Major findings grassing the bare patches demonstration

1. Introduction

Grassing The Bare Patches was a citizen science demonstration on three small farms in the Capital Region surrounding Canberra, two in Bywong and one nearby in Sutton. A protocol was developed to test methods for improving grassy groundcover on persistent bare patches of pasture in acidic, low fertility soils. Some initial soil testing was done to work out the soil limitations affecting each site in a bare patch and good patch of pasture. A demonstration protocol was designed to test different soil amendments and physical treatments against a control on each farm, a common treatment was applied on all three farms. The strategies for tackling bare patches were chosen to be practical and easily applied on small scale.

The aim was to ameliorate the soil to a point where pasture species could recolonise the bare patch. Vegetation changes were monitored with the percentage ground cover, dry matter and species composition compared before and after treatment. The ground cover monitoring was done quarterly over a 16-month period ending in autumn 2022 . Soil sampling was done in spring 2020 and after treatment in spring 2021. The demonstration sites were chosen to represent the bare patches of pasture on each farm and were fenced to exclude livestock and kangaroos.

The idea for the demonstration was conceived in 2019 when the area was in drought, the total rainfall for on one of the farms in 2019 was 441 mm compared to 1284 mm in 2021. The variation in rainfall had many effects, including increasing pasture productivity and decreasing sodium ion levels. These changes are evident in the dry mater level of the control patches and the sodium ions in the bare and good patches. Sodium levels decreased in the control patches when the second soil tests were analysed. See Appendix 1 for detailed rainfall data and Appendix 2 for soil analysis.

Farm 1 – bare patches 2020 and after the treatments in 2021

1.1 Treatments

Each site had two control plots, a common improved treatment plot and a number of treatment variations that differed between farms. These treatments summarised in **Error! Not a valid bookmark self-reference.**. All plots were 5m x 5m. The treatments were applied in spring 2020 with mowing and grass seed sowing (where applicable) in autumn 2021.

The common treatment was designed to address acidity, erosion and organic matter issues and provide an improved environment for plant growth. This involved:

- surface application of lime (Aglime250 Superfine at 150g/m2 - equivalent to 1.5 tonne/ha)
- broadcasting green manure seed (ryecorn and crimson clover) at 20g/m^2
- covering the plot with jute mesh (pinned to ground) to reduce erosion
- Applying a 1cm layer of compost on the soil surface (municipal green waste compost by QPRC)
- the plot was left to grow through summer
- mowing or slashing the standing plant material and leaving the cut material in place
- broadcasting pasture grass seed (cocksfoot and phalaris on farm 2, a mix of native grass species on farm 3, none on farm 1)

As well as the common treatment, each farmer chose additional treatments that they wanted to test. These are summarised below:

Table 1 - Summary of treatments used on each farm

Plot	Farm 1	Farm 2	Farm 3
Control 1	no treatment	no treatment	no treatment, not mowed
Control 2	no treatment	no treatment	no treatment mowed
Common improved plot	lime, green manure, jute, compost	lime, green manure, jute, compost	lime, green manure, jute, compost
Variation 1	lime, green manure, compost	green manure, compost	lime, green manure, compost, ripping
Variation 2	ripping, lime, green manure	compost tea only	lime, green manure, compost, dynamic lifter
Variation 3	lime, superphosphate	green manure and lawn clippings	
Variation 4	Cool burning in Autumn		

1.2 Soil testing

Dr Jason Condon from Charles Sturt university recommended a series of soil tests to find out what was happening with the soil chemistry. The tests provided a comparison of soil patches considered good and too acidic and were used to highlight differences between the soil on the three farms. Initial soil sampling was completed in September 2020 with two sites tested on each farm, one from a good patch of pasture and one from a bare patch. The soil was sampled in 5 cm depth increments from 0-20cm. The Nutrient Advantage test numbers were CT179 and CT122 and details of the tests are provided in Appendix 2.

A second set of soil samples were collected from each treatment plot and tested in November 2021. The second test allowed a comparison to show effects of the treatments on pH, fertility, organic carbon, electrical conductivity and other aspects of soil chemistry. About 10 core samples were taken for each treatment plot. To minimise variation, the cores were bulked for each treatment in 5 cm depth increments from 0-20 cm lots. The mixed soil was bagged and sent for the same soil tests that were done on the original samples.

1.3 Vegetation monitoring

In addition to soil sampling, each demonstration plot was monitored quarterly for ground cover using a GrassMaster pasture probe and changes in species composition were recorded. The sampling method was to walk in a grid pattern across the treatment site. The ground cover percentage was estimated using a four-square quadrat, the estimation was done by eye and included the total area of ground covered by plants and organic matter (trash, grass roots, leaves). For the results of the ground cover percentage and species changes see Appendix 2.

2. Results

2.1 Limiting factors on each farm before and after

Dr Jason Condon analysed the soil chemistry on each of the farms prior to the treatments being applied to the demonstration plots. The main problems were low soil pH with high aluminium on two of the farms (farms 1 and 3) and low availability of nutrients such as carbon and phosphorus on farm 2.

Below is a summary of the target levels for major nutrients measured in the demonstration, further details of the target ranges for each nutrient are provided in Appendix 2.

pH $CaCl_2$ - 5.0 (ideally above pH 5.5)

Aluminium 0% (0 cmol/kg)

Potassium (K) 0.5 (cmol/kg)

Phosphorus (P) 20 mg/kg for native pasture and 30 mg/kg improved

Exchangeable sodium percentage (ESP),measures sodicity – ESP below 6%

Organic Carbon (OC) – above 2%

Calcium: Magnesium Ratio (Ca:Mg) above 2

Cation Exchange Capacity (CEC) – above 10

A summary of the major limitations identified after the first round of soil testing is provided in Table 2, this analysis was done by Dr Jason Condon in 2020.

Table 2 Major soil limitations on each farm identified from initial soil testing in Spring 2020.

Farm 1	Farm 2	Farm 3
ACID – low pH good patch pH 4.5 bare patch pH 4.2	Good pH 5.6	ACID – low pH good patch pH 5.0 bare patch pH 4.4
Low Potassium (K) good 0.33 cmol (+)/kg bare patch 0.22 cmol(+)/kg		Low Potassium good patch 0.54 cmol (+)/kg bare patch 0.17 cmol (+)/kg
	Low phosphorus good patch 8.3 mg/kg bare patch 4.9mg/kg	Low phosphorus good patch 5.3 bare patch 0.15
	Low organic carbon 1.6 %	Low organic carbon 2.22% Bare patch Low CEC 3.9 at 5 cm
Low Ca:Mg Good patch 2.0 at 5 cm and down to 1.3 at 20cm Bare Patch 2.0 at 5 cm and 0.3 at 20cm		Low Ca:Mg Good patch 2.5 at 5 cm and 0.5 at 20cm Bare patch 0.5 at 5 cm and 0.1 at 20cm
	Sodic ESP 4	Sodic ESP 6

The table below shows the changes that the common treatment had on the limiting factors identified in the initial soil testing for each farm. The common treatment improved the soil conditions in the top 5 cm on all of the farms, increasing the soil pH to a level where most pasture species can grow. On Farm 3 the ESP increased below 5 cm to 6 indicating an increase in sodicity at depth after the treatment.

