Identifying economic ways to incorporate lime using machinery already owned by the farmer

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Contents

Introduction

Using lime to reduce soil acidification in this region is a necessity for better food production as this issue is one of the main limiting factors for increased production here. It reduces detrimental soil issues including poor soil biota, non-wetting soils, and decrease issues caused by wind and water erosion.

The lime required to effectively ameliorate topsoil (0-10 cm) and subsurface (10-20 cm and 20-30 cm) acidity in one pass or treatment can be very high (more than 6t/ha) as the lime is being spread over 3x the volume of soil when compared to only treating the topsoil (approx. 2t\ha). Recently, many farmers and research groups have been exploring the use of tillage to incorporate the lime through the soil profile, increasing contact between lime and acidic soil which raises soil pH in a shorter period of time.

The amount lime required to effectively ameliorate soil acidity is mainly determined by the starting soil pH, the volume of soil to be treated and the neutralising value (NV) of the lime, amongst other things. For example, topsoil (10 cm of soil) with a starting pH of 4.5 will require around 2 t/ha of 96% NV limesand to increase the final pH to above 5.5. The lime required to effectively ameliorate an acidic topsoil (0-10 cm) and subsurface (10-20 cm and 20-30 cm) profile in one pass/treatment can be very high (more than 6t/ha) as the lime is being spread over 3x the volume of soil when compared to only treating the surface.

As the Moora Miling agricultural area is very advanced in managing soil pH (can be backed up by Chris Gazey DAFWA - Lime advisor), the next step is for farmers to look at speeding up the movement of lime through the soil profile so they can get a faster return on money invested in lime. This project will compare lime incorporation techniques using different and on-hand equipment on different soil types in the Moora-Miling region.

Considerable work on lime incorporation has been completed and is continuing on lighter soils. The West Midlands Group, Liebe Group and the Mingenew Irwin Group all have trials ongoing looking at Lime Incorporation. This work complements work done by other grower groups and also provides insight into lime incorporation on heavy soils using cheap methods provided by the farmer.

Recent activity on lime incorporation has been focusing on the more expensive options such as mouldboard ploughing and spading. If this project can demonstrate that some of the machinery lying around on our farms is able to incorporate the lime, it will provide a very cost effective option for farmers.

If the lime can be assisted to move through the soil profile quicker then the farmer will be able to correct his soil pH in a more timely manner which will lead to increase crop and pasture yields.

Very little work has been completed on lime incorporation in the Moora-Miling area, especially on acid loams. Farmers in the area have identified soil acidity at depth through their individual soil testing regimes, and now want to limit yield losses by lifting subsoil pH faster than would be achieved by surface application of lime.

Trial location

Trial sites were located across the Moora-Miling Pasture Improvement Group (MMPIG) area, covering the extent of soil types across the region (Table 1). Figure 1 illustrates the distribution of the trial sites across the MMPIG area. Farmers were selected on previous liming histories and availability of machinery. Trials were located on each of the properties using old soil test data to depth, although after initial soil testing some site variability was identified, which was not ideal for simplicity of the project.

Table 1 Summary of Trial Sites

Site Name	Soil Type	GPS Location	Equipment Used	Previous Lime?
Tony White	Sandy loam, some granite	-30.441273 S, 116.305619 E	One way plough	Yes
Jeremy Lefroy*	Loam, some clay at depth.	-30.553443 S, 116.257695 E	Scarifier	Yes
Richard Humphry	Sandy Loam with granite.	-30.572310 S, 116.219702 E	Scarifier	Yes
David Hamilton	Sandy Loam, with some load at depth.	-30.593231 S, 116.115914 E	Cultitrash	No
Jim Hamilton	Yellow Sand	-30.614481 S, 115.97741 E	Spader	Yes

