Focus Site Project Review

Exploring techniques to create compost in 28 days at Caerhys Farm

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1 Summary

1.1 Farm background

Caerhys organic farm is part of a project producing vegetables near St David, Pembrokeshire. Caerhys Organic Community Agriculture **(COCA)** http://www.coca-csa.org/ is an agricultural scheme run for and supported by the local community. COCA members share organic food grown in partnership with local farmers as part of this community food initiative.

The farm also runs a 37 head Welsh Black suckler herd plus followers, a few sows and some outdoor pork weight pigs. This self-sufficient unit recycles nutrients based on producing compost using straw based muck from winter housing the cattle plus some green fresh vegetable waste.

The Miles family who own Caerhys – Gerald and Ann and their son, Cazz - use composted manure from their herd of Welsh Black cattle to grow cereals and vegetables at Caerhys, near St Davids.

Business aspirations:

Caerhys aims to operate as a self-sufficient unit, as regards the provision of nutrients to the crops and livestock grown on-farm. The Miles' recycle nutrients based on producing compost using straw based muck from winter housing the cattle plus some green fresh vegetable waste.

Until this year they stored manure uncovered, with no interventions until it was spread on the land. The family was keen to establish whether nutrient values could be enhanced if the manure was treated differently, as they felt the resource could be better utilised than was the current practice.

Therefore the Focus Farm project was based on trialling composting methods of home produced manures, with a view to develop a rapid composting system, providing higher quality nutrition for vegetables, including crops in polythene tunnels. This was undertaken in conjunction with a comprehensive assessment of the nutrients available both in fields and poly-tunnels on the farm, in order to make better use of applied manures/compost/fertilisers.

Nutrient Management Planning is fundamental for ensuring that nutrients are managed efficiently to save both money and reduce environmental impact. It is important that these plans are practical and easy to implement on-farm on a day to day basis. Applying the correct rate of fertilisers/manures using the most efficient methods of application can reduce costs and environmental impact. Nutrient Management Plans also take into consideration priorities during different seasons of the year.

Focus Farm Project key objectives:

To produce predictable sustainable composted manures as quickly and efficiently as possible while promoting optimal performance from farm resources. Specific objectives were as follows:

- Understand the overall nutrient availability on the farm in the context of an organic, stock led, system.
- Use the Farming Connect nutrient management planning service to assess present practices, and provide baseline data of nutrient requirements and availability.
- Compare the process and end product of covered and uncovered composting stacks
- Improve the speed of the composting process
- Retain any nutrients in the stack
- Manage a stack with relatively low input and use of farm equipment
- Improve weed control especially docks *Rumex spp*

1.2 Project Conclusions

1.2.1 Comparison of the nutrient value from covered vs uncovered manure composting – Caerhys headlines:

- The potash value in the covered heap was double that of the control – 5.99kg/tonne/fresh weight compared to 2.73kg.
- The phosphorous value was much higher too, at 3.71kg compared to 2.8kg.
- The magnesium value was also greater than the control stock, at 1.9kg/tonne/fresh weight compared to 1.49kg.

1.2.2 The value of soil sampling and undertaking a nutrient management plan.

The winter 2016/17 soil sampling results, in conjunction with an assessment of field management activity, cropping regime and nutrients used, by a qualified specialist resulted in the following conclusions:

- **Soil sample results.**

88% of the fields tested required lime to be applied, to correct soil pH. Optimum soil pH is vital to maximise the uptake of nutrients.

- **Phosphate levels.**

All of the samples were at the desired P index. Only maintenance levels of P would be required, to cover crop off take and maintain P levels at the optimum index. Applying additional P to these fields will increase the risk of diffuse pollution.

- **Potassium levels.**

41% of samples were below the desired soil index, which would warrant additional K to be applied to these specific fields, to meet crop needs. A derogation from the farm’s organic certification body would be required prior to buying in approved forms of potash.

- **Magnesium levels.**

None of the samples were below the desired soil index but 35% of the samples were at Index 4 or 5 which is regarded as high, so no more Mg should be added to these fields.

- **Ensure that application rates stay within those recommended within the Code of Good Agricultural Practice.**

The Code of Good Agricultural Practice for the Protection of Water, Soil and Air for Wales currently states that, to reduce leaching losses from manures, one should not apply more than 250 kg per ha (200 units per acre) of total nitrogen in organic manures in any 12 months. Application rates have exceeded this on some fields. Ensuring this ceiling is adhered to will help make cost savings in the business, and reduce pollution risk.

