Strategies to optimise production on an organic dairy farm

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Demonstrating Sustainable Farm Practices

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Introduction

This three-year sustainable agriculture project trialled several organic nutrient inputs in conjunction with three different soil aeration techniques. The trial took place in a 2.5 hectare paddock on a certified organic dairy farm with the aim of improving pasture production.

Peter, Wendy, Ash & Toby Wallace run a 116-hectare organic dairy farm at Ellinbank, which was certified organic with the National Association for Sustainable Agriculture (NASAA) in 2005. One challenge facing organic dairy farmers is the availability of cost effective nutrient sources, which are allowable under an organic system.

Figure 1 Peter Wallace with consultant Chris Alenson

There is a strong focus in organic farming to optimise nutrient cycling and the building of soil fertility through organic matter management and stimulation of biological activity, however organic standards do allow a range of inputs based on a demonstrated need (National Organic & Biodynamic Standards, 2016). The Wallace family follow this approach through utilising available on-farm resources such as calf shed waste, dairy effluent and farm produced compost, with the aim of improving soil nutrient cycling and soil fertility. The compost is made from calf shed and feed pad manure and spent hay. Dairy effluent is also spread over 15ha of the farm (but not over the demonstration paddock).

The farm also uses a range of allowable inputs including Enviro Crop Biofactor foliar spray which is reported to increase plant root exudates and microbial activity, Guano Gold (a phosphorus containing foliar spray), and Rapid Raiser (a pelletised poultry manure).

Figure 2 Soil sod showing good structure

The soils in the demonstration paddock are Ferrosols derived from older basalts of Tertiary geological age (20-40 million years).

Ferrosols are deep, friable, well-structured red to brown clay loam soils characterised by a high iron oxide content. As well as being moderately acid, they also tend to have the ability to ‘fix’ phosphorus making it less available to plants. This means that in an acid soil, particularly with a pH of below 5 in water, the phosphorus binds with aluminium and iron mineral particles making it unavailable.

Demonstration site establishment

The trial site is situated on a north facing 2.5ha paddock, which was producing below its potential. The demonstration measured how the pasture responded to the application of three organic nutrient inputs. Three soil aeration techniques were also applied to stimulate nutrient cycling and these ran at a 90-degree angle to the test plots.

The three nutrient sources trialled included:

- Biofactor (300ml/ha) + 20ml Biomin calcium
- An organically certified fertiliser (Rapid Raiser) at 400kg/ha, analysis N 4%, P2.5% and K1.5%
  This equates to an annual application rate of 16kg/ha nitrogen, 10kg/ha phosphorus and 6kg/ha potassium.

- Guano Liquid Gold (4L/ha) - and farm made compost at 2t/ha (wet weight) or 900kg/ha dry weight) which analysed at (N 1.68%, P 0.41%, K 1.08%)
  The compost addition equated to an annual application rate of 15kg/ha nitrogen, 3.6kg/ha phosphorus and 10kg/ha potassium.

The three aeration techniques trialled were:

- Spiked roller
- Yeoman's plough
- Soilkee soil aerator

Figure 3 Yeomans plough

Figure 4 Spiked roller

Figure 5 Soilkee soil aerator

Figure 6 Field peas sown with the Soilkee soil aerator

All machines were run at 90 degrees across the three-fertiliser treatments to compare the different aeration techniques. An advantage of the Soilkee is that it has a seed box attachment and can sow seed while rehabilitating the soil. As only 17% of the soil is disturbed in each pass, livestock can be introduced immediately to the renovated pasture. The SoilKee has been successfully trialled on a number of properties across the Gippsland region.

