Hort Innovation

Milestone Report

Project title:

Integrated Pest Management of Nematodes in Sweetpotatoes

Project code:
PW17001

Milestone number:
MS108

Project leader:
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Delivery partner:
Department of Agriculture and Fisheries

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Confidentiality:
Is this report confidential?
☒ No
☐ Yes (whole report)
☐ Yes (sections of report are confidential)
If sections of the report are confidential, list them here:

Milestone description:
Report to industry on cover crops in grower fields.
Pot trials completed; results transferred to growers.
Nematicide trials commence

Milestone achievement criteria:
Update on long term grower and farming system trials.
Report to industry on performance of cover crop pot trials.
Update including metagenomics data and soil biology data.
Round 3 Nematicide trials commenced.
Project Reference Group meeting(s) held and minutes provided.

Funding statement:
This project has been funded by Hort Innovation, using the Hort Innovation sweetpotato research and development levy, co-investment from Department of Agriculture and Fisheries, Queensland and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

Abbreviations

ASPG	Australian Sweetpotato Growers Association Inc.
BRF	Bundaberg Research Facility
DAF	Department of Agriculture and Fisheries
DES	Queensland Department of Environment and Science
GRF	Gatton Research Facility
NTF	Nematode Trapping Fungi
PRG	Project Reference Group
PT	Pathogen Tested
RKN	Root-knot Nematode

General project overview

Nematodes are an important pest of sweetpotatoes, with current estimates suggesting they cost the Australian industry $20 M per year (ASPG pers. com.). This project aims to extend existing knowledge and develop new knowledge specific to sweetpotato farming systems on soil health and nematode management. Surveys will be conducted across production areas to identify nematode species present. A range of management options such as volunteer and host weed control, suitable summer and winter cover/rotation crops, low/minimum till, long term beds and nematicide efficacy are being investigated.

Summary

A very successful project update and field walk was conducted in Bundaberg in October 2021. This was the first face to face field walk that we had been able to deliver for some time, due to Covid restrictions. Growers were provided with the latest updates on the long-term trial, cover crop screening for RKN resistance, herbicide plant back experiments and nematicide trials. Copies of the grower handout, milestone reports, specific project reports and updates have been forwarded to