WEST MIDLANDS GROUP

Improving the outcomes of sowing serradella by using clay

1712-05-11

Improving the outcomes of sowing serradella by using clay is being delivered by the West Midlands Group. This project is supported by the Northern Agricultural Catchments Council, through funding from the Australian Government's National Landcare Program.

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Improving the outcomes of sowing serradella by using clay

1.0 AIM

This project aimed to address the following questions

- Does the application of clay to typical sandplain pasture paddocks of the Northern Agricultural Region (NAR) have a positive effect on pasture production and erosion control?
- Does it help with the establishment of serradella?
- Does increase pasture growth on clayed soils cover the cost of claying, and if not, what is the pay off period i.e. does the claying benefits increase with age e.g. what is percentage
- Is there a potash and sulphur benefit from claying?

2.0 BACKGROUND

Non-wetting soils prone to wind erosion are common in the NAR. The value of clay application to address soil water repellence has been demonstrated to improve crop productivity by increasing moisture infiltration to allow a more even wetting of soil. This results in an improvement in plant germination and establishment, increased uptake of nutrients, better soil structure, and a reduction in soil wind erosion. Longer term benefits of clay spreading and removing soil water repellence are that there can be an increase in soil organic carbon and microbial activity that is associated with improved plant growth and nutrient cycling. While these benefits of clay spreading have been well documented in cropping systems, there has been little work that has focussed on the benefit for improved pasture production. Pasture paddocks often have more fragile soils than those used for cropping as pastures are mostly based on soils that are not suitable for cropping. They are often deep white sands, have low clay content, and often have a strong water repellent nature. Clay spreading has been used by some farmers in the district in grazing systems to reduce the potential for wind erosion when grazing in summer, but the effect of this has not been measured on pasture production. To encourage adoption of clay spreading for pasture production, farmers need to fully understand the benefits to the whole farm system and the economics associated with it.

3.0 DEMONSTRATION SITE/S DETAILS

The site was located at Zac Robert's farm 'Strathmore', approximately 12 km north of Dandaragan on the Dandaragan-Badgingarra Road. The soil type was predominantly grey and white deep sand that exhibited severe water repellence. The paddock had three distinct areas that had been spread with clay, each being from a different clay source. Clay A was a white clay with low clay content, Clay B was a gravelly clay from the top of the ridge, and Clay C was a high clay content clay that was taken from the nearby creek system. While these clays were not tested prior to application, it is expected that each clay would differ in the amount of clay and nutrient content.

