FINAL REPORT 2017/012

SOUTHERN SUGAR SOLUTIONS

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ABSTRACT

The Southern Sugar Solutions project was a novel project that linked research; development and extension activities that were being conducted by DAF with funding support from GRDC to monitor impact on the subsequent cane crop.

The project activities were governed by a local steering committee made up of growers, agronomists, and advisors. The committee met on an annual basis to discuss results, identify and prioritise issues that were local productivity constraints. The project team developed activities to address the committee's prioritised issues. Annual field days exposed the growers and advisors to the trials that were implemented to address identified issues.

Trials implemented highlighted opportunities to improve the productivity and profitability of sugar production in the Southern Canelands. The application of mill-mud/ash improved the cumulative sugarcane crop gross margin by $239/ha and improved cumulative sugar yield by almost 9%. The fallow management trial identified peanuts, soybean and pigeon pea were the most profitable grain legume rotations offering cumulative gross margins (legume break + plant cane + R1) of $4,228; $2,344 and $2,734 more than a monoculture respectively.

A total of 278 people participated in the three field days conducted by the project. Independent project impact report highlighted that 65% of growers interviewed had planned to implement an on-farm practice change as a direct involvement with the project.

EXECUTIVE SUMMARY

The Coastal Farming Systems Team of the Queensland Department of Agriculture and Fisheries (DAF) had secured Grain Research and Development Corporation (GRDC) funding to establish trails to address productivity constraints associated with growing grain legumes in sugar-based farming systems of the Coastal Burnett. Growers were frustrated that trials established in the grain phase of the cropping system could well benefit the subsequent sugarcane crop and that data was not being collected. A funding submission to Sugar Research Australia (SRA) was successful in allowing these data to be captured.

The Southern Sugar Solutions project was governed by a steering committee that identified and prioritised constraints in the grain cropping phase and prioritised trials where the subsequent sugarcane productivity would be monitored through the life of the project (three years).

The ‘Carbon Trial’ was initiated to determine the impact of organic matter additions (cane trash, mill-mud/ash and biochar) and their placement (surface incorporated or slotted at depth) on the break and cane crop performance, it was established in 2016. The ‘Fallow Management Trial’ was established to determine the ‘best’ legume crop to be grown in rotation with sugarcane in 2017. In 2018 problematic weed control in soybean crops and potential release of sulfonylurea (SU) herbicide tolerant soybean varieties offered the potential to control these weeds. However, growers were concerned that SU herbicides could have a negative impact on the productivity of the subsequent cane crop. As a result, the “SU Trial” was established to address these concerns.

The timing of these trials allowed the ‘Carbon Trial’ to be monitored for three cane crops (plant, 1st ratoon R1 and 2nd ratoon R2); the ‘Fallow Management Trial’ for the plant and R1 crops and the ‘SU Trial’ for the plant cane crop only.

All trials were established as small plot replicated field trials to allow for rigorous statistical analysis. All legumes were grown using current industry best practice with pests and diseases controlled with registered crop protectants once thresholds were met. The only exception was the SU trial where herbicides are yet to be registered for the soybean crop. Both the Carbon and Fallow Management Trials were irrigated with a high-pressure travelling irrigator, whereas the SU Trial was irrigated with a low-pressure boom.

Both the Carbon and Fallow Management trials were planted using a whole-stick planter with the seed cane sourced from the Isis Productivity Limited ‘mother plots’ to ensure disease free plant material. The SU trial was planted with a commercial billet planter and seed cane was sourced from Isis Cane Services EMDEX farm nucleus cane plots. All trials were established on 1.83m row configuration and all in-field tractor operations (except for commercial harvest) utilised a tractor on 1.83m wheel spacing with RTK auto-steer capability. All cane yields were determined by hand harvesting at least 18.3m^2 in each plot, with stalk count, individual stalk weight, total dry matter production, cane yield, CCS and sugar yield data collected, collated, and analysed from each plot.

Growers, farm managers, agronomists, advisors, and agribusiness were exposed to trial sites at the annual project field day / bus tour. This activity allowed for important peer-to-peer grower networking that was mentioned as a highlight to those surveyed in the independent impact report survey. 278 people were involved with this activity over the life of the project. Final trial results are scheduled to be delivered to industry in update meetings planned for June 2021 and to the Australian Society of Sugar Cane Technologist conference in 2022.

Outcomes from these trials have benefits that can be readily implemented and generate improvements in productivity, profitability and sustainability. The ‘Carbon Trial’ demonstrated that whilst the application of mill-mud/ash did not statistically improve the sugarcane productivity in any one year, it did result in an 8.94% increase in cumulative sugar yield (Plant + R1 + R2) when compared to the control. This response represents a $236/ha improvement in cumulative cane gross margin. The results from the Fallow Management Trial highlight that whilst all legumes significantly reduced populations of root lesion nematodes, Onyx mungbean significantly increased populations of root knot nematodes. Peanut, soybean and pigeon pea rotations provided cumulative crop cycle gross margins (rotation + plant cane + R1) of $4,228, $2,344 and $2,734 respectively more than cane monoculture ($417/ha). All of the other rotation options did not a cumulative crop cycle gross margin that was statistically better than a monoculture. The ‘SU Trial’ highlighted that herbicide strategies employed in the soybean cropping phase did not adversely impact on the productivity of the subsequent cane crop.

The concept of allowing growers to be actively involved in the identification and prioritisation of local RDE together with follow-up field days and update meetings has proven to be a good model to increase adoption of new techniques. The independent project impact report highlights that 65% of the growers surveyed planned to make an on-farm practice change and 90% of advisors changed the advice that they gave to growers due to direct involvement in the project.

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1. BACKGROUND

1.1 Yield Decline

Yield decline is defined as the loss in the productive capacity of sugarcane soils under long-term monoculture (Garside *et. al.* 1999). There has been significant investment into this issue from SRDC, BSES, QDPI and QDNR through two phases of the Sugar Yield Decline Joint Venture (SYDJV). This vast body of work highlighted that the chemical (Bramley *et.al.* 1996), physical (Ford and Bristow, 1995) and biological (Magarey and Croft, 1995) status of the soil had been degraded under the traditional sugarcane farming system.

As a result, the SYDJV advocated that a sustainable sugarcane farming system had to be supported by four key components: legume rotations, reduction in tillage, controlled traffic and trash retention.

Legume rotations significantly improve the productivity of the subsequent cane crop (Garside *et.al*. 1999) and improve soil health by increasing beneficial soil biota (Pankhurst et.al. 2003; Stirling *et.al*. 2001). The more favourable climate in proximity to markets makes grain legume production a viable proposition in the Bundaberg, Childers, and Maryborough districts (Bell *et.al.* 1998).

Cane trash retention improves the soil carbon status (Bell *et. al*. 2001) and provides a labile carbon source essential to the development of soil suppression against plant parasitic nematodes (Stirling 2008).

Controlled traffic and reduced tillage technologies have the potential to significantly improve the profitability of sugarcane farming (Braunack *el.al.* 1999; Halpin *el.al*. 2008). The SRDC/GRDC investment into improving the integration of legumes in grain and sugarcane farming systems in Southern Queensland project evaluated trash and tillage management options when transitioning in and out of the legume break crop phase (Halpin *et. al*. 2013).

Grain legume production offers income diversification as well as reduced input costs to the subsequent sugarcane crop through legume nitrogen fixation. Because of these benefits there has been significant sugar industry support for the development of the grain legume industry in the region; examples of which are the formation of the Grain in Cane Co-operative in 2008 by Bundaberg CANEGROWERS and agronomic support by the Isis Sugar Partnership (CANEGROWERS Isis, Isis Central Sugar Mill and Isis Productivity Limited) (Target 100). This effort has been rewarded with a stable core group of farmers growing ~ 2,500ha of soybean and ~1,000ha of peanuts annually for grain production. The Peanut Company of Australia has received 4,990ha of peanuts over the past 5 years injecting another $25M into the farming community. This represents a 532 tonnes of urea fertiliser reduction to the plant cane crop if growers reduce their nitrogen inputs by 70kgN/ha, in that 5-year timeframe

It is also worth noting that the favourable climate and access to irrigation has resulted in the emergence of competing tree cropping industries with approx. 9,220ha of macadamia and 2,790ha avocado orchards (Dr Andrew Robson pers. comm.) in the region with another 800ha expansion planned for the coming three years. For sugar factories to remain viable, more marginal soils are being brought into cane production to make up for land losses to other crops. These marginal soils are typically low in organic matter and nutrient and water holding capacity.

The Grains Research and Development Corporation (GRDC) has recognised the expansion of grain legume cropping in the sugar-based farming systems of the Coastal Burnett. The GRDC has invested in the Coastal grower's solution project for Queensland and Northern NSW (DAQ00184) and more recently that project has been expanded to include the Burdekin in the GRDC Growers solution project for Coastal/Hinterland Queensland and the NSW North Coast (DAQ00204).

The GRDC grower's solution project is all about finding local solutions for local grain growing issues and it is the link between regional research and localised development resulting in fast-tracked locally relevant outcomes to research questions that help growers and agronomists to make decisions on-farm and result in practice change that will increase farm production and profitability. As part of this charter this project is linked to Dr Seymour Optimising nitrogen fixation in grain legumes Northern region (DAQ0081); Prof. Bell's Regional soil testing guidelines for the Northern grain s region (UQ00063); Dr Rachaputi Queensland pulse agronomy initiative to increase reliability and yield of summer and winter pulses (UQ00067) projects; as well as the peanut and soybean improvement programs.

The GRDC grower's solution project is managed by an overarching steering committee, with a regional committee in each of the nodes (Coastal Burnett; Burdekin; Inland Burnett and Grafton). The Coastal Burnett regional committee consists of sugar producers from the Bundaberg, Isis and Maryborough sugarcane supply districts, representatives from the productivity boards, agronomists and managers of the corporate mill farms.

Typically, the project will implement up to four field trials annually to answer specific research questions. Some of the experiments implemented have investigated productivity/profitability impacts of row configurations, population, irrigation frequency, fungicide application strategies, general and specific nutrition as well as the addition of soil ameliorants. Given the transition to more marginal soils soil ameliorants have become an increasing focus of the group. For example, this season (2016/17) a large field trial has been implemented investigating the impact of four carbon sources (Nil, mill-mud, cane trash and biochar) by two placements (surface applied or slotted at depth), to determine treatment impact on productivity.

The Coastal Burnett regional committee are increasingly frustrated that the subsequent cane crop that is planted over these existing experiments is not monitored and the productivity documented, especially given the focus on improving cane productivity after the legume crops. The Chairs of the three CANGROWER organisations and CEOs of the sugar factories have written to SRA, expressing their concern of not capturing the farming system benefit of these established field experiment sites.

This project is targeted at addressing that knowledge gap. To achieve this goal and to improve research capacity in the region a junior agronomist will be appointed to conduct the sugarcane crop cycle and report on crop performance. This project will be managed by a local steering committee so that industry is involved in the RDE process.

1.2 Rationale for the Southern Sugar Solutions Project

Growers in the Southern region have embraced grain legume rotations to improve the sustainability of their farming system. In recognition of grain production in sugar-based farming systems the Grains Research and Development Corporation (GRDC) has Funded the DAF lead 'Growers solution project for Coastal/Hinterland Queensland and NSW North Coast' DAQ00204. Each node of this project has a steering committee of growers and agronomists that identify and prioritise project activities. All of the growers on the project steering committee are also sugar growers. Growers are becoming increasingly frustrated that the impact of trials established during the legume (GRDC) phase cannot be measured in the subsequent cane crop. This proposed Southern Sugar Solutions project is envisaged to run in parallel to the GRDC project to capture treatment effects on the subsequent cane crop. The CEOs of the three sugar milling companies and Canegrower organisations have written a letter supporting this project in the Maryborough/Childers/Bundaberg region. The appointment of a Junior Agronomist to the project will be a vital boost to this regions capacity to conduct robust field trial experimentation.

2. PROJECT OBJECTIVES

2.1 Specific Research Objectives

This project's specific research direction was set on an annual basis by the project steering committee. The steering committee was made up of growers, advisors and agronomists from the Maryborough, Childers and Bundaberg sugar factory cane supply districts. Sugarcane trials were established on sites that were initiated under the GRDC phase to determine treatment effect on the subsequent sugarcane cycle (plant and ratoon crops). In the following years of the project the steering committee will select one more GRDC trial site to be monitored through the sugarcane cycle. The trials were showcased to the wider growing community at an annual field day event. The inclusion of growers, advisors and agronomists in the research process, together with the annual field day event is expected to improve knowledge transfer and adoption; thereby improving grower profitability.

1.1.1 Specific Trial Objectives

The ‘Carbon Trial’ was initiated to evaluate if the additions of organic matter (cane trash, mill-mud and biochar) or placement (surface incorporated or slotted at depth) would improve the productivity of grain legumes (peanut and soybean) and the subsequent cane crop. This trial was conducted on a marginal soil (yellow dermosol) with low water and nutrient holding capacity.

The objective of the ‘Fallow Management Trial’ was to identify the best rotation option to be implementing in the sugarcane farming system. This was based on growers reporting much higher sugarcane productivity (10tc/ha) following variety Kairi peanuts compared to variety Holt. Similarly, the consensus among growers is that there is better cane productivity following peanuts, compared to soybean.

The ‘SU Trial’ was implemented to determine the impact of herbicide use strategy employed in the soybean-cropping phase would have on the subsequent sugarcane crop. The driver for this activity was the development of soybeans with increased tolerance of sulfonylurea herbicides. Growers were concerned that these new herbicides could pose a productivity constraint to their cane crops.

3. OUTPUTS, OUTCOMES AND IMPLICATIONS

3.1 Outputs

There were three outputs listed in the research agreement i). Steering committee meeting where trial data was disseminated to the committee allowing prioritisation for subsequent year activity; ii) Annual field day / bus trip to the sites; iii) Results will be shared with the wider industry through ASSCT papers/posters. Furthermore, the opportunity was taken to engage an independent 'Impact Report' that was conducted by Coutts J&R Pty Ltd.

The steering committee meetings were well attended. The 'Impact Report' highlights that members were satisfied with opportunities to provide input into project RDE process, with an average 7.4/10 satisfaction rating. Growers on the steering committee had a satisfaction rating of 8/10, advisors 7.3/10 and others 6.7/10. Overall, steering committee members were happy with the level of industry participation in the project with a 7.2/10 satisfaction rating; again, growers were more positive with industry participation rating the project 8.4/10.

Annual field days were very well attended with 278 attendees over the three years of the project (113 in 2018; 65 in 2019 and 100 in 2020). Field day participants were asked to provide a feedback survey at the end of the day. Most people (94%) reported that they had increased their knowledge by attending and an average of 51% of people over the three years reported that they had plans to make changes to their farming system based on the project (60% in 2018; 50% in 2019 and 43% in 2020).

The sharing of results to the wider industry will occur outside the term of the project. Industry updates are planned for mid-late June 2021. Trial summary reports (appendix 2) are draft papers intended for submission to the 2022 Australian Society of Sugar Cane Technologists (ASSCT) conference in Mackay.

3.2 Outcomes and Implications

At the project concept level, the Impact Report surveyed 58 attendees of the project's events (steering committee meeting and annual field days). These 58 survey participants manage 127,600ha of caneland in the Bundaberg Sugar, Isis Central Mill and Maryborough Sugar Factory cane supply districts. Some of the key findings of the survey were that the DAF team delivered the project well with a high level of consultation and communication with industry. The project successfully involved the Southern sugar growing community in the research process and achieved a reasonable level of industry participation. DAF successfully provided a link between GDRC and SRA research, highlighting DAF's role in bringing together the different organisation and resources to complete the trial work.

The impact report documents clear evidence that the project has increased participants knowledge, understanding and skills relevant to their business, with particular mention to soil health, compaction, fertiliser and better understanding of the economics associated with rotational cropping.

17 of the 26 growers surveyed (65%) in the impact report indicated that they had made changes to their farming system as a result of engaging in project activities. 10 of the 11 advisors surveyed made changes to their advice to growers as a direct result of project participation.

The impact report also identified that the survey participants would have liked more sites, bigger scale demonstration activities and that a similar concept should be rolled out across other sugar growing districts. There was also mention of the length of time that trials run for with respondents wanting a productivity data captured further into the cropping cycle.

The 'Carbon Trial' identified the addition of organic matter had no impact on the productivity to the grain legume crop or any individual cane crop, analysis of the cumulative sugar yield (plant + R1 + R2) demonstrated an 8.9% increase in sugar yield was achieved through the application of mill-mud/ash blend. This productivity response was potentially due to addressing available silicon levels at this site.

The 'Fallow Management Trial' highlighted a number of outcomes. There was no evidence that peanut rotations improved subsequent sugarcane productivity relative to soybean rotations. Red Caloona cowpea provided the highest nitrogen contribution to the subsequent cane crop as all the other legume species were harvested for grain. However, the subsequent plant and R1 crops in the Red Caloona plots were not statistically more productive than the cane monoculture. The cumulative gross margin of peanuts was $4,645/ha compared to cane monoculture $417/ha. Soybean and pigeon pea rotations had significantly higher cumulative gross margin of $2,891 than continuous cane. All other rotations (Mungbean, bare fallow, Red Caloona cowpea) did not provide a cumulative gross margin that was statistically better than continuous cane. These data suggest that a legume decision support tool would be advantageous to growers and advisors to maximise financial returns to growers.

Results from the 'SU Trial' demonstrated that herbicide strategies employed in the soybean cropping phase did not adversely impact on the productivity of the subsequent sugarcane crop. However, this one field trial highlighted that the selection of soybean variety in the legume rotation phase has the potential to affect the productivity of the subsequent sugarcane crop. The rotation with soybean variety Kuranda resulted in significantly less cane and sugar yield compared to a rotation with soybean variety A6785. The reduction in productivity could not be explained by plant parasitic nematode, residual herbicide or nutritional samples collected. Further experimentation is required to determine the repeatability of this result; and if repeated, determination of the causal agent.

4. INDUSTRY COMMUNICATION AND ENGAGEMENT

4.1 Industry engagement during course of project

This project has had significant industry engagement. Initially with grower, advisor and adoption officer involvement in project steering committee meetings in 2017, 2018 and 2019. Interim results have been shared at annual update meetings (August 2017, 2018 and 2019). March 2018 annual field day / bus tour involved 113 attendees. Surveys were handed out at the end of the day. Whilst only 61 attendees responded results demonstrated a 93% increase in knowledge, 37% of those registered a 75% increase in knowledge as a direct result of the day; 64% of attendees were growers; 100% agreed with linking GRDC and SRA projects.

Southern Region Group meeting in August 2018 organised by SRA adoption officer, provided an opportunity to update growers and advisors of the interim results from the 'Carbon Trial'

A 'Southern Coastal Farming Systems closed group' Facebook page was initiated to keep the local farming community abreast of the team's day-to-day activities. This has been a great vehicle to showcase the amount of work that goes into field trial experimentation. Currently there are 78 members of the group.

March 219 annual field day had 65 attendees with 52% being growers. Survey results highlighted a 95% increase in knowledge as a result of attending the field day. Encouragingly 50% of respondents were considering making a practice change as a result of attending the day. Changes under consideration were implementing legume fallows and altering row configuration.

December 2019 the Southern Group Bus Tour, co-ordinated by SRA adoption officer and funded by Enhanced Education and Extension Project visited the 'Fallow Management Trial' field trial site. The 44 attendees were exposed to the trial and interim results

November 2019 Soil Health Legume Agronomy Roadshow was organised through the SRA soil health project. The interim results from the Southern Sugar Solutions project were showcase to 185 Burdekin growers at four locations. Growers were very interested in the project and wanted a similar approach for their district

The 2020 field day was conducted just prior to Covid19 lock-down. There were 80 attendees, 62% of whom were growers managing 7,523ha of caneland. A further 290,650ha of land influenced by agronomists / extension officers that also attended. 43% of the growers identified changes that they planned to make actual practice change as a result of attending the event.

4.2 Industry communication messages

Final trial results are planned to be delivered to the Bundaberg, Childers and Maryborough farming communities in late June 2021. The trial results reports (appendix 2) will be developed into papers to be presented to the Australian Society of Sugar Cane Technologists conference in Mackay 2022.

5. METHODOLOGY

5.1 Overall project methodology

This project will have two main components; the first component is the field trial program, the second component of this project is enhanced grower/industry participation in the project.

Methodology: field trial program

This will be driven by a project steering committee consisting of Growers, Agronomists, Researchers, Productivity Officers and Advisors from the Bundaberg/Isis/Maryborough mill supply areas. The committee will meet annually to review the results of the field trials that were conducted as part of the GRDC 'Grower's solution project for Coastal/Hinterland Queensland and the NSW North Coast' activity. Typically, the GRDC project will establish four to five field trials every season. The task of the steering committee is to select one in the first year and one site in the subsequent years. To facilitate this process each committee member will then vote on what they determine are the top three GRDC trials that they would like the subsequent sugarcane productivity monitored on. Each vote will be weighted; nominally 1 = 10 points, 2 = 5 points and 3 = 2 points. Every committee member will vote using an interactive keypad to ensure anonymity. The highest point value will be the focus of that season's trial activity. All trials will be statistically robust with a minimum of 12 degrees of freedom. The steering committee meeting will also serve as a field trial up-date session so that the steering committee is familiar with progress of the project

To improve the research capacity in the region, the project will appoint a junior farming systems agronomist to work along-side the chief investigator. It will be the junior agronomist's role to conduct and report on the field trial program.

Field trial will be established on what was previously a GRDC investment into grain legume production. Exactly what experiments will have the sugarcane productivity monitored on will be at the discretion of the project steering committee. The current GRDC field trial experimentation has been implemented on 1.83m beds using RTK-GPS auto-steer technology. Prior to establishing the sugarcane phase a SiS soil survey will be conducted to provide greater understanding of the sub-soil characteristics.

Methodology: enhanced grower/industry participation in the project

The steering committee is the first level of enhanced industry participation in the research, development and extension process. The steering committee will have the ability to interact with and scrutinise the data and project team. It is anticipated that this process will ensure that the steering committee will have greater ownership of the data and trial outcomes.

The next level of enhanced industry participation will be the annual field day / bus trip that will showcase the trials to the greater industry. The timing of this activity is likely to be in May each year prior to crop harvest, yet after the six-month biomass sampling. This will allow grower interaction with the project team and the steering committee. The aim of this level of engagement is to provide the growing community with greater ownership in the RDE process that should result in practice change that will increase farm production and profitability.

1.1.1 Carbon trial methodology

To evaluate the effect of organic matter additions (nil, cane trash, mill-mud and biochar) and their placement (surface applied and incorporated with a rotary hoe or slotted at depth ~250mm) on soybean and peanut productivity a strip-split plot trial was implemented. The soil type was a Yellow Dermosol (Australian Soil Classification); Kepnock (mapping unit code). The trial was designed as a strip-plot with legume crop randomly assigned to plots in one direction and organic matter addition to plots in the alternate direction with organic matter placement assigned to sub-plots within the organic matter plots. Each experimental unit (plot) was 137.25m^2.

The organic matter additions were applied in the first week of December 2016 at the rate of 11t/ha, 60t/ha and 9.74t/ha for the cane trash, mill-mud and biochar respectively. The amount of organic matter applied was aimed at adding ~ 4t of Carbon/ha. The site was sown the following week to soybean variety A6785 at a rate to establish 325,000 plants/ha and peanut variety Holt to establish 120,000 plants/ha using a 'Janke' inclined plate planter. Inoculants were water injected and the planting furrow was opened with a single inclined disc.

Figure 1: Organic matter additions at depth, Cane trash on the left and mill-mud on the right

Figure 2: Site overview December 2016.

One month prior to organic matter additions gypsum was applied at 2t/ha to ensure adequate calcium supply. Micro-nutrients boron and zinc were applied by spraying the elements onto the soil surface prior to the organic matter additions. Fertiliser blend 'Legume-max' was applied at a rate to supply 15kg, 32kg, 70kg, 23kg, 19kg/ha of nitrogen, phosphorus, potassium, calcium and sulphur respectively. The crop was irrigated using a high-pressure travelling irrigator. Peanut foliar diseases were managed with applications of Chlorothalonil (720g/L) at 1.8L/ha on a 10-14 basis. Pod sucking insects in the soybean crop were controlled with Deltamethrin (12.5g/L) at 500 mL/ha and salt at 5g/L water volume, once spray thresholds were met.

For the peanut plots a 1.83m^2 quadrat was destructively sampled from selected treatments to determine maximum biomass production (aboveground leaves and stems and below ground components pod and plant crown) 166 days after planting. The samples were placed in labelled hessian bags, later removed and washed free of soil, placed back into hessian bags, dried at 60oC until a constant dry weight was achieved.

The crop was dug on 5/6/17; 183 DAP. A yield quadrat of 14.64m^2 was marked out of each plot. The crop was field dried for nine days. The yield samples were then threshed using a stationary thresher with the pods collected in labelled hessian bags that were placed into a tobacco barn with the fan only running.

The samples were then put over a 'KEW peanut cleaner' at DAF Kingaroy research station to remove soil and extraneous matter. The sample was then weighed. A 1,000g sub-sample was then hulled and hand shelled to remove peanut shell. The kernels were then placed over the 'KEW peanut grader' to determine treatment impact on grade/quality using the following sieves:

- Oil = kernels that passed through a 21/64th round sieve
- Split = kernels that passed through a 16/64th slotted sieve
- MFG = kernels that passed through a 22/64th round sieve
- 2's = kernels that passed through a 24/64th round sieve
- 1's = kernels that passed through a 25/64th round sieve
- J's = kernels that passed over the 25/64th round sieve.

The percent of each grade was determined by dividing the weight of each grade (in grams) by the original 1,000g sample. Shell percentage was determined by the difference of the sum of all the grades from the original 1,000g sample. Gross Crop Value has been calculated from the 2015 peanut supply contract for runner peanuts $1,500/t for J's; $1,400/t for 1's; $1,300/t for 2's; $1,200/t for splits; $450/t for MFG; $150/t for Oil's.

For Soybeans, dry matter production was determined 104 Days after planting and the crop was harvested 140 DAP. Dry matter was determined by hand harvesting all the plants in a 1.83m^2 area in each plot; with the sample placed in a tobacco barn at 60°C then weighed.

One week prior to machine harvest the trial was desiccated using Reglue® at registered rates. Immediately prior to harvest plant height, height of lowest pod and lodging of each plot was recorded. Grain production was determined by harvesting two rows in each plot with a KEW small plot harvester. The samples were placed in a labelled hessian bag, samples placed in a tobacco barn with the fan only running until a constant dry weight was achieved. The samples were placed over a ‘Bodington’ seed cleaner to remove extraneous matter and weighed. A 100 seed sample was also weighed to determine treatment effect on seed size. This sub-sample was then placed in a dehydrator at 103°C for 17hours to determine moisture content. All plot yields were converted to a standard moisture content prior to statistical analysis.