- **The importance of routinely soil sampling to match nutrients with crop requirement.**

Nutrition on the farm was good in some fields, but there is variability across the farm in terms of field nutrient values. Soil analyses for pH, N, P, K and Mg every 3 to 4 years should be undertaken, as part of business management. This is especially important as the farm prioritises the use of home produced organic manures, and wants to ensure this is done effectively.

1.3 Take home points for the industry

Enhancing the nutrients in manure is of benefit to all farmers, regardless of their system. Effective composting results in more nutrients in each tonne of manure so a smaller quantity can be used on a larger area.

This has particular implications for farms in Nitrate Vulnerable Zones which are limited on the volume of manure they can apply to their land.

Key messages:

- Manures are a valuable resource on both organic and conventional farms
- Simple composting principles will improve the benefits of the manures
- Machinery available on farm or locally will turn the stack
- Simply covering your manure pile with a silage type sheet shows a lot of benefits
- Weed seed and some pathogens will be killed if the stack gets hot enough
- Turning the stack results in a more consistent product
- Use analysis of both soil and manures to give a holistic view of nutrient requirements and supply
- Well composted manures also improve soil structure
- Worm activity in the stack helps improve the breakdown into friable humus
- Leaching of the stack by rain may cause point source pollution, and loss of valuable nutrients; this will be reduced if covered
- Nutrient management on farms is a long term process and information adds to the accuracy – which underlines the value of regular soil testing
- Use of a Nutrient Management Plan is a formal way of recording this management, and taking a planned whole farm approach
- Soil analysis is cheap and gives a lot of information at the field level

By analysing the compost, farmers can apply it at the correct rate for the crop being grown. A Farming Connect Nutrient Management Plan provided soil analysis of the growing areas and poly tunnels at Caerhys

Mr Miles found, as a result of the NMP, that some growing areas had a potash and phosphorous index of 3, equivalent to the values more commonly associated with high input systems. This would not have been expected in an organic system, showing the potential of what can be achieved in a self-contained system, whether low or high input.

2 Business Review

2.1 Business Background.

Caerhys is a 48 hectare mixed organic farm. The farm participates in both Glastir Advanced and Glastir Organic schemes. The farm grows around 10 hectares of heritage varieties including black oats. Around 24 hectares of baled haylage and silage are also grown. No bagged fertiliser is used.

The farm also supports a Community Supported Enterprise (CSA) with 2 poly tunnels used to grow tomatoes, peppers and salads, along with field scale vegetables.

Stock numbers are based on a suckler herd of 21 spring calving Welsh Back sucklers plus followers. Store cattle are currently sold at around 12 months of age. The farm also supports a pig enterprise comprising 5 Oxford Sandy & Black and Saddleback sows. Pigs are generally fattened although some weaners are occasionally sold. Pigs are outdoor reared, while cows are loose housed so cattle Farm Yard manure (FYM) is generated on the holding. Sheep are also tacked on the farm for the winter.

It is estimated that roughly 25 t/ha (10 t/ac) of FYM is spread as an application in the spring, but only around 6 hectares are covered. The majority of the farm is available for spreading manures, but limited manures are available. The Miles' therefore wanted to maximise the use of what is a limited, valuable resource on-farm, i.e. their home produced cattle manure.

2.2 KPIs and business performance indicators

The business performance areas Mr Miles wanted to work on in this project were:

- Undertaking, and then implementing the results of a whole farm nutrient planning approach
- Understanding the composting process better, in order to improve the composted product available to the farm, increasing farm self-sufficiency as regards nutrient re-use
- How to improve the composting process in practical terms
- Whether dock control be improved by composting

Whilst these are not KPIs specifically, these were the key areas of business improvement for this Focus Farm project. Progress against these is detailed under section 3.4 of this report.

2.3 Potential impact of the project on the business

Nutrition of plants is a key to good organic farming

An understanding of composting methodology could improve the farm's overall feeding policy

There are animal manures produced on the farm and any increase in the knowledge and management of the resource will benefit the farm

Any improvements in the use of manures will help the farm achieve the best results without using imported materials

3 Project Review

3.1 What is composting?

Composting is a process that biodegrades organic waste. i.e. food waste, manure, leaves, grass trimmings, paper, wood, feathers, crop residue etc., and turns it into a valuable organic fertilizer.