Table 3 – Common treatment (lime/GM/jute/compost) after treatment

Farm 1	Farm 2	Farm 3
Increased pH to a good range for pasture plants 0-5 cm 5.5 5-10cm 4.5	Improved soil pH 0-5 cm6.5 5-10cm 5.5	Increased soil pH 0-5 cm 5.7 5-10cm 4.8
Potassium (K) improved 0-5 cm to 0.4 cmol/kg 5-10 cm 0.18 cmol/kg		Potassium improved compared to control 0-5 cm to 0.4 cmol/kg 5-10cm to 0.2 cmol/kg
	High Phosphorus 120mg/kg	High phosphorus 100mg/kg
	Organic carbon 0-5 cm4.5% 5-10 1.65%	Organic carbon increased 0-5 cm 6% 5-10cm 2% CEC 15 at 5 cm
Improved Ca:Mg 0-5 cm to 5 5-10cm 1		Improved Ca:Mg 0-5 cm3.5 5-10cm 0.5 (no effect)
	Improved ESP 0-5 cm0.4	Improved ESP in the top 5 cm but increased ESP at depth 0-5 cm 2 5-10cm 5

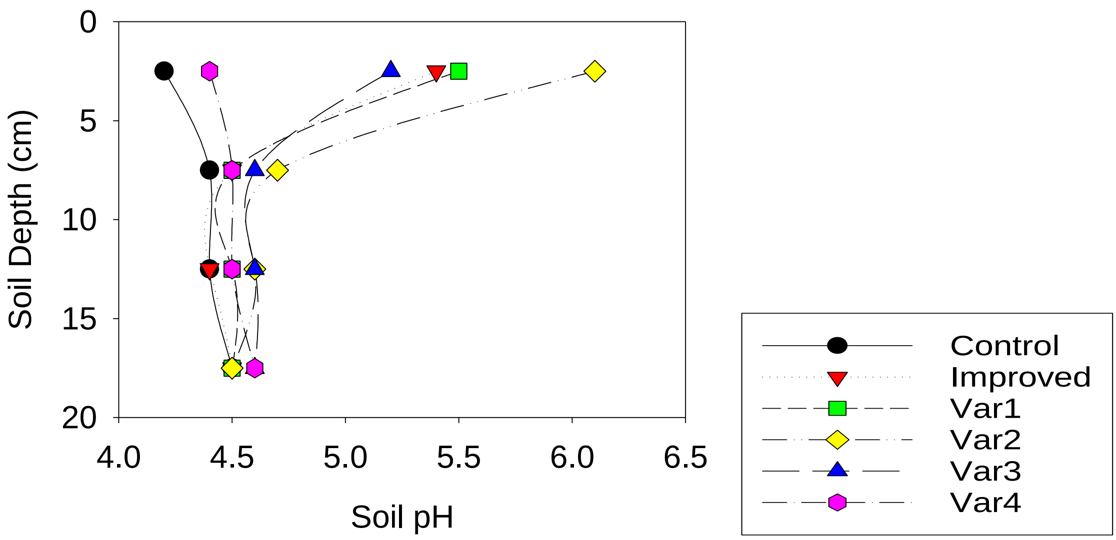
		10-15 cm 6.2 15-20cm 6

2.1 Soil Test Results

A full analysis of the soil testing data before and after is shown in Appendix 2. The soil analysis was done by Chris Curtis from Roogulli Farm and Dr Jason Condon, Charles Sturt University. Below is an analysis of the main findings from the demonstration.

Soil pH - Applying compost and lime increased the pH in the top 5 cm of soil on all of the farms where it was used. The pH change was considered a soil improvement.

Figure 1 – Farm 1 soil pH ($CaCl_2$) after treatment #



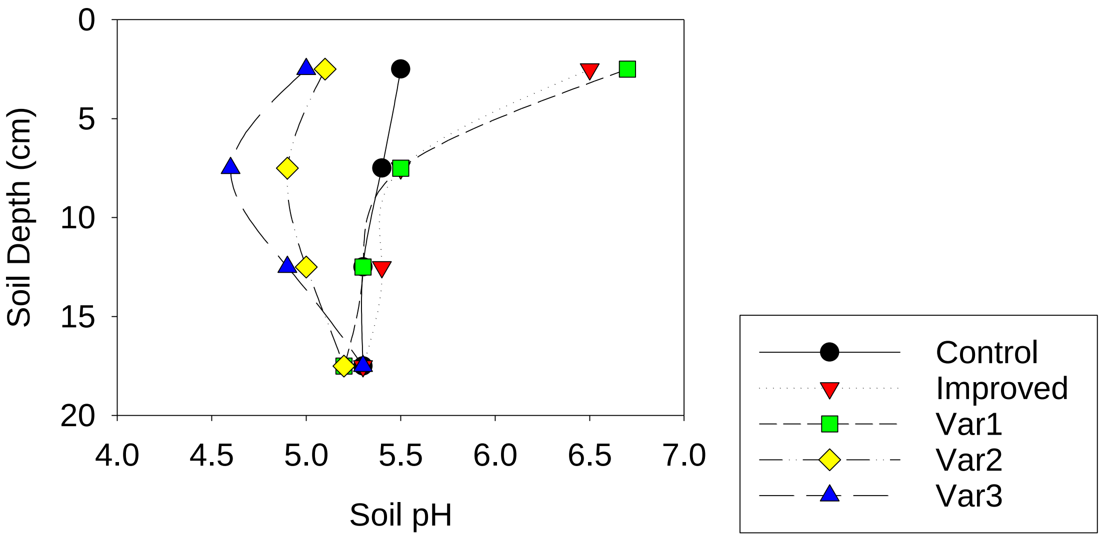
 # All figures supplied by Dr Jason Condon

 # Improved = common treatment

Farm1 pH

On Farm 1 treatments with lime increased the pH in the top 5cm. Cultural burning had little effect on pH relative to the control.

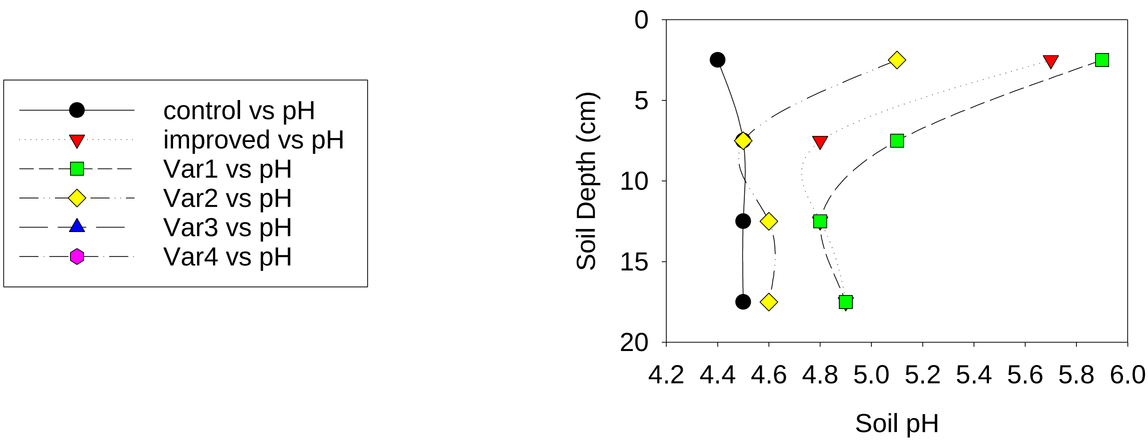
Figure 2 – Soil pH ($CaCl_2$) after treatment Farm 2



Farm2 pH

Using compost tea (Farm 2 – Variation 2) caused acidification, the soil pH decreased and the Al% increased. Grass clippings (Variation 3) caused acidification, decreasing the soil pH in the top 15 cm. The shape of the pH stratification is similar to what is seen in stock urine patches or where urea fertiliser is top dressed.

Figure 3 -Soil pH (CaCl2) after treatment Farm 3

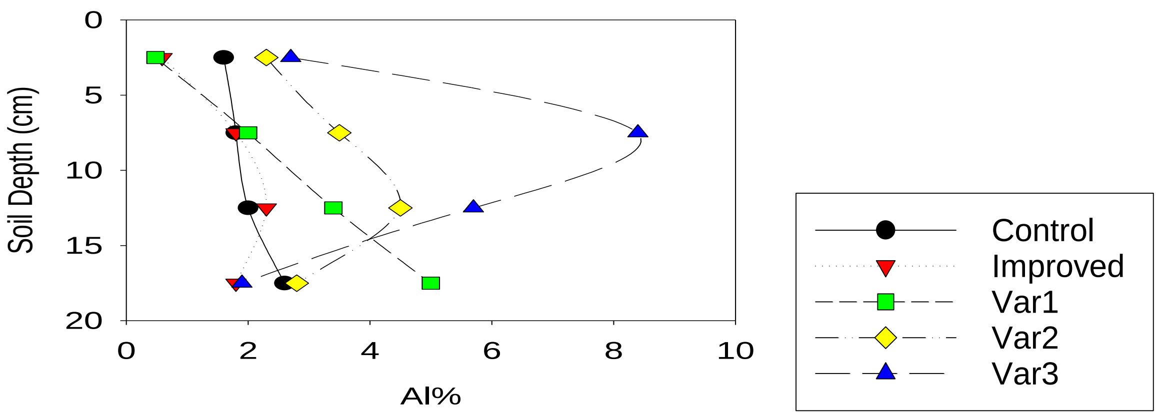


Farm 3 pH

On Farm 3 the common treatment and variation 1 increased pH to 5.8 and 6 in the top 5cm, to levels that are good for pasture growth.

