Project Catalyst Trial Report

Multi-species Fallow – Use of Species That Can Also Be Used for Silage or Grazing

Grower Information	
Grower Name:	Liam Davies
Entity Name:	Rangemore Pastoral
Trial Farm No/Name:	PSM-01190
Mill Area:	Proserpine
Total Farm Area ha:	3000 ha grazing and cane
No. Years Farming:	2nd generation
Trial Subdistrict:	Kelsey Creek
Area under Cane ha:	80ha

Trial Status

Completed

Authors: Che Trendell (Farmacist) and Nick Hill (Farmacist). For further information contact Che on Mb. 0439 588 627 or Nick on Mb. 0428 422 997.

Background Information

Aim: To investigate the soil health and cattle fodder production benefits of incorporating mixed species fallow crops into the farming system.

Background

Currently there is increased interest within the sugarcane industry for utilising multispecies fallow crops with the aim of improving soil health. Some disadvantages identified by growers is the fact that multispecies fallow crops are an increased cost to establish but there is no dollar return as they cannot be harvested like a single legume crop. There is also limited quantifiable data to identify the actual improvements in soil health.

The Davies family are interested in the potential soil health improvements available from a multispecies fallow, as well as the potential to harvest the crop as a cattle feed source. By either baling or grazing the fallow crop, the multispecies fallow has potential to provide an economic return to the farming enterprise.

Three trial treatments were established to determine a) the changes in soil health/properties, and b) the economic return from a multispecies fallow compared to a traditional bare/weedy fallow.

Treatment 1 (standard industry practice) – bare grassy fallow

Treatment 2 (single species fallow to bail) – oats

Treatment 3 (multi species) – mixed species incorporating tillage radish, buckwheat, black mustard, chicory, popany vetch, cover canola, oats, sunflower

Potential Water Quality Benefit:

The practice can lead to improved water quality benefits by increasing soil stability, increasing nitrogen use efficiency (NUE), improving water infiltration and reducing nutrient and sediment run-off due to improved ground coverage.

Expected Outcome of Trial:

Multispecies fallow crops lead to improved soil health, and there is potential for higher gross margins by using the crops for fodder.

Service provider contact: Farmacist Pty Ltd

Where did this idea come from: Liam Davies

Plan - Project Activities		
	Date:	**Activities:**
Stage 1	**June 2020**	Trial established – baseline soil data collected; treatments planted
Stage 2	**July 2020**	Monthly assessments undertaken – nematode samples; OC %; Total N%; Solvita microbial respiration; soil compaction
Stage 5	**August 2020**	Monthly assessments undertaken – nematode samples; OC %; Total N%; Solvita microbial respiration; soil compaction
Stage 6	**September 2020**	Monthly assessments undertaken – nematode samples; OC %; Total N%; Solvita microbial respiration; soil compaction
Stage 7	**October 2020**	Monthly assessments undertaken – nematode samples; OC %; Total N%; Solvita microbial respiration; soil compaction
Stage 8	**November 2020**	Monthly assessments undertaken – nematode samples; OC %; Total N%; Solvita microbial respiration; soil compaction Bail or graze treatments
Stage 9	**December 2020**	Analyse soil health results and changes over time Economic assessment of treatments
Stage 10	**February 2021**	Final Report

Project Trial site details	
Trial Crop:	Oats treatment Multispecies treatment
Variety: **Rat/Plt:**	NA
Trial Block No/Name:	2-1

Block History, Trial Design

Trial layout considerations

This trial design and layout was determined to capture the observed variation in yield and the associated correlation with soil type/constraint (approx. East to West) across the block (Figure 1). This layout reduced the likelihood of these factors influencing the trial outcomes by capturing each zone of variation within each treatment. This allows for direct comparisons to be made between and within treatments. This trial design was developed to ensure:

- Each yield zone is included within each treatment – providing a direct comparison between trial outcomes.
- Ease of treatment application; and
- Reduced cost of irrigation - only required to irrigate Treatments 2 & 3.

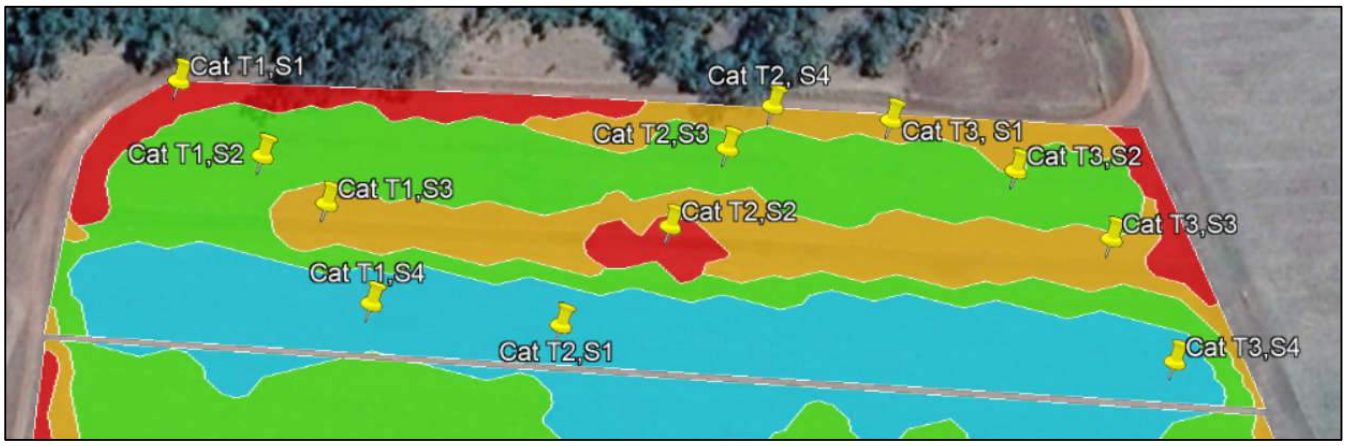

Figure 1. Established monitoring points - 4 samples within each treatment to represent each productivity zone.

Nth

T1	T2	T3

Figure 2. Trial design to capture variation in historical yield outcomes for each treatment.

The three treatments of the trial were:

T1 (standard industry practice) – Bare grassy fallow

T2 (single species fallow to bale) – Oats

T3 (multi species) – Mixed species incorporating tillage radish, buckwheat, black mustard, chicory, popany vetch, cover canola, oats, sunflower (Figure 3)

Figure 3. Multi-species fallow. Brassica spp. in flower.