Figure 7 Plot Layout							
			North				
		Compost @ 2T/Ha + Guano Liquid Gold @ 4L/Ha	Biofactor @ 300ml/Ha + 20ml Biomin Calcium	Rapid Raiser @ 400Kg/Ha	Control No inputs		
		48m	29m	29m	34m		
No aeration	42m	**4**	**3**	**2**	**1**	37m	**No Aeration**
Spike Roller	38m	**5**	**6**	**7**	**8**	45m	**Spike Roller**
Yeomans	54m	**12**	**11**	**10**	**9**	49m	**Yeomans**
SoilKee	45m	**13**	**14**	**15**	**16**	39m	**SoilKee**
		43m	43m	40m	35m		
		8236m^2	**6428m^2**	**6146m^2**	**5955m^2**		

Monitoring

Sixteen plots were monitored comprising three nutrient inputs applied over three aeration techniques along with control plots (see Figure 7 for plot layout). Monitoring parameters included;

1. Soil tests were taken at the beginning and end of the trial to monitor soil nutrient levels.
2. As part of the monitoring the Solvita Soil Health Test was utilised. This is a technology and method that allows the soil CO_2 respiration of microorganisms to be measured in the field. As biological activity increases and organic matter cycles, CO_2 is released. The rate of CO_2 release is regarded as an indicator of soil health. The scale reads from 0-5 with 5 being the highest level of biological activity and 0 being the lowest level of biological activity. Soil samples were taken from each plot in the trial paddock and placed in sample jars. Indicator probes were inserted into the soil and the lids secured and kept at room temperature for 24 hours. The colour of the

Figure 8 Solvita Soil Health Test Guano/Compost Plot 4

probes were compared with a supplied colour key which indicated the levels of CO_2 released and hence the degree of biological activity.

3. Pasture yield was measured with an electronic 'GM Pro' Pasture Meter. The pasture was measured prior to the cattle entering the paddock for each grazing.
4. Application rates and costs of inputs were documented and compost analyses were undertaken to establish nutrient content.

Figure 9 Pete Ronalds taking pasture readings

Compost analysis

Aerobic compost was produced on farm from dairy waste, manure and spent hay, and this was then turned with a front-end loader.

An important indicator of the quality of compost is the carbon nitrogen (C:N) ratio, which in well-made compost should be less than 15:1. As the ratio becomes wider the availability of N reduces significantly. Analyses of key components in the batches is tabulated below.

The Wallace's compost was a mature, well-made compost which indicates 17.5% -20% of nitrogen is able to be mineralised after application (Prasad, 2009).

The analytical results of compost made over the three years are tabulated below.

Figure 10 Analysis of the on-farm produced compost for each year

Nutrient	Compost				Compost Guide
	2015	2016	2017	Ave of 3 years	
Nitrogen %	1.59	1.92	1.54	1.68	2
Phosphorus %	0.38	0.5	0.34	0.41	0.5
Potassium %	1.06	1.15	1.04	1.08	0.8
Sulphur %	0.29	0.27	0.25	0.27	<0.5
Carbon %	19.9	21.1	18.6	19.9	>30
Calcium %	1.26	1.47	1.07	1.27	3
Magnesium %	0.48	0.56	0.36	0.47	0.5
Sodium %	0.18	0.23	0.18	0.20	>0.2
Carbon: Nitrogen Ratio	12.5	11	12	11.8	<15
Organic matter %	34.8	37	32.5	34.8	>50
pH (1:5 water)	7.5	6.9	7.6	7.3	5.0-7.5
Conductivity (1: 5 water)	3.7	4.2	4.7	4.2	No limit

Figure 11 $ Value of nutrients in compost that was applied (annual basis on DM basis)				
Nutrient	**Nutrient kg/tonne**	**kg Nutrient applied @ 900kg/ha/DM**	**Nutrient value $/kg ***	**$ Value of compost @ 900kg compost (DM)**
Nitrogen	16.8	15.12	$ 1.27	$ 19.20
Phosphorus	4.1	3.69	$ 4.40	$ 16.24
Potassium	10.8	9.72	$ 1.68	$ 16.33
Calcium	12.7	11.43	$ 0.50	$ 5.72
Sulphur	2.7	2.43	$ 0.70	$ 1.70
Carbon	199.0	179.1	$ -	$ -
			TOTAL	**$ 59.18**

* based on March 2010 fertiliser prices (calculate $/tonne by the % nutrient/tonne)

Source: https://www.aora.org.au/wp-content/uploads/2018/03/pasture_cropping_members.pdf

Value of nutrients spread at 2t/ha annually = $59.18

Intangible benefits

Organic matter contained in compost contributes to increased soil moisture holding capacity. In addition, increased carbon is a benefit to soil productivity. Based on a C content of 19.9% and a spread rate of 2t/ha, a total of 398kg/ha of C was applied on an annual basis.