Composting is a natural biological process, carried out under controlled aerobic conditions (requires oxygen). In this process, various microorganisms, including bacteria and fungi, break down organic matter into simpler substances. The effectiveness of the composting process is dependent upon the environmental conditions present within the composting system i.e. oxygen, temperature, moisture, material disturbance, organic matter and the size and activity of microbial populations.

3.2 The value of composting – key principles

The following provides a narrative on the benefits of using compost, and the rationale behind Caerhys' interest in improving its use of composted material, and overall production of this valuable product.

3.2.1 Resource management benefits of using compost

Applying composted material improves soil organic matter, which in turn helps create good soil structure, improved water holding properties, improved microbial activity and soil health. Such benefits can improve overall production by:

- Reducing the need for bagged fertiliser
- Reducing nutrient leaching
- Increasing yield potential
- Potential to improve drainage in heavier soils, and improve water holding in light soils
- Reduced erosion risk and better soil structure – improved workability of soils and increased traffic tolerance
- Beneficial soil microorganisms will aid soil aggregation, nutrient recycling and plant disease suppression
- Compost will also act as a slow release fertiliser for N and P whilst providing readily available K. Mg, S and other trace elements can also be provided by compost.
- The improvements made by inorganic N fertiliser should also improve the uptake of future compost applications due to improvements in overall nutrient supplies and improvements in the rooting environment
- There are also small liming benefits associated with composting in addition to it being a valuable source calcium [1]
- Improvements are made in soil biota, which will:
    - Improve soil health
    - Maximise crop potential
    - Reduce reliance on artificial fertilisers
    - Improve food supplies for farmland wildlife
    - Improve disease resistance

[1] Earthcare Technical. 2016. *What is Green Composting and why should I use it?* Earthcare Technical Scotland. Available from: http://www.greenwastecompany.com/webeasycms/hold/uploads/downloads/Green-compost-Factsheet-2016.pdf. (Accessed 8th December 2017).

- Improving soil biota and soil health will increase earthworm populations. Earthworms play a vital part in the decomposing of cycling organic matter whilst releasing nutrients to the soil. They also improve soil porosity, aeration, water infiltration, water conductivity, aggregate size and stability, reduce surface crusting and increase root growth and improve future yields[2].

3.2.2 Financial Benefits of Compost

- An improvement in soil structure and fertility will lead to an increase in the crops yield potential
- Compost acts as a substitute for costly fertiliser, containing available nutrients for crop uptake
- Compost use can also help improve soil indices which can help to reduce reliance on purchased fertilisers.
- Composting will improve the overall soil structure which will not only allow fields to be worked easier, but also result in less fuel usage
- Improved fertiliser usages as farmers have a better understanding of compost nutrient content, which will in turn help ensure correct spreading rates for maximising production benefits
- When farmers generate their own compost this reduces transport costs from suppliers, this will also prevent double handing of manure/fertilisers between suppliers, hauliers and the farmer[3]

3.2.3 Pros and cons of using compost – research results

A review by ADAS and IGER indicated benefits such as:

- Reduced odour
- Killing of weed seeds and pathogens
- Reduced volume of material
- Production of a more uniformed product
- Nitrogen stabilised in an organic form

While they felt some disadvantages would be

- Turning process can cause large loss of ammonia
- Aeration of slurry can increase N losses – particularly if aeration is too vigorous
- Carbon lost as carbon dioxide
- N in compost is less readily available to following crop in short term[4]

[2] Campaign For The Farmed Environment. Not Dated. *Soil Management for your farm business.* CPE. Available from: http://www.cfeonline.org.uk/soils-leaflet-final/. (Accessed 8th December 2017).

[3] OLUS. 2017. *Compost in Agriculture – The Practical and Financial Benefits.* OLUS. Available from: http://www.olus.co.uk/Compost-in-agriculture. (Accessed 8th December 2017).

[4] ADAS, IGER & HDRA. 2006. *Soil and Nutrient Management on Organic Farms.* DEFRA. Available from: http://www.organicresearchcentre.com/manage/authincludes/article_uploads/iota/technical-leaflets/soil-and-nutrient-management-on-organic-farms.pdf. (Accessed 8th December 2017).