Following harvest of the legume crops the trial was maintained as a bare fallow with applications of Round-up® and Starane®. In July 2017 the ‘bed’ zones were tilled with two ripper tynes 75cm apart (one tyne either side the ‘slot’) with a crumble roller attached, providing adequate tilth for sugarcane establishment. The site was sown to sugarcane cv Q252 on 24/25 August 2017 using a whole-stick planter with a conventional mould-board opener. Fertiliser CK55S at 197kg/ha supplying 24 kgN/ha, 28 kgP/ha, 23 kgK/ha and 11 kgS/ha; and crop protectants to prevent Pineapple Disease (Shirtan® @ 200mL/100L) and wire worm attack (Lorsban 500 EC® @ 1.5L/ha) were used to ensure successful germination and establishment of the cane crop. The planting material was sourced from the Isis Productivity Limited ‘mother plots’ to ensure disease free seed cane. The crop was fertilised and filled-in on 23.11.2017; the crop receiving 75 kgN/ha, 30 kgP/ha, 95 kgK/ha and 25 kgS/ha in total between the planting and fill-in applications. All in-field operations (installation of the organic matter treatments, cultivation, legume planting and harvest, cane planting, fertiliser application and fill-in) were conducted on a 1.83m row configuration using a tractor fitted with RTK GPS Auto-steer to minimise compaction and maximise treatment alignment precision.

Monitoring of the plant cane crop development was performed by pegging out an 18.3m2 quadrat and counting shoot development. This quadrat became the permanent final yield sampling point. Determination of treatment effect on productivity at six months was achieved through destructively sampling a 9.15m2 quadrat and counting the number of stalks in the sample. The total biomass weight and stalk count recorded. A six-stalk subsample was then mulched and two one litre Chinese containers of the mulched material was weighed wet, dried at 60o C until a constant dry weight was achieved allowing the total biomass to be expressed on a dry weight basis.

Six months after sugarcane establishment the plots were sampled (15.3.2018) to determine treatment impact on adverse soil biology, namely plant parasitic nematode populations. Briefly, the process involved taking 20 soil cores (22mm diameter) to a depth of 150mm from each plot. The 20 cores were combined, gently mixed and ~300mL sub-sample was placed into labelled plastic bag, stored in an esky and set to DAF EcoScience Precinct for nematode extraction.

Treatment effect on plant nutrient status was checked by examining leaf tissue concentration of the third leaf as outlined in Panitz *et al* (2007). Briefly the technique involves collecting 30+ 3rd leaf leaves from each plot, cutting the leaf into top, middle and bottom sections, discarding the top and bottom sections. The mid-rib is then removed from the mid-leaf section and discarded. Sample placed into a labelled paper bag, dried at 60° C then ground <2mm and sent to SRA labs for analysis. This sample was collected at the same time as the mid-season biomass and soil biology samples.

Measurement of organic matter addition on soil bulk density was measured after plant cane crop in the plots that had previously sown to soybean. Bulk density is a measure of compaction, the higher the bulk density the lower the porosity thereby restricting root proliferation and water storage potential. Sampling consists of pushing a 92mm diameter soil tube into the soil with the aid of a tractor-mounted hydraulic ram. The samples carefully extruded and cut into 100mm sections dried at 105° C and weighed once constant dry weight is achieved. Bulk Density is expressed as the weight of soil per volume of soil (g/cm^3)

Productivity of the Plant and subsequent ratoon crops was determined by hand harvesting 18.3m^2 quadrat, recording the number of stalks, weighing the total biomass, sub-sampling approx. 30 cane stalks, weighing total weight, removing the cabbage, green and leaf and re-weighing. This allows for the determination of % millable stalk from the total biomass. The stalks counted in the sub-sample allows for calculation of mean individual stalk weight (ISW). A second six stalk sub-sample similarly partitioned in to millable stalk and trash components. These individual components are then mulched, mixed thoroughly and two one litre ‘Chinese’ containers filled, weighed wet, placed in a dehydrator at 60° C until constant dry weight was achieved then reweighed allowing for determination of moisture content to allow for fresh biomass conversion to dry matter production. Another six stalk sub-sample was taken for CCS determination at Bundaberg SRA via NIR SpectraCane.

Treatment significance was analysed by ANOVA with the commands Treatment Previous legume * organic matter * placement; Blocks were Rep/previous legume + Rep/organic matter/placement using Genstat version 18.2 VSN International statistical package.

However, during the sugarcane crop phase an underlying change in soil became apparent in the top right of the trial affecting the top two legume plots in rep 1 and the top legume plot in reps 2 and 3. Therefore, these plots were excluded from analysis in both the cropping and cane phases.

1.1.1 Fallow management trial methodology

During the 2017 Steering Committee meeting of the Southern Sugar Solutions Project (SRA 2017/12), growers highlighted that they only grow legumes to maximise their sugarcane productivity. Some growers observed better sugarcane growth (10tc/ha) following peanut variety Kairi compared to Holt; others believed that sugarcane productivity was superior following peanuts than soybeans. Growers wanted the project to identify the 'best' legume to use as a break crop in their sugar-based farming systems.

The definition of 'the best' legume crop becomes very much an individual grower target. Does best mean the highest economic return; is it the highest nitrogen contributor; or the crop that minimises plant parasitic nematode populations?

In an attempt to address this issue, a replicated field trial (randomised complete block design) was established to answer the broad research question 'what is the best legume to grow in my sugarcane farming system'? The trial investigated the following 10 rotation options these were replicated three times

- Kairi – peanuts
- Holt – peanuts
- 2B35-808 – soybean – SU tolerant line
- A6785 – soybean
- Jade – mungbean
- Onyx – mungbean
- Sunrise – pigeon pea
- Red Caloona
- Bare Fallow
- Continuous Cane – Plough Out Re-Plant (PORP)

The trial was located approximately 11km SSW of Bundaberg on Redoxic Hydrosol (Australian Soil Classification) 'Alloway' (Mapping unit) soil type. Prior to any tillage, the site was sampled and gypsum was applied at 2t/ha to improve the soil calcium/magnesium ratio. The previous sugarcane (Q208) stool was destroyed by two rotary hoe operations. Solubor (2kg/ha) and sodium molybdite (500g/ha) sprayed on the soil surface in between rotary hoe operations to ensure adequate levels of Boron and Molybdenum. The final bed geometry was achieved by ripping the bed area only with a three tyne ripper and waisted crumble roller and the wheel tracks left un-cultivated.

Plots were five cane rows (1.83 m) wide by 30 m long and treatments were randomly allocated to plots within the three replicate blocks. The legume crops were planted on a four rows/bed configuration and fertilised with LegumeMax at 370kg/ha in December 2017. The site was irrigated with a high-pressure travelling irrigator; a summary of crop inputs is listed in Table 1. The peanut, soybean, mungbean and pigeon pea crops were grown through to grain and harvested. Red Caloona cowpea was grown as a green manure crop and therefore it didn't generate an income.

Table 1: List of inputs for the different crops

Inputs/ # of	Peanuts	Soybean	Mung beans	Pigeon pea	Caloona Pea
Land prep	4	4	4	4	4
Basal Fertiliser	1	1	1	1	1
Trace element	2	2	2	2	2
Plant	1	1	1	1	1
Fungicides	6	0	0	0	0
Insecticides	2	6	5	4	1
Herbicides	3	3	3	3	2

Total dry matter production at physiological maturity of the legume crops was determined by destructively sampling a 1.83 m^2 quadrat from each plot with samples placed in a dehydrator at 60° C until constant dry weight was achieved. After obtaining the dry-weight of the sample, a sub-sample of approximately 12 plants taken and weighed, the plant hand-threshed into grain and material other than grain components (residue), grain weight recorded and expressed as a percentage of total dry matter thereby providing a harvest index. The grain and residue components were then ground to <2mm and sent for analysis to determine N concentration (TKN).

Crop productivity was determined via KEW small plot threshers to provide 'commercial yields'. The grain from the soybean, mungbean and pigeon pea plots were sent to 'Bean Growers Australia' to provide a grade / crop price to allow gross crop value and gross margin determination. The peanut samples were taken to the DAF Kingaroy research facility, cleaned of dirt and extraneous matter, weighed and a 1,000g sub-sample hulled and graded to determine payment pricing based on the 2017 PCA contract, enabling yield, gross crop value and gross margin calculations.

Sugarcane Phase

Following harvest of the legume crops the trial was maintained as a bare fallow with applications of Round-up® and Starane®. The site was planted to sugarcane Q240 August 2018 using a whole-stick planter. Crop protectants to prevent Pineapple Disease (Shirtan® @ 200mL/100L) and wire worm attack (Lorsban 500 EC® @ 1.5L/ha) were used at planting to ensure successful germination and establishment of the cane crop. The planting material was sourced from the Isis Productivity Limited 'mother plots' to ensure disease free seed cane. Only phosphorus was supplied at planting except for the continuous cane plots that were supplied with 25kgN/ha. Potassium (120kgK/ha) was supplied at 'fill-in' (27/11/18). Nitrogen (as urea) was applied to the planting drill, immediately prior to 'fill-in' where treatment N requirement was built up to 160kgN/ha less what was supplied as N in crop residue based on the biomass sampling in the legume phase (Rates in Table 2). The opportunity was taken to split the Peanut cv. Holt, Soybean cv. A6785 and the Bare fallow plots to +/- N. This was done to add information to the Six Easy Steps toolbox. However, since it was not the original intent of the trial the –N splits will not be reported on here.

Table 2: Nitrogenous fertiliser additions supplied to the treatments at 'fill-in' to ensure similar nitrogen contribution.

Treatments		N addition at fill-in (kg/ha)
Peanut	Holt	64
Peanut	Kairi	68
Soybean	2B35-808	68
Soybean	A6785	110
Mung Bean	Onyx	94
Mung Bean	Jade	88
Pigeon Pea	Sunrise	41
Cowpea	Red Caloona	0
Bare Fallow	Bare Fallow	160
Plough O,R,P	Plough O,R,P	135 (25 KgN supplied at planting)

Treatment effect on cane productivity at six months was determined by hand harvesting a 27.45m^2 quadrat, sample weighed, and number of stalks recorded. A sub sample of six stalks was mulched with a petrol powered garden mulcher, components thoroughly mixed and two of 1000mL 'Chinese' containers filled and placed into an esky. These sub-samples were later weighed then placed in a dehydrator at 60° C until a constant dry weight was achieved. The samples then re-weighed allowing for calculation of moisture content and conversion of quadrat yield to a dry matter yield.

At the same time (Six months), the plots were sampled to determine treatment impact on adverse soil biology; namely plant parasitic nematode populations. Briefly, the process involved taking 20 soil cores (22mm diameter) to a depth of 150mm from each plot. The 20 cores were combined, gently mixed and ~300mL sub-sample was placed into a plastic labelled bag, stored in an esky and set to DAF EcoScience Precinct for nematode extraction.

Treatment effect on plant nutrient status was checked by examining leaf tissue concentration of the third leaf as outlined in Panitz et al (2007). Briefly, the technique involves collecting 30+ 3rd leaf leaves from each plot, cutting the leaf into top, middle and bottom sections, discarding the top and bottom sections. The mid-rib is then removed from the mid-leaf section and discarded. Sample placed into a labelled paper bag, dried at 60° C then ground <2mm and sent to SRA labs for analysis. This sample was collected at the same time as the six-month biomass and soil biology samples.

Treatment effects on plant cane yield were determined by hand harvesting 27.45m^2 quadrat, recording the number of stalks, weighing the total biomass, sub-sampling approx. 30 cane stalks, weighing total weight, removing the cabbage, green and leaf and re-weighing. This allowed for the determination of % millable stalk from the total biomass. The stalks counted in the sub-sample allowed for calculation of mean individual stalk weight (ISW). A second six-stalk sub-sample similarly partitioned in to millable stalk and trash components. These individual components are then mulched, mixed thoroughly and two of one litre 'Chinese' containers filled, weighed wet, placed in a dehydrator at 60° C until constant dry weight was achieved then reweighed allowing for determination of moisture content to allow for fresh biomass conversion to dry matter production. Another six-stalk sub-sample was taken for CCS determination at Bundaberg SRA via NIR SpectraCane.

Crop gross margin were calculated by inputting the individual plot yield, quality and current product price less crop growing costs; these data were input into Farm Economic Analysis Tool (FEAT) on-line tool with assistance from an Agricultural Economist.

Treatment significance was analysed by ANOVA with Genstat version 18.2 VSN International statistical package. Pair-wise comparison was determined using 'Fishers Protected LSD' method.

All plots received the same fertiliser program in the R1 cropping phase of 140kgN/ha and 100kgK/ha.

1.1.1 SU trail methodology

Please note that some of the herbicides used in this experiment are currently not registered for use in soybean production in Australia and as such should NOT be used in the production of soybeans. These treatments should be redacted if this paper is reproduced.

The Steering Committee of the GRDC Growers Solution project identified that weed control, particularly problematic weeds like, Phasey Bean, Siratro, Bell Vine and milk weed, were the biggest production issues that they encounter when growing soybeans in coastal farming systems. The committee identified that new soybean variety 'Kuranda' had single gene tolerance to SU herbicides and that this variety in conjunction with SU herbicides might offer the potential solution to the issue. The Steering Committee of the Southern Sugar Solutions project agreed that these herbicides may resolve the weed issue in the soybean phase, but they were concerned about the potential negative effects on the subsequent sugarcane crop. It was determined at the most recent meeting on 8 August 2019 that the next Southern Sugar Solutions trial would be planted at the SU Herbicide Trial, which compared herbicide effects on soy varieties A6785 and Kuranda. The treatments (Table 3) were applied to both varieties.

A strip-plot trial with three replicates was established to determine the impact of a range of herbicide strategies (Table 3) on the current commercial standard variety, A6785 and the recently released variety Kuranda. Herbicide trade name, active ingredient, active ingredient concentration and application rates are documented in Table 4.

Table 3: Herbicide strategy treatment number, description and abbreviation.

Treatment	Abbreviation
1. Mechanical	Mech
2. Dual Gold® only	DG
3. Dual Gold® + Spinnaker® Early	DG + Spin E
4. Dual Gold® + Spinnaker® Pre-Flowering	DG + Spin PF
5. Dual Gold® + Sempra® Early	DG + Semp E
6. Dual Gold® + Sempra® Pre-Flowering	DG + Semp PF
7. Associate® Only	Assoc
8. Associate® + Spinnaker® Early	Assoc + Spin E
9. Associate® + Sempra® Early	Assoc + Semp E
10. Dual Gold®+ Flame® Pre-Flowering	DG + Flame PF

Table 4: Herbicide trade name, active ingredient, active ingredient concentration and application rate.

Trade Name	Active Ingredient	ai Conc.	Application Rate
Dual Gold®	S-Metolachor	960 g/L	2 L/ha
Spinnaker®	Imazethapyr	700 g/kg	140 g/ha
Sempra®	Halosulfuron-Methyl	750 g/kg	130 g/ha
Associate®	Metsulfuron-Methyl	600 g/kg	7 g/ha
Flame®	Imazapic	240 g/L	400 mL/ha

The site selected for this trial was a Wallum (Mapping unit) soil type (Redoxic Hydrosol Australian Soil Classification) on Isis Cane services 'Takalvan' property 8km SSE from the Bundaberg Airport. Six weeks prior to planting dolomite was applied at 2t/ha to ensure adequate calcium and magnesium supply as well as to correct soil pH. Micronutrients boron, molybdate and zinc were applied by spraying the elements onto the soil surface prior to the final tillage event. Fertiliser to supply 30kg, 40kg and 100kg/ha of nitrogen, phosphorus, and potassium respectively was applied six weeks pre-plant and incorporated into the soils using disc harrows.

The soybeans were sown using a 'Janke' inclined plate planter that had been calibrated to supply enough seed to establish 325,000 plants/ha on 20/12/18. The planting furrow was opened with a single inclined disc 'Flexi-coil Barton' and then rhizobia inoculant (Group H) as a peat slurry was water injected onto the seed in the planting furrow.

Each plot was 30m long and five soybean rows wide. The Dual Gold® was applied to treatments 2, 3, 4, 5, 6 and 10 on 21/12/18; whilst Associate® was to be applied pre-plant, was also applied post-plant-pre-emergence (PPPE) immediately after the Dual Gold® application, due to practical limitations. Treatments 3, 5, 8 and 9 that required herbicide applications at the first trifoliate stage (E) had herbicides applied on 2/1/19 (13DAP); whilst treatments 4, 6 and 10 had herbicides applied on 24/1/19 (35DAP) when the crop was just about to start flowering (PF).

All herbicides were applied using a three-point linkage mounted spray rig on a tractor using RTK auto-steer technology. The spray rig was a 'Croplands' 700L tank with a folding boom equipped with TTI 015 'TeeJet' nozzles operating at 5 bar pressure delivering a total spray volume 250L water volume/ha.

The crop was grown using supplementary irrigation supplied via a low-pressure over-head boom that delivered approximately 30mm every 7 to 10 days. The crop was scouted for insects twice weekly from flowering onwards to determine insect pressure and insects were controlled once spray thresholds warranted using registered pesticides.

One week prior to machine harvest, the trial was desiccated using Diquat at registered rates. Immediately prior to harvest, plant height and height of lowest pod of each plot was recorded. Grain production was determined by harvesting 20m of two rows in each plot with a KEW small plot harvester. The samples were placed in a labelled hessian bag and then placed in a tobacco barn with the fan only running until a constant dry weight was achieved. The samples were placed over a 'Bodington' seed cleaner to remove extraneous matter and weighed. A sub-sample was then placed in a dehydrator at 103ºC for 17hours to determine moisture content. All plot yields were converted to a standard moisture content prior to statistical analysis.

Following harvest of the soybean crop the site was maintained as a bare fallow with applications of glyphosate and 2,4-D amine. Eight weeks prior to planting sugarcane, soybean residues were incorporated with a single rotary hoe operation. The cane (var. SRA 11) was commercially billet planted on 5 October 2019 with "Cane Starter" at 100L/ha (11.9kg N, 15kg P). The sugarcane was sown into a 1.83m single row configuration. It was side dressed on 11 December with CK140S at 500kg/ha (116N, 10P, 88K, 19S). This rate was slightly high for this trial because it was applied by the private farmer and was calculated based on the rest of the farm, which had a crop of bailed barley following the legume fallow. The crop had an initial pre-emergent herbicide application of Dual Gold® and Gramoxone® 360, and an out-of-hand application of Gramoxone® 360 and Flame® was applied to the inter-row area in late February.

Early cane growth following Kuranda soybeans appeared to be retarded compared to the A6785 soybean plots. Soil samples (20 cores/plot of 22mm diameter soil core to 100mm depth) were collected from selected treatments (Mech, DG + Spin E, DG + Semp PF, Assoc + Spin E and DG + Flame PF) from both soybean varieties. The soil was sent by overnight transport to DES laboratories to determine levels of residual herbicides differed between where residue levels were tested.

Treatment effect on cane productivity at six months was determined by hand harvesting a 1.83m^2 quadrat, sample weighed and number of stalks recorded. This was a smaller sample size due to Covid19 restrictions. A sub sample of six stalks was mulched with a petrol powered garden mulcher, components thoroughly mixed and two of 1000mL 'Chinese' containers filled and placed into an esky. These sub-samples were later weighed then placed in a dehydrator at 60º C until a constant dry weight was achieved. The samples then re-weighed allowing for calculation of moisture content and conversion of the quadrat biomass yield to a dry matter yield.

At the same time (Six months), the plots were sampled to determine treatment impact on adverse soil biology; namely plant parasitic nematode populations. Briefly, the process involved taking 20 soil cores (22mm diameter) to a depth of 150mm from each plot. The 20 cores were combined, gently mixed and ~300mL sub-sample was placed into labelled plastic bags, stored in an esky and set to DAF EcoScience Precinct for nematode extraction.

Treatment effect on plant nutrient status was checked by examining leaf tissue concentration of the third leaf as outlined in Panitz et al (2007). Briefly, the technique involves collecting 30+ 3rd leaf leaves from each plot, cutting the leaf into top, middle and bottom sections, discarding the top and bottom sections. The mid-rib is then removed from the mid-leaf section and discarded. Sample placed into a labelled paper bag, dried at 60º C then ground <2mm and sent to SRA labs for analysis. This sample was collected at the same time as the six-month biomass and soil biology samples. Only two of the three replicates were sampled due to Covid19 restrictions.

Treatment effects on plant cane yield were determined by hand harvesting 18.3m^2 quadrat, recording the number of stalks, weighing the total biomass, sub-sampling approx. 30 cane stalks, weighing total weight, removing the cabbage, green and leaf and re-weighing. This allowed for the determination of % millable stalk from the total biomass. The stalks counted in the sub-sample allowed for calculation of mean individual stalk weight (ISW). A second six-stalk sub-sample similarly partitioned in to millable stalk and trash components. These individual components are then mulched, mixed thoroughly and two of one litre 'Chinese' containers filled, weighed wet, placed in a dehydrator at 60º C until constant dry weight was achieved then reweighed allowing for determination of moisture content to allow for fresh biomass conversion to dry matter production. Another six-stalk sub-sample was taken for CCS determination at Bundaberg SRA via NIR SpectraCane.

The trial design was a strip-plot with the soybean varieties randomised within reps and treatments were randomised within reps but treatments are not randomised within varieties - a row within a rep has the same treatment for both varieties. Treatment effects were analysed by ANOVA with the model; Treatments = Variety*treatment; Block = Rep/(row+column) using Genstat version 18.2 VSN international statistical package.

6. RESULTS AND DISCUSSION

6.1 Project Governance

The concept of allowing growers to be actively involved in the identification and prioritisation of local RDE together with follow-up field days and update meetings has proven to be a good model to increase adoption of new techniques. The independent project impact report highlights that 65% of the growers surveyed planned to make an on-farm practice change and 90% of advisors changed the advice that they gave to growers due to direct involvement in the project.

1.1.1 Carbon Trial

The addition of organic matter (cane trash, mill-mud and biochar had no impact on the productivity of the soybean and peanut crops. Placement of organic matter; either incorporated into the soil surface or slotted at depth (250mm) also had no effect on legume performance. However, the grain yield, maximum biomass production and gross crop value of peanuts were significantly higher than peanuts, see Table 5. Statistical analysis demonstrated that there was no effect of organic matter addition on legume yield (grain for soybean or nut-in-shell for peanuts) similarly the addition of organic matter had no effect on gross crop value, maximum biomass or plant population, Table 5. The placement of organic matter had no effect on grain yield, gross crop value and plant populations, however the slotting of organic matter produced significantly more maximum biomass than surface incorporation. There were no significant interactions between crop, organic matter and placement. Notably peanut productivity and gross crop value were significantly better than soybean at this site. It is suspected that the yield potential of soybeans was limited by sclerotinium base rot. There was no treatment effect on the incidence of the disease (visual assessment data not shown).

Table 5: The effect of legume choice, organic matter amendment, and placement of organic matter on grain yield, maximum biomass, biomass nitrogen concentration, amount of N in biomass and residue, and gross crop value.

Preceding legume	Grain Yield (t/ha)	Maximum Biomass (t/ha)	TKN – biomass (N%)	N in biomass (kgN/ha)	N in residue (kgN/ha)	Gross Crop Value ($/ha)
Peanut	5.873 [a]	11.549 [a]	2.308	266.8	46.8	5,704
Soybean	1.700 [b]	6.039 [b]	2.204	133.6	36.7	935
P Value	**<0.001**	**<0.001**	**0.388**	**<0.001**	**0.364**	**<0.001**
LSD	0.591	0.531	-	25.35	-	406.4
Organic Matter						
Nil	3.931	9.011	2.201	200.5	35.8	3,536 [a]
Cane Trash	3.662	8.090	2.367	192.1	37.5	3,130 [b]
Mill Mud	3.899	9.257	2.193	209.6	44.9	3,464 [ab]
Biochar	3.654	8.819	2.263	198.5	48.8	3,149 [b]
P Value	**0.380**	**0.105**	**0.647**	**0.801**	**0.808**	**0.045**
LSD	-	-	-	-	-	343.4
Placement						
Surface	3.769	8.589 [b]	2.361[a]	204.5	44.0	3,330
Slotted	3.805	8.999 [a]	2.152[b]	195.9	39.5	3,309
P Value	**0.754**	**0.044**	**0.034**	**0.435**	**0.635**	**0.898**
LSD	-	0.399	0.192	-	-	-
Interaction P Values						
Leg*OM	0.162	0.638	0.306	0.276	0.936	0.028
Leg*Place	0.183	0.091	0.932	0.777	0.686	0.772
OM*Place	0.108	0.061	0.787	0.319	0.408	0.308
Leg*OM*Place	0.137	0.369	0.892	0.718	0.841	0.370

Plant cane phase

Six month sampling demonstrated a 5% higher stalk count in the peanut plots relative to soybean plots, a result that continued until harvest of the plant cane crop. There was a significant organic matter placement effect where slotting resulted 13% more dry matter production compared to surface application. However, this effect was not sustained through to harvest (data not shown).

There were no treatment effects on the Nitrogen, Phosphorus, Calcium, Magnesium and Sulphur concentrations in the 'third leaf' samples. The application of Mill-mud and Biochar significantly increased the potassium concentrations in the third leaf relative to that of the Nil treatment (1.261 K%), see Figure 3. However, all treatment potassium concentrations were above documented critical value of 1.1% and as such is likely to have no impact on yield. All macronutrient concentrations in the third leaf sample were above industry accepted critical values, indicating that any yield responses would be unlikely due to macronutrient deficiency

Figure 3: Soil organic matter amelioration effect on sugarcane third leaf Potassium concentrations six months after planting. Treatments with the same letter are NOT statistically different (P=0.05). The orange line indicates industry accepted critical value.

Similarly, all micronutrient concentrations were above critical values with the exception of silicon concentrations. The application of Mill-mud increased third leaf silicon concentrations by 24% compared to the Nil treatment. The silicon concentration in the third leaf of the Mill-mud amended plots were the only one above the critical value of 0.7%, Figure 4.