The pasture yields for this demonstration indicated an increase in pasture growth from the application of compost and guano both with and without aeration. There may also be an added benefit from the addition of mineral elements contained in the compost, increased organic matter and organic carbon.

Figure 12 Soil Analysis (grouped by aeration methods)

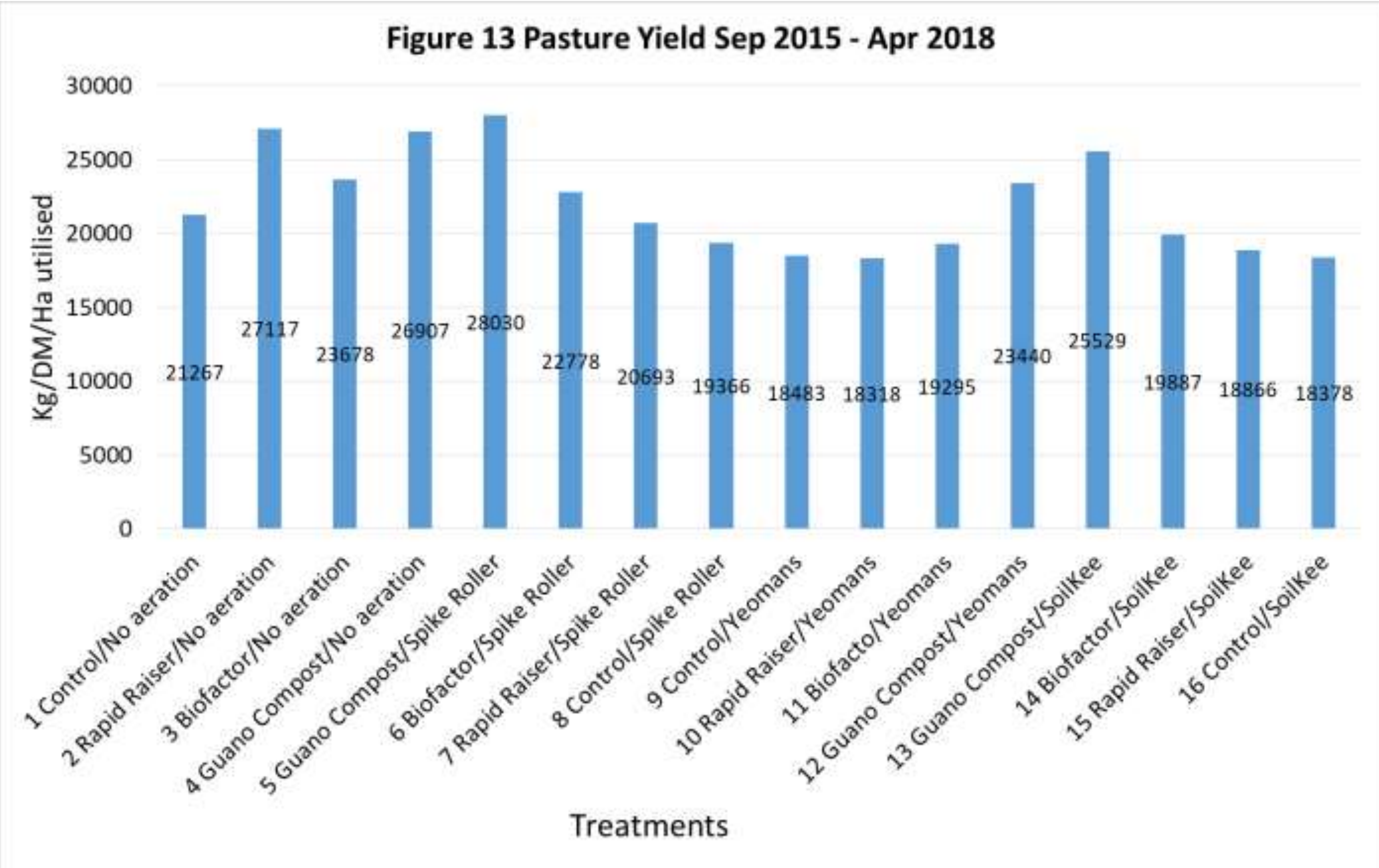
Nutrient mg/kg	No Aeration				Spike Roller				Yeoman				Soilkee			
	1 No input	2 Rapid Raiser	3 Biofactor	4 Compost & Guano	8 No input	7 Rapid Raiser	6 Biofactor	5 Compost & Guano	9 No input	10 Rapid Raiser	11 Biofacto r	12 Compost & Guano	16 No input	15 Rapid Raiser	14 Biofactor	13 Compost & Guano
Calcium (Morgan) mg/kg	1551	1967	1001	1547	1695	1702	1742	1710	1728	1783	1816	1660	1771	1752	1626	1644
Morgan K mg/kg	136	241	703	268	56	93	204	202	85	78	62	170	89	81	102	198
Phosphorus (Colwell) mg/kg	45	63	31	48	44	47	52	56	44	54	51	51	18	47	47	51
Phosphorus (Olsen) mg/kg	10	12	7.2	10	9.1	9.0	11	10	8.9	11	10	8.9	11	12	11	11
Nitrate Nitrogen (KCl) mg/kg	8.3	34	8.0	17	10	17	22	24	9.9	8.7	10	22	12	8.6	11	17
