QUT ife
Institute for Future Environments

DEAKIN UNIVERSITY CERRF CENTRE FOR REGIONAL AND RURAL FUTURES

Unlocking the true value of organic soil amendments

June 2020 update

An innovative farm-ready tool for the effective management of manures and composts into farm fertiliser budgets for environmental, soil health and economic sustainability.

Key partners

- **Queensland University of Technology** (Module 1 and 5)
- **The University of Queensland** (Module 2)
- **Deakin University** (Module 3)
- **La Trobe University** (Module 4)

The project

This project will provide farmers, agronomists and suppliers of manures and composts with a decision support tool for integrating organic amendments into farm nutrient budgets.
On-farm field validation and demonstration sites from Queensland to Victoria across vegetables, cotton, cropping and pasture will showcase this tool and provide case studies of reduced fertiliser use and cost reductions, yield benefits possible from using organic amendments, and potential additional soil health and sustainability benefits.
The manure and compost nutrient calculator will be available as a farmer-friendly web and smart phone application (app). This app will, for the first time, directly link producers and suppliers of organic amendments through a national standardised approach for assessing and reporting product and nutrient quality, facilitating the supply of products that can be used with confidence within the farming community.

Project rationale

The integration of plant nutrients released from organic soil amendments into farm fertiliser budgets allows not only for the reduction of synthetic fertiliser rates without compromising crop yield (Figure 1), but also multiple environmental and soil health co-benefits. This preliminary report presents the outcomes from a series of experimental field and laboratory trials conducted across different Australian agricultural industries i.e. horticulture, fodder production, cotton and grain, aimed at demonstrating these circumstances. The amount of plant available nitrogen (PAN) released from applied organic amendments (OAs) over time that can be deducted from the standard farming fertiliser rate was estimated from laboratory trials and evaluated in a series of field trials across various agricultural industries. This data will form the foundation of the Soil Organic Amendment Nutrient Release Calculator (OA nutrient calculator).

Module 1. Characterisation of OA nutrient release

Laboratory incubation tests for nitrogen release or immobilisation from different OA products have been conducted at the QUT laboratories since the beginning of 2019. A total of 28 different trials have examined the effect of OA type, application rate, soil type, water content and temperature on the release and accumulation of inorganic nitrogen (N) over 100 days. The release of inorganic N ($NO_3^- + NH_4^+$), or mineralisation rate (MR) from these products was calculated over 7, 14, 28, 56 and 100 days, representing the short-medium term release of N under field conditions. Other possible predictors of the mineralisation rate such as soil respiration (CO_2 evolution – as an indicator of labile Carbon (C)), parameters of applied OAs (C:N and P:N ratios, inorganic N, dissolved N and C and various carbon fractions) have been analysed on each product to improve nutrient availability estimations in the OA nutrient calculator.

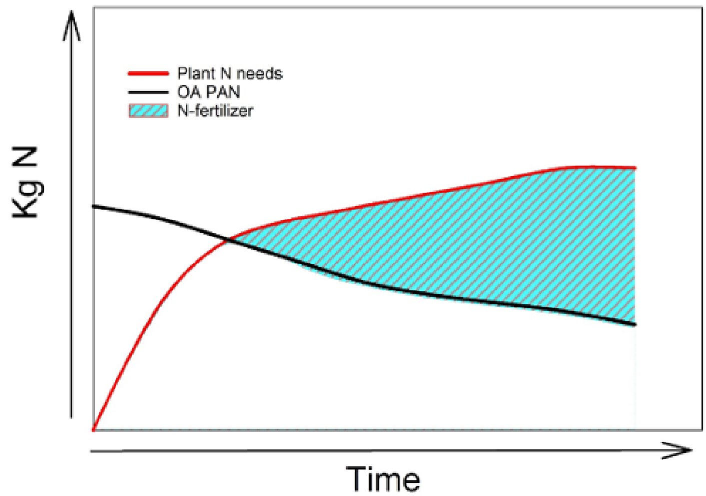


Figure 1. Visual representation of optimal nitrogen (N) application rate where crop Plant Available N (PAN) requirements are matched by N released from organic amendments plus supplementing fertiliser N application.

Experiments have focused on four questions:

1. Variability in nutrient release among OA products and individual sources
   A total of 7 different products from 4 different sources have been tested to date with an additional 6 results pending (refer to Table 1).
2. Variability in nutrient release within different soil types
   A range of soil types have been evaluated to date ranging from heavy clay to sand.
3. Effect of application rate
   To account for soil/OA interaction and overcoming high variability of OA products an application rate trial was conducted using chicken litter at the equivalent of 3, 6.5 and 13 t/ha.
4. Nutrient release under different environmental conditions
   Nutrient release from OA's has been tested at a range of temperatures (22-30°C) and soil water contents (50, 80 and 100% field capacity) to allow lab results to be extrapolated to field conditions.

Each of the OAs tested were fully characterised for nutrient content (Table 1). The characterization of OAs highlighted a high degree of variability even within the same type of OA tested (e.g. chicken litter) suggesting the need of frequent product analysis by the commercial producer to guarantee that accurate information is provided to the buyer.

