Unlocking the true value of organic soil amendments

2021 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 and 5)
- 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 South Australia across vegetables, cotton, cropping and pasture willshowcase 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 and help reduce mineral fertilizer use.

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, but also multiple environmental and soil health co-benefits. This update presents the outcomes of 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 fertilizer 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 new Soil Organic Amendment Nutrient Release Calculator (OA Nutrient Calculator).

Module 1. Characterisation of Nutrient Release from OAs

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 (NO3- + NH4+), 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. The results showed a variable 100-day mineralization potential across the tested products (Fig. 1-1**) ranging from 7% to 1.3% of organically bound N at time of application**. However, the mineralization rates sensibly decreased towards the 100-day mark. The results provided the necessary data to build the first model and its integrated graphical user. Interface for the N release curve app (Fig. 1-2).

With the model, it is possible to predict N release over time by only selecting OA N and C content and OA application rate. However, so far, the model has only been parametrised for clay soils. Further incubations conducted using sandy to loamy soils will guarantee to capture the entire variability attributed to initial and site-specific soil conditions.

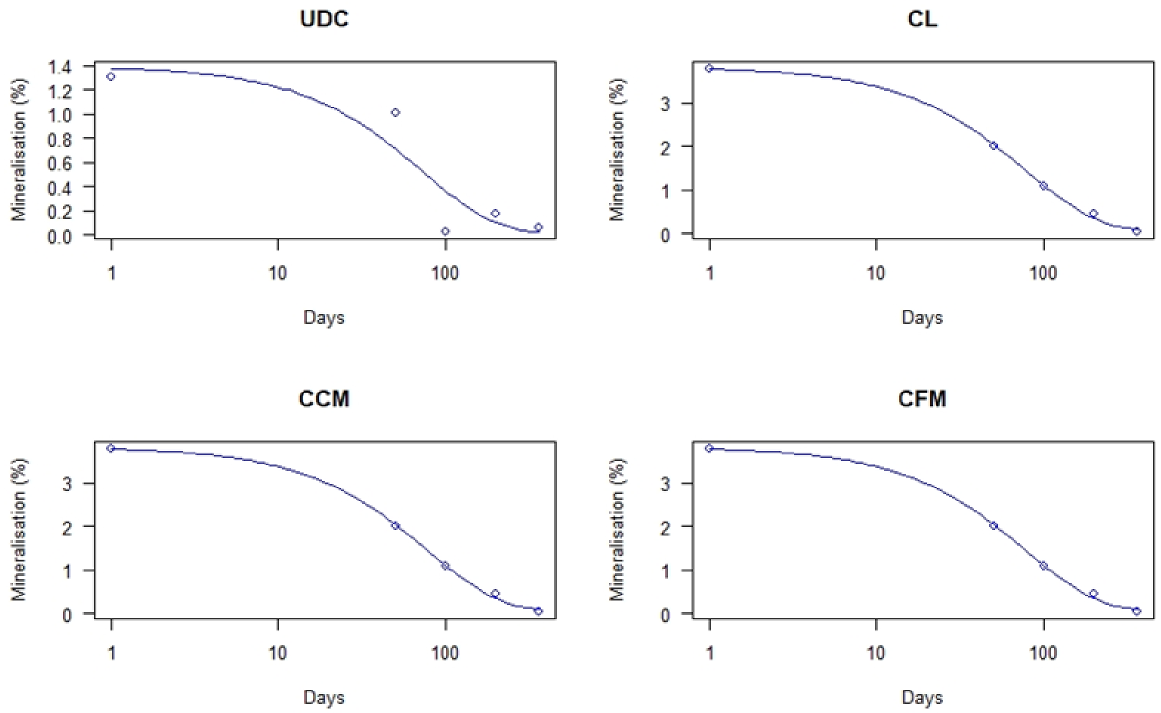


Fig. 1-1 N mineralization curves for composted feedlot manure (CFM), composted chicken manure (CCM) chicken litter (CL) and urban derived compost (UDC)

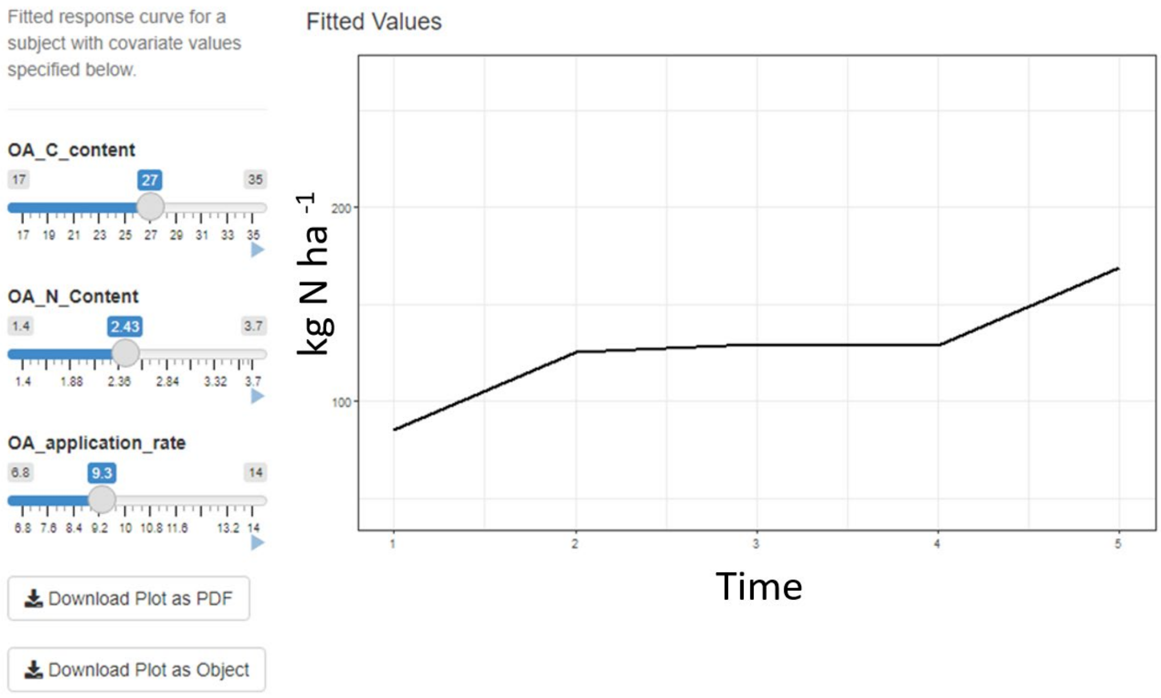


Fig. 1-2 Graphical user interface of the N mineralisation model.

Additional sets of laboratory analysis have been performed to assess the supply of macro and micronutrients with chicken litters, layer manures, feedlot manures and urban derived composts (Fig. 1-3 and Table1-1). The chicken litters and layer manures provide the highest amount of manganese (Mn) and molybdenum (Mo) per dry tonne of product followed by feedlot manures and urban derived composts. The results highlight the added value of OAs as a source of essential plant micronutrients often neglected in agricultural cropping systems.

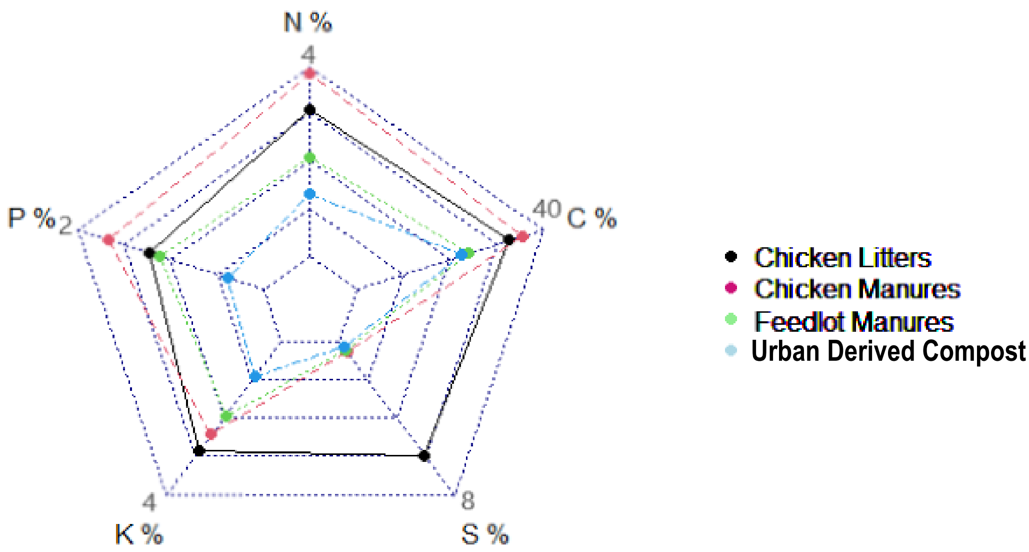
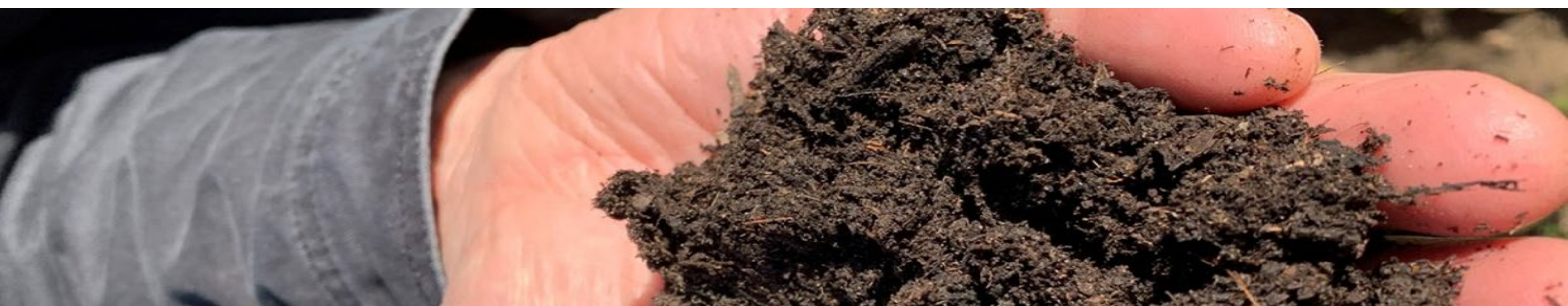


Fig.1- 3 Comparison of the four major OA in terms of total nutrients

	Total Mn	***Total Mo***	***Total Co***	***Total Bo***	***Total Zn***	***Total Se***	***Total Cu***
	kg / t	**kg / t**	**kg / t**	**kg / t**	**kg / t**	**kg / t**	**kg / t**
Chicken Litter	0.580	0.130	0.005	0.052	0.354	0.002	0.407
Layer Manure	0.494	0.007	0.003	0.043	0.365	0.001	0.070
Feedlot Manure	0.423	0.002	0.011	0.030	0.564	0.001	0.115
Urban derived compost	0.280	0.002	0.006	0.029	0.173	0.000	0.046

Table 1-1 Micronutrient composition of four different types of organic amendments, portrayed in kg/tonne DM of product



Module 2: Compost and Manure Products Application to Field Trials

It has been estimated that, in Queensland for example, around 2.7 million dry tonnes of agro-industrial organic residues were utilised for soil management purposes in 2015/16. More than half (51%) of all organic residues utilised as soil amendments were animal manures, 46% of which was poultry manure (without bedding). However, significant quantities of food and fibre processing residues (28%) were also utilised. Urban derived residues made up 15% with the majority of these products being used in urban environments.