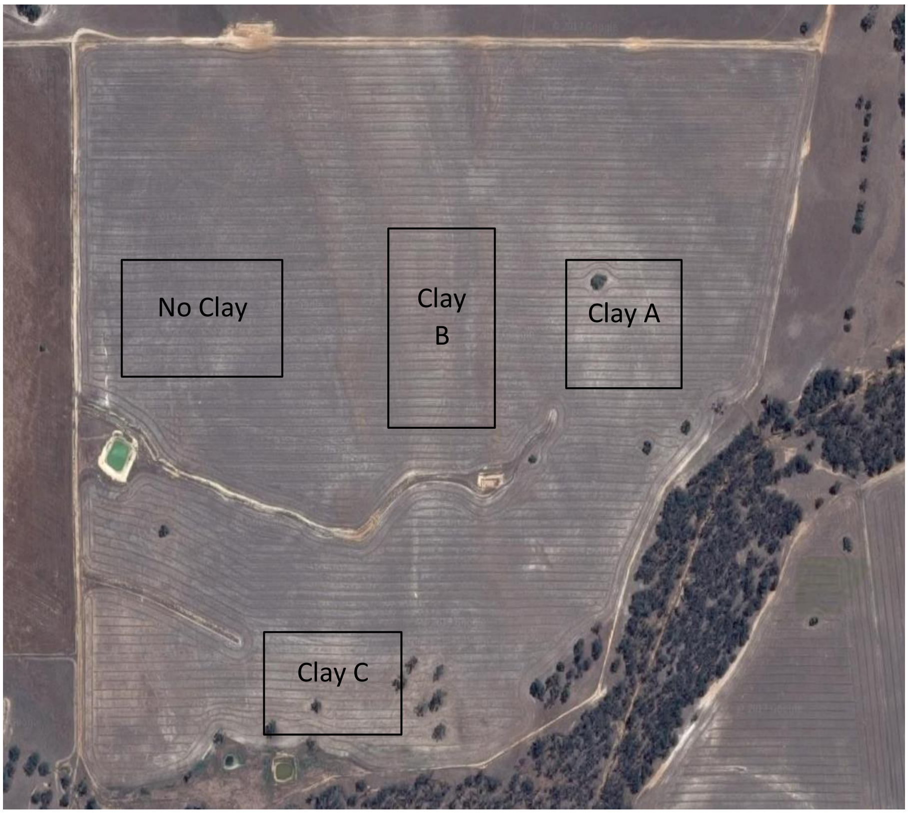

Figure 1. Location of treatments in the paddock at the Roberts site. *Note:* Clay C results were confounded due to the lateral flow of water over the landscape and is most likely not representative of the paddock conditions.

4.0 METHOD

A demonstration site was established at Zac Roberts' property, Dandaragan, where there were four distinct sections of the paddock (Figure 1) where three types of clay were spread, and an area that has not been spread with clay (No clay). The previous rotation was: 2012 lupins, 2013 barley, 2014 lupins, 2015 canola, 2016 wheat.

The site was set to be sown with a serradella and barley mix in early 2017. This was delayed until May 2017 due to below average rainfall in April and May. The paddock was sown to a mix of Marguerita serradella (9 kg/ha), Santorini serradella (2.5 kg/ha) Prima Gland clover (2 kg/ha), and Scope CL barley (20 kg/ha) on the 16/5/2017. ALOSCA inoculant was also applied at a rate of 7.5 kg/ha for the GS type and 9.5 kg/ha for the C type inoculant. Barley was included as a cover crop to reduce the potential for erosion and increase early grazing production. Herbicide control of weeds was achieved using a pre-emergent application of 100 g/ha Spinnaker that was incorporated by sowing.

The number of plants that had emerged was measured at 2 and 4 weeks following the break of the season. Plant biomass and ground cover was measured at four dates during the growing season, with pasture cages used to limit the effect of grazing on the measurement of dry matter production. Grazing records were kept by the farmer of what stock were in the paddock, when and for how long (Table 1). Pasture growth was measured as the change in pasture biomass in the pasture cages from one sampling to the next, and represents the growth of ungrazed pasture. The cumulative amount of pasture grown was determined as being the sum of pasture growth in each period. These biomass samples were dried at 60°C for 72 hours to determine the amount of dry matter present, or samples were sent to Feedtest to be analysed for metabolisable energy, crude protein, digestibility, and neutral detergent fibre (NDF).

This project was based on a demonstration site design with no replication and so there been little opportunity to perform a statistical analysis on the data. Pasture emergence was measured at multiple sites within each treatment area, and so an analysis of variance could be performed. However, pasture cuts were limited by the use of large pasture cages to keep cattle out, and there was not enough ungrazed pasture area to take multiple cuts, and so this data was not analysed.

Table 1. Livestock grazed in demonstration paddock over the course of the pasture growing period.

Number & Type	Days on Feed	DSE/ha
460 large Poll Dorset ewes with 535 lambs	14/7 to 27/7 (13 days)	18.1
66 heifers (approx. 430kg)	15/9 – 15/10 (30 days)	5.4
808 lambs (approx. 40kg)	2/10 – 7/11 (36 days)	10.7

Soil tests (0-10cm) were conducted in March 2017 to determine the background fertility of each site. At this time samples were also taken for soil water repellence analysis. Two tests were conducted; molarity of ethanol droplet and water droplet penetration time by Dr.Stephen Davies (DPIRD). Soil surface condition and wind erosion hazard assessment was undertaken using the guidelines set out in DAFWA Land Evaluation Standards for Land Resource Mapping (Resource Management Technical Report 298 3rd Edition 2005).

5.0 RESULTS

Claying did not impact the cumulative dry matter production of serradella in this demonstration with the No Clay control having the highest dry matter production over the growing period (Figure 2). However, the claying appeared to have an impact on the dry matter production of barley (Figure 3). When combined, the additional barley growth in the clayed areas meant that the overall cumulative dry matter production was higher in the clayed treatments (Figure 4). There appeared to be an inverse relationship between the dry matter production of serradella and barley. Interestingly, when the relationship between serradella and barley production was examined, a weak inverse relationship was identified where serradella growth was found to be lowered by the presence of barley (R^2=0.52, Figure 5).