3.2.4 Pointers on producing good quality compost in covered stacks on-farm -controlling aeration, temperature and pH

- Temperature above 40 degrees and a pH below 6 severely inhibits the composting process. It is possible to increase the activity and shorten the this 'acidic phase' (i.e. low pH phase) by increasing the aeration rate even if the temperature still remains at 40 degrees
- Temperature will determine microbial activity and therefore degradation rate
- Evaporation reduces the moisture content, this is important for degradation rate directly as it affects microbial activity and indirectly as it affects the structure and oxygen supply
- The heat generated by decomposition and the heat removed by aeration will determine the energy balance
- To maximise efficiency the decomposition rate needs to be maximised, but this can be challenging, as the rate is not a physical property easily measured – aeration rate affects the measurable quantities and the decomposition rate [5]
- Aeration is an essential feature of effective composting, ensuring the correct oxygen supplies to support aerobic organisms

Moisture Content

- All living organisms need water, so the composting process needs moisture. There is no upper limit for the water content regarding microorganisms but too much moisture will reduce the air space in the compost matrix which in turn will limit oxygen [6]
- Large scale composting sees the water loss mainly determined by the accumulated decomposition – the process temperature has little effect on water loss [7]
- The importance of achieving the **correct PH levels** for the job:
    - Process will work between pH 5.5 – 9
    - Most effective between pH 6.5 and 8
    - Below pH 6 will slow decomposition
    - Above pH 8 will release ammonia – smell
    - Low pH is often caused by low oxygen levels so by turning the pile this will increase aeration and raise the pH
- **Surface Area management**
    - Smaller particles increase the? amount of nutrients and energy available to microorganisms but can also reduce air space within composting
    - Need a balance – want particles of circa 5cm diameter

[5] Sundberg, C. 2005. *Improving Compost Process Efficiency by Controlling Aeration, Temperature and pH.* Faculty of Natural Biometry and Engineering Uppsala. Available from: http://pub.epsilon.slu/950/1/CeSu103fin0.pdf. (Accessed 8th December 2017).

[6] Miller, F, C. 1993. Composting as a process based on the control of ecologically selective factors. *Soil Microbial Ecology.* Marcel Deekker, New York. 515 – 544.

[7] Sundberg, C. 2005. *Improving Compost Process Efficiency by Controlling Aeration, Temperature and pH.* Faculty of Natural Biometry and Engineering Uppsala. Available from: http://pub.epsilon.slu/950/1/CeSu103fin0.pdf. (Accessed 8th December 2017).

- **Temperature control**
    - Temperature is an indicator of how well the composting process is going
    - Will increase soon after the pile has been created – to 48 to 60 degrees C
- **Retention Time**
    - Will depend on the factors already mentioned
    - Proper moisture content and C:N ratios = fastest composting period [8]

3.3 Overall aims of the project

To provide predictable, sustainable, composted manures to get the best performance from farm resources.

The project aim was to try and speed up the composting process, plus the generation of parameters about monitoring a manure stack, how the nutrient content of the stack could be improved and how the manure could be used to improve nutrient levels in organic vegetable production including protected cropping.

Analysis of manure in the stack, and treatments of the manure, in terms of stack size, turning frequency and analysis at the end of the process to enable predictable application of nutrients to vegetables as detailed in the Reference Book RB209 as an industry standard.

Composting manures avoids the nitrogen deficiency induced with fresh manures and also result in predictable levels of N, P, K, Mg and pH. This level of certainty is of benefit as regards precision feeding of semi intensive vegetable production including soil grown protected cropping.

3.4 Project Methodology

Gerald Miles of Caerhys farm was convinced he could improve the usage of home produced manures on the farm and together with one of his volunteers carried out some small experiments on mixing manures with un-composted green material and found this greatly speeded up the composting process. This is in line with the established thirds technique, one third green (plant material), one third manure and one third carbon (straw or other substrate).

It was decided to start with a look at the overall process on the farm which consisted of cattle, pig and sheep manure from the farm being heaped in a 4-5m stack on an old concrete apron and left to weather and compost.

For a quick gain it was decided to simplify the process by creating smaller stacks, and turning when the temperature reached 60^{0}C or activity stopped. On top of that the turned stack was covered with a silage type sheet weighed down with tyres etc.

To monitor temperature some electronic Tiny Tags were installed in the heap, these devices record temperature over a period and can be downloaded onto a computer giving a real time record of stack temperatures.

[8] Sherman, R. Not Dated. *Large Scale Organic Material Composting.* North Carolina Cooperative Extension Service. North Carolina.