Organic soil amendments, comprising raw and composted animal manures and urban derived compost products were applied at 15 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 2-1. A standardized, 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. It became also evident that nutrient concentrations in nominally identical products (e.g., chicken litter), even when they were from the same supplier, could vary markedly. Likewise, on occasions when compost that had been stockpiled for up to 2 years was supplied, nutrient and carbon content had declined by about two thirds, diminishing many of the beneficial effects expected from compost use. To enable the best possible, tailored use of organic amendments, and prevent disappointment from lack of tangible benefits, both suppliers and users need to be aware of product characteristics, and changes that occur during prolonged storage. A standard chemical analysis from an accredited laboratory usually provides a good indication of potential benefits and risks. Compost and manure suppliers should have their products tested regularly, and users should request recent analytical results before making a purchase decision. Yet, as farmers often find it difficult to interpret laboratory analysis reports, this project also aims to improve the reporting platform, so that analytical reports for organic amendments provide meaningful information for farmers.

Also, a step in the right direction of transparency and providing users with product information is the declaration of minimum or average macro nutrient contents on packaging (Fig. 2-1).

Research Questions

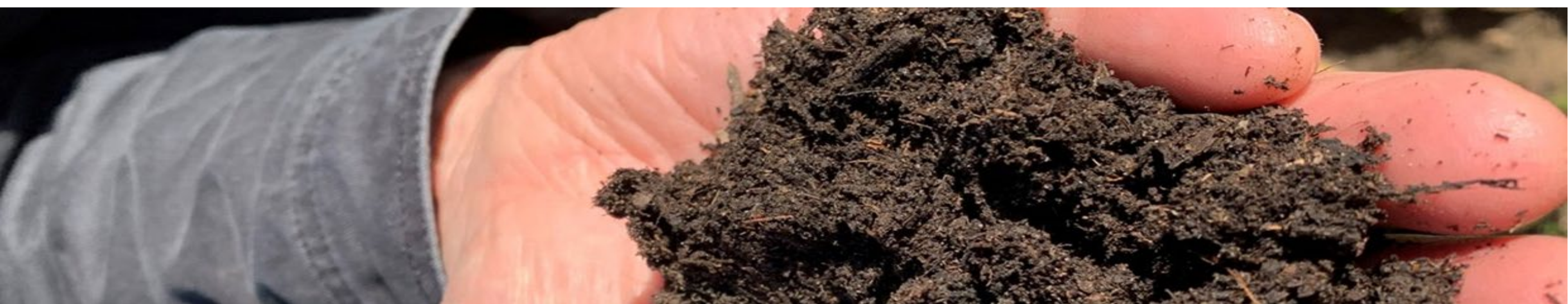
The spatial and quantitative (t/ha) distribution of applied organic amendments, i.e., spreading patterns, was assessed repeatedly at most large-scale demonstration sites in relation to the target application rates (Fig. 2-2). As can be expected, spreading patterns and distribution across the spreading area do vary markedly depending on physical productcharacteristics and type of spreaders used. The uneven distribution of the applied organic amendments results in obvious difficulties anduncertainties when it comes to soil sampling and small plot harvesting. It was

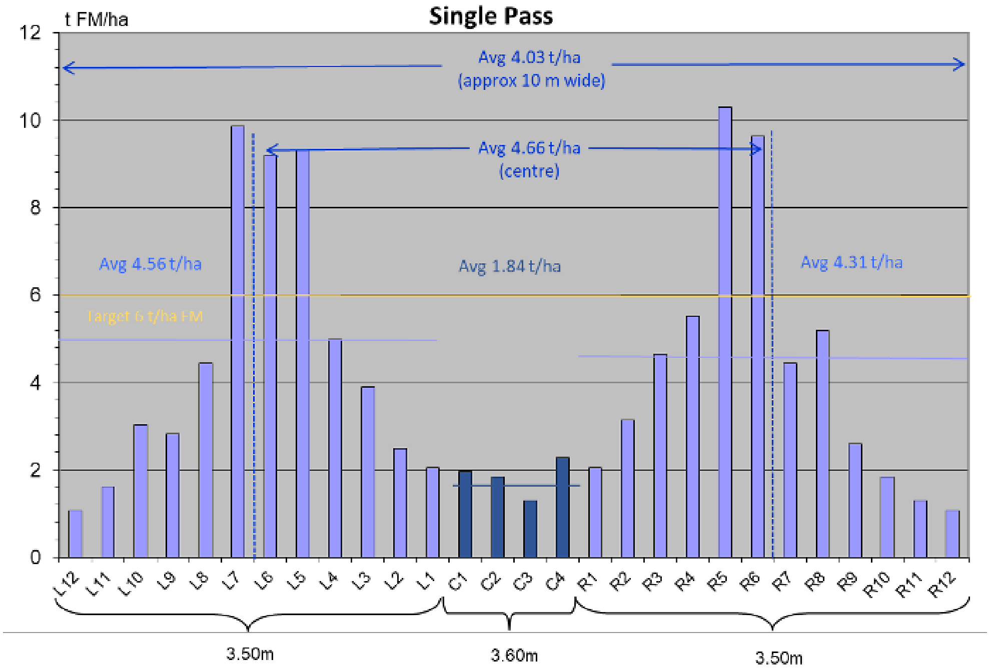
surprising to realise that actual application rates were often markedly different from target applicationrates, even with commercial spreading contractors. It was also noticed that several equipment suppliers do not provide guidance for equipment settings when compost is applied, while this guidance is available for manures, lime or fertilisers.

Fig. 2-1 Packaging for granulated feedlot manure compost

Belt spreaders with spinners are usually appropriate for applying compost, while manure spreaders with vertical or horizontal beaters are not. Spreaders that provide the best compost and manure distribution are so called universal spreaders, which have horizontal milling beaters, an adjustable tailgate and two spreading disks (Fig. 2-3). This kind of spreader prevents uneven spreading due to lumps of material shearing off in conventional belt spreaders that result in typical sequential high and low application rates within short distances by constantly milling off material as it moves towards the back of the spreader. The enclosed tailgate guides the milled-off material in a steady stream to the spinners at its base. This universal spreading technology distributes all manner of organic soil amendments as evenly as possible (Fig. 2-2). The ultimate control over spreading rates and patterns for screened, non-lumpy products however provide truck-mounted belt spreaders equipped with a digital spreading controller (Fig. 2-4).

Manure and compost application equipment that is ill-suited and results in uneven material distribution and applications that miss the target application rate by a significant margin jeopardise accounting for all benefits attributable to the use of organic amendments, regardless of whether it is nutrients, soil health or carbon.





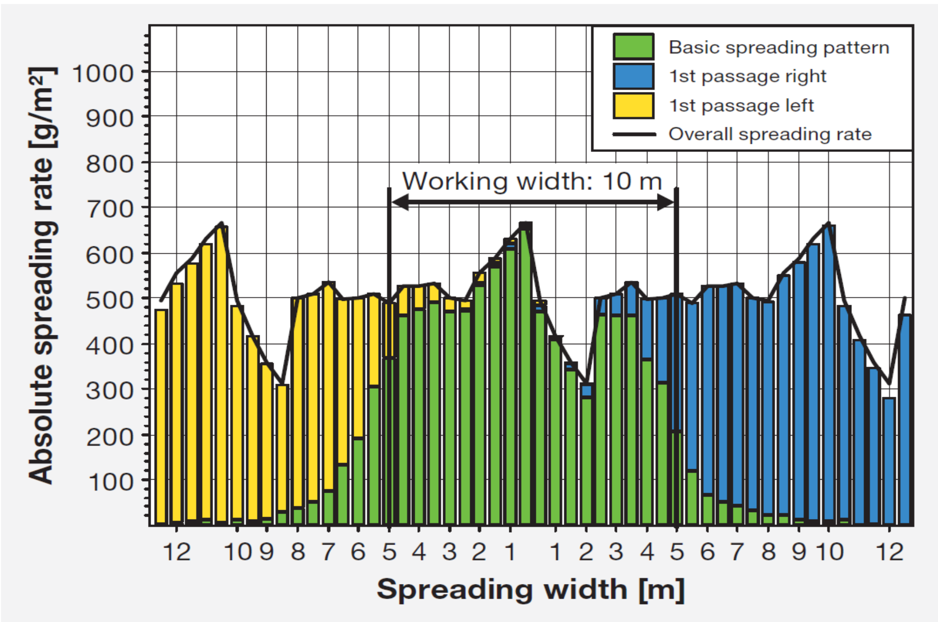


Fig. 2-2. Example of the spatial applicate rate (target: 5 t FM/ha) for composted layer chicken manure across the spreader width (10.6 m) with ill-suited spreader (top) and spreading pattern with universal spreader, also aiming at 5 t/ha application rate (bottom) (Source of bottom diagram: DLG (German Agricultural Society) Test Report, 2012) .

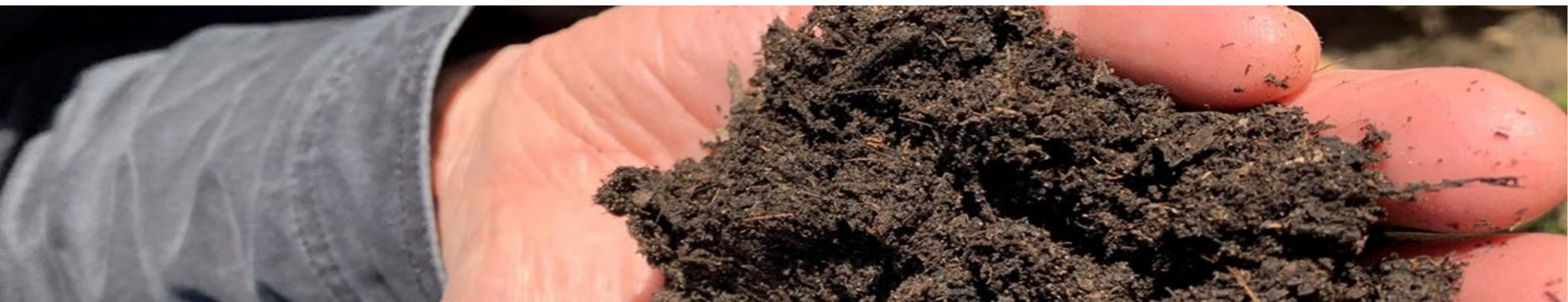
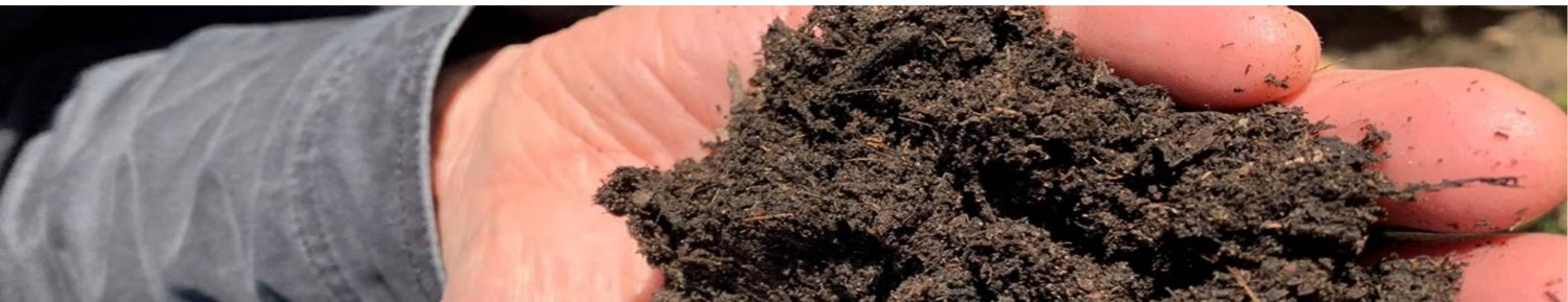