Results

Microbial respiration (CO_2)

Averaged results for sampling date and yield zone combined (Figure 4) identified that T1 achieved significantly less CO_2 respiration than T3 or T3 which were not significantly different (P>0.05). However, as seen in Figure 3, the Oats (T2) did achieve greater CO_2 respiration. Analysis of averaged CO_2 results for treatments by yield zone (Figure 5), showed that amongst all treatments the 'Very Poor' yield zone achieved significantly higher CO_2 respiration (P<0.05). Within the Oats (T2) and Multi spp. (T3) treatments CO_2 respiration by zone was consistent and was viewed in the following order: Very poor> Good> Very Good>Poor. Within the Bare weedy fallow CO_2 respiration by zone was viewed in the following order: Very Poor>Poor>Good>Very Good. Analysis of CO_2 respiration by date showed that across different zones the final sampling event on the 15th of September had significantly more CO_2 (P<0.05) than the 21st of July sampling event. The 22nd of June and 10th of August sampling events were not significantly different (Figure 6).

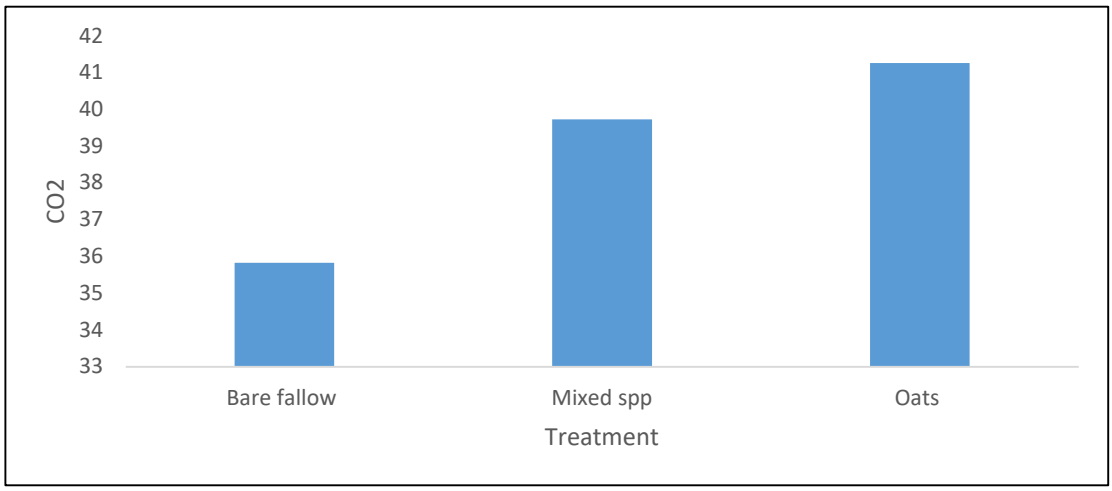

Figure 4. Proserpine fallow comparison trial. Microbial CO_2 respiration by Treatment.

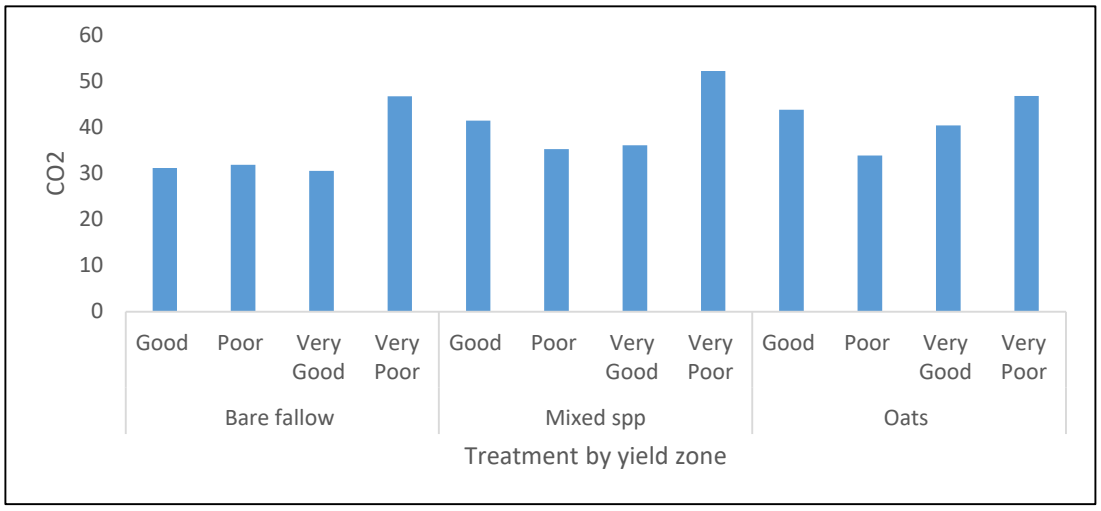

Figure 5. Proserpine fallow comparison trial. Solvita CO_2 respiration by treatment and yield zone.

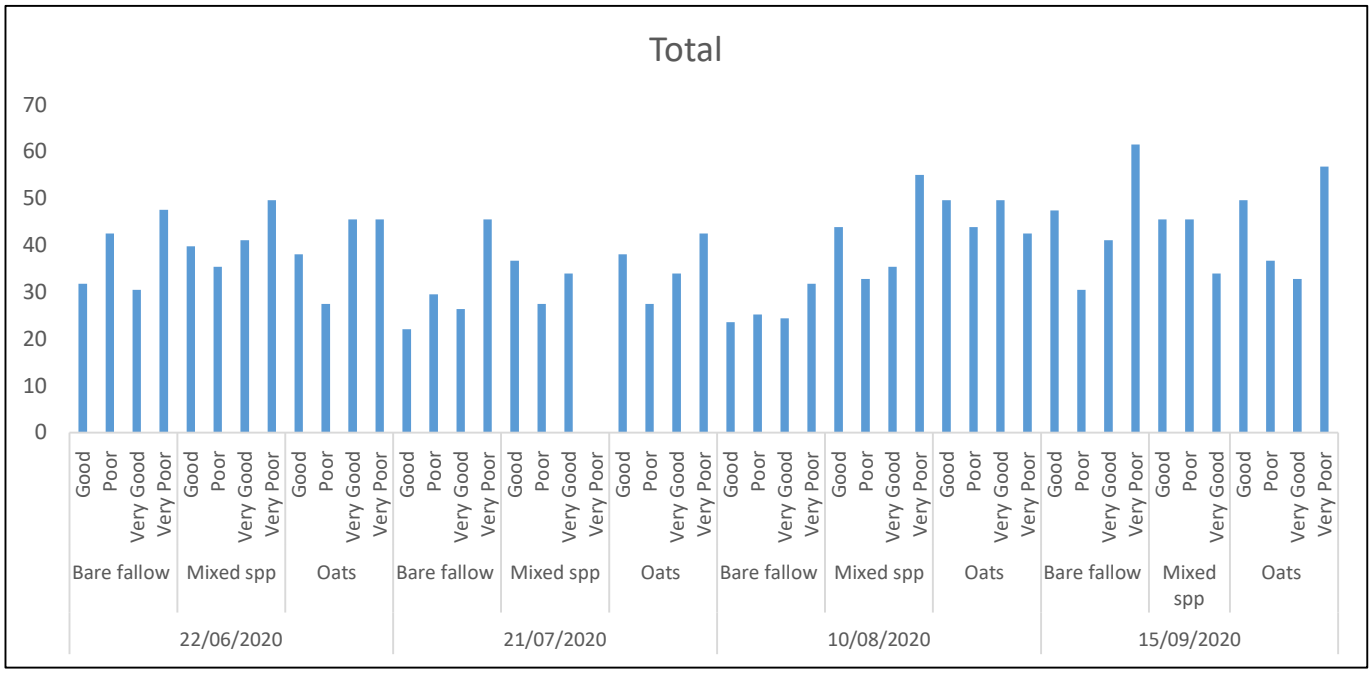

Figure 6. Proserpine fallow comparison trial. Solvita CO_2 respiration by Treatment, yield zone and sample date.