	Composted chicken manure (CCM)	Chicken manure (CM)	Chicken litter (CL1)	Chicken litter (CL2)	Composted feedlot manure (CFM)
C:N ratio	11.9 ± 0.01	5.8 ± 2.0	10 ± 3.1	8.8 ± 0.1	8.7 ± 0.0
Total N (%)	4.2 ± 0.03	6.0 ± 0.1	3.5 ± 0.1	3.1 ± 0.1	1.1 ± 0.0
Total C (%)	29.4 ± 0.15	35.1 ± 0.4	35.6 ± 0.3	27.37 ± 0.2	9.3 ± 0.05
NO_3--N (mg/kg)	55.1	24.5 ± 4.7	975.1 ± 2.7	398.6	1364.1
NH_4+-N (mg/kg)	5755.7	362.4 ± 18.3	127.1 ± 1.4	2095.5	111.2
N immediately available (% of total applied)	13.8	0.6	3.1	8.0	13.4
pH	6.9	6.3	7.3	7.6	7.7
DOC (mg/kg)	83.9 ± 11.8	19013.0 ± 0.0	51510.9±0.0	719.4 ± 0.0	36.3 ± 0.7
DON (mg/kg)	117.4 ± 9.9	-	-	552.2 ± 0.6	-
Protein (mg/l)	27.1	27.9	26.9	28.7	5.5

Table 1. Characteristics of four different amendments from the egg and meat chicken industries and composted feedlot manure.

Preliminary results indicate that mineralisation of both composted manures and chicken litter increases as soil temperature increases to 30 °C. The influence of different water contents was less prominent, with mineralisation rates relatively similar at the three wetting levels.

Large variation in mineralisation rates was evident across the composts and various chicken litter products (Figure 2). Raw manures, i.e. chicken litter (Figure 2c and 2d) and layer manure (Figure 2e) displayed substantially different rates of mineralisation, despite similar C:N ratios and initial available N content. Negative mineralisation values in the chicken litter from breeder sheds after 28 days (Figure 2c) indicate high initial N availability which declined over time as N became immobilised. Slight immobilisation also occurred in the composted feedlot manure towards day 28 (Figure 2b), while N mineralisation was observed for the remainder of the monitoring period.

Overall composted feedlot manure showed a low rate of mineralisation while composted chicken manure (CCM) was consistently high. Our incubation experiments showed that mineralisation rates from raw (Figure 2e) and composted (Figure 2a) layer chicken manure were more or less identical. The large variability between mineralisation (release) and immobilisation (uptake) between amendments was attributed to differences in composition and amount of recalcitrant organic compounds, and the balance between available N and C. Further investigation into the organic N fractions within each organic amendment has commenced at QUT, including methodologies for measuring other organic forms of N such as Alpha amino-acid nitrogen.

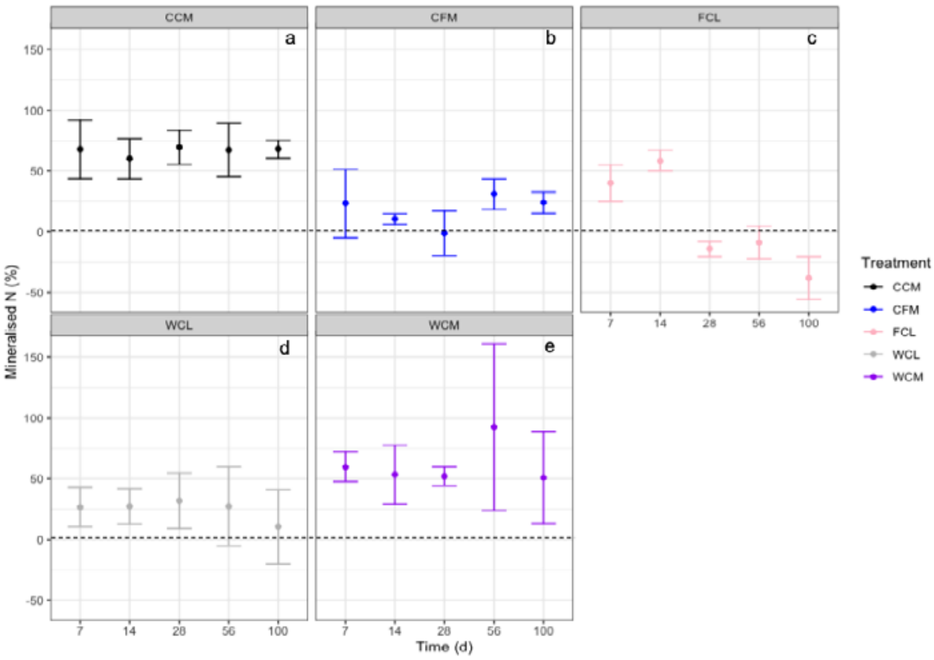


Figure 2. Percentage of applied N in the OA product that was released (as $NO_3^- + NH_4^+$) over the QUT laboratory incubation (100 days) for a) composted chicken-manure, b) composted feedlot-manure, c) chicken litter (breeder), d) chicken-litter (rice-husk bedding) and e) raw chicken-manure.