*Winter liming site

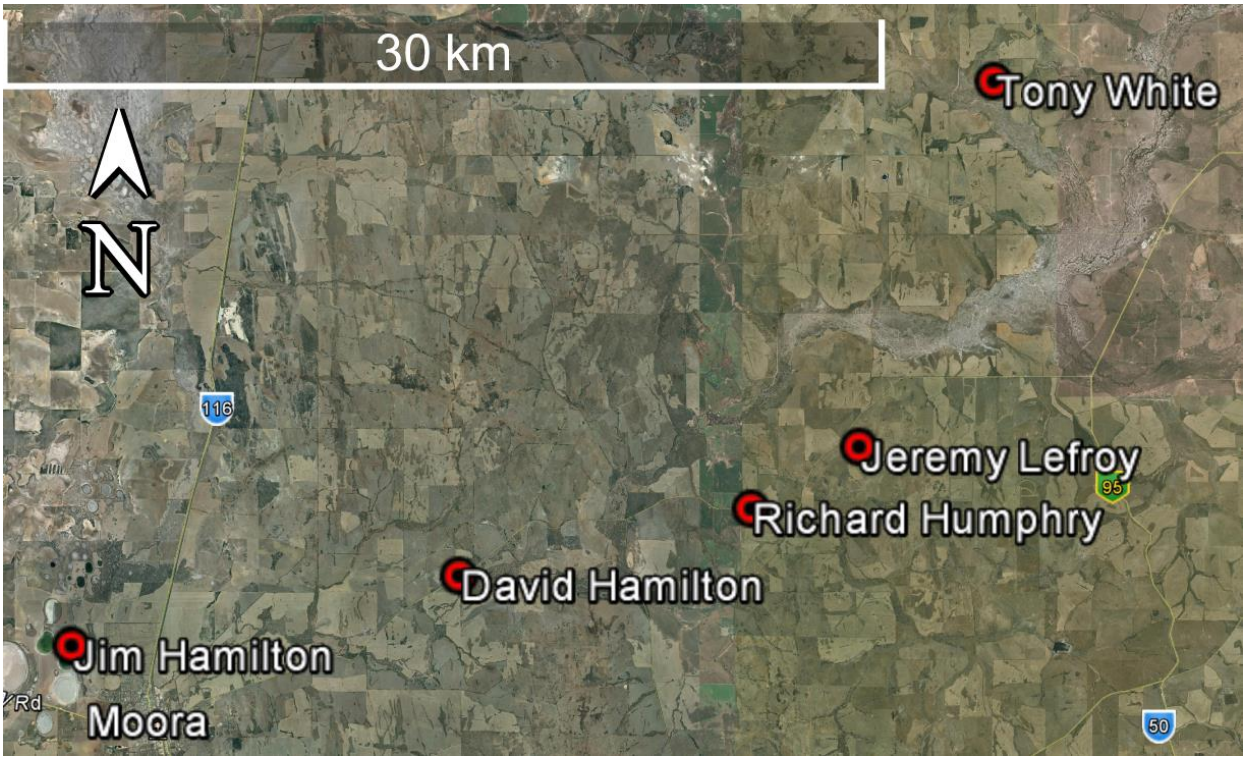

Figure 1: Locations of trial sites across the MMPIG region.

Methodology

A total of four treatments were applied, replicated three times at each trial site. Plots were 10m wide and 25m long. Treatments were randomized in each replicate. A gap was left between

