PERENNIALPASTURESYSTEMS
MAKING PASTURE GO THE DISTANCE

Sub Soil Amelioration Project 2011 -2017

The project was supported by an A W Howard Memorial Trust – Grant-in Aid

the aw howard memorial trust

Jallukar Sub Soil Project – Final report

The Perennial Pasture Systems (PPS) subsoil amelioration project was located at Jallukar Park which is 25 km North West of Ararat, Victoria. The subsoil site forms part of the wider PPS project which has had over one hundred and fifty farm enterprises join as members since 2007.
The subsoil amelioration project is based on the work of Dr Peter Sale from LaTrobe University and trial work on cereal crops at Yalloak at Ballan, Victoria.

Jallukar Park

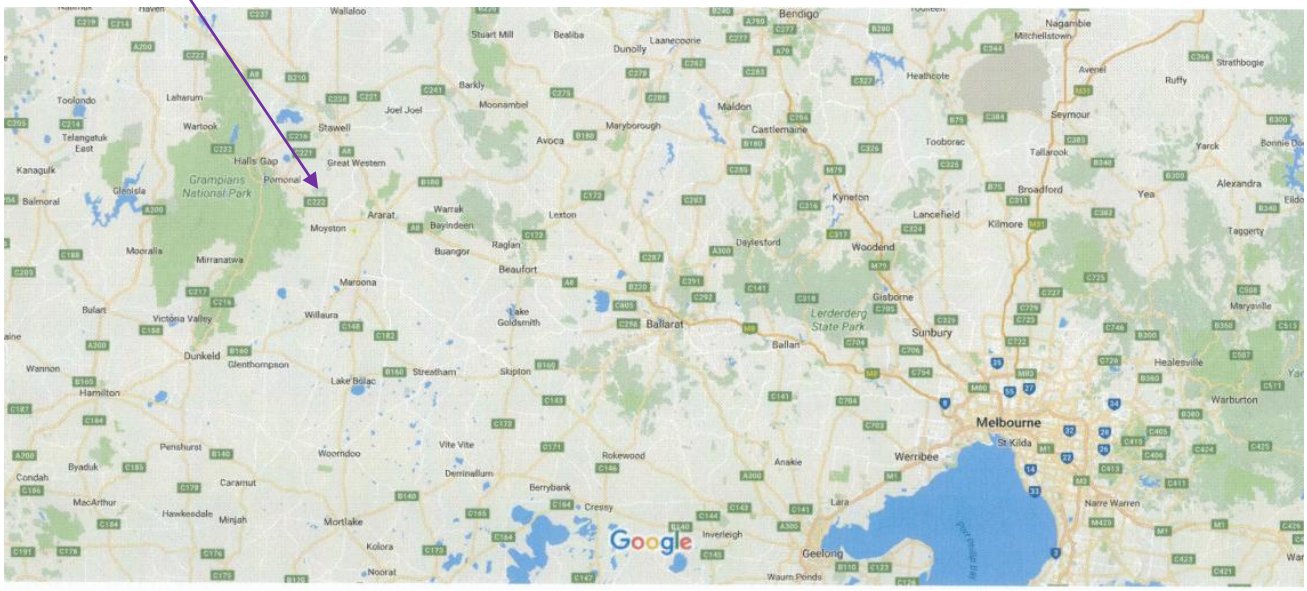

Figure 1; Location of trial site

Background

PPS has been interested in the possibility of increasing pasture production through the procedure of subsoil manuring in the duplex soils found in the Central region of Victoria. PPS has studied the results from the trials conducted on cropping soils at Yalloak near Ballan by Dr Peter Sale from La Trobe University. PPS has also investigated further trials in cropping paddocks by the farmer group Southern Farming Systems. Some of these trials have shown that there are significant crop yield increases after the soil manuring procedure has been carried out. As noted by Dr Sale in the paper presented at the 2010 Grasslands conference there has been little research into the procedure in permanent pasture systems.

Funding

PPS has received funding for the subsoil project from the A W Howard memorial trust grants in aid program.The AW Howard Memorial Trust was established by the Australian Institute of Agricultural Science (now AIAST) in 1964 to commemorate the unique contribution of Amos Howard in the use of subterranean clover as a pasture plant in Australia. In 1889 Amos William Howard found subterranean clover growing, he recognised its great promise and was the pioneer of its use in sown pastures.
The aim of the Trust is to encourage and promote research and investigation in the fields of natural science and social science, including economics which relate to the development, management and use of pastures.

Trial Design
The PPS subsoil amelioration project is located at Jallukar Park which is 25 km North West of Ararat, Victoria. The site was established in July 2011 prior to the area being sown with a Q75 winter active lucerne pasture. There were three treatments, a control, a deep ripped area and a deep ripped area ameliorated with approximately 10 tonnes/ha of pig manure, replicated eight times. The trial area covers approximately 0.5 ha.

Figure 1; Dr Peter Sale at the subsoil site during a visit to the PPS group in 2012

Trial Area July 2011
8 replicates –3 treatments
(1) Control – no treatment
(2) Deep ripped
(3) Deep ripped with ameliorant added

The site was established with an extended ripper digging the soil to around 900mm, the pig manure ameliorant was applied with a machine modified by host farmer Simon Brady which was very effective in placing into slot created by the deep ripper.
The ameliorant reached a depth of 700mm in a vee pattern, narrowing as it became deeper.

Figure 2; PPS members Simon Brady, Ken Hall & Paul Harrington with project advisor Kelly Johnson; Gorst Rural (ex Landmark) at the site prior to trial set up.