Module 2: Compost and manure products and application to field trials

Organic soil amendments, comprising raw and composted animal manures and urban derived compost products were applied at 12 field demonstration and trial sites in Queensland, New South Wales, Victoria and South Australia. Details concerning the type and supplier of organic amendments used, location of the farm site, type of trial (large-scale, extensively monitored or small-scale, intensively monitored), and the crops grown are shown in Table 2. A standardised full chemical analysis of all organic soil amendments was carried out at a single commercial laboratory to ensure uniformity of sample handling and use of analytical methodologies. In some cases, the obtained analytical results differed markedly from information provided by suppliers of organic amendments.

Research Questions

The spatial and quantitative (t/ha) distribution of applied organic amendments, i.e. spreading patterns, was assessed at five of the seven large-scale demonstration sites in relation to the target application rates (Figure 3). As can be expected, spreading patterns and distribution across the spreading area do vary markedly depending on physical product characteristics and spreaders used. The uneven distribution of the applied organic amendments results in obvious difficulties and uncertainties when it comes to soil sampling and small plot harvesting. It was surprising to realise that actual application rates were often markedly different from target application rates, even with commercial spreading contractors. It was also noticed that several equipment suppliers do not provide guidance for equipment settings when compost is applied, while this guidance is available for manures, lime or fertilisers.

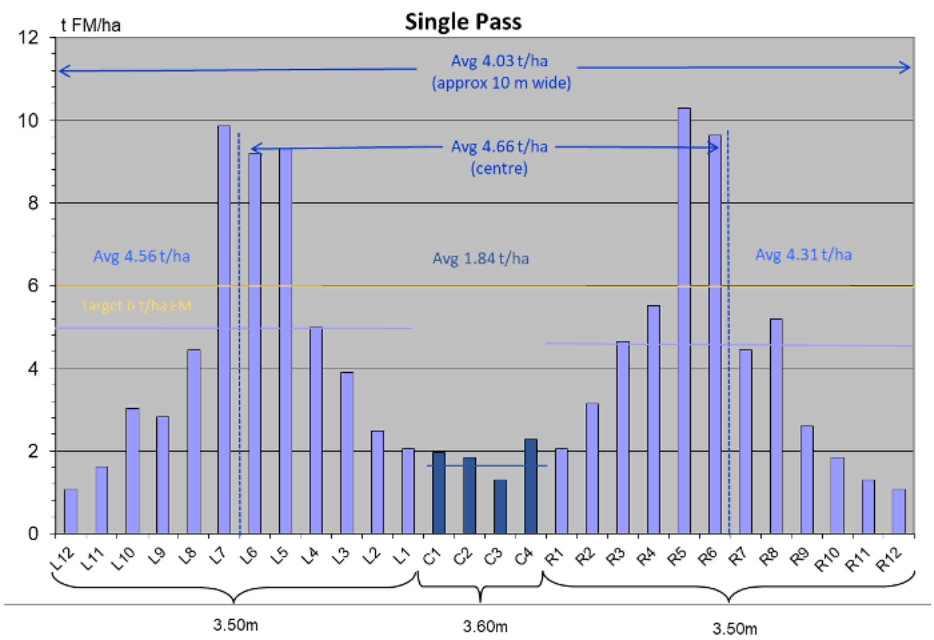
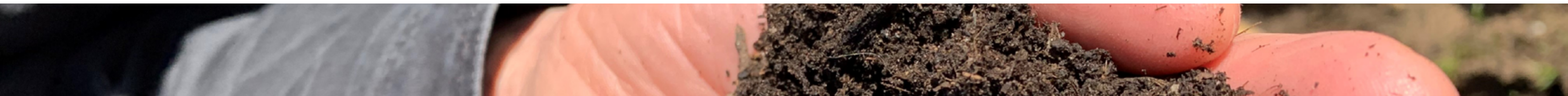


Figure 3. Example of the spatial applicate rate (tonnes per hectare) for composted layer chicken manure across the spreader width (10.6 m).