Aluminium (Al) –. The changes in Al% on the farms were most noticeable in the top 5 cm with the Al% decreasing in the treatments where lime was used. On Farm 3 the common and lime/GM/compost/rip treatments deceased the Al% in the surface 20cm. On Farm 1 the burning treatment caused no changes relative to the control with the exception of a small decrease in Al% which was related to a small increase in pH (see Appendix 2).

Figure 4 – Exchangeable Al% after treatment – Farm 2



Farm 2 Al%

On Farm 2 the common and compost treatment decreased the Al% to 0 in the top 5cm. Treating the soil with compost tea and grass clippings (Var 2 and Var 3) increased the Al% relative to the control in the samples taken below 5 cm (see Figure 4). The acidification increased the Al% in the 5-15 cm layers relative to the control.

Electrical conductivity (EC) – The soil treatments used in this study had little effect on soil EC, this was consistent across all the farms. The treatment cultural burning in autumn had an effect on the potassium concentration which increased in all layers but not to levels that would affect plant growth.

Phosphorus Colwell P – Compost and lime had a significant effect on Colwell P in the top 5 cm in all of the treatments where compost was used. The biggest effect was seen on Farms 2 and 3, these farms had no history of fertiliser use. The Colwell P increased in the top 5 cm of both the common and compost treatments of plots on Farm 2. The concentrations were measured well in excess of the critical values for pasture species. The Colwell P level was not changed much by burning, compost tea and grass clippings treatments.

Figure 5 – Farm 2 Colwell P after treatment

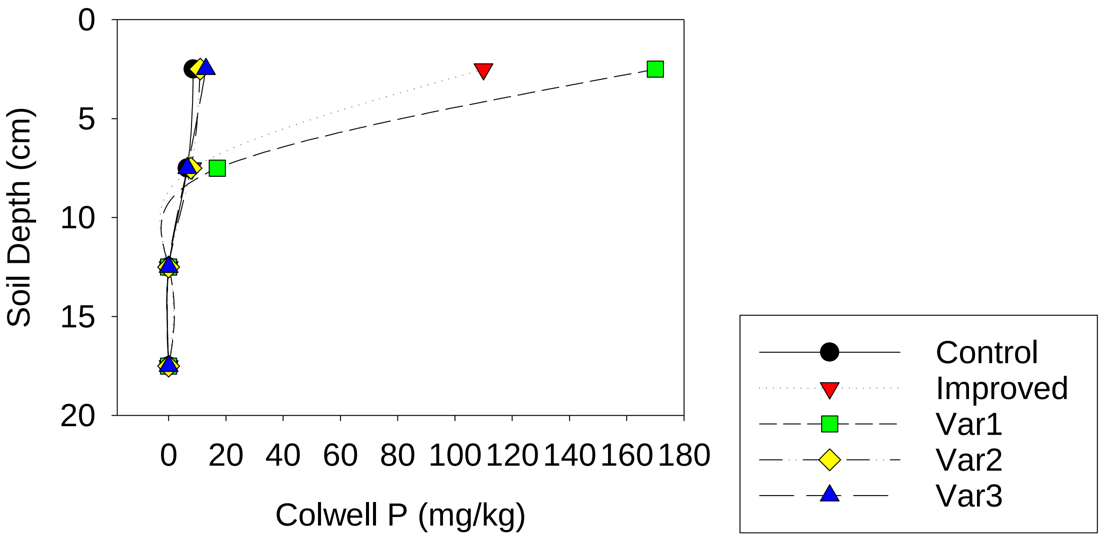
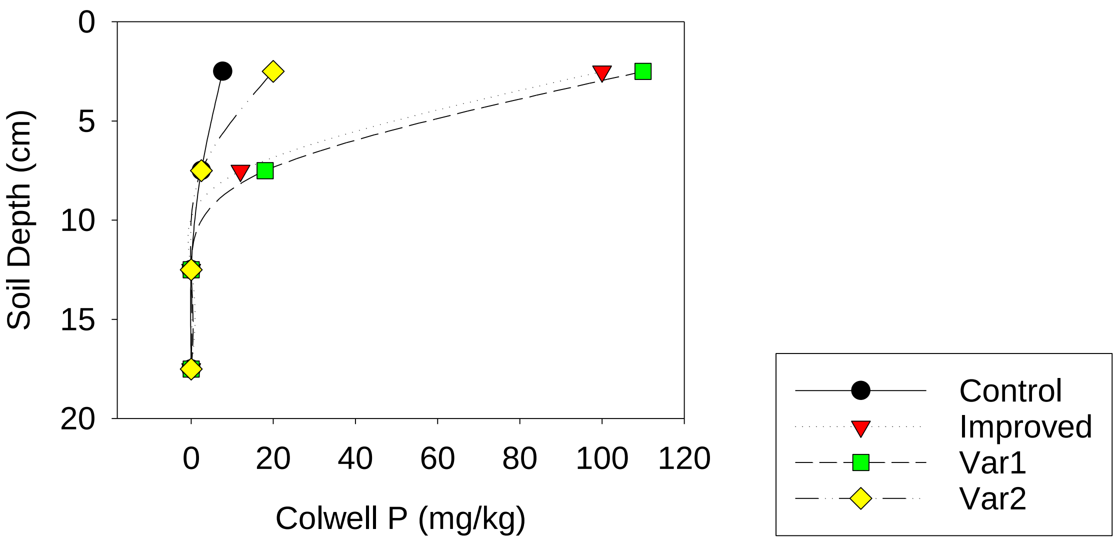


Figure 6 – Farm 3 Colwell P analysis after treatment



Calcium (Ca)- The compost and lime treatments increased soil Ca. The effect was measured around the top 5 cm on all of the farms. The compost tea, grass clippings and burning treatments had little effect on soil Ca.

Potassium (K) – The effect on K was greatest on Farm 2 in the compost and lime treatment, on the other farms the level of K increased to above or just below the critical level of 0.5 cmol(+)/kg. The cultural burning completed in autumn had an effect on the potassium concentration which increased in all layers.

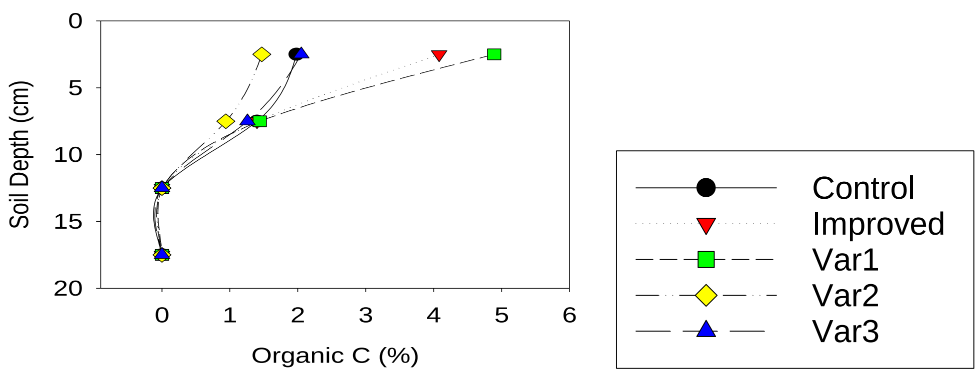
Magnesium (Mg) – All the compost and lime treatments except one had higher Mg levels after treatment. Compost tea, grass clippings, rip/lime/GM either reduced or only slightly increased the amount of Mg in the soil.

Sodium (Na) – The sodium levels stayed the same or decreased slightly in most of the treatments. The cultural burning treatment on Farm 1 increased the EC in the 10-15 cm layer but this level was still below thresholds that would harm plants (EC 0.4 dS/m).

Cation exchange percentage (CEC) – The treatments with compost showed the greatest increase in CEC in the top 5cm, ripping with added lime and green manure was the next best treatment. Lime and super was only slightly better than burning. Compost tea and grass clippings had a negative effect on CEC.