Fig. 2-3. Schematic drawing of universal spreader

Fig. 2-4. The cockpit of a modern, truck-mounted compost / manure spreader



Site	Organic amendments Animal manures (raw orcomposted)	Organic amendmentsupplier	Farm location	Trial type	Crops grown
1	Composted piggery pond sludge and feedlot manure	Organic Nutrients	Roma, QLD	Large scale	Oats for hay
2	Aged dairy manure Composted layer chicken manure Aged feedlot manure	Brown Farm Organic NutrientsMcLean Farms	Dajun, QLD	Large scale	Forage sorghum (cut for hay)
3	Aged litter from chicken breeding sheds Composted layer chicken manure Aged 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	Trial discontinued
5 and 6	Aged meat chicken litter Layer chicken manure	Bidgee Bulk Plc	Griffith, NSW	Large scale	Cotton
7	Auto nest chicken litter 9-12 months old	McNaughts Transport	Griffith	Small Scale	Cotton
8	Aged meat chicken litter	South East Organic Fertiliser	Werribee, VIC	Small scale	Fioretto, cauliflower, fennel
9	Aged meat chicken litter	South East Organic Fertiliser	Baxter, VIC	Small scale	Celery, corn (cover crop)
10	Aged meat chicken litter Pelletised meat chicken litter	Southeast Organic Fertiliser	Toolangi, VIC	Small scale	Strawberry Runners
11	Aged meat chicken litter Composted pig manure	Worland Mechanical Services Elmore Compost	Freshwater Creek, VIC	Large scale	Wheat
13	Feedlot manure Composted feedlot manure Chicken litter	Grassdale Fertilisers Grassdale Fertilisers Woodlands Fertilisers	Crows Nest, QLD	Large scale and small scale	Pasture renovation
14	Granulated feedlot manure compost	Grassdale Fertilisers	Grassdale, QLD	Large scale	Sorghum
15	Composted layer chicken manure	Organic Nutrients	Goovigen, QLD	Large scale	Lucerne, multi-species mix

	Urban derived compost				
4	Urban derived compost	Candy Soils	Mulgowie, QLD	Small scale	Trial site discontinued
7	Urban derived compost	Carbon Mate	Wagga Wagga, NSW (new trial site)	Large scale	Pasture renovation, oats for hay
8	Urban derived compost	Camperdown Compost	Werribee, VIC	Small scale	Fioretto, cauliflower, fennel
9	Urban derived compost	Camperdown Compost	Baxter, VIC	Small scale	Maize or Sorghum (cover crop)
11	Urban derived compost	Camperdown Compost	Freshwater Creek, VIC	Large scale	Wheat
12	Urban derived compost, bulk and granulated	Peats Soil and Compost Supplies	Brinkley, SA	Large scale	Wheat

Table 2-1. Organic amendments used in field trial and farm demonstration sites in 2021

Module 3: Optimising Management of Poultry Litter in Southern Cotton Production

Poultry litter from the Riverina's chicken industry has the potential to top-up fertiliser programs on 30,000 ha of cotton in the Murrumbidgee Valley. Poultry production farms are close to or within the southern cotton growing areas and poultry litter has useful levels of inorganic nitrogen, phosphorus, potassium, and micronutrients.

Nutrient and moisture content of poultry litter is variable, based on production, handling operations and storage. However, each tonne delivered to farm typically contains approximately 15 kg available nitrogen, 8 kg available phosphorus and quantities of trace elements such as zinc, manganese and copper.

The litter is sourced from poultry production sheds around Leeton, Griffith and Darlington Point and applied at 4, 8 and 16t/ha in conjunction with urea, to ensure the crop has enough nitrogen, and provides sufficient phosphorus to reduce the requirement of inorganic fertiliser sources for these nutrients. The quantity of available zinc in the litter also exceeded what is available in 1 L/ha of a liquid zinc fertiliser. The application of poultry litter, and urea, to the crop has no detrimental effect on productivity, lint yield or lint quality.

Case study – Whitton Field Station

Fig. 3-1. Cotton modules of different sizes from different trial treatments comparing combinations of urea and chicken litter with a conventional urea program, at the IREC Field Station, Whitton.

Summary of results (3 years)

- Poultry litter, sourced from chicken meat and layer sheds in the Riverina, can potentially reduce fertiliser applications and increase yields in cotton crops.
- A three-year study on a red-brown earth showed that poultry litter spread at 15 m^3/ha and incorporated in July/August, can offset 80 kg N/ha and 35 kg P/ha of nutrient traditionally applied by inorganic (mineral) fertilisers.
- Poultry litter can replace pre-plant fertiliser and reduce seasonal fertilizer costs by ~17-20% (2018-2020 figures).
- Over three years, the cumulative yield was highest in plots where litter was applied, which translated to increased revenue from yield, for that period, of $2,000/ha.
- Increasing the amount of litter N to meet the total crop N requirement did not result in significant carry over of N (0-30 cm) for subsequent seasons. Annual patterns of N accumulation were variable and likely caused by interactions between seasonal weather conditions, plant growth and N losses to the environment.
- Increasing the amount of litter N to meet the total crop N requirement resulted in significant carry over of potassium and phosphorus species for subsequent seasons which led to accumulation. These elements acted conservatively for chicken litter amendment and may present opportunity for soil tests to be used to quantitatively evaluate medium to long term impacts of litter amendment on soil fertilizer.
- There were no significant changes in soil (0-30 cm) pH, CEC or Zn for amended compared with non amended treatment after 3 years.
- There were no significant changes in microbial biomass-C or TOC in litter amended compared with non amended soils (0-30cm) although mineral fertilizer treatments presented the lowest values, suggesting these were less conducive environments for the promotion of microbial communities

Yield increase with annual litter application

For three seasons of back-to-back cotton, the cumulative yield for plots where chicken litter was applied (and supplemented with urea applications), compared with plots where just urea was applied, was 2.1–3.8 bales/ha more (Fig. 3-2). This equates to a potential increase of income of up to $2,000/ha over three years.

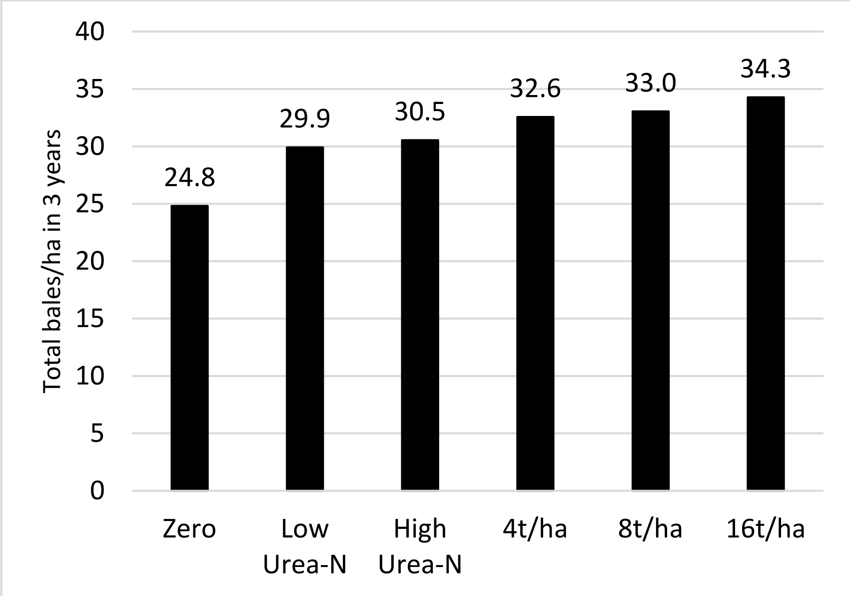


Fig. 3-2. Cumulative yield of commercially grown cotton (Var 714), for three seasons.

In Year 1 of the trial (2017–18), there were no significant differences in yield between any of the treatments other than with the control. The high urea application rate (300 kg N/ha) did not give significantly higher yields than the low urea rate (150 kg N/ha). In Year 2 (2018–19), the highest rate of litter (16 t/ha) gave an increase in yield of approximately 1.0 bale/ha, compared with the high urea treatment. In general, yields were lower in the second season than the first, which is often observed in back-to-back cotton. However, in the treatments with the highest rate of chicken litter, second season yield decline did not occur, suggesting manure has a place in back-to-back cotton production systems. In Year 3 (2019–20), the highest yields were achieved in all litter amended treatments compared with treatments of urea only

Estimates of cost benefits of using poultry litter in association with mineral fertilizer in cotton crop nutrient budgets.

Usually in commercial cotton crops around Griffith, 85 kg of N is applied pre-plant. A likely scenario may be that N would be applied with 150 kg/ha of urea and 140 kg/ha of Granulock Z, which also supplies 31 kg/ha of P. Amounts of nutrients supplied by poultry litter were 6 kg/m^3 of available N and 2.6 kg/m^3 of available P, indicating that 15m^3/ha of litter would need to be applied to provide the equivalent commercial mineral applications. Estimated direct cost of using 15m^3/ha poultry litter as a typical basal pre-plant source of nutrients compared with urea-N and mineral P are shown in Table 3-1. The prices shown are 2021 prices and clearly there are quite significant differences between the costs of using poultry litter compared with mineral fertilizer (up to ~$142/ha) for pre-plant fertilising. Throughout the trial the cost of litter delivered to the Whitton trial varied quite substantially. In 2019 it was 15.50/m^3 delivered and in 2020, it was only $6/m^3 delivered. Similarly, in 2018 and 2019, the price of urea was approximately $500/tonne while in 2021 it increased to $>700/tonne. The costs in Table 3-1 relate to the most recent (September, 2021) prices. If the cost

of urea was $500/tonne and included the costs of mineral P in Table 3-1 for comparison with that contained in litter, then growers would not see direct cost benefit in terms of nutrients, if the cost of poultry litter rose to more than $13.50/m^3.