Figures 3 & 4; ameliorant being applied

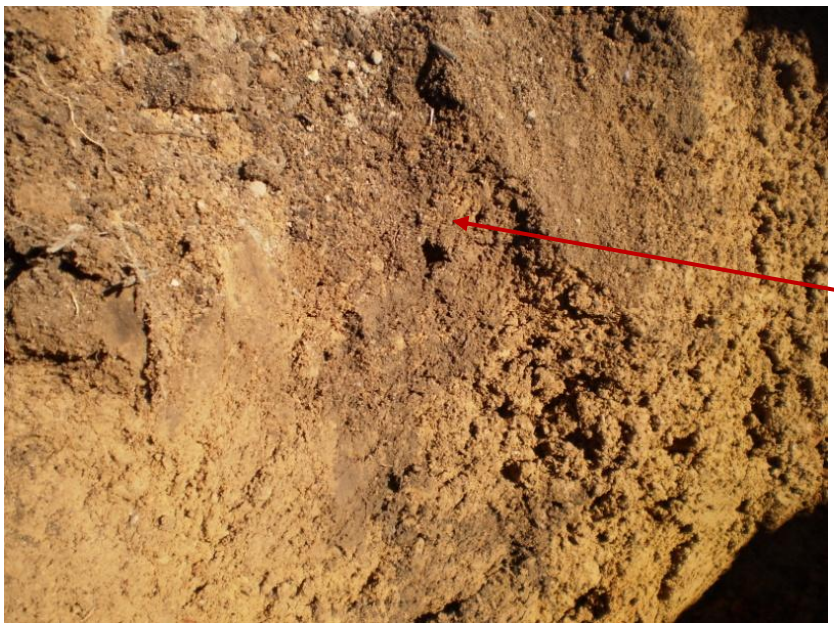

Figure 5; soil profile after soil amelioration

Figure 6; site prior to lucerne establishment

Soil Description
PPS was able to get a soil description on a similar paddock to the trial site during a separate project in 2015. The paddock is around one km from the trial site but would reflect the soil type fairly accurately.

SITE: PPSPP23 **Property:** S & Y Brady
Location: Pomonal **Geo. Ref:** 653283E 5880390S

Aust. Soil Class.: Bleached-Mottled, Eutrophic, Brown CHROMOSOL
Northcote Factual Key: Dy3.42
General Landscape Description: Undulating plain
Site Description: Upper slope; 4%
Aspect: 320□ (NW)
Vegetation: Pasture; Phalaris

Soil Profile Morphology

A1 0 - 10 cm Dark greyish brown (10YR4/2); hard setting surface condition; *coarse sandy loam;* weak very fine subangular blocky structure; rough ped fabric; very weak consistence, dry; contains many medium to coarse subrounded sedimentary gravel; pH (field) 5.0; clear change to:
A2 10 - 40 cm Light yellowish brown (10YR6/4), bleached, white (10YR8/2d); *coarse sandy loam;* apedal; massive; sandy fabric; very weak consistence, dry; contains a few medium subrounded sedimentary gravel; common fine ferro-manganiferous nodules present; pH (field) 6.0; abrupt change to:
Subsoil:
B21 40 - 70 cm Yellowish brown (10YR5/4), common medium distinct red and yellow brown mottles; *light clay;* moderate very fine angular blocky structure; rough ped fabric; weak consistence, dry; contains many medium subrounded sedimentary gravel; contains very few fine ferro-manganiferous nodules; pH (field) 6.5; diffuse change to:
B22 70 - 90 cm Yellowish brown (10YR5/4), with common medium distinct red and yellow brown mottles; light clay, coarse sandy; moderate very fine to fine angular blocky structure; rough ped fabric; firm consistence, dry; contains a few medium subrounded sedimentary gravel; contains very few fine ferro-manganiferous nodules; very highly calcareous; pH (field) 6.0.

Profile Described by: Grant Boyle, Ag Vic and Jim Caldwell, SFS 12th March 2015.

Figure 7; soil description of similar paddock on Jallukar Park

Soil ameliorant analysis

The pig manure used as the ameliorant was sourced from pig farm near Ballarat; a typical analysis was provided by the supplier. While the analysis reflects the product used in the trial, it should be noted that individual batches may vary.

Table 1; typical analysis of pig manure ameliorant.

Nutrient	Measure	Typical analysis
Nitrogen	%	3.25
Potassium	%	0.28
Phosphorus	%	5.66
Calcium	%	7.47
Magnesium	%	1.27
Sulphur	%	N/A
Sodium	%	0.10
Cholride	%	N/A
Iron	ppm	4500
Manganese	ppm	953
Copper	ppm	82
Zinc	ppm	758
Boron	ppm	11
Molybdenum	ppm	4
Cobalt	ppm	8

Table 2; Trial Map

Replicate	Treatment	Distance from centre of rep to powerline (metres)
1	control	0.0
1	ripped	2.2
1	Ripped + ameliorant	4.1
2	control	6.2
2	ripped	8.1
2	Ripped + ameliorant	9.9
3	control	11.8
3	ripped	13.7
3	Ripped + ameliorant	15.8
4	control	17.6
4	ripped	19.0
4	Ripped + ameliorant	20.7
5	control	22.9
5	ripped	24.3
5	Ripped + ameliorant	26.4
6	control	28.1
6	ripped	29.5
6	Ripped + ameliorant	31.5
7	control	33.3
7	ripped	34.9
7	Ripped + ameliorant	36.7
8	control	38.4
8	ripped	40.1
8	Ripped + ameliorant	42.2

Trial Measurements
Dry Matter Comparison
The trial was measured using dry matter comparisons between the treatments; pasture cuts were taken in the spring, dried and weighed to get dry matter results.
Due to dry springs only one grazing was possible in the lucerne pasture, therefore only one DM measurement was taken prior to grazing. Figure 8 shows a comparison between average cumulative rainfall and the cumulative rainfall for the measurement period using figures for Ararat.