Total Nitrogen% (TN%)

As observed in Table 1., there is limited variation in TN% between treatments, yield zone sites or sampling dates. T2 (Oats) recorded significantly higher TN% than T1 (Bare weedy fallow) ($P<0.05$) and T3 was not significantly different to either (Figure 7). TN% by treatment, yield zone and sampling date (Figure 8) shows that for T2 (Oats), TN% declined overtime within each yield zone. Within T1 (Bare weedy fallow), variation in TN% can be seen between sampling dates and zones. For T3 (Mixed spp.), a general decline in TN% can be seen in the Very Poor/Poor zones, the Very Good zone initially declined then increased and the Good zone declined and then remained stable. Among fallow treatments TN% was greater in the Very Poor zone and least in the Very Good zone.

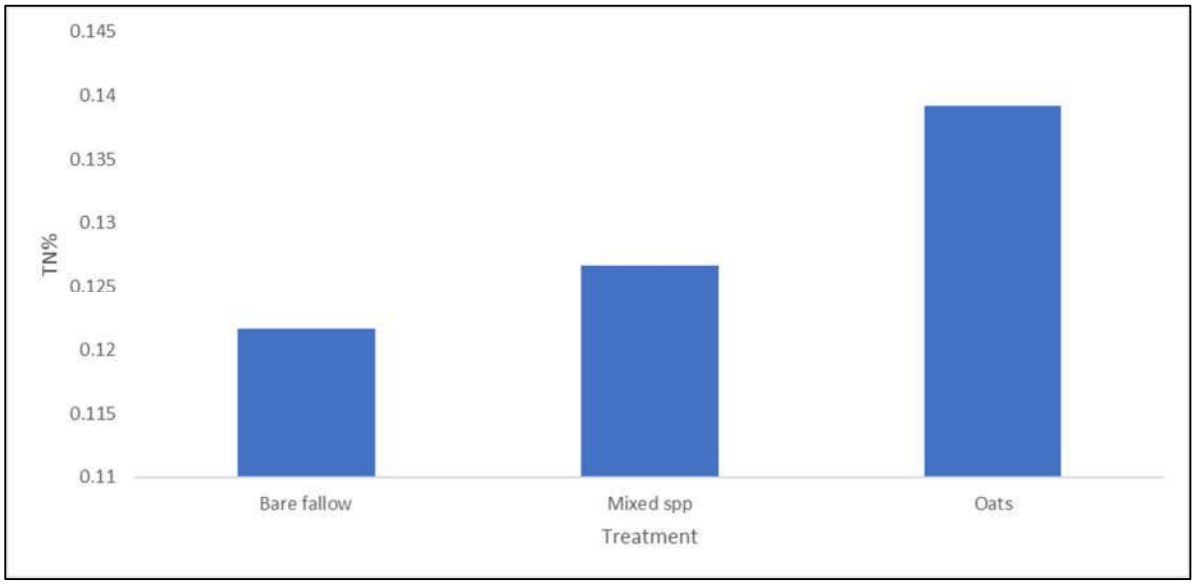

Figure 7. Proserpine Catalyst fallow comparison trial. Total Nitrogen% by Treatment.

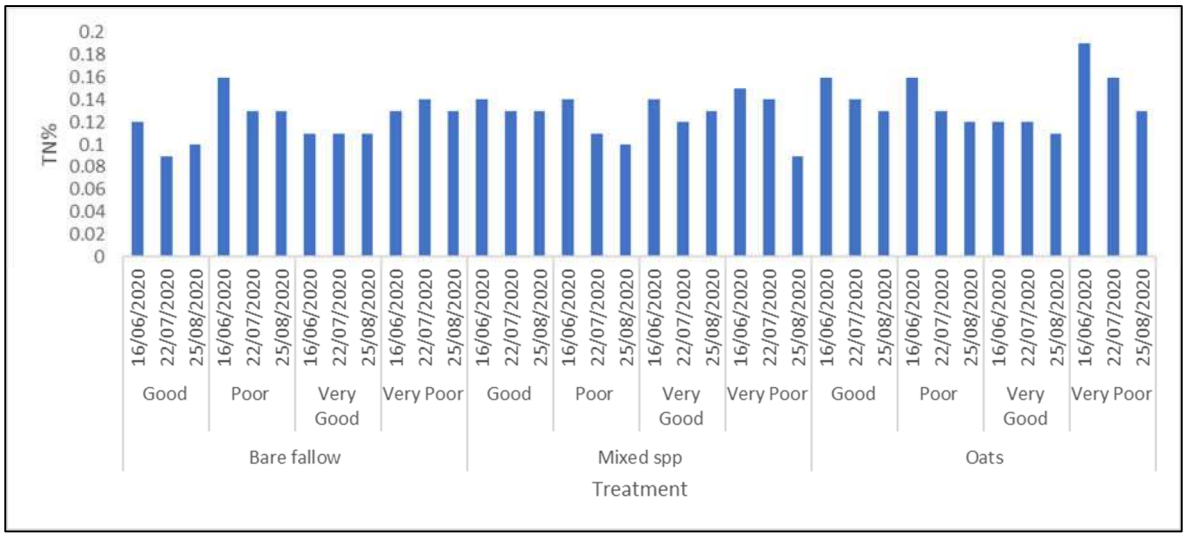

Figure 8. Proserpine fallow comparison trial. Total Nitrogen% by Treatment and sample date.

Table 1. Total Nitrogen% and Organic Carbon% by treatment, sample date and yield zone.