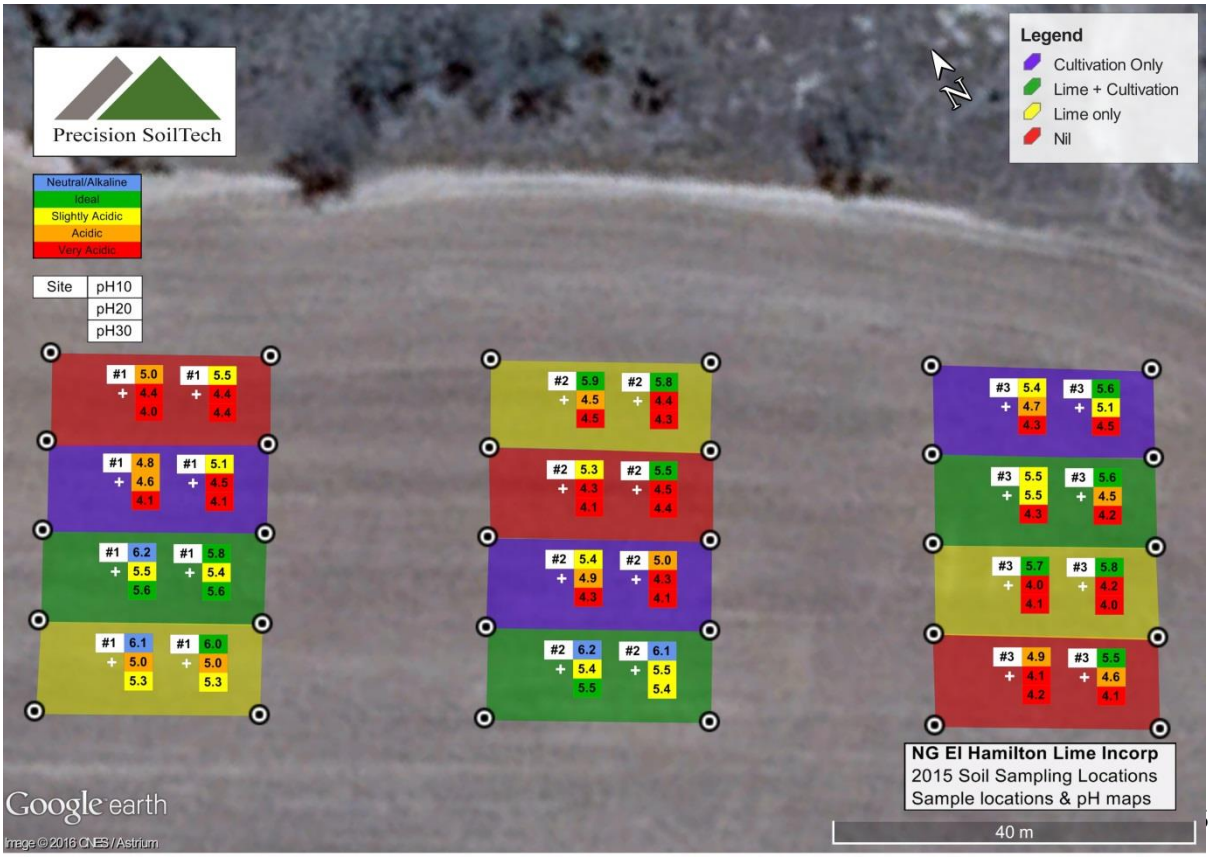

Figure 2: Example trial design and pH results from the trial at Jim Hamilton's.

replicates so machinery could turn and move between plots. In each case the lime and the incorporation was supplied by the farmer.

Two soil sampling sites were taken from each plot, the same distance from each end. Samples were taken from 0-10cm, 10-20cm and 20-30cm using Precision SoilTech's pneumatic soil sampling machine. All samples were analysed for pH ($CaCl_2$).

Both the final pH measurements and also the pH change were analysed for differences.

Results and Discussion

Figure 3 and Figure 4 summarises the raw pH data at the conclusion of the project and the pH change observed during the project. Results varied significantly from site to site, dependent on a large number of site related factors.

Jim Hamilton

At Jim Hamiltons the largest response to lime and cultivation was observed. For the lime and cultivation (spader) treatment, pH was increased 0.25 units in the topsoil, 0.5 pH units in the midsoil and 0.5 pH units in the subsoil. As expected, the lime treatment only increased pH in the topsoil (0-10cm), while little change was observed in the mid and subsoil. With the cultivation only treatment, pH in the topsoil fell, while slight increases were observed in the mid and subsoil. This is a result of higher pH topsoil being mixed through the subsurface soil.

The spader was able to mix the limesand to a deeper depth, which resulted in higher increases in soil pH in the subsoil than at other sites. Two factors heavily contributed to this. The first was the spader itself compared to other machines – naturally due to its characteristics it is a lot more effective at mixing limesand to depth. The site was sandy which was more penetrable for incorporation, compared to other sites.

Tony White

Very little response to any of the treatments was observed at Tony Whites. Topsoil pH increased across all treatments by 0.5 of a pH unit. The midsoil and subsoil fell by between 0 and 0.5 of a pH unit.

At this site, the one way plough was unable to influence soil pH below a depth of 10cm, largely due the small relative size of the disks, and the soil type.

Richard Humphry

Like the one way plough site at Tony Whites, the scarifier at Richard Humphrys was unable to get lime to the depth required to treat the acidity. Very little difference was observed in the pH below 10cm of soil.

David Hamiltons

David Hamiltons was the only site where lime had not been previously applied. Little difference in pH was observed between the cultivation only and the nil plots. No large differences were observed in pH in the 10-20cm and the 20-30cm across all plots due to the machinery not reaching those depths. Movements in topsoil pH were observed in the limed plots and even greater pH differences were observed in the lime and cultivation plots.

Jeremy Lefroy

Treatments at Jeremy Lefroy's were installed during the September 2015 to analyse the effects of winter liming. Unfortunately after initial baseline sampling revealed that it was a highly variable site. The majority of the site was also found to be either neutral or alkaline, which was the major cause of some variable results. During the following winter, large increases in pasture growth were observed in the cultivation plots, which illustrate the cultivation has assisted to ameliorate a compaction issue. See appendices for photos.

