Project Catalyst Trial Report

Mixed Species Fallow into Sugarcane

Grower Information	
Grower Name:	Denis Pozzebon
Entity Name:	The Trustee for POZZEBON FARMING TRUST
Trial Farm No/Name:	BKN-09462A
Mill Area:	Pioneer/Kalamia
Total Farm Area ha:	117.97
No. Years Farming: (Grower Experience)	
Trial Subdistrict:	Mt. Kelly
Area under Cane ha:	117.97

Trial Status

~~CONTINUING~~/COMPLETE (1st Year)

Background Information

Aim:

To utilise planted mixed species in a fallow block to improve and increase natural soil health. This will be done by improving beneficial biology and bacteria, water retention and drainage, as well as reduce sediment loss from runoff and inorganic Nitrogen inputs for the subsequent sugarcane crop.

Background: (Rationale for why this might work)

It is widely accepted that breaking the monoculture of sugarcane with a fallow crop has many advantages, this has now become common practice in the Burdekin region with legumes such as mungbeans and soybeans. The ability of these cover crops to fix nitrogen means reduced inputs and potentially higher yields for subsequent sugarcane crops, but these fallow crops are still a monoculture and therefore still have many of the issues associated with monocultures (i.e. pests and disease build up and resilience, organic matter levels, water usage and soil compaction). It is proposed that some of these issues can be alleviated by planting a mixed species fallow crop, with benefits associated with reducing tillage and soil compaction, increasing soil OM, greatly improving soil biology (e.g. increasing beneficial nematode numbers) and increasing the available nutrients.

There has been documented success of mixed species fallow crops in the Wet Tropics (Mossman and Tully regions) but a trial of this nature has never been conducted in the Dry Tropics (Burdekin region).

Potential Water Quality Benefit:

- An increase in overall organic matter in soil
- Improvement in soil biology (more specifically a reduction in parasitic nematodes)
- Increased soil aeration and access to deeper subsoil nutrients and moisture
- Reduce soil compaction (reducing tillage),
- Improved drainage and soil structure
- Increase the availability of plant available nitrogen.
- Reduce sediment loss and erosion.

By reducing the amount on N applied to the subsequent sugarcane crop, we are reducing the amount of potential Nitrogen runoff, and by providing structure and cover for the fallow block, there will be a reduction in sediment loss to adjacent water courses. In addition, improving drainage and water retention within the soil will improve irrigation efficacy, limit overall losses of chemical and nutrient to run off and deep drainage.

Expected Outcome of Trial:

The required Nitrogen rate for the subsequent cane crop will be reduced, there will be an increase in beneficial nematodes, organic matter level will increase and yield will be higher for the subsequent cane crop.

Service provider contact: Mika Rowston (Mobile: 0429 165 046 Email: mikar@farmacist.com.au)

Where did this idea come from: Denis Pozzebon approached Farmacist

Plan - Project Activities	Date : (mth/year to be undertaken)	Activities :(breakdown of each activity for each stage)
Stage 1	Sept 19-Nov 19	Harvest of paddock and appropriate working of fallow block to prepare for planting of mixed species fallow. Collect Baseline app data + P2R Data, create Nutrient Management Plan.
Stage 2	Oct 19-Jan 20	Take baseline measurements including; Nematode counts, Soil biology measurements, soil compaction measures, soil tests, soil profile assessment.
Stage 3	Dec 19	Buy & Plant Mixed species fallow.
Stage 4	Jan 20-Mar 20	Monitor mixed species progression. e.g. Plant counts, biological assays, nematode counts, Soil compaction.
Stage 5	Mar 20	Finish mixed species either by green manuring, baling or removing biomass from paddock if necessary.
Stage 6	Mar 20-Apr 20	Work paddock and plant cane.
Stage 7	Mar 20-Aug 21	Monitor plant cane crop.