In general, there was a greater amount of dry matter production from barley when compared with serradella including at the first pasture cut at 9 weeks post seeding on the 21 July 2017. Conversely, the emergence of serradella when counted at 6 and 9 weeks post seeding was significantly higher than the emergence of barley (Figure 6). There was no significant difference between the emergence of serradella in treatments Clay B, Clay C and No Clay.

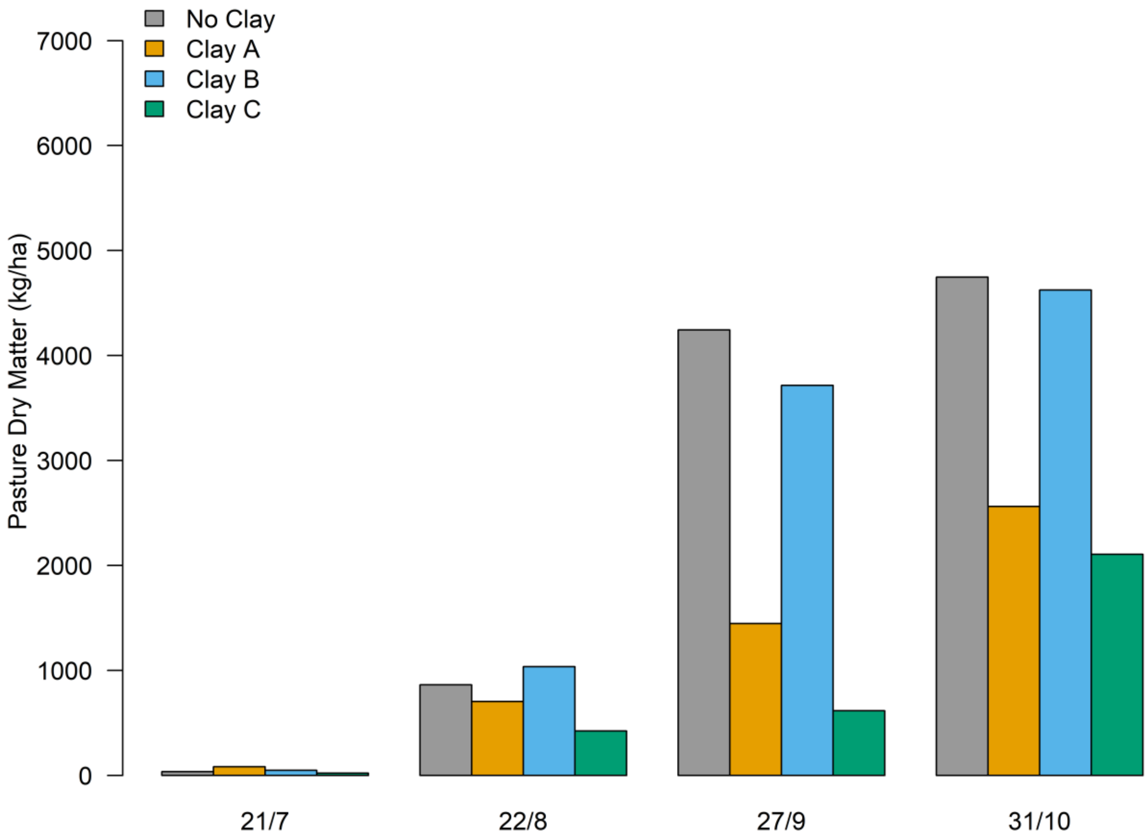

Figure 2. The cumulative growth of serradella dry matter production (kg/ha) over the growing period.