Ammonium Nitrogen (KCl) mg/kg	6.2	7.0	6.7	7.7	8.0	8.4	10	15	6.0	5.8	7.8	8.8	6.4	5.9	9.2	6.7
Sulphur (KCl) mg/kg	15	21	86	14	9.4	15	13	14	12	12	11	14	7.8	16	11	15
pH (1:5) water	6.36	6.49	5.92	6.36	6.43	6.30	6.37	6.37	6.47	6.41	6.38	6.28	6.41	6.42	6.32	6.34
Organic matter %	12.2	14.6	7.9	15.8	12.5	15.2	15.6	16.4	13.3	14.3	15.1	16.6	14.7	15.2	15.7	16.2
Effective Cation Exchange Capacity cmol+/kg	18.74	22.57	13.90	22.20	19.90	21.88	24.04	23.97	20.67	22.29	22.51	21.28	22.13	22.16	21.89	21.89
ECEC Calcium %	79.4	78.3	53.0	73.3	82.0	78.5	77.0	76.0	80.2	81.1	80.1	76.3	78.3	77.1	76.4	76.2
ECEC Magnesium%	14.0	14.2	24.9	17.9	14.0	16.4	15.9	17.4	15.2	14.3	15.6	17.5	17.1	18.4	18.9	17.2
ECEC Potassium %	3.9	5.1	19.7	6.4	1.8	2.6	4.5	4.6	2.4	2.4	1.8	4.0	2.3	2.1	2.5	4.4
ECEC Sodium %	1.9	1.7	1.7	1.7	1.6	1.8	1.8	1.4	1.6	1.6	2.0	1.7	1.8	1.9	1.7	1.6
Total Carbon %	6.98	8.34	4.49	9.04	7.13	8.70	8.93	9.40	7.62	8.15	8.65	9.46	8.42	8.69	8.95	9.28
Total N %	0.57	0.69	0.36	0.75	0.60	0.72	0.74	0.76	0.62	0.69	0.66	0.76	0.69	0.69	0.70	0.77