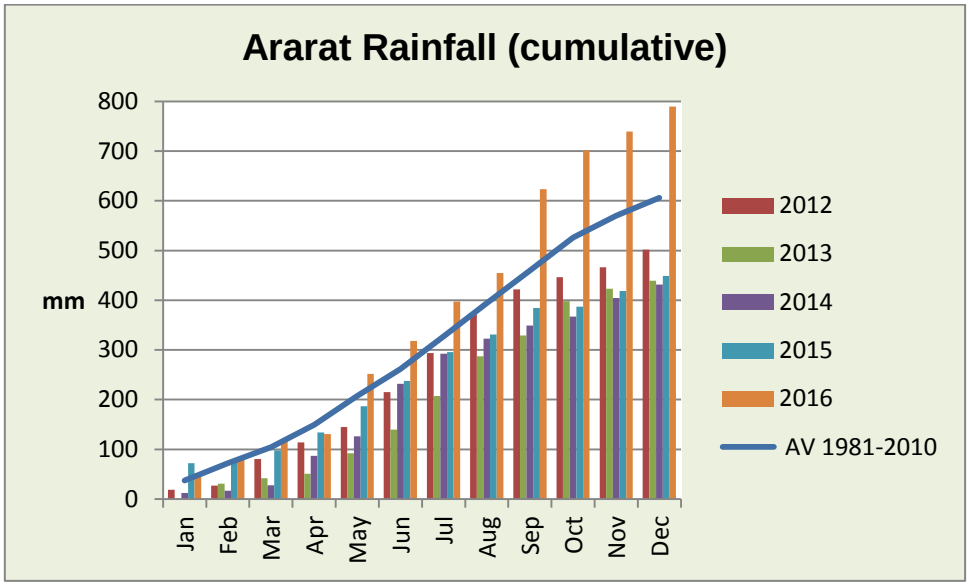

Figure 8; cumulative rainfall for Ararat

DM measurements were not able to be conducted after 2015 as the lucerne pasture failed in 2016. The wet conditions of that year encouraged annual weed growth and weed control was unable to be carried out due to the wet conditions not allowing machinery to traffic the paddock.

Dry Matter Results 2012 – 2015
Note *Due to the small area of the trial, the nature of lucerne growth and the treatments being in a single rip line there is a margin for sample error, although the dm results do reflect the visual assessment of the trial.*

The 2012 results showed a response to both the rip only and the rip + manure treatments.

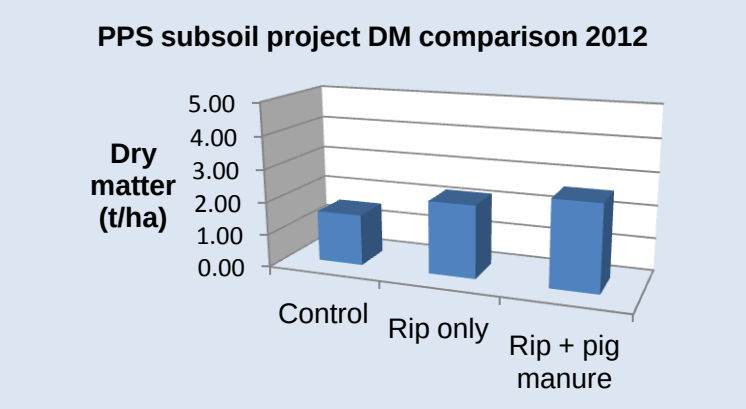

Figure 9; 2012 DM results

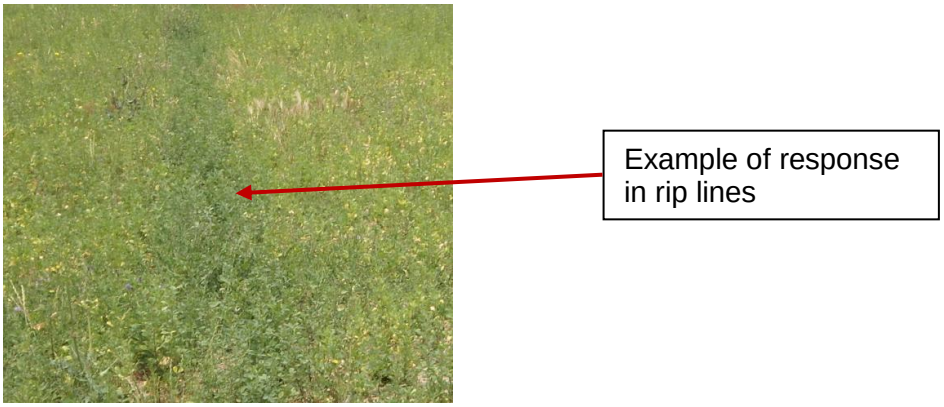

Figure 10; example of the response in the rip only and the rip + manure treatments

The 2013 results show a continued response to the rip + manure treatment but the response to the rip only treatment has declined to be below the control.

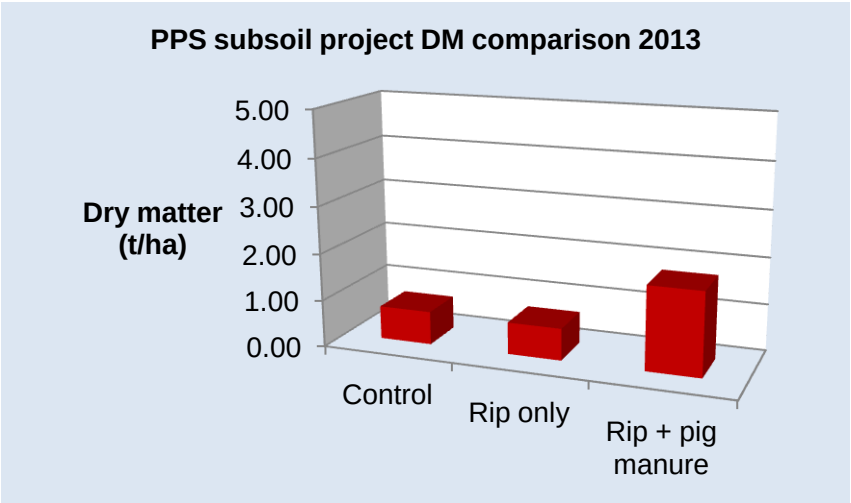

Figure 11; 2013 DM results

The 2014 results showed a 194% increase in dry matter in the rip + manure treatment in comparison to the untreated area.