Site	Organic amendments Animal manures (raw or composted)	Organic amendment supplier	Farm location	Trial type	Crops grown
1	Composted piggery pond sludge and feedlot manure	Organic Nutrients	Roma, QLD	Large scale	Oats for hay planted (crop failed)
2	Aged dairy manure Composted layer chicken manure Aged feedlot manure	Brown Farm Organic Nutrients McLean Farms	Dajun, QLD	Large scale	Forage sorghum (cut for hay)
3	Aged litter from chicken breeding sheds Composted layer chicken manure Composted feedlot manure	Davanya Grains Organic Nutrients Organic Nutrients	Felton South, QLD	Small scale	Grain sorghum planted (crop failed)
4	Aged meat chicken litter	Hardmyle	Mulgowie, QLD	Small scale	Broccoli
5 and 6	Aged meat chicken litter Layer chicken manure	Baiada chicken grower	Griffith, NSW	Large scale	Cotton
8	Aged meat chicken litter	South East Organic Fertiliser	Werribee, VIC	Small scale	Fioretto, cauliflower, fennel
9	Aged meat chicken litter	Graeme Clay	Baxter, VIC	Small scale	Celery, corn (cover crop)
11	Aged meat chicken litter	Worland Mechanical Services Graeme Clay	Freshwater Creek, VIC	Large scale	Barley for hay (re-sown after poor winter barley crop ploughed in)
	Urban derived compost				
4	Urban derived compost	Candy Soils	Mulgowie, QLD	Small scale	Broccoli
7	Urban derived compost Composted biosolids	Carbon Mate	Wagga Wagga, NSW	Large scale	Canola planted (crop failed)
8	Urban derived compost	Camperdown Compost	Werribee, VIC	Small scale	Fioretto, cauliflower, fennel
9	Urban derived compost	Camperdown Compost	Baxter, VIC	Small scale	Celery, corn (cover crop)
11	Urban derived compost	Camperdown Compost	Freshwater Creek, VIC	Large scale	Barley for hay (re-sown after poor winter barley crop ploughed in)
12	Urban derived compost, bulk and granulated	Peats Soil and Compost Supplies	Langhorn Creek, SA	Large scale	Barley

Table 2. Organic amendments used in field trial and farm demonstration sites



Module 3: Irrigated broadacre crops (Riverina, NSW)

The cotton module of the project will provide case studies of fertiliser use and cost reductions in the Riverina, yield benefits possible from using organic amendments, and offer additional soil health and sustainability benefits. The CeRRF (Centre for Regional and Rural Futures) Deakin University research team are based in Griffith, NSW and collaborate closely with the Irrigation Research Extension Committee (IREC) and individual local farmers to develop the research. This ensures research findings are as relevant as possible for end users with a high rate of adoption.

Poultry litter is in abundance in the Riverina region of NSW, supplied from regular meat chicken industry production cycles. Poultry production facilities are in close proximity to cotton growing areas in the Murrumbidgee Valley and therefore have realistic potential to supply significant areas of cotton (up to 30,000 ha) by topping up inorganic fertilizer budgets with available N, P, K and micronutrients at practical application rates. Although the litter nutrient and moisture composition in different loads is variable based on production, handling operations and storage, generally the product (per delivered tonne) typically contains ~15 kg available N, 8 kg available P and quantities of trace elements such as Zn, Mn and Cu. Commercial field trial results involving different proportions of litter with urea to meet N budgets and replacing DAP completely with litter indicated that on transitional red brown earths near Griffith, NSW, chicken litter can be used within season as a partial N and complete P substitute for inorganic fertilizers with no detriment to productivity, lint yield or lint quality.

Farm application rates are typically at 5 t/ha suggesting that on clay-loam soils, urea-N rates for cotton could be cut by 75 kg N/ha and total seasonal Colwell-P may be supplied completely by litter. These amounts, for inorganic N and P alone, equate to approximately $211/ha and compare with current litter and spreading costs of $46/ha. In litter amended treatments cotton lint yield was maintained in both clay loam and heavy clay soil types while nitrogen use efficiency (NUE) and lint quality was unchanged compared with the standard mineral fertilizer programmes. Research has been undertaken through replicated field trials at IREC Field Station Whitton, NSW, a commercial scale community owned research farm and at a commercial farm at Widgelli near Griffith. A research trial site has been established in readiness for the 2020-21 cotton growing season at Gundaline Station (Customised Farm Management, the largest cotton grower in the Murrumbidgee Valley).

Research Questions

Whitton and Gundaline Station

Can chicken litter be used to reduce dependence of commercial cotton cropping on finite phosphate fertilizers and fossil fuel derived fertilizers such as urea?

Is mineral N fertilizer less available when the application rate of manure is greater due to immobilization of mineral derived urea-N by greater microbial activity and biomass? Do manure: urea-N fertilizer combinations cause a temporary immobilisation of N to provide a better synchronised supply to plant requirements. Can optimal urea-N: manure-N combination for fertilizer N use efficiency and yield be derived either generically or for particular soil types?

Does applying organic amendments in one season cause nutrient carry-over effects which can be utilised by subsequent crops?

Are urea-chicken litter combinations able to improve fertility, nutrient input efficiency and maintain or increase yield in landformed and laser levelled paddocks?

Results

At Widgelli, seasonal above-ground biomass showed some increase as the amount of chicken litter increased but the differences were not significant (Figure 4). There was significantly less biomass in the 20 cm land levelled cut at first flower compared with the 4 cm cut. However, there was no significant difference by defoliation according to soil profile cut.

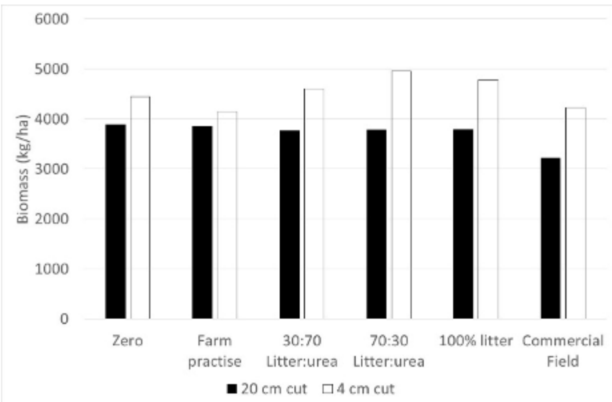
Nitrogen concentrations were similar in both boll material and vegetative compartments. The 20 cm cut area boll total nitrogen (TN) was consistently higher than the 4 cm cut area.