Two windrow type stacks were created (see Fig 1.), 2m high and 3m wide at the base, and the tags were installed. Manure samples were taken from the stack for analysis before the windrows were set up, to establish a baseline level.

One of the stacks was covered with a silage sheet and the other was not. One of the Tiny tags was a probe type set 1m into the stack and this had a dial reader in addition to the recording facility so the temperature could be checked when needed.

Note that weed is growing on top of the stack that wasn't covered, that could lead to field contamination later on. Also, worm activity seemed to be much higher in the covered stack, with a band of intense activity in the top 30cm of the stack.

Fig 1. The two stacks at Caerhys farm, on the right is the untreated control stack.

3.5 Project results and discussion

3.5.1 Summary of results.

	Performance attribute	What was the project result?
1	Undertaking, and then implementing an NMP approach	NMP plan was of great benefit in balancing nutrients across the farm
2	Improved understanding of the composting process	This was clearly much improved with sheeting and turning, speeding up the process
3	Improvements in the composting process	Smaller windrows, consistent sheeting and regular temperature monitoring likely to give better results
4	Dock control	The trial stack heated up to temperatures at which dock seed would have been killed

3.5.2 Nutrient management plan (NMP) – general recommendations.

The business had never undertaken a comprehensive farm-wide nutrient management review before. The results of the soil sampling & analysis provided a basis for more specific nutrient applications, based on crop requirement. The results and recommendations of the nutrient management review were as follows.

- Aim to carry out a standard soil analysis [pH, phosphorus (P), potassium (K), magnesium (Mg)] over 25% of the fields each year, or once every 4 years. This will provide a picture of the soil fertility on the farm and a basis of future fertiliser/manure planning. Testing for conductivity (Cf) and Nitrate (NO3 N) is recommended for the polytunnels.
- Horticultural businesses in Wales, if registered with Farming Connect, can receive 80% funding towards the cost of undertaking a nutrient management review.
- Farm Yard Manure (FYM) should be regarded as a valuable resource. Manures should generally be returned to fields with the lowest indices and cropping fields to help balance offtake.
- The Code of Good Agricultural Practice for the Protection of Water, Soil and Air for Wales currently states that, to reduce leaching losses from manures, you should not apply more than 250 kg per ha of total nitrogen in organic manures in any 12 months. This equates to 42 tonnes/ha (17 t/ac) cattle FYM based on standard figures from RB209 Fertiliser Manual.

3.5.3 Nutrient management plan (NMP) -field specific results:

- **Soil pH**: **88% of the samples required lime to be applied to correct soil pH.** Optimum soil pH is vital to maximise the uptake of nutrients. The optimum pH for grass in mineral soils is 6.0 and 6.5 for arable crops.
- **Soil Phosphorus (P): None (0%) of the samples were below the desired soil index requiring additional P for crop needs.** Therefore, only maintenance levels of P would be required, to cover crop off take and maintain P levels at the optimum index. The optimum phosphorus index for crop yield is 2 (16-25 mg/l).
- **Soil Potassium (K)**: **41% of samples were below the desired soil index, which would warrant additional K to be applied to meet crop needs.** The optimum soil K index for crop yield and the utilisation of other nutrients is 2 - (121-180 mg/l). A derogation from the farm's organic certification body would be required prior to buying in approved forms of potash.
- **Soil Magnesium (Mg)**: **None (0%) of the samples were below the desired soil index. 35% of the samples were at Index 4 or 5 which is regarded as high, so no more Mg should be added to these fields.** The optimum soil magnesium index for crop yield and the utilisation of other nutrients is 2 - (51-100 mg/l).

3.5.4 Results from the composting element of the project.

The trials were not replicated so the figures produced from analysis only offer a guide to likely outcomes. After the stacks were split, the samples should have given very similar values

Table 1. Summary of results

Nutrient	Old stack	At splitting		At end	
Kg per fresh tonne		Control	Trial	Control	Trial
Nitrogen	7.61	5.64	8.83	5.60	5.39
Phosphorus	3.76	4.19	4.47	2.80	3.71
Potassium	7.35	4.88	8.05	2.73	5.99
Magnesium	2.09	2.15	2.38	1.49	1.90

In this situation the results did not give a clear picture suggesting the heap was variable and nutrition results could be misleading however in the final analysis it appeared the P,K, and Mg values were higher than the control or uncovered stack.