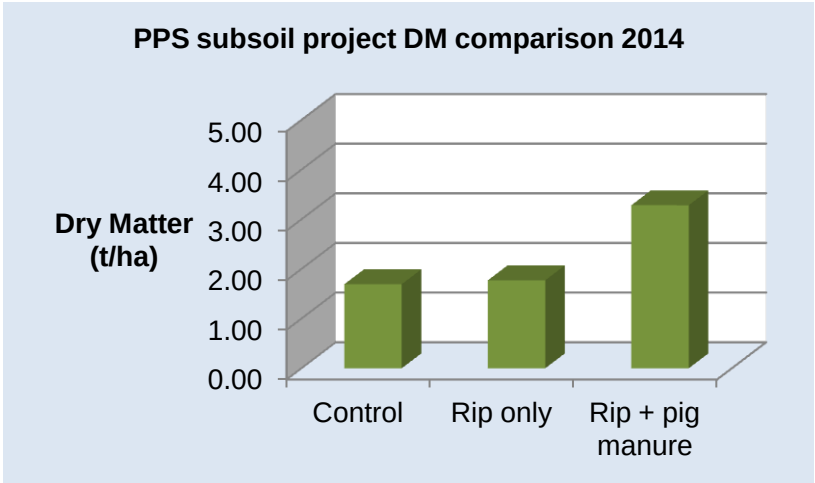

Figure 12; 2014 DM results

The 2015 results show the highest yield in the measurement period; the rip+manure showed a 97% increase over the control, while the rip only treatment had a 16% increase.

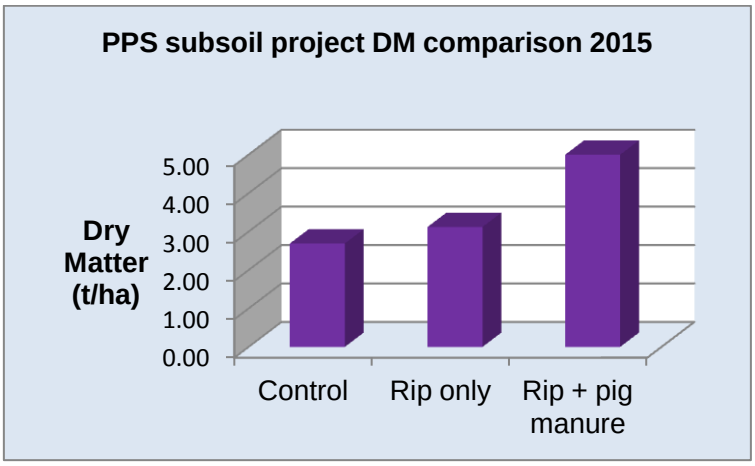

Figure 13; 2015 DM results

Table 3; summary of DM results (tonne/dm/ha)

	Sep-12	Nov-13	Oct-14	Oct-15	Total
Control	1.56	0.71	1.69	2.69	6.65
Rip only	2.21	0.68	1.77	3.12	7.78
Rip + pig manure	2.62	1.78	3.28	5.30	12.98

Cumulative results

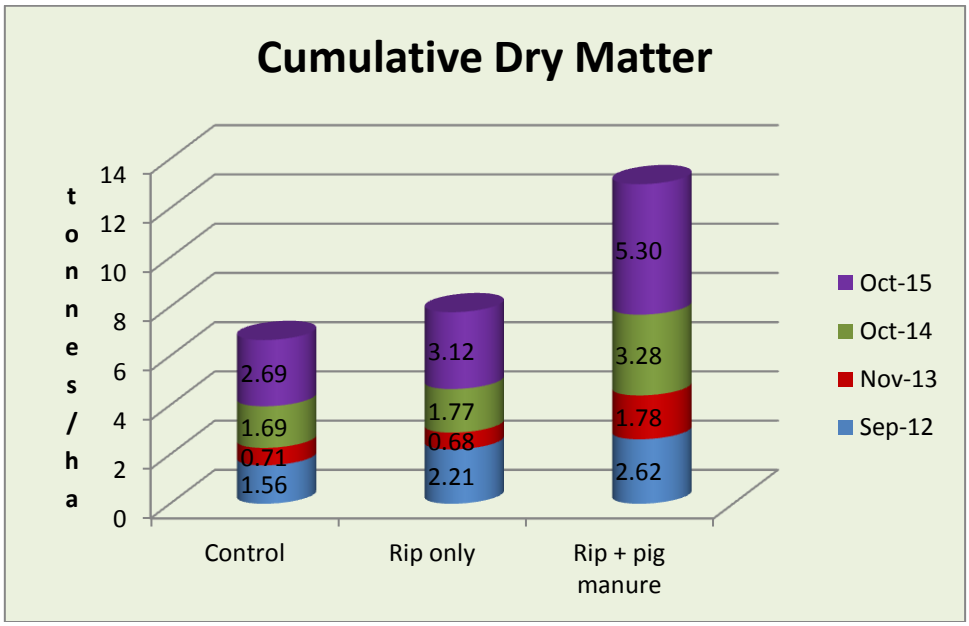

Figure 14; cumulative DM results

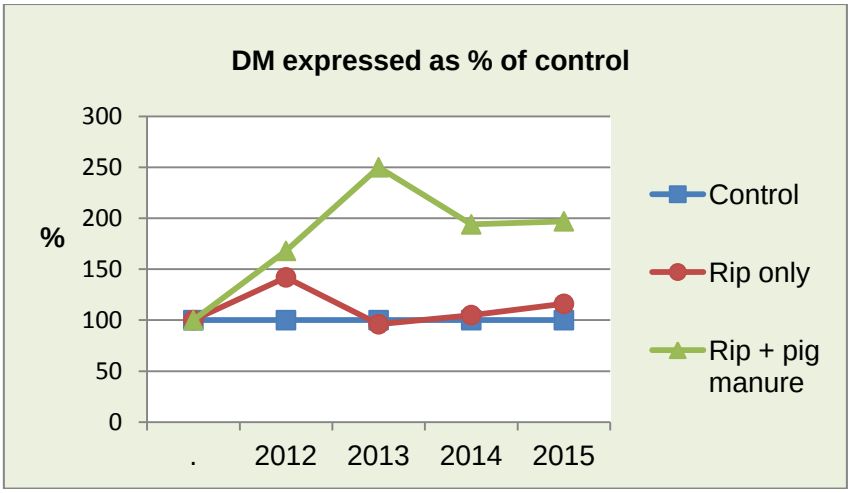

Figure 15; DM % comparison to control (nil) treatment

Feedtest Analysis

Samples were taken from the control and the rip+manure treatments in spring 2014 and 2015; the results are shown in tables 4 & 5.