Fallow	Sampling Date	Zone	Total Nitrogen (Kjeldahl) %	Organic Carbon (W&B) %
Bare fallow	16/06/2020	Good	0.12	1.57
		Poor	0.16	1.8
		Very Good	0.11	1.38
		Very Poor	0.13	1.48
	22/07/2020	Good	0.09	1.32
		Poor	0.13	1.77
		Very Good	0.11	1.29
		Very Poor	0.14	1.51
	25/08/2020	Good	0.1	1.53
		Poor	0.13	1.64
		Very Good	0.11	1.34
		Very Poor	0.13	1.63
Mixed spp	16/06/2020	Good	0.14	2.07
		Poor	0.14	1.8
		Very Good	0.14	1.78
		Very Poor	0.15	2.4
	22/07/2020	Good	0.13	2.12
		Poor	0.11	1.62
		Very Good	0.12	1.74
		Very Poor	0.14	2.24
	25/08/2020	Good	0.13	2.3
		Poor	0.1	1.66
		Very Good	0.13	1.52
		Very Poor	0.09	1.38
Oats	16/06/2020	Good	0.16	1.99
		Poor	0.16	1.88
		Very Good	0.12	1.3
		Very Poor	0.19	2.16
	22/07/2020	Good	0.14	1.71
		Poor	0.13	1.62
		Very Good	0.12	1.34
		Very Poor	0.16	2.14
		Good	0.13	2

	25/08/2020	Poor	0.12	1.62
		Very Good	0.11	1.68
		Very Poor	0.13	1.88

Organic Carbon% (OC%)

Analysis for individual treatments shows that when all sampling dates and yield zones were combined, T3 (Multi spp.) and T2 (Oats) treatments recorded significantly higher OC% than T1 (Bare weedy fallow), though not significantly different from each other (P<0.05). T3 (Mixed spp.) achieved greater OC% than the other treatments (Figure 9). Viewing Yield zone by sample date for the individual Treatments (Figure 10) shows that within T2 (Oats), OC% showed a general decline in the Very Poor and Poor yield zones, a general increase in the Very Good zone, and a decline followed by an increase in the Good zone. Within T3 (Mixed spp.), OC% declined over time within the Very Poor and Very Good zones, increased within the Good zone and, a decline followed by a minimal increase within the Poor zone. For T1 (Bare weedy fallow), OC% increased over sampling events within the Very Poor zone, declined within the Poor zone, and decreased and then increased within the Good and Very Good zones.

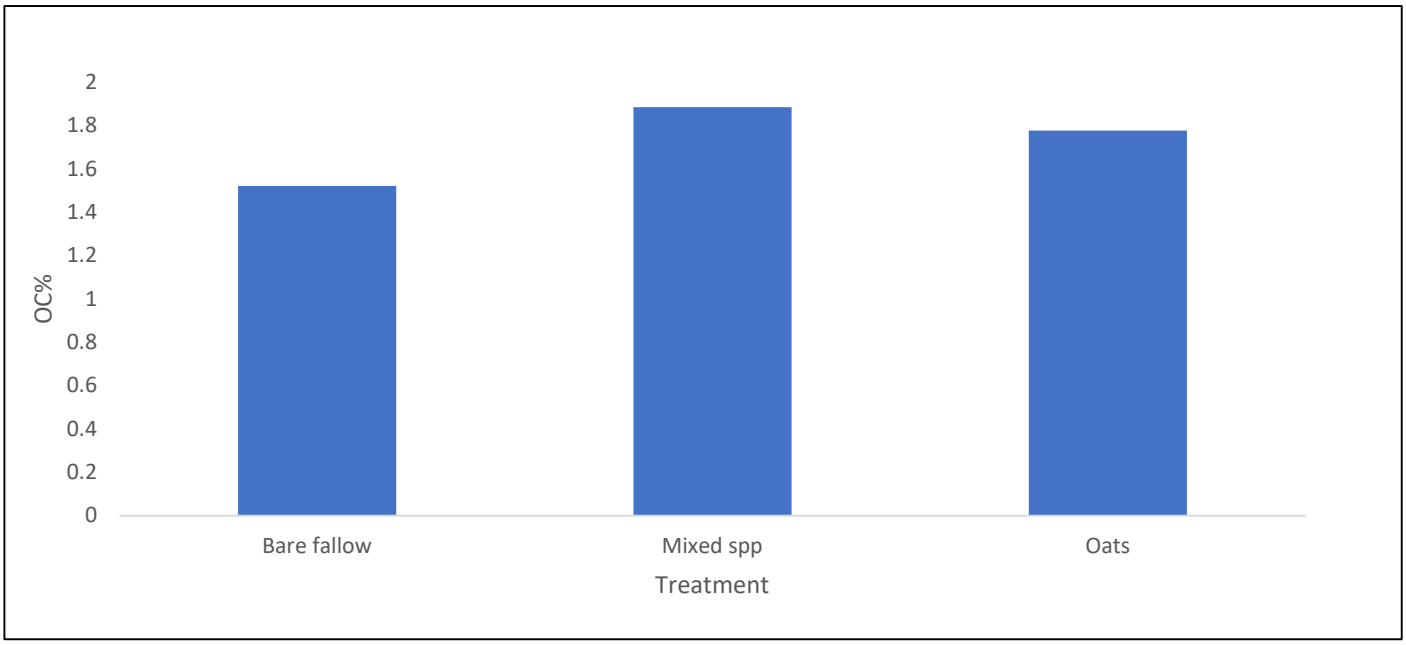

Figure 9. Proserpine Catalyst fallow comparison trial. Organic Carbon% by Treatment.