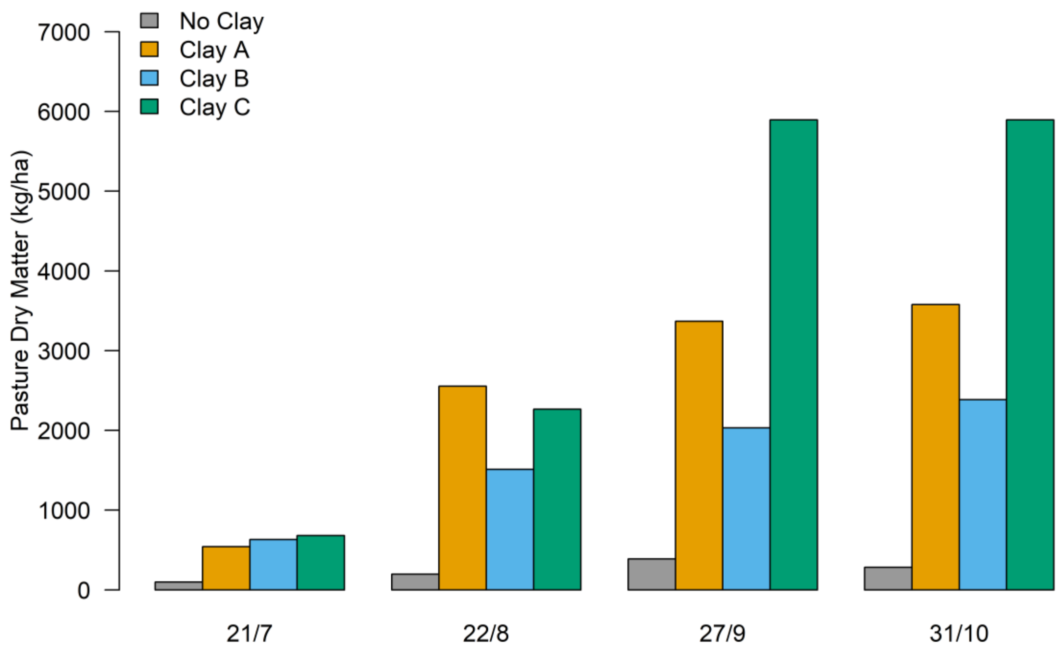

Figure 3. The cumulative growth of barley dry matter production (kg/ha) over the growing period.

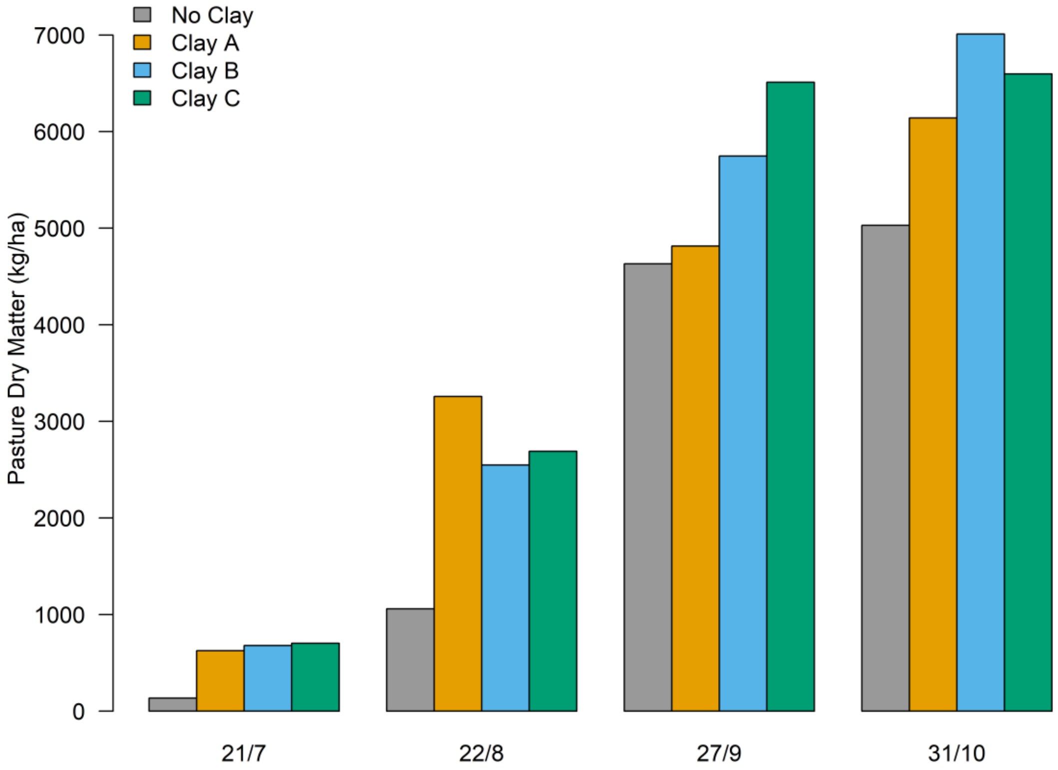

Figure 4. The combined cumulative growth of serradella and barley dry matter production (kg/ha) over the growing period.