Table 4; Feedtest results spring 2014

FEEDTEST OCTOBER 2014	CONTROL	RIP + MANURE
Dry Matter %	44.2	42.7
Moisture %	55.8	57.3
Crude Protein (% of DM)	21.4	26.2
Acid Detergent Fibre (% of DM)	22.9	20.4
Neutral Detergent Fibre (% of DM)	32.6	28.5
Digestibility DMD (% of DM)	72.6	76.4
Digestibility DOMD (% of DM)	68.4	71.5
EST ME mj/kg/dm	10.9	11.5

The 2014 feed quality data resulted in the rip plus manure showing an increase in protein (4.8%) and overall increase of ME of 0.6 over the control.

Figure 16; lucerne trial site,spring 2014

Table 5; Feedtest results spring 2015

FEEDTEST OCTOBER 2015	CONTROL	RIP + MANURE
Dry Matter %	22.8	22.4
Moisture %	77.2	77.6
Crude Protein (% of DM)	30.8	33.3
Acid Detergent Fibre (% of DM)	21.2	21.8
Neutral Detergent Fibre (% of DM)	29.0	27.5
Digestibility DMD (% of DM)	75.6	76.5
Digestibility DOMD (% of DM)	70.8	71.6
EST ME mj/kg/dm	11.4	11.5

The 2015 feed quality data resulted in the rip plus manure showing an increase in protein (2.5%) over the control.

Soil test
Soil tests were undertaken on the control (nil) treatment and the rip+manure treatment in January 2016; Testing was done at 0 – 30 cm & 30 – 60 cm.

Table 6; soil test results

	0 -30 cm Control	0 – 30 cm Ameliorant	30 -60 cm Control	30 – 60 cm Ameliorant	60 -80 cm Control	60 – 80 cm Ameliorant
pH (CaCl)	5.7	5.4	5.1	5.9	5.2	6.1
Organic carbon (Wakely Black %)	0.91	0.91	0.37	1.00	0.33	0.43
Phosphorus (Cowell) mg/kg	33	180	12	960	8	170
Phosphurus Buffer Index (PBI)	29	41	59	320	280	540
Nitrate nitrogen (KCl) mg/kg	16	18	2	26	1	7
Potassium (Amm-acet) cmol+kg	0.14	0.26	0.14	0.42	0.22	0.30
Sulfate – S (KC140) mg/kg	5.1	7.3	15.0	160.0	47.0	160.0
Aluminium saturation %	<1	<1	2.5	<1	1.5	<1
Zinc (DTPA) mg/kg	0.85	7.50	0.31	44.00	0.15	3.20
Manganese (DTPA) mg/kg	5.9	5.3	2.5	20.0	1.5	1.0
Copper (DTPA) mg/kg	0.10	0.55	0.09	3.00	<0.10	0.06
Magnesium (Amm-acet) cmol+kg	0.3	0.5	1.7	5.7	4.8	8.8
Iron (DTPA) mg/kg	97.0	110.0	27.0	47.0	10.0	7.0

The soil tests showed differences in some nutrients, these are shown in red text.

Observations

Both the rip and the rip+manure showed extra growth in 2012 but the effect on the rip only treatment lasted only one year and subsequently the results showed little difference to the control.

The rip+manure treatment showed extra growth as well as a dark leaf colour in all years. Areas of extra growth and darker leaf colour were also observed in the first two years where there was spillage of the pig manure onto the soil surface during loading stops; this suggests that these observations were a response to nitrogen in the ameliorant.

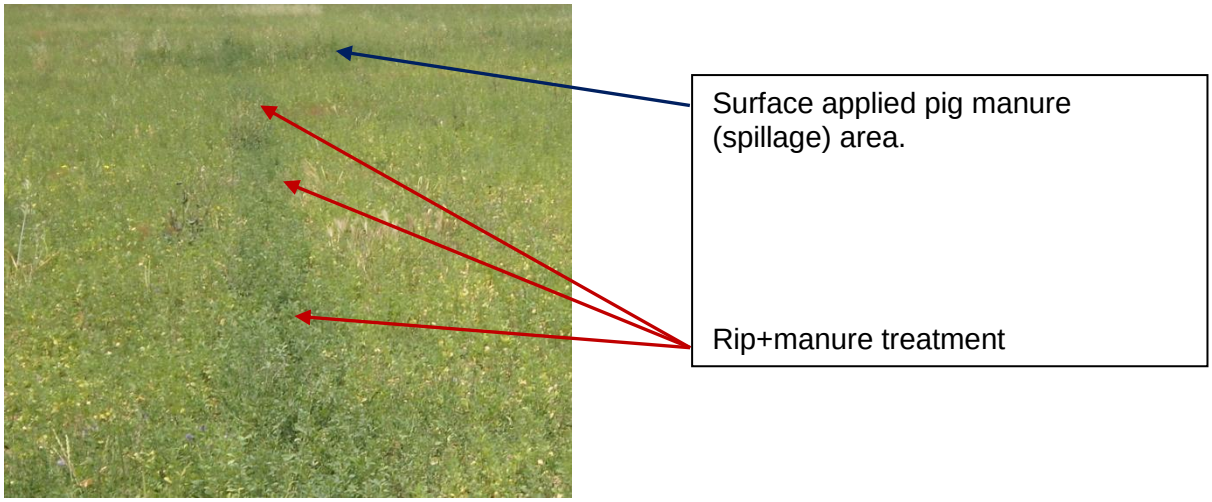

Figure 16; picture taken in September 2012 showing areas of extra growth.