Project Trial site details	
Trial Crop:	Soybean, Mungbean, Cowpea, Sorghum, Tillage Radish, Shirohie Millet, Sunflower
Variety: **Rat/Plt:**	Fallow to Plant
Trial Block No/Name:	13-2
Trial Block Size Ha:	9
Trial Block Position (GPS):	-19.670335°, 147.334097°
Soil Type:	4Ucc Deep coarse sand and sandy loam with bleached A2 horizon AND 4Gnb Red and brown podozolic soil with loamy sand to light sandy clay loam A horizon and colour A2 horizon

Block History, Trial Design:

Planting of the trial involved utilising the grower's existing John Deere MaxEmerge 1700 planter, we planted 3 mixes of seeds, and also a soybean only treatment for comparison to standard fallow practice. We have a control treatment that will be kept bare throughout the trial.

Planting ratios for seeds were calculated using standard seeding rates and adjusted accordingly, we halved the standard seeding rates for the mixed treatments as there will be three times as many plants growing. Planting density and depth was adjusted on the planter to suit the mix that was being planted.

The mix species were planted in dual rows along the drill, the furrow/inter-row was not planted as the grower operates a zonal tillage system and maintains a permanent drill and inter-row. Each treatment was randomised and was replicated three times (15 plots and 3 replicates).

Not inc. in trial area	T1R1	T2R1	T3R1	T4R1	T5R1	T1R2	T4R2	T2R2	T5R2	T3R2	T1R3	T5R3	T2R3	T3R3	T4R3	Not inc. in trial area
GUARD	REPLICATION 1					REPLICATION 2					REPLICATION 3					GUARD
12 Rows Guard	CONTROL Bare (weed free)	Soybeans Only	Mix 1	Mix 2	Mix 3	CONTROL Bare (weed free)	Mix 2	Soybean Only	Mix 3	Mix 1	CONTROL Bare (weed free)	Mix 3	Soybeans Only	Mix 1	Mix 2	43 Rows Guard
	6 Rows	6 Rows	6 Rows	6 Rows	6 Rows	6 Rows	6 Rows	6 Rows	6 Rows	6 Rows	6 Rows	6 Rows	6 Rows	6 Rows	6 Rows	

SEED MIX 1 (Biomass)	SEED MIX 2 (Nitrogen)	SEED MIX 3 (Soil Health)
Ebony Cowpea (Large Seed 5-12K/kg)	Ebony Cowpea (Large Seed 5-12K/kg)	Tillage Radish (Small Seed 70-88K/kg)
Leichhardt (Soy) (Large Seed 6K/kg)	Leichhardt (Soy) (Large Seed 6K/kg)	A6785 (Soy) or Stuart (Large Seed 6K/kg)
Jumbo Sorghum (Small Seed)	Jade Mung Bean (Medium Seed)	Sunflower (16k/kg)
		Millet (Very Small Seed 187K/kg)

Treatments:

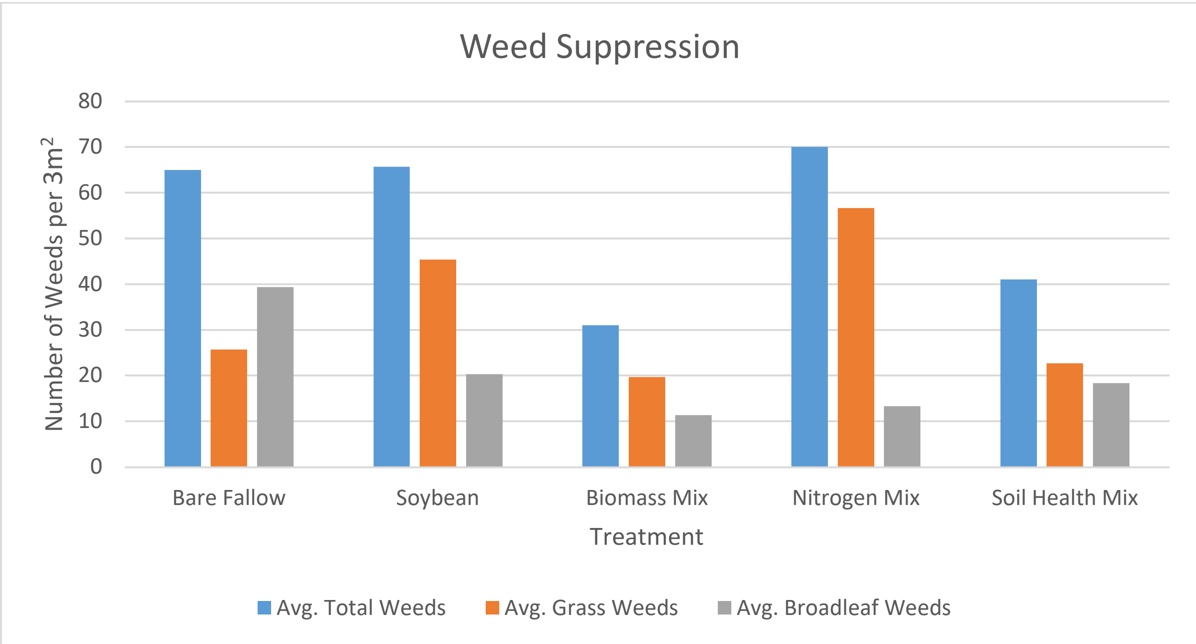
Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5
Control (Bare fallow)	Leichardt Soybean	Leichardt Soybean Ebony Cowpea Jumbo Sorghum	Leichardt Soybean Ebony Cowpea Jade Mungbean	A6785 Soybean Tillage Radish Shirohie Millet Sunflower

Sampling and Analysis:

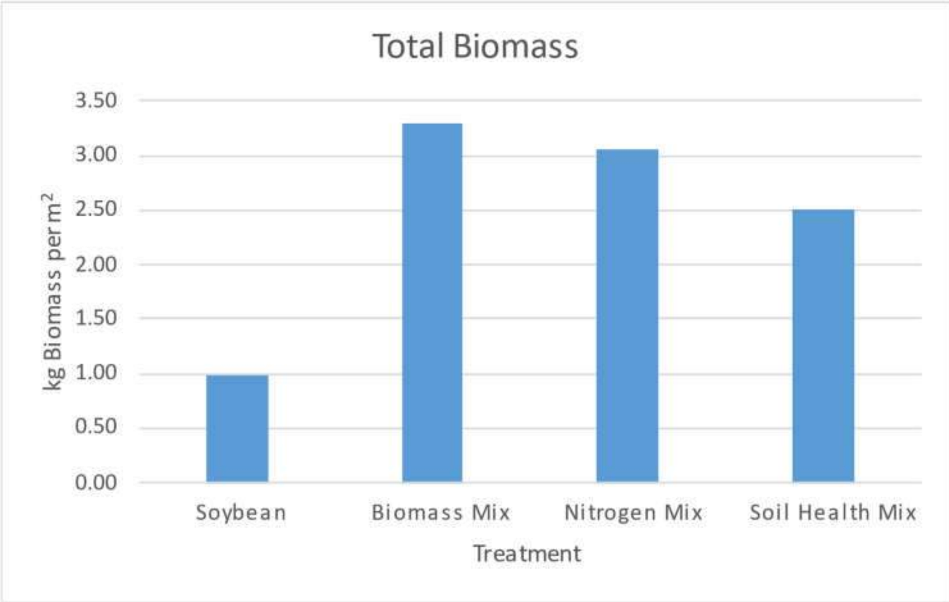
Nematode counts
Full soil testing
Labile carbon analysis
Solvita burst analysis
Nitrate testing
Biomass assessments and plant counts

Results:

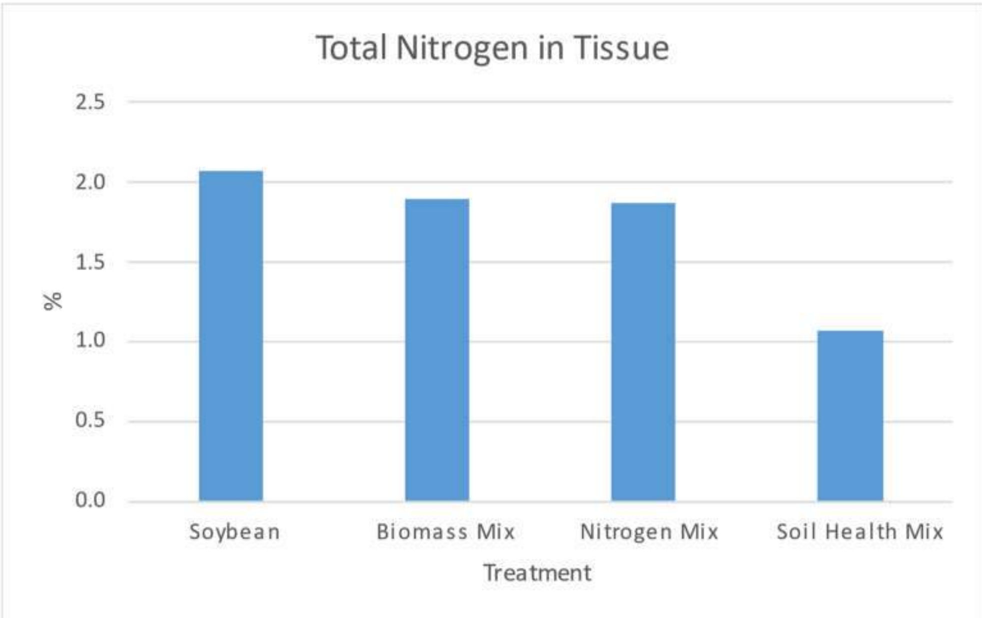
Sampling and analysis occurred in each plot, with exact georeferenced locations. Sampling locations where chosen based on soil and EC zones to reduce natural variation. Three sampling events have currently taken place with a fourth planned before harvest of the cane crop that has been planted following the mixed fallow crop. Results are shown below.



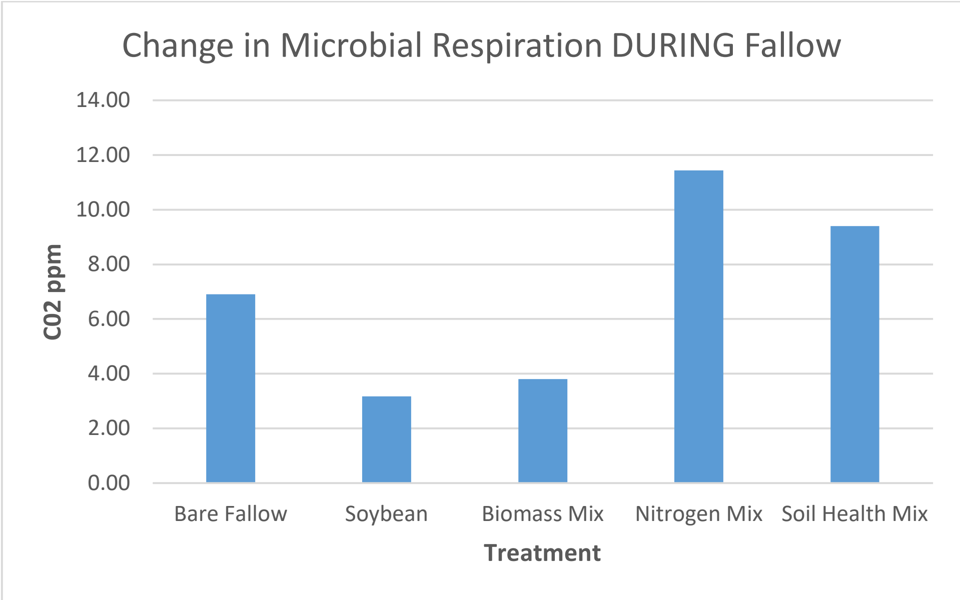
The above figure shows the weed controll in relation to treatment, weed counts were conducted approximately three weeks prior to the mixed species fallow termination. These results show that the more cover/biomass present, the less space there is for weeds to compete, and this is to be expected.



