Claying Permanent Pastures

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Key Messages

- In 2024, early season pasture production was better on clayed treatments in dry seeding conditions. Notably this was not observed in 2022 or 2023 where good early season soil moisture did not induce non-wetting issues.
- The addition of the clay amendment was effective in ameliorating the non-wetting in the soil's non-wetting zone (0-10cm), as evident in the improvement in MED results.
- Incorporation of clay was advantageous, particularly in the first year after application. Where clay was not incorporated – plant establishment was poorer.
- In 2023 and 2024, there was an improvement in plant available water towards the end of the growing season where the heavy clay rates were applied.
- The addition of the clay improved soil retention of phosphorus.
- The incorporation of a high PBI clay reduced free-P (measured as CaCl2-extractable P) which is a key measure of the component of plant available P that can be lost by leaching and/or runoff from low P retention sandy soils.

BACKGROUND

As part of the Healthy Soils and Pasture Systems project, Western Dairy funded an SCF project exploring the use of claying as an amelioration technique to improve pasture production and also to manage nutrient run-off and improve fertility. Clay spreading is a common practice for soil amelioration on light sandy soils in broadacre agriculture along the South Coast of WA to reduce the impacts of non-wetting, however, the practice is considered novel on permanent pastures due to the upfront costs.

The trial examined three differing clay rates, as well as a nil control, to determine the most efficient level of clay to improve pasture production. Additionally, there is an incorporation treatment, where two replications of the plots have been incorporated with a speed tiller, while the clay has been left on the soil surface of the other two replications. The novel nature of claying in the dairy industry and the difference in scale compared to broadacre claying saw the need to adapt and use farmer-held equipment to apply the treatments.

METHODOLOGY/TREATMENTS

The treatment plots were designed in consultation with DPIRD, Western Dairy, DWER and the host farmer to establish the most rigorous trial design that was achievable with the farmer-held equipment. The trial was both replicated and blocked in a fashion to ensure statistical relevance; however, randomisation could not be achieved with the farm scale equipment. A nil control was been implemented across both the incorporated and unincorporated zones in order to effectively show the incorporation (tillage) effect only.

Clay Spreading

The clay for the project was sourced from pits dug into the subsoil on-farm, and prior to spreading the clay was sampled and tested for clay content, P retention capacity (PBI and PRI), pH and nutrients. Soil samples were also

taken from the paddock to ascertain the baseline clay %, soil nutrient status and P retention properties.

The clay was spread using a Marshall Muck spreader with the rate set using measurements of applied clay per m2, per pass, the approximate incorporation depth, and the targeted clay percentage. These rates were determined by running the spreader over a tarp covering the full throw width, measuring the fall area, collecting and weighing the clay falling on this area and calculating the amount of clay per m2.

Pasture composition assessments

Visual pasture composition assessments were taken at the same time as the dry matter cuts, to record the changes in pasture composition over time. Plant establishment counts were taken within 21 days of germination.

Pasture Dry Matter Measurements

Pasture cuts for biomass quantification were collected throughout the season prior to each grazing. Four in-season cuts for dry matter were taken in 2024.

RESULTS AND DISCUSSION

The results presented examine the data gathered from the 2024 field trial in depth, whilst selectively highlighting data gathered throughout the entire length of the trial as it relates to the both the 2024 season and the overall outcomes of the project.

Initial Soil and Clay Analysis

The subsoil from the on-farm pit measured an average of 38% clay with a PBI of 141, PRI of 676 and a pH (CaCl2) of 5.7. Soil samples from the trial site prior to clay application were contained an average clay percentage of the 10cm topsoil horizon was 2.94%.

Soil Results – 2024

The third-year soil tests for Denmark highlighted the same trend observed in the second year. There is a degree of variability to the results, however this is likely due to the variation between the plots due to slope and large size of the trial site. The soil repellence has largely been removed by the addition of clay with the MED dropping below 3 when rates of +1% clay were applied (Table 2).There was a reduction in Free-P showing that the increase in PBI with incorporating the clay had been effective in reducing P at risk of leaching or runoff without reducing the P available for plant uptake. Colwell P effectively remained stable across the site having the same relative patterns that were apparent prior to the trial being established.