Organic carbon (OC) - Farms 1 and 3 that had the lowest initial OC had the greatest improvement. The common treatment improved the OC levels on all farms, on Farm 2 OC doubled in the common and compost treatments. On Farm 3 the common and rip/compost/lime/GM treatments increased the OC by over 60% to a value of almost 6% in the surface 5cm. On farm 1 the Organic OC increased by more than 1% after to the common and lime/compost/GM treatments. The lime super, compost tea and burning treatments reduced OC in the top 10cm.

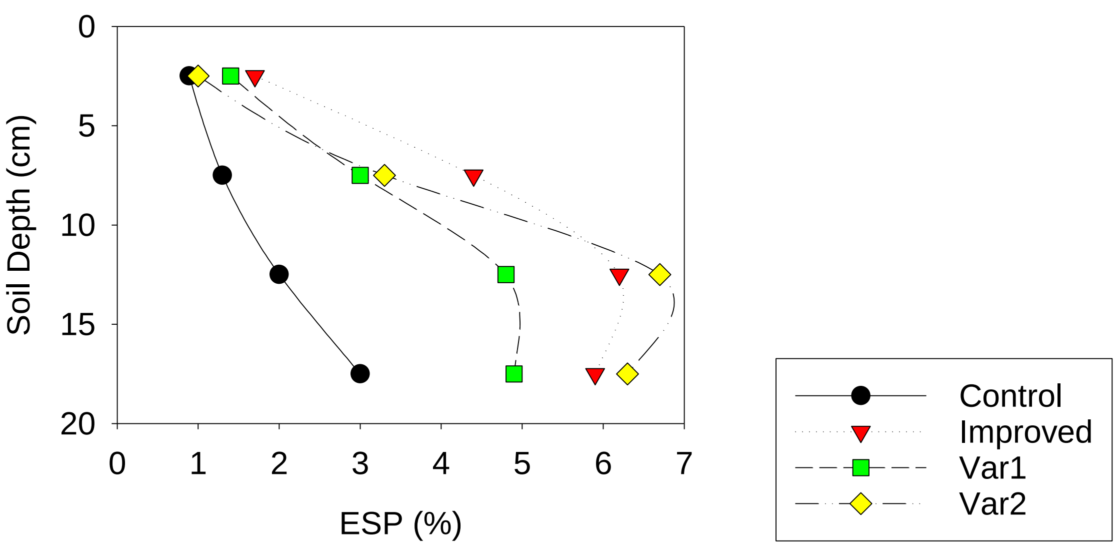
Figure 7 – Farm 2 organic carbon after treatment



Ca:Mg ratio – (target above 2) -All of the farms in this experiment had Ca:Mg ratios under 3 below 10cm, indicating sodic soils at depth. Some treatments affected the Ca:Mg ratio around the top 5 cm. On Farm 1 the rip/lime/compost and common treatments increased the Ca:Mg ratio above the critical value of 2. The treatments on Farm 3 increased the Ca:Mg ratio above 2 which is beneficial for the soil structure. Farm 2 Variation 1 increased Ca:Mg in the top 5 cm, however the Ca:Mg was still below the threshold of 2 below 15 cm.

Exchangeable sodium percentage (ESP) – is a measure of sodicity, anything greater than 6% is classed as sodic. Increases in ESP below 5 cm were observed on Farm 1 in Variation 3 (rip/lime/GM) but remained below the threshold of 6%. Comparing the control with the treatments showed all the treatments on Farm 3 increased the ESP below the 5 cm soil depth, this is not good for structural stability below 10cm.

Figure 8 Farm 3 – Exchangeable Sodium Percentage (ESP) after treatment



The figure above shows the effect that the treatments had on ESP in relation to the control. For ESP the target values is less than 6. Anything greater than 6 is considered sodic. In this graph improved = the common treatment plot.

2.2 Soil structure observations

Soil chemistry testing is only part of the story when it comes to understanding ground cover management. Although the 'symptom' in the pasture was a bare patch of soil, the causes for the loss of ground cover on each farm were quite different. The relationship of soil chemistry and soil structure started to make sense to the farmers when they dug soil pits with Dr Jason Condon. For example, the farmers were able to see what soil sodicity (ESP <6 and low Ca:Mg) looked like in the paddock. On Farm 1 the Ca:Mg ratio was 0.3 at 20cm, when this soil was tested for sodicity the soil particles could be seen dispersing (see photo 1 below).

The effect of low soil pH and high aluminium on grass roots below 10cm in the paddock bare patches could be seen from the sod samples and soil sodicity test. Below 10cm the roots were not growing in the acidic soil (pH 4.5).

Photo 2 Sodic soil demonstration Farm 1 0-15cm

Photo 3 Dig stick sampling showing the effect of pH on plant roots

Photo 4 – Cultivation hardpan on Farm 2

The cultivation hard pan on Farm 3 would not have been discovered if Jason had not dug a hole in the paddock, further discussion with the farmer revealed that the plants growing on this patch of ground were the first to dry out and die.

2.3 Ground Cover Monitoring

Rainfall increased dry matter production on all of the farms. Farm 2. Variation 1 (compost and GM) had the greatest increase in dry matter production of all of the treatments at the end of the demonstration. The dry matter in this treatment increased from 763 kgDM/ha in spring 2020 to 1573 kgDM/ha at the end of the demonstration in March 2021. The trash produced by the green manure crop inhibited the establishment of pasture grasses on Farms 1 and 3. Dry matter production was lower where grass clippings and compost tea treatments were used compared to the control. A full description of the species changes and photos for each farm is in Appendix 3.

After the project the farmers observed sheep and kangaroos preferentially grazing the treatments where lime was used. Plant succession was noticeable coming out of the drought with a higher proportion of weeds found in the control patches at the beginning of the project than after the demonstration, this was especially noticeable on Farm 2 (see Appendix 3). Some species such as *Crassula sieberiana* were observed at the start of the demonstration and were not seen again. The green manure crop supressed seed germination on two of the farms, however the trash from the green manure crop did cover the bare patches to prevent runoff and provided a seed bed for other plants to establish.

3. Recommendations

These are the recommendations from the farmers in relation to the methods trialled in the demonstration.

Jute mesh

Jute mesh was limiting in this demonstration because the cover crop could not be mowed without machinery becoming entangled in the mesh. Jute mesh can be used in erosion sites and bare patches in pasture where they will not be mowed. Grazing after pasture establishment may be an alternative to mowing, but was not trialled in this demonstration.

Green manure

Green manure crops need to be managed by mowing or grazing to keep them short during the growing season prior to planting grass seed. When the green manure was left to grow high the trash that that remained after slashing prevented the grass seed from germinating. Further study is required to determine the best management of green manure crops and grass seed sowing. The improved pasture established well on Farm 2 when the ground cover was at 25-40% in autumn compared to the other farms that had high trash cover from the green manure crop when the seed was planted.

Soil sampling

Soil sampling to 20cm requires planning and effort, best practice is to use a soil corer and follow the advice of South East Local Land Services in relation to sampling regimes. Sampling is easier after rain but not when the soil is too saturated or too dry. Where possible use silicone spray to loosen the soil sample in the tube. A dig stick can be used to get an idea of soil acidity if a soil corer is not available.

Lime Application Increase the rate of lime application 2.5 tonnes/ hectare as per recommendations from previous research (Burns et al). You can purchase small lime and grass seed applicators to tow behind a mower or quad bike, spreading by hand can be patchy but still effective on small bare patches.

Ripping

This demonstration showed the importance of understanding soil sodicity and how cultivation might impact erosion and pasture seed establishment. Soils with a Ca:Mg ratio below 3 are prone to dispersion and slaking which can make them vulnerable to erosion. On Farm 3 pasture deep ripping affected the germination of grass seed because the subsoil had been brought to the surface. Crusting and poor drainage of the subsoil may have affected the pasture seed germination in this plot.

4. Conclusion

Bare patches on farms can be caused by many different factors, in the Bywong/Sutton area this demonstration showed that low soil pH, high aluminium % and low fertility are associated with a loss of ground cover. Adding compost and lime improved the soil in the top 5 cm and was beneficial for pasture establishment, facilitating the repair of the bare patches. Soil testing is one of the tools that can help farmers learn about the soil on their farm. Understanding soil structure issues are equally important to understanding soil chemistry. Learning to recognise the symptoms of low pH, soil sodicity and cultivation hard pans was very useful to explain some of the problems in maintaining ground cover. Using a combination of methods including a dig stick to test soil pH in the field can be beneficial.