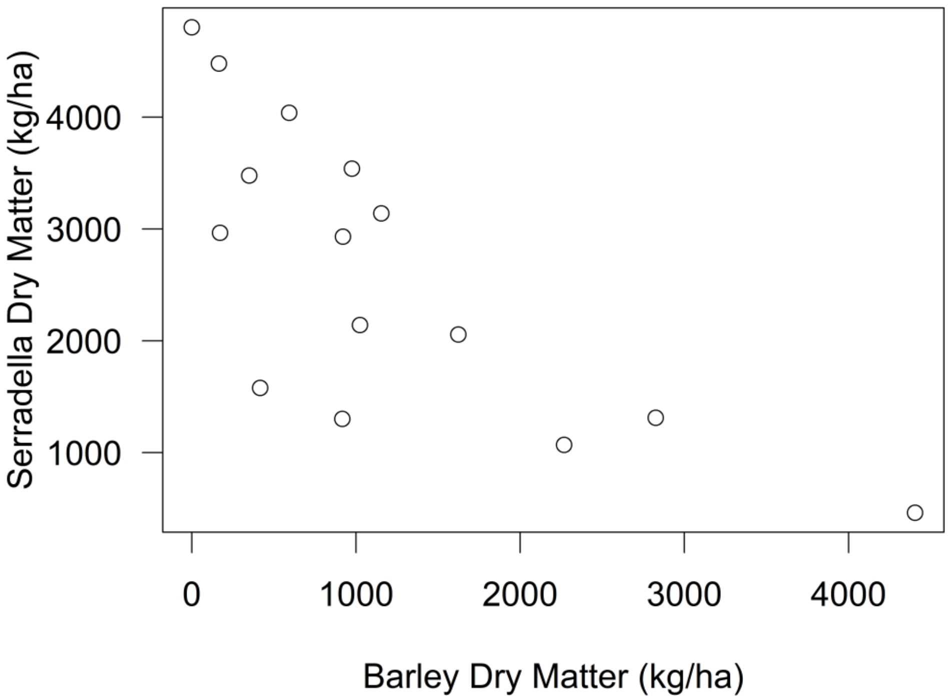

Figure 5. Relationship between barley and serradella dry matter production (R^2=0.52).

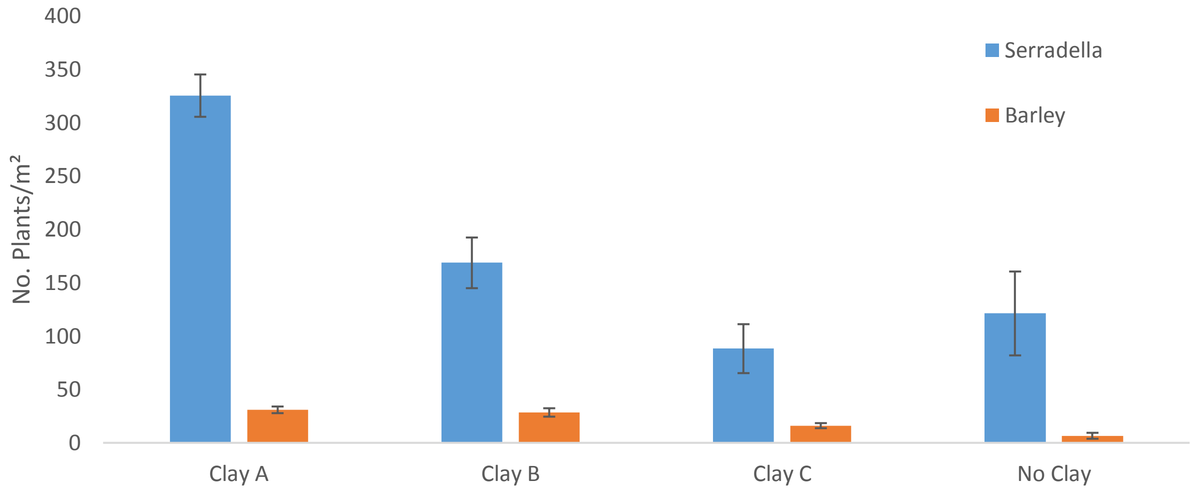

Figure 6. Average emergence of serradella and barley at each treatment site ± the standard error.