Higher rates of chicken litter either alone (22t/ha) or in combination with urea-N (30:70) to meet 280 kg N/ha provided the highest yields. The effect was most significant in the higher, 20 cm cut area. The site remained relatively unresponsive however with commercial field data insignificantly different from the zero control.

Chicken litter soil amendment had insignificant effect on cotton quality. Differences in lint quality have been observed to be caused by seasonal differences rather than fertilizer source.

In the second year of back to back cotton at Whitton yield increased as chicken litter as a component of total fertilizer budget for N and P increased.

Higher rates of applied chicken litter may be responsible for yield maintenance compared with mineral fertilizer only.
Soil analysis for carryover of nutrients to subsequent crops is ongoing.



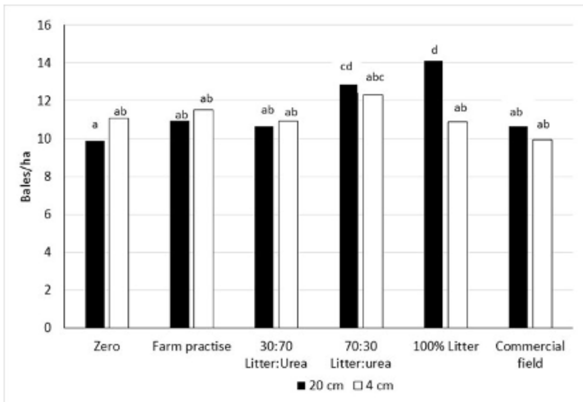


Figure 4. Cotton a) first flower biomass yield and b) lint yield at Widgelli (NSW) 2019

Module 4: Southern Vegetable systems and intensive horticultural crops research, demonstration trials and extension

Two long term field sites have been set up in Victoria on vegetable farms to identify if the nutrients in organic amendments can offset the need for full inorganic fertilizer programs. In doing so reductions are being made to the amount of inorganic fertilizers used when applied in combination with two different organic amendments (e.g. chicken litter and urban derived compost). In the temperate environment in Victoria growers are able to crop soils continuously throughout the year and can grow up to three crops annually. The organic amendment treatments applied are consistent with those used in the associated vegetable cropping regions and this means they are applied either once or twice per year depending on the sites.

Research Questions

At all sites the treatments have included; No fertilizer treatment (Control), Standard inorganic fertilizer, chicken litter (Manure) alone, urban derived compost (Green waste compost - GWC) alone, Standard inorganic fertilizer combined with manure or GWC and a reduced inorganic fertilizer program combined with manure or GWC (Manure+red inorg and GWC+red inorg).

Site 1: Intensive site at Baxter

At this site, results for the first celery crop sown directly after the application of organic amendments showed that biomass accumulation during cropping and yields at harvest were similar to the full inorganic fertilizer + manure program when the inorganic fertilizer rates were reduced to account for nutrient supplied by the organic amendments (Figure 5). Nitrous oxide (N_2O) emissions were lower in the treatment where manure was applied with a reduced rate of inorganic fertilizer (Figure 6).