Previous legume, organic matter addition or placement had no impact on the most important nematode species root-knot and lesion (Table 6). There were also no treatment interactions for these two major pests. Whilst there were some statistical differences with the other two nematode pests in the samples, the levels present were of little commercial importance (Dr G. Stirling *Pers. Comm.)*

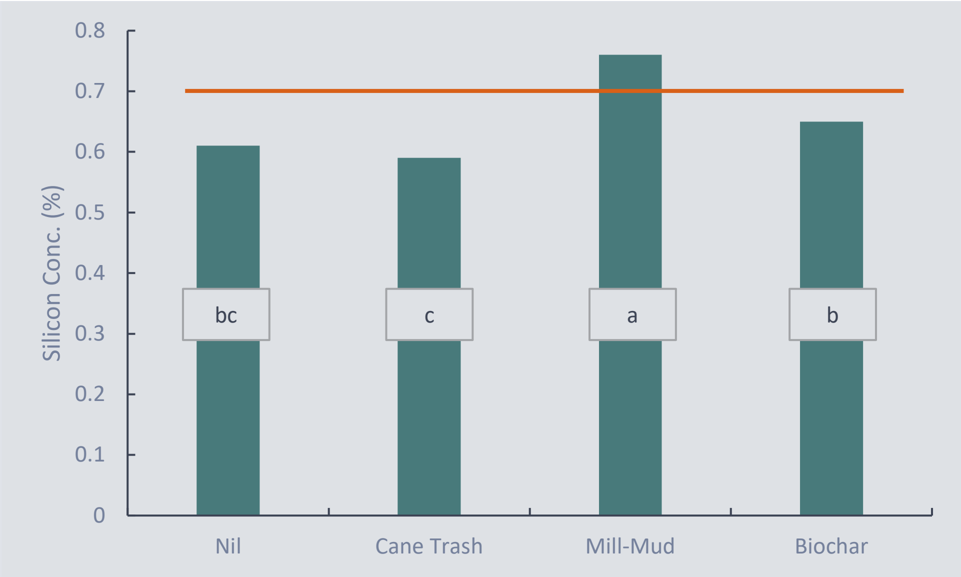

Figure 4: The effect of soil organic matter amendments on the silicon concentration of the third leaf of sugarcane variety Q252. Treatments with the same letter are NOT statistically different (P=0.05). The orange line indicates industry accepted critical value.

Table 6: Previous legume crop, organic matter addition, organic matter placement effect on plant parasitic nematodes six months after plant cane crop establishment. Values in parenthesis are back-transformed means (log x+1); Values in columns with different letters are statistically different (P=0.05)

	Nematodes/200mL soil			
Previous legume	Root-Knot	Lesion	Ring	Spiral
Peanut	5.14 (169)	5.87 (353)	1.16 [a] (2.2)	2.05 [b] (6.7)
Soybean	5.50 (244)	5.88 (358)	0.05 [b] (0.1)	4.14 [a] (62.0)
P Value	0.449	0.932	0.002	0.021
Organic Matter				
Nil	5.61 (272)	5.94 (379)	0.60 (0.8)	2.93 [b] (17.8)
Cane Trash	5.58 (263)	5.38 (356)	0.62 (0.9)	3.59 [a] (35.2)
Mill-Mud	5.34 (207)	5.89 (361)	0.55 (0.7)	2.74 [b] (14.5)
Biochar	4.76 (115)	5.79 (327)	0.64 (0.9)	3.12 [ab] (27.1)
P Value	0.424	0.902	0.998	0.025
Placement				
Surface	5.34 (208)	5.81 (333)	0.39 [b] (0.5)	2.90 (17.2)
Slotted	5.30 (199)	5.94 (380)	0.82 [a] (1.3)	3.29 (25.8)
P Value	0.841	0.355	0.025	0.108
P Values				
Legume*OM	0.639	0.494	0.970	0.304
Legume*Placement	0.881	0.428	0.085	0.896
OM*Placement	0.222	0.862	0.179	0.961
Leg*OM*Place	0.313	0.606	0.088	0.041

At harvest of the plant cane crop there was no impact of previous legume crop, organic matter or it’s placement on all parameters measured with the exception of stalk count. There were 3,727 more stalks/ha in the plots where peanuts were grown relative to the soybean plots, Table 7. This lack of response to the different legume options differs from the opinion of the local growing community where they believe that sugarcane productivity is better after peanuts than soybean. It is possible that the increased stalk population observed in this experiment is the reason that growers have formed this opinion in the absence of robust trial data to support that perception.

There was a trend (P=0.066) for the application of Mill-mud to increase mean individual stalk weight by 0.18 kg/stalk. Other than that trend, organic matter addition had no impact on productivity for the plant cane cropping phase.

Table 7: The effect of previous legume crop, organic matter addition and placement of organic matter on cane yield, CCS, sugar yield, individual stalk weight, stalks/ha and total dry matter production of the plant crop. Treatments in columns with the same letter are NOT statistically different (P=0.05)

Preceding legume	Cane Yield (t/ha)	CCS	Sugar Yield (t/ha)	Individual Stalk Weight (kg/stalk)	Stalks/ha	Dry Matter Production (t/ha)
Peanut	122.8	17.05	20.94	1.61	80,251 [a]	43.14
Soybean	121.1	17.19	20.76	1.63	76,524 [b]	41.93
P Value	0.665	0.542	0.817	0.713	0.034	0.551
LSD	-	-	-	-	3,185	-
Organic Matter						
Nil	118.6	17.16	20.34	1.55	78,586	40.59
Cane Trash	119.5	17.31	20.57	1.54	76,708	42.64
Mill Mud	129.1	16.98	21.94	1.73	80,956	44.75
Biochar	120.7	17.02	20.54	1.66	77,300	42.17
P Value	0.463	0.766	0.365	0.066	0.417	0.650
LSD	-	-	-	-	-	-
Placement						
Surface	120.7	17.12	20.63	1.61	77,515	42.71
Slotted	123.3	17.12	21.07	1.64	79,260	42.36
P Value	0.363	0.993	0.378	0.545	0.229	0.750
LSD	-	-	-	-	-	-
Interaction P Values						
Leg*OM	0.051	0.801	0.074	0.181	0.059	0.464
Leg*Place	0.399	0.655	0.592	0.235	0.455	0.820
OM*Place	0.790	0.282	0.912	0.657	0.328	0.415
Leg*OM*Place	0.408	0.429	0.299	0.208	0.787	0.760

1st Ratoon Cane Phase

Soil sampling of the soybean plots post-harvest of the plant cane crop to determine organic matter and its placement effect on bulk density demonstrated that the addition of organic matter did not have any effect. However, there was a trend (P=0.083) for the addition of Mill-mud to reduce soil bulk density in the 20-30cm layer. The action of slotting did reduce soil bulk density in the 20-30cm and 30-40cm layers, Table 8. The slotting placement effect in the 20 – 40cm layers was driven by the significant organic matter by placement interaction where the slotting of Mill-mud had the lowest bulk density in the 20 – 30cm and 30 – 40cm layers, see Figure 5.

Table 8: Treatment effect on soil bulk density in the top 60cm, post-harvest of the plant cane crop. Values with the same letter are NOT significantly different (P=0.05).

Soil bulk density (g/cm³)						
Organic Matter	0 – 10cm	10-20cm	20-30cm	30-40cm	40-50cm	50-60cm
Nil	1.289	1.398	1.533	1.694	1.837	1.744
Cane Trash	1.287	1.444	1.507	1.664	1.820	1.799
Mill-Mud	1.277	1.416	1.433	1.482	1.822	1.769
Biochar	1.298	1.375	1.568	1.663	1.839	1.790
P Value	**0.918**	**0.224**	**0.083**	**0.188**	**0.966**	**0.831**
LSD (P=0.05)	-	-	-	-	-	-
Placement						
Surface	1.268	1.384	1.548 [a]	1.743 [a]	1.839	1.759
Slotted	1.308	1.432	1.472 [b]	1.508 [b]	1.819	1.792
P Value	**0.150**	**0.097**	**0.020**	**<0.001**	**0.568**	**0.189**
LSD (P=0.05)	-	-	0.061	0.108	-	-
Treatment interaction P Values						
OM*Placement	0.527	0.588	0.005	0.022	0.732	0.188

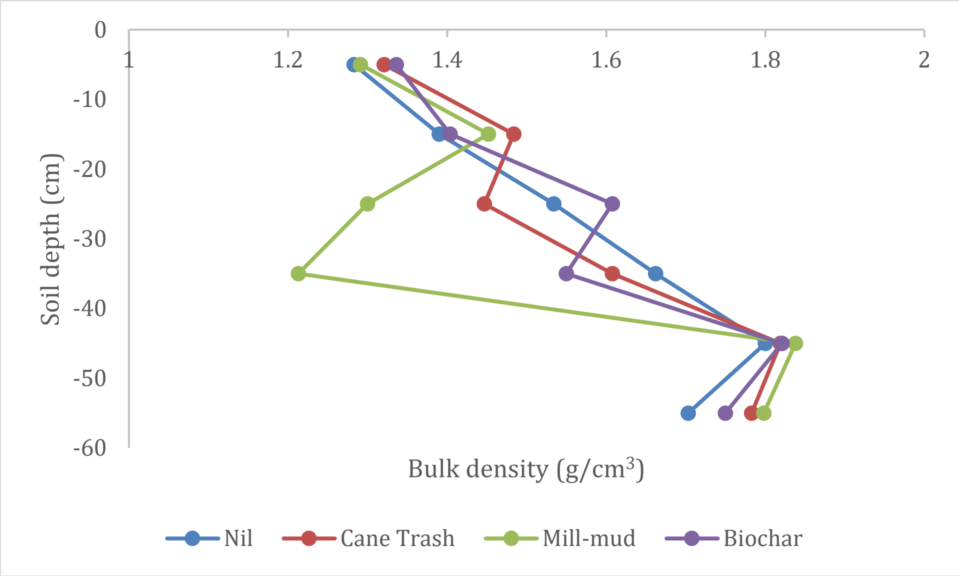

Figure 5: The effect of organic matter addition on soil bulk density in the 'Slotted' placement treatments post-harvest of the plant cane crop.

The action of slotting the organic matter at depth necessitated a large ripper tyne being dragged at depth to open a 'slot' for the organic matter to drop into. This action significantly reduced soil bulk density in the 20-30cm and 30-40cm layers (Table 4). It is plausible that this reduction in soil bulk density could have resulted in the improved sugar yield for the slotted treatment in the R1 crop. Slotting resulted in 1,776 more stalks/ha and 0.72t/ha more dry matter than the surface incorporated placement treatment. Similarly, there was a trend (P = 0.089) for the slotting treatment to improve cane yield, Table 9.

At harvest of the 1st ratoon sugarcane crop there were 3.5% more stalks/ha in the plots that had been sown to peanuts two years prior, when compared to the soybean plots. This effect resulted in a trend for the peanut plots to have higher cane and sugar yields. However, these effects were not statistically different with P values of 0.090 and 0.063 respectively, Table 9.

Table 9: The effect of previous legume crop, organic matter addition and placement of organic matter on cane yield, CCS, sugar yield, individual stalk weight, stalks/ha and total dry matter production of the 1st ratoon crop. Values in columns followed by a different letter are statistically different (P=0.05)

Preceding legume	Cane Yield (t/ha)	CCS	Sugar Yield (t/ha)	Individual Stalk Weight (kg/stalk)	Stalks/ha	Dry Matter Production (t/ha)
Peanut	86.9	15.76	13.70	1.15	78,068 a	29.43
Soybean	82.0	15.59	12.79	1.10	75,360 b	27.44
P Value	0.090	0.139	0.063	0.297	0.006	0.099
LSD	-	-	-	-	1,233	-
Organic Matter						
Nil	83.4	15.93	13.28	1.12	77,049	28.29
Cane Trash	86.0	15.53	13.38	1.15	75,364	29.23
Mill Mud	88.6	15.71	13.88	1.12	79,351	29.57
Biochar	79.8	15.61	12.43	1.09	75,091	26.63
P Value	0.439	0.783	0.444	0.841	0.102	0.308
LSD	-	-	-	-	-	-
Placement						
Surface	82.4	15.58	12.81 b	1.10	75,826 b	27.51 b
Slotted	86.5	15.81	13.67 a	1.14	77,602 a	28.23 a
P Value	0.089	0.121	0.021	0.094	0.048	0.033
LSD	-	-	0.700	-	1,160	1.66
Interaction P Values						
Leg*OM	0.272	0.886	0.355	0.391	0.042	0.102
Leg*Place	0.197	0.056	0.452	0.949	0.517	0.299
OM*Place	0.393	0.045	0.189	0.083	0.538	0.151
Leg*OM*Place	0.925	0.711	0.893	0.852	0.507	0.700

For CCS there was a significant interaction between organic matter and placement where the incorporation of 60t/ha of mill-Mud into the surface suppressed CCS compared with the same quantity of Mill-Mud slotted at depth. Excessive nutrients, namely nitrogen, has been implicated with reductions in CCS. Having Mill-Mud in the surface could potentially increase nutrient supply to the crop thereby reducing CCS, see Figure 6.

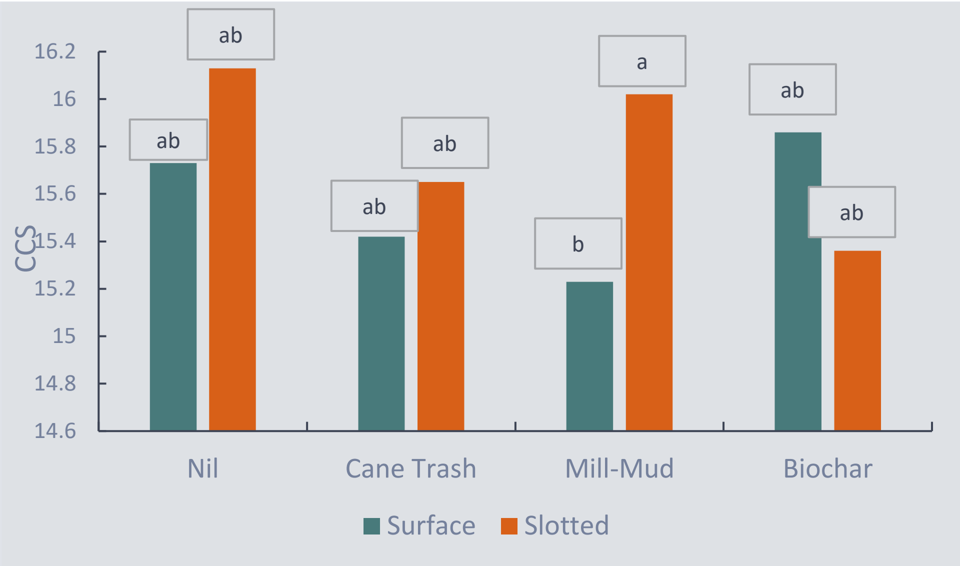

Figure 6: Significant organic matter by placement interaction on CCS levels in the R1 cropping phase. Treatments with the same letter are NOT statistically different (P=0.05)

The application of mill mud to the peanut crop significantly increased stalks/ha in the R1 cropping phase; whereas the soybean plots with mill mud were unaffected. Conversely, the addition of cane trash in the soybean crop reduced stalks/ha in the cane R1 cropping phase and the peanut crop was unaffected (Figure 7)

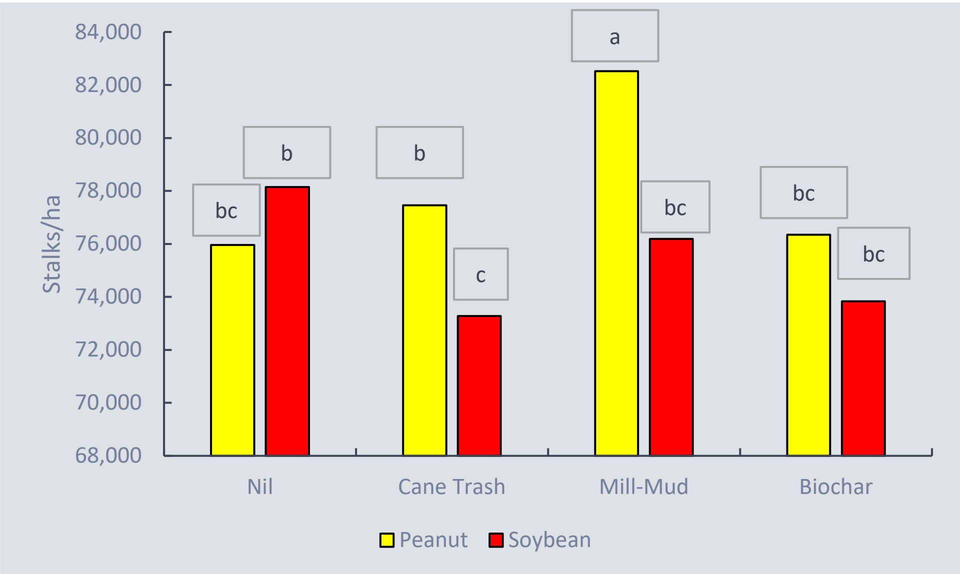

Figure 7: Preceding legume crop and organic matter addition effect on stalks/ha in the R1 cropping phase. Treatments with the same letter are NOT statistically different

2nd Ratoon Crop Phase

Despite the positive effect of slotting on sugar yield, stalks/ha and dry matter production in the R1 cropping phase, there were no treatment effects on cane yield, CCS, sugar yield, individual stalk weight, stalks/ha or dry matter production in the R2 cropping phase, Table 10. There was a significant preceding legume by placement interaction (P=0.025) where the cane yield was 6.6t/ha lower in the plots that were sown to peanuts and organic matter was surface incorporated compared to plots that were sown to soybean and organic matter was surface incorporated, 93.3 tc/ha and 99.9 tc/ha respectively. There was no difference with preceding legume crop where the organic matter had been slotted.

Table 10: The effect of previous legume crop, organic matter addition and placement of organic matter on cane yield, CCS, sugar yield, individual stalk weight, stalks/ha and total dry matter production of the 2nd ratoon crop.

Preceding legume	Cane Yield (t/ha)	CCS	Sugar Yield (t/ha)	Individual Stalk Weight (kg/stalk)	Stalks/ha	Dry Matter Production (t/ha)
Peanut	95.4	16.66	15.90	1.23	80,472	37.73
Soybean	98.3	16.69	16.40	1.26	80,633	38.76
P Value	0.347	0.734	0.380	0.215	0.943	0.299
LSD	-	-	-	-	-	-
Organic Matter						
Nil	92.4	16.60	15.35	1.18	80,294	36.40
Cane Trash	92.3	16.72	15.40	1.27	76,138	37.10
Mill Mud	104.5	16.79	17.54	1.27	82,743	41.19
Biochar	98.1	16.59	16.29	1.26	83,037	38.28
P Value	0.138	0.762	0.148	0.725	0.324	0.061
LSD	-	-	-	-	-	-
Placement						
Surface	96.6	16.67	16.08	1.25	80,811	37.93
Slotted	97.1	16.69	16.21	1.25	80,295	38.56
P Value	0.887	0.855	0.802	0.970	0.729	0.617
LSD	-	-	-	-	-	-
Interaction P Values						
Leg*OM	0.572	0.317	0.470	0.992	0.301	0.358
Leg*Place	0.025	0.251	0.076	0.339	0.246	0.055
OM*Place	0.728	0.726	0.667	0.464	0.723	0.445
Leg*OM*Place	0.204	0.401	0.097	0.120	0.362	0.066

Cumulative cane yield

Analysis of the cumulative cane crop data highlighted no difference in cane and sugar yield between cane grown after peanuts or after soybean. This is contrary to local grower belief. Although there were no differences in sugar yield among organic matter treatments in any crop phase, the application of Mill-Mud before the legume cropping phase resulted in an 8.96% improvement in sugar yield over the entire cropping cycle Table 11. This improvement in productivity could be a response to soil silicon levels; only the mill-mud amended plots had leaf silicon levels above critical levels when measured in the six months after planting.

Table 11: The effect of previous legume crop, organic matter addition and placement of organic matter on cumulative cane yield, cumulative sugar yield and cumulative total dry matter production of plant, R1 and R2 crops. Values in columns followed by the same letter are NOT statistically different (P=0.05)

Preceding legume	Cumulative Cane Yield (t/ha)	Cumulative Sugar Yield (t/ha)	Cumulative Dry Matter Production (t/ha)
Peanut	305.18	50.53	110.29
Soybean	301.34	49.94	108.13
P Value	0.520	0.576	0.423
LSD	-	-	-
Organic Matter			
Nil	294.46	48.97 [b]	105.28
Cane Trash	297.71	49.35 [b]	108.98
Mill Mud	322.27	53.36 [a]	115.51
Biochar	298.61	46.26 [b]	107.08
P Value	0.094	0.016	0.190
LSD	-	2.69	-
Placement			
Surface	299.70	49.52	108.15
Slotted	306.83	50.95	110.27
P Value	0.271	0.175	0.405
LSD	-	-	-
Interaction P Values			
Leg*OM	0.176	0.068	0.645
Leg*Place	0.060	0.156	0.272
OM*Place	0.916	0.836	0.555
Leg*OM*Place	0.824	0.843	0.375

1.1.1 Fallow Management Trial

Legume Phase

Statistical analysis demonstrated that peanuts had the highest gross margin irrespective of variety ($3,145/ha); soybean and pigeon pea were the next most profitable ($769/ha). Mungbean variety Onyx ($104/ha) was significantly more profitable than Jade ($-783/ha). Since both Red Caloona cowpea and the bare fallow didn't generate an income, they had a negative gross margin. The extremely low cane productivity (~40 t/ha) combined with the low sugar price resulted in a low gross margin for the cane treatment (Table 12).

Table 12: Treatment effect on gross margin, yield, amount of crop residue and nitrogen contribution of the legume residue. Values in columns followed by the same letter are not statistically different (P=0.05)

Treatment	Gross margin ($/ha)	Crop yield (t/ha)	Crop residue (t/ha)	Nitrogen contribution of residue (kgN/ha)
Kairi – peanut	3,125 a	6.73 a	5.99 cd	92.0 cd
Holt – peanut	3,165 a	6.66 a	6.95 bc	96.0 bc
2B35-808 – soybean	420 c	3.71 c	6.55 bcd	66.7 de
A6785 – soybean	533 bc	4.29 b	5.60 de	49.7 e
Jade – mungbean	-783 e	1.17 f	5.42 de	71.7 cde
Onyx – mungbean	104 d	1.64 e	4.60 e	65.7 e
Sunrise – pigeon pea	769 b	2.18 d	9.30 a	118.7 b
Red Caloona cowpea	-660 e	-	7.54 b	158.3 a
Bare fallow	-578 e	-	-	-
PORP	494 c	-	-	-
P Value	<0.001	<0.001	<0.001	<0.001
LSD (P=0.05)	240.7	0.42	1.27	25.9

Sunrise pigeon pea generated the greatest crop residue levels (9.3 t/ha) and mungbean, irrespective of variety, the least (5.0 t/ha) (Table 12). Red caloona cowpea provided the greatest amount of nitrogen in crop residue (158 kg N / ha) due to the grain not being harvested, while soybean and mungbean provided the least N (58.2 and 68.7 kg N / ha, respectively). The peanut crops returned 94 kg N / ha to the farming system in the crop residue (Figure 8). Please note that these values are only the nitrogen contribution in the above-ground biomass. The Six-Easy-Steps process also factors in another 30% nitrogen to account for the N in the root system and nodules.

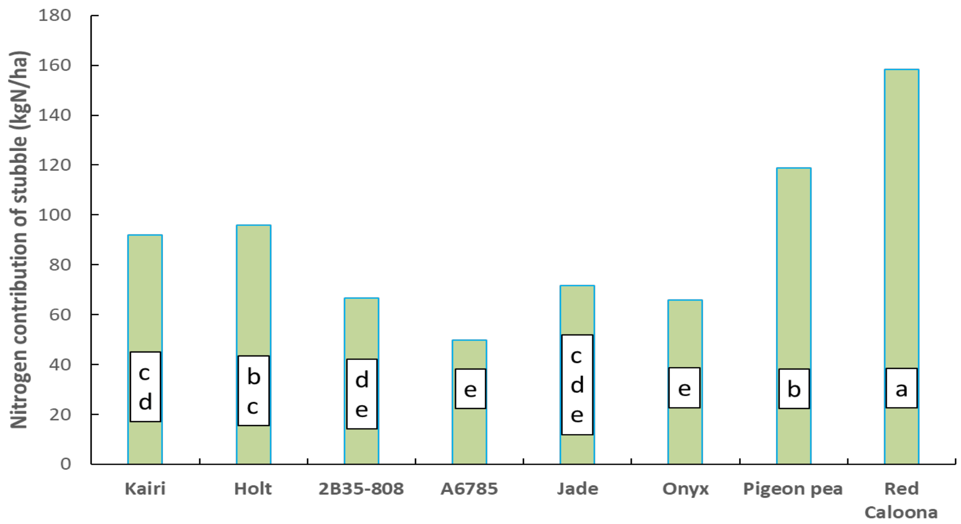

Figure 8: Nitrogen contribution from the residue of the different legumes. Treatments with the same letter are NOT statistically different (P=0.05)

The two most important plant parasitic nematodes in sugarcane farming systems are root knot and lesion nematodes. All the legume options reduced the pressure of lesion nematodes relative to continuous cane (Table 13). There was a large variation in the population of root knot nematodes with the various legume options; peanuts were the only legumes, along with bare fallow, to have statistically fewer root knot nematodes than continuous cane (Table 13).

Table 13: Treatment effect on plant parasitic nematode populations/200 mL soil at the end of the rotation phase. Values are log (x+1) transformed counts with back-transformed means in parentheses. Values in columns followed by the same letter are not statistically different (P=0.05).

Treatment	Lesion		Root-knot	
	Log Transformed	Back-Transformed mean	Log Transformed	Back-Transformed mean
Kairi – peanut	1.27 d	(2.6)	1.25 de	(3)
Holt – peanut	1.29 d	(2.6)	0.73 e	(1)
2B35-808 – soybean	2.66 bcd	(13.3)	3.69 bcd	(39)
A6785 – soybean	3.58 bc	(34.7)	3.48 bcd	(32)
Jade – mungbean	1.48 cd	(3.4)	6.09 ab	(439)
Onyx – mungbean	2.28 bcd	(8.7)	7.22 a	(1,361)
Sunrise – pigeon pea	2.58 bcd	(12.1)	2.72 cde	(14)
Red Caloona cowpea	1.20 d	(2.3)	3.91 bc	(49)
Bare fallow	4.03 ab	(55.4)	1.13 de	(2)
PORP	5.95 a	(382)	5.22 abc	(184)
P Value	0.005		<0.001	
LSD (P=0.05)	2.22		2.62	

Stunt, Stubby, Ring and Dagger are considered moderately pathogenic. Stunt and Dagger (data not shown) nematodes were of low numbers and there were no statistically significant treatment effects to report. Whilst not statistically significant there was a clear trend for peanuts to increase the densities of Ring nematode relative to continuous cane and there was a trend for Kairi to host more Ring nematodes than Holt (Table 14). Cowpea, pigeon pea, mungbeans and soybean variety A6785 hosted significantly less Ring nematodes than the cane and peanut plots.

Whilst there was a trend for all legumes to reduce Stubby nematode populations, Onyx mungbean and both of the soybean varieties were not statistically different to the continuous cane treatment. Variety Holt peanut hosted the lowest levels of Stunt nematodes.

Table 14: Treatment effect on plant parasitic nematode populations/200 mL soil at the end of the rotation phase. Values are log (x+1) transformed counts with back-transformed means in parentheses. Values in columns followed by the same letter are not statistically different (P=0.05).