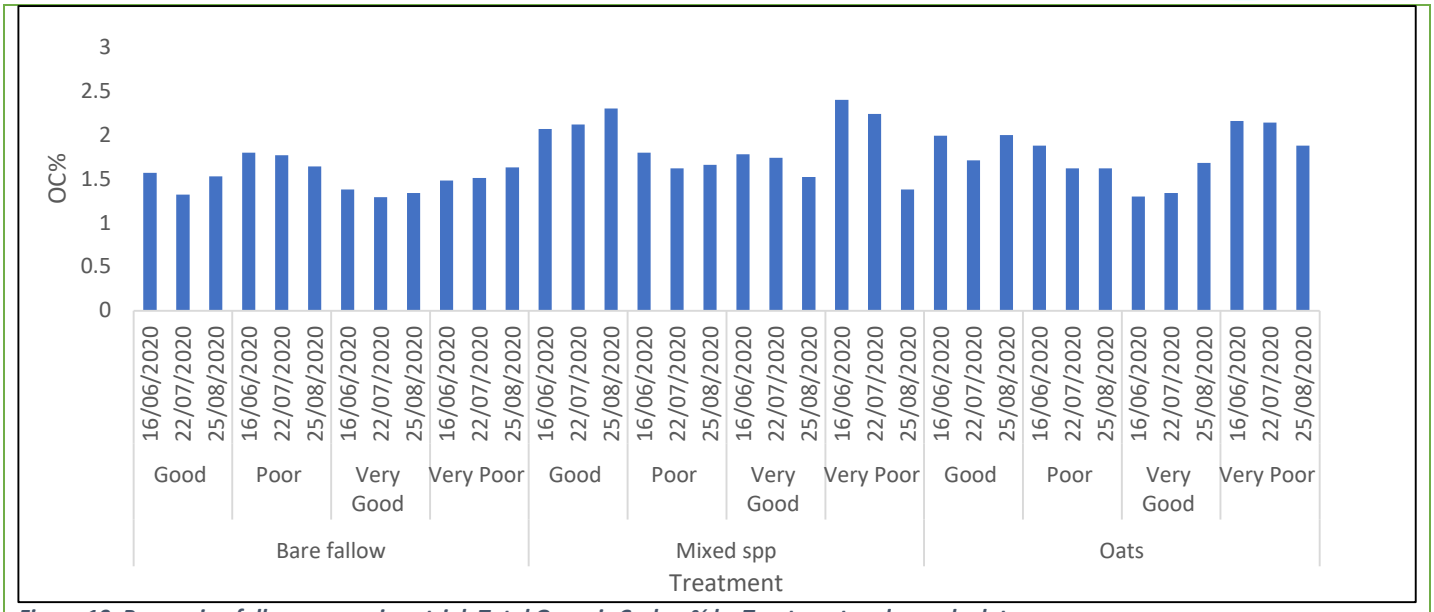

Figure 10. Proserpine fallow comparison trial. Total Organic Carbon% by Treatment and sample date.

Correlation analysis: TN% and OC%; Microbial respiration (CO_2) and TN% and OC%.

Figure 11 provides the outcome of a Pearson's correlation analysis on the relationship between TN% and OC%. It identified a highly significant correlation between factors (P<0.05, R=0.66) for all treatments and yield zones combined, with OC% identified as a strong predictor of TN% (t=5.16). Correlation analysis upon the impact of TN% (Figure 12) and OC% (Figure 13.) upon CO_2 microbial respiration (Figure 10.) identified a significant impact (P<0.05), however, there was only moderate correlation (TN%: R=0.39; OC%: R=0.46) and predictive capacity (TN%: t=2.443; OC%: t=3.04).

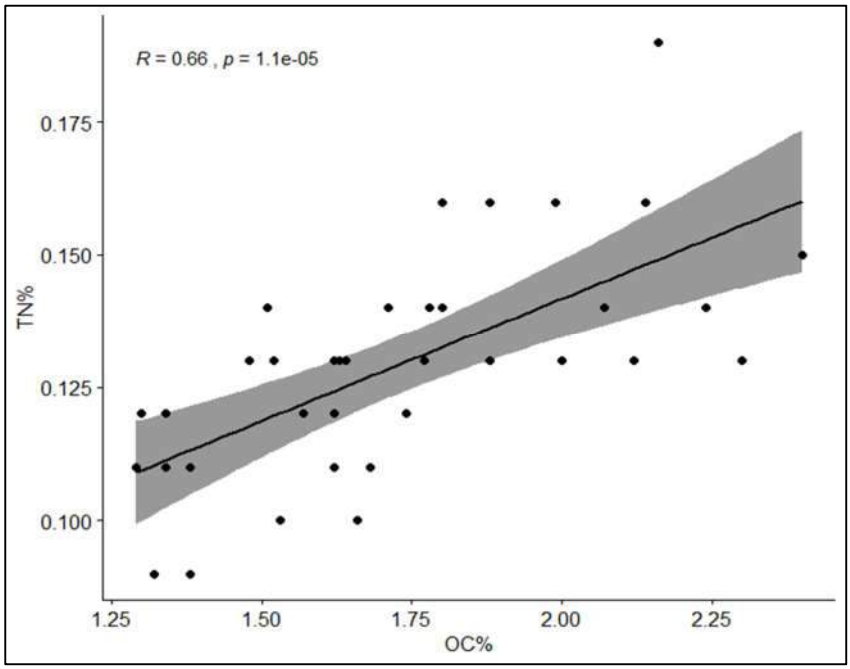

Figure 11. Proserpine fallow comparison trial. Correlation between Total Nitrogen % and Organic Carbon%.

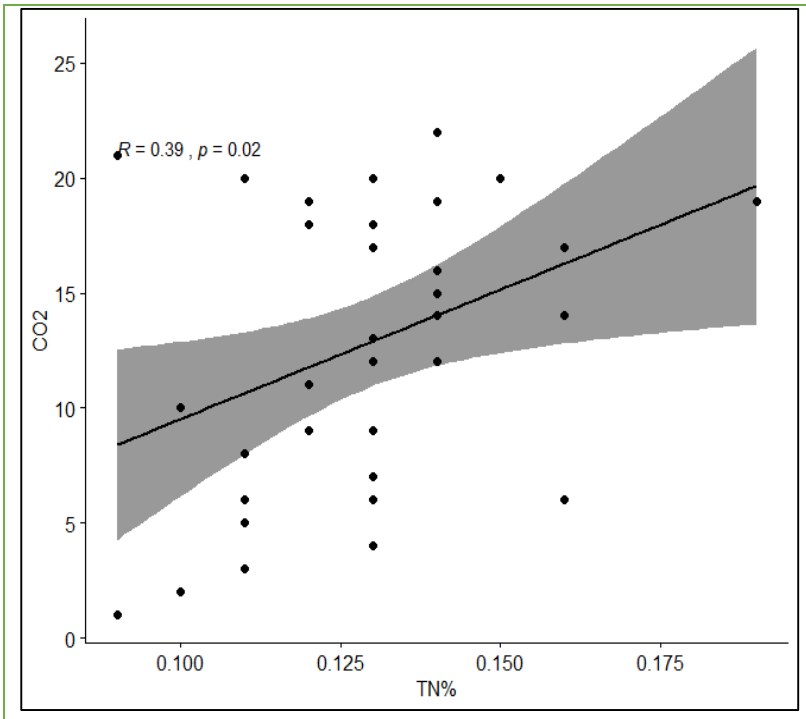

Figure 12. Proserpine fallow comparison trial. Correlation between Total Nitrogen % and microbial respiration (CO_2).

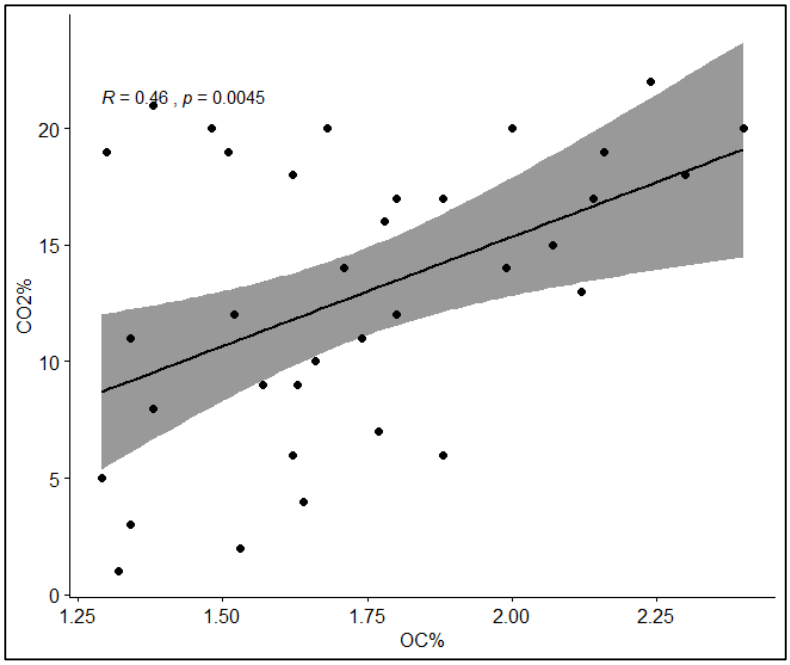

Figure 13. Proserpine fallow comparison trial. Correlation between Organic Carbon % and microbial respiration (CO_2).