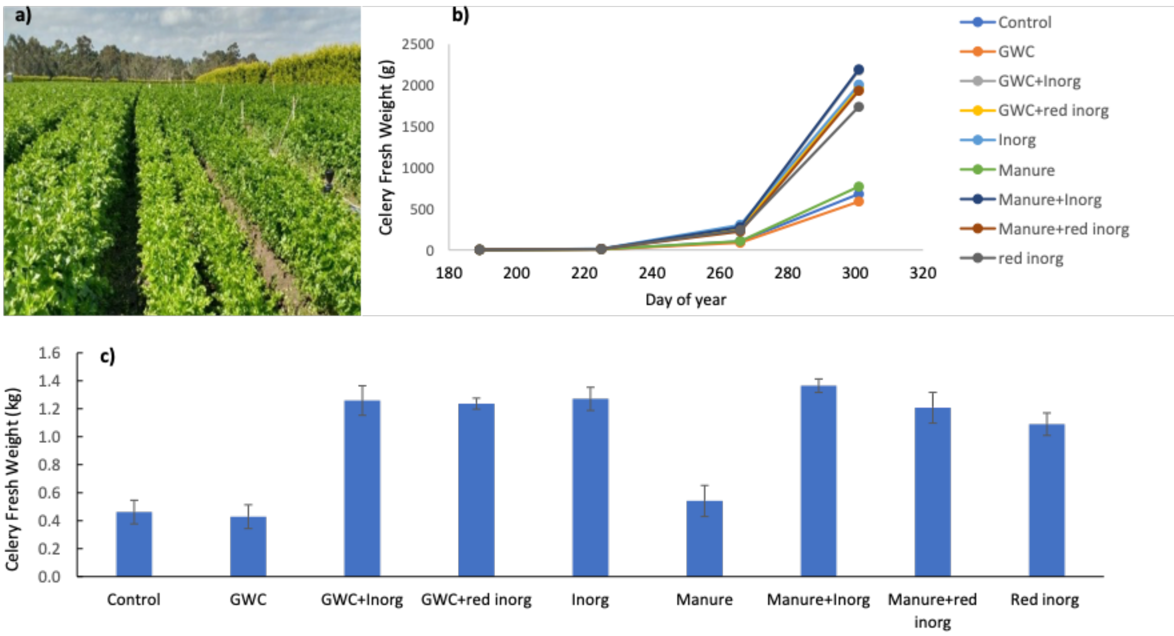


Figure 5. Celery trial at Baxter, Victoria showing a) visual yield response to fertiliser, b) treatment differences at different growth stages and c) in the final yield.

Site 2: Werribee.

Organic amendments were applied prior to the cropping of three successive crops (fioretto, cauliflower and fennel) on the same plots. During each crop soil samples have been taken for nutrient assessment to determine the changes in nutrient level caused by the inorganic and organic nutrient supply treatments.

Results have shown that there was no significant difference in yield for the first crop (fioretto), most likely due to relatively high background nutrient levels (Figure 7). Reduced yields occurred for the second two crops (cauliflower and fennel) for the control treatment and the organic amendment only treatments. When soil mineral analysis results are available the mineralization rates of the organic amendments over the annual cropping cycle can be estimated.

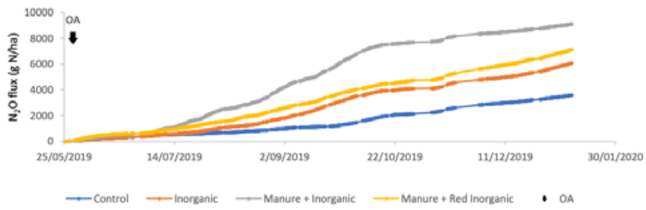


Figure 6. Cumulative emissions of the greenhouse gas N2O at Baxter, Victoria over the celery growing season.

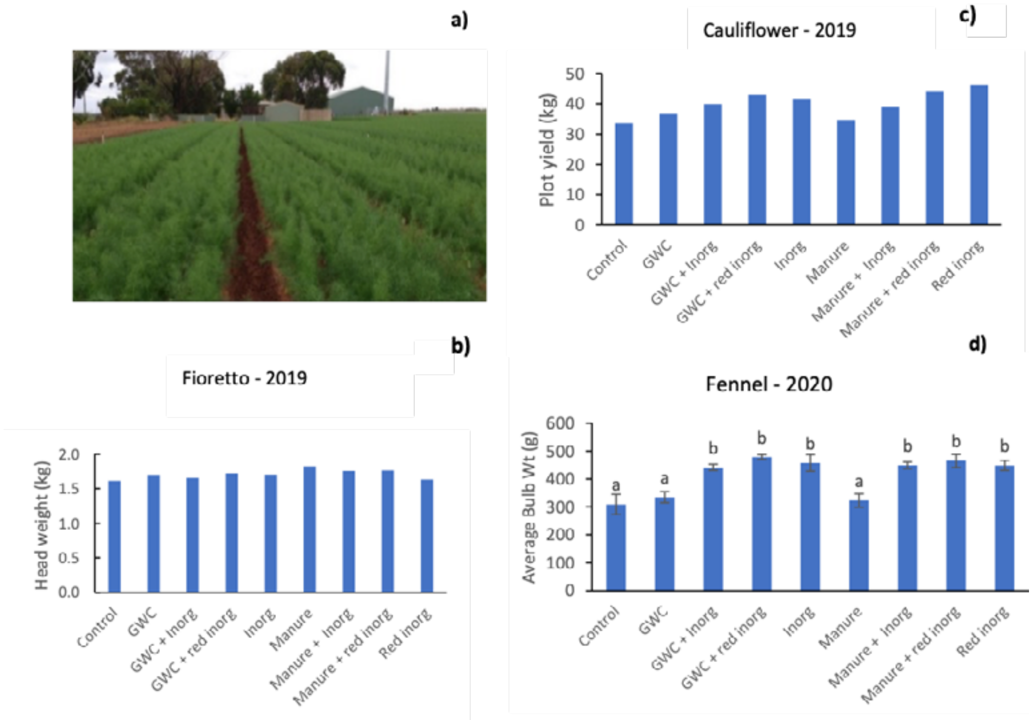


Figure 7. Intensive vegetable trial at Werribee, Victoria showing a) visual and b) yield response to fertiliser in fennel, c) treatment differences in Cauliflower and c) Fennel yields.