Treatment	Stubby		Ring	
	Log Transformed	Back-Transformed mean	Log Transformed	Back-Transformed mean
Kairi – peanut	1.27 [d]	(3)	7.35 [a]	(1,559)
Holt – peanut	0.46 [d]	(1)	6.33 [ab]	(559)
2B35-808 – soybean	3.79 [ab]	(43)	2.84 [cde]	(16)
A6785 – soybean	3.84 [ab]	(46)	0.98 [e]	(2)
Jade – mungbean	3.04 [bc]	(20)	2.59 [de]	(12)
Onyx – mungbean	4.62 [ab]	(101)	1.50 [de]	(4)
Sunrise – pigeon pea	3.12 [bc]	(22)	1.18 [de]	(2)
Red Caloona cowpea	2.00 [cd]	(6)	0.0 [e]	(0)
Bare fallow	1.94 [cd]	(6)	4.12 [bcd]	(60)
PORP	5.08 [a]	(159)	5.72 [abc]	(302)
P Value	<0.001		<0.001	
LSD (P=0.05)	1.61		2.96	

<u>Sugarcane phase</u>

The six-month biomass sampling of the plant cane crop highlighted a trend (P=0.08) that breaking the cane monoculture with soybean improved sugarcane productivity by an average 70% when compared to Plough Out Re-Plant (PORP) treatment. Cane productivity post peanuts was not different to that of the plots that were previously sown to soybean. Interestingly this trial did not support grower belief that cane performs better after peanuts than soybean (a similar finding to this project's 'Carbon Trial'). Similarly, there was no evidence that peanut variety Kairi offered a cane productivity advantage over 'Holt' as a rotation option see Figure 9.

The trial did provide some evidence that different rotation options can have an impact on subsequent sugarcane productivity with Mungbean varieties Jade and Onyx rotation option yielding similarly to a monoculture (PORP). The poor performance of sugarcane post Mungbean is not completely unexpected given the build-up in Root Knot nematode populations in those plots at the harvest of the legume crops.

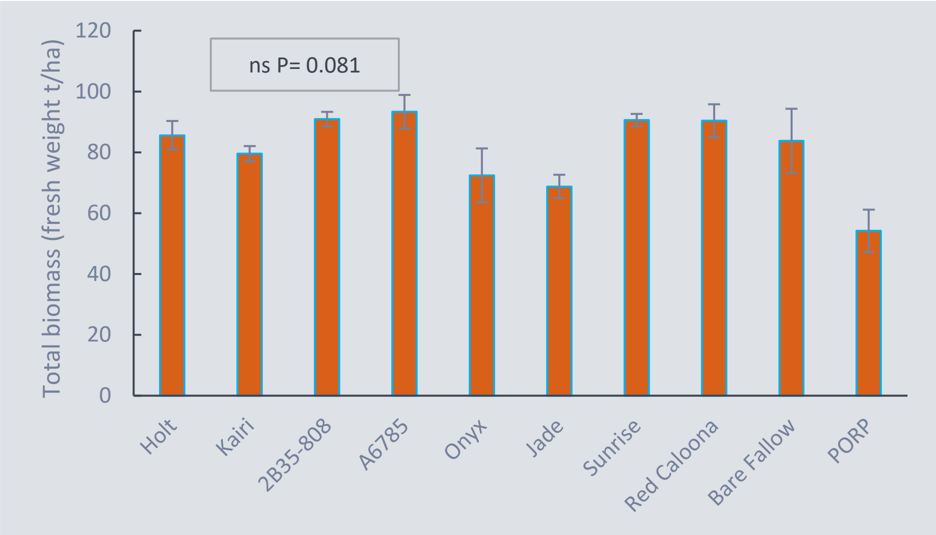

Figure 9: Previous rotation effect on the productivity of sugarcane Q240 six months post plant. Error bars are ± standard error of treatment mean.

When sugarcane productivity is compared on a dry weight basis the treatment differences follow a similar trend (P=0.102) with the PORP treatment having the lowest productivity. There is no evidence in the dry matter production data, that peanuts are a better rotation option than soybeans or that peanut growers should choose the new variety Kairi over Holt to boost the productivity of the subsequent sugarcane crop.

Stalk number data at six-month harvest highlighted that the PORP treatment had the lowest population and soybean variety 2B35-808 the highest; representing a 22.5% increase in stalk number by sowing soybean variety 2B35-808 as a break crop compared to sugarcane monoculture, Table 15.

Table 15: Treatment effect on dry matter production and stalk numbers, six months post planting. Treatments with the same letter are not statistically different (P=0.05)

Treatment – Previous fallow	Dry Matter Production (t/ha)	Stalks/ha
Holt	17.05	73,770 [ab]
Kairi	15.67	68,610 [abcd]
2B35-808	17.46	75,592 [a]
A6785	17.74	71,038 [abc]
Onyx	15.35	59,199 [de]
Jade	13.73	63,449 [cde]
Sunrise	18.81	68,610 [abcd]
Red Caloona	18.46	64,663 [bcd]
Bare Fallow	16.73	68,913 [abcd]
PORP	11.02	57,984 [e]
P Value	0.102	0.019
LSD (P=0.05)	-	9,781

Results from the six-month soil biology sampling are presented in Table 16. The data is interesting because the population of Root Knot Nematodes (RKN) have not increased to the levels experienced in previous field trials (past experience was that nematode populations proliferate in the plant cane phase). Despite the highly significant (P=<0.001) crop rotation treatment effects on RKN populations at the end of the legume phase, there is no evidence of that effect six months into the plant cane crop phase. All treatments still have statistically significantly fewer Lesion nematodes than that of the PORP treatment.

Stunt and spiral nematodes are considered to be moderately pathogenic to sugarcane. All treatments, with the exception of Bare Fallow treatment have a statistically similar Stunt nematode population to that of the PORP treatment; the Bare Fallow treatment has statistically higher populations, though still at reasonably low populations. Both soybean varieties and pigeon pea ‘Sunrise’ rotations increased the populations of Spiral nematodes relative to the PORP treatment. The plots that had peanut rotations had significantly fewer Spiral nematodes relative to the soybean rotation plots.

Table 16: Previous crop rotation effect on plant parasitic nematode populations at six month biomass sampling. Values in columns with the same letter are not statistically different (P=0.05).

	Plant Parasitic Nematodes/200mL soil					
Treatment – Previous fallow	**Lesion**	**Root Knot**	**Spiral**	**Stunt**	**Dagger**	**Stubby**
Holt	89.7 bc	264	3.7 c	3.0 d	0.0	13.0
Kairi	70.0 bc	563	0.0 c	31.3 bcd	1.7	3.0
2B35-808	126.7 bc	381	93.3 ab	44.3 bcd	0.0	26.0
A6785	179.7 bc	529	178.0 a	94.3 b	0.0	19.0
Onyx	19.7 c	5	7.7 bc	85.3 bc	0.0	0.0
Jade	19.7 c	402	9.0 bc	11.3 cd	0.0	3.7
Sunrise	79.7 bc	478	123.0 a	16.7 bcd	1.7	21.3
Red Caloona	36.3 bc	285	0.7 c	6.0 cd	0.0	4.7
Bare Fallow	233.0 b	398	8.7 bc	198.7 a	0.0	13.0
PORP	516.3 a	459	13.0 bc	27.3 bcd	4.3	2.0
P Value	**0.002**	**0.771**	**0.002**	**0.002**	**0.331**	**0.608**
LSD (P=0.05)	198.8	-	86.65	82.02	-	-

There was a statistically significant correlation (P=0.017) between lesion nematode populations and total biomass production (fresh weight basis) at the six month sampling. However, the R2 value was only 0.1875, Figure 10.

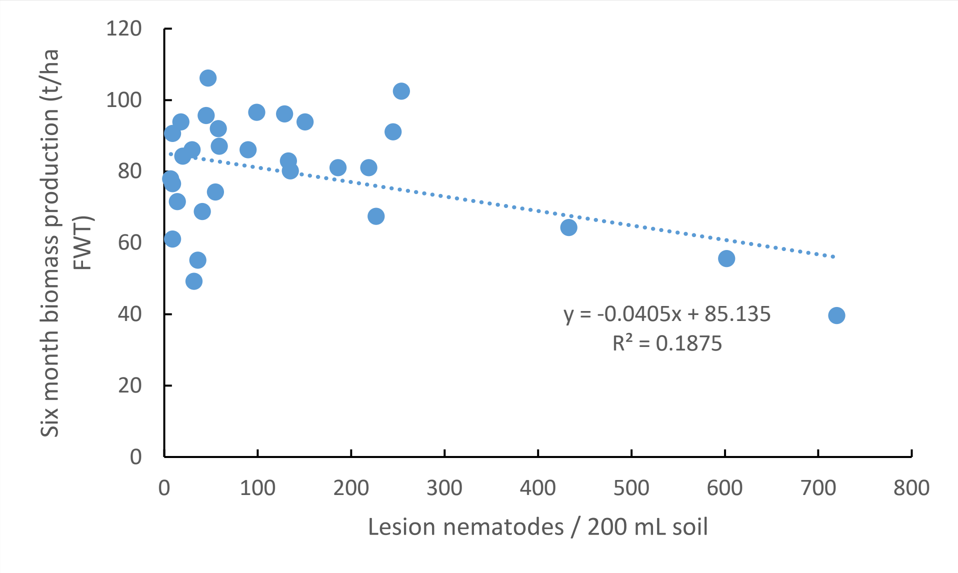

Figure 10: Correlation between lesion nematode populations in the soil and sugarcane Q240 biomass production six months after planting, following a range of rotation options.

Six-month indicator (third leaf) sampling highlighted that there were no treatment effects on leaf tissue macronutrient concentrations, (Table 17). All tissue macronutrient concentrations were above the critical values, indicating that nutrients were unlikely to have driven any productivity effects.

Table 17: Treatment effect on leaf tissue macronutrient concentrations. Critical values are highlighted in red.

Treatment – Previous fallow	Nitrogen (%)	Phosphorous (%)	Potassium (%)	Calcium (%)	Magnesium (%)	Sulfur (%)
Holt	2.25	0.22	1.25	0.27	0.20	0.23
Kairi	2.23	0.21	1.24	0.29	0.18	0.24
2B35-808	2.18	0.21	1.21	0.27	0.19	0.23
A6785	2.28	0.21	1.21	0.30	0.20	0.24
Onyx	2.20	0.21	1.29	0.27	0.18	0.23
Jade	2.23	0.21	1.33	0.27	0.17	0.24
Sunrise	2.26	0.21	1.18	0.30	0.21	0.25
Red Caloona	2.21	0.21	1.26	0.28	0.19	0.24
Bare Fallow	2.22	0.21	1.20	0.27	0.19	0.23
PORP	2.30	0.21	1.28	0.30	0.18	0.24
P Value	0.211	0.974	0.243	0.673	0.361	0.552
LSD (P=0.05)	-	-	-	-	-	-
Critical Value	**1.8**	**0.19**	**1.1**	**0.2**	**0.08**	**0.13**

Manganese was the only micronutrient where rotation options affected the leaf tissue concentrations. The PORP treatment had the highest concentration and the Red Caloona cowpea the lowest at 39.3 mg/kg and 21.3 mg/kg respectively (Table 18). The only micronutrient that was below critical value was silicon. However, there were no treatment interactions on leaf Si concentrations.

Table 18: Treatment effect on leaf tissue nutrient concentration – Micronutrients. Treatments with the same letter are not statistically different (P=0.05)

Treatment – Previous fallow	Iron (mg/kg)	Copper (mg/kg)	Sodium (mg/kg)	Manganese (mg/kg)	Silicon (%)	Zinc (mg/kg)
Holt	123.7	6.45	690.0	26.0 [cde]	0.31	20.77
Kairi	98.7	6.37	658.3	28.3 [bcde]	0.33	18.63
2B35-808	130.7	7.13	590.0	25.3 [cde]	0.34	18.10
A6785	105.0	6.30	688.7	31.0 [bcd]	0.35	18.37
Onyx	107.0	6.17	585.0	35.7 [ab]	0.34	18.97
Jade	110.3	7.20	466.3	33.0 [abc]	0.35	17.53
Sunrise	124.7	7.77	638.7	23.7 [de]	0.40	18.37
Red Caloona	104.7	6.20	668.3	21.3 [e]	0.34	17.83
Bare Fallow	130.7	6.17	649.7	29.0 [bcde]	0.29	19.33
PORP	108.3	6.26	688.3	39.3 [a]	0.38	20.43
P Value	0.408	0.654	0.657	0.006	0.467	0.312
LSD (P=0.05)	-	-	-	8.3	-	-
Critical Value	**-**	**2**		**15**	**0.7**	**15**

There was a significant impact of farming system on the productivity of the plant cane crop. Monoculture sugar (PORP) had the lowest cane yield, the lowest sugar yield and the lowest total dry matter production. The rotation with soybean variety A6785 increased the subsequent sugarcane productivity by 54%. Similarly, rotations with pigeon pea cv Sunrise; Soybean cv 2B35-808; bare fallow; peanut cv Kairi and peanut cv Holt significantly improved sugarcane productivity by 48%; 45%; 40%; 39% and 33% respectively, compared to a monoculture, see Table 19.

Rotations that included Mungbean cv Jade and Onyx and Red Caloona cow pea were not statistically more productive than a monoculture. This is despite an increase in almost 17 tc/ha more cane in the Mungbean cv Jade plots, when compared to the monoculture.

Sugar yield followed a similar pattern to cane yield, with rotations of Onyx Mungbean and Red Caloona cowpea not producing statistically more sugar than a monoculture. All other rotations produced significantly more sugar than PORP. The highest sugar yield was from sugarcane following soybean variety A6785 that produced 5.94 tonnes of sugar/ha than PORP, a 59% increase in sugar yield.

Table 19: The effect of rotation option on cane yield, CCS, sugar yield, individual stalk weight (ISW), stalks/ha and total dry matter production for the subsequent plant cane crop of Q240. Values in columns with the same letter are not statistically different (P=0.05).

Treatment – Previous fallow	Cane Yield (t/ha)	CCS	Sugar Yield (t/ha)	ISW (kg/stalk)	Stalks/ha	Total Dry Matter Production (t/ha)
Holt	86.72 ^{ab}	15.63	13.53 ^{ab}	1.44	64,967	28.78 ^{abcd}
Kairi	90.73 ^{ab}	15.56	14.10 ^{ab}	1.32	64,481	31.82 ^{ab}
2B35-808	94.67 ^{ab}	15.67	14.82 ^{ab}	1.46	65,452	33.07 ^{a}
A6785	100.5 ^{a}	15.85	15.97 ^{a}	1.57	64,967	32.86 ^{a}
Onyx	79.88 ^{bc}	16.01	12.81 ^{bc}	1.27	60,716	26.49 ^{cd}
Jade	82.16 ^{bc}	16.12	13.24 ^{ab}	1.38	59,624	27.04 ^{bcd}
Sunrise	96.91 ^{ab}	15.81	15.32 ^{ab}	1.59	63,267	31.82 ^{ab}
Red Caloona	80.08 ^{bc}	15.86	12.71 ^{bc}	1.44	59,745	27.47 ^{bcd}
Bare Fallow	90.60 ^{ab}	15.27	14.00 ^{ab}	1.50	64,481	29.56 ^{abc}
PORP	65.33 ^{c}	15.34	10.03 ^{c}	1.14	60,595	23.79 ^{d}
P Value	**0.020**	**0.210**	**0.029**	**0.281**	**0.151**	**0.014**
LSD (P=0.05)	17.56	-	2.93	-	-	5.023

Some of the plant cane treatment effects were repeated at harvest of the 1st ratoon crop (R1), with rotations such as pigeon pea and soybean outperforming the monoculture (PORP) plots. The R1 cane productivity following Sunrise Pigeon Pea was 71% higher than PORP; similarly, R1 cane following soybean was on average 70% better than PORP. Cane following Jade Mungbean was also amongst the highest yielding in the R1 cropping phase yet wasn't statistically better in the plant cane phase. Despite a 38% improvement in cane productivity following peanuts, these plots were no longer statistically different to the PORP plots.

Sugar yield followed a similar pattern to that of cane yield; however the effects were not statistically significant (P=0.052). There was no rotation impact on mean individual stalk weight, CCS, stalks/ha or dry matter production (Table 20).

Table 20: The effect of rotation option on cane yield, CCS, sugar yield, individual stalk weight (ISW), stalks/ha and total dry matter production for the 1st ratoon crop of Q240. Values in columns followed by the same letter are NOT statistically different (P=0.05)

Treatment – Previous fallow	Cane Yield (t/ha)	CCS	Sugar Yield (t/ha)	ISW (kg/stalk)	Stalks/ha	Total Dry Matter Production (t/ha)
Holt	53.55 abc	16.69	8.93	0.83	69,581	21.58
Kairi	50.79 abc	17.05	8.65	0.77	67,395	20.49
2B35-808	64.95 a	16.80	10.90	0.90	74,681	27.11
A6785	63.80 ab	16.84	10.74	0.81	76,624	25.00
Onyx	46.38 bc	17.18	7.98	0.76	72,495	21.06
Jade	65.31 a	16.60	10.81	0.94	73,953	25.79
Sunrise	65.39 a	16.82	11.00	0.82	75,653	27.11
Red Caloona	52.63 abc	16.82	8.86	0.69	73,103	23.75
Bare Fallow	56.83 ab	16.80	9.55	0.74	75,410	23.62
PORP	37.80 c	17.14	6.48	0.61	62,902	17.71
P Value	**0.047**	**0.507**	**0.052**	**0.527**	**0.169**	**0.144**
LSD (P=0.05)	17.56	-	-	-	-	-

Comparing the impact of rotation options on the cumulative production of cane and sugar for the plant and R1 crops demonstrates that the monoculture has the lowest productivity. However, the Red Caloona cow pea and Onyx Mungbean rotations despite producing 29.7tc/ha and 23.2tc/ha more cane than the monoculture respectively, were not statistically better than the PORP treatment, see Table 21. There was no evidence to support local grower experience that cane grows better after peanuts than soybean with cumulative yields of 140.9tc/ha and 161.95 tc/ha respectively.

Analysis of the cumulative sugar data demonstrated that only the Onyx Mungbean rotation produced a statistically similar cumulative sugar yield to that of the PORP treatment. The cumulative sugar yield response was A6785[a] ≥ Sunrise[ab] ≥ 2B35-808[abc] ≥ Jade[abc] ≥ Bare Fallow[abc] ≥ Kairi[abc] ≥ Holt[abc] ≥ Red Caloon[abc] ≥ Onyx[cd] ≥ PORP[d].

Table 21: The effect of rotation option on cumulative cane yield, cumulative sugar yield and cumulative total dry matter production for the plant and 1st ratoon crop of Q240. Values in columns with the same letter are not statistically different (P=0.05).

Treatment – Previous fallow	Cumulative Cane Yield (t/ha)	Cumulative Sugar Yield (t/ha)	Cumulative Total Dry Matter Production (t/ha)
Holt	140.3 abc	22.46 abc	50.4
Kairi	141.5 abc	22.75 abc	52.3
2B35-808	159.6 ab	25.72 abc	60.2
A6785	164.3 a	26.72 a	57.9
Onyx	126.3 cd	20.79 cd	47.6
Jade	147.5 abc	24.04 abc	52.8
Sunrise	162.3 ab	26.32 ab	58.9
Red Caloona	132.7 bcd	21.57 bc	51.2
Bare Fallow	148.4 abc	23.55 abc	53.2
PORP	103.1 d	16.50 d	41.5
P Value	**0.020**	**0.016**	**0.054**
LSD (P=0.05)	31.49	5.02	-

There are large treatment differences on gross margin that would impact on grower profitability. The impact of crop choice on gross margin in the rotation phase has already been discussed. However, it is worth highlighting the gross margin potential of a peanut rotation.

In the plant cane phase all rotation options produce a better gross margin than continuous cane (-$272/ha). The average gross margin for cane following peanuts and soybean is $799.5/ha and $1,132/ha respectively, whilst not statistically different differs from local wisdom. Sugarcane performance following Sunrise Pigeon Pea is reflected in plant cane gross margin figures.

There are similar trends in the gross margin analysis of the R1 cane crop. However, treatment effects are not statistically different (P=0.057).

Not all rotation options are the same. This experiment demonstrates the lowest gross margin farming system is a Mungbean cv Jade rotation, generating a -$77/ha combined rotation and plant cane gross margin, this is despite the fact that this treatment had significantly higher cumulative cane productivity when compared to the monoculture. By comparison, the combined gross margin of Kairi peanut and plant cane crop was $4,056/ha more than Jade Mungbean option, Table 22.

Table 22: Rotation option effect on the gross margin (GM) of the rotation option, plant cane crop and combination of fallow and plant cane systems. Values in columns with the same letter are not statistically different (P=0.05).

Treatment – Previous fallow	Rotation option GM ($/ha)	Plant cane GM ($/ha)	R1 GM ($/ha)	Combined GM of legume and plant cane crops($/ha)
Holt	3,165 a	745.0 a	720	3,910 a
Kairi	3,125 a	854.0 a	681	3,979 a
2B35-808	420 c	1,021.0 a	1,168	1,441 bc
A6785	533 bc	1,243.0 a	1,137	1,776 b
Onyx	104 d	594.0 a	537	698 cd
Jade	-763 e	706.0 a	1,128	-77 d
Sunrise	769 b	1,187.7 a	1,194	1,956 b
Red Caloona	-660 e	691.3 a	715	31 d
Bare Fallow	-578 e	667.7 a	866	90 d
PORP	494 c	-272.0 b	195	222 d
P Value	**<0.001**	**0.011**	**0.057**	**<0.001**
LSD (P=0.05)	273.1	677.2	-	781.6

Cumulative gross margin analysis of rotation option, plant cane and R1 combined demonstrates that peanut rotation provides the highest gross margin of $4,645/ha, significantly better than Sunrise Pigeon pea $3,151/ha and soybean of $2,7650/ha. The peanut, pigeon pea and soybean cumulative gross margins were significantly better than all the other options. This means that rotations other than peanuts, soybean and Sunrise pigeon pea were not more economically attractive than PORP, Figure 11.

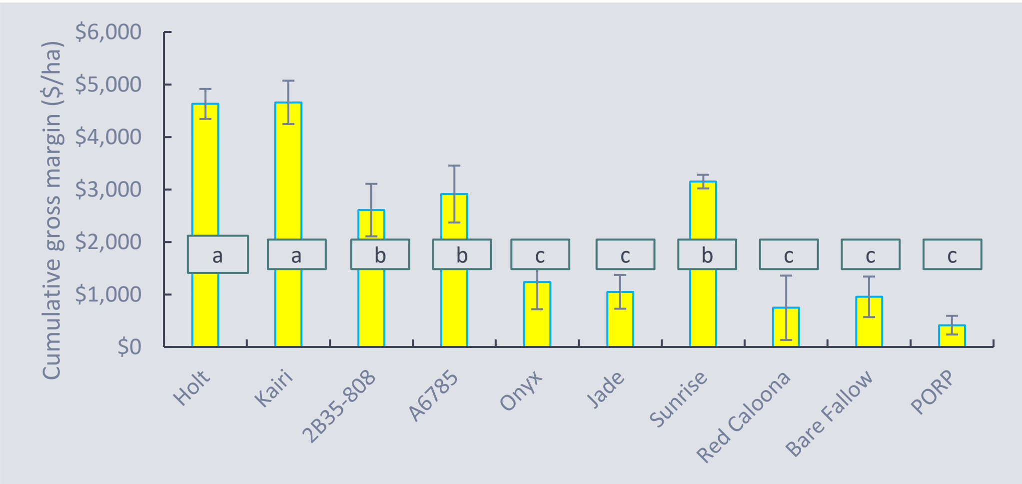

Figure 11: Treatment effect on cumulative (rotation + plant cane + R1) gross margin. Treatments with the same letter are NOT statistically different (P-0.05). Error bars are +/- SE of treatment mean.

1.1.1 SU Trial

Please note that some of the herbicides used in this experiment are currently not registered for use in soybean production in Australia and as such should NOT be used in the production of soybeans. These treatments should be redacted if this paper is reproduced.

Soybean phase

Figure 12: Photo showing the effect of DG + Semp E treatment with variety A6785 on the left and Kuranda on the right.

There was a highly significant ($P < 0.001$) variety by herbicide interaction where the application of Sempra® significantly reduced the yield of A6785 whereas Kuranda was unaffected, see Figure 12. However, both soybean varieties were unaffected by the application of Associate® that was applied post-plant pre-emergence. Whilst A6785 was unaffected by the application of Associate® pre-planting the additional application of Spinnaker® (Spin) at first trifoliate growth stage significantly reduced yield by 0.66t/ha, whereas the yield of Kuranda was unaffected. Interestingly the application of Spinnaker® following the application of Dual Gold® pre-emergent herbicide did not reduce the yield of A6785 implying that A6785 could tolerate Associate® or Spinnaker® by themselves but not when they were combined (see Figure 13).

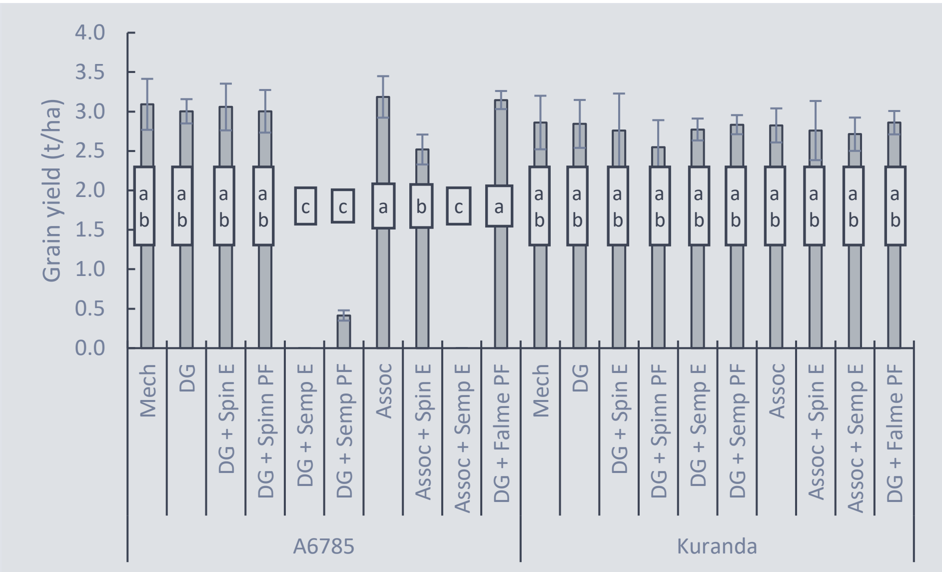

Figure 13: Significant soybean variety and herbicide application interaction on the grain yield of soybean varieties A6785 and Kuranda. Treatments with the same letter are NOT statistically significant (P=0.05). Error bars are +/- SE of treatment mean.