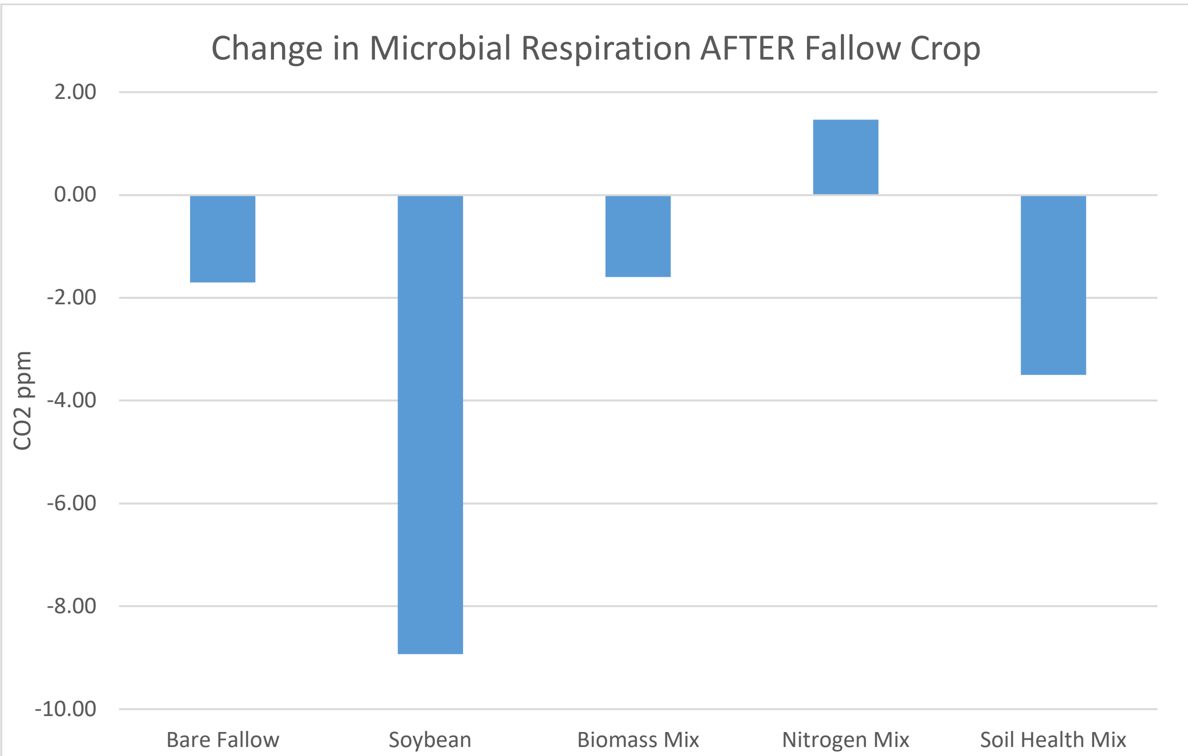
This graph shows the total biomass in kilograms per square meter, the soybean treatment is markedly lower than the other treatments and was underrepresented in the trial. Seed quality for the soybean planting was poor (an issue faced by many growers this season across the Burdekin), and this is shown in the these results. It is expected that the biomass mix would yield the highest amount of organic matter and this is seen in these results.