Nutrient	kg/m^3	kg/15m^3 to act as pre-plant basal	Nutrient value $/kg	PL $/15 m^3/ha	Pre-plant mineral fertilizer (kg/ha)
Available N	6	90	***1.5	135	135
Available P	2.6	39	****3.2	124.8	#80.6
Poultry litter				*90	
Spreading costs				24	**40
Total costs				**114**	**256**

PL = poultry litter
*$6/m^3 delivered (Bidgee Bulk, delivered to Whitton, 2020).
31 kg of P as Granulock
** $40/tonne freight and spreading
*** 2021 prices
****price estimate can vary depending on P product used ($1.5 - $4/kg).
***** spreading cost varies according to contract or individual spreader rates ($2-$6/m^3).

Table 3-1 Estimates of the costs (Sept, 2021) involved for applying equivalent amount of pre-plant available nutrients required for high yielding cotton in the Murrumbidgee Valley, NSW, contained in chicken litter compared with mineral nitrogen and phosphorus.

Case Study – Gundaline Station, Carrathool, NSW

At Gundaline Station, Carrathool, NSW, poultry (chicken) litter (PL) was evaluated as an alternative starter P-fertiliser, when amending alone (4, 10, 15 t/ha) or integrated with monoammonium phosphate (4 t/ha PL+150 kg/ha MAP) compared with a standard practice of mineral P-fertilisation (150 kg/ha MAP) for cotton P nutrition and production in a grey vertisol.

Phosphorus fertilisation resulted in an insignificant increase in cotton lint and seed yields compared with non-fertilised control. The integrated 4t/ha PL plus 150 kg/ha MAP application produced maximum lint and seed yields among the P-fertilisers (Fig. 3-3). Soil P availability were consistent across different P-fertilisers, but the 15 t/ha PL resulted in 2-times more Colwell-P when compared with the control later during the season suggesting high PL application rate can supply P for an extended period of time that could have beneficial carryover effects in subsequent crops (Fig. 3-4).

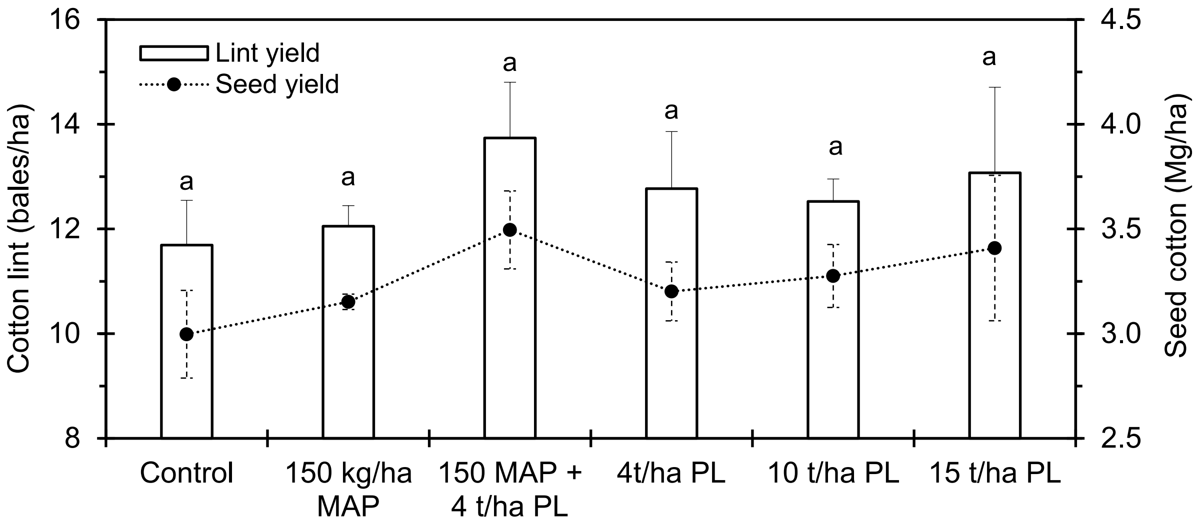


Fig. 3-3. P-fertilisers effect on cotton lint and seed yields at Gundaline Station, Carrathool, NSW

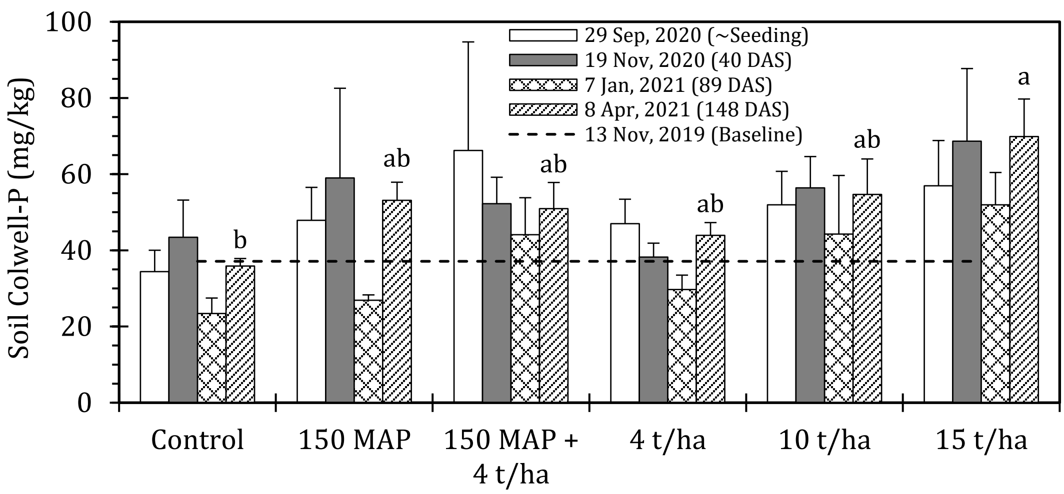


Fig. 3-4. Seasonal soil Colwell-P concentrations as affected by P-fertilisers at Gundaline Station, Carrathool, NSW.

The influence of poultry litter amendment on fertilizer 15N recovery and soil nutrient availability in an irrigated cotton field - Griffith, NSW

A field trial for cotton was designed to test the influence of poultry litter (PL) on fertiliser N uptake and loss in the soil-plant system, as well as track the release of supplemental nutrients under real-farm conditions. Specific research questions were 1) what is the optimum ratio of PL to urea-N fertiliser to maximise nitrogen fertiliser use efficiency and minimise N losses, 2) how much plant available nutrients are released from PL, and 3) is the timing of nutrient supply from PL and soil synchronised to meet the crop needs?

Method

A total of 32 microplots ($2m^2$) were established on a cotton farm in Benerembah, NSW (near Griffith). Plant nutrient supply was estimated for the top 15 cm of surface soil using using plant root simulator probe supply rates.

Timing of Nutrient release over the Cotton growing season

We found that most of the NH_4 derived from PL was released one week after litter application and incorporation, prior to any urea. Besides the initial two week period after PL application, PL did not have any significant effect on soil N supply over the rest of the growing season. The initial soil conditions at the field trial site had a good baseline store of mineral N (~125 kg N/ha within the top 0.2 m), which may be one of the reasons N treatments did not differ greatly from the control.

P and K patterns

Soil K and P supply rates displayed different trends over the growing season, but were both significantly higher in litter amended sites across all measurement stages. The highest soil K availability was seen in the first two months after PL application, while P supply steadily increased over time. Towards the end of the growing season urea-N rates appeared to have an effect on P supply rates, with highest soil available P observed in the highest urea-N treatment (300 kg N ha^{-1}).

Meeting the plants needs when it matters most

Plants were likely getting all their N requirements across all urea treatments during the key N uptake phase (Fig. 3-5). In fact, yield results from this experiment indicated that N inputs above 50 kg N / ha did not result in higher cotton yield. While PL provided significantly greater amounts of K and P compared to non-amended treatments, these supply rates in top 15 cm soil profile were only meeting 7% and 11% respectively of the crops needs during peak demand. The release of P from amended soils is controlled by many factors, including the forms of P compounds in PL, the absorption capacity of the soils, and the release of other nutrients.

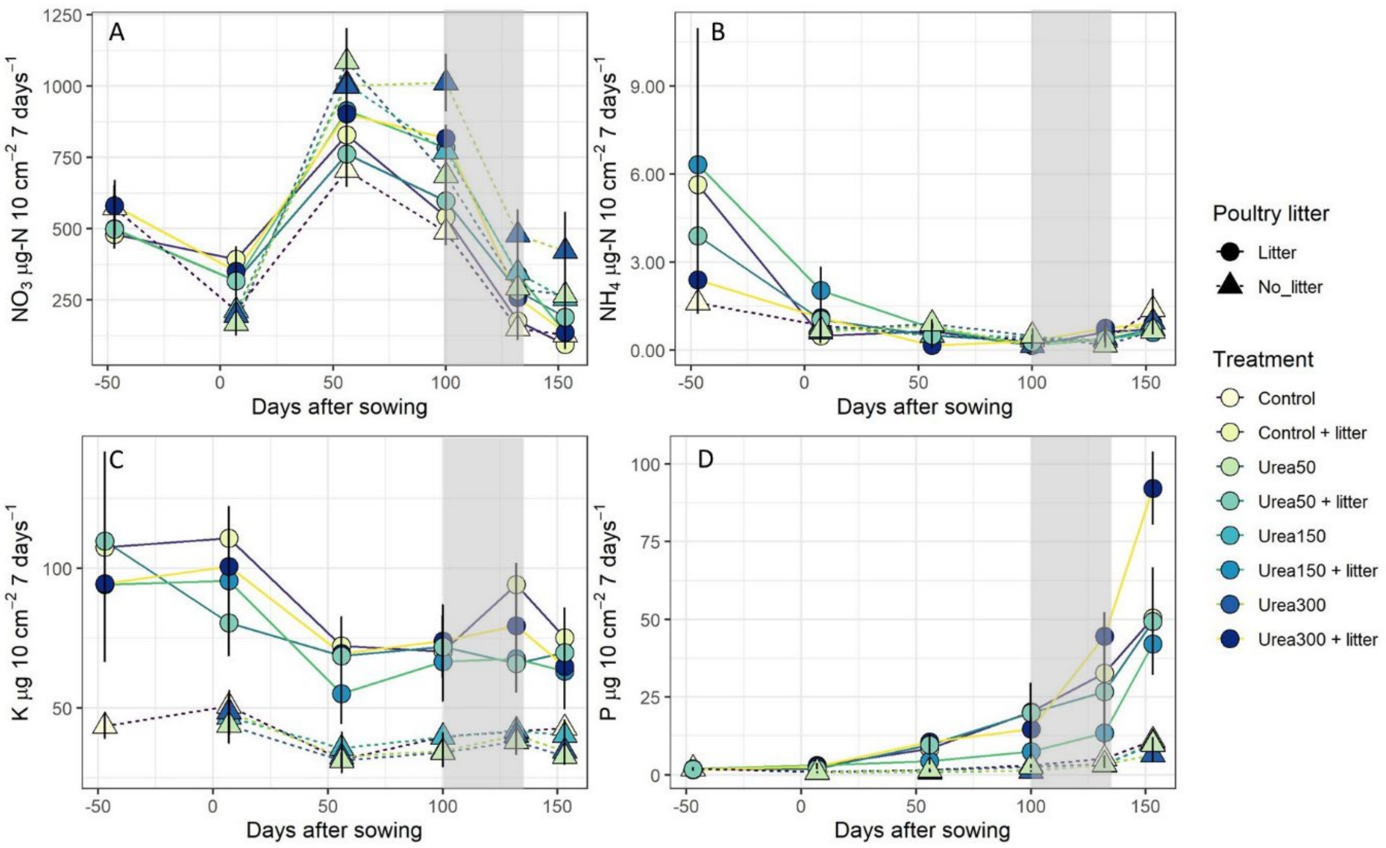


Fig. 3-5: Time series of soil NO3-N, NH4-N, K, and P supply rates across PL amended and non-amended urea treatments in field microplots. Shaded area indicates assumed period of highest nutrient uptake according to Rochester et al., (2012).