Nematodes

Total average of Nematodes by treatment, all sample dates and Yield zones combined, identifies no significant difference between Treatments (P>0.05). Viewing the data (Figure 14) identifies that T1 (Bare weedy fallow) recorded the highest average number of nematodes. There was minimal difference between T3 (Mixed spp.) and T2 (Oats).

Treatments by yield zone and date (Figure 15) shows T2 (Oats) nematode numbers increased within the Good and Very Good zones and increased, then decreased, for the Poor and Very Poor zones. Within T2 (Mixed spp. fallow), nematode numbers decreased, then increased, within the Good and Poor zones; increased, then decreased, within the Very Good zone; and increased within the Very Poor zone. Outcomes for T1 (Bare weedy fallow) yield zones show a general increase in nematode numbers from the first to the second sampling event, followed by a general decline in the final event. Determination of factors influencing nematode populations identified no significant effect of TN%, OC% or Yield zone upon Nematode numbers (P>0.05).

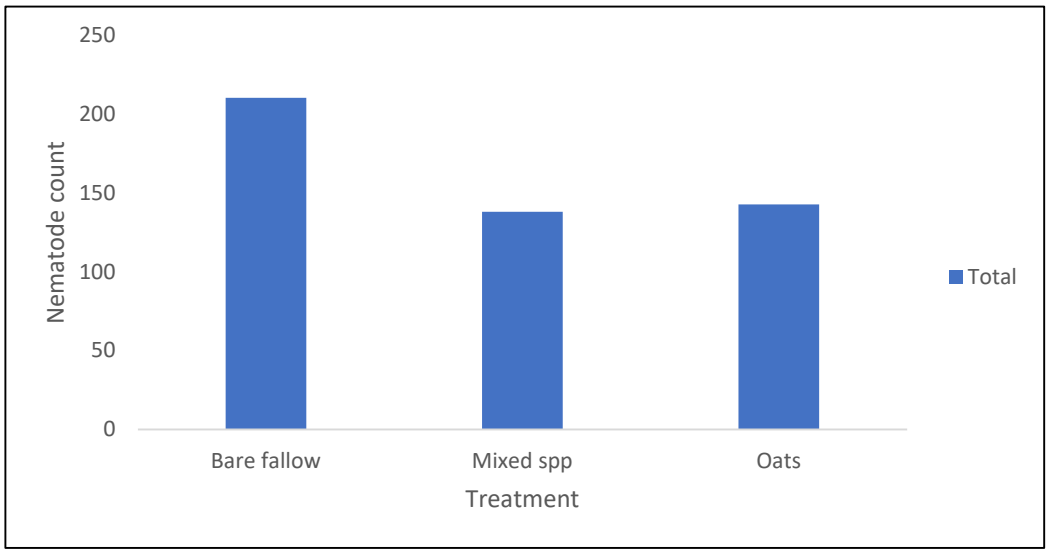

Figure 14. Proserpine fallow comparison trial. Nematode count by Treatment, all sample dates and yield zones combined.

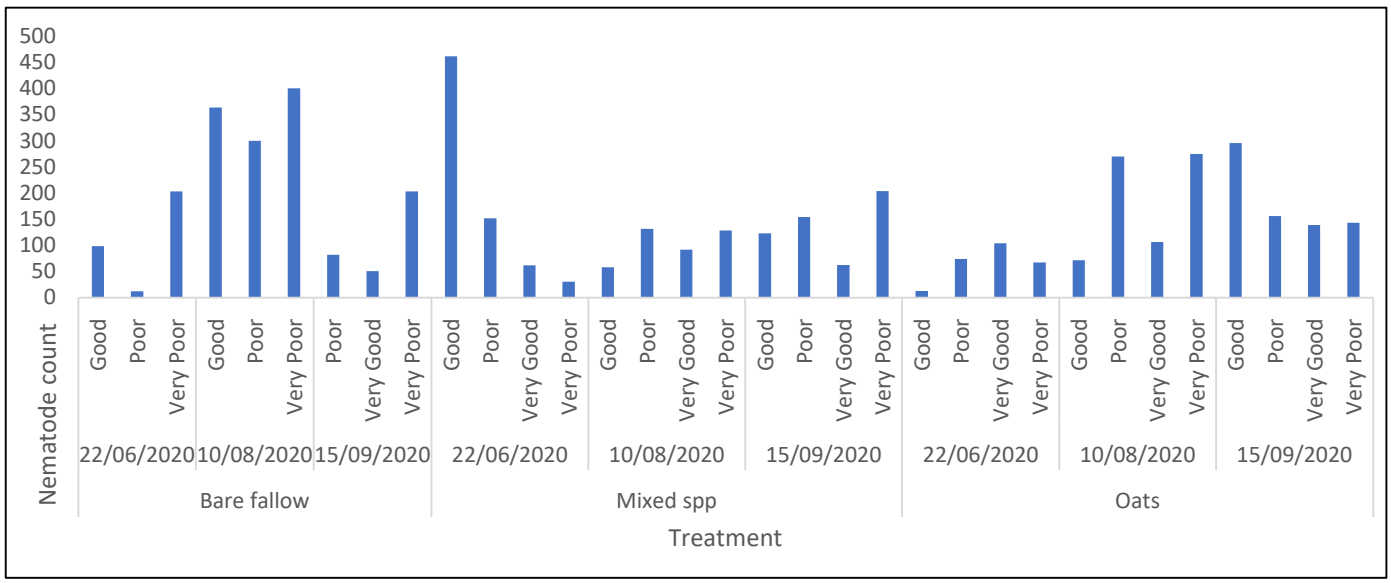

Figure 15. Proserpine fallow comparison trial. Nematode count by treatment, sample dates and yield zone.

Trial site rainfall and irrigation outcomes.

As identified in Figure 16, trial site rainfall followed the expected pattern for the wet season with rainfall events until March 2020. For the following months, rainfall continued until, and following, trial site establishment. Post early August rainfall ceased and irrigation was applied to T2 (Oats) to ensure harvest outcomes (Table 2).