Table 2. Feedtest results from serradella and barley plant tissue samples taken at each site on 30 October 2017.

		Serradella				Barley			
		Clay A	Clay B	Clay C	No Clay	Clay A	Clay B	Clay C	No Clay
Est. Metabolisable Energy Calculated	MJ/kg DM	6.6	7.5	8.3	7.8	10	8.5	10.6	8.4
Neutral Detergent Fibre	% of DM	54.2	54.5	49.2	54	53.7	60.2	48	58.7
Crude Protein	% of DM	10.3	10.3	13.1	11.3	8.2	4.2	7	5.7

The feed test results (Table 2) show a lower than expected metabolisable energy (ME) and crude protein (CP) content. The ME for serradella ranged from 6.6-8.3 MJ/kg DM in the clayed treatment and 7.8 MJ/kg DM in the no clay control. In the barley the clayed treatments ranged from 8.5-10.6 MJ/kg DM compared to a slightly lower ME value of 8.4 MJ/kg DM for the no clay control (Table 1). There didn't appear to be a significant impact of claying on the CP or ME of the serradella or barley.

Table 3. Soil test results (0-10cm) from March 2017 and February 2018. Colours indicate levels in the soil

High | OK/Sufficient | Marginal | Low

		Clay A		Clay B		Clay C		No Clay	
		Mar-17	Feb-18	Mar-17	Feb-18	Mar-17	Feb-18	Mar-17	Feb-18
pH Level (CaCl2)		5.9	6.2	6	6.4	6.1	6.5	6	6.3
Ammonium Nitrogen	mg/kg	2	2	3	3	2	4	4	3
Nitrate Nitrogen	mg/kg	8	13	11	11	9	14	9	10
Phosphorus Colwell	mg/kg	8	8	11	13	20	19	10	9
Potassium Colwell	mg/kg	30	17	47	26	44	41	37	23
Sulphur	mg/kg	3.9	3.8	4.1	4.0	4.1	4.2	4.7	5.2
DTPA Copper	mg/kg	0.34	0.33	0.61	0.49	0.6	0.41	0.29	0.37
DTPA Iron	mg/kg	13.36	10.52	23.9	14.80	26.65	23.80	16.09	9.75
DTPA Manganese	mg/kg	1.05	1.84	1.68	2.36	1.33	2.85	1.83	2.56
DTPA Zinc	mg/kg	1.07	1.04	1.24	1.13	1.4	1.54	0.85	0.99

The soil tests at the start and end of the demonstration (Table 3) show an acceptable pH across all treatment sites, marginal to sufficient phosphorus, marginal to low potassium and marginal sulphur. There was high levels of zinc and marginal to sufficient copper. There was an increase in nitrate nitrogen on three out of the four sites however, this is unlikely to be significant.

The soil type in the demonstration paddock was a grey and white deep sand that is typical of the region. Wind erosion was a risk post seeding during the late autumn, early winter period prior to emergence. There was some difference in the surface soil between the clayed and unclayed sections however, when using the DAFWA Land Evaluation Standards for Land Resource Mapping (Resource Management Technical Report 298 3rd Edition 2005) the susceptibility to wind erosion was assessed as moderate across the paddock.

Table 4. Soil repellence testing conducted by Dr. Stephen Davies, DPIRD Geraldton. Molarity of ethanol droplet (MED) and water droplet penetration time (WDPT).

	Avg MED	WDPT	Repellence Rating
Clay A	0	1sec	Nil
Clay B	0.75	24sec	Low
Clay C	0.75	32sec	Low
No Clay	1.75	2mins 30sec	Moderate

The results from the soil water repellence testing overall repellence ratings that fit with expectations, with the untreated soil having moderate repellence and the clayed sites having nil-low repellence (Table 4).

6.0 CONCLUSION

Pasture biomass production

This demonstration has shown that there are varied responses by serradella and barley in this paddock across the clayed and unclayed sites. It was hypothesised in this study that there would be an increase in emergence and growth in the clayed treatment when compared with the unclayed control. However, the emergence of serradella was only higher in Clay A. The other two treatments were not statistically different from the unclayed treatment. This variability in emergence response to claying is likely to be due to seasonal conditions experienced at the site in 2017, where a late break to the season, followed by good rainfall in late May and June allowed for the soil to wet up more evenly and reduce the impact of soil water repellence on serradella emergence. The small seed size of serradella relative to barley may also have meant that smaller amounts of soil moisture were able to germinate the serradella, and the soil may not have been wet enough for barley emergence in the unclayed treatment.