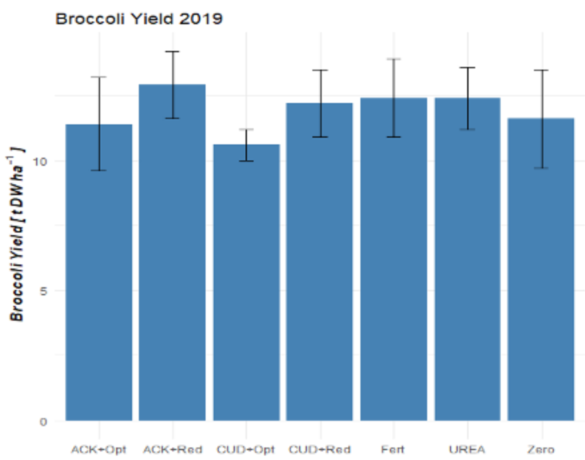
Module 5: Northern Vegetable systems and broadacre cropping

At the northern horticultural site at Mulgowie (QLD) the strategic application of OAs in combination with reduced fertiliser rate allowed to reduce fertiliser application rate between 44% and 67% of N and 100% for P and K while maintaining the same broccoli yield of the full synthetic fertiliser NPK rate (Figure 2). Additionally, the application of OAs did not increase nitrous oxide emissions (N_2O) but high N_2O emissions were observed following the incorporation of broccoli residues (Figure 8).

The strategic combination of OAs and reduced fertiliser rate was also tested at different grain field sites across Australia. At Felton (QLD) the first year OAs application was conducted in December 2018 followed by planting of sorghum. Due to the extensive drought registered during the 2019 rain season it was not possible to obtain the full germination of the sorghum crop.

On the other hand, the crop failure of 2018/19 provided the opportunity to test the residual effect of previous year OAs application. Indeed, at the same location a winter grain crop will be planted. The results of this experiment will provide important insight on the use of OAs under variable climatic conditions. At the same site, an additional field experiment was established in January 2020, testing the difference between incorporation and surface application of OAs in combination with reduced fertiliser rate.

At the broadacre cropping site Brinkley (SA) reducing N fertiliser inputs by 50% when combined with OAs showed no difference from standard farm practice. While at Freshwater creek (VIC) demonstration site the subsurface placement of urban derived compost in combination with reduced fertiliser rate resulted in the highest biomass production across all treatments.



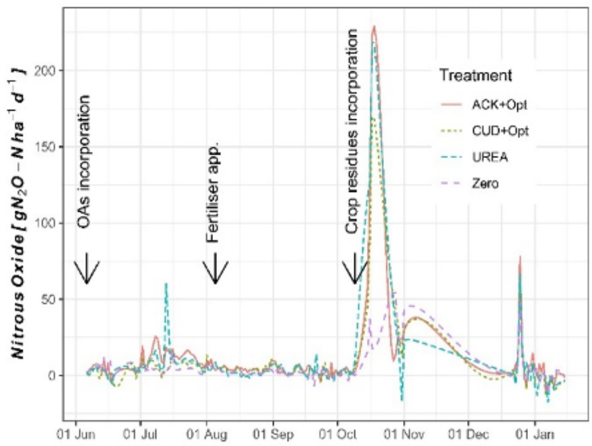


Figure 8. Broccoli yield and N_2O emissions at Mulgowie, QLD for Urban-derived Compost (CUD) and Aged-Chicken Manure (ACK), combined with Optimal (Opt – accounting for product N release), Reduced (Red) and Urea only fertiliser treatments.

Module 5. Communication and Extension

The following communication and extension activities were undertaken

- Co-organised and presented at farmer meeting in Roma (QLD) titled ‘Conventional Farming – Lean and Green Alternatives’. Presentation: ‘Benefits and challenges of using compost and other organic soil amendments.

- Presented at field day in Pittsworth (QLD). Presentation ‘Determining the value of organic amendments.

- Presented at Australian Organics Recycling Association (AORA) Conference 2019 in Perth (WA). Presentations: ‘Unlocking the True Value of Organic Soil Amendments‘, and ‘Optimising the Use of Organic Amendments in Sub-tropical Vegetable Cropping Systems for Improved Environmental and Agronomic Outcomes’.

- Annual Steering Committee meeting held at La Trobe University Victoria visiting our Victorian field sites in Werribee, Freshwater Creek and Baxter.

- Organised a Subsoil Manuring Seminar in Toowoomba (QLD).

- A field day was held at the IREC Field Station near Whitton at the Widgelli Cotton Research and demonstration site with the proposed research activities and preliminary results from the field trial presented by Dr Wendy Quayle.

- Article published in the IREC Farmers Newsletter – Spring 2019 edition titled “Integrating manures and composts into farm fertiliser budgets”

- As part of the 7th International Symposium on Soil Organic Matter in Adelaide (SA), organised and hosted a panel discussion entitled ‘How can we translate SOM research into improved farming practices?’ The symposium included a field trip to the field demonstration site at Langhorn Creek (Site # 12) where an overview of the ‘Unlocking the true value of organic soil amendments’ project was given.

- Negotiated with the organising committee of the 8th Global Nitrogen Conference (re-scheduled for 2021 in Berlin, Germany) to organise and host a panel discussion entitled ‘Is it possible to limit excessive agricultural nitrogen use without regulations?’

- Published ‘Farmers to benefit from cross-industry decision support tool’ in Queensland Country Life.