Module 4: Southern Vegetable Systems and Intensive Horticultural Crops Research, Demonstration Trials and Extension

Two long term field vegetable sites and a third site at a strawberry runner farm have been set up in Victoria 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 amendment treatments (e.g., chicken manure and urban 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 vegetable and strawberry cropping in the region.

At all vegetable sites the treatments have included; no fertilizer treatment (Control), standard inorganic fertilizer (Inorg), chicken litter (Manure) alone, urban compost (UC) alone, standard inorganic fertilizer combined with manure or UC and a reduced inorganic fertilizer program combined with manure or UC (Manure+Red Inorg and UC+Red Inorg). At the strawberry site the UC treatments were replaced with a pelletized chicken litter compost product.

Site 1: Baxter

Results from a second year of celery crop production (Fig 4-2) showed that yields in soils treated with organic amendments and reduced rates of fertilizers were equivalent to those in the full fertilizer treatment (Fig. 4-1). The manure only treatment had a higher yield at harvest than the control treatment while the urban compost (UC) treatment did not. This indicates that the manure is a better source of plant available nutrients than the UC, and has better prospects for reducing growers' requirements for inorganic fertilizers. **Manure amendment in soils treated with inorganic fertilisers increased nitrous oxide (N_2O) emissions to the atmosphere considerably relative to an inorganic only fertilizer program** (Fig. 4-3). This indicates that there are strong opportunities to capture more of this nitrogen for the crop through the use of nitrification inhibitors on fertilisers, or with other mitigation strategies

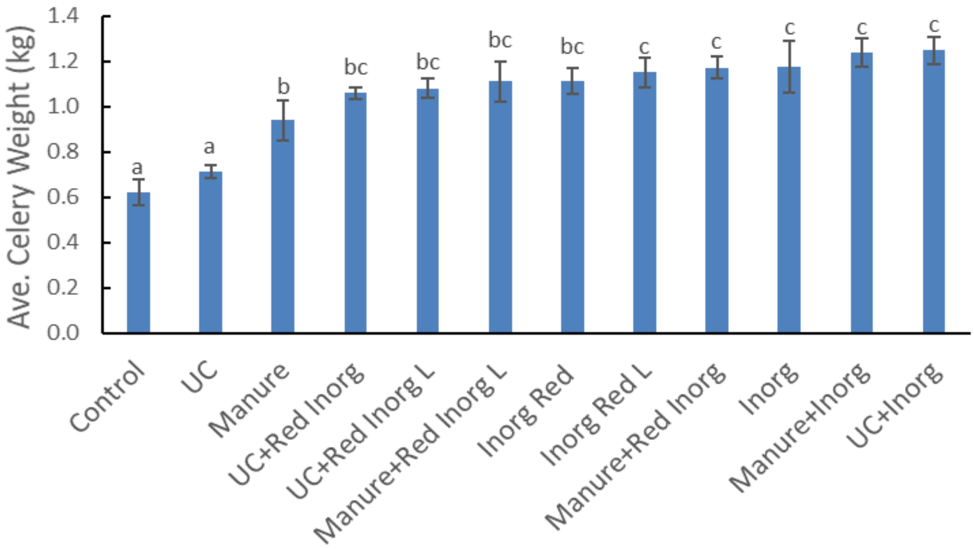


Fig. 4-1 Celery yield at Baxter site in year 2 (UC=Urban Compost, Red=Reduced rate, Inor=Inorganic fertilizer)

Fig. 4-2. Celery crop at Baxter, year 2

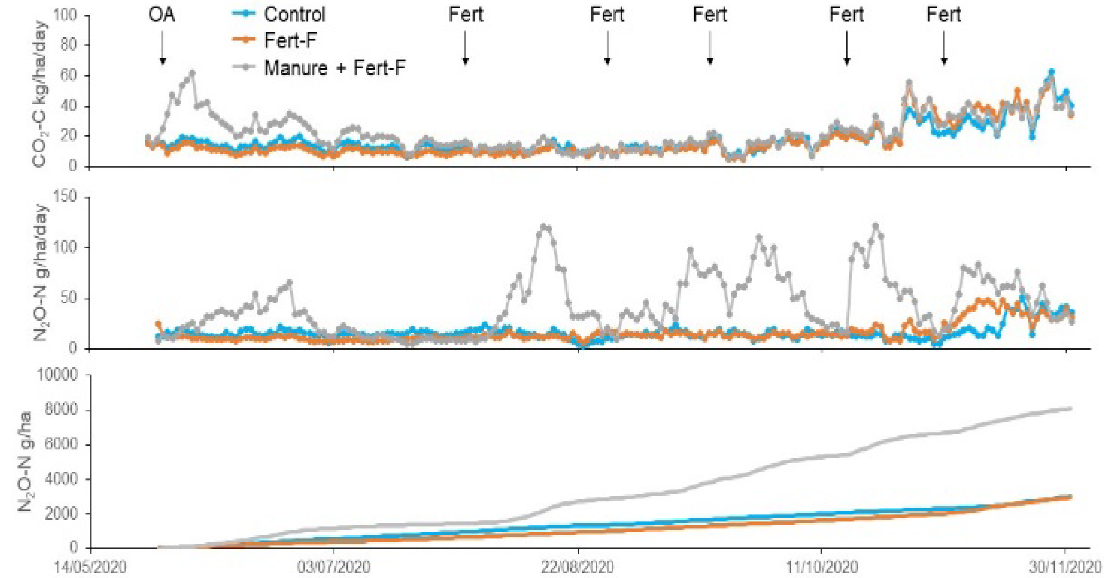


Fig. 4-3. Soil greenhouse gas emissions at Baxter, year 2

Site 2: Werribee

A cauliflower crop was grown following the previous fennel crop which received organic amendments prior to planting. There was a small but not statistically significant increase in yield for the manure treatment relative to the control treatment, indicating there is little carry-over nutrient supply from the amendment applied to the previous crop. There was no difference in yield for the urban compost (UC) treatment relative to the control treatment. Reduced inorganic fertiliser rates, with or without organic amendments achieved the same yield as the full inorganic fertiliser rate.

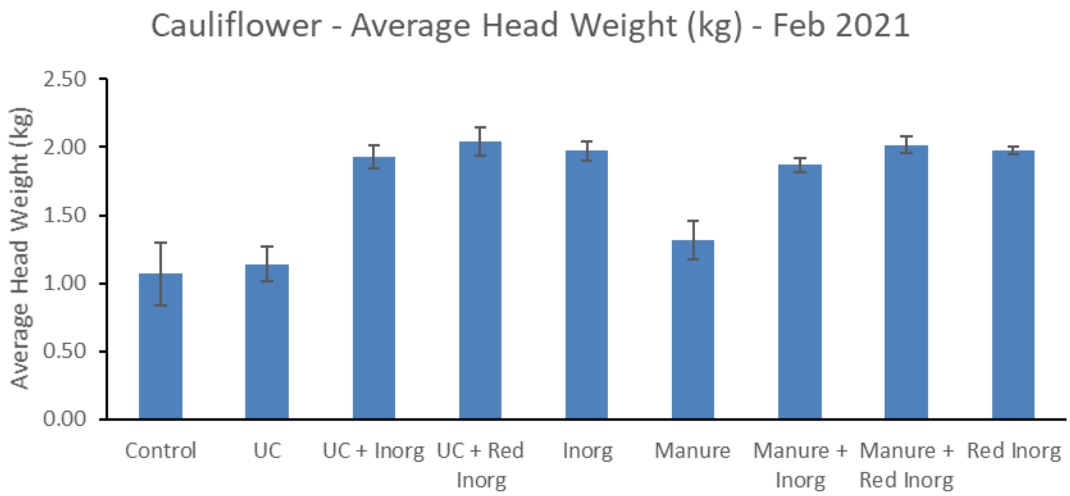


Fig. 4-4. Cauliflower yield at Werribee, year 2 (UC=Urban Compost, Red=Reduced rate, Inor=Inorganic fertilizer)

Site 3: Toolangi

A third trial site has been established at Toolangi, Victoria, at a strawberry runner farm. Organic amendments have been applied (chicken litter and a pelletized chicken litter product) and greenhouse gas emission measurements have begun using an automated chamber system (Fig. 4-5). It is expected that the use of organic amendments in the strawberry industry will have important implications for reducing synthetic fertiliser inputs for crop production. This is due to grower's current reliance on high nitrogen inputs from inorganic fertilisers, combined with their use of chemical fumigants that produces an ammonium-flush in treated soils.

Fig. 4-5. Strawberry runner trial at Toolangi, 2021

Module 5: Broadacre Cropping and Pasture

Broadacre cropping systems

Felton (QLD)

A new field experiment was established at the Felton site on 1 July 2020 with the incorporation of OAs and the planting of winter wheat in locations with high and low soil clay content. The field experiment comprised the application of 8t DW / ha of aged chicken litter from breeding sheds (CM) and feedlot manure (FM) in combination with urea as full N fertiliser rate (+CONV) or optimal N fertiliser rate, (+OPT, ~ 50% of full N fertiliser rate), as well as urea only at the full and reduced rate. Results indicate that the combination between OA (feedlot and chicken manures) and optimal N fertiliser rate closely matched the soil mineral N values observed in the CONV treatment while the standard farm practice of applying the full rate of fertiliser on top of OA application provided excess soil mineral N content (Fig. 5-1). At both locations (high and low soil clay content) the CM+OPT treatment provided the highest wheat yield (Fig. 5-2). However, marked differences were observed between locations in terms of average crop yield and crop biomass. This was most likely linked to differences in plant water availability.