Sugarcane phase

There was a trend (P=0.058) for the preceding soybean variety to influence crop establishment (11.12.19) and this was reflected in shoot numbers, where the A6785 plots had 126,667 shoots/ha compared to the Kuranda plots 95,027 shoots/ha; this represents 33% more shoots in the A6785 plots *cf* Kuranda. There was no evidence of the herbicide program in the soybean cropping phase affecting sugarcane population in the early growth phase (P=0.354) and there was no soybean variety by herbicide interactions (P=0.944). Herbicide residue testing determined that there were no previous soybean variety differences in the concentration of the herbicides tested, Table 23. Sempra® (Halosulfuron) was reported at levels below reportable at <0.20 µg/kg. Similarly, Associate® (Metsulfuron) was reported at levels below detection at <0.01 µg/kg. This would suggest that the difference in sugarcane early growth was not due to herbicide applications in the soybean phase

Table 23: Results of chemical residue testing in the 0 – 10cm layer in the soil, February 2020. Values followed by the same letter are NOT statistically different (P=0.05).

Treatments	**Dual Gold® S-Metolachlor (µg/kg)**	**Spinnaker® Imazethapyr (µg/kg)**	**Flame® Imazapic (µg/kg)**
Previous soybean Variety			
A6785	41.0	0.23	0.22
Kuranda	31.8	0.22	0.22
P Value	**0.324**	**0.941**	**0.383**
LSD (P=0.05)	-	-	-
Herbicide strategy in soybean phase			
Mech	30.53	0.009	<0.20 [b]
DG + Spin PF	43.90	0.557	<0.20 [b]
DG + Semp PF	50.35	0.078	<0.20 [b]
Assoc + Spin E	26.12	0.393	<0.20 [b]
DG + Flame PF	31.28	0.100	0.343 [a]
P Value	**0.097**	**0.067**	**0.050**
LSD (P=0.05)	-	-	*0.114*

Six month biomass sampling highlighted significantly higher cane productivity following A6785 relative to Kuranda, see Figure 14. SRA11 had significantly higher biomass (wet weight), number of stalks/ha and dry matter production after soybean A6785 compared to after Kuranda.

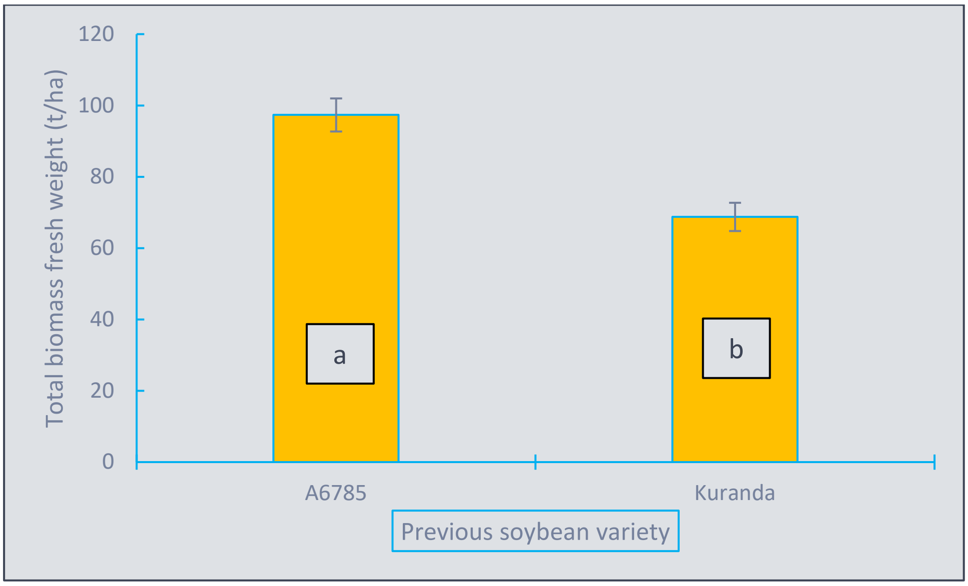

Figure 14: The effect of previous soybean variety on the productivity of sugarcane variety SRA 11 six months after planting. Treatments with the same letter are NOT statistically significant (P=0.05). Error bars are +/- SE of treatment mean.

Whilst the DG + Semp E treatment resulted in the highest biomass, stalk count and dry matter production; and Assoc + Semp E treatment produced the lowest biomass, stalk count and dry matter production, there were no statistically significant effects of herbicide application strategies employed in the soybean phase having an impact on the subsequent cane crop six months post planting, Table 24. However, there was 41% more biomass, 17% more stalks and 46.7% more dry matter production in plots that were sown to A6785 relative to the Kuranda plots.

Table 24: The effect of previous soybean variety and herbicide application strategy on the productivity of sugarcane variety SRA11 at 6 months from planting. Values followed by the same letter are NOT statistically different (P=0.05)

Treatments	**Biomass (t/ha)**	**Stalks/ha**	**Dry matter production (t/ha)**
Previous soybean variety			
A6785	97.3 [a]	87,432 [a]	21.97 [a]
Kuranda	68.8 [b]	74,681 [b]	14.98 [b]
P Value	**0.013**	**0.019**	**0.005**
LSD (P=0.05)	*13.97*	*7,719*	*2.236*
Herbicide strategy in soybean phase			
Mech	85.8	86,521	19.37
DG	88.2	83,789	18.71
DG + Spin E	78.2	80,146	17.19
DG + Spin PF	80.8	75,592	17.43
DG + Semp E	97.1	91,075	22.01
DG + Semp PF	74.4	81,056	16.35
Assoc	79.1	76,503	17.19
Assoc + Spin E	82.8	78,324	18.63
Assoc + Semp E	73.2	75,592	16.69
DG + Flame PF	90.8	81,967	21.19
P Value	**0.728**	**0.372**	**0.795**
LSD (P=0.05)	-	-	-
Variety * Herbicide Interaction P Value	**0.473**	**0.245**	**0.322**

Statistical analysis of plant parasitic nematode data does not provide any explanation of the superior cane productivity post A6785 relative to Kuranda. If anything, there appears to be very similar if not slightly higher plant parasitic nematode numbers following A6785. However, only the ring nematode numbers were statistically different, Table 25. Soybean herbicide application strategy had no impact on plant parasitic nematode populations and there were no variety by herbicide interactions (data not shown).

Table 25: Previous soybean variety effect on plant parasitic nematode populations in sugarcane variety SRA11, six-months post-plant. Values in columns followed by the same letter are NOT statistically different (P=0.05)

	Plant Parasitic Nematode numbers/200mL soil						
Variety	**Root-knot**	**Lesion**	**Reniform**	**Ring**	**Spiral**	**Stubby**	**Stunt**
A6785	384	178	9.6	90.9 [a]	11.0	8.2	1.03
Kuranda	359	119	2.0	48.2 [b]	9.5	8.5	0.70
P Value	**0.494**	**0.090**	**0.131**	**0.029**	**0.373**	**0.881**	**0.643**
LSD (P=0.05)	-	-	-	*31.9*	-	-	-

There was no effect of previous soybean variety or the herbicide application strategy in the soybean phase on the concentration of nitrogen, phosphorus, potassium, calcium and sulphur as measured in the indicator leaves six-month post planting. There were significantly higher concentrations of magnesium in the plots that had previously been sown to soybean A6785 cf Kuranda. However, those values were well above the suggested 'critical values' that would be considered a constraint on productivity, see Table 26. There were no treatment effects in the micronutrients (data not shown). These data would suggest that the plant growth responses seen, were not nutritionally related.

Table 26: The effect of previous soybean variety and herbicide application strategy on the Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg) and Sulphur (S) concentration of 'Indicator leaf' of sugarcane variety SRA 11, six months post planting. Values in columns followed by the same letter are NOT statistically different (P=0.05)

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)
Previous soybean variety						
A6785	2.045	0.195	1.484	0.390	0.170 [a]	0.188
Kuranda	2.071	0.196	1.510	0.415	0.159 [b]	0.185
P Value	**0.251**	**0.627**	**0.205**	**0.567**	**0.018**	**0.148**
LSD (P=0.05)	-	-	-	-	*0.025*	-
Herbicide strategy in soybean phase						
Mech	2.068	0.196	1.521	0.421	0.155	0.181
DG	2.093	0.197	1.490	0.428	0.164	0.186
DG + Spin E	2.048	0.199	1.578	0.381	0.176	0.191
DG + Spin PF	2.083	0.204	1.538	0.446	0.156	0.184
DG + Semp E	2.088	0.195	1.488	0.411	0.165	0.185
DG + Semp PF	2.040	0.195	1.498	0.410	0.156	0.181
Assoc	2.062	0.199	1.515	0.378	0.166	0.188
Assoc + Spin E	2.028	0.190	1.458	0.396	0.164	0.189
Assoc + Semp E	2.010	0.189	1.405	0.378	0.161	0.179
DG + Flame PF	2.060	0.193	1.477	0.380	0.182	0.203
P Value	**0.104**	**0.660**	**0.240**	**0.216**	**0.361**	**0.248**
LSD (P=0.05)	-	-	-	-	-	-
Variety * Herbicide Interaction P Value	0.806	0.383	0.110	0.622	0.726	0.340
Critical Value *	1.7	0.19	1.1	0.2	0.08	0.13

The reduced productivity of sugarcane sown after soybean variety Kuranda relative to soybean variety A6785 was maintained until harvest of the plant cane crop. There was 55%, 55.7% and 55.8% more cane, sugar and dry matter respectively when sugarcane followed soybean variety A6785 when compared to Kuranda. This response was due to 15,137 stalks/ha more in the A6785 plots, a 24.4% increase combined with a trend (P=0.083) of a 0.25kg/stalk increase in individual stalk weight (ISW), see Table 27.

Both the DG + Spin PF and DG + Semp PF treatments had significantly higher commercial cane sugar (CCS) content compared to the Mechanical control (Mech) treatment. The CCS effect was the only measured impact of herbicides used in the soybean cropping phase effecting the subsequent sugarcane crop.

Table 27: The effect of previous soybean variety and herbicide application strategy on the cane yield, CCS, sugar yield, individual stalk weight (ISW), stalks/ha and total dry matter production at harvest of the subsequent sugarcane crop variety SRA 11.

Treatments	Cane yield (t/ha)	CCS	Sugar yield (t/ha)	ISW (kg/stalk)	Stalks/ha	Total dry matter production (t/ha)
Previous soybean variety						
A6785	82.3 ^{a}	16.72	13.72 ^{a}	1.12	77,268 ^{a}	29.51 ^{a}
Kuranda	53.1 ^{b}	16.75	8.87 ^{b}	0.87	62,131 ^{b}	18.94 ^{b}
P Value	**0.025**	**0.916**	**0.030**	**0.083**	**0.011**	**0.018**
LSD (P=0.05)	*20.39*	-	*4.77*	-	*6,742*	*6.238*
Herbicide strategy in soybean phase						
Mech	73.1	16.54^{bc}	12.13	1.00	72,860	25.94
DG	60.1	16.56^{bc}	10.21	0.99	65,027	21.15
DG + Spin E	63.9	16.57^{bc}	10.62	0.96	68,306	23.02
DG + Spin PF	57.6	17.11^{a}	9.84	0.89	64,117	20.44
DG + Semp E	67.3	16.71^{abc}	11.13	0.99	70,401	24.10
DG + Semp PF	63.2	17.11^{a}	10.85	1.00	68,852	22.82
Assoc	80.0	16.59^{bc}	13.27	1.05	72,860	28.33
Assoc + Spin E	67.1	16.57^{c}	11.03	1.02	69,854	24.27
Assoc + Semp E	67.5	16.47^{ab}	11.41	0.92	71,220	24.42
DG + Flame PF	77.2	16.80^{abc}	12.92	1.10	73,497	27.75
P Value	**0.831**	**0.047**	**0.828**	**0.940**	**0.853**	**0.800**
LSD (P=0.05)	-	*0.44*	-	-	-	-
Variety * Herbicide Interaction P Value	0.168	0.315	0.223	0.386	0.146	0.245

7. CONCLUSIONS

7.1 Project process

Results from the independent project impact report demonstrate that direct engagement of growers, agronomists, advisors and farm managers in the RDE process where activities are targeted at locally relevant issues was valued by industry. "The active involvement of growers and advisors in guiding the project has been valued and has seen as successfully influencing project activities and outcomes. This reflects best practice and should be built into future similar projects" (page 35 of Impact Report).

Success can only be gauged by survey response where the impact report documents clear evidence that the project has increased participants knowledge, understanding and skills relevant to their business. Particular mention of soil health, compaction, fertiliser and better understanding of the economics associated rotational cropping.

65% of growers surveyed in the impact report indicated that they had made changes to their farming system as a result of engaging in project activities. 10 of the 11 advisors surveyed made changes to their advice to growers as a direct result of project participation.

The impact report also identified that the survey participants would have liked more sites, bigger scale demonstration activities and that a similar concept should be rolled out across other sugar growing districts. There was also mention of the length of time that trials run for with respondents wanting a productivity data captured further into the cropping cycle.

7.2 Carbon Trial

The addition of organic matter did not have an effect on the dry matter production, grain yield or gross crop value of the legume break crops (peanuts and soybean). The slotting placement of organic matter improved legume dry matter production by 4.8%, but that was the only significant treatment effect during the legume phase. Peanuts produced a much higher gross crop value than soybean.

There were significantly more stalks/ha in sugarcane planted after peanuts compared to soybean plots, but that effect did not translate to improved cane or sugar yield of the plant cane crop. The organic matter ameliorants did not improve sugarcane productivity in the plant cane crop.

The addition of Mill-mud significantly increased the potassium and silicon concentration in the third leaf samples six months after planting, indicating elevated nutritional status. The addition of Mill-mud raised the silicon third leaf concentration to above the critical value, highlighting the ability of this product to ameliorant sub-optimal soil silicon levels.

The preceding legume crop, addition of organic matter or where the organic matter was placed had no measurable effects on populations of the two major plant parasitic nematodes root knot nematode (*Meloidogyne Sp.*) and root Lesion nematode (*Pratylenchus zae*) in the soil six months after sugarcane establishment.

The slotting treatment significantly reduced soil bulk density in the 20 – 40cm layer relative to the surface incorporated treatment. The reduction in soil bulk density possibly explains the improved sugar and dry matter yields and the number of stalks in that treatment in the R1 crop.

There were no treatment effects on the R2 crop. However, analysis of cumulative cane crop data demonstrated an 8.96% improvement in sugar yield in the Mill-mud amended plots relative to the Nil plots. A course analysis of cane crop gross margin between the Nil and Mill-mud plots over the cane cycle demonstrates a $236/ha improvement in cumulative gross margin to the farmer through the application of Mill-mud before the legume cropping phase, representing a 3.9% improvement in gross margin ($/ha). (This is assuming a price of $400/t for sugar and a 4-unit CCS deduction allowing for milling costs and a mill-mud application cost of $600/ha).

Given the long length of time between the application of Mill-Mud and the positive productive response and the potential impact of pre-legume crop mill-mud application reducing nitrogen fixation; investigation as to when is the most appropriate time to apply mill-mud to marginal soils is worthy of further investigation. This is particularly important when the application at 60t/ha is likely to cost the grower around $600/ha.

The slotting of organic matter has proven very beneficial in grain cropping soils of northern Victoria limited by sodic sub-soil constrains. Whilst this site did not have sodicity as a sub-soil constraint, it did have very low moisture and nutrient holding capacity. The slotting of organic matter in this field experiment had no measurable productivity gain on the peanut, soybean and sugarcane crops. More work on organic matter type, rate, placement and understanding of soil type interaction is required to materialise a productivity gain in the coastal cropping systems of the Coastal Burnett.

Interestingly this experiment was not able to verify local grower belief that peanuts are the 'best' grain legume crop to improve the productivity of the subsequent sugarcane cropping cycle. Further, this experiment highlights the importance of monitoring treatment effect on cane productivity through a crop cycle and this represents a challenge to funding sources.

7.3 Fallow Management Trial

The data from the Fallow Management Trial demonstrate that peanuts and soybean are valuable rotations in sugarcane farming systems in terms of boosting grower profitability as well as boosting the productivity of the subsequent sugarcane crop. This trial also highlights the potential of pigeon pea as a future rotation crop. Interestingly, there was no evidence that sugarcane productivity was better after peanuts relative to soybean. This result differs from local grower belief.

Peanut rotations are somewhat restricted by soil type, requiring friable soil for successful digging of the crop. As a general 'rule of thumb', peanut production is restricted to soils with a cation exchange capacity below 7meq/100g. Soybean production is not restricted by soil type in the same way. However, hard-setting soils do present an establishment challenge if rain occurs post plant and pre-emergence of soybean crops. Tillage regimes that maximise surface trash retention will greatly assist soybean establishment in these soils.

This one field trial has highlighted that whilst Red Caloona cowpea was the 'best' legume, in terms of nitrogen contribution, that this not translate to the 'best' cane productivity or the 'best' profitability. Whilst the peanut rotation provided the 'best' profitability (cumulative gross margin), by the first ratoon Sunrise Pigeon pea provided the 'best' sugarcane yield.

All legume rotations significantly reduced populations of root Lesion nematode when measured six-months after establishment of the plant cane crop. The poor sugarcane performance of the plots where Mungbean variety Onyx were used as a rotation option is possibly reflective of the sandy soil and the high numbers of plant parasitic nematodes (Root Knot Nematode) that proliferated on them. Data collected at this field experiment suggests that the industry would benefit from the development of a legume decision support tool to assist growers in making profitable farming system decisions.

7.4 SU Trial

Data from this one field trial would suggest that application of currently registered herbicides in the soybean cropping phase has no impact on the productivity of the subsequent sugarcane crop. Allaying growers' concerns about the potential strategies available with SU tolerant soybeans affecting their cane productivity.

However, this trial has highlighted that the selection of a soybean variety in the legume rotation phase has the potential to affect the productivity of the subsequent sugarcane crop in a sugar-based farming system. The rotation with soybean variety Kuranda resulted in significantly less cane, sugar and dry matter production when compared to a rotation with soybean variety A6785. The sugarcane emergence appeared to be affected by Kuranda with a trend for lower shoot counts two months post planting and resulted in a reduction in cane stalks at harvest. The reduction in productivity wasn't explained by nutrition (as highlighted by indicator leaf assessment), adverse soil biology (plant parasitic nematode populations) or residual herbicides in the soil.

Further experimentation is required to determine the repeatability of this result and if repeated determination of the causal agent.

8. RECOMMENDATIONS FOR FURTHER RD&A

The sub-optimal performance of sugarcane variety SRA11 following Kuranda soybean relative to soybean variety A6785 warrants further investigation.

Growers feedback in the impact report warrants consideration, where they would like to see selected treatments being applied in larger scale trials. There was also constructive feed-back they would have preferred that more trials were conducted than the number that were implemented in this project.

There is strong evidence that an inclusive RDE process has the capacity to better engage the cane growing community. This is particularly poignant given current industry realignment of adoption activities.

9. PUBLICATIONS

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10. ACKNOWLEDGEMENTS

This activity would not be possible without the contribution from David Reid, DAF Biometry Services, for review of statistical analysis; Ian Dart and farm staff from Bundaberg Sugar Limited; Troy Manderson and Isis Cane Services for access to the site and associated field staff in the conduct of this experiment. These complex field trials would not have been possible without the excellent contributions of the DAF team; Steve Gins (Senior Extension Agronomist), Angela Marshall (Agronomist); William Rehbein (Technician) and Ken Bird (Technician).

Funding support from GRDC for Growers Solution Project for Coastal/Hinterland Queensland and NSW North Coast (DAQ00204); SRA Southern Sugar Solutions project (2017/012) and Queensland Government through Department of Agriculture and Fisheries was essential to conduct this body of work.

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12. APPENDIX

12.1 Appendix 1 METADATA DISCLOSURE

<Delete these guidelines prior to submission. Please do not change font styles. Fill in the following details regarding the data generated in the course of this project. Provide details about the location, accessibility and contact details of those managing the data. Delete if not required.>

TABLE 28 METADATA DISCLOSURE 1

Data	Data files; Excel spreadsheets containing yield, soil biology and nutrition data for the field trials
Stored Location	Queensland Department of Agriculture and Fisheries, Bundaberg Research Facility 49 Ashfield Rd Bundaberg
Access	Restricted
Contact	Justin Davies, Facility Manager

12.2 Appendix 2

COUTTS J&R
MANAGING AND EVALUATING CHANGE

IMPACT REPORT

SRA Southern Sugar Solution Project

March 2021

Acknowledgements

This report would not have been possible without the help of the DAF project team in developing the survey and providing contact details. Without the growers who willingly gave their time to talk through their experiences of the project there would be no meaningful impact data to include in this report.

Amy Samson
Principal Consultant

Ben Coutts
Principal Data Analyst

Liesel Rennie
Survey Manager and Researcher

Dr Jeff Coutts
Director

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March 2021

Summary

About this Report

This is an end of project impact report drawing from provided secondary data and a survey of 58 growers and consultants participating in the project.

About the Project

The Southern Sugar Solutions project was co-funded by SRA and run by the Queensland Government's Department of Agriculture and Fisheries (DAF). It ran from 2017 to the end of 2020 and focused on establishing the impact of legume crops established during the Grains Research and Development Corporation (GRDC) Grower Solutions Project, on subsequent sugarcane crops. It aimed to capture the farming system benefit of established legume field experiments. This was achieved through the establishment of three sugarcane trial sites following the legume trials initiated under the GRDC project.

Key Findings

PROJECT APPROACH:

- **The DAF project team delivered the project well.** The team's high level of consultation and communication with the sugar industry as well as their interest and dedication to the project was noted by survey respondents. At a governance level, Steering Committee members were generally satisfied with their opportunities to provide input into the project's research, development and extension (RD&E) process.

- **The project successfully involved the southern sugar growing community in the research process and was thought to have achieved a reasonable level of industry participation.** Survey respondents across all stakeholder groups felt that the project had provided enough opportunities to participate and had adopted a practical approach to sharing relevant information and communicating with the sugar industry.

- **DAF successfully provided a link between SRA and GRDC research.** Feedback from bus tours and survey respondents highlighted the importance of DAF's role in bringing together the different organisations and resources necessary to complete the trial work. Steering Committee members pointed out that a good job had been done linking the projects within limited funding available and the project team's capacity and associated constraints as a government organisation.

- **Suggestions for the future** included increasing the scale (e.g. bigger blocks) of the trials, wider industry engagement (e.g. across regions) and research topics (e.g. variety selection impact on rotational cropping).

Synergy with GRDC Grower Solutions Project

The strong links between the GRDC funded Grower Solutions project and the Southern Sugar Solutions project has successfully developed synergies, economies and maximised benefits to growers. These cross-RDC opportunities should be identified and maximised where possible.

Industry Guidance

The active involvement of growers and advisers in guiding the project has been valued and seen as successfully influencing project activities and outcomes. This reflects best practice and should be built into future similar projects with training provided to industry participants where needed to maximise their effective input.

Government Delivery

The DAF team in this project should be commended on the way they effectively fostered grower and consultant engagement and ownership and were able to work across organisations to achieve synergies. The very positive feedback from growers and advisers about their approach and professionalism reflects the ongoing relevance and role to be played by government agencies.

ACTIVITIES:

- **The project activities and information were seen as very relevant and valuable to the industry, particularly in relation to building a more sustainable system through crop rotation**. Survey respondents felt that the format had worked well, effectively covered relevant issues of direct interest to growers, provided practical activities and sound research, and effectively worked to find solutions and solve problems.
- **Specific feedback about activities included:**
  - Bus trips were very useful, well organised and a networking tool.
  - Update meetings were useful, well targeted and provided scientific data.
  - The Facebook group provided easy access to information and survey respondents not aware of its existence were interested in joining, however, it was not for everyone.
- **The project facilitated better connection across the industry.** Survey respondents agreed that involvement in the project and its activities had helped participants across all stakeholder groups better connect with researchers, growers, advisers and others in the sugar growing industry.

The project used activities well-suited to the project objectives, grower needs and preference with direct trial experience and practical examples proving to be effective extension methods. There is scope to increase awareness of the project, including the use of social media to maximise learning and industry engagement.

IMPACTS AND BENEFITS:

- **There is some evidence that the project has improved participant knowledge, understanding and skills around the impact of legumes on the farming system.** Feedback from bus trip participants and survey respondents indicated increased awareness of and access to industry relevant information to help inform decisions and a better understanding of the impact of legumes on soil health, fertiliser and pest management needs.
- **There is some evidence that the project has prompted on farm change and sharing of practice change advice, with those having made changes seeing improved productivity, improved soil and improved profitability.** Across all the feedback (bus trip and survey), around half of respondents indicated they were making or planning changes as a result of engaging in one or more project activities (e.g. changes to legume varieties). For many, the project had also confirmed current approaches, prompted a search for more information and provided a support network.
- **The project approach was thought to increase adoption of trial findings.** Survey respondents generally appreciated the project's approach involving the sugar growing community in the research process and felt that this would result in the trial findings more likely to be adopted. It was also noted that despite the best efforts of the project people can still be resistant to change.
- **The project is thought to be enabling some yield improvements in the region.** Some steering committee members mentioned sugar yield increases of between 10 to 20 percent while others noted the additional sustainability benefits of the move towards a rotational system.

The high level of positive impact on grower and adviser project participants confirmed its relevance and effectiveness of its process. There was a clearly expressed belief that growers who had undertaken/were undertaking actions based on the project outcomes were gaining benefits as a result. These impacts support the project's value and highlight the need for it to be expanded to include other geographical contexts and explore new approaches to engage with growers less willing to participate in current activities.

RECOMMENDATIONS

It is not clear whether there is an intention by funding bodies to continue or extend this project. However, based on the evidence of this review, there is a strong argument to continue farming systems research and to extend the project's base and reach.

Recommendation 1

It is recommended that there should be a continuation and extension of this project to build on the base established to date, and to multiply the impact of the work already undertaken.

This project and its approach were significant because of the strong involvement of growers and advisers in providing input and guiding the trials and activities. Feedback proved that this was very much appreciated and effective. The bus trips and trial visits demonstrated their value and suitability as a means to expose growers and advisers to the research work in practice and the associated farming system recommendations. Additionally, directly linking the SRA and GRDC research projects not only connected relevant research across two industries, but also added efficiencies as well as leveraging funds and grower time.

Recommendation 2

The lessons on the value of involving growers and advisers in guiding on-farm research and associated activities should be applied to other similar projects in the future.

Recommendation 3

Every opportunity should be taken to link with other RDC funded projects where there is common interest and value across industries.

Contents

1. Introduction

1.1 About this Report

This impact report for the Sugar Research Australia (SRA) funded Southern Sugar Solutions project draws from provided secondary data and a survey of growers and consultants (February 2021) who participated in the project.