- Published ‘Integrating Organic Soil Amendments into Farm Fertiliser Budgets’ in the Australian Organics Recycling Association (AORA) newsletter.

To learn more about this project follow our group on Twitter @UnlockSoilOAs

Dairy farmer 2019-20 results

Site Name:	Djuan	**Dates:**	OA application		23/12/19
			Sowing / planting		15/1/20 approx
			Harvest	26/03/2020 (biomass)	14/05/2020 - cut for hay
Farmer Name:	Scott Brown	Crop:	Forage sorghum		

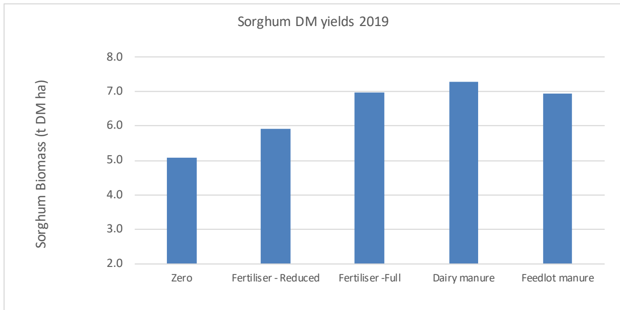
Soil Profile

Conventional fertiliser

Date	Depth (cm)	*Nitrate-N (kg/ha)*	*Ammonium-N (kg/ha)*	*Total Profile Mineral N (kg/ha)*	*Phosphorus*
25/10/19	0-20	101.55	6.41	107.96	
25/10/19	20-40	25.29	0.68	25.98	
25/10/19	40-70	16.33	-1.50	14.83	
				148.77	
Manures					
25/10/19	0-20	144.3	21.3	165.55	
25/10/19	20-40	58.2	55.2	113.35	
25/10/19	40-70	10.4	-0.9	9.55	
				288.45	

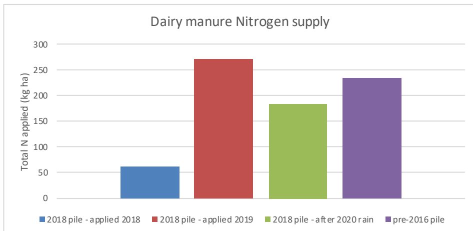
Organic amendment nutrient content (OA)	**Fresh dairy manure (<1 year)**	**Feedlot Manure (Grassdale)**	*Estimated seasonal (9 months) availability* **Fresh dairy manure (<1 year)**	**Feedlot Manure (Grassdale)**
Amendment type				
Total N (%)	3.0	2.8	24%	20%
Mineral N (mg kg)	4,546.9	288.9		
Total P (%)	1.08	0.71	40%	40%
Cowell P (mg kg)	5806	4143		
Total K (%)	1.84	2.39	80%	20%
Exchangeable K (mg kg)	2907	7671		
Total Calcium (%)	2.7	2.3		
Total Magnesium (%)	1.4	0.8		
Total Sodium (%)	0.4	1.3		
Total Sulphur (%)	0.4	0.0		
Total Zinc (mg kg)	265.6	208.4		
Total Manganese (mg kg)	446.5	227.5		
Total Copper (mg kg)	40.5	49.0		
Total Boron (mg kg)	23.8	58.3		
Total C (%)	32.4	41.3		
Liming effect				
OA pH	7.54	8.45		
Application	*(Actual application)*			
Application rate FM (t/ha)	12.5	8		
Application rate DM (t/ha)	8.9	6.6		

Yield



Applied nutrients		
Nitrogen		
Total (kg N ha)	270.5	182.3
Immediately available (kg N ha)	40.4	1.9
Total seasonal available (kg N ha)	***95.6***	***38.0***
Phosphorus		
Total P (kg P ha)	96.0	47.1
Cowell P (kg P ha)	51.5	27.4
Total seasonal available (kg P ha)	***38.4***	***18.9***
Potassium		
Total K (kg ha)	163.4	157.8
Exchangeable K (kg ha)	25.8	50.8
Total seasonal available (kg K ha)	***130.7***	***126.3***
Micronutrients		
Calcium, Magnesium, Sulphur, Zinc, Manganese, Copper, Boron, Carbon		
Total Ca (kg Ca ha)	238.1	154.4
Total Mg (kg Mg ha)	128.7	53.0
Total Na (kg Na ha)	38.1	83.0
Total S (kg S ha)	39.4	1.4
Total Zn (kg Zn ha)	2.36	1.38
Total Mn (kg Mn ha)	3.96	1.51
Total Cu (kg Cu ha)	0.36	0.32
Total B (kg B ha)	0.21	0.39
Total C (kg C ha)	2880.3	2731.1

Annual variation in nutrient application



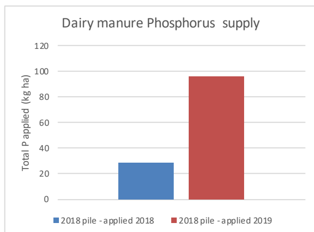


Figure 9. Example of a project outcome report generated for the farmer at one of the demonstration sites displaying organic amendment nutrient analysis and preliminary yield data.