The farmers leading this demonstration agree that if you have bare patches of soil on your farm start digging holes and learn about the soil. Then think about the treatments that might make a difference, doing something is better than leaving the soil bare and vulnerable to erosion and weed infestation. Future bare patches studies could look at the biological aspect of the soil as well as the chemical and physical aspects. These future studies could apply a wider range of methods to improve poor soils including testing the growing number of biological activity stimulators and ecological soil additives.

Project Contributors

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The Small Farms Network Capital Region received funding from the Australian Government's National Landcare Program for this demonstration.

Photo 5 The project team (Left to right) Chris Curtis, Allan Spencer, Harjinder Dhindsa, Ross Kuchel, Jennie Curtis, Jason Condon and Alex James.

5. References

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Appendix 1 – Rainfall

Table 2 - Rainfall (mm) at Roogulli Farm (farm 1) 2018-2022

Month	**2018**	**2019**	**2020**	**2021**	**2022**	**Long term mean (2008-2021)**
Jan	54	77.5	15.5	86.5	130.5	61.7
Feb	71.5	56	131.5	75	32	82.1
Mar	15.5	74	101	203.5	62	86.2
Apr	19	16	92	80.5	90	45.4
May	16.5	66.5	31.5	13	140	36.2
Jun	57.5	32.5	69.5	140.5	20.5	70.2
Jul	14	15	41	79.5	37	49.8
Aug	57	20.5	151.5	60.5	146.5	58.1
Sep	2	44	51	114.5	97	55.7
Oct	35	18	155.5	74	185.5	56.5
Nov	63.5	21	118	224.5		90.6
Dec	144.5	0	42	132.5		76.3
Annual	**550**	**441**	**1000**	**1284.5**		**768.6**

Source: Chris Curtis – Roogulli Farm

Appendix 2 – Soil test results

The soil test analysis was done by Chris Curtis from Roogulli Farm and Dr Jason Condon from Charles Sturt University.

What to test for and target values

Soil pH($CaCl_2$)

The target pH ($CaCl_2$) is 5.0-5.5 for optimum pasture productivity. In this demonstration the soil pH in the bare patches for farms 1 and 3 ranged from 4.2-4.5 in the bare patches and in the good patches 4.5-5.2. The lower the pH the more acidic the soil, with a pHCaCl of 7 being neutral and becoming more alkaline as the pH increases. Soils with a low pH have lower microbial activity, soil microorganisms will be most active in soils with a pH 5.0 to 7.0 (NSW DPI).

Aluminium (Al)

Soil pH is closely linked the influence of aluminium ions in the soil and its toxicity to plants. The target range for Al is 0% (0 cmol/kg), at high levels Al will become toxic to plants and impact plant growth. Al will occupy the cation exchange sites on soil particles and displace other ions on the cation exchange sites that are important for soil fertility.

Phosphorus (Colwell P) The target for Colwell P is 20 mg/kg native pasture/30 mg/kg improved pasture. According to the NSW DPI phosphorus is a stable element that does not move far from where it is applied because it reacts rapidly with the soil. It quickly binds with iron an aluminium in the soil and becomes unavailable to plants when the soil pH is below 5.0 ($CaCl_2$).

Potassium (K) The target range is greater than 0.5 (cmol(+)/kg).

Exchangeable sodium percentage (ESP) The target range for ESP <6%. ESP is one of the most important factors affecting dispersion in soils, the ESP describes the fraction of absorbed sodium (Na) in the cation exchange sites in the soil. A sodic soil is defined as a soil with an ESP of greater than 6% of the cation exchange capacity.

Electrical Conductivity (EC) is a measure of salts in the soil. A productive soil's conductivity should be below 0.15 dS/m (decisiemens per metre).

Total Organic Carbon (OC) is a measure of the organic matter in the soil, it includes undecomposed plant litter, soil organism and humus, the preferred level is above 2% (NSWDPI).

Calcium/Magnesium Ratio (Ca:Mg) The preferred Ca:Mg ratio is above 3, the ratio can go as high as 20.1 and not affect plants. If the Ca:Mg ratio is below 2, it is more difficult for plants to take up potassium, in addition soil structure can break down due to slaking and dispersion (NSW DPI).

The Ca:Mg ratio gives an indication of soil aggregate stability, the soil aggregates can be affected by physical properties such as a lack of physical bonds associated with organic materials, fungi hyphae and roots. When the soil is wet the chemical bonds within the microaggregates becomes weaker due to hydration, the clay swelling and the dilution of cations that electrochemically bind the clay particles together, the combination of soil physical characteristics and chemistry causes the soil to disperse. Ca tends to prevent dispersion because it is a multivalent cation, whereas Mg and Na with a small charge or hydration radius will increase dispersion (Hall, D 2021).

Cation Exchange Capacity (CEC)– The CEC is a measure of the ability of the soil to hold the nutrients calcium, magnesium and potassium, target is above 10. Sandy soils often have a low CEC because they don't have much clay.

pH (CaCl2)

CONTROL patch

	FARM 2		FARM 1		FARM 3	
Depth	pH before	pH after	pH before	pH after	pH before	pH after
5	5.2	5.5	4.2	4.2	4.4	4.4
10	5.1	5.4	4.4	4.4	4.4	4.5
15	5.1	5.3	4.4	4.4	4.5	4.5
20	5.2	5.3	4.4	4.5	4.7	4.5

GOOD patch

	FARM 2		FARM 1		FARM 3	
Depth	pH before	pH after	pH before	pH after	pH before	pH after
5	5.6	5.0	4.5	4.5	5.0	5.2
10	5.1	4.9	4.4	4.4	4.7	5.0
15	4.9	4.9	4.4	4.4	4.7	4.7
20	5.0	4.8	4.4	4.5	4.8	4.6

Change in pH[1]

FARM 2						
Depth	CONTROL	GOOD	COMMON	CMPST.GM	CMPST.TEA	VARIATION.3
5	0.3	-0.6	1.3	1.5	-0.1	-0.2
10	0.3	-0.2	0.4	0.4	-0.2	-0.5
15	0.2	0	0.3	0.2	-0.1	-0.2
20	0.1	-0.2	0.1	0	0	0.1

FARM 1							
Depth	CONTROL	GOOD	COMMON	CMPST.LIME.GM	LIME.SUPER	RIP.LIME.GM	BURN
5	0	0	1.2	1.3	1	1.9	0.2
10	0	0	0.1	0.1	0.2	0.3	0.1
15	0	0	0	0.1	0.2	0.2	0.1
20	0.1	0.1	0.1	0.1	0.2	0.1	0.2

FARM 3					
Depth	CONTROL	GOOD	COMMON	CMPST.LIME.GM	RIP.CMPST.LIME.GM
5	0	0.2	1.3	0.7	1.5
10	0.1	0.3	0.4	0.1	0.7
15	0	0	0.3	0.1	0.3
20	-0.2	-0.2	0.2	-0.1	0.2

[1] For all treatments (except GOOD), the change is the difference between the test value for the treatment at the end of the trial and the test value for the CONTROL at the start of the trial. For GOOD, the change is the difference in the test value of the GOOD patch at the end and start of the trial.