There was a dynamic relationship observed between the serradella and barley in terms of emergence and resulting dry matter production. The inverse relationship between serradella and barley dry matter production in spring indicates that while pasture production can be increased by mixing the two species, barley is a faster growing pasture species and can be detrimental to serradella dry matter production. The lower emergence of barley in the unclayed treatment would have reduced the competition with serradella for light, water and nutrients, allowing the serradella to grow better in the latter part of the season. Plant emergence was an important aspect of this study, however, serradella had a higher average plant emergence 9 weeks after sowing, but dry matter production was already greater in the barley compared to the serradella. Incorporating the barley into the serradella provided early, high dry matter production plant growth that allowed for heavy grazing of the paddock in July for 13 days with Poll Dorset ewes and lambs.

This is an important implication for growers, as feed production in new pastures can be boosted by the addition of a cereal, however, the seeding rate of barley needs to be kept low (15-25 kg/ha) to limit this antagonism between species. It is important to note that this demonstration was not a replicated trial, and results are expected to differ across our variable landscape, and further work should be completed in years with differing rainfall and on soil types that have a greater range of water repellence.

The analysis of dry matter of serradella and barley for crude protein (CP) and metabolizable energy (ME) gave results that were below expectation. Earlier research that focussed on the feed value of French serradella indicated that it is a high quality forage, with CP ranging from 19-25%, dry matter digestibility 70-80%, and an ME of 10-12MJ/kg DM (Loi & Revell). Our results are lower than this and is likely due to the fact that the analysis was conducted on pasture dry matter samples that were collected in October when pasture quality is known to decline in quality. We would expect that an analysis of serradella in early spring during the period of rapid growth would have achieved quality measurements similar to previously published values. The results from late in the season in this study does highlight that pasture quality does vary during the season, and while the farmer successfully fattened lambs during mid spring on this paddock, the late season feed would be most likely not be suitable for such purposes. Farmers need to take this into account when planning their feed allocation for the season when fattening lambs.

Gross Margin Analysis and Return on Investment

Table 5. Gross Margin analysis of a serradella and barley pasture in the year of establishment. Income has been calculated on liveweight gain (lwt) and an over-the-hooks (OTH) carcass weight price. Pasture grazing production based on farmer records for the paddock. Further assumptions are provided in Appendix A.

INCOME					$
Graze 1. Ewes and Lambs					Not quantified
Graze 2. 66 Heifers	3227	kg lwt gain @	$2.06	/kg	$2,991
Graze 3. 808 Lambs	774	kg lwt gain @	$3.20	/kg	$1,114
Total Income					**$4,105**
Total Income per hectare					**$42**
VARIABLE COSTS	Rate		Unit price		$/ha
Spinnaker	100	g/ha @	$ 110.00	/kg	$11
Alpha-Cypermethrin	80	ml/ha	$ 21.00	/litre	$2
Margurita Serradella	9	kg/ha @	$ 9.35	/kg	$84
Santorini Serradella	2.5	kg/ha @	$ 9.35	/kg	$23
Spartacus CL Barley	15	kg/ha @	$ 1.50	/kg	$23
Prima Gland Clover	2	kg/ha @	$ 5.50	/kg	$11
ALOSCA GS inoculant	7.5	kg/ha @	$ 1.36	/kg	$10
ALOSCA C inoculant	9.5	kg/ha @	$ 1.36	/kg	$13
			Sub-total seed cost:		$164
			Seed cost spread over 3 years		$55
Total Variable Costs					**$17,329**
Total Variable Costs per hectare					**$177**
Surplus/Deficit					**-$13,223**
Surplus/Deficit per hectare					**-$135/ha**
Surplus/Deficit per hectare – seed cost spread over 3 years					**-$25/ha**
Likely break-even time period					**2nd year**

