Innovation project success in increasing adoption of multispecies break crops to improve soil health and water quality run-off

Farmacist Mackay has recently completed a GBRF funded Innovation project focused on incorporating multispecies break crops in the sugarcane system. The project's key aims were:

1. Developing affordable and practical ways to plant multi species break crops using existing farm implements.
2. Develop management strategies to assist growers with species selection, weed control, crop termination, sourcing seed etc.
3. Determine if there are any soil health benefits from planting multispecies crops in a subtropical sugarcane system.

Summary

This project was successful in developing affordable, practical options for growers to use existing machinery to plant multispecies crops. Trial and demonstration sites showed improvements in soil physical, chemical and biological properties following multispecies break crops. Basic water run-off analysis shows the bare/weedy fallow had increased nutrients compared to cropped fallow systems, however more work is required to make definitive conclusions. Overall, the multispecies treatments showed favourable results in comparison to other fallow management crops. It should also be noted that all break crops, multispecies and monoculture, showed improvements compared to the bare/weedy fallow treatments.

What did this project do?

Planting multispecies crops during the sugarcane fallow period is still a relatively new concept for the majority of the sugarcane industry. Trials conducted in other industries, and countries, have shown many benefits achieved from planting a multispecies crop, however there was limited information on the actual benefit provided to a tropical sugarcane growing region. Farmacist Mackay worked alongside local sugarcane growers to address this limitation and collect information on soil physical, chemical and biological changes as a result of multispecies break crops. The project conducted two replicated trials and 9 demonstration sites in the Mackay region.

The overarching benefits of multi species fallow include:

- Breaking the sugarcane monoculture and not replacing it with a legume monoculture
- Increase plant diversity which will lead to an increase in soil biology diversity
- Provide a food source for a broader range of soil biology
- Provide soil cover and protection from erosion
- Create a range of rooting depths to address compaction
- Stimulate nutrient mineralization
- Include legumes for nitrogen fixation
- Increase soil organic matter
- Assist with weed suppression

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This Project is funded by the partnership between the Australian Government's Reef Trust and the Great Barrier Reef Foundation.

This project has led to a significant increase in the area planted to multi species fallow in the Mackay-Whitsunday region. The hectares of sugarcane farms planted to multi species crops as a direct result of involvement with this project are highlighted in Table 1. As can be seen, the area has increased each year of project operation, and break crops have been planted in winter as well as summer, which was not anticipated prior to project commencement.

Year	Winter	Summer
2020		64
2021	14	250
2022	80	488
2023	81	688 & counting

Table 1: Hectares planted to multispecies due to direct involvement with the project.

The project team have proven there are quick and affordable options available to plant multispecies crops using existing equipment. The machinery that has been used to plant these break crops includes wavy disc, rotary hoe, power harrow, weeder rake, bed renovator, sugarcane harvester, fertiliser box etc.

After using the project equipment, six growers have purchased their own air seeders. We have also noticed an increase in air seeder purchases made by growers, productivity boards and NRM groups, not directly involved in the project.

Impact on soil chemical properties

Using before and after soil samples taken in the low and high EC zones at 9 different sampling blocks across the Mackay region, with a total of 38 samples, a trend for changes in soil chemical properties was identified. These included:

- 89% of samples showed an increase in phosphorous Colwell following the multispecies crop
- 84% of samples had:
  - an increase in Organic Carbon
  - an increase in Potassium % and Nitric K
  - an increase in EC (1:5)

A statistical analysis (via the R Studio package: Lme4 linear model analysis, to address effect of site, followed by an analysis of deviation – Type II Wald chi square test – at the 95% confidence limits) identified at 8 sites that:

- for Organic carbon % EC significantly affected results with the high EC zone recording increased levels of organic carbon % both pre and post multispecies treatment
- pH after multispecies significantly declined
- sulphur results showed a significant increase after the multispecies crop
- no significant effect on phosphorous or potassium following multispecies however a nominal increase is noted post multispecies treatment for both low and high EC zones.

The following table shows the average soil analysis results for the high and low EC zones across the 8 sites. Note the increase in organic carbon %, phosphorous (BSES), potassium (Nitric K) and sulphur following the multispecies crop, and the reduction in pH (1:5 water).

Soil analysis results	EC	Al%	K(nitric)	OC%	P(BSES)	pH	S
Prior to multi spp.	High	1.49	1.45	1.04	21.86	6.06	8.14
	Low	7.15	1.40	0.89	29.43	5.55	6.89
Post multi spp.	High	3.86	1.55	1.16	30.57	5.54	15.13
	Low	7.00	1.44	1.09	44.86	5.34	10.51

Table 2: Averaged soils analysis results, pre and post Multi spp., fallow cover cropping by soil electrical conductivity (EC) zone. Phosphorus (P), potassium (K), sulphur (S), pH (Water), organic carbon percentage (OC%) and percentage of aluminium saturation (Al%).

Impact on soil chemical properties

In a replicated trial, the Haney soil health score was used to compare the changes to the average score across 4 different fallow treatments. The results indicated that planting any break crop was more beneficial than a bare/weedy fallow as can be seen in Table 3.