Electrical conductivity (EC)
(dS/m)

CONTROL patch

	FARM 2		FARM 1		FARM 3	
Depth	**EC before**	**EC after**	**EC before**	**EC after**	**EC before**	**EC after**
5	0.04	0.06	0.11	0.05	0.08	0.05
10	0.04	0.05	0.05	0.03	0.04	0.03
15	0.03	0.04	0.03	0.03	0.03	0.02
20	0.03	0.04	0.02	0.03	0.03	0.02

GOOD patch

	FARM 2		FARM 1		FARM 3	
Depth	**EC before**	**EC after**	**EC before**	**EC after**	**EC before**	**EC after**
5	0.07	0.08	0.08	0.07	0.12	0.08
10	0.05	0.07	0.04	0.04	0.06	0.07
15	0.04	0.04	0.03	0.03	0.03	0.03
20	0.04	0.03	0.03	0.03	0.02	0.03

Change in EC

FARM 2						
Depth	**CONTROL**	**GOOD**	**COMMON**	**CMPST.GM**	**CMPST.TEA**	**VARIATION.3**
5	0.02	0.01	0.06	0.07	0.01	0.04
10	0.01	0.02	0.02	0.02	0	0.01
15	0.01	0	0.01	0	0	0
20	0.01	-0.01	0.01	0	0	0

FARM 1							
Depth	**CONTROL**	**GOOD**	**COMMON**	**CMPST.LIME.GM**	**LIME.SUPER**	**RIP.LIME.GM**	**BURN**
5	-0.06	-0.01	-0.03	0	-0.04	0.03	-0.05
10	-0.02	0	-0.01	-0.01	0	-0.01	-0.01
15	0	0	0	0	0.2	0	0.19
20	0.01	0	0.01	0.01	0.03	0.01	0.01

FARM 3					
Depth	**CONTROL**	**GOOD**	**COMMON**	**CMPST.LIME.GM**	**RIP.CMPST.LIME.GM**
5	-0.03	-0.04	0.03	-0.03	0.03
10	-0.01	0.01	0	-0.01	0.01
15	-0.01	0	0	0	0
20	-0.01	0.01	0	0	0

Phosphorus (P)

(mg/kg)

CONTROL patch

	FARM 2		FARM 1		FARM 3	
Depth	**P before**	**P after**	**P before**	**P after**	**P before**	**P after**
5	4.9	8.6	39	18	5.3	7.7
10	4.9	6.5	9.6	7.4	4.9	4.9

GOOD patch

	FARM 2		FARM 1		FARM 3	
Depth	**P before**	**P after**	**P before**	**P after**	**P before**	**P after**
5	8.3	45	26	16	15	11
10	6.2	19	10	6	5.8	6.4

Change in P

FARM 2						
Depth	**CONTROL**	**GOOD**	**COMMON**	**CMPST.GM**	**CMPST.TEA**	**VARIATION.3**
5	3.7	36.7	105.1	165.1	6.1	8.1
10	1.6	12.8	3.3	12.1	2.9	1.6

FARM 1							
Depth	**CONTROL**	**GOOD**	**COMMON**	**CMPST.LIME.GM**	**LIME.SUPER**	**RIP.LIME.GM**	**BURN**
5	-21	-10	27	35	-9	-21	-27
10	-2.2	-4	-0.4	3.4	-0.7	-1.8	-3.6

FARM 3					
Depth	**CONTROL**	**GOOD**	**COMMON**	**CMPST.LIME.GM**	**RIP.CMPST.LIME.GM**
5	2.4	-4	94.7	14.7	104.7
10	0	0.6	7.1	0	13.1

Aluminium (Al)
(cmol(+)/kg)

CONTROL patch

	FARM 2				FARM 1				FARM 3			
Depth	Al before		Al after		Al before		Al after		Al before		Al after	
5	0.09	1.8%	0.09	1.6%	1.4	25%	1.2	26%	0.77	20%	0.81	18%
10	0.09	2.1%	0.09	1.8%	1.3	26%	1.1	29%	0.88	28%	0.8	25%
15	0.09	3.1%	0.09	2%	1.4	35%	1.2	32%	0.63	22%	0.77	32%
20	0.09	3.0%	0.11	2.6%	1.6	38%	1.3	31%	0.43	15%	0.71	32%

GOOD patch

	FARM 2				FARM 1				FARM 3			
Depth	Al before		Al after		Al before		Al after		Al before		Al after	
5	0.09	1.7%	0.12	2.3%	0.69	9.6%	0.68	12%	0.1	1.1%	0.09	1.1%
10	0.09	2%	0.12	2.7%	1.0	23%	1.1	30%	0.57	11%	0.24	3.6%
15	0.09	2.4%	0.16	4.4%	0.96	34%	1.1	35%	0.57	18%	0.63	19%
20	0.11	2.4%	0.21	4.1%	1.2	44%	1.0	36%	0.46	15%	0.64	21%

Change in Al

FARM 2						
Depth	CONTROL	GOOD	COMMON	CMPST.GM	CMPST.TEA	VARIATION.3
5	0	0.03	0	0	0.01	0.03
10	0	0.03	0	0	0.04	0.17
15	0	0.07	0	0	0.05	0.07
20	0.02	0.1	0	0.04	0	0

FARM 1							
Depth	CONTROL	GOOD	COMMON	CMPST.LIME.GM	LIME.SUPER	RIP.LIME.GM	BURN
5	-0.2	-0.01	-1.31	-1.31	-1.24	-1.31	-0.52
10	-0.2	0.1	-0.37	-0.4	-0.48	-0.59	-0.4
15	-0.2	0.14	-0.3	-0.4	-0.54	-0.47	-0.53
20	-0.3	-0.2	-0.4	-0.4	-0.7	-0.5	-0.68

FARM 3					
Depth	CONTROL	GOOD	COMMON	CMPST.LIME.GM	RIP.CMPST.LIME.GM
5	0.04	-0.01	-0.68	-0.68	-0.68
10	-0.08	-0.33	-0.52	-0.1	-0.68
15	0.14	0.06	-0.22	0.04	-0.2
20	0.28	0.18	-0.13	0.23	-0.13

Calcium (Ca)

(cmol(+)/kg)

CONTROL patch

	FARM 2		FARM 1		FARM 3	
Depth	**Ca before**	**Ca after**	**Ca before**	**Ca after**	**Ca before**	**Ca after**
5	3.2	4.1	2.5	2.0	1.1	1.9
10	3.0	3.6	1.8	1.3	0.65	0.95
15	1.9	3.0	1.0	0.9	0.31	0.5
20	1.7	2.4	0.7	0.7	0.17	0.35

GOOD patch

	FARM 2		FARM 1		FARM 3	
Depth	**Ca before**	**Ca after**	**Ca before**	**Ca after**	**Ca before**	**Ca after**
5	3.6	3.1	4.0	3.1	6.0	5.5
10	3.1	2.6	1.9	1.5	2.4	3.4
15	2.4	1.8	1.0	0.95	1.0	0.85
20	2.3	2.1	0.75	0.65	0.65	0.44

Change in Ca

FARM 2						
Depth	**CONTROL**	**GOOD**	**COMMON**	**CMPST.GM**	**CMPST.TEA**	**VARIATION.3**
5	0.9	-0.5	9.8	12.8	-0.3	-0.6
10	0.6	-0.5	0.5	0.1	-0.6	-1.2
15	1.1	-0.6	0.6	-0.3	-0.2	-0.4
20	0.7	-0.2	0.9	-0.5	0.2	0.7

FARM 1							
Depth	**CONTROL**	**GOOD**	**COMMON**	**CMPST.LIME.GM**	**LIME.SUPER**	**RIP.LIME.GM**	**BURN**
5	-0.5	-0.9	7.5	9.5	2.4	7	0
10	-0.5	-0.4	-0.3	0.6	-0.4	0.5	-0.4
15	-0.1	-0.05	-0.05	0.3	-0.1	0.1	-0.15
20	0	-0.1	0	0.2	0	0	0.1

FARM 3					
Depth	**CONTROL**	**GOOD**	**COMMON**	**CMPST.LIME.GM**	**RIP.CMPST.LIME.GM**
5	0.8	-0.5	9.9	4.9	9.9
10	0.3	1	0.75	0.45	1.75
15	0.19	-0.15	0.24	0.17	0.34
20	0.18	-0.21	0.12	0.11	0.18

Potassium (K)
(cmol(+)/kg)

CONTROL patch

	FARM 2		FARM 1		FARM 3	
Depth	**K before**	**K after**	**K before**	**K after**	**K before**	**K after**
5	0.46	0.49	0.22	0.17	0.17	0.31
10	0.36	0.36	0.11	0.087	0.12	0.18
15	0.21	0.23	0.074	0.067	0.09	0.15
20	0.2	0.21	0.084	0.069	0.095	0.13

GOOD patch

	FARM 2		FARM 1		FARM 3	
Depth	**K before**	**K after**	**K before**	**K after**	**K before**	**K after**
5	0.95	0.69	0.33	0.18	0.54	0.44
10	0.54	0.51	0.22	0.092	0.26	0.31
15	0.31	0.33	0.14	0.087	0.19	0.16
20	0.31	0.36	0.13	0.079	0.28	0.13

Change in K

FARM 2						
Depth	**CONTROL**	**GOOD**	**COMMON**	**CMPST.GM**	**CMPST.TEA**	**VARIATION.3**
5	0.03	-0.26	0.41	0.44	0	0.28
10	0	-0.03	0.31	0.33	-0.05	0.05
15	0.02	0.02	0.23	0.17	0.03	0.01
20	0.01	0.05	0.24	0.06	0.02	0.11

