Summary of Project Findings

The objectives of the project were to investigate, test and communicate the suitability of multi species cover crops in a range of environments across south-eastern Australia. Activities measured the impacts cover cropping had on soil health. Soil analyses were selected to both test relevant and innovative soil health and biological parameters such as nitrogen cycling pathways and microbial community structure, and place these in the context of more traditionally understood agronomically-important soil properties. In addition, cover species suitable for environments across south-eastern Australia was investigated and cover crop termination methods were compared.

Outcomes achieved were efficient knowledge transfer to growers, facilitating optimum cover crop choice and termination methods suited to their farming systems and environment, and improved understanding of soil fertility, structure, biological health, and invertebrate impacts across south-eastern Australia for improved farm resilience and profitability.

This project was severely impacted by drought, hailstorms, bushfire and the Covid pandemic however the resilience and determination of the grower group network involved in the project meant that alternative methods of extension were developed and delivered including meeting in smaller groups at the local level; becoming proficient in using video conferencing; and using social media platforms and SMS messaging to a much greater degree

A range of specific practical findings observed from the project for the benefit of farmers in south-eastern Australia include:

- Seed varieties that were certain performers were French white millet, tillage radish, buckwheat and sunflowers.
- Tillage Radish assisted with breaking up soil compaction, by producing ground penetrating tap roots combined with strong lateral roots although it was somewhat limited by soil strength in soils with very low moisture retention.
- Top growth of Tillage Radish produced very good biomass to be used for mulching or stock grazing.
- Tillage Radish carry-over did become a host for cutworm and in the absence of spraying it seemed to become the preferred target to the benefit of other crop types
- It was confirmed that aerial spreading of cover crop seed prior to harvesting a crop in Spring can be successful on Kangaroo Island.

- Glyphosate provided certain termination of the cover crop in the trials whereas the roller crimper was only effective dependent on plant growth, stem thickness and strength.
- Spring sowing showed better results than summer sowing for warm season cover crops, although not viable in every year, could be included when conditions are suited.
- Soil aggregation visually improved at the Waikerie site under multi species by trial's end. Diversity appeared to have triggering improved soil culture with minimal inputs.
- In some of the multi seed mix trials ryegrass and oats dominated depending on soil depth. The resulting cover crop canopy shaded out competition leading to a reduced winter/spring weed presence.
- Mallee region multi-species plots developed improved soil aggregation and infiltration characteristics over the project duration.
- Summer cropping at the Langhorne Creek site demonstrated that tillage radish, faba beans, wheat, cereal rye, oats and sunflower were realistic options. Rye grass dominance impacted these crops reaching full maturity.
- Crop species linked some isolated observations which demonstrated pest suppression or reduced risk of pest outbreaks.
- Following two years of cover crop treatments, spring barley in 2020 showed up some quite visual biomass differences at the Sister's Creek site, Tasmania.

Soils and Agronomy Analysis

The main finding of the soils and agronomy analysis on the cover crop demonstration trials is that whilst expectedly climate driven (the most successful sites generally had the highest rainfall, and the least successful had the lowest).

Whilst at several of the lower-rainfall sites there was a negative impact on crop yield, this was not observed at most sites, and indeed yield increases (where data was available) were observed at a similar number. Whilst growing a summer cover crop likely utilises some soil water which may impact eventual yield of winter crops, reduced soil moisture did not appear to impact yield at most sites in what was mostly a reasonable growing season in 2021.

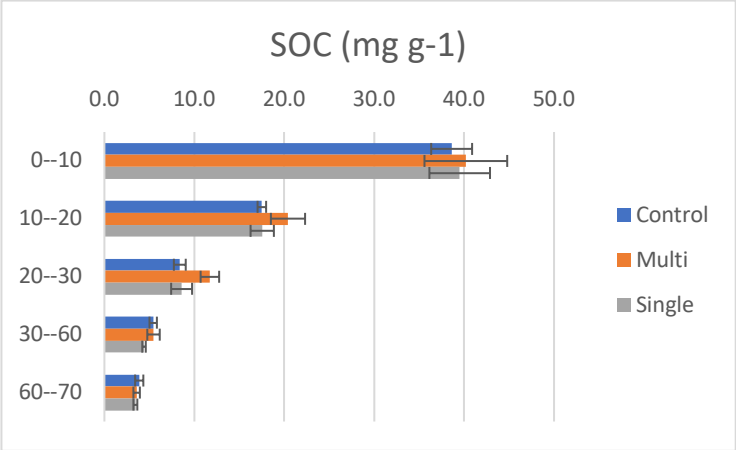
The main biogeochemical finding we observed was a decrease in nitrate-N at many of the cover crops sites, accompanied by an increase in both dissolved organic N (DON) and microbial biomass N (MBN), as well as proteolysis and amino acid uptake. Taken together, these findings suggest that cover cropping has reduced the concentration of the most lossy form of plant-available nitrogen (nitrate), whilst also increasing the amount of N that is potentially available (DON + MBN), and its rate of delivery (proteolysis and amino acid uptake). Assuming that cover crops can be integrated into systems without imparting either a yield penalty or excessive monetary cost, this finding suggests that they may act to reduce N losses, retaining N in an easily mineralizable form, and increasing the rate of that mineralisation.