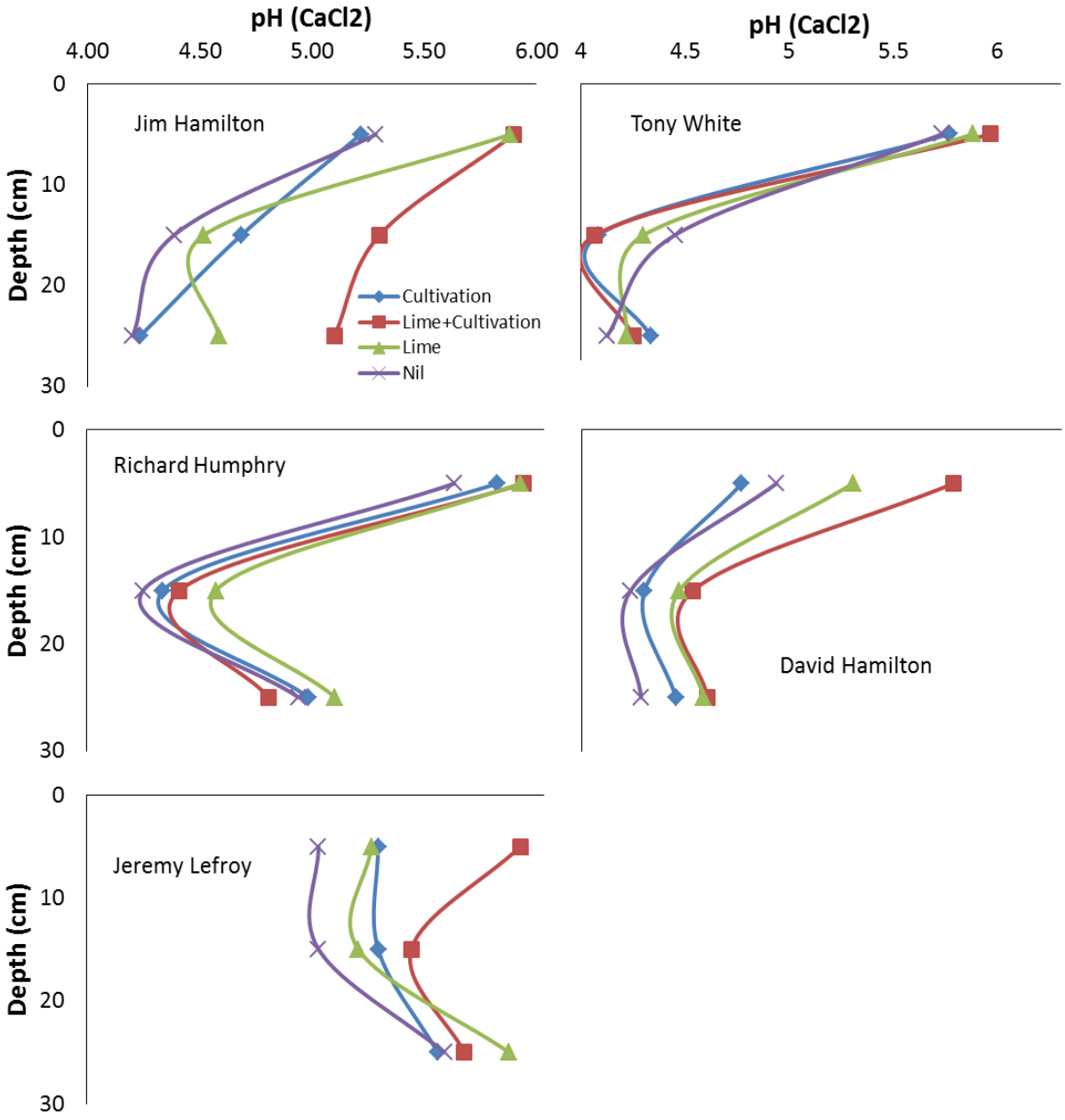

Figure 3: Summary of pH data measurements at the conclusion of the project.