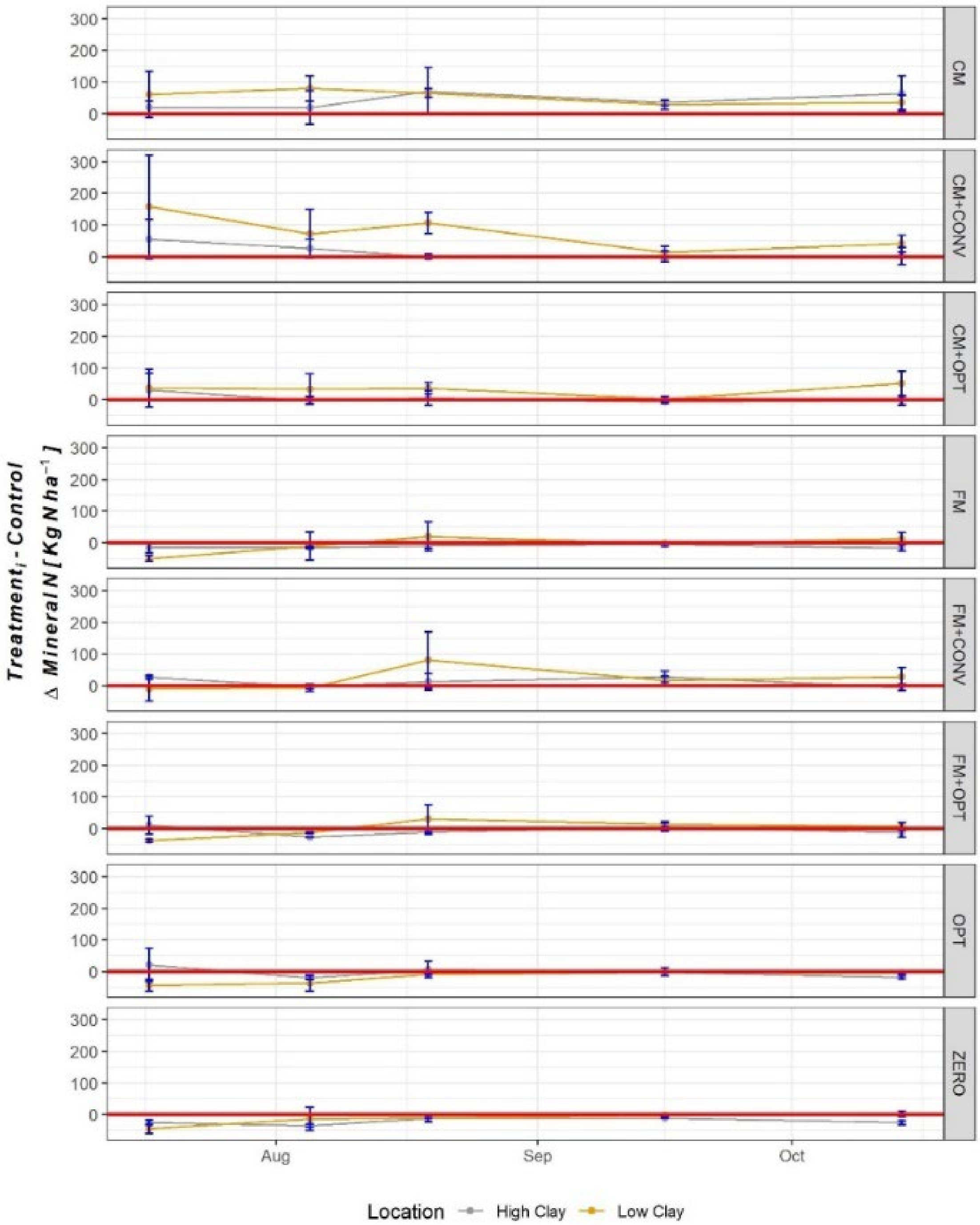


Fig. 5-1 Soil mineral N content during the wheat cultivation at Felton (QLD) site 2020. CONV= standard farm practice N; ZERO= no N application, FM=feedlot manure, CM =aged chicken manure; OPT=optimum N fertiliser rate calculated by accounting for the N release from OA.

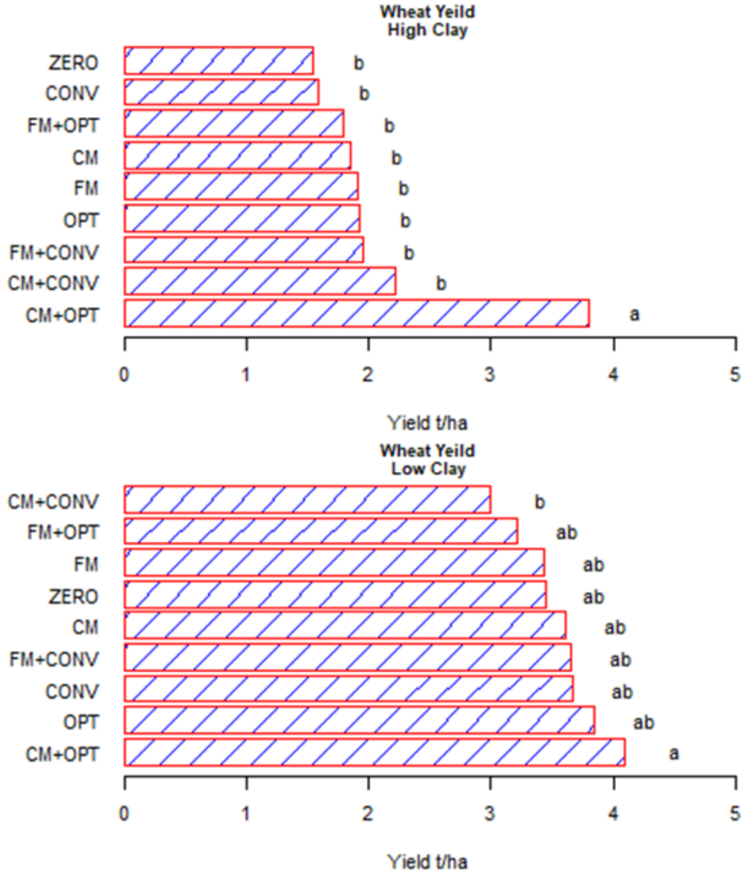


Fig. 5-2 Wheat yield at Felton (QLD) site 2020. CONV= standard farm practice N; ZERO= no N application, FM=feedlot manure, CM =aged chicken manure; OPT=optimum N fertiliser rate calculated by accounting for the N release from OA.

Roma (QLD)

At this trial site, compost made from piggery pond sludge and feedlot manure was applied in December 2018. Oats planted in early 2019 failed due to lack of rain, and were grazed to salvage the little biomass that was there. No biomass measurements were taken. The trial site remained uncropped until oats were planted again in March 2020 without repeat compost application. Soil mineral N levels were low prior to planting without any treatment differences (with / without compost at 5 t FM / ha and full, halve and zero mineral fertiliser). Due to variable soil and moisture conditions, plant growth (oats for hay) in the 180m x 180m trial area was very uneven in 2020 (Fig. 5-3), making representative harvesting of small sub-plots challenging.

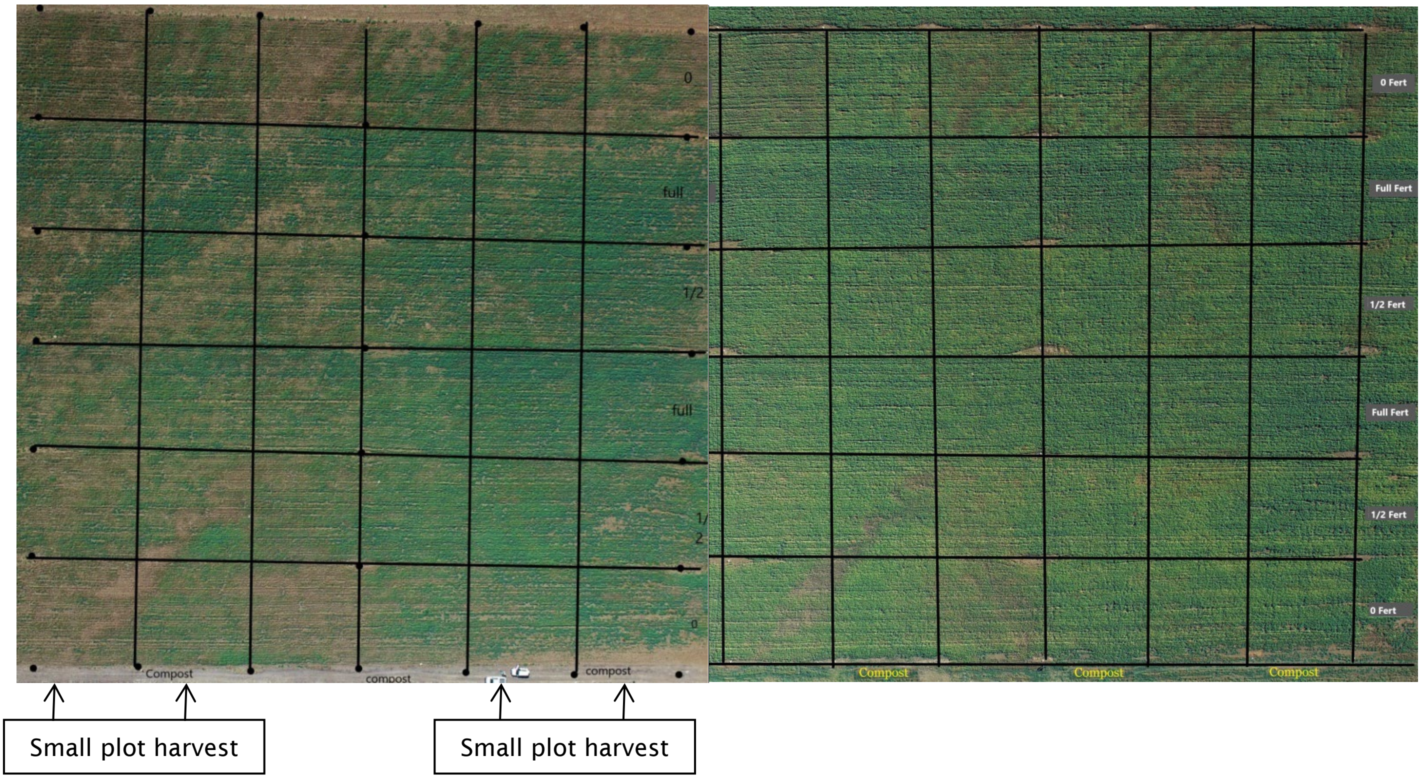


Fig. 5-3: Roma field trial site, overlayn with grid showing treatments prior to harvest in 2020 (left) and 2021 (right)

Subplots (3m x 3m) were harvested at the large-scale trial site to assess biomass yield. Across all fertiliser treatments, compost use increased dry matter yield by 14.8% (8.5% - 19.8%) (Fig. 5-4). However, due to large variations, treatments showed no significant difference. Compost use resulted in dry matter yield increases of 635, 363 and 820 kg/ha for zero, reduced and standard fertiliser use.

In early April 2021, the same type and quantity (5 t FM/ha) of compost was applied as was used previously. However, since the supplier had stored the compost for more than two years in the open, nutrient and carbon concentrations were reduced by about 2/3 of what they were at the end of 2018, delivering relatively small nutrient and carbon inputs. Oats for hay were planted again, but with increased mineral fertiliser rates than in previous years.

Subplots (1m x 1m) were harvested for assessing biomass yield. Across all fertiliser treatments, compost use increased dry matter yield by 7.3% (3.3% - 15.0%), although no significant treatment differences were observed due to large variations (Fig. 5-4). Compost use resulted in dry matter yield increases of 912, 249 and 348 kg/ha for zero, reduced and standard fertiliser use.