3.5.5 Results from the compost/manure sample analysis

Table 2. **The original compost heap** was sampled to give an idea of the levels present, and this stack was spread on the farm early in 2017

MANURE ANALYSIS RESULTS (Metric Units)

Sample Reference : MANURE HEAP

Sample Matrix : MANURE

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References

Report Number 40668

Sample Number 76964

Date Received 28-NOV-2016

Date Reported 08-DEC-2016

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result	Amount per fresh tonne	Amount applied at an equivalent total Nitrogen application of 250 kg N/ha	Units
Oven Dry Matter	%	24.7	247.00	8117	kg DM
Total Nitrogen	% w/w	3.08	7.61	250	kg N
Total Phosphorus (P)	% w/w	0.665	3.76	123.61	kg P2O5
Total Potassium (K)	% w/w	2.48	7.35	241.56	kg K2O
Total Magnesium (Mg)	% w/w	0.510	2.09	68.72	kg MgO
Total Copper (Cu)	mg/kg	19.5	< 0.01		kg Cu
Total Zinc (Zn)	mg/kg	75.3	0.02	0.61	kg Zn
Equivalent field application rate	—	1.00		32.86	tonnes/ha

Table 3. Analysis taken soon **after the stack was split into the two windrows, this was the uncovered and not turned control stack** at the start of the monitoring

MANURE ANALYSIS RESULTS (Metric Units)

Sample Reference : CONTROL

Sample Matrix : MANURE

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References	
Report Number	66596
Sample Number	82791
Date Received	18-JUL-2017
Date Reported	25-JUL-2017

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result	Amount per fresh tonne	Amount applied at an equivalent total Nitrogen application of 250 kg N/ha	Units
Oven Dry Matter	%	22.1	221.00	9804	kg DM
Total Nitrogen	% w/w	2.55	5.64	250	kg N
Total Phosphorus (P)	% w/w	0.827	4.19	185.67	kg P2O5
Total Potassium (K)	% w/w	1.84	4.88	216.47	kg K2O
Total Magnesium (Mg)	% w/w	0.587	2.15	95.53	kg MgO
Total Copper (Cu)	mg/kg	48.3	0.01	0.47	kg Cu
Total Zinc (Zn)	mg/kg	173	0.04	1.70	kg Zn
Equivalent field application rate		—	1.00	44.36	tonnes/ha

Table 4. The trial stack shortly **after setting up the two windrows**.

MANURE ANALYSIS RESULTS (Metric Units)

Sample Reference : TRIAL

Sample Matrix : MANURE

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References	
Report Number	66596
Sample Number	82792
Date Received	18-JUL-2017
Date Reported	25-JUL-2017

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result	Amount per fresh tonne	Amount applied at an equivalent total Nitrogen application of 250 kg N/ha	Units
Oven Dry Matter	%	25.9	259.00	7331	kg DM
Total Nitrogen	% w/w	3.41	8.83	250	kg N
Total Phosphorus (P)	% w/w	0.753	4.47	126.42	kg P2O5
Total Potassium (K)	% w/w	2.59	8.05	227.86	kg K2O
Total Magnesium (Mg)	% w/w	0.554	2.38	67.42	kg MgO
Total Copper (Cu)	mg/kg	226	0.06	1.66	kg Cu
Total Zinc (Zn)	mg/kg	127	0.03	0.93	kg Zn
Equivalent field application rate		—	1.00	28.31	tonnes/ha

Table 5. Samples taken from the trial **turned and covered stack at the end of the monitoring period.**

MANURE (Metric Units)

Sample Reference : TRIAL STACK

Sample Matrix : MANURE

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References	
Report Number	73930
Sample Number	84491

Date Received	14-SEP-2017
Date Reported	22-SEP-2017

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result	Amount per fresh tonne	Amount applied at an equivalent total Nitrogen application of 250 kg N/ha	Units
Oven Dry Matter	%	20.2	202.00	9363	kg DM
Total Nitrogen	% w/w	2.67	5.39	250	kg N
Total Phosphorus (P)	% w/w	0.801	3.71	171.75	kg P2O5
Total Potassium (K)	% w/w	2.47	5.99	277.53	kg K2O
Total Magnesium (Mg)	% w/w	0.568	1.90	88.28	kg MgO
Total Copper (Cu)	mg/kg	35.6	0.01	0.33	kg Cu
Total Zinc (Zn)	mg/kg	134	0.03	1.25	kg Zn
Equivalent field application rate		—	1.00	46.35	tonnes/ha