The extra growth in the rip+manure treatment was easily observed throughout the trial with plants showing more density and height.

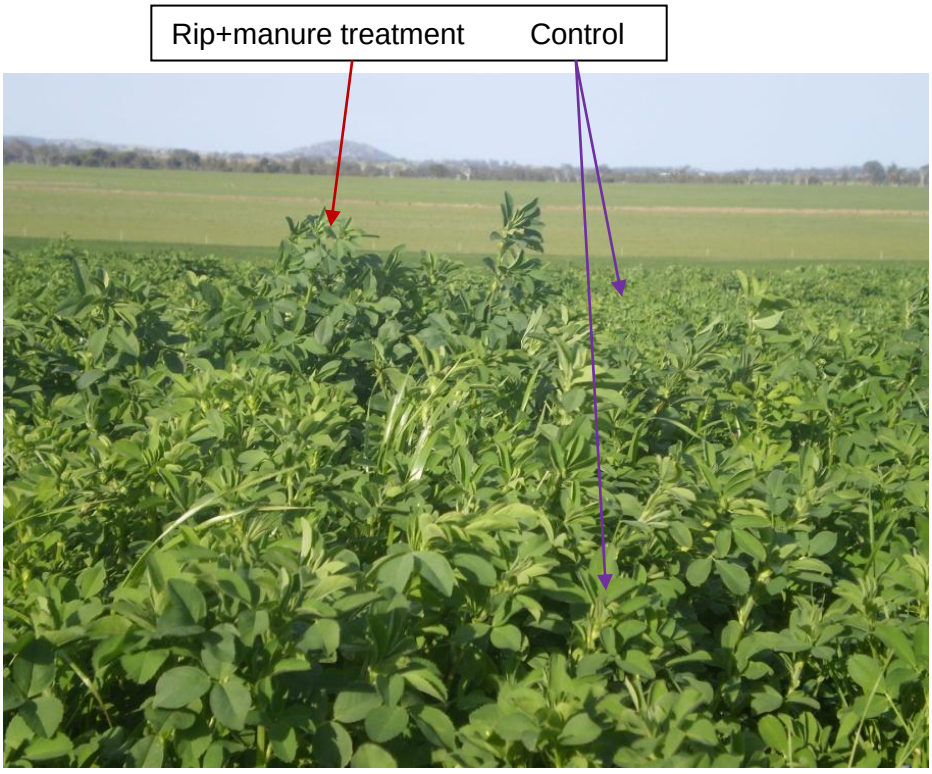

Figure 17; Picture from September 2014 showing difference between rip+manure treatment & control.

Figure 18; Picture from September 2014 showing difference between rip+manure treatment & control.

In the drought year of 2014, as well as producing growth, the rip + manure treatments stayed greener in the dry spring. No difference was noted between the control (nil) & the Rip only treatments.

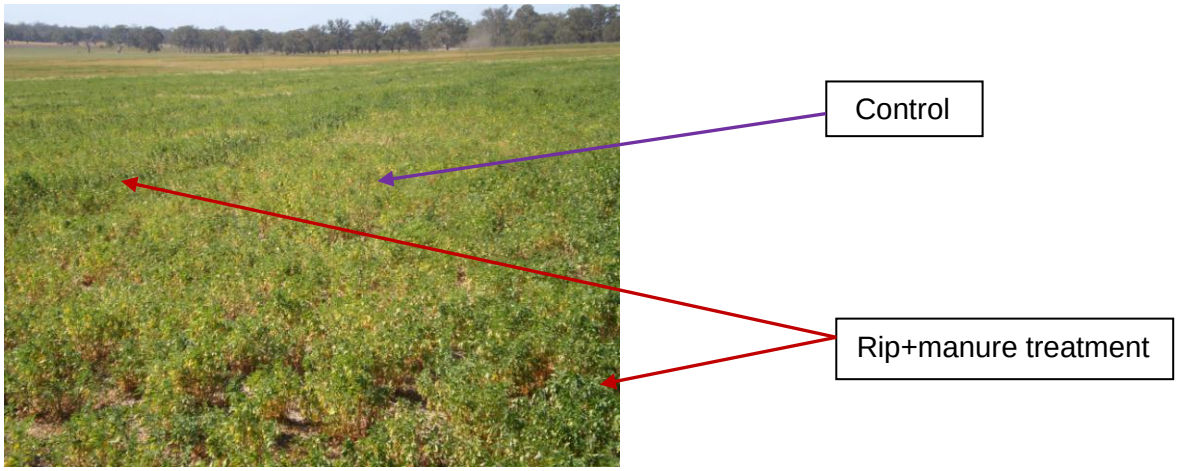

Figure 19; Trial site 4th October 2014

Soil Pit
A soil pit was opened at the site in October 2015 for inspection during the PPS annual spring field day. Differences in soil texture and lucerne root depth were observed.

Figure 20; Subsoil October 2015
Left - control (untreated) Right - Rip + Manure treatment

Figure 21; Host farmer Simon Brady comparing the deeper lucerne root penetration in the Rip + Manure treatment (Red arrow) with the control (untreated) section (Purple arrow)

2016 observations
The lucerne pasture became infested with annual ryegrass during 2016 and due to the wet conditions being experienced, it was impossible to access the paddock to conduct a weed control spray.
There were no discernible differences in the growth of the lucerne in any of the replicates in spring 2016; no plant cuts were conducted.

2017 observations
The weed infestation of 2016 and the inability to control the weeds due to the inaccessibility for machinery because of the wet conditions reduced the lucerne to the point where it was no longer a viable stand. The paddock will be resown to a new pasture in the near future.
The only observation in relation to the ameliorated replicates was the presence of marshmallow plants in the treatment lines; it was mostly absent in the rest of the paddock.