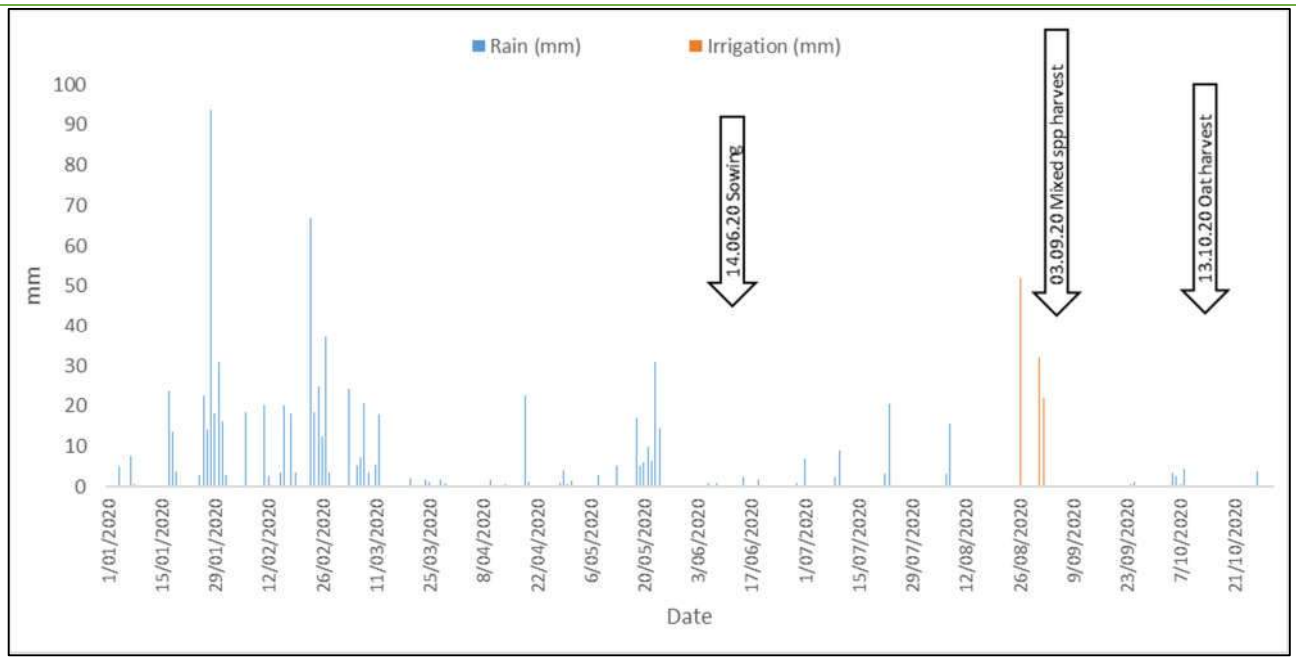

Figure 16. Proserpine comparison trial. Rainfall. (Source: https://www.longpaddock.qld.gov.au/silo/)

Table 2. Proserpine fallow comparison trial. Oat irrigation power and water usage.

Date	kWh *	Irrigation applied (ML)**
26-Aug	151.2	0.5235
31-Aug	84.8	0.3219
1-Sep	63.9	0.219
Total used	299.9	1.0644
Price per unit	$1.24	$12.14
Cost per input	**$371.88**	**$12.92**
Total cost	**$384.80**	

Note:
*** kWh cost is based upon Tariff 11 and includes supply charge per day.**
Source: https://www.ergon.com.au/retail/residential/tariffs-and-prices/general-supply-tariffs
**** Irrigation cost is based upon Kelsey creek water board Fixed allocation charge Part A.**
Source: https://www.sunwater.com.au/wp-content/uploads/Home/Customer/Fees-Charges/Proserpine_River_Fees_and_Charges_2019-2020.pdf

Biomass outcomes

Comparison of dry biomass (kg/ha), taken at physical maturity, shows that T2 (Oats) achieved greater biomass than T3 (Mixed spp.) (Figure 17). Within T3 yield zones, the Very Good zone achieved highest dry biomass with the Very Poor achieving the least. The Poor zone recorded greater dry biomass than the Good zone. It should be noted that T3 (Mixed spp.) Very Poor zone was impacted upon by grazing, and spatial variation in crop density was observed in both the fallows. Within T2, highest dry biomass was recorded in the Good zone, the lowest in the Poor zone, and the Very Poor zone recorded higher dry biomass than the Very Good zone.

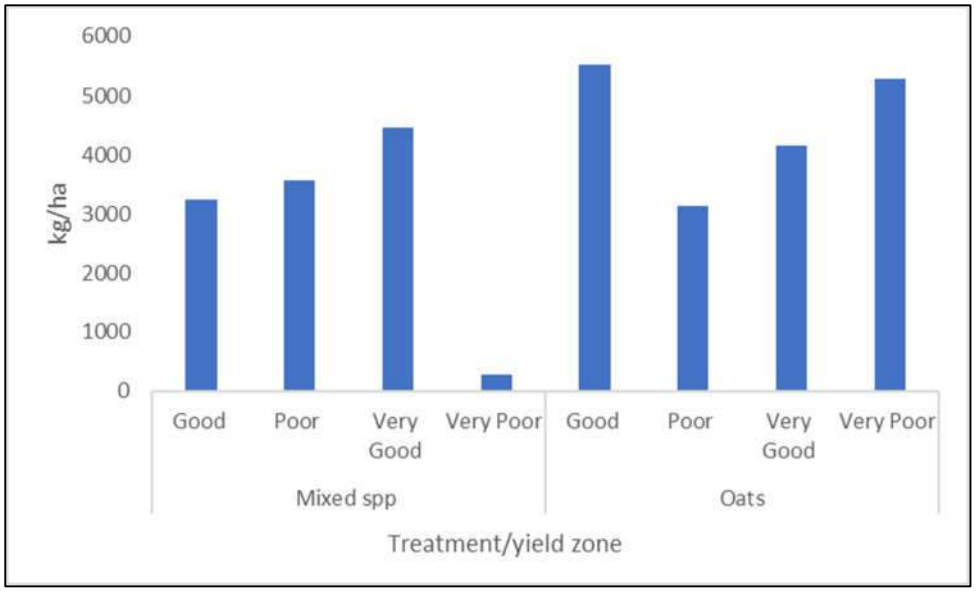

Figure 17. Proserpine Catalyst fallow comparison trial. Mixed spp. and Oats biomass (kg/ha) by yield zone.

Production outcomes

Production outcomes identify comparable costs for the sowing and harvesting of both T2 (Oats) and T3 (Mixed spp.). Harvest outcomes identify that T2 achieving more bales of silage than T3. As a general cost analysis (December 2020), different forms of plastic baled silage (i.e., wheat, mixed pasture, sorghum etc) were sold for a comparable income of $80 (source: Farmtender.com.au), consequently this figure is used for the analysis outlined in Table 3. Using the costings provided by the grower to establish, maintain, harvest, and bale the different fallows identifies that T2 returned a total net profit of $964.65 and T3, $535.15. (Table 3.).