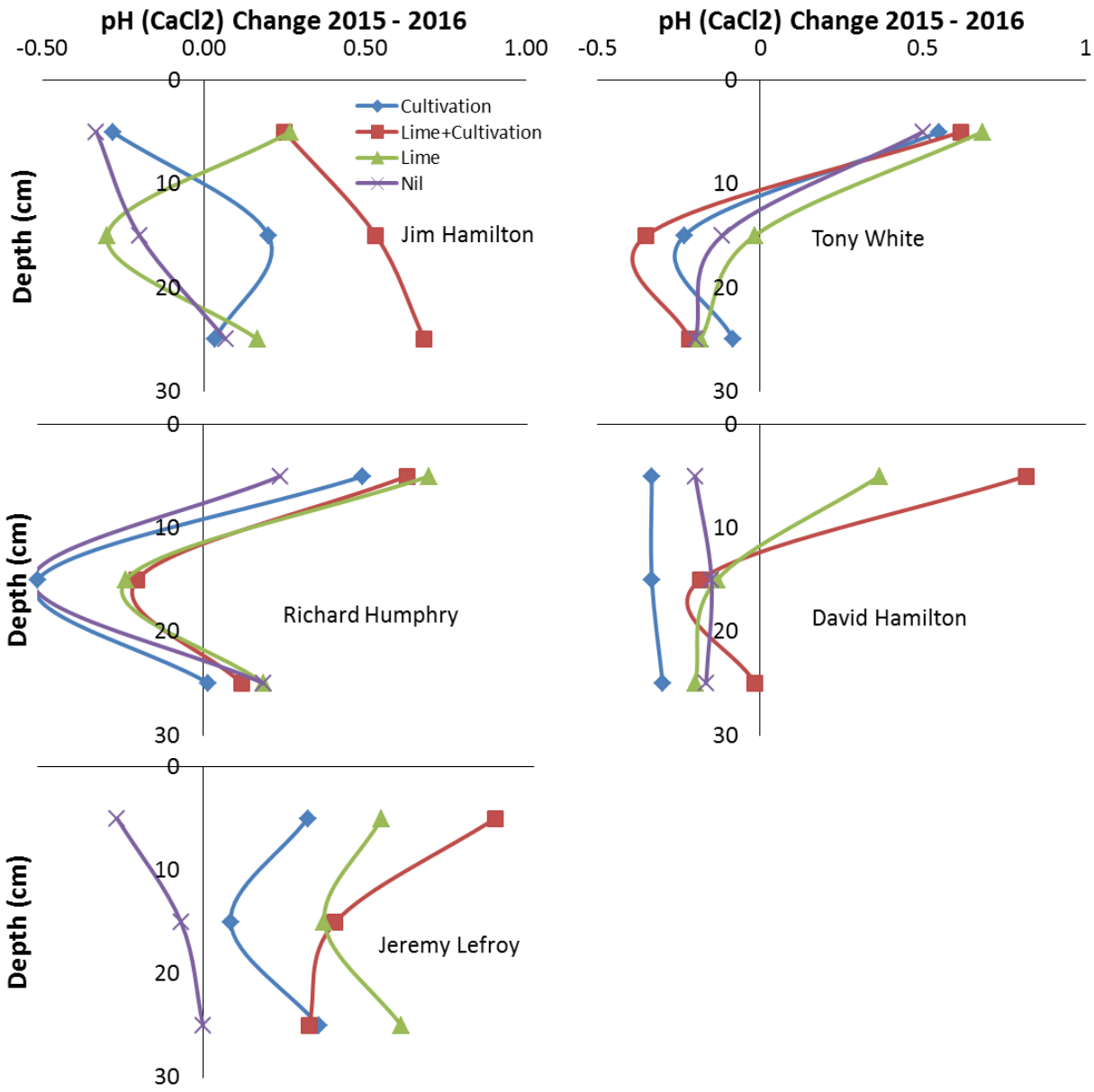

Figure 4: Summary of pH change from 2015-2016 at each of the sites.

Recommendations

The project has primarily identified the difficulties of mixing lime to below 10cm in heavy soil with old machinery. The next step is to analyse the durability and cost effectiveness of using newer model tillage machinery to mix lime at depth. Heavier soils pose a greater challenge to ameliorate due to a higher buffering capacity. Incorporation is also more difficult as bigger machines are required to gain penetration into the soil, with larger towing horse power required.

Appendices

Appendix 1 – Interesting Compaction Results

Pasture growth from cultivation plots at Jeremy Lefroy's. Left of the post is not cultivated, right is cultivated. Photo: Wes Lefroy

Appendix 2 – Pictures of Machinery Used

Figure 5: Scarifier bar used at Jeremy Lefroys and Richard Humphrys.
Photo: Wes Lefroy

Figure 6: Culti-Trash used at David Hamiltons
Photo: David Hamilton

Figure 7 - A similar one-way chamberlain plough to the one used at Tony Whites. Photo: Alton Materials