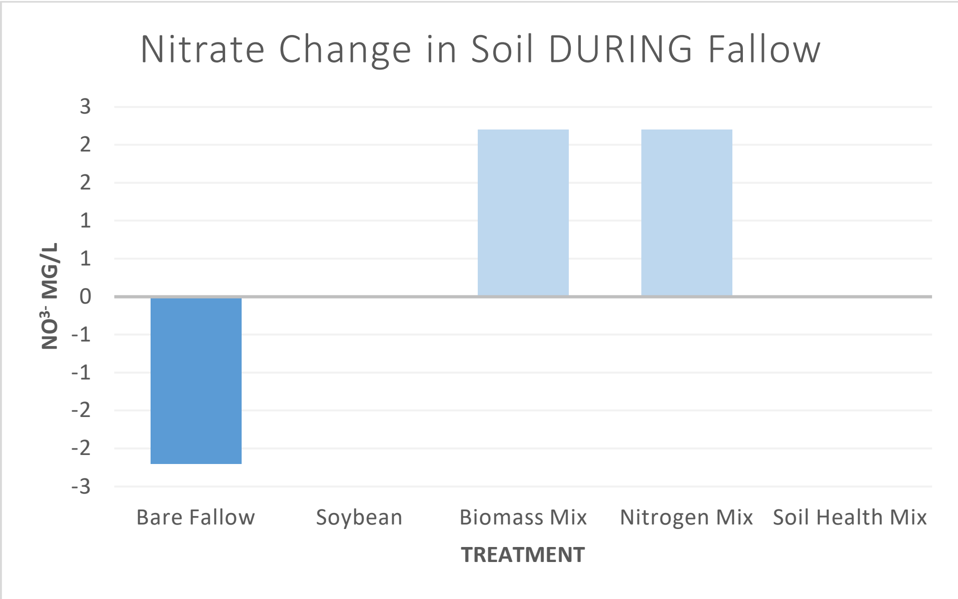
The above graph shows the total Nitrogen in tissue samples collected from each treatment. As expected, the treatments that contain Nitrogen fixing legumes contain the highest perecentage of N. The soil health mix comprised of only one legume species, whereas the other treatments were primarily legume based or only contained legumes.



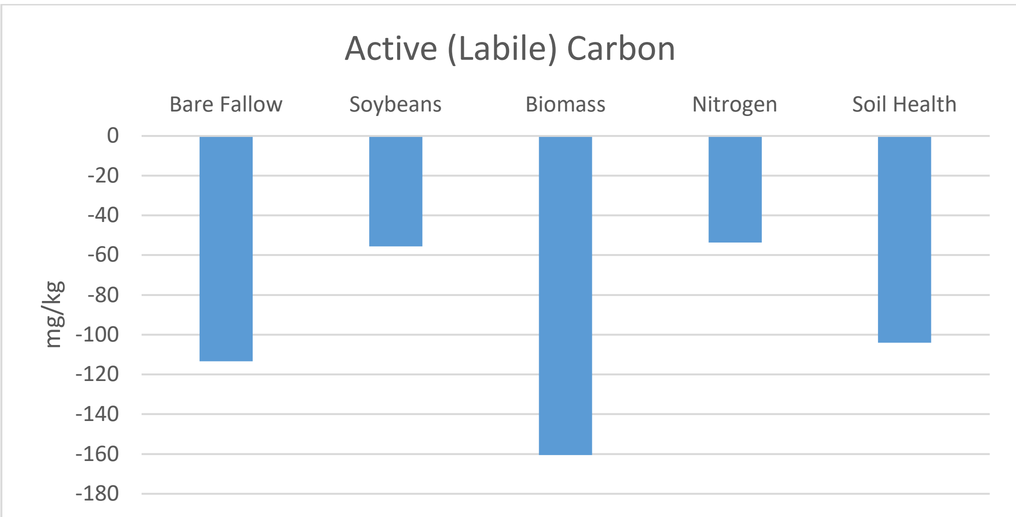
This figure outlines the change in microbial respiration over the course of the mixed fallow. This data was generated by using the Solvita Burst test, which measures $C0_2$ respiration of microbes in the soil. This can be an indicator of soil health, the higher the microbial respiration, the greater the soil health as there are more microbes and detritivores living in the soil, increasing the rate of nutrient cycling and breakdown of organic matter. Microbial respiration has increased across all treatments. During the fallow we saw increases in microbial activity, including substantial activity in the bare fallow treatment.