Table 6. Results from the **uncovered stack at the end of the monitoring period**

MANURE (Metric Units)

Sample Reference : CONTROL

Sample Matrix : MANURE

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References	
Report Number	73930
Sample Number	84492

Date Received	14-SEP-2017
Date Reported	22-SEP-2017

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result	Amount per fresh tonne	Amount applied at an equivalent total Nitrogen application of 250 kg N/ha	Units
Oven Dry Matter	%	18.8	188.00	8389	kg DM
Total Nitrogen	% w/w	2.98	5.60	250	kg N
Total Phosphorus (P)	% w/w	0.650	2.80	124.87	kg P2O5
Total Potassium (K)	% w/w	1.21	2.73	121.81	kg K2O
Total Magnesium (Mg)	% w/w	0.478	1.49	66.57	kg MgO
Total Copper (Cu)	mg/kg	37.2	0.01	0.31	kg Cu
Total Zinc (Zn)	mg/kg	152	0.03	1.28	kg Zn
Equivalent field application rate		—	1.00	44.62	tonnes/ha

3.5.6 Project SWOT analysis

STRENGTHS	• Improved composting technique • Analysis gives a useful guide –both as regards soil and manure nutrients • Better understanding of nutrient management options • Simple techniques can improve the process –can be applied with basic farm machinery and expertise • Composted manures improve soil structure, and are more useful to the farm business, particularly if running an organic system
WEAKNESSES	• Manure quality can be variable, so a consistent product may not be achievable in standard farm set ups • Trends not easy to see over a short time frame; need to assess new approaches over several seasons before coming to definitive conclusions • Un-replicated trial so no statistical results from this project
OPPORTUNITIES	• Composting could be improved on farms, with relative ease • Simple techniques could be introduced on all farming systems, where manure is a component of soil nutrient supply • Monitoring of nutrient values both in the soil and via manure sampling is easy, and provides useful guidance for nutrient planning
THREATS	• Difficult to obtain enough compost to meet whole farm requirements, unless stock numbers are increased, and/or other organic manure sources are identified

3.5.7 Farmer perspective of the project

The Miles family were entirely supportive of the project throughout. They were impressed with the improvement a simple silage sheet gave to the composting process, and the NMP process resulted in a more focussed approach to manure application and livestock management across the farm.

Management of the stack was easily accomplished with simple on farm machinery.

In future all of their stacks were going to be done in covered windrows.

Gerald said he would buy in some of the monitoring equipment for future use. He also commented that:

'Farmers always spread manure at 10 tonnes an acre and then find they have run out. By taking time and a little effort to manage the manure we can produce good manure that will cover a far greater area on the farm.'

'I think composted manure is the most valuable by-product of farming and it is an asset we should all really manage better to fertilise our farms,' Gerald Miles concluded.

3.6 Impact on individual business

For the full summary list of the impact of the project on the business, refer to the Project Conclusions in section 1.2 of this report.

3.7 Impact on wider industry

Take home points for the industry are outlined in section 1.3 of this report.

3.8 Impact on Welsh Government's cross cutting and priority themes

Climate change

Making best use of home produced manures reduces business requirement for bought in fertilisers, which have associated production and transport GHG emissions.

The project shows that the nutritive value of manure can be protected/enhanced, which could help businesses facing manure application restrictions, due to NVZ regulatory requirements and wider pollution risks.

Animal Health and Welfare (AHW)

Livestock need to be managed well, as are a key source of nutrients for an organic system that has limited options as regards fertiliser sources.

Future Generations

Organic production is an important element of sustainable farming systems long term.

The project forms part of a wider business ethos at Caerhys, associated with short supply chains between food producers and consumers, encouraging participation by the local community in how their food is grown. The self-sufficiency aspect of manure production and processing is part of this farming philosophy.

Tackling Poverty

The farm provides opportunities for volunteers from the local community to participate in the growing and harvesting of crops, the manure management side of things is part of this production system.

The principles of good quality, accessible food is part of the Caerhys farming philosophy.

Both the wider business, and the specific project provides upskilling/educational opportunities for workers on the farm. This relates to both those in the farming business, and volunteer workers who are trained in crop production, organic growing and marketing.