Table 2. 2024 Denmark soil analysis

Plot	Water Repellency (MED)	PBI	Free-P (0.01M CaCl2 Extractable P as mg/kg)	Colwell P (mg/kg)
A Nil	3	<1	18.6	21
B 1% clay	1	<1	11.4	17
C 3% clay	2	1.2	14.2	25
D 6% clay	2	14.3	8.5	68

2024 Plant Establishment

Due to the extremely dry start to the 2024 season, a grass dominant mix of barley, oats and rye was seeded to encourage early plant vigour and maximise early growth and productivity in a marginal and shortened season. The dry start to the 2024 season provided the critical conditions to observe the impact of the clay amelioration on plant establishment – where there was clearly greater emergence where greater amounts of clay were spread (Figure 4). Clay incorporation had less of an impact on establishment.

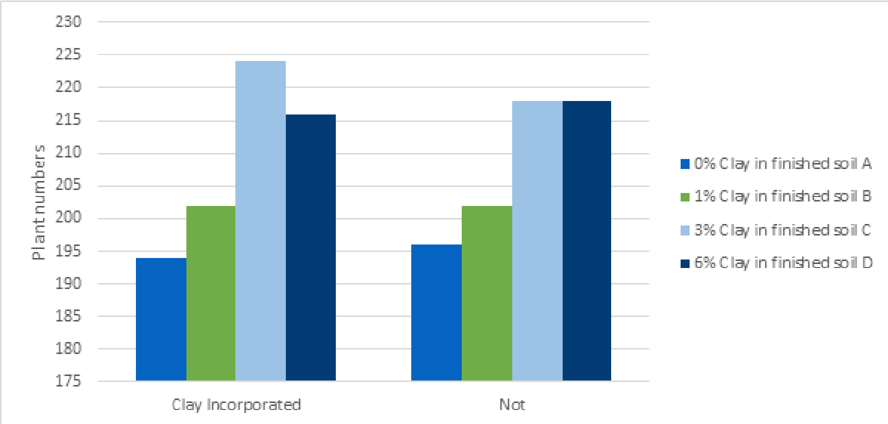

Figure 4. Denmark 2024 plant establishment (plants per m2).

Dry Matter Production

In 2024, the trial site showed an increase in pasture production early in the season as a result of the claying application (Figure 5). The site experienced extremely dry conditions at the start of 2024. As a result, the pasture was seeded into dry conditions which likely increased the impacts of any non-wetting conditions in the soil profile on germination and establishment. The increase in early pasture growth was driven by the increased plant numbers at establishment (Figure 4), which highlights the benefits of claying on establishing pastures in seasons with late or patchy breaks. As the season progressed the pasture production largely evened up, coinciding with the increase in rain through July and August (Figure 5).

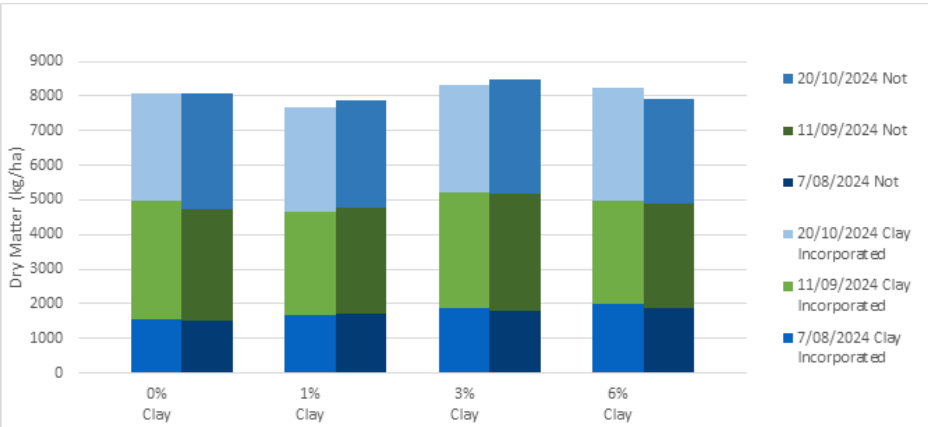

Figure 5. Cumulative Dry Matter Yields (kg/ha) of the incorporated versus the unincorporated plots ahead of each of the three grazing's throughout the 2024 growing season at the Denmark site.