Collectively, the demonstration sites can be grouped by rainfall into three categories:

Low rainfall. These sites will typically not benefit from the integration of summer cover crops unless there is either exceptional summer rainfall to support an opportunistic planting that is carefully monitored for water usage. Cover crops may be suitable (single or mixed) when sown in winter in place of a cash crop. However, if biomass is then harvested for hay or grazed, their positive impact on soil function would likely be reduced (whilst noting their contribution to the farm business through the provision of biomass/fodder). For summer cover crops in these environments there is a risk that soil health outcomes may actually regress due to excessive water use curtailing growth and carbon input from the following winter cash crop.

Medium rainfall. These sites may benefit from either summer or winter cover crops, though care would need to be taken when looking towards growth in the summer season to avoid a water penalty for the following winter crop. Nonetheless, it is apparent that within the context of the short study period this project allowed, there are positive, neutral, and negative outcomes across the medium rainfall sites.

High rainfall. These sites (found on the eastern side of the LEP, KI, Vic and Tas in the present study) showed the most consistently positive outcomes, with many suggesting an increase in cash crop yield as well as multiple soil health benefits, even after the relatively short time period afforded by the project. Care would still need to be taken regarding excessive water use.
Out of the higher rainfall sites, the site at Stokes Bay (KI) showed most promise, with a 1 t/ha increase in yield of the oats cash crop following 1½ summers of mixed species cover crop. Notably, even after such a relatively short adoption period, this also resulted in an increase in SOC concentration in the 10-20 cm and 20-30 cm layers (refer to chart below), with the lower of these two depths being a statistically significant increase.



Invertebrate Analysis

The inclusion of polycultures, such as inter-cropping or cover cropping, may have multiple benefits under Australian conditions where fields are large, and there is a need to diversify crop cultivars, type and flowering time to minimise the risk of crop failures in dryland systems. This is essentially a means of spreading risk by incorporating a diverse mixture containing species that succeed more in wetter and drier conditions, ensuring that a species that can capitalise on prevailing conditions is present regardless of the eventual rainfall. What was clear is management needs to understand the context in which it is being applied and its tolerance to sporadic risk if pest threats are less where plant diversity is increased on farm.

Species Evaluation

The species evaluation trials demonstrated that even in southern Australia's dry climate, multiple species with differing growth traits were found to tolerate these conditions, either as summer or winter options. At one site (Minnipa), additional work was undertaken to assess the relationship between the winter cover crops, soil properties, and yield of the following winter cash crop after an intervening summer fallow period. This found that mixtures of 3-6 cover crop species resulted in greater wheat yield in the following winter season as a result of greater inputs from the cover crops retaining more soil moisture and increasing the amount of slow-release nitrogen.

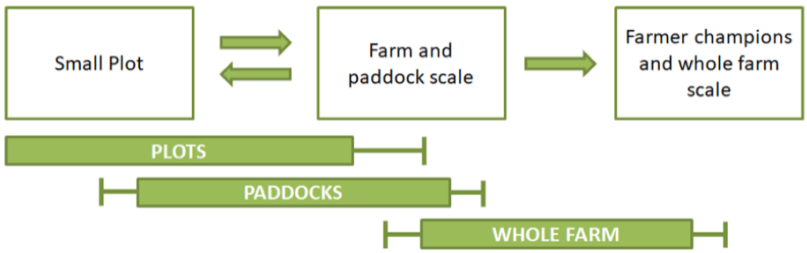
Information on potential suitability of cover crop candidates for south-eastern Australia was compiled at the start of the project. This provided information about different plant species to ensure the best outcome planning and implementing cover cropping pursuits. The evaluations were based on a species' suitability as a cover crop, rather than for its cash crop performance.

Cover Crop Termination Evaluation

The termination trials showed that whilst in certain situations non-chemical (knife roller) means of termination could be effective, chemical means of termination was most successful. In some areas, crops effectively "self-terminated" due to lack of water, which from a disease, weed, and pest management perspective, has the desired outcome without chemical or labour inputs.

Extension and Communications

The extension and communications plan for the project was developed and implemented on a three-tier engagement process, at paddock level through small plots and demonstration trials; then how this translate to the whole farming system through engagement with the farming systems groups; and then to the broader farming community through farmer champions who hosted the demonstration trials and the participating farming systems groups through their existing communications channels and extension activities.