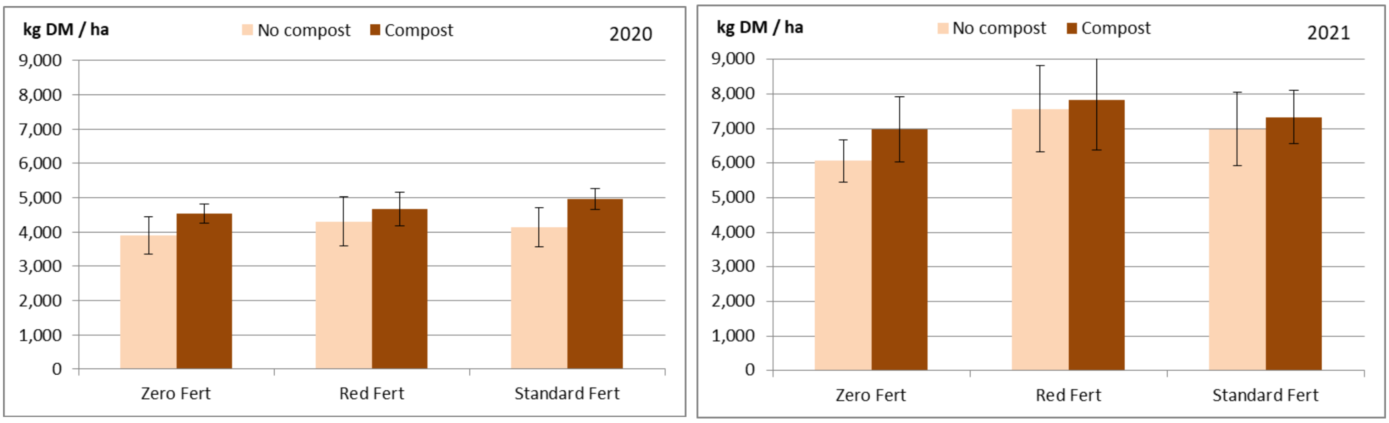


Fig. 5-4: Effect of compost use and variable fertilizer rates on oat biomass yields in 2020 and 2021.

Grassdale (QLD)

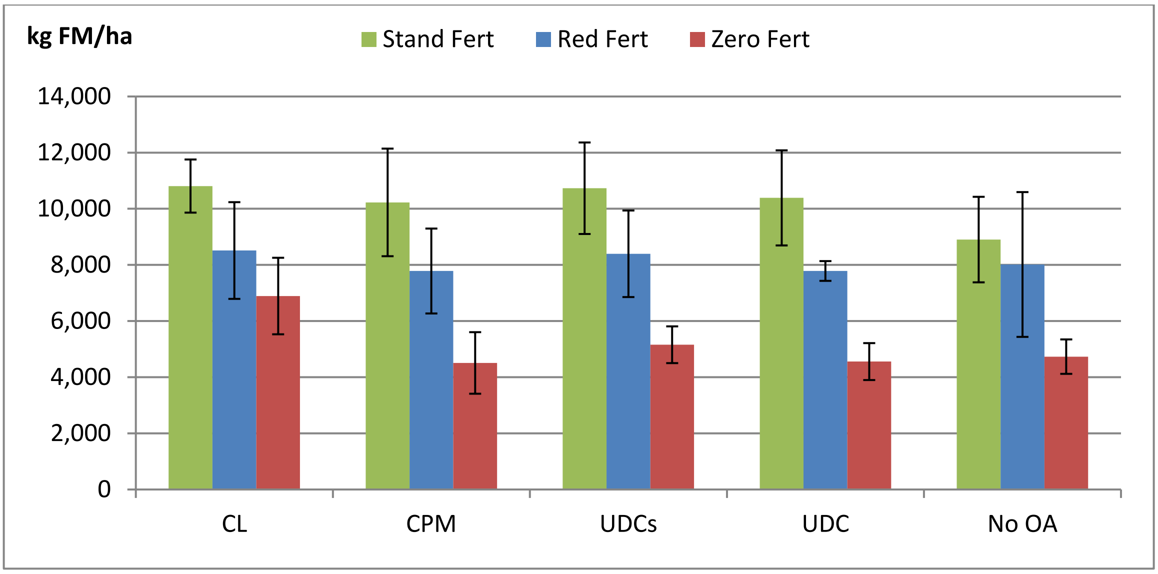
A new large-scale field trial covering two soil types (sandy and clay, each measuring 48m x 320m) was established in September 2020. Apart from standard base fertiliser (350 kg/ha Cotton Sustain) a mixture of base fertiliser and granulated feedlot manure compost was applied subsurface with an air seeder at two rates (Fig. 5-5). Due to malfunctioning irrigation equipment, planting of the trial area with sorghum occurred only in late January 2021. The trial harvest was delayed for several months due to wet weather and COVID restrictions.

Fig. 5-5: Sub-surface application of compost granule and fertiliser mixture with air seeder.

Freshwater Creek (VIC)

In early January 2021, subplots (2 x 1m^2) were harvested within the large-scale trial site (270m x 200m), which was planted with wheat in May 2020.

Preliminary fresh matter (FM) harvest yields are presented in Fig. 5-6. Results indicate that use of organic amendments resulted in increased yield when standard fertiliser rates were applied, but not when reduced fertiliser rates were used. Chicken litter showed markedly higher yield than other or no organic amendments when no fertiliser was applied. Treatments in which urban derived compost was applied at depth (ca 30 cm) only in the first year, showed similar yields to other treatments that had received organic amendments twice.



CL = chicken litter, CPM = composted pig manure, UDCs = sub-surface applied urban derived compost, UDC = urban derived compost, No OA = no organic amendments

Fig. 5-6: Effect of using various organic amendments and variable fertilizer rates on wheat biomass yield.

Canola was planted at the end of April 2021 together with 100 kg DAP, erroneously applied to all treatments. This occurred prior to soil sampling and OA application. Soil samples were taken between rows in early May and compost / manure was applied over the top without incorporation at the end of May 2021.

Brinkley (SA)

No sub-plot yield measurements were taken for wheat grown in 2020 since it was not possible to apply bulk compost as an appropriate compost spreader was not available. In contrast, a very good Jeantil universal compost spreader (Fig. 5-7; compare Module 2) was used in 2021. Urban derived compost was applied in early June 2021 at two rates (5 t FM/ha and 10 t FM/ha) after barley had been planted a few days earlier (29 May 2021) together with 80, 40 and 0 kg/ha DAP as standard, reduced and zero-base fertiliser rates, respectively. 50% of the area for each fertiliser treatment also received 100 kg FM/ha of granulated compost, applied with air seeder.

Fig. 5-7: Calibrating compost application rate with Jeantil universal spreader at Brinkley trial and demonstration site.

Pasture

Crows Nest (QLD)

A new trial was established on a beef cattle property near Crow's Nest, Queensland. Treatments were applied in early January to both small-plot trials and larger field plots (Fig. 5-8). The objectives of the trial were to determine the cost-benefits of applying OA's during the pasture renovation process – typically a once per 15–20-year event. Three different OA's were applied at different rates: composted feedlot manure (2.5 and 5.0 t / ha), raw feedlot manure (2.5, 5.0 and 10.0 t / ha) and chicken litter (2.5 and 5.0 t / ha). The trial will examine pasture yield benefits from the applied treatments on two different soil types as well as co-benefits such as increased soil carbon sequestration and mitigation of GHG emissions. Economic analysis and return on investment for each OA option will be considered.

Figure 5-8. Site preparation, manure spreading and GHG measurements at the new trial site near Crow's Nest, QLD.

Wagga Wagga (NSW)

A new trial and demonstration site near Wagga Wagga was identified to replace the previous site. The large-scale trial site (128m x 45m) forms part of a paddock that is renovated with the help of compost. 'Enhanced' urban derived compost was applied in 2021 and will be re-applied again in 2022 at a standard rate of 7.0 t FM/ha and a high rate of 14.0 t FM/ha to renovate the paddock (Fig. 5-9). Baseline soil samples were taken, and compost was applied in early July. Subsequently, off-set disks were used to incorporate the compost and turn the old pasture in, prior to oats being planted and fertilised with full, halve and zero mineral fertiliser rates.

Fig. 5-9: Compost application on old Lucerne/grass pasture prior to incorporation as part of paddock renovation.

Goovigen (QLD)

A new trial and demonstration site was established in Goovigen, near Biloela (QLD). Establishment and monitoring of the site is funded through the Commonwealth Future Drought Fund - NRM Drought Resilience Program. Results from this soil health demonstration trial will flow into the pool of results that inform building the nutrient calculator tool.

The farm hosting the trial produces primarily hay, and the large-scale trial comprises two identical treatment areas, one planted with Lucerne, and another planted with a tailored seed mix. Treatments include four rates of composted layer manure (0, 3, 6, 12 t/ha FM) and three rates of mineral fertiliser (zero, low and standard rate), replicated four times across each trial area. Baseline soil samples were taken in mid-July prior to composted layer manure being applied. Planting occurred a few days later with a Great Plains No Till seeder (Fig. 5-10).

Fig. 5-10: Great Plains No Till seeding drill (left) used to plant Lucerne and multi-species mix, shown after emergence (right)

Characterising and assessing pelletised and granulated organic amendments

Interest in the production and use of pelletised and granulated organic amendments has significantly grown in recent years. The widespread adoption of minimum till cropping systems resulted in these products now often left on the soil surface, where their effectiveness in enhancing soil properties and delivering plant nutrients is diminished. It may well be that many of the beneficial effects attributed to using organic soil amendments, such as improving soil properties and supplying plant nutrients, are not being delivered in minimum/zero till cropping systems.

Pelletised animal manures have been available for a long time, but these products primarily supplied niche markets and were usually too expensive for use in broadacre farming operations. The large-scale production of granulated compost products, which resemble granular fertiliser (Fig. 5-11), is seen as a game changer for broadacre farming. The granular compost products, which can contain additional macro and micro nutrients or soil ameliorants (e.g., gypsum or lime) and be blended with or applied alongside mineral fertiliser, provide minimum-till farmers with an opportunity to apply organic based fertilisers with existing air-seeding or strip-tilling equipment.

Fig. 5-11: Compost granules and granular mineral fertiliser.

Work was undertaken to characterise six granulated / pelletised compost products, and assess potential negative effects of these products on seed germination and early plant growth when applied in close proximity to seeds. Apart from a full chemical analysis, the following characteristics were determined:

- Moisture content, capacity to absorb and retain moisture,
- Leachate characteristics, including EC, pH, NO_3, NH_3, Cl, Na, Ca and other macro / micro nutrients
- Maturity testing: Solvita (CO_2 and ammonia evolution) and OxiTop (CO_2 evolution) testing
- Phytotoxicty Testing - effect of product distance on seed (corn) germination
  - effect on germination of cress
  - effect on germination and root elongation of radish

Laboratory and glasshouse tests showed various degrees of phytotoxic effects on seed germination and early plant growth (Fig. 5-12). These effects could be caused by elevated EC (salt) levels, high ammonium, chloride or sodium content, or the presence of phytotoxic substances contained in manure or immature compost products. However, phytotoxic effects were much less visible (sandy soil) or largely absent (clay soil) when granules / pellets were placed in the centre of 1L pots that were seeded with cress (Fig. 5-12). Negative phytotoxic effects on germination and early plant growth of silage corn were also not observed when compost granules were banded at rates equivalent to 900 kg FM/ha in a glasshouse trial (Fig. 5-13).