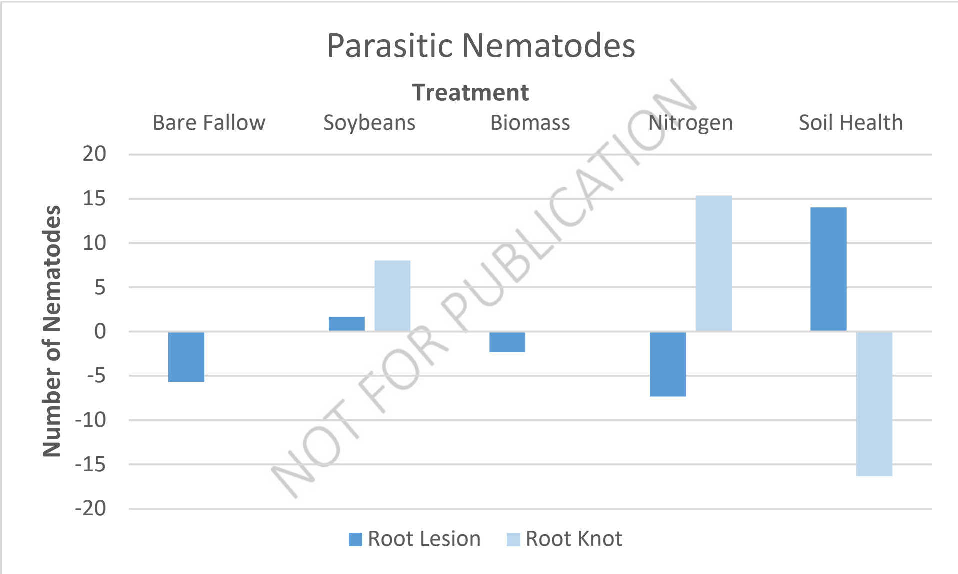
The above graph outlines the results from sampling done when the subsequent cane crop was planted and at the out of hand stage. These results are polarising when compared to the previous graph when sampling was done during the fallow crop. Microbial respiration has decreased overall when compared to the baseline sampling event, except for the nitrogen mix cover crop which has increased slightly. This could be an indicator that microbial activity is driven by other factors such as moisture or heat in association with the particular species planted.



The above graph outlines the change in nitrate within the soil. We would have expected an increase in nitrate levels from the soybean treatment but, as stated above, there was a poor strike and a healthy soy bean crop was not established and therefore cannot be considered representative in this context. Interestingly, there was a decrease in nitrate levels in the bare fallow, indicating that some mineralisation has occurred over the course of the fallow period.



This figure presents some interesting results, one of the main expected outcomes from this trial is an increase in organic carbon in the soil. These preliminary results show a contrast, in all treatments organic carbon levels decrease quite significantly, even though all biomass was incorporated into the soil. This is because the organic matter produced by the mixed species fallow has not had enough time to decompose/breakdown to become readily available. Measuring changes in organic carbon is difficult to do over a short period of time and it is expected that changes may not be measurable until a fallow of this nature is practiced for several crop cylces. Further results will be presented after the next sampling event before harvest of the plant cane crop currently in the ground.



Baseline nematode numbers were very low and therefore drawing any conclusions from this data is difficult, nematode numbers saw very little change over the course of the fallow. These numbers a far below threshold levels for sugarcane. It has been included in this report to demonstrate that this variable has been considered.

The subsequent sugarcane crop has been planted with variety KQ228 and we will continue to monitor the crop and sampling will continue to measure changes of the mixed species fallow into the mature cane crop. We expect to see a dramatic increase in the nematode numbers with a mature cane root system in the ground.

We will also be analysing for full nematode communities during the next sampling event (close to harvest of the currently planted KQ228 crop). Results from this will be presented with harvest data once full sampling is complete.