1.2 About the Project

The Southern Sugar Solutions project was co-funded by SRA and run by the Queensland Government's Department of Agriculture and Fisheries (DAF). It ran from 2017 to the end of 2020 and focused on establishing the impact of legume crops established during the Grains Research and Development Corporation (GRDC) Grower Solutions Project, on subsequent sugarcane crops. It aimed to capture the farming system benefit of established legume field experiments. This was achieved through the establishment of three sugarcane trial sites following the legume trials initiated under the GRDC project. These were:

- Woodward Road "Carbon Trial" on Bundy Sugar Farms
- Gillens Creek Road "Fallow Management Trial" on Bundy Sugar Farms
- Takalvan "SU Herbicide and A6785 vs Kuranda Trial" on ISIS Farms

The project's research directions were set annually by a Steering Committee *made up of growers, advisers and agronomists from the Maryborough, Childers and Bundaberg sugar factory cane supply districts*[1]. The Steering Committee members changed from year to year allowing a higher level of involvement from more stakeholders. Including stakeholders in the research process was an important aspect of the project and aimed to *improve knowledge transfer and adoption; thereby improving grower profitability*[2]. The overall outcome of this project is intended to be a sugarcane growing community that is actively involved and contributing to the RDE process in the Southern Region with enhanced adoption of trail results. This is to be achieved though active industry participation in the project.

Activities over the life of the project included:

- Annual bus trip field visits to the trial sites open to the wider growing community - providing a platform to showcase the research more widely.
- Grower Update meetings held annually in Bundaberg, Childers and Maryborough where the results from the season were presented and ideas for the next season gathered.
- Steering Committee meetings

1.3 Evaluation Approach

The two key data sources contributing to this report include secondary data supplied by DAF and the project participant survey undertaken by Coutts J&R.

SECONDARY DATA

The secondary data contributing to this report includes:

- Project milestone reports 2,3,4,5,6,7
- Trial bus tour evaluation reports 2018, 2019, 2020
- Facebook analytic data – 19 February 2021

PROJECT PARTICIPANT SURVEY

The survey was undertaken with project participants during February 2021. DAF provided a contact list and late January emailed those with phone numbers to advise that they may be contacted to provide feedback about the project. They were also provided with an opportunity to opt out of being called if they did not wish to participate.

Fifty-eight project participants contributed to this review of the Southern Sugar Solutions Project including:

- 32 growers

[1] https://sugarresearch.com.au/research-portfolio/#?area=key-focus-area-4&project=southern-sugar-solutions

[2] https://sugarresearch.com.au/research-portfolio/#?area=key-focus-area-4&project=southern-sugar-solutions

- 13 consultants/ advisers /agronomists
- 2 resellers
- 1 extension officer
- 10 others including field officers, farm managers and sales and agriculture representatives

For reporting purposes, the graphs in the findings section below group respondents into three categories: growers; advisers; and others.

STEERING COMMITTEE

Fifteen participants interviewed had served as a member of the project steering committee at some point. These people included:

- 7 consultants/ advisers /agronomists
- 1 extension officer
- 5 growers
- 2 others (Farm manager and ISIS representative).

HECTARES FARMED OR INFLUENCED

The survey asked respondents to indicate the hectares (Ha's) they farm or have influence over. The following table shows the number of people who provided these details. Growers (n=26) farmed an average of 467 Ha's ranging from 35 to 6,000. Advisers (n=11) had influence over an average of 4,427 Ha's ranging from 1,000 to 9,000. Those in the 'other' category influenced an average of 7,394 Ha's ranging from 100 to 30,000.

Table 29: Respondents and Ha's farmed or influenced

Category	No. of respondents	Total Hectares
Grower	26	12,372
Adviser	11	48,700
Other	9	66,550
Overall	46	127,622

2. Findings

2.1 Project Approach

Relevant project impact areas include:

- Industry engagement in the project will improve knowledge-transfer between trial results and practice change within the growing and research communities.
- Major stakeholders (levy payers) having a direct input on where their RDE investment is spent.
- Fostering collaboration, developing and supporting relationship linkages between three mill districts.

2.1.1 Project Milestones

Each of the project milestones reported that targets had been completed and delivered indicating that the project management was effective. The only mention of COVID-19 restrictions impacting on project activities was in the Milestone 7 July 2020 report which noted that the six month biomass sampling of cane *was modified due to the social distancing restrictions in place during the Covid-19 pandemic. This meant a drastically reduced labour force in the paddock, so only 1m biomass samples were cut.*

2.1.2 Steering Committee Input to RD&E Process

MEMBERS WERE SATISFIED WITH THEIR LEVEL OF INPUT
Overall, Steering Committee members were satisfied with the opportunities to provide input into the project's research, development and extension (RD&E) process as a result of participating in these meetings (average rating 7.4/0 n=15). Interestingly, growers on the Steering Committee were more satisfied (average rating 8/10, n=5) with advisers (average rating 7.3/10 n=7) and others (average rating 6.7/10 n=3) rating their satisfaction levels slightly lower.

There was general agreement that the project process and format was *very open,* that the meetings were *well run* and brought members together to communicate in an *open and* friendly manner. Overall, Steering Committee members felt they had the opportunity to voice their opinions and viewpoints on local area requirements during meetings and expressed the hope that this process would continue as a means for growers and researchers to interact.

> *The meetings themselves were run very well and all the people had the opportunity to voice their opinions and to work out what the research focus should be for the following season.* (Adviser)

A concern was raised around the potential for disagreement when a number of people are trying to agree on a focus for local area requirements. Some also noted that it was unclear whether actions were being taken as a result of the opinions being shared.

2.1.3 Steering Committee Impact on Levy Spending

ABILITY TO INFLUENCE PROJECT-LEVEL SPENDING OF LEVY FUNDS
Steering Committee members were fairly circumspect in their ratings around whether they felt their involvement had impacted on where levy payer funding is being spent (average rating 5.9 n=15). This feeling of a moderate level of impact was shared across respondent categories.

Within the boundaries of the project itself, Steering Committee members generally felt that they had an equal influence over project-level decisions. For example, it was explained that being involved with the Steering Committee meant a level of influence over the local spending of funds and which trial would be conducted: *it was a group decision to vote between five to six potential options.* One grower said that because the Steering Committee recognised their industry experience and credibility, they felt that their suggestions were listened to and respected.

A couple of Steering Committee members noted that spending of levy payer funds was a decision made at a higher level than the Steering Committee and they had limited knowledge on this process. One member commented that they would like to have a greater influence on where levy money was being spent while another had concerns about the available funds to extend all the information moving forward. They said: *Even though the project is going fairly well it is understaffed.*

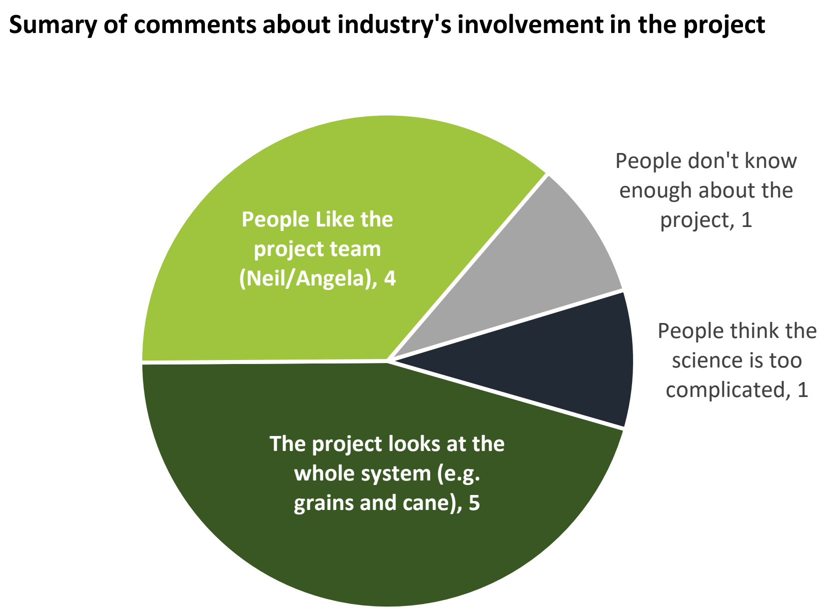
2.1.4 Level of Industry Participation

A REASONABLE LEVEL OF INDUSTRY PARTICIPATION ACHIEVED - STEERING COMMITTEE

Overall, Steering Committee members felt the project has achieved a reasonable level of industry participation (average rating 7.2 n=15). They agreed that it had done well to involve all sectors of industry including, a *fair representation across the farming community* (including corporate and progressive farmers), agronomists, as well as large and smaller milling businesses. Growers on the Steering Committee were more positive about the level of industry participation (average rating 8.4/10 n=5) than advisers (average rating 6.6/10 n=7) and others (average rating 6.7/10 n=3).

The DAF project team was noted to be well respected within the industry for their ability to foster open discussion and ideas within project constraints. There were several comments around the interest from most farmers in the project and appreciation that it is working to address a whole of farm system. This was noted to have been driven by falling sugar prices and that many in the sugar industry are investing in other areas or concentrating on crops that have a higher return value (including legumes and macadamia).

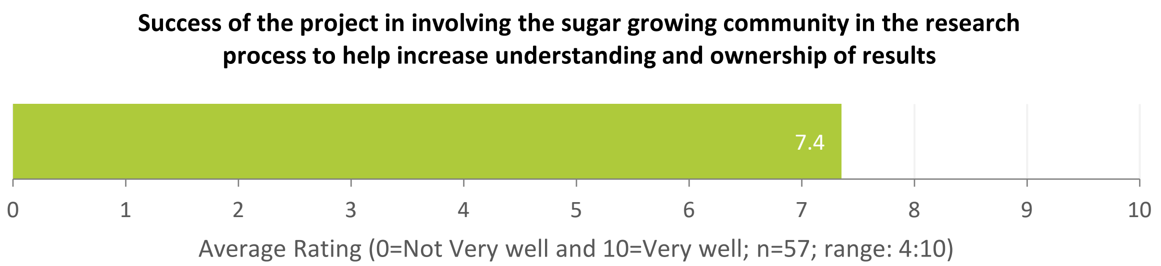
Figure 15



There was some frustration expressed by Steering Committee members about the difficulties in getting farmers to attend and participate in project activities. It was noted by several that although there was some early adoption and change fifteen years ago, people have forgotten or stopped these practices. There was also a suggestion that some growers who think that what they are doing is *fine*. One Steering Committee member commented about industry progress more broadly with the example of controlled traffic and how *the industry is yet to get everyone to agree on a row spacing*!

PROJECT SUCCESSFULLY INVOLVED THE SUGAR GROWING COMMUNITY IN THE RESEARCH PROCESS

Figure 16



Survey respondents generally rated the project as being fairly successful at involving the sugar growing community in the research process to increase their understanding and ownership of the results (average rating 7.4). Respondents across all stakeholder groups felt that the project and DAF had done well to adopt a *practical approach* to sharing information and communicating with the sugar industry.

The DAF team were commended for visiting local grower properties, inviting broader community observations, reviewing and discussing topics with growers and providing adequate feedback and advice. It was also agreed that the project had provided enough opportunities and avenues for local grower participation. There was a suggestion that anyone who felt they had not been effectively engaged or been involved, had not taken up any of the opportunities available to attend or speak up at events.

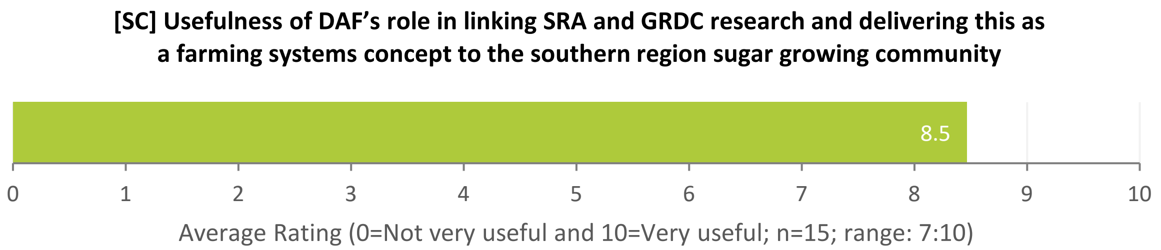
As a result of its effort, the information delivered by the project was thought to be directly related to helping growers address self-identified problems and issues affecting their properties. One respondent explained that as a result of trial work done on marginal soils, they felt *ownership from day one and felt involved* in the process. The proactivity of the DAF team around sharing changes or updates impacting trial sites was also noted as a positive.

A couple of growers commented that while they appreciated being actively involved in the project, other factors (including a lack of time) sometimes impacted their event participation. In addition, current market factors (low sugar prices, low returns) had impacted the implementation of any big changes and causing a reluctance to change.

2.1.5 DAF's Role

DAF HAS SUCCESSFULLY PROVIDED A LINK BETWEEN SRA AND GRDC RESEARCH

Figure 17



Feedback from those attending the 2018 and 2019 bus tours[3] indicated a very high level of support for the Southern Sugar Solutions project in terms of linking GRDC projects to the sugarcane farming system. Similarly, Steering Committee members agreed that DAF's role had been very useful in working to link SRA and GRDC research and delivering this as a farming systems concept to the southern region sugar growing community (average rating 8.5).

DAF was noted as being *very important,* a *critical part of it,* providing a *positive link* in terms of bringing together different organisations, and the resources necessary to complete the trial work. The local DAF team were described as being well led, *dedicated*, *well respected*, *knowledgeable*, and *supportive.* They were commended for performing well and doing a good job with limited funds. It was also mentioned that in its capacity as a government organisation and the associated constraints, DAF had done well to link the projects effectively.

While many agreed that DAF had worked well to support a link between SRA and GRDC research and were *upholding their end of the equation,* there were a couple of comments about funding partners including the relatively short length of the time funding is available in relation to cropping cycles, and a perception of reluctance to be involved. Another respondent felt that the parallel projects could have been better leveraged into each other, although qualifying with the comment that this was the way the *funding has been set up.*

> *We are very lucky that we have the dedicated people at DAF here. We are sugar millers, we know how to grow sugarcane, but peanuts, soybeans and other crops are all foreign to us, so they have been very supportive. (Other)*

[3] Milestone Report 5 and Milestone Report 3

DAF HAS DELIVERED THE PROJECT WELL

Overall participants across all stakeholder groups agreed that the role of the DAF team in delivering this project has been *exceptional.* They appreciated the level of consultation and communication and agreed that the team's passion, interest, and dedication to the project has been evident and it was hoped that this level of interest and involvement in the project would continue. Without the leadership of the DAF team, it was suggested that *the industry would be sorely hampered.* The team was commended on delivering new information to the sugarcane industry in an easy to understand and useable manner, *opening people's eyes to improving their soil structure and their yields.*

The guys from DAF are pretty important in the work that they do and their cross-cropping experience and also their ability to take outside influences and relate them to the trial work is a credit to what they do. (Adviser)

There is a definite benefit for the whole of the sugar industry in this Southern Regions Project and it's the hands-on approach which is convincing people. And please make sure that we keep these two people here in the local area! (Other)

2.1.6 Suggestions for Improvement

Survey respondents were asked to reflect on what they felt could make this project (even) better or more relevant to growers and advisers. Many took this opportunity to commend the project on what it had achieved to date. Overall, it was agreed that the project was successful within the constraints of available resources and that it was *one of the few pathways helping and informing canegrowers*. It was felt that having SRA and GRDC on board was beneficial and that there was potential for government to be *more proactive in supporting these projects.*

THE NEED FOR A LONGER TRIAL PERIOD

Several respondents including growers and advisers had strong opinions regarding the timeframe for project funding (12 mentions), suggesting that a longer period is needed for trials to provide a clear indication of results over a full crop cycle. It was felt that particularly in the sugar industry, trials need to extend beyond the standard two-to-three-year project funding period, due to a longer rotational crop cycle. To get a true indication on results and returns, a five-to-six-year research period was suggested. Several commented that by ending projects after a three-year period, results are only providing *half the picture (the planting and the first two ratoons and that's it!)* and that to *pull the pin too early, we don't get to see the results on the last ratoon before the replant.*

To continue on beyond the funding cycle. My biggest concern with this is that you really need to follow this on from the fallow block right through plant cane, first ratoon, second ratoon, third ratoon and fourth ratoon (that's talking about a six-year project). There is not one government body that funds anything like that and I find that a great disappointment because you get so far ... and you want to know what happens across the whole six years. (Other)

INCREASE THE SCALE OF TRIALS

It was also suggested by some survey respondents that trials should be implemented at *a bigger scale* (6 mentions) over larger blocks (or the whole block) to be more relevant. It was felt that there was potential to run more trials with a larger regional spread (i.e. including: regions with red soils; the whole of the Burnett; and Maryborough) which could add a *greater degree of complexity*. Being able to demonstrate replication across other farms would also be valuable to show smaller farmers how to copy, adapt and implement these new practices. Several respondents acknowledged that while more trials would be valuable, the project had done a good job within the constraints of limited budget and resources available. One grower commented that smaller plots were restricting the *'bigger picture'* and suggested that instead of doing a little plot in the paddock, to do the whole paddock.

In response to the suggestions for larger scale trials, the DAF team explained that the science behind the smaller plot trials was to be able to statistically replicate the results before progressing to larger scale 'on farm' demonstrations (that would also need some replication). This research process allows growers the chance to evaluate the technique from trial through to adoption. The DAF project team reflected that there was an opportunity to better communicate the research in terms of its purpose and process (including statistical validation) to growers.

One adviser noted the importance of the project continuing, particularly in light of reef regulations making it important that farmers continue to improve their practices.

> *To have more replication on other farms and not just be stuck on one or two farms. In our area (e.g. on smaller farms) we need to show them how to use what they have and be able to see by scale how to copy/adapt to new things. A frequent comment is oh Bundy Sugar, they have everything, they have the machinery, they have the money, so they think they can't copy it on their farms.* (Adviser)

WIDER INDUSTRY ENGAGEMENT

The need for wider industry engagement was raised by respondents across all stakeholder groups as important for the continued relevance the project (16 mentions). While the project was commended for delivering scientifically sound research, it was also suggested that feedback from a wider community perspective was needed (different regions), including discussions with those not currently growing legumes (to demonstrate the benefits to be achieved). It was also thought that more feedback could be gathered at a grower level and that demonstrating the economic benefits would be valuable to help increase grower involvement.

Another suggestion was that the project would benefit from increased industry visibility, more resources and *bodies on the ground* (*talking to the farmers and helping them in the fields*). One adviser pointed out that there is currently not much information being delivered via SRA and that without DAF, there would be nothing.

> *They need to be a bit more proactive with all the advisers. They are trying to get directly to growers which is fine, but the growers use agronomists now so they should be more hands on. Have the agronomists out there on the trials so they are getting hands on, so then they can become more of the communication in between.* (Other)

In terms of a wider sharing of information around project activities across canegrower regions, there was a suggestion for more field days which could potentially be streamed on the SRA website because there are *a lot of other growers from other regions that could benefit from that information.*

SUGGESTIONS FOR FUTURE RESEARCH TOPICS

Respondents provided some suggestions for future and extended research topics (7 mentions) to help growers make more informed decisions. Several highlighted the need for continued updates and more information and research relating to varieties and how these practices influence the sugarcane farming system. This included: information about selection; planting density impacts and the impacts on soil health; disease tolerance; rust susceptibility; and the herbicide tolerance of new varieties.

The need for more information about rotational cropping was also mentioned, particularly in terms of the impact of different varieties. It was felt that this would add to an overall improved understanding of soil health related to a whole of farm change and how to improve practices as well as economic benefits.

> *…Growers could then really make an informed choice, for example if I plant Kuranda soybeans, am I raising my nematode population or not? Especially with the rotations that we're getting into, people need to understand what impact it has in the rotation.* (Adviser)

INFORMATION RELATING TO COASTAL REGIONS

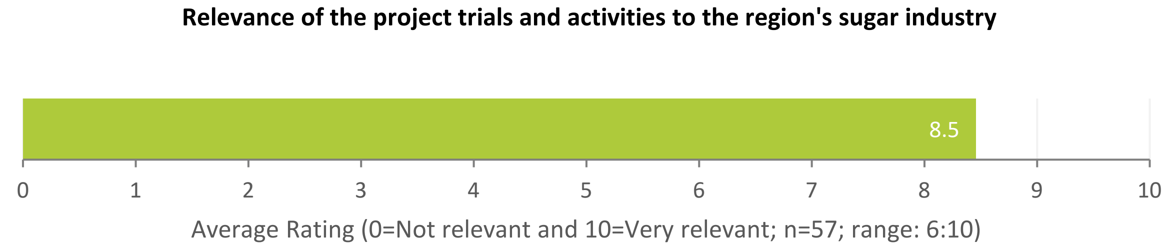
A couple of participants discussed the need for continued information and research relating to coastal regions where crops under different environmental conditions (humidity and soil type) perform differently to inland crops.

2.2 Activities

2.2.1 Relevance of Trials and Activities

PROJECT ACTIVITIES WERE VERY RELEVANT TO THE INDUSTRY

Figure 18



The trials and activities (including bus trips and update meetings) associated with the project were rated by survey respondents across stakeholder groups to be very relevant to the region's sugar industry (average rating 8.5). Respondents felt it was worth acknowledging that the project format worked *really well*, had effectively covered relevant issues, and provided practical activities and sound research. It was generally agreed that DAF's work in the region was valuable (*they probably do it the best out of most industries)* with respondents indicating a desire to see a continuation of these sort of research field days and services. One respondent said: *Any support they can get would be helpful for us!*

> *It was definitely the most useful research project that I've come across with really meaningful results. (Grower)*

BUILDING A MORE SUSTAINABLE SYSTEM THROUGH CROP ROTATION

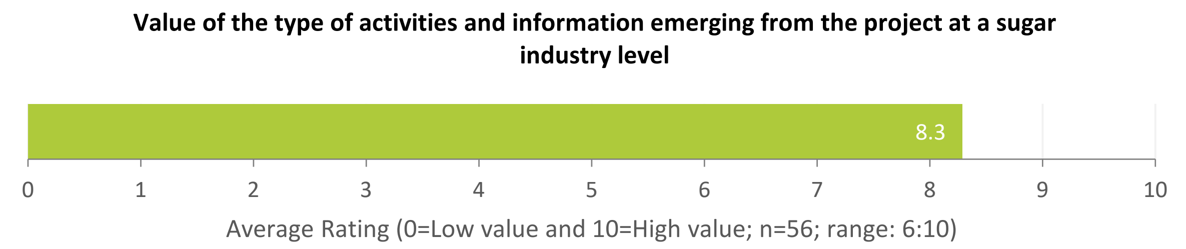
Survey respondents discussed the relevance of the project in terms of helping growers to improve their yields and rotation of crops. It was widely agreed that the project had *exposed famers to new and better ideas* and demonstrated *how to build a more sustainable system* where a rotation of sugarcane and legumes is critical. The relevance of the project was further discussed in light of the current sugar prices and that farmers are looking at legume crops to try and make ends meet.

> *Still a lot of people getting out of sugar and ground going to other crops everyday but that's industry-wide. If only people would realize that by getting onto controlled traffic system with legumes, you can lower your costs and you can compete on a lower price. Just got to get people to understand that. (Other)*

2.2.2 Value of Activities

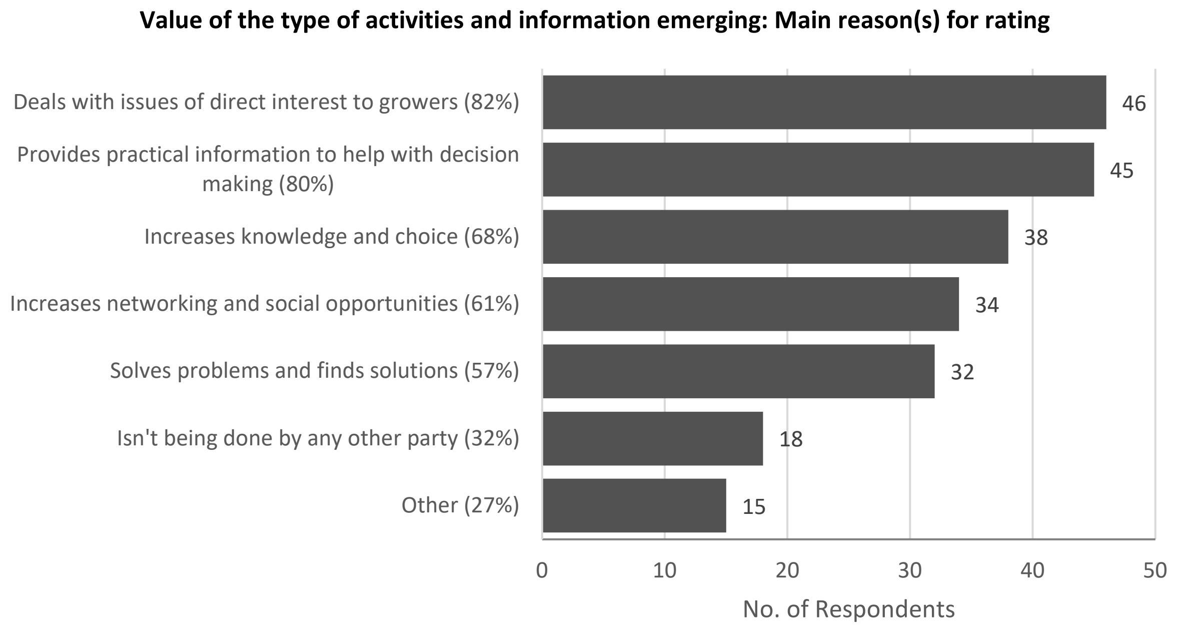
PROJECT ACTIVITIES AND INFORMATION WERE VERY VALUABLE

Figure 19



Overall, survey respondents across all stakeholder groups felt that at a sugar industry level, the type of activities and information emerging from the Southern Sugar Solutions project were very valuable (average rating 8.3). The chart below describes the main reasons respondents provided for their ratings.