Figure 8: The spader used at Jim Hamiltons. Photo: Jim Hamilton

Appendix 3 – Raw pH Results

Tony Whites

Paddock	Site	Date	pH Topsoil	pH Midsoil	pH Subsoil	Date	pH Topsoil	pH Midsoil	pH Subsoil
Cult	1	4/04/2015	5.3	4.2	4.2	15/04/2016	5.7	4.1	4.3
Cult	2	4/04/2015	5.5	4.8	4.6	15/04/2016	5.9	4	4.2
Cult	3	4/04/2015	5	4.1	4.4	15/04/2016	5.7	4	4.4
Cult1	1	4/04/2015	5.1	4.1	4	15/04/2016	5.8	4	4.1
Cult1	2	4/04/2015	5.6	4.6	4.8	15/04/2016	5.8	4.2	4.4
Cult1	3	4/04/2015	4.8	4.1	4.5	15/04/2016	5.7	4.2	4.6
Lime	1	4/04/2015	5.4	3.9	4.2	15/04/2016	6.1	4.2	4.1
Lime	2	4/04/2015	4.9	4.2	4.1	15/04/2016	5.8	4.2	3.9
Lime	3	4/04/2015	5.3	4.4	4.4	15/04/2016	5.8	4.5	4.3
Lime Cult	1	4/04/2015	5.3	4.8	4.4	15/04/2016	6	4	4.2
Lime Cult	2	4/04/2015	5.5	4.8	4.5	15/04/2016	5.8	4.1	4.3
Lime Cult	3	4/04/2015	5.3	4.3	4.4	15/04/2016	6.2	4	4.2
Lime Cult1	1	4/04/2015	5.7	4.5	4.4	15/04/2016	5.9	4	4.4
Lime Cult1	2	4/04/2015	5.2	4.5	4.7	15/04/2016	6	4.2	4.3
Lime Cult1	3	4/04/2015	5.1	4.4	4.4	15/04/2016	5.9	4.1	4.1
Lime1	1	4/04/2015	5.4	4.8	5	15/04/2016	5.8	4.4	4.3
Lime1	2	4/04/2015	5.1	4.3	4.3	15/04/2016	5.5	4	4.4
Lime1	3	4/04/2015	5.1	4.3	4.4	15/04/2016	6.3	4.5	4.3
Nil	1	4/04/2015	4.9	4	4.1	15/04/2016	5.2	3.9	4.1
Nil	2	4/04/2015	5.4	4.7	4.5	15/04/2016	6	4.2	4.2
Nil	3	4/04/2015	5.5	5.4	5.5	15/04/2016	5.9	5.2	6.8
Nil1	1	4/04/2015	5.3	4.2	4.1	15/04/2016	5.6	3.9	4
Nil1	2	4/04/2015	5.1	4.3	4.6	15/04/2016	5.8	4.2	4.2
Nil1	3	4/04/2015	5.2	4.8	5.2	15/04/2016	5.9	5.3	6.7

Jim Hamilton

Paddock	Site	Date	pH Topsoil	pH Midsoil	pH Subsoil	Date	pH Topsoil	pH Midsoil	pH Subsoil
Cult	1	14/04/2015	5.8	4.3	4.1	5/04/2016	4.8	4.6	4.1
Cult	2	14/04/2015	6	4.5	4	5/04/2016	5.4	4.9	4.3
Cult	3	14/04/2015	5.4	4.2	4.1	5/04/2016	5.4	4.7	4.3
Cult1	1	14/04/2015	5.3	4.2	4.1	5/04/2016	5.1	4.5	4.1
Cult1	2	14/04/2015	4.9	4.5	4.4	5/04/2016	5	4.3	4.1
Cult1	3	14/04/2015	5.6	5.2	4.5	5/04/2016	5.6	5.1	4.5
Lime	1	14/04/2015	5.2	5.1	4.7	5/04/2016	6.1	5	5.3
Lime	2	14/04/2015	5.7	5	4.6	5/04/2016	5.9	4.5	4.5
Lime	3	14/04/2015	5.9	5.1	4.1	5/04/2016	5.8	4.2	4
Lime Cult	1	14/04/2015	5.8	5.1	4.8	5/04/2016	6.2	5.5	5.6
Lime Cult	2	14/04/2015	5.6	5	4.7	5/04/2016	6.2	5.4	5.5
Lime Cult	3	14/04/2015	5.7	4.5	4	5/04/2016	5.5	5.5	4.3
Lime Cult1	1	14/04/2015	5.5	5.2	4.3	5/04/2016	5.8	5.4	5.6
Lime Cult1	2	14/04/2015	5.7	4.8	4.6	5/04/2016	6.1	5.5	5.4
Lime Cult1	3	14/04/2015	5.6	4	4.1	5/04/2016	5.6	4.5	4.2
Lime1	1	14/04/2015	5.6	4.9	4.8	5/04/2016	6	5	5.3
Lime1	2	14/04/2015	5.6	4.5	4.2	5/04/2016	5.8	4.4	4.3
Lime1	3	14/04/2015	5.7	4.3	4.1	5/04/2016	5.7	4	4.1
Nil	1	14/04/2015	5.3	4.1	3.8	5/04/2016	5	4.4	4
Nil	2	14/04/2015	5.7	4.4	4.2	5/04/2016	5.3	4.3	4.1
Nil	3	14/04/2015	5.6	5	4.2	5/04/2016	4.9	4.1	4.2
Nil1	1	14/04/2015	5.7	4.8	4.5	5/04/2016	5.5	4.4	4.4
Nil1	2	14/04/2015	5.7	4.4	4	5/04/2016	5.5	4.5	4.4
Nil1	3	14/04/2015	5.7	4.8	4.1	5/04/2016	5.5	4.6	4.1