The project steering committee kept a motivating partnership with the collaborators and delivery partners. By being involved with their communication and extension activities enabled the project to deliver an extensive range of activities and reach a broad audience. Project outputs are summarised in the table below.

Extension & Communications:

55 events;
1,600 attendees

73 social media post;
11,066 reach

43 publications;
3,010 reach

Project website maintained:
https://research.csiro.au/mixedcovercrops/

Collaborator Support:

- 15 project updates
- 3 project forums
- Google Drive
- SANTFA on-ground support

Trials & demonstrations (61):

- 20 demonstration trials
- 5 species evaluation trials
- 9 termination trials
- 27 invertebrate trials / assessments
- Data analysis

Monitoring & Evaluation:

- 77 collaborator reports
- 9 funder reports
- Baseline and end of project evaluation

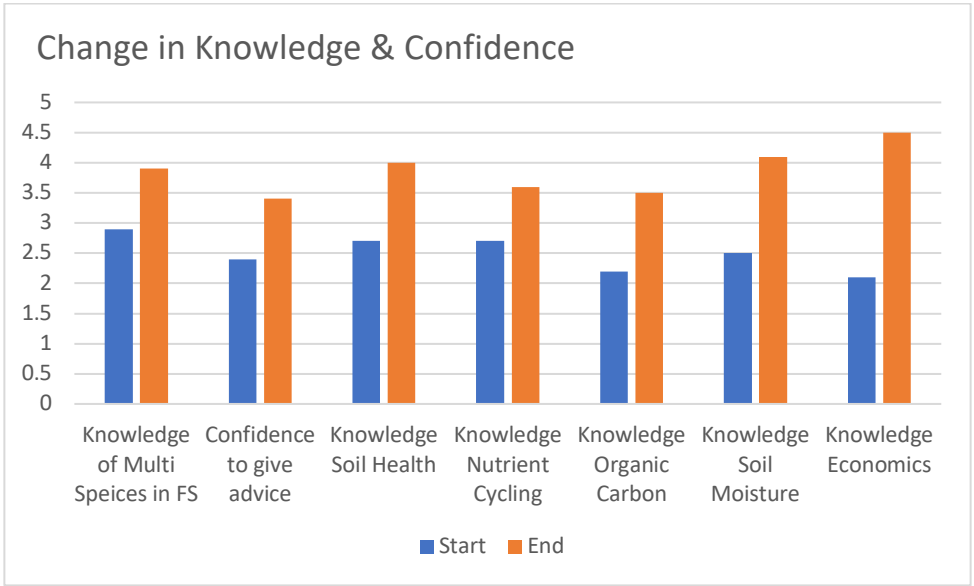
Baseline and end of project evaluation of knowledge and confidence relating to the science of mixed species cover crops and giving advice was conducted with representatives from the collaborating organisations. The eleven project collaborators have a direct influence on over 2,000 farm group members in south-eastern Australia plus social media connections with over 11,000 account holders.

Monitoring and Evaluation

The project set up a range of mechanisms to monitor the progress and evaluate the success of the project. A baseline and end of project survey was conducted with project collaborators asking the following questions:

- Rate your knowledge of applying multi species cover crops in farming systems (*1 – Very poor, 2 – Below Average, 3 – Average, 4 – Above Average, 5 – Very Good).*
- How confident are you about giving advice to your peers and/or farmers about incorporating multi species cover crops in farming systems (*1 – Would not give advice, 3 – Confident to give some advice, 5 – Very confident to give advice)?*
- Rate your knowledge (*1 – poor, 3 – average, 5 – very good)* of the impacts of cover cropping on:
- Soil health
- Nutrient cycling and stratification
- Organic carbon and fractions
- Soil moisture
- Economic benefits to following cash crops

Results of the evaluation are presented in the table below. For all the project parameters being evaluated, there was an increase in knowledge and confidence.



A range of comments on the value of the project were volunteered by project collaborators including:

- *"It has raised my knowledge of comparative regional trials and a range of evaluated approaches - this is valuable and, in my mind, a critical first step towards improving collective understanding of the cover crops system."*
- *"Project has produced tangible data that shows the specific pros and cons based on location, system, rainfall, etc."*
- *"I feel like I have learned enough to be confident about giving advice."*

Project Proponents

Project Funders

For further information on mixed species cover crops for south-eastern Australia go to:

https://research.csiro.au/mixedcovercrops/

Project Steering Committee

Mark Stanley, Ag Excellence Alliance
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Stephen Loss, GRDC

The project was delivered in collaboration with:

Murraylands and Riverland Landscape Board
Michael Nash (What Bugs You – Entomologist)
Mallee Sustainable Farming (MSF)
Ag KI
Southern Farming Systems (SFS)
Agricultural Innovations and Research Eyre Peninsula (AIR EP)
Upper North Farming System (UNFS)
MacKillop Farm Management Group (MFMG)