Financial Analysis
PPS completed a simple financial analysis using the dry matter results using lucerne hay production as a proxy. The results show a potential three year payback period for the sub soil amelioration treatment.

Financial Analysis1 (Rob Shea; PPS Project Manager & Kelly Johnson; Agronomist Gorst Rural)
The results from a simulated lucerne hay scenario are shown in the graphs below. These show the potential of a three year payback period for the procedure. The assumptions in the hay analysis were treatment cost of $1000 per ha and a return of $250 per tonne of lucerne hay.
The cost of the subsoil treatment is an estimate only as the procedure is not currently available commercially.
It should be noted that the three years of the trial have had dry late spring and summer periods which did not allow for any regrowth. A second cut or grazing of lucerne would alter the results somewhat.

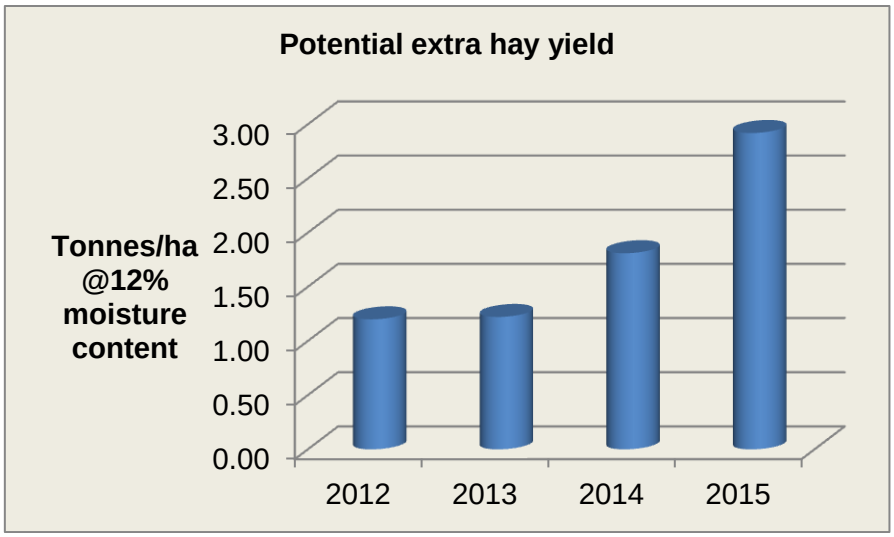

Figure 22; Estimated potential hay yields

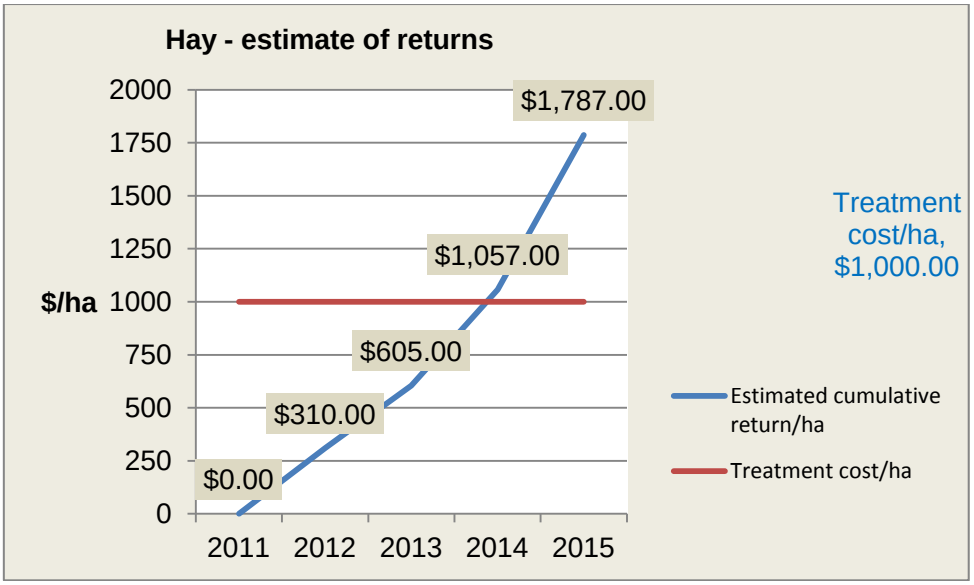

Figure 23; Estimated returns & payback period

Financial Analysis 2 (Simon Brady; host farmer)

Simon Brady conducted an analysis of the trial results in late 2015; assumptions were that the cost of the subsoil treatment would be $1,000/Ha and a lamb price of $5.50 dressed weight.

The entire 12 ha lucerne pasture which contains the trial replicates was stocked with 150 lambs from November 1st 2014 until December 15th 2014. Stocking rate equivalent was 12.5 dse/Ha

Table 7; liveweight results

Live weight at start1/11/14	33 kg
Live weight at finish 15/12/14	47 kg

The live weight gain per head was 14 kg or 311 grams per day. The live weight per Ha was 175 kg/Ha for the 45 days or 3.9 kg/Ha per day.

At a dressing percentage of 45% this gave the following dressed lamb weight performance.
Dressed weight gain 78.7 kg per Ha over 45 days or 1.75 kg/Ha/day
Lamb dressed weight sale price was $5.50 per kg which equals $432 per Ha return over the 45 days for the entire paddock.
Note: the lambs were adapted to the lucerne pasture as they had previously been grazing another lucerne paddock on the farm.

Assumptions

A comparison was simulated using a rip+manure pasture and a control pasture using the dry matter results, the 2014 lamb growth rates and the 2014 dressed lamb price of $5.50 per kg.

Table 8; Dry Matter results

Year	**Control** DM t/ha	**Rip+manure** DM t/ha	Increase in rip + manure over the control DM t/ha	**Control** % of 2014 DM control area result	**Rip+manure** % of 2014 control area result
2012	**1.56**	**2.62**	**1.06**	**92**	**155**
2013	**0.71**	**1.78**	**1.07**	**42**	**105**
2014	**1.69**	**3.28**	**1.59**	**100**	**194**

Table 9; Financial estimates- using 2014 return for control area of $432/ha

Year	**Control** Estimate % of 2014 control area stocking rate	**Control** $ per ha return	**Rip+manure** Estimate % of 2014 control area stocking rate	**Rip+manure** $ per ha return	**Estimate of potential increased return per ha in rip + manure treated area**
2012	**92**	**$397**	**155**	**$670**	**$273**
2013	**42**	**$181**	**105**	**$476**	**$295**
2014	**100**	**$432**	**194**	**$838**	**$406**

The results for the lamb simulation show that the breakeven point has almost been reached in year three similar to the hay simulation.
Note: no financing costs were taken into account in either the hay or lamb scenarios.

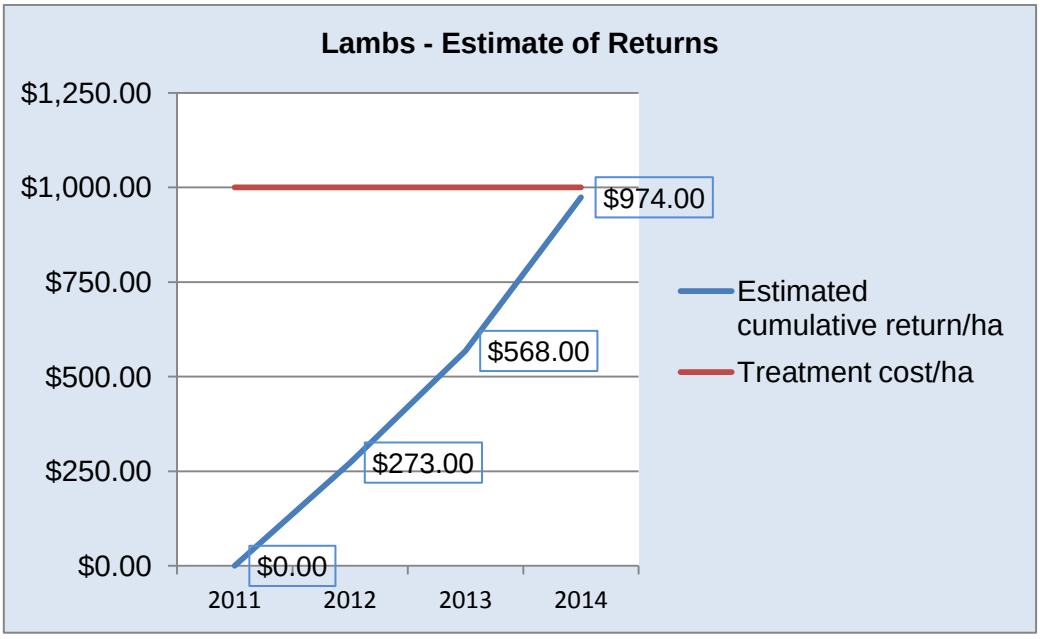

Figure 24; Lamb simulation results

Figure 25; lucerne trial site, at peak production

Discussion

PPS believes that the results in the Jallukar trial show that the technique of sub soil amelioration has potential to produce large increases in productivity in certain soils in the Upper Wimmera region.

The drier than average springs allowed for only one dry matter cut each year; more favourable seasons may have altered the results.

Although the results did show large gains in the ameliorated areas, questions were raised during the trial as to whether just topdressing the manure would have achieved similar results as the ameliorated replicates. As discussed on page 13 there were visible responses where the pig manure went directly onto the soil surface when there was overflow during the loading of the machine. This is shown in figure 16 and was visible for the first two years of the trial; it is suspected that this was a nitrogen response. The effect was not evident in the final four years of observations.

It was also noted that the same level of nutrients could have been supplied through the addition of fertiliser at a lower cost. Solid pig manure being applied at 10tn/ha equate's to:

80kg Nitrogen = 200kg Urea Approx
46kg Phosphorus = 200kg MAP Approx
100kg Potassium = 250kg Muriate of Potash
77kg Sulphur = 300kg Sulphate of Ammonia

The equivalent nutrients could be applied for approx $550 Ha using MAP/MOP/SOA blend.

It should be noted that while the level of nutrient application would be the same as that in the pig manure, any beneficial effect from the sub soil amelioration would not be achieved. This trial is unable to quantify the benefit of the amelioration process in comparison to direct application of fertiliser.

As the treatment is expensive, further trial and demonstration of the technique is needed to ground truth the results at Jallukar Park. If these were successful, the technique may be used by producers to improve productivity and soil health in the region.

Trial Communication

Trial aims, progress and results have been included in PPS quarterly newsletters.

The site was inspected by PPS members at the end of year event in 2012 with Dr Peter Sale from LaTrobe University in attendance, who gave a talk on the process of soil amelioration.

The site has been visited as part of farm tours by the Ararat Bestwool/Bestlamb group and the Elmhurst Evergraze “whole farm grazing course” which was facilitated by PPS in 2013.

The site was visited in May 2015 by members of the Central Branch of the Grasslands Society as part of a study tour of PPS sites.

PPS members visited Yalloak Estate at Ballan to view some of the soil amelioration work carried out in cropping paddocks during 2013.

PPS members inspected a soil pit at the site in October 2015.

Two interim reports on the project were produced and sent to PPS members as well as being posted on the PPS website.

References
Johnson K. (2007) Subsoil amelioration using organic amendments; La Trobe University

Lawson A. (2017) New investment helps crops achieve their yield potential in sub-par subsoils. *GRDC News*

Sale P. (2010) Subsoil manuring; do the benefits warrant the cost? *Proceedings of the 51st Annual Conference of the Grasslands Society of Southern Australia Inc.*

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Trial measurement; PPS member Wayne Burton
Trial management; PPS Project Manager Rob Shea

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Wimmera CMA

Australian Government | National Landcare Programme