FARM 1							
Depth	**CONTROL**	**GOOD**	**COMMON**	**CMPST.LIME.GM**	**LIME.SUPER**	**RIP.LIME.GM**	**BURN**
5	-0.05	-0.15	0.16	0.16	-0.07	0.06	0.11
10	-0.023	-0.128	0.05	0.09	-0.023	0.04	0.04
15	-0.007	-0.053	0.036	0.046	-0.007	0.046	0.023
20	-0.015	-0.051	0.011	0.016	-0.02	0.006	0.013

FARM 3					
Depth	**CONTROL**	**GOOD**	**COMMON**	**CMPST.LIME.GM**	**RIP.CMPST.LIME.GM**
5	0.14	-0.1	0.21	0.19	0.47
10	0.06	0.05	0.1	0.1	0.21
15	0.06	-0.03	0.05	0.06	0.1
20	0.035	-0.15	0.045	0.055	0.065

Magnesium (Mg)

(cmol(+)/kg)

CONTROL patch

	FARM 2		FARM 1		FARM 3	
Depth	Mg before	Mg after	Mg before	Mg after	Mg before	Mg after
5	1.5	1.6	1.3	1.2	1.6	1.4
10	1.2	1.6	1.6	1.2	1.4	1.2
15	0.91	1.5	1.4	1.4	1.7	0.91
20	1.2	1.4	1.6	2.0	1.9	0.99

GOOD patch

	FARM 2		FARM 1		FARM 3	
Depth	Mg before	Mg after	Mg before	Mg after	Mg before	Mg after
5	1.2	1.2	2.1	1.6	2.5	3.2
10	1.1	1.1	1.1	0.99	1.7	2.6
15	1.2	1.2	0.64	0.91	1.4	1.6
20	1.7	2.3	0.62	0.99	1.6	1.6

Change in Mg

FARM 2						
Depth	CONTROL	GOOD	COMMON	CMPST.GM	CMPST.TEA	VARIATION.3
5	0.1	0	1.6	2.2	-0.59	-0.59
10	0.4	0	0	-0.21	-0.38	-0.57
15	0.59	0	0.39	-0.17	0.08	0
20	0.2	0.6	1	-0.29	0.1	1.1

FARM 1							
Depth	CONTROL	GOOD	COMMON	CMPST.LIME.GM	LIME.SUPER	RIP.LIME.GM	BURN
5	-0.1	-0.5	0.8	1.1	-0.31	0.1	0.4
10	-0.4	-0.11	-0.4	0	-0.5	-0.2	0
15	0	0.27	-0.1	0	-0.2	0.1	0
20	0.4	0.37	0	-0.2	-0.2	0.4	0.3

FARM 3					
Depth	CONTROL	GOOD	COMMON	CMPST.LIME.GM	RIP.CMPST.LIME.GM
5	-0.2	0.7	1.8	-0.1	2.3
10	-0.2	0.9	0.9	0	1.2
15	-0.79	0.2	0.9	-0.5	1.4
20	-0.91	0	1.7	-0.5	2.1

Sodium (Na)

(cmol(+)/kg)

CONTROL patch

	FARM 2				FARM 1				FARM 3			
Depth	Na before		Na after		Na before		Na after		Na before		Na after	
5	0.48	8.4%	0.048	0.76%	0.1	1.8%	0.083	1.8%	0.21	5.4%	0.04	0.89%
10	0.065	1.4%	0.074	1.3%	0.15	3%	0.1	2.6%	0.13	4.1%	0.042	1.3%
15	0.061	1.9%	0.1	2%	0.14	3.5%	0.13	3.5%	0.13	4.5%	0.048	2%
20	0.1	3%	0.11	2.6%	0.17	4%	0.17	4%	0.17	6.1%	0.065	3%

GOOD patch

	FARM 2				FARM 1				FARM 3			
Depth	Na before		Na after		Na before		Na after		Na before		Na after	
5	0.11	1.8%	0.1	1.9%	0.1	1.4%	0.087	1.6%	0.14	1.5%	0.2	2.1%
10	0.061	1.2%	0.074	1.7%	0.065	1.5%	0.061	1.6%	0.074	1.5%	0.17	2.5%
15	0.048	1.2%	0.065	1.8%	0.039	1.4%	0.07	2.3%	0.061	1.9%	0.14	4.1%
20	0.07	1.6%	0.12	2.4%	0.044	1.6%	0.078	2.8%	0.087	2.8%	0.17	5.7%

Change in Na

FARM 2						
Depth	CONTROL	GOOD	COMMON	CMPST.GM	CMPST.TEA	VARIATION.3
5	-0.432	-0.01	-0.438	-0.44	-0.415	-0.402
10	0.009	0.013	-0.017	-0.032	0	-0.017
15	0.039	0.017	-0.004	-0.024	0.004	-0.013
20	0.01	0.05	0.02	-0.043	-0.009	0.01

FARM 1							
Depth	CONTROL	GOOD	COMMON	CMPST.LIME.GM	LIME.SUPER	RIP.LIME.GM	BURN
5	-0.017	-0.013	-0.026	-0.048	0.02	0	0.01
10	-0.05	-0.004	-0.089	-0.089	-0.05	-0.04	-0.04
15	-0.01	0.031	-0.044	-0.057	-0.01	-0.01	-0.03
20	0	0.034	-0.03	-0.06	0	0.02	-0.02

FARM 3					
Depth	CONTROL	GOOD	COMMON	CMPST.LIME.GM	RIP.CMPST.LIME.GM
5	-0.17	0.06	0.04	-0.127	0.02
10	-0.088	0.096	0.07	-0.01	0.04
15	-0.082	0.079	0.11	0.05	0.09
20	-0.105	0.083	0.1	0	0.08

Cation exchange capacity (CEC)
(cmol(+)/kg)

CONTROL patch

	FARM 2		FARM 1		FARM 3	
Depth	**CEC before**	**CEC after**	**CEC before**	**CEC after**	**CEC before**	**CEC after**
5	5.7	6.3	5.5	4.7	3.9	4.5
10	4.7	5.7	5.0	3.8	3.2	3.2
15	3.2	4.9	4.0	3.7	2.9	2.4
20	3.3	4.2	4.2	4.2	2.8	2.2

GOOD patch

	FARM 2		FARM 1		FARM 3	
Depth	**CEC before**	**CEC after**	**CEC before**	**CEC after**	**CEC before**	**CEC after**
5	6.0	5.2	7.2	5.6	9.3	9.4
10	4.9	4.4	4.3	3.7	5.0	6.7
15	4.1	3.6	2.8	3.1	3.2	3.4
20	4.5	5.1	2.7	2.8	9.3	9.4

Change in CEC

FARM 2						
Depth	**CONTROL**	**GOOD**	**COMMON**	**CMPST.GM**	**CMPST.TEA**	**VARIATION.3**
5	0.6	-0.8	11.3	15.3	-1.3	-1.3
10	1	-0.5	0.8	0.2	-1	-1.6
15	1.7	-0.5	1.2	-0.3	-0.1	-0.4
20	0.9	0.6	2.2	-0.7	0.3	1.9

FARM 1							
Depth	**CONTROL**	**GOOD**	**COMMON**	**CMPST.LIME.GM**	**LIME.SUPER**	**RIP.LIME.GM**	**BURN**
5	-0.8	-1.6	7.5	9.5	0.8	5.5	0
10	-1.2	-0.6	-1.1	0.2	-1.5	-0.3	-0.8
15	-0.3	0.3	-0.4	-0.1	-0.8	-0.2	-0.7
20	0	0.1	-0.5	-0.5	-1	-0.1	-0.3

FARM 3					
Depth	**CONTROL**	**GOOD**	**COMMON**	**CMPST.LIME.GM**	**RIP.CMPST.LIME.GM**
5	0.6	0.1	11.1	4.1	12.1
10	0	1.7	1.3	0.4	2.5
15	-0.5	0.2	1	-0.2	1.7
20	-0.6	-0.1	1.8	-0.1	2.3

Total organic carbon (OC)

(%)

CONTROL patch

	FARM 2		FARM 1		FARM 3	
Depth	OC before	OC after	OC before	OC after	OC before	OC after
5	1.6	1.98	4.18	4.24	2.22	3.64
10	1.35	1.4	1.98	1.63	1.42	1.94