N.B. "Sample 3 Results for Biofactor with no aeration are not consistent with the other samples taken from the same paddock. The variation across a number of soil parameters (potassium, magnesium, sulphur, organic matter, effective cation exchange, total nitrogen and total carbon) is sufficient for these results not to be included in the trial discussion".

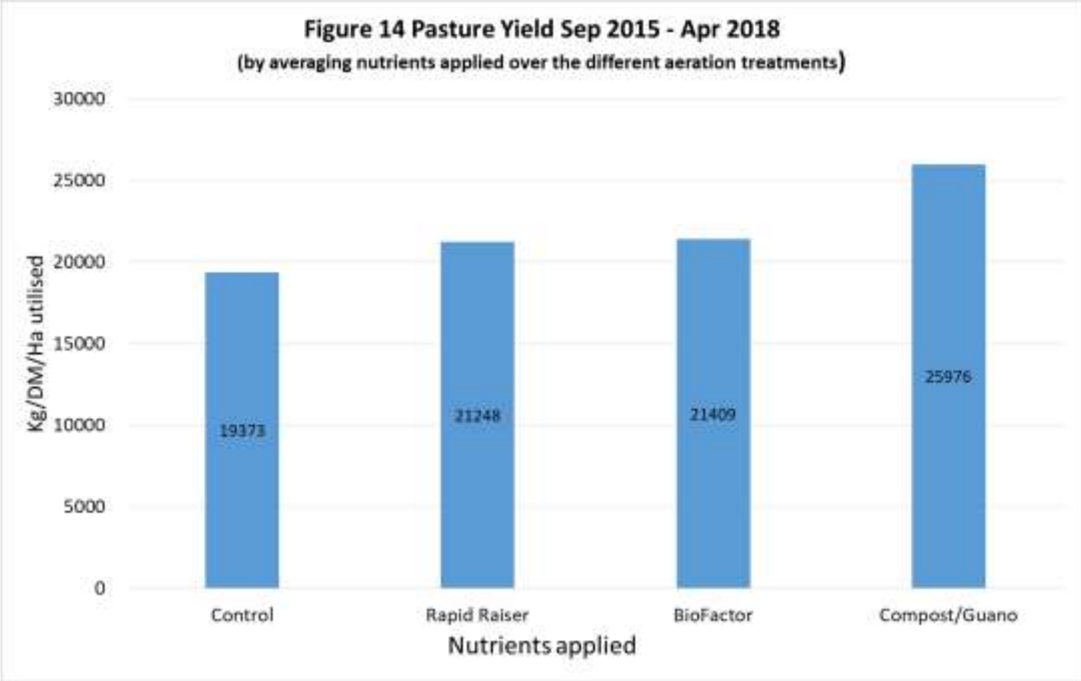
Soil analyses summary

- Compost/Guano increased available potassium, nitrate nitrogen, total nitrogen, organic matter, total carbon and ECEC
- Decrease in potassium across all aerated plots with no inputs
- Increase in available calcium across all Spiked Roller, Yeomans and Soilkee plots
- Increase in available nitrogen across all plots except the Yeomans Rapid Raiser and Yeomans Biofactor plots
- Total nitrogen, organic matter and total carbon increased across all plots with inputs applied