Jeremy Lefroy

Paddock	Site	Date	pH Topsoil	pH Midsoil	pH Subsoil	Date	pH Topsoil	pH Midsoil	pH Subsoil
Cult	1	2/09/2015	5.2	5.9	5.8	4/06/2016	5.6	6.1	6.7
Cult	2	2/09/2015	4.7	4.7	5.2	4/06/2016	5.2	5.7	5.9
Cult	3	2/09/2015	4.8	5.6	4.7	4/06/2016	5.2	4.3	4.7
Cult1	1	2/09/2015	5.8	5.5	6	4/06/2016	5.9	5.9	6
Cult1	2	2/09/2015	5.2	5.2	5.2	4/06/2016	5.2	5.9	5.8
Cult1	3	2/09/2015	5.2	5.4	5.6	4/06/2016	5.7	4.9	5.5
Lime	1	2/09/2015	5.5	5	5.7	4/06/2016	5.4	5.5	6.1
Lime	2	2/09/2015	4.6	5.1	5.6	4/06/2016	5.8	5.8	
Lime	3	2/09/2015	4.3	4.4	4.7	4/06/2016	4.6	4.7	
Lime1	1	2/09/2015	5.1	5	5.5	4/06/2016	6.4	6.1	6.6
Lime1	2	2/09/2015	5.6	6	5.5	4/06/2016	5.6	5.5	6.6
Lime1	3	2/09/2015	5.4	4.5	5.4	4/06/2016	4.8	4.6	5.2
LimeCult	1	2/09/2015	5.6	5.2	5.1	4/06/2016	5.8	5.2	5.7
LimeCult	2	2/09/2015	4.9	5.9	6.4	4/06/2016	6.4	5.9	6.2
LimeCult	3	2/09/2015	4.9	4.7	5.5	4/06/2016	6.1	5.7	5.7
LimeCult1	1	2/09/2015	5.2	5.5	5.7	4/06/2016	6.1	5.3	5.6
LimeCult1	2	2/09/2015	5.7	4.7	4.8	4/06/2016	6.6	6	6.5
LimeCult1	3	2/09/2015	5.5	5.4	4.6	4/06/2016	6.1	5.7	5.7
Nil	1	2/09/2015	5.4	5	5	4/06/2016	5	4.9	6.1
Nil	2	2/09/2015	5.5	6	6.5	4/06/2016	4.5	4.8	6.1
Nil	3	2/09/2015	5.1	4.5	5.5	4/06/2016	5.3	5.7	5
Nil1	1	2/09/2015	5.3	5.6	5.9	4/06/2016	4.8	5.1	5.7
Nil1	2	2/09/2015	5.5	5.5	6.3	4/06/2016	5.9	5.9	6.6
Nil1	3	2/09/2015	4.3	4.8	5.6	4/06/2016	5.5	4.6	5.3