Table 3. Proserpine Catalyst Trial site. Establishment and harvest costings/profit.

Factor	Oats	Oats	Multi spp.	Multi spp.
Area	1.11ha		Area: 1.05ha	
Sowing rate	60kg/ha Seed: $1.45kg	$96.57	18.75kg/ha Seed: $5.05kg	$99.42
Fertiliser (DAP) $830t	120kg/ha	$110.56	120kg/ha	$110.56
Planting time: $70ph	2hrs	$140	2hrs	$140
Planting fuel @$1.10p/ltr	14ltrs	$15.40	14ltrs	$15.40
Rolling time: $70ph	1/2hr	$35	1/2hr	$35
Rolling fuel @ $1.10ph	3.5ltr	$3.85	3.5ltr	$3.85
Harvest fuel (L) @$1.10p/ltr	37.5	$41.25	37.5	$41.25

Harvest time @ $70ph				
Inoculant cost/bale	$3.33	$86.58	$3.33	$46.62
Plastic wrap cost/bale	$9.09	$236.34	$9.09	$127.26
Silage, no of bales achieved @ $80.00 per bale.	26	$2,080	14	$1,120
Irrigation cost	$384.80		NA	
Total cost	$ 1,115.35		$584.36	
Total est. returns	$2,080		$1,120	
Total Net profit	**$964.65**		**$535.64**	

Conclusions and comments

This is an early stage trial, supplementary to the main innovation program and will be completed subject to the programs future funding.

For the 2020 winter fallow period, overall trial outcomes identified clear benefits of a winter fallow crop compared to a bare weedy fallow. Trial outcomes further identified that the Oat crop fallow provided greater soil health and financial benefit when compared to a Multi spp. fallow, however, in-crop rainfall can be considered to have been an influential factor in this outcome.

Figure 18. Farmacist team member inspecting a tillage radish within the Multi species treatment.

Soil biology is considered an indicator of soil health across current industry projects and as seen in Figure 4, both the Oat crop and Mixed spp. fallows achieved greater microbial CO_2 respiration. This demonstrates greater biological activity and, by default, improved soil health when compared to the bare fallow. The Oats and Mixed spp. fallow also recorded greater TN% and OC% than the Bare weedy fallow (Figures 7 and 9), and as demonstrated by analysis (Figures 12 and 13) there was a significant relationship between TN%, OC% and Microbial respiration ($P<0.05$). Consequently, the higher levels of microbial respiration within the Oats and Mixed spp. fallows correlate to the higher rates of TN% and OC% observed within these fallows when compared to the Bare weedy fallow (Figures 7 and 9).

A further beneficial outcome was the impact of the Oats and Mixed spp. fallow upon nematode population(s). Parasitic nematodes negatively impact upon cropping systems. Analysis upon all sampling dates and yield zones combined shows that there was no significant difference between treatments for average numbers of nematodes ($P>0.05$). However, when viewing overall trial outcomes (Figure 14) the Bare weedy fallow had a higher average nematode count than either the Mixed spp. or the Oats fallow, indicating that maintaining a Bare weedy fallow had less of an effect in suppressing nematode populations.

Viewing the impact of Yield zone upon: Microbial respiration, TN% and OC% (Figures: 5, 8 and 10) provides an unexpected outcome with the Very Poor zone consistently achieving higher Microbial respiration, TN% and OC% within each of the fallows. The position of the Very Poor zone in the landscape may have had an impact on trial outcomes as it was located at the base of the slope, consequently water likely transported organic matter from the higher to lower parts of the site, resulting in elevated levels of OC%. The accumulation of OC% would have provided a food source for the microbes which, combined with ideal soil moisture, could have resulted in an increased microbial population and an increased mineralisation of OC resulting in increased N release. TN% was assessed via Kjeldahl analysis which identifies total levels of N via Ammonium, Proteins, urea, and DNA, and as such the microbes themselves would have also formed a component of this outcome. Consequently, as TN% and OC% were significantly related (Figure 11), and there was a significant relationship between these factors and Microbial respiration (Figures 12 and 13), it can be assumed that TN% and OC% provided a significant impact upon what defined the individual yield zones.

Combined biomass for all sampling events and yield zones combined (Figure 17) is relatively consistent with Microbial respiration and TN% results, with the Oats demonstrating greater outcomes than the Mixed spp. fallow. however, it must be noted that the Mixed spp. fallow was somewhat impacted by grazing. As an observation, the Oat fallow biomass for the individual yield zones approximately follows the response for Microbiological respiration and TN%, demonstrating a combined impact of these factors upon biomass outcomes. Production outcomes are the same as the combined biomass outcomes, demonstrating that the Oats fallow returned a greater yield and net profit than the Mixed spp. fallow (Table 3).

Overall, results show the benefit of a winter Oat and Mixed spp. fallow, compared to maintaining a Bare weedy fallow, due to the viewed increase in microbiological respiration, OC%, TN%, and decrease total average nematode numbers. Cropping a winter fallow provides further benefits via maintaining soil cover and reducing potential impact upon water quality; i.e. reducing erosion and associated sedimentation and nutrification of waterways due to rainfall event(s). Cropping a winter fallow also provides an opportunity to diversify on-farm income with Oats, in this instance, observed to have achieved beneficial financial outcomes. As a caveat, it must be stated that for most of the duration of the trial, in-crop rainfall was received, therefore negating need for supplementary irrigation. As seen in Tables 2 and 3, the cost of electricity and water for irrigation, required to bring the Oats to harvest, reduced net profit. Consequently, crop selection and the potential for in-crop rainfall during the winter/Northern Queensland dry season should be carefully considered.

Figure 19. The final product. Baled multispecies pasture.

Advantages of this Practice Change:
In this individual trial, establishing either a Mixed spp. or Oat fallow over the winter fallow period increased soil microbial activity, OC%, TN% and reduced Nematode populations compared to a Bare weedy fallow. These indicators of soil health also have potential to provide benefits for successive crops. Establishing an oat fallow was observed to provide increased outcomes compared to the Mixed spp. fallow, with a further benefit of a greater net profit. Winter fallow cropping also maintains ground cover which can be assumed to benefit water quality outcomes via reducing the impact of rainfall events upon soil erosion, which can lead to sedimentation and nutrification of waterways.

Disadvantages of this Practice Change:
Establishment of a winter crop comes at a cost (Table 3.). Due to the potential for reduced rainfall during the winter months / Northern Queensland dry season, supplementary irrigation may be required to achieve yield outcomes which could reduce the profitability benefits of this practice change.

Will you be using this practice in the future: The practice needs to be considered based upon forecasted seasonal conditions (i.e., predicted rainfall).

% of farm you would be confident to use this practice: Will be dependent upon seasonal forecasts. An informed decision based upon seasonal predictions and current purchase fodder costs.