Terminal soil moisture – soil volumetric water

A TDR soil moisture probe was used to measure volumetric soil moisture content to 12cm on the 14th of November 2024. This showed a slight increase in soil volumetric water content as the clay rates increased. The +6% treatment contained 2.5% more plant available water compared to the +1% treatment. Clay can increase the soils water holding capacity, particularly sands where there is a course texture to the soil.

CONCLUSIONS

In the first two seasons of the trial (2022 & 2023) there were few observable effects of the claying treatments on early plant establishment or overall pasture production. This was due to nil non-wetting issues from the ideal (good soil moisture) seeding and establishment conditions experienced in those years. In the 2024 season, however, increases in early production at Denmark were observed where the higher clay rates were applied. The dry start to the 2024 season led to risky sowing conditions with pastures being seeded into marginal soil water, and with marginal rainfall immediately following seeding. Under these conditions the effects of non-wetting on germination and establishment became much greater in the light sandy soils and were where the claying had greatest effects on productivity.

However, claying does not just alleviate non-wetting, it also changes the soils' structure and chemistry and by the end of the three seasons there were clear effects of the claying treatments on soil nutrient retention, availability, and water holding capacity. In 2023 and 2024, late in the season, the effects of increased water holding capacity were observed where the higher rates of clay were applied. In 2024, a greater level of plant available water was observed in the clayed plots at the end of the growing season.

It should be noted that incorporation of the clay was critical to improving pasture production. In the first season, there was a significant reduction in pasture production (dry matter t/ha) where the clay had been left on the surface. The early positive incorporation effect was likely driven by two key factors, firstly the stimulation of biological activity likely increased mineralisation and N availability. Secondly, where the clay was left on the surface, it essentially capped the soil surface and formed a physical barrier for plant and root growth. If claying is to be undertaken it is important that the right tillage implement is chosen to evenly incorporate the clay throughout the soils' non-wetting zone (10-15cm).

The final soil test results showed some exciting positive environmental gains such as increased retention of P. Immediate increases in P retention by incorporation of a high PBI clay reduced free-P (measured as CaCl2-extractable P) which is a key measure of the component of plant available P that can be lost by leaching and/or runoff from low P retention sandy soils. Keeping the free-P low with a small increase in P retention (PBI) should eventually lead to improved plant available P over the long-term, with greater P being retained in the soils for plant production rather than being seasonally leached.

Claying is a permanent soil amelioration technique that has proven to be highly productive in the right system. The large immediate gains in production seen in the broadacre cropping systems where yields can double after the addition of clay are extremely unlikely to occur in pasture systems, particularly if there are other limitations to production (including subsoil compaction and nutrient deficiencies). As a result, the economics that drive the decision making to undertake a claying program should be viewed through a long term and more holistic lens. Given that claying is a permanent amelioration technique, small gains in productivity that can be hard to measure in the field or depend on dry starts or finishes to the season, can still drive an economic return over a prolonged period of time. However, the environmental co-benefits from claying can't be understated. The ability to reduce the runoff and leaching of P in high intensity production systems is hard to put a dollar figure to, however the benefit for the entire ecosystem and the overall soil and water health on-farm may make claying a more appealing proposition to undertake.

Overall, the three-year trial showed that the impact of the claying on pasture dry matter production was marginal, and on-going benefits would only likely be evident in seasons where decile 1-5 rainfall is received, or where there is a false break to the growing season.

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