David Hamilton

Paddock	Site	Date	pH Topsoil	pH Midsoil	pH Subsoil	Date	pH Topsoil	pH Midsoil	pH Subsoil
Cult	1	25/03/2015	5.3	4.5	5	15/04/2016	4.7	4.4	4.4
Cult	2	25/03/2015	5.3	4.7	4.8	15/04/2016	5.1	4.3	4.7
Cult	3	25/03/2015	4.7	4.3	4.6	15/04/2016	4.4	4.1	4.6
Cult1	1	25/03/2015	5.1	5.2	4.7	15/04/2016	4.9	4.4	4.3
Cult1	2	25/03/2015	5.4	4.8	4.9	15/04/2016	4.9	4.5	4.5
Cult1	3	25/03/2015	4.8	4.3	4.5	15/04/2016	4.6	4.1	4.2
Lime	1	25/03/2015	5.3	5.3	5.1	15/04/2016	5.1	4.6	4.9
Lime	2	25/03/2015	5.1	4.5	4.6	15/04/2016	5.4	4.4	4.6
Lime	3	25/03/2015	4.6	4.4	5.1	15/04/2016	5	4.4	4.5
Lime Cult	1	25/03/2015	5.1	4.8	4.7	15/04/2016	5.9	4.5	5.1
Lime Cult	2	25/03/2015	4.9	4.8	4.9	15/04/2016	5.3	4.4	4.6
Lime Cult	3	25/03/2015	5.1	4.7	4.4	15/04/2016	6.1	4.6	4.5
Lime Cult1	1	25/03/2015	4.9	5.2	5	15/04/2016	6.3	4.8	4.7
Lime Cult1	2	25/03/2015	5.1	4.6	4.5	15/04/2016	5.5	4.3	4.5
Lime Cult1	3	25/03/2015	4.7	4.2	4.2	15/04/2016	5.6	4.6	4.2
Lime1	1	25/03/2015	4.8	4.6	4.6	15/04/2016	5	4.3	4.3
Lime1	2	25/03/2015	5.3	4.6	4.4	15/04/2016	5.5	4.5	4.6
Lime1	3	25/03/2015	4.5	4.2	4.9	15/04/2016	5.8	4.6	4.6
Nil	1	25/03/2015	5.4	4.2	4.3	15/04/2016	5.8	4.3	4.1
Nil	2	25/03/2015	4.9	4.4	4.3	15/04/2016	4.6	4.2	4.3
Nil	3	25/03/2015	4.8	4.2	4.2	15/04/2016	4.6	4	4.1
Nil1	1	25/03/2015	5.5	4.7	4.7	15/04/2016	5.3	4.4	4.3
Nil1	2	25/03/2015	5	4.5	4.7	15/04/2016	4.6	4.3	4.5
Nil1	3	25/03/2015	5.2	4.3	4.5	15/04/2016	4.7	4.2	4.4

Richard Humphry

Paddock	Site	Date	pH Topsoil	pH Midsoil	pH Subsoil	Date	pH Topsoil	pH Midsoil	pH Subsoil
Cult	1	4/04/2015	5.6	5	5.4	15/04/2016	6.3	4.3	5.5
Cult	2	4/04/2015	5.6	5	5.1	14/04/2016	5.9	4.3	4.7
Cult	3	4/04/2015	5.9	4.3	4.7	14/04/2016	5.9	4.6	5.2
Cult1	1	4/04/2015	5.7	5	4.9	15/04/2016	6.2	4.4	5.5
Cult1	2	4/04/2015	5.1	4.9	5.4	14/04/2016	5.6	4.4	4.8
Cult1	3	4/04/2015	5.6	5.1	5.1	14/04/2016	6.5	4.3	5
Lime	1	4/04/2015	5.5	4.5	5	15/04/2016	6.3	4.4	4.7
Lime	2	4/04/2015	5.7	5	4.9	14/04/2016	6.3	4.6	5.2
Lime	3	4/04/2015	5.3	4.6	4.6	14/04/2016	5.8	4.7	5.2
Lime Cult	1	4/04/2015	5.8	4.9	5.3	15/04/2016	6.4	4.8	5.6
Lime Cult	2	4/04/2015	5.4	5.4	5.5	14/04/2016	6.5	4.7	5.4
Lime Cult	3	4/04/2015	5.3	4.9	5.1	14/04/2016	5.8	4.7	5.4
Lime Cult1	1	4/04/2015	5.8	4.8	5.1	15/04/2016	6.3	4.4	5
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Lime1	2	4/04/2015	5.6	4.6	4.5	14/04/2016	6.2	4.6	4.7
Lime1	3	4/04/2015	5.3	4.9	4.9	14/04/2016	5.9	4.6	4.1
Nil	1	4/04/2015	5.6	5.3	5.1	15/04/2016	6.1	4.2	4.8
Nil	2	4/04/2015	5.6	4.6	4.9	14/04/2016	6.2	4.7	5.3
Nil	3	4/04/2015	5.5	4.6	4.5	14/04/2016	5.4	4.2	4.9
Nil1	1	4/04/2015	5.6	4.6	4.6	15/04/2016	5.6	4.3	5.2
Nil1	2	4/04/2015	5.7	4.6	5	14/04/2016	5.9	4.1	5.3
Nil1	3	4/04/2015	5.7	5.1	5.2	14/04/2016	5.9	4.2	4.9