Treatment	Details	Average Haney soil health score* change	Cost of seed
Bare/weedy fallow	sprayed fallow	-2.55	$0
Multispecies crop broadcast	10 species mix broadcast and worked in	1.6	26kg/ha $114.64/ha
Soybeans on beds	2 rows soybean planted on preformed beds	1.6	60kg/ha $210/ha
Cowpea broadcast	Ebony cowpea	1.15	35kg/ha $126/ha

**Calculation (Solvita CO2/10) + (Total water Extractable Carbon/100) + (Total Water Extractable Nitrogen/10)*
Table 3: Results from fallow management trial 2021-2022.

A second replicated trial was used to compare Solvita CO2 burst tests and Microbiometer readings across different fallow treatments. Solvita CO2-Burst test is a measure of soil CO2 respiration from processed, pre-dried soils. It measures respiration following rewetting of the soil and serves as an overall indicator of soil microbial potential. The microbiometer is a soil test for microbial biomass and fungal to bacterial ratio which can be used to assist in determining the health of the soil (higher fungi % is generally healthier soil). Results showed that the multispecies treatment had increased fungi % in both replications and increased Solvita CO2.

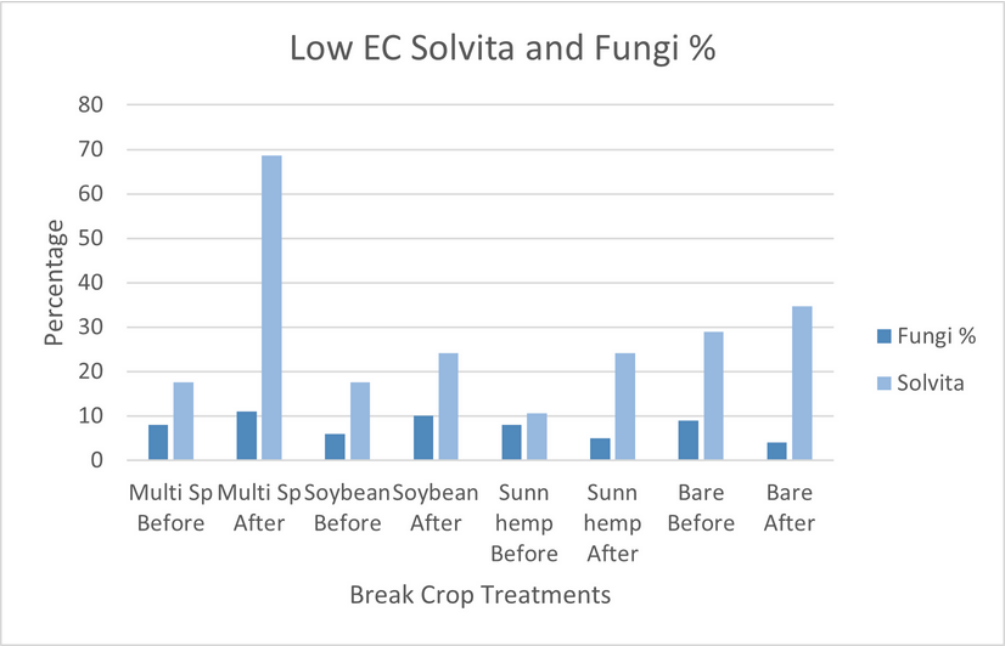

Figure 1: Solvita CO2 reading and microbiometer fungi % readings from the low EC zone in replicated trial.

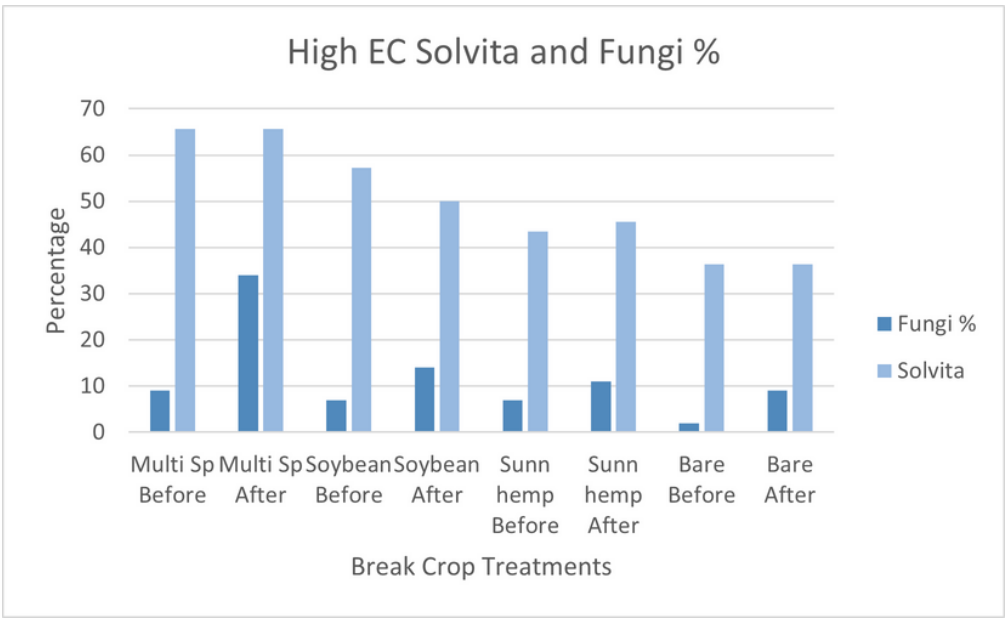

Figure 2: Solvita CO2 reading and microbiometer fungi % readings from the high EC zone in replicated trial.