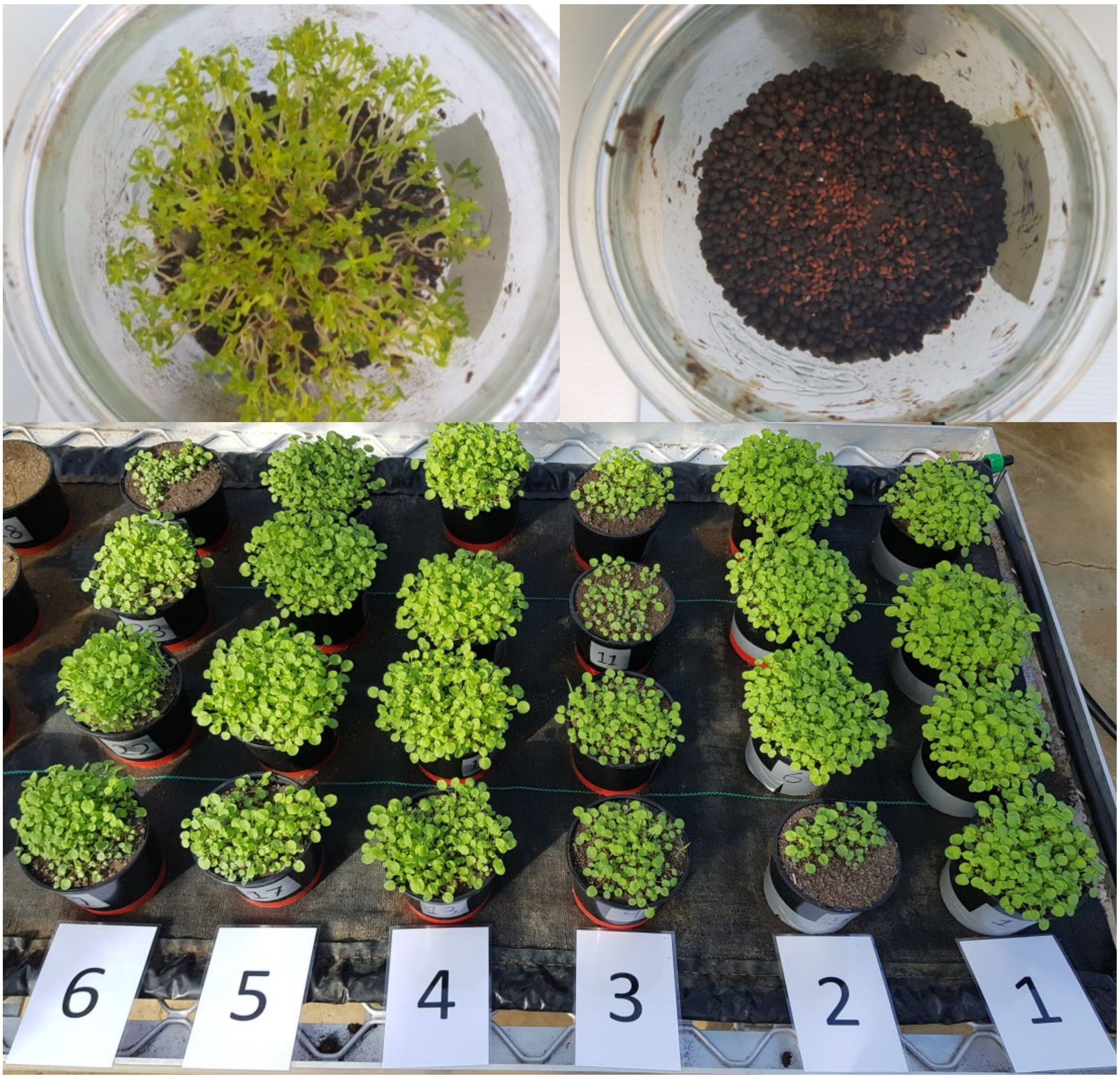
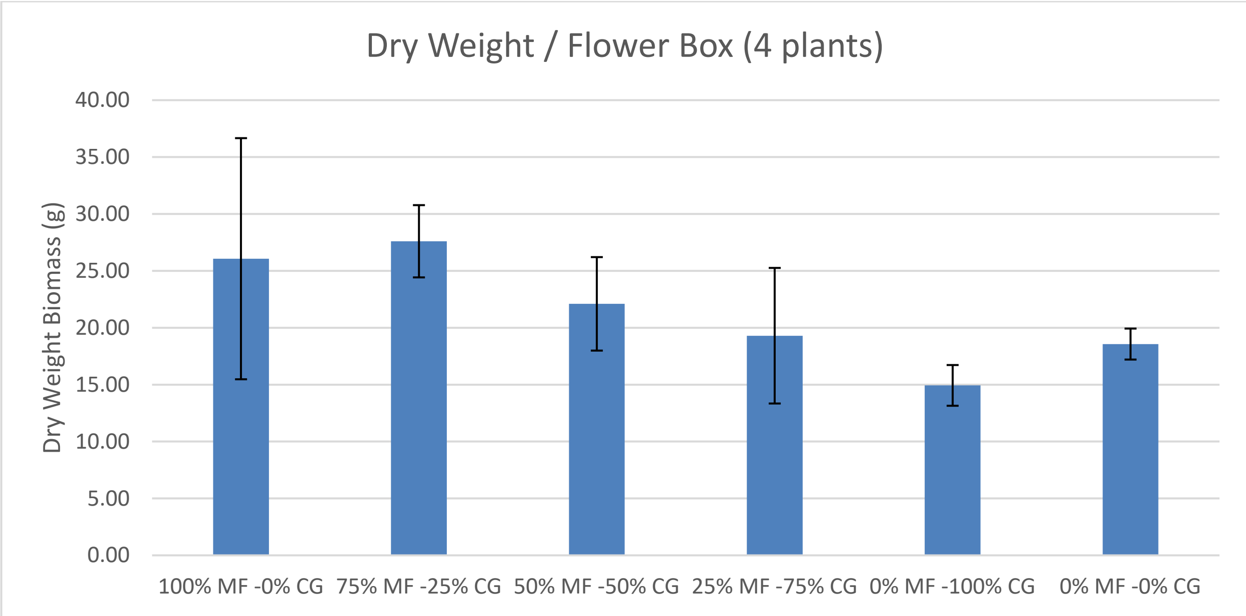


Fig. 5-12: Cress test in the laboratory (Top; left- control, right - pelletised / granulated OA) and glasshouse (Bottom; clay soil).

A glasshouse trial mimicking the banded application of fertiliser and/or compost granules was conducted to assess the potential of substituting mineral base fertiliser with compost granules in a sandy soil. Compost granules were applied at rates that approximately replaced 0%, 25%, 50%, 75% and 100% of N, P, and K supplied with 50 kg/ha of mineral base fertiliser. Estimates of N and P supply from compost granules was based on soluble nutrient content at time of application plus assumed release after application through mineralisation.

Silage corn biomass data, obtained 60 days after sowing, indicate that it might be possible to replace 25% of mineral base fertiliser with compost granules in sandy soil (Fig. 5-19) without yield penalties. However, low biomass yields in treatments with high (75% and 100%) fertiliser substitution indicate also that nutrient supply from compost granules was probably overestimated.

Fig. 5-13: Use of compost granules in glasshouse trial, mimicking banded application with air seeder



MF = mineral fertiliser, CG = compost granules

Fig. 5-14: Effect of mineral fertilizer / compost granule mixture on silage corn biomass in sandy soil.

Module 6. Communication and Extension

The following communication and extension activities were undertaken

- Presented a virtual talk at Australian Soil Association Soils 21 Conference, Cairns, QLD 27 June – 2nd July 2021. ‘Optimising the management of chicken litter in southern cotton production’.

- Virtual poster presentation Soil Association Soils 21 Conference, Cairns, QLD 27 June – 2nd July, 2021. Awale, R., Molesworth, A., Hornbuckle, J., Ballester, C., Quayle, W.C. (2021). Poultry litter applications increased cotton productivity in a landformed clay loam of the Riverina, NSW.

- Published article in Spotlight Magazine, Innovation Edition, Winter 2021 p. 25. ‘There’s money in manure if you know how to use it’. https://www.crdc.com.au/publications/spotlight-magazine-winter-2021

- 2 x Presentations at Australian Soil Science Society, ‘Parna and Cotton Soils Workshop, Yanco, 29-30 April 2021. Riverina Branch. https://www.slideshare.net/riverina_asssi

- ’Optimising the management of poultry litter in Southern Cotton’, Published article in Farmers Newsletter, 2020 Spring Edition, 204, p 25.

- Presented 15N trial at 2 field walks ‘Cotton Catch Up’ run by Cotton Info, Benerembah, Griffith NSW 17th November, and 4th March 2021.

- 4 x 4-page reviewed conference papers submitted and accepted to National Agronomy Conference, Toowoomba, QLD, postponed to February 2022.
  - Awale, R. Hornbuckle, J. and Quayle, W. (2021). Spatial patterns of CO2 fluxes across litter amended non-amended, and native soils on cotton farms in southern NSW.
  - Webb, J. Awale, R. and Quayle, W.C. (2021). Spatial patterns of CO2 fluxes across litter amended non-amended, and native soils on cotton farms in southern NSW.
  - Awale, R, Hornbuckle, J. and Quayle W.C. (2021). Can poultry litter supply adequate P nutrition to irrigated cotton in an alkaline vertosol?
  - Biala, J., Wilkinson, K., Henry, B., Shweta, S., Bennett-Jones, J. and De Rosa, D. (2021) The potential for enhancing soil carbon levels through the use of organic soil amendments in Queensland

- Compost calculator: knowing the value of organic amendments in your vegetable nutrition program in Victoria, Webinar - National Vegetable Extension Network, Wed 17th Feb 2021

- Improving organic amendment use in Australian vegetable production, 8th Global Nitrogen Conference, 30 May-3 June 2021 (online).

- De Rosa, D., Biala, J., Nguyen, T. H., Mitchell, E., Friedl, J., Scheer, C., Grace, P. R., and Rowlings, D. W. (2021). Environmental and economic trade-offs of using composted or stockpiled manure as partial substitute for synthetic fertilizer. Journal of Environmental Quality

- Biala, J., Wilkinson, K., Henry, B., Shweta, S., Bennett-Jones, J. and De Rosa, D. (2021). The potential for enhancing soil carbon levels through the use of organic soil amendments in Queensland, Australia. Regional Environmental Change 21:95

- Attended project kick-off field day in Goovigen (near Biloela, QLD) and presented “Using Organic Amendments for Soil Health and Plant Nutrition Benefits”