties. Although sub soil compost trials have been widely carried out, the trials have previously been mostly on cropping soils with less developed structure than Gippsland grazing pastures. The potential end result however still depends on the action of microorganisms to convert humus products into plant nutrients. Soil texture, soil temperature, moisture and open soil pores are essential components in the microbial degradation of the sub soil compost.

The trials were undertaken over a relatively short time scale and it is considered that in the next couple of years growth cycles may allow pasture roots to access both the sub soil compost and the ripped strips where nutrient cycling may be enhanced and pasture yield increased. Research has also indicated the longer term benefit of surface applied compost where microbial action releases nutrients over a longer term than perhaps our trial allowed.

It is difficult to draw any conclusions as to whether the application of compost in the root zone was of benefit in the short term as the monitoring only took place over 1 year, however, in the lighter soils of Officer and Nar Nar Goon North, there appeared to be a better response with pasture yield on the sub soil compost strips.

In the heavier soils of the Neerim area, the surface applied compost appeared to have provided an increase in pasture yield. The ripped strips, with and without compost at the two farms at Neerim and Nayook were rolled after considerable surface disturbance and this could have adversely impacted pasture yield.

The landholders welcomed the trial and were willing to share information about the individual paddock or crop's performance during the monitoring and are to be commended for their involvement in the process.

This trial has engaged with many farmers to not only consider the use of alternative fertilisers, but also compare the soil health impacts of applying the products at the root zones. It was anticipated that the application method would improve soil health through providing an initial feed source for soil biology whilst also opening up the soil and allowing additional oxygen and water into the profile.

The project was promoted through farming bodies, government agencies, Landcare Groups and three Landcare Networks. Field days were well attended demonstrating the methods of compost application. Regular updates on the project were released through the quarterly WPCLN newsletter and articles placed in additional Landcare newsletters.

Peter Ronalds
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Sub-Soil Compost Trial

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