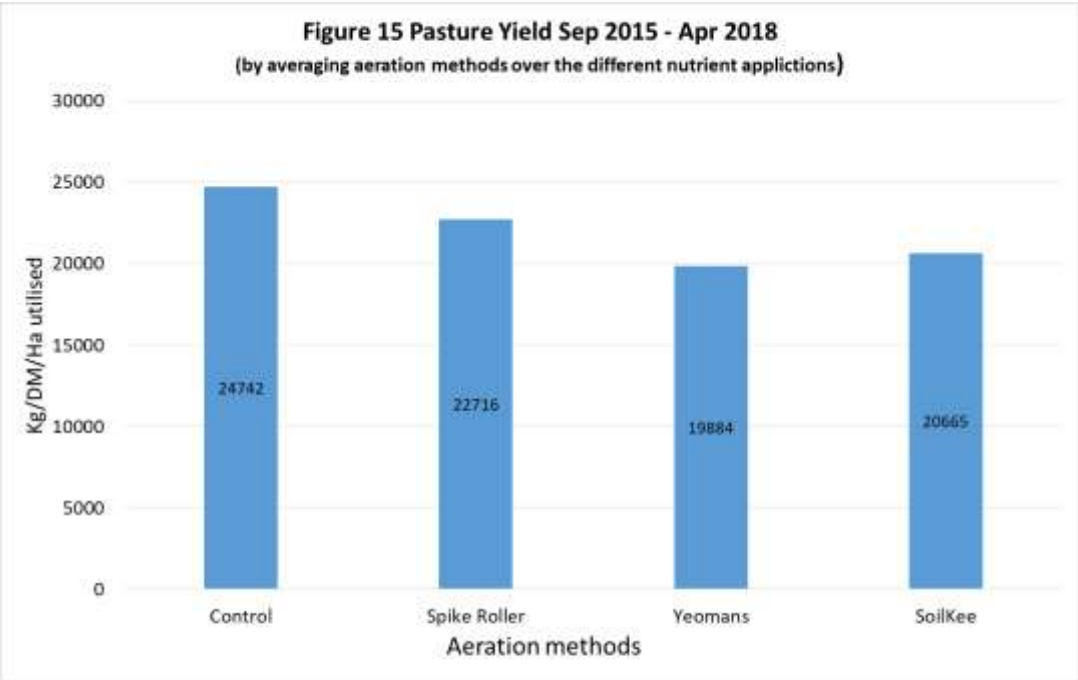
Pasture yield



Pasture species yield was monitored prior to every grazing and measured with an electronic 'GM Pro' Pasture Meter. The rotation length varied from between 20 days in spring up to 140 days through Summer. The graph above displays the pasture yields for each plot. It should be noted that any ungrazed (or residual) pasture was not measured post grazing, however for the purposes of the demonstration it was estimated that the post grazing residual was an average of 1400kg/DM/Ha over the length of the demonstration.



Results show that the Compost/Guano application produced the highest quantity of feed (20% more than both the BioFactor and Rapid Raiser & over 30% more than the control) when averaged over the different aeration treatments.



It should be noted that the soil aeration conducted on 20th August 2015 was followed by an extensive dry period. Results suggest that all the aeration methods impacted negatively on pasture yield for 2 seasons following treatment due to the low rainfall immediately following aeration. The spike roller was less aggressive, and as a result pasture yield was not as severely impacted as with the more aggressive Yeomans method. The SoilKee didn't disturb the soil significantly, however the newly sown plants died soon after germination due to lack of moisture which resulted in a lower than expected yield. The SoilKee aeration was located at the top of the north facing hill which was higher and more exposed than the other aeration methods. The location of this method could have also have impacted on pasture yield.

Costs and benefits

Figure 16 Annual costs for different treatments $/ha	
Biofactor 300ml/L (not including spreading)	$40
Compost 2t/ha spread @ $60t/DM basis (not including making)	$240
Rapid Raiser + Guano 400kg/ha @ $618t	$247
Soil aeration (Spiked roller) x 3 times, 1hrs/year @ $100hr	$150
Soil aeration (Yeomans) x 1 times, 2hours $100hr	$300
Soilkee x 2 times, 1hrs/year @$180/hr	$270

The cost of the compost was based on a commercial rate which was estimated at $120t/DM or $240/ha @ 2t/DM/ha spread rate. The pasture yields for this trial indicated an increase in pasture growth from all plots that had the compost and Guano applies.

Summary

- The initial soil assessment (2015) indicated a well-structured soil with a chemical analysis that indicated below adequate levels of Phosphorous (P) and Potassium (K). At the end of the demonstration, both P and K were still at below recommended levels for optimum pasture production.
- The trial design examined the effectiveness of three inputs allowable under organic standards. These were used in conjunction with three types of soil aeration equipment.
- Comprehensive monitoring of the plots included full soil analysis, pasture yield and Solvita Soil Health Tests to ascertain soil health and pasture productivity.
- The summary of the soil test results comparing the 2017 control indicated that the application of inputs had positive increases in organic matter, total nitrogen, nitrate nitrogen and Effective Cation Exchange (ECEC).
- The most effective aeration strategy was the Soilkee, which increased organic matter, total nitrogen, nitrate nitrogen and total carbon.
- Soil aeration initially depressed pasture yield as the aeration was conducted in Sep 2015 and this was followed by an unseasonably dry spring and summer.
- Although the timing of soil aeration initially resulted in a lower pasture yield, soil chemistry results indicate that some increases in organic matter and total nitrogen may result in increased yields in the future.
- Guano and compost input provided the best results for pasture yield and soil chemistry. It should be noted that the guano and compost input was applied at levels lower than is generally applied.

References

National Standard for Organic and Bio-Dynamic Produce—Edition 3.7 September 2016

Prasad, M,. Dr., 2009, A literature review on the availability of nitrogen from compost in relation to the nitrate regulations SI 378 of 2006, EPA Strive Program, 2007-2013

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