Figure 20

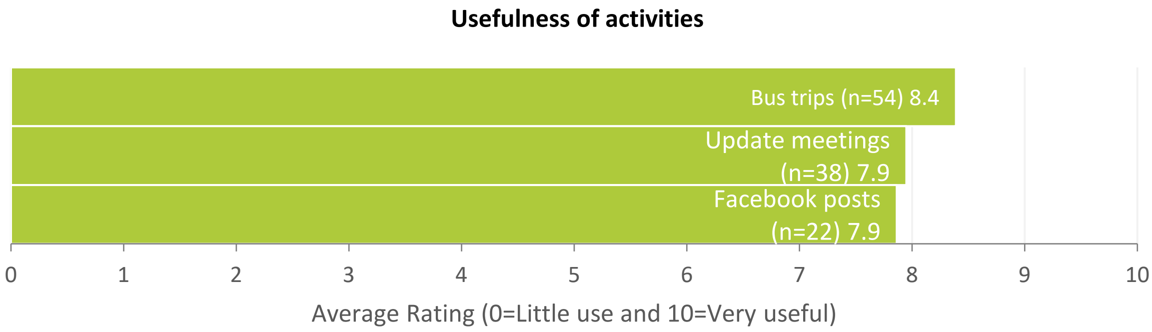


There was agreement that project information and activities dealt with issues of direct interest to growers (46 mentions) and an appreciation of the budget available to run trials. The local nature of events was also mentioned as was the timely and efficient manner of their delivery. In particular, respondents welcomed the quality and dedication of the staff conducting the research, that growers were being asked about what they would like to see done, and the work to ensure there was no duplication across other projects. It was felt that this was not being done by any other organisations (18 mentions). Respondents believed the project helped to improve knowledge and understanding of alternative choices (38 mentions) and provide increased networking and social opportunities (34 mentions).

It was also felt the project had provided practical information to help with decision making (45 mentions) and effectively worked to find solutions and solve problems (32 mentions). DAF was noted as being a professional body looking at and analysing actual results and working hard to present information that would help growers remain competitive. For example, demonstrating how to improve profitability by making money from fallow land as well as considering environment benefits.

2.2.3 Usefulness of Activities

Figure 21



Overall, each of the project activities were rated by respondents as being quite useful. Each activity is discussed further below.

BUS TRIPS – VERY USEFUL, WELL ORGANISED AND A NETWORKING TOOL

Bus trips aimed to demonstrate *to the stakeholders how industry funds are being spent on locally relevant research*[4]. Over half of those participating in bus tours were growers (based on bus tour feedback form respondents). Attendee figures for each of the annual trial bus tours were 113 in 2018, 65 in 2019 and 80 in 2020.

Other bus tours included:

- **The 2019 SRA Southern Group bus tour (December 2019)** coordinated by SRA and funded by the Enhanced Extension Coordination in GBR project. There were 44 participants visiting trial and demo sites across the region and receiving updates about the project including the Fallow Management Trial[5].
- **The Soil Health Legume Agronomy Roadshow (Sep 2019)** visiting four locations was organised through the Soil Health project with findings from the Southern Sugar Solutions field trials and preceding Grower Solutions trials providing the basis for much of the presented information. About 185 growers and other interested parties were reported to have attended. It was noted that this event generated a high level of interest around the Southern Sugar Solutions project with attendees indicating legume agronomy and soil health benefits an influential topic.

The majority of survey respondents (55) had attended one or more of the project bus trips and overall found them to be very useful (average rating 8.4). These were described as *fantastic* and well organised with one respondent noting they had *learnt a lot more about the industry*. Respondents highlighted grower interest in what is happening in the region as well as the trial results and the work undertaken on the different types of legumes. Bus trip participants indicated an appreciation of seeing the trial sites, better understanding the processes, the results and what work has been done. It was generally agreed that bus trips are one of the best activities to *get people out and about, to see what is going on, to see what the latest is, what everyone else has tried, what worked and what has failed* (grower).

Many survey respondents noted they always came away with new information from the bus trips including: new varieties; combinations of peanuts and soybeans; and soil and crop health. The trials were felt to have been well conducted with the results very clear and helpful. The role of the DAF team was positively mentioned in relation to the trial work, event facilitation and industry information sharing. The availability of researchers in the local community was felt to have been beneficial as they were known, respected and trusted.

The bus trips were also valuable because they were not just an opportunity to access the latest research and trial outcomes, but also a *networking tool*. Those who participated enjoyed the chance to visit other farms and the opportunities to *mingle* and *talk off the record and frankly* about farmer needs. Many acknowledged the value gained from meeting growers they normally would not interact with and from talking with others and learning how they might approach similar issues.

[4] Milestone Report 3 – July 2018
[5] Milestone Report 6

Most of those bus trips all visited my farm but you're always picking up things from the cohort and like-minded people and it's a great opportunity to interact with them and hear their views. It's an open forum for people to comment as well. (Grower)

It is always good to hear from researchers face to face and growers equally as well as getting out there and kicking dirt around and have a look at plants growing and it is a good day out. It is good for the soul sometimes. (Grower)

These activities are only as good as the person who is relaying the information, from Neil and the guys doing the trials on the ground and having the right person for the job facilitating the days and getting that information to all the stakeholders in the industry is fantastic. (Adviser)

UPDATE MEETINGS – WELL TARGETED, PROVIDED SCIENTIFIC DATA

Four annual update meetings were held between 2017 and 2020. More than half of all survey respondents had attended one or more of the meetings (37) and found them to be quite useful (average rating 7.9). The meetings were described as being *well targeted* and *informative* with a number of respondents particularly appreciating the level of detail provided.

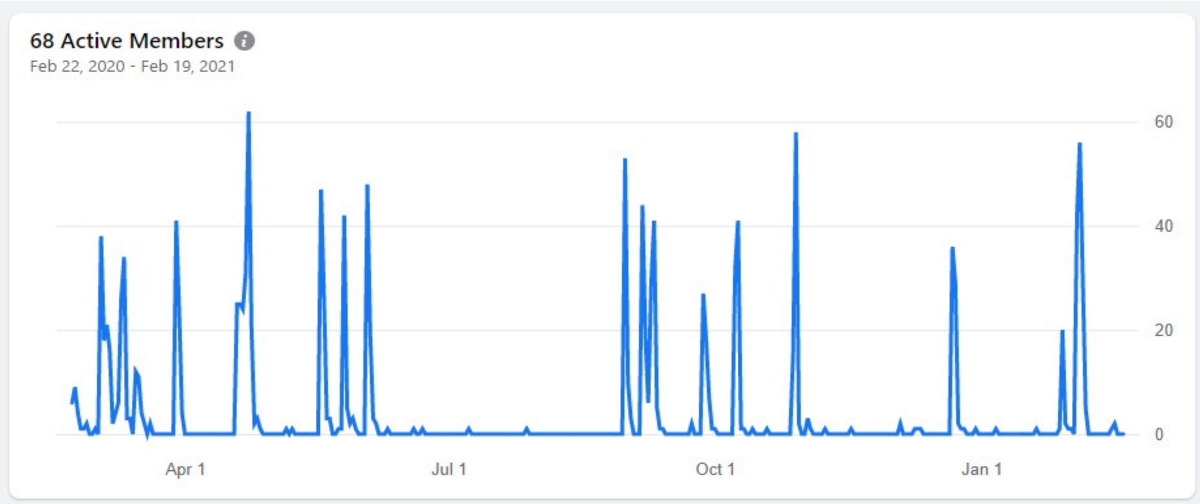
One adviser said they had found the update meetings to be *extremely important* in terms of being able to access the scientific data. They explained that this helped them to determine *if there was statistically significant difference between the data or not. This way I get to understand the statistical findings so that when I talk to the growers I'm using scientific evidence to explain the practice to them*. They also highlighted the importance of being able to accurately deliver information that demonstrates the cost of production and how the effects on outcomes.

FACEBOOK GROUP – EASY ACCESS TO INFORMATION, FURTHER INTEREST IN JOINING, BUT NOT FOR EVERYONE

Milestone 5 noted that a 'Southern Coastal Farming Systems' Facebook group had been established to keep the local farming community up to date with the team's day-to-day activities. It has been used to demonstrate the level of work that goes into field trial experimentation.

Facebook analytic figures (provided by DAF, 19 February 2021) show 78 members of the group. The majority engage around DAF instigated posts by commenting on posts, reacting to posts (e.g. like button) or clicking links. The chart below indicates the level of engagement with the project's Facebook page since it was started.

Figure 22: Facebook analytic figures (provided by DAF, 19 February 2021)



Just over a third of survey respondents had accessed the project's Facebook page (23). They found it to be quite useful (average rating 7.9) and commented on its value for easy access to useful information at their fingertips (i.e. on the phone). One adviser noted that the project delivered engaging resources including the Facebook group as an example. They also noted how useful Facebook at been during COVID when it became difficult to get to events and the DAF team were able to continue to provide valuable updates via the group. Several survey respondents mentioned they were not aware of the Facebook group associated with the project and were interested in looking it up and joining.

Some respondents however expressed their concerns about the value of relying on Facebook to deliver important information. It was suggested that this was a great resource to connect with younger members of the industry, but that those who would also benefit from the information and who really need to change farming systems, tend to be older and perhaps not Facebook users.

2.2.4 Networking Benefits

PROJECT FACILITATED BETTER CONNECTION ACROSS THE INDUSTRY

Figure 23

Overall, survey respondents agreed that involvement in the project and its activities had helped participants across all stakeholder groups better connect with researchers, growers, and others in the sugar growing industry (average rating 7.9). Comments were made specifically about the update meetings and bus trips being one of the main advantages of this type of project, where different stakeholders (e.g. agronomists, researchers, ag and grain commodities representatives, resellers, growers) are eager to participate and set aside the date each year to attend. Talking face-to-face and sharing ideas with industry representatives who might not normally interact was noted to be a major benefit of the update meetings. These were also thought of as a great forum to encourage idea sharing and *lateral thinking* which was felt to be critical to the whole process.

In addition, it was also noted that the bus trips and field days provided important interaction between farmers and researchers and an opportunity to ask questions and receive face-to-face feedback on topics of concern (e.g. improving yields).

> *The networking aspect of the project was just so good between the research side of things and the commercial side of things (e.g. planting densities) with what people were doing and why, and what was the research showing and what was commercial outcomes showing. It wasn't just the formal research but also the interaction which in turn helps build your network. Neil and Angela were forever approachable and engaged and willing to put you in touch with others to further find solutions etc. (Adviser)*

2.3 Impacts and Benefits

Relevant project impact areas include:

- Increased grower awareness of productivity constraints, including technological, production and socio-economic benefits.
- Increased access to industry-relevant information to inform decisions about investments, production priorities and practice changes.
- Reduced risk of production loss through cost-effective systems approaches for addressing productivity constraints.
- Increased productivity potential to address the market place demands
- Targeted information and approaches to address constraints

2.3.1 Technical Results

Trials undertaken during the Southern Sugar Solutions project demonstrated the following:

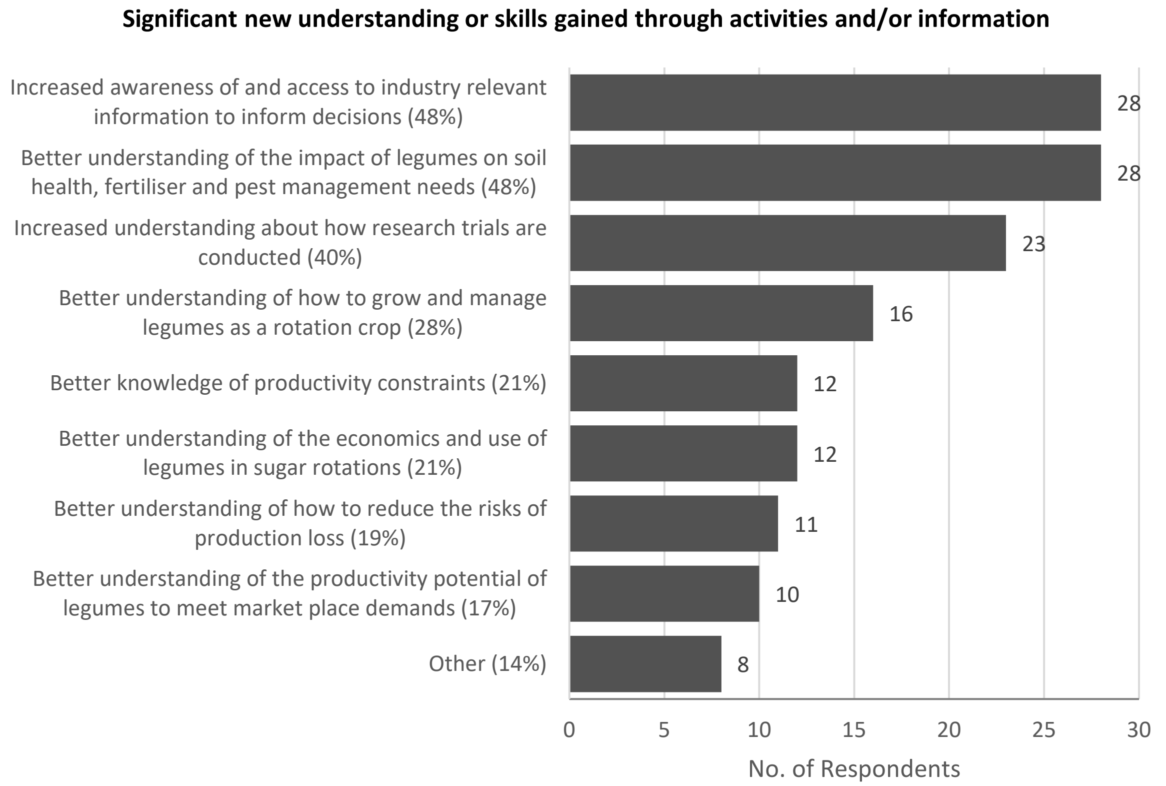
- **Carbon trial** - The addition of soil ameliorants (cane trash, mill-mud and biochar) had no statistical impact on soybean and peanut productivity or in cane yield in any year. However, the cumulative cane yield (plant + 1st ratoon + 2nd ratoon) demonstrated a 4.8% yield increase to the addition of mill-mud.
- **Fallow Management Trial** - Demonstrated that peanut, soybean and pigeon pea rotations were significantly more profitable than other rotation options. Mungbean cv Onyx rotations in sandy sugarcane soils should be avoided due to the potential of exacerbating adverse soil biology.
- **SU Takalvan Trial** – Demonstrated the very evident ability for soybean variety Kuranda to tolerate SU herbicides. However, there was significantly higher sugarcane productivity for the plots that were planted to soybean variety A6785 compared to those sown to Kuranda. This result requires further investigation.

2.3.2 Understanding and Skills

THE PROJECT HAS IMPROVED KNOWLEDGE AND UNDERSTANDING AROUND THE IMPACT OF LEGUMES

There is clear evidence that the project has improved participant understanding and skills. Those attending bus trips indicated that these had a significant impact with more than 90% filling out the feedback forms indicating an increase to their knowledge on at least one topic. Similarly, survey respondents indicated gains to their awareness, understanding and skills relevant to their business and/or the advice they provided to clients. The chart below provides further detail.

Figure 24



Almost half of survey respondents said that the project had increased their increased awareness of and access to industry relevant information to help inform decisions (28 mentions). Comments were that people felt more informed and up-to-date on what industry information was currently available.

Survey respondents described gaining a better understanding of the impact of legumes on soil health, fertiliser and pest management needs (28 mentions). An improved understanding of the impact of different soil types (in terms of soil health, compaction, fertiliser and nutrients) and rotational cropping on yield was also noted. In terms of growing and managing legumes as a rotational crop, a number of survey respondents (16 mentions) said they had improved their understanding. Examples were given around watering, planting densities, differences to planting populations, where certain varieties would be more successful, fertilisers, mill mud and mulch, practical information on how to implement machinery adjustments and the use of new technologies.

Survey respondents also gained a better understanding of the economics relating to the use of legumes in sugar rotations (12 mentions), better knowledge of productivity constraints (12 mentions); better understanding of how to reduce the risks of production loss (11 mentions); and the productivity potential of legumes to meet marketplace demands (10 mentions). One respondent in the other category, pointed out that lower sugar prices had added an increased incentive for farmers to include these as a rotation crops while an adviser suggested that *anyone who is growing cane is going broke very quickly.* They felt that project meetings have been valuable in demonstrating options for break out crops that are *financially rewarding, reduce tillage and control traffic.*

> *In the last 2 months the cost of sugar has been below cost and we are seeing a lot of people exit the industry, especially the older generation so it feels like we don't have that community spirit like before. (Grower)*

For others who had already been planting soybeans and alternative crops in rotation, the research findings were noted to have been useful in terms of reinforcing, confirming, and updating understanding.

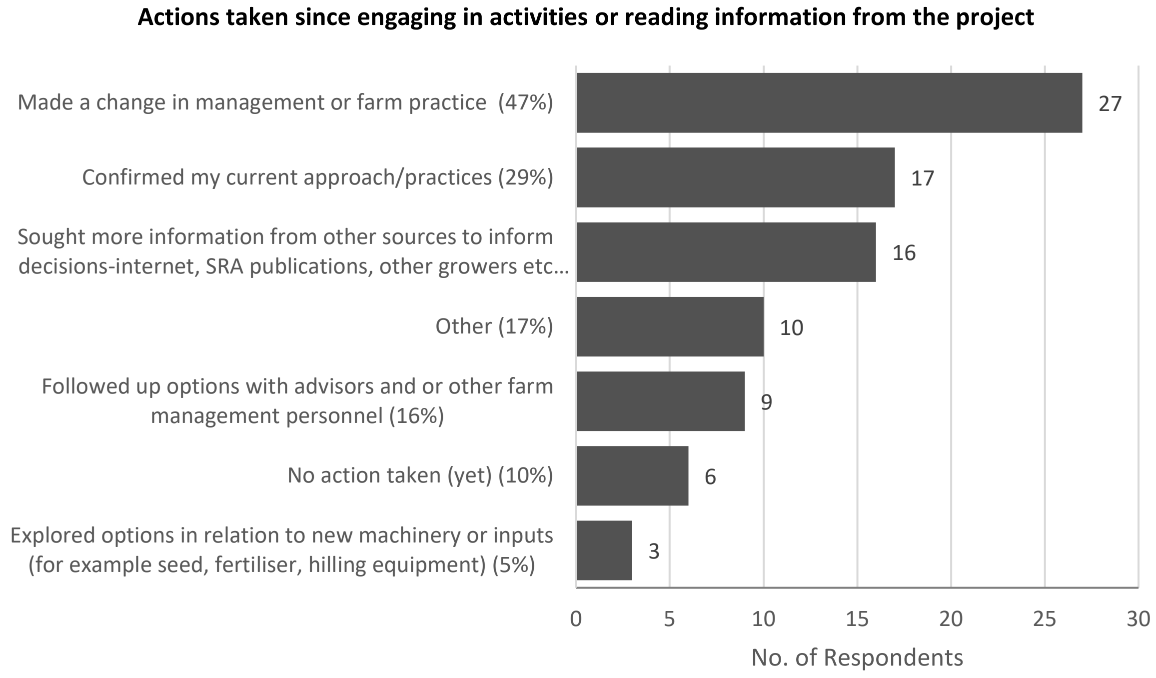
2.3.3 Actions Taken or Planned

THE PROJECT HAS PROMPTED ON FARM CHANGE AND FURTHER SHARING OF PRACTICE CHANGE ADVICE

Based on the feedback received from participants, there is evidence that changes have been made or are planned on farm and that advisers have shared practice change advice, based on project activities and information. Across the feedback collected from the bus tours, attendees indicated they had planned to make a change on their farm, or in the case of agronomists and extension personnel, identified practice change concepts they would share with their clients[6]. This included 64% in 2018, 50% in 2019 and close to 50% in 2020.

Survey respondents also indicated they were making or planning changes as a result of engaging in one or more project activities. Twenty-seven participants indicated they had made changes made to their farm practices/management or in the case of advisers, the advice they provide to clients (17 growers and 10 advisers).

Figure 25



CHANGES TO LEGUME VARIETIES, PLANTING STRATEGIES, FARMING SYSTEMS, CHEMICAL USE, AND ADVICE GIVEN

Seventeen growers had made changes to their farm management practices including *changes made to legume varieties* selected (7 mentions), for a range of differing reasons. One grower changed to soybeans as a result of water scarcity, one decided to not plant soybeans at all during the current season, and another changed variety in order to be able to spray herbicides and other products over the crop.

Growers had also made changes to planting strategies as a result of attending project activities (10 mentions) as well as to their *whole farm system*. Examples of the types of changes made include:

- moved to control traffic farming
- made changes to row spacing, population and cultivation methods
- included more legume rotation where they used to *do a fair bit of plough out and replant*
- more *deep soil ripping*
- *changed timing* and improved monitoring of soil health and nutrition

[6] Milestone Reports 3, 5 and 7

- cutting back on chemical use (3 mentions)
- going back to cultivation
- trying to better monitor weed control, chemical use and fertiliser usage
- the use of mill mud as a more cost-effective option (noting it worked well on some soil types and not on others)

Ten advisers said they had made *changes to the advice they provide to their clients*. This was in terms of planting legume crops between sugarcane crops as well as advice around the selection of varieties selection. Types of advice given included:

- Engaging more with productivity services and sharing information with growers where the project had seen benefits achieved in *nitrogen retention in post-fallow legume operations.*
- Encouraging people to consider their sugarcane and soybean yields and trying to demonstrate the environmental benefits as well as bottom line benefits to be gained.
- Using project information to highlight how legumes could add value to a potential new sugar/peanut grower's operation
- Implementation of new strategies including *different row spacing for peanuts*
- Investment into changed strategies over a 90-hectare block to better understand project research

We are continuing along that track and giving our growers new information. My job is to keep them informed and a lot of growers are growing alternative crops now. (Adviser)

a)

CONFIRMED CURRENT APPROACHES, PROMPTED A SEARCH FOR MORE INFORMATION AND PROVIDED A SUPPORT NETWORK

For many survey respondents, participation in project activities had confirmed their current approaches and practices (17 mentions) with growers commenting they continually monitor weeds, chemical use and different varieties available. One grower commented that they always tried to make sure they conform and that their practices were not impacting the reef.

I started this pretty much 20 years ago so it just proves that we're on the right track. This is the third large farm I've managed and I've brought the same approach and I've increased production on every farm by 20 plus per cent. We're 1.8 controlled traffic and legume rotation. (Other)

Some survey respondents had sought out more information from other sources to inform decisions, including the internet, SRA publications other growers (16 mentions). This is in addition to following up information with advisers or other farm management personnel (9 mentions). One grower was investigating the option of growing legume rotations on their property and several others had explored options in relation to new machinery or inputs (for example seed, fertiliser, hilling equipment) (3 mentions). The process of keeping up to date with farming involves ongoing learning and information, which one grower pointed out that the project helped them to do, in conjunction with other internet based research.

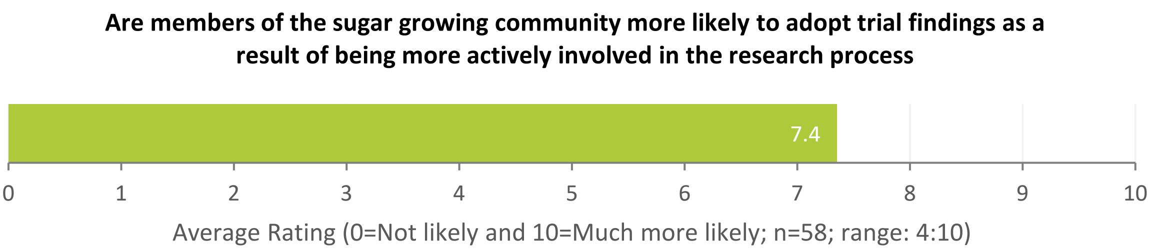
Several advisers explained that their involvement in the project had given them access to a network of support in performing their current roles. One involved in soil health said that they had shared information from the trial work with farmers and then worked to help them source *products that are cost effective enough for them to implement the change to their farming practices: in order to get a return on investments.*

Six survey respondents had made no changes as a result of project participation. Despite this, project activities and information gained was noted to have added to an improved understanding and knowledge about options.

2.3.4 Impact of Project on Adoption

PROJECT APPROACH THOUGHT TO INCREASE ADOPTION OF TRIAL FINDINGS

Figure 26



Overall, survey respondents across stakeholder groups generally appreciated the project's approach involving the sugar growing community in the research process and felt that this would result in the trial findings more likely to be adopted (average rating 7.5). Those with trials on their properties were more invested and interested in seeing the outcomes, while others said that the best way to understand results was to be able to see and experience them firsthand at the trial sites.

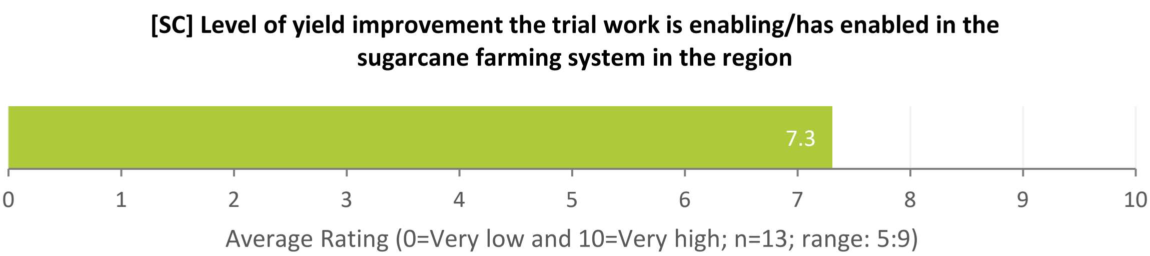
Several advisers expressed an opinion that although the project approach has been done well and the efforts of the DAF team have been *awesome,* it can still sometimes be difficult to get people interested and to determine whether they will go ahead with changes. They described the generational mentality of some growers around practice change: *dad did it that way, granddad did it that way so I'm going to do it that way.*

One adviser thought that the adoption of trial outcomes could be seen through increased quantities of peanuts grown in rotation over the past two years and more growers achieving an increase in production, even with the dry conditions. They felt there was a noticeable increase in soybeans planted in rotation this year. Another explained that in their region, although they had seen an uptake in rotational legume cropping, *the region had also experienced a lot of loss of area to other crops during the same time, making it difficult to accurately assess how beneficial the project has been* (Other).

2.3.5 Impact of Project on Yields

PROJECT IS ENABLING SOME YIELD IMPROVEMENTS IN THE REGION

Figure 27



Members of the Steering Committee felt that project trial work had enabled/was enabling a solid yield improvement in the region's sugarcane farming system (average rating 7.3). Those who felt the project had contributed towards higher levels of improvement (ratings 8-9) mentioned sugar yield increases of between 10 to 20 percent by those who had effectively implemented changes.

The movement towards a rotational system was noted by some Steering Committee members to have additional sustainability benefits. Others suggested that while yield improvements were beneficial, if this was not achieved or obvious, there were still definite benefits to be gained from fallow management including improved weed control and soil management. The introduction of a break crop also introduced economic opportunities by improved cash flow after the harvest and sale of beans.