Soil physical conditions

Measurements were collected from a replicated trial, before and after a multispecies crop, which showed improvements in effective rooting depth, earthworm counts and water infiltration as a result of planting multispecies crops, presented in the following tables.

Treatment	Before (mm)	After (mm)	Change (mm)
Multi species higher EC soil	**264**	**584**	**320**
Sprayed fallow higher EC soil	**224**	**433**	**209**
Multi species lower EC soil	**185**	**364**	**179**
Sprayed fallow lower EC soil	**240**	**269**	**29**

Table 4: Effective Rooting Depth (penetrometer reading) before and after fallow treatments.

Treatment	Before (number found)	After (number found)	Change (number)
Multi species higher EC soil	17	25	8
Sprayed fallow higher EC soil	14	9	-5
Multi species lower EC soil	0	7	7
Sprayed fallow lower EC soil	4	9	5

Table 5: Earthworm Counts from each treatment before and after fallow treatments.

Treatment	Before (mm/min)	After (mm/min)	Change (mm/min)
Multi species higher EC soil	3	25	22
Conventional higher EC soil	2.2	8.5	6.3
Multi species lower EC soil	5	3.16	-1.84
Conventional lower EC soil	6.17	6.57	0.4

Table 6: Water Infiltration comparison before and after fallow treatments.

Through trial and demonstration sites, the project has shown an improvement in soil physical, chemical and biological properties as a result of planting multispecies crops.

Koumala grower Rob Hand inspecting his multispecies crop. Credit: Rob Sluggett/Farmacist

Pinevale grower Andrew Deguara with Rob Sluggett from Farmacist inspecting sugarcane planted using zero tillage into sprayed out winter multispecies crop. Credit: Jess Bennett/Farmacist

Water run-off results

KP water samplers were installed at a replicated trial site comparing 4 fallow treatments – multispecies, sunn hemp, soybean and bare fallow. The run-off results from the unfiltered water samples showed the bare fallow had the greatest loss of Nitrate, Nitrite, total nitrogen and total phosphorous. This highlights the benefits of having a cover crop rather than bare fallow. The multi species treatment had the highest loss of total organic carbon which could be attributed to the higher biomass in this treatment compared to the soybean and sunn hemp. See Table 7 for a summary of the unfiltered water results.

	Multi Species		Multi Species		Bare fallow		Soybean	
	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
Nitrite + Nitrate as N	6.29	6.21	7.39	6.52	6.69	14.1	9.4	8.25
Total Kjeldahl Nitrogen as N	1	1.5	9.44	1.3	1.2	0.8	1.3	1
Total Nitrogen as N	7.3	7.7	8.7	7.7	7.5	15.4	11	9.2
Total Phospho-rous as P	0.04	0.16	0.02	0.09	0.06	0.26	0.05	0.16
Total Organic Carbon	4	9	3	5	2	2	2	4

Table 7: Unfiltered water run-off results.

	Multi Species		Sunn Hemp		Bare fallow		Soybean	
	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
Filtered Ammonia as N	0.02	<0.01	0.2	0.01	0.04	0.02	0.52	<0.01
Nitrite + Nitrate as N	6.43	6.1	9.44	6.43	6.72	13.4	8.36	6.42
Dissolved TKN as N	1	1.2	2.2	0.9	1	2.2	2.6	1.2
Filtered Total Nitrogen as N	7.4	7.3	11.6	7.3	7.7	15.6	11	7.6
Filtered Total Phosphorous as P	0.06	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Dissolved Organic Carbon3	3	8	4	5	2	2	2	4

Table 8: Filtered water run-off results.

Water run-off results

- Water run-off samples indicate bare/weedy fallow had increased nutrients compared to cropped systems
- Cost-effective and practical solution successfully developed to allow growers to plant multispecies crops
- Soil health improvements identified – soil chemical, physical and biological improvements
- Reduced nitrogen application in plant cane following multispecies crops incorporating legumes

Top: Rob Sluggett from Farmacist presenting at a field day to growers at a winter planted multispecies demonstration site. Credit: Mandy Jeppese/Farmacist. Bottom: Growers attending a field day in Koumala to inspect the air seeders and a multispecies crop. Credit: Ashlee Reddacliff

For more information and detail regarding the trial results please visit the Farmacist website.

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Farmacist would like to thank all our contributing growers for trailing equipment, planting new and exciting species, volunteering for case studies or trial sites and hosting field days.