Conclusions and comments

There have been several important learnings developed during the course of this trial. Before developing a plan to implement a mixed species fallow, it is important to step back and determine why we fallow ground to begin with. One major advantage of fallowing ground is the unselective control of weeds and reducing the weed seed bank in the paddock to reduce the pressure of weeds in the subsequent crop. In addition, to control volunteer cane to reduce the carry-over risk of diseases.

We implemented two treatments that had grasses present in the mix, jumbo forage sorghum and shirohie millet. Ordinarily in a broadleaf fallow crop, such as soybean, growers have the opportunity to use grass selective herbicide to control grasses and volunteer cane. As a result of the grasses being planted in the mixed species fallow we did not have this option, and volunteer cane and grass weeds remained uncontrolled in some treatments which can be a risk for the subsequent crop. In addition, as the mixed species crop matured, some species set seed (Forage Sorghum and millet), we attempted to control this by slashing the treatments with grasses but we still had some escapes. This caused forage sorghum and millet to germinate in the subsequent plant cane crop, this prompted us to spend significantly more on herbicide in crop than the grower would normally use, at quite an expense.

Seed quality was also an issue with some treatments, particularly where soybean was planted. The soybean seed was of poor quality and this showed with germination and also vigour. This fact basically rendered the soybean only treatment a failure, therefore it is difficult to draw comparisions with this treatment and the others. In addition, as we wanted to maintain permanent beds and plant in rows we were only able to plant a one depth, each species has dramatically varying seed sizes which changes the ideal depth for germination. We had to make compromises on seed planting depth and this will affect the germination of each species dramatically.

In terms of measurable soil health outcomes, it is apparent that measuring quantifiably in this space is quite difficult and what defines a healthy soil is very ambiguous. Measuring changes in soil intensivley over a 12 month period has also shown that there is a large of amount of within paddock variation (even within soil type and EC zone). Temporal and elevation changes can also influence results quite dramatically and eliminating this variation is very difficult. In relation to nematode sampling, developing a robust sampling program proved to be difficult, especially when changes in moisture is a key driver in nematode mobility and activity, drawing quantifiable conclusions from the nematode data is difficult as nematodes exist in clusters and without identifying where clusters exists it is near impossible to accurately measure changes in their populations. This fact aside we will continue to monitor the plant cane crop and present all of the relevant nematode population data with the harvest trial report.

The underlying idea behind the success of a mixed species cover crop is developing ecosystem and biological synergies between the different species (this includes many groups of plants: brassicas, legumes, grasses and many others). If these relationships do not develop because we have selectively chosen to remove grasses from the mix, then perhaps we may not see all of the potential benefits a mix species cover crop can offer. We intend to continue testing a number of other mixes over the next year on Denis's farm to determine what is most easily managed in the cane rotation so we can maximise yield without compromising soil health and the sustainability of the system.

Advantages of this Practice Change:
If practiced for several crop cycles, the grower hopes to see improvements in irrigation management and soil water holding capacity especially on very sandy paddocks. In addition, improvements in soil microbial activity should lead to improved productivity and a reduction in soil borne diseases and parasitic nematodes.

In mixes that have a significant contribution of nitrogen due to legume nodulation, there is the capacity to reduce nitrogen rates. When determing how much we can reduce by, it is very important to determine how much the cover crop is actually contributing and how much is actually available for plant uptake, especially after significant decomposition and mineralisation of the fallow crop residues.

Disadvantages of this Practice Change:
As mentioned aboved there were issues with grass control during the fallow and also in the subsequent cane crop, and this needs to be considered.

Adopting this type of practice change also means that you are not able to grow a cash cover crop during the fallow period. As the Burdekin region is fully irrigated, growers do have the potential to make substantial profits from cover crops if harvested, this will be a significant barrier for broader adoption of this practice.

Will you be using this practice in the future:
Yes, the grower currently has another paddock being trialled as a mixed species cover crop.

% of farm you would be confident to use this practice :
100% of fallow ground – 20% of farm area