The difficulty converting information and understanding to practice change due to financial burdens and farmer resistance to change was also pointed out by a Steering Committee member. Another explained that while they considered themselves an 'early adopter', it was important to remember that change takes time. They felt however that gains had been made and others were *slowly coming around.*

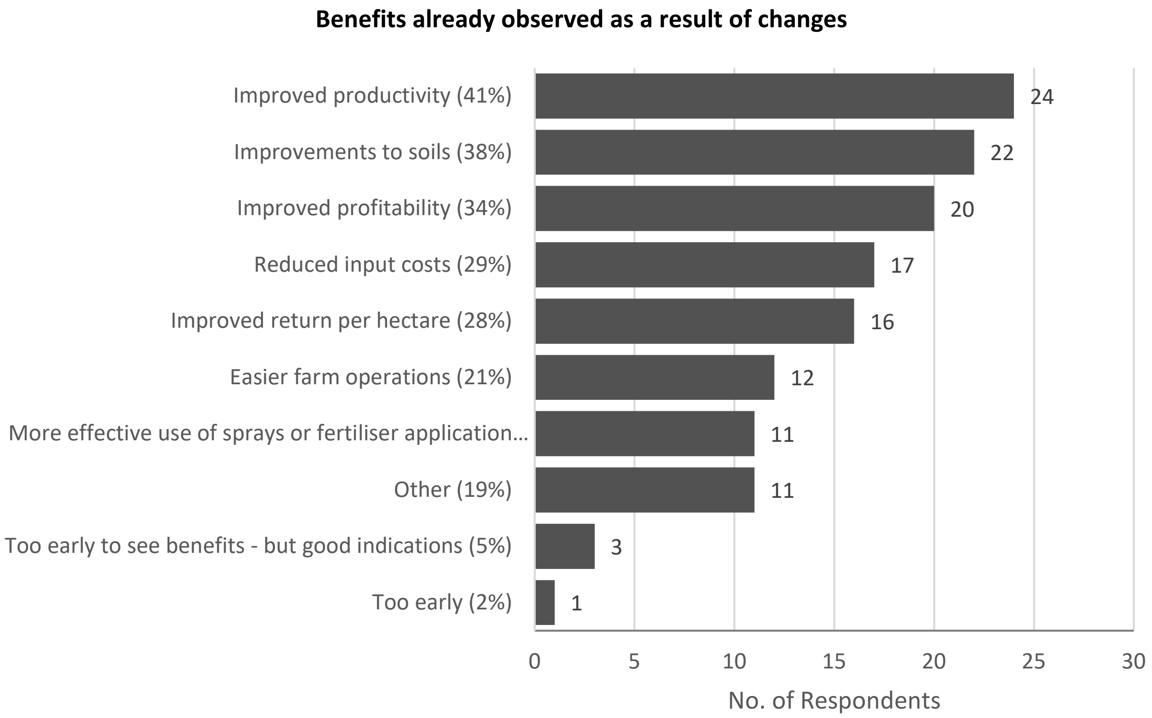
Some Steering Committee members were unsure about the impact of project activities and trial outcomes on yield improvements, with some pointing out the drought conditions under which trials were conducted. Because of this, crops were irrigated versus measuring the impacts of rainfall and it was felt that this could impact or mask the results and that outcomes had the potential to be worse if nothing was being done.

> *It's a bit difficult to explain because on our farms we farm marginal soils and it's better than what they predicted. It's the input of the people on the ground here, who are willing to listen to us and to trial different things.* (Other)

2.3.6 Benefits of Changes Made

THOSE WHO HAVE MADE CHANGES ARE SEEING IMPROVED PRODUCTIVITY, IMPROVED SOIL AND IMPROVED PROFITABILITY

Figure 28



Benefits are starting to be seen by those who have made changes as a result of project activities and information. Examples of what has been observed to date include:

- **Improved productivity (24 mentions):** One grower said that although they could not provide actual data, they estimated a 5 to 10 percent improvement on production. An adviser explained that they had achieved *improved sugar cane growth in the consecutive cropping out of our legumes* and another commented that some of the growers who had planted the new soybean varieties (e.g. *Kuranda* which has been out for only a few years) were now cutting a lot more cane.
- **Improved soil health (22 mentions):** Participants agreed that legume rotations had successfully contributed to improvements in soil health with the added benefit of using less or no fertilisers.
- **Improved profitability (20 mentions):** One grower said that their sugarcane income was *quite minimal* and that having legumes has increased this income from $50,000 to $100,000. They have been able to use this additional turnover to hire a new employee.

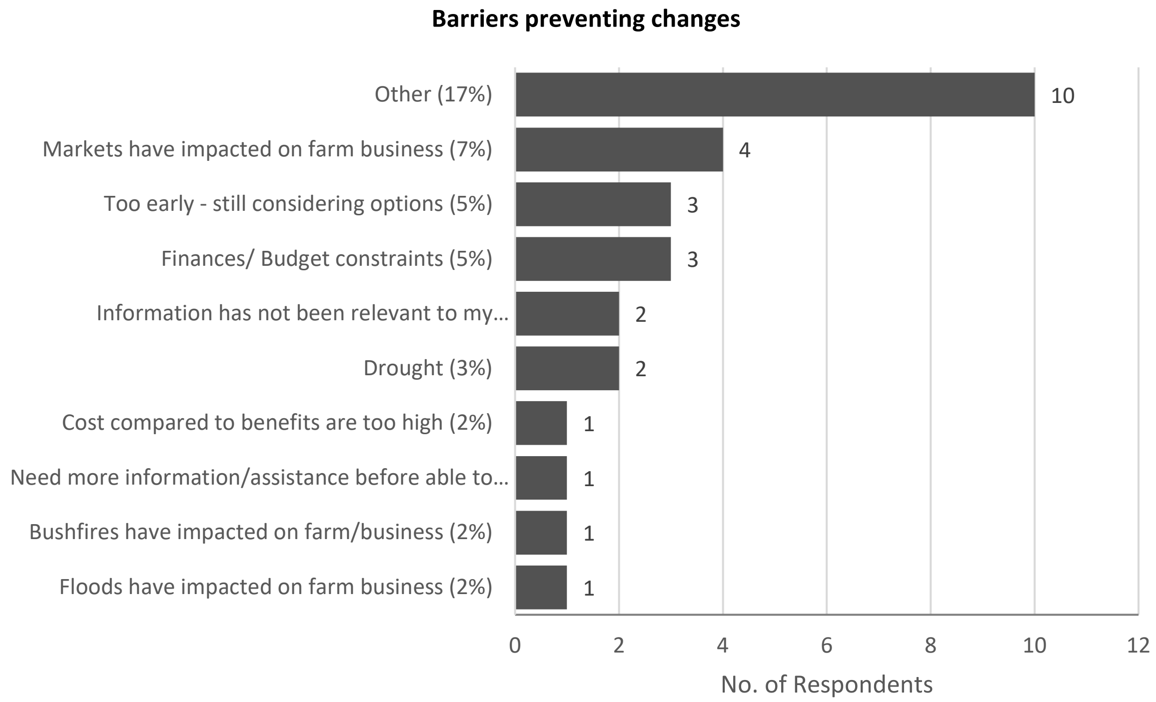
- **Reduced input costs (17 mentions):** As well as financial gains, survey respondents also identified reduced input costs (e.g. reduced fuel and more efficient technologies) as being a beneficial outcome from changes made: *we're probably spending a quarter less money on ground prep and general operations because we're not doing what we used to do* (Grower). Several respondents also mentioned cost savings due to improved water efficiency and reducing the amount of water used to grow a crop. One adviser explained that by taking into account variety choice and planting timing, growers were able to find better solutions resulting in better outcomes.
- **Improved return per hectare (16 mentions):** In line with improved productivity, many also noted improved returns per hectare, with one participant commenting that after one year into the trial, achievements on marginal country showed a difference between 88 tons per hectare and 123 tons per hectare. They also raised that this 25% variation was an outcome they would like to better understand.

> *Improved soil health is the distinct benefit. In our area we've been playing around with minimizing soil turnover once harvested: whether to actually just put that crop back on top and plant through it again with the next crop. This has seen some good benefits at the moment.* (Other)

- **More effective use of sprays or fertiliser application (11 mentions):** Some survey respondents used less fertilisers (i.e. reduced nitrogen) while still achieving productivity improvements. One adviser mentioned that as a result of the DAF trials more people in the industry are *recognising the benefits of liming where they are going to [plant] their beans.* Another adviser explained that *keeping weeds out to get to full fat to edible at 2.5 ton per hectare soybeans without weeds would deliver a good income for farmers doing it hard with sugar prices low.* They said that with the herbicide trial only happening last year, actual figures were not available yet, but that visual impacts looked good.
- Other benefits to date included **easier farming operations (12 mentions)** and **improvements in knowledge, understanding and confidence within the industry** (4 mentions). Survey respondents felt that growers were asking a lot more questions and wanting to learn more about alternative crops. Project outcomes were also noted to have given growers more confidence. From an adviser perspective having a network and a team to direct people to for more information, was also noted as valuable.

2.3.7 Barriers to Change

Figure 29



Bushfires, floods and drought conditions were noted as factors impacting changes made by some participants (total 4 mentions). Floods and bushfires were acknowledged as issues that would always be a part of farming. Drought conditions (lack of water) were noted as impacting one grower's ability to plant legumes in the past year and another commented on the dry conditions in Bundaberg and issues relating to water security in the region and how this had an impact on big capital spends for their business.

Current sugarcane industry market impacts (a low return on sugar) (4 mentions) were also noted as a barrier to changes being made on farm. One adviser explained that while there is not much money to be made in sugarcane at the moment, they have encouraged farmers to plant legume crops in rotation with sugar, while another suggested that market pricing issues would be impacting growers' ability to implement some of these cropping systems. Others agreed that if changes had not been implemented it was a result of a lack of finances (3 mentions).

Others who had not made any changes as a result of their involvement in project activities felt it was too early and they were still considering options (3 mentions). One grower noted they were just planting peanuts this year and another currently had other rotation crops planted, which made the cost compared to benefits too high (1 mention).

A couple of respondents commented that information had not been relevant to their farm/business/clients (2 mentions); that they did not have a need to make changes; or would like more information/assistance before considering change (1 mention).

3. Discussion and recommendations

3.1 Value of the Project's Approach

The approach used for this project had some key features. These were:

- **Synergy with GRDC Grower Solutions Project** – it worked in with a GRDC funded project that had overlapping interests.
- **Industry guidance** – growers and agronomists formed a Steering Committee to guide the project.
- **Government delivery** – the project was delivered by government (DAF).

- **Trials, bus trips and Facebook** – the approach was centred around on-farm trials and providing opportunity for growers and advisers to view practical examples. Social media was also used.

These features and what they added to achieving positive outcomes are discussed below.

3.1.1 Synergy with GRDC Grower Solutions Project

As noted in the introduction, this SRA funded project focused on determining the impact of legume crops (established during the Grains Research and Development Corporation (GRDC) Grower Solutions Project) on subsequent sugarcane crops. It aimed to capture the sugarcane farming system benefit of established legume field experiments.

As reported earlier, feedback from bus tours attendees and survey participants indicated a very high level of support for how the Southern Sugar Solutions project was linking with the GRDC project in relation to the sugarcane farming system. This was because it strengthened the ability to look at the whole farming system involving cane and legumes. The only concern expressed by some was the need for a longer time period to fully observe the impact of rotations on subsequent cane crops.

The links demonstrated in this project reflect the Federal Government's encouragement for Rural Development Corporations (RDCs) to work collaboratively. The success of the collaboration between SRA and GRDC (as demonstrated in this report and reflected in industry feedback) has highlighted the value and need to maximise further collaborative opportunities at the RDC level across mutual areas of interest. This project has benefited from economic and technical efficiencies of project operations, management and grower time.

> The strong links between the GRDC funded Grower Solutions project and the Southern Sugar Solutions project has successfully developed synergies, economies and maximised benefits to growers. These cross-RDC opportunities should be identified and maximised where possible.

3.1.2 Industry Guidance

Central to the project was its aim to maximise industry input to its research direction and hence develop industry ownership of the project, its results and subsequent adoption. As described earlier, the project's research directions were set annually by a Steering Committee made up of growers, advisers and agronomists from the Maryborough, Childers and Bundaberg sugar factory cane supply districts.

Steering Committee members who were interviewed, reported a good level of satisfaction with their opportunity to provide input into the project's research, development and extension (RD&E) process – with growers particularly positive about the process. Members felt they had the opportunity to voice their opinions and viewpoints on local area requirements during meetings and expressed the hope that this process would continue as a means for growers and researchers to interact.

The broader group of growers and advisers surveyed also viewed the project as being successful at involving the sugar growing community in the research process. Importantly there was agreement that project information and activities dealt with issues of direct interest to growers with the local nature of events also mentioned.

The way industry stakeholders have been involved in this project is consistent with best practice in the Research Development & Extension (RED&E) process. Much has been written and implemented around a more participative approach to RD&E using an 'Innovation Systems Approach' (building different perspectives into the planning and operation) being the way forward in gaining faster more useful research results and quicker adoption.

> The active involvement of growers and advisers in guiding the project has been valued and seen as successfully influencing project activities and outcomes. This reflects best practice and should be built into future similar projects with training provided to industry participants where needed to maximise their effective input.

3.1.3 Government Delivery

There is a range of organisations involved in the delivery of RD&E to cane growers, including SRA staff, productivity services, private agronomists and government. Government has traditionally had a relatively smaller role (with the history of BSES) and developed a niche which is more strategic and focused on applied research and development. Their work is intended to complement other RD&E processes occurring within the industry.

As reported earlier, grower and adviser survey respondents saw DAF as being *very important,* a *critical part,* and providing a *positive link* in terms of bringing together different organisations and resources necessary to complete the trial work. This included their ability to foster open discussion and ideas within project constraints. The delivering DAF team in this project were described as being well led, *dedicated*, *well respected*, *knowledgeable*, and *supportive.* They were commended for performing well and doing a good job with limited funds.

Importantly, DAF was seen to have done well to adopt a *practical approach* to sharing information and communicating with the sugar industry. As a result of its effort, the information delivered by the project was thought to be directly related to helping growers address self-identified problems and issues affecting their properties. Some went so far as to suggest that *without the leadership of the DAF team, the industry would be sorely hampered.* The team was commended on delivering new information to the sugarcane industry in an easy to understand and useable manner, *opening people's eyes to improving their soil structure and their yields.*

Facilitating open discussion and developing links between organisations are highlighted as central to successful innovation systems which are about maximising synergies and developing broad industry support for change and improvement. Government is seen to be 'neutral' in terms of technology and recommendations (i.e. not selling or promoting specific commercial products) and has the capacity to leverage expertise from across the agency. In this project, the DAF team delivered on these critical innovation system aspects .

> The DAF team in this project should be commended on the way they effectively fostered grower and consultant engagement and ownership and were able to work across organisations to achieve synergies. The very positive feedback from growers and advisers about their approach and professionalism reflects the ongoing relevance and role to be played by government agencies.

3.1.4 Trials, Bus Trips and Facebook

There was very strong support across stakeholder groups for the central approaches used in the project. The trials and activities (including bus trips and update meetings) associated with the project were seen to be very relevant to the region's sugar industry, effectively covering relevant issues, and providing practical activities and sound research. As already noted, those with trials on their properties were more invested and interested in seeing the outcomes, while others said that the best way to understand results was to be able to see and experience them firsthand at the trial sites. Despite this, the difficulty of engaging some growers in these activities was raised by survey respondents with a few describing the reluctance of growers to change practices that have been used for generations.

An interesting feature of the approach has been the use of Facebook as part of the communication and engagement process. As the analytics showed, there were almost 80 members of the project Facebook group with many actively engaging by commenting, reacting to and following links on posts. Several interviewees had not been aware (until asked) of the Facebook group and indicated an interest to join. Others felt that this was mainly for younger growers with those older growers who needed to learn and make changes not being users of social media.

> The project used activities well-suited to the project objectives, grower needs and preference with direct trial experience and practical examples proving to be effective extension methods. There is scope to increase awareness of the project, including the use of social media to maximise learning and industry engagement.

3.2 Impact and Benefits

Proof of the value of different approaches and delivery of RD&E lies in the impact that it has on participating growers and advisers and the resulting benefits. Feedback was sought through the project from growers who went on the bus trips and questions were also asked in the end of project survey about impact and benefits. Although gains in knowledge and skills are often seen as steps leading to immediate practice change, they are also indicators for the motivation and capacity to continue in ongoing improvements over time. This is about growing social capital and a culture of improvement.

NETWORKING:
Part of social capital is also strengthening networks and relationships to allow peer to peer learning and support for change. Importantly, in this project, participating growers and advisers reported that the project activities helped them to better connect with researchers and other growers and advisers in the industry – a key precursor to enabling change over time.

KNOWLEDGE GAINS:
As shown earlier in the report, over 90% of bus trip participants reported gains in their understanding and knowledge in at least one topic. This was also reinforced through the survey results where all respondents said they increased their understanding in a range of areas – including how to better access information to inform decision-making, a better understanding of the economics of rotations and management factors impacting on costs, productivity and profitability. All of these were objectives of the project and the feedback from industry participants demonstrated that these capacity gains were achieved.

ACTIONS TAKEN:
The earlier analysis reported that by the end of the project a large percentage of those who participated in project activities identified opportunities to use the information gained to make changes on their farms or in their advice to growers. Some came away from the activities with confidence that what they were doing was in keeping with what the research was showing – another important outcome.

Sixty-five percent of growers interviewed who participated in project activities said that they had already made changes to their farm practices as a result of what they learned. Changes included choices of legume varieties, planting strategies and other overall farming system changes. Most participating advisers also indicated that they would be making/modifying advice to their grower clients. Again, this is in keeping with what the project was intending to achieve.

This high level of positive impact on participating growers and advisers is impressive, however as has been pointed out above, there are many other growers who could benefit who either chose not to participate or fell outside the scope and reach of the resourcing of this project. This means that there is potential to build on the work that has been started to benefit a larger number of growers across the regions.

BENEFITS:
In long term crops such as sugar cane and with the complexities of farming systems, it is difficult to quantify the farm level benefits from changes that have been made within the project timeframe. However, Steering Group members who were more informed about the broader project, believed that the use of insights from the research was leading to 'solid' gains in farm yields. Other survey respondents also believed that productivity gains had been achieved from changes, with some citing yield gains in the range of 10-20%. There were also a high number of growers who said that their costs had been reduced (e.g. from reduced ground preparation) and profitability improved (in one case from $50,000-100,000 over the farm). Soil health benefits were also reported.

The levels of these benefits are yet to be fully and rigorously measured over time, however, this preliminary feedback from grower and adviser participants provides a good basis for optimism. It also sends a positive message to the broader industry about the value of the project and the practices being developed.

VALUE OF PROJECT:
Survey respondents discussed the relevance of the project in terms of helping growers to improve their yields and rotation of crops. It was widely agreed that the project had *exposed famers to new and better ideas* and demonstrated *how to build a more sustainable system* where a rotation of sugarcane and legumes is critical. The relevance of the project was further discussed in light of the current sugar prices and that farmers are looking at legume crops to try and make ends meet.

> The high level of positive impact on grower and adviser project participants confirmed its relevance and effectiveness of its process. There was a clearly expressed belief that growers who had undertaken/were undertaking actions based on the project outcomes were gaining benefits as a result. These impacts support the project's value and highlight the need for it to be expanded to include other geographical contexts and explore new approaches to engage with growers less willing to participate in current activities.

3.3 Future Focus

It is not clear whether there is an intention by funding bodies to continue or extend this project. However, based on the evidence of this review, there is a strong argument to continue farming systems research and to extend the project's base and reach.

As discussed above, growers and advisers who participated were very positive about the approach, delivery and relevance of the project to them. There was also a high level of gain in understanding across participants with many already converting this into action and implementing findings.

As noted in the analysis, however, despite the acknowledged success this project by industry participants, the need for even wider industry engagement was raised by respondents across all stakeholder groups as important for its continued relevance. This was to allow more experience from different regions to be considered and to include input from those not currently growing legumes. Others also were interested in larger trials on a wider range of soils and climate. There was a recognition that this was not in the scope of the current project given the resources and staff numbers involved.

Recommendation 1

It is recommended that there should be a continuation and extension of this project to build on the base established to date, and to multiply the impact of the work already undertaken.

This project and its approach were significant because of the strong involvement of growers and advisers in providing input and guiding the trials and activities. Feedback proved that this was very much appreciated and effective. The bus trips and trial visits demonstrated their value and suitability as a means to expose growers and advisers to the research work in practice and the associated farming system recommendations. Additionally, directly linking the SRA and GRDC research projects not only connected relevant research across two industries, but also added efficiencies as well as leveraging funds and grower time.

Recommendation 2

The lessons on the value of involving growers and advisers in guiding on-farm research and associated activities should be applied to other similar projects in the future.

Recommendation 3

Every opportunity should be taken to link with other RDC funded projects where there is common interest and value across industries.

12.3 Appendix 3 Secondary Data Summary

Outputs

Output	Details	Source
Update Meetings	• Update Meeting 2017 • Update Meeting 2018 • Update Meeting 2019 • Update Meeting 2020	•
Annual field day / bus trip to trial sites	**2020 Trial Site Bus Tour (16/3/2020)** • 80 attendees – 62% growers • 7,523 ha cane represented by growers. • 290,650 ha of land influenced by agronomists/ extension officers attending. • All the attendees who filled in the survey reported that they had increased knowledge on at least one topic as a result of attending the day • Close to two-fold increase in knowledge on the main topics discussed. • 18 identified changes growers planned to make to their farm - equates to about 43% of attendees who could go on to make an actual change to their farming practice. • 8 people (agronomists and extension personnel) identified practice change concepts that they would take back to share with their clients. • More R&D work into crop specific agronomic practices was the most frequently identified issue, followed by requests relating to breeding programs and chemical trial.	Milestone 7 Report 2020 Trial Site Bus Tour Report
	2019 SRA Southern Group Bus tour (4/12/19) • Coordinated by SRA and funded by Enhanced Extension Coordination in GBR project. • 44 attendees visited a number of trial and demo sites across the region and were given project updates. • Discussed the most recent results from the Southern Sugar Solutions Fallow Management Trial.	Milestone 6 Report
	Soil Health Legume Agronomy Roadshow (Sep 2019) • Organised through the Soil Health project, findings from the Southern Sugar Solutions field trials and their preceding Grower Solutions trials were the basis of a lot of the information presented. • Four locations and around 185 growers and other interested parties. • Legume agronomy and soil health benefits being singled out at as the most interesting and influential topics covered on the day.	Milestone 6 Report

	• A lot of interest in what this project is doing in Bundaberg was generated from these events.	
	2019 Trial Site Bus Tour (Mar 2019) • Fallow Management trial showcased. • 65 attendees from Maryborough, Childers and Bundaberg areas – 52% growers. • 95% reported an increase in knowledge. • 50% are considering making a change to their practices (e.g. implementing legume fallow, new varieties, row spacing) • 98% agreed that linking GRDC projects to the sugarcane farming system through the Southern Sugar Solutions project is a good idea. • 18% of people were unsure about whether the Southern Sugar Solutions project will help improve the profitability of farming practices, highlighting an area of opportunity for future work to really bring trial results back to a gross margin analysis. • One person commented that it was "good to see growers talking through problems and sharing solutions", and another praised the event for "keeping it real by getting dirt on boots".	Milestone 5 Report 2019 Trial Site Bus Tour Report
	SRA 'Southern Region Group' meeting (Aug 2018) • Growers made aware of 'Carbon Trial' progression	Milestone 4 Report
	2018 Trial Site Bus Tour (March 2018) • Introduced growers to the Southern Sugar Solutions Project and showed them the first two trial sites. • 113 attendees with 61 people completing a survey. • 64% of survey respondents were growers. • 93% reported an increase in knowledge as a direct result of the field day – 37% of those indicating they had learnt a significant amount. (impact target metric of 75% increased knowledge has been achieved) • 64% of growers (n=40) indicated they were considering making a change as a result of things seen at the tour (e.g. legume rotations, split fertiliser applications, reduced tillage, trickle irrigation) • Strong support for the Southern Sugar Solutions project – 100% agreed that linking GRDC projects to the sugarcane farming system is a good idea.	Milestone 3 Report 2018 Trial Site Bus Tour Report
Milestone reports (6)	**Milestone 7 (1/7/2020): 6mth biomass sampling** • Completed and delivered on all targets. • 2019/20 plant cane trial sampled at the 6-month mark for biomass, indicator leaf nutrients, and soil biology. • All results analysed and reported.	Milestone 7 Report

	Milestone 6 (1/1/2020): Harvests and planting • Completed and delivered on all targets. • 2018/19 plant cane trial and 2017/18 R1 cane trial sampled at harvest for biomass, CCS and soil nutrients. • All results analysed and reported.	Milestone 6 Report
	Milestone 5 (1/7/2019): 6 Month Biomass Sampling • Completed and delivered on all targets. • 2018/19 plant cane trial has been sampled at the 6 month mark for biomass, leaf tissue and soil biology. • The 2017/18 plant cane Carbon Trial has been sampled for 6 month biomass. • All results analysed and reported.	Milestone 5 Report
	Milestone 4 (1/1/2019): Plant Cane Harvest • Completed and delivered on all targets. • 2018/19 plant cane trial established. • 2017/18 plant cane crops have been harvested and all data collated, analysed, and reported. Six-month leaf tissue samples and soil biology data analysed.	Milestone 4 Report
	Milestone 3 (1/7/2018): Six Month Biomass Sampling • Completed and delivered on all targets. • Crop development has been captured to date at both trial sites. • Dewlap height increases monitored for the Carbon Trial, along with leaf sampling and soil biology sampling. • Next-seasons trial site determined and set to be planted in September 2018.	Milestone 3 Report
	Milestone 2 (1/1/2018): Progress Report • Project successfully initiated with all set goals for Milestone 2 achieved. • Both field trials successfully planted. • Crop development captured to date by determining treatment impact on crop establishment and tiller development. • 'Trimble soil information system' survey completed. • Project promoted at four events to date and the Junior Agronomist has met with industry stakeholders.	Milestone 2 Report
Social media group	• A 'Southern Coastal Farming Systems' Facebook group established to keep the local farming community abreast of the team's day-to-day activities. This has been a great vehicle to	Milestone 5 Report

	showcase the amount of work that goes into field trial experimentation.	
Media releases	• A social media post was produced following the 2018 bus tour and was shared with the funding bodies from the event. This post was also placed on the DAF intranet news blog and the success of the day communicated with upper management.	Milestone 3 Report

13. SRA-RMS MANAGER, RESEARCH MISSIONS' RECOMMENDATION

(To be completed by the SRA-RMS Manager, Research Missions)

Milestone Number			
Milestone Title	Final Report		
Final Report Due Date		Date submitted	
		Date of submission of revised version (if relevant)	
Date Reviewed		Date of review of revised version (if relevant)	
Reason for delay (if relevant)			
Milestone Payment			
Total Project Funding by SRA-RMS			
Project Objectives (Contracted)			
Success in achieving the objectives	☒ Completely Achieved ☐ Partially Achieved ☐ Not Achieved		

SRA-RMS Manager, Research Missions' Comments:

Project Outputs (brief version)

Activities to further develop, disseminate, commercialise or exploit the Project Outputs (after discussion with CI)