GOOD patch

	FARM 2		FARM 1		FARM 3	
Depth	OC before	OC after	OC before	OC after	OC before	OC after
5	1.6	1.98	4.95	4.79	5.86	4.97
10	1.35	1.4	2.41	2.03	3.5	2.89

Change in OC

FARM 2						
Depth	CONTROL	GOOD	COMMON	CMPST.GM	CMPST.TEA	VARIATION.3
5	0.38	-0.2	2.48	3.29	-0.13	0.45
10	0.05	-0.39	0.05	0.09	-0.41	-0.09

FARM 1							
Depth	CONTROL	GOOD	COMMON	CMPST.LIME.GM	LIME.SUPER	RIP.LIME.GM	BURN
5	0.06	-0.16	0.59	1.32	-1.18	-0.2	-0.47
10	-0.35	-0.38	-0.27	0.19	-0.36	0.02	-0.14

FARM 3					
Depth	CONTROL	GOOD	COMMON	CMPST.LIME.GM	RIP.CMPST.LIME.GM
5	1.42	-0.89	3.63	1.79	3.26
10	0.52	-0.61	0.24	0.28	0.64

Soil Test Laboratory information

Test Code CT122 – used for the soil samples 0-5 cm and 5-10cm (includes organic carbon)

Includes Calculation of: Organic Matter, as Organic Carbon x 1.72 Phosphorus (Colwell) Exchangeable Calcium, Magnesium, Potassium, Sodium, Aluminium, CEC (BaCl2/NH4Cl) (Gillman & Sumptor) pH (1:5 water), pH (1:5 CaCl2), Electrical Conductivity (1:5 water), Organic Carbon (Walkley & Black).

Test Code CT179 – for the 5 cm samples 10-20cm Exchangeable Calcium, Magnesium, Potassium, Sodium, Aluminium, CEC (BaCl2/NH4Cl) (Gillman & Sumptor) pH (1:5 water), pH (1:5 CaCl2), Electrical Conductivity (1:5 water).

The soil tests were completed by Nutrient Advantage.

Appendix 3 Ground cover monitoring all farms

The table below shows a comparison of the ground cover monitoring kgDM/ha of the different treatments in the demonstration. The best pasture growth was achieved with the compost and green manure crop on Farm 2. On this farm ground cover decreased in the grass clippings and compost tea treatments.

	DRY MATTER ASSESSMENT kgDM/ha				
	13-Oct-20	11-Feb-21	31-Jul-21	02-Nov-21	28-Mar-22
Farm 1 Roogulli Farm					
Control 1	875	580	1350	1649	1276
Common treatment		1301	1477	2558	1010
V1 compost.lime.GM		1408	1573	2579	933
V2 rip.lime.GM		1041	1296	1679	982
V3 Lime.super		703	1361	2064	1139
V4 burn			858	956	1011
Farm 2 - Harji					
Control	763	1235	932	1112	1363
Control 2		1454	962	724	1207
Common		809	1084	977	1085
V1 compost.GM		1087	955	689	**1573**
V2 Compost tea		867	682	592	644
V3 Lawn clip.GM		815	791	656	929
Farm 3 - Allan					
Control not mowed	1075	1258	1317	1913	915*
Control mowed		914	1568	1910	915*
Common		1193	1658	2261	822*
V1 Lime.GM.compost.rip		2012	1459	1702	820*
V2 Lime.GM.compost.dynamic lifter		515	1262	2479	820*
*For farm 3 on the final assessment the fence was removed and the kangaroos had access to the plot					

The effect that the treatments had on dry matter, ground cover and species composition is shown in the following descriptions for each farm.

Farm 1 Control plot - October 2020

- Plants observed: Sweet vernal grass, wallaby grass, white clover, common storks bill (erodium species), Austrostipa spp., Crassula sieberiana, mosses, liverwort and hares foot clover.
- Dry matter: 875 kg/DM/hectare
- Estimated ground cover: 50-70%

Farm 1 All plots - 28 March 2022 (end of project)

Plot	**Dry matter assessment kgDM/ha**	**Estimated % ground cover**	**Species composition**
Control 1	1276	100	Hairy panic, native love grass (Eragrostis brownii), windmill grass, Austrostipa, clover germinating, small amount of sorrel (less than 10%)
Control 2			Same as above/no difference observed in the treatments
Common improved plot (lime, GM, jute, compost)	1010	100	Sorrel 50%, fog grass, oxalis, hairy panic, clover and germinating grass seed, trash
Variation 1 (lime, GM, compost)	933	100	Clover, sorrel, hairy panic, cocksfoot, windmill grass, native love grass, wallaby grass and trash from the GM crop
Variation 2 (lime, GM, ripping)	982	100	Hairy panic, Austrostipa, native love grass, club grass and trach from the GM crop
Variation 3 (lime, superphosphate	1139	100	Chloris truncata (windmill grass), wallaby grass, hairy panic, clover, Austrostipa, clover
Variation 4 (cultural burning)	1011	80	Chloris truncata, hairy panic, native love grass, phalaris, Austrostipa, Cats ear flat weed, lomandra

Farm 1 site of the common improved plot and variation 1 at the start of the project and at the end 3 November 2021.

Farm 2 Control Plot – 13 October 2020

- Plants observed: Cape weed, Patterson's Curse, hares foot clover, burr medic and rye grass. The area was mostly covered with weeds.
- Dry matter: 763 kg/DM/hectare
- Estimated ground cover: 25-50%

Farm 2 All plots 28 March 2022 (end of project)

Plot	**Dry matter assessment**	**Estimated % ground cover**	**Species composition**
Control	1363	75-80	Mostly hairy panic (*Panicum effusum*), club grass, red legged grass, paspalum, St John's Wort, slender pigeon grass, Seteria parviflora, Chloris truncata (windmill grass), Austrostipa
Control 2	1207	80-90	Hairy panic, red leg grass, St John's Wort, Seteria parviflora, seed of Wallaby Grass, Austrostipa
Common improved plot	1085	95	Cocksfoot, club grass, plantain, Seteria parviflora (Slender Pidgeon Grass), hairy panic, and flat weed.
Variation 1 (GM, compost)	1573	90	Cocksfoot, flat weed, rye corn seed heads, hairy panic on margins only
Variation 2 (compost tea only)	644	55-65	Austrostipa, hairy panic, cocksfoot seedlings
Variation 3 (lawn clippings and green manure)	929	80-85	Hairy panic, paspalum, Austrostipa, cocksfoot seedlings, paspalum

The Common improved plot and variation 1 (GM, compost) had the greatest improvement ground cover and species composition compared to the control. This farm had the best germination of pasture seed and dry matter production in the demonstration. The reason for this is the green manure crop did not germinate in spring and the ground cover percentage in autumn was about 45% when the grass seed was planted.

Variation 2 (compost tea) and Variation 3 (grass clippings) had lower soil fertility after the treatments were applied. Ground cover monitoring showed the impact this had on the germination of grass seed and pasture composition, these plots had a higher proportion of lower pasture value grasses (*Austrostipa and Panicum species).*

Photo series below showing Farm 2 Variation 1 (compost and GM) left to right the patch before treatment, applying the compost and green manure and photo 3 after treatment.

Farm 3 Control Plot – 2 February 2021

- Plants observed: kangaroo grass, wallaby grass, moss, hairy panic, native forbs, sheep sorrel
- Dry matter: 1258kg/DM/ha

Farm 3 All plots – 28 March 2022

Plot	Dry matter assessment	Estimated % ground cover	Species composition*
Control not mowed	915	80	Microlaena, Austrostipa, other natives
Control mowed	same as above	90	As above
Common improved plot (lime, GM, jute, compost)	822	50-75	Cocksfoot, sheep sorrel, reeds
Variation 1 (lime, GM, compost, ripping 10 cm)	820	50-75	Cocksfoot, sheep sorrel, reeds
Variation 2 (lime, GM, compost, dynamic lifter)	820		Cocksfoot, sheep sorrel, thistles
Acid bare patch below the site	330	25	Wallaby grass, century, thistle, Bog Sedge *Schoenus apogon*

* At the end of the project the fencing had been removed and kangaroos were grazing the site, the effect of this can be seen in the dry matter assessment figures and species composition.

Farm 3 Photos bare patches before and after treatment, variations 1 and 2.