While there was an increase in pasture growth on the clayed treatments, all treatments still had a negative return on the investment in pasture establishment. This would have been a larger negative value if the cost of claying was included in this analysis (Appendix A). It is important to note that to be economic claying is primarily done in cropping paddocks, the benefits can then carry through to pastures during the pasture phase of the rotation. It is not often done to scale in pasture only paddocks due to the negative return on investment in a livestock only operation. The improvement of pastures using serradella appears to be an unprofitable exercise, however, there are many factors that need to be considered when interpreting this gross margin. The 2017 season was not a good season to be seeding pastures as there was a late break that lead to a shorter than usual growing period. Early establishment of pastures, particularly in sown pastures, is important to maximise pasture growth in any season. Serradella also has a high seed cost and is often unlikely to be profitable in the first year of sowing, even with optimum growing conditions. The paddock used in this demonstration will have a long pasture phase (3 years) before being returned to a cropping phase. In a long pasture phase, there will be regeneration of the serradella from the established seed in subsequent years and allow this seed cost to be spread over the three-year period. The implication for farmers looking to implement a phase of serradella into their farming system is that they need to consider a multi-year serradella pasture to be able to recoup the cost of establishing the serradella pasture. There may be further opportunities to address the high cost of serradella establishment, such as farmers growing their own seed for large scale plantings to reduce seed cost. Quantification of the serradella emergence in the years following the establishment year would be interesting to quantify to accurately assess the return on investment.

Improved nutrient availability from claying:

One aim of this study was to assess the increase in nutrients, particularly potash and sulphur that may arise from claying. This site was not clayed immediately before implementing this demonstration, rather, was clayed about 5 years earlier. Any increase in nutrient availability from nutrients held in the clay sub-soil would have either been used up in the period before this demonstration was implemented or been leached to depths lower in the soil profile. We found no evidence that clay spreading results in a greater retention of nutrients near the soil surface.

This study did find a small increase in soil nitrogen in three of the four treatments by the legume that many previous studies have reported. Other potential non-economic benefits that come from the rotation benefits of an annual legume break crop such as a disease and nematode break, and as a strategy for weed management. The nitrate nitrogen increases in three out of the four sites may have been a result of nitrogen fixing of the serradella, although these increases are unlikely to be significant. Any potential nitrogen fixed by serradella during this demonstration was most likely utilised by the barley and may have contributed to the higher biomass production of barley, but could also be held in the soil at depths greater than 10 cm (which was the depth of sampling in this study).

The use of claying to improve serradella establishment and pasture growth was not consistent in this study. Further research to more accurately quantify the long-term potential economic benefits is required on a larger number of sites and differing seasons, as there was no increase in production of serradella on clayed soils when compared to the no clay site. The increase in growth of barley in the clayed versus unclayed sites appears to be a large contributor to the return on investment of claying soils in the long term.

Appendix A. Assumptions used in the calculation of the Gross Margin.

- Exclusion of labour and machinery use costs
- Income from weight gain only, no allocation for wool production
- Cattle Price Assumptions (MLA Market analysis, 15 Oct 17)
    - Muchea | Yearling Heifer | 400+ kg | Pastoral Cattle | 2
- Lamb Price Assumptions (MLA Market analysis, 9 Nov 17)
    - Western Australia | Sheep | 24+ kg | 2 - 4 | 6-20 MLA

- The income from livestock sales only considers the weight gain that was achieved on the paddock during this demonstration.
- The live weight is estimated based on a paddock providing 11MJ ME/kg and 45%NDF during mid spring.
- Cost of Santorini serradella has been calculated at the same price as Margurita serradella, this is most likely an overestimate of the price.
- Exclusion of the cost of claying ($320/ha for 140t/ha) as it was completed many years prior.

Calculation of liveweight gain:

	#	Days on feed	End wt	Start wt	ADI	Wt gain	Total kg LWG	Total Intake	$/kg cwt OTH	Dressing %	Income
1	460;535	13									
2	66	30	479	430	12.1	49	3227	23983	2.06	45%	$ 2,991.24
3	88	36	49	40	1.2	9	774	3738	3.20	45%	$ 1,114.18

7.0 ACKNOWLEDGMENTS

Improving the outcomes of sowing serradella by using clay is being delivered by the West Midlands Group. This project is supported by the Northern Agricultural Catchments Council, through funding from the Australian Government's National Landcare Program.

Thank you to Zac Roberts for the use of his paddock and providing grazing records, and to Steve Davies (DPIRD) for his support in understanding the limitation of non-wetting sand at the site and conducting the soil water repellence testing.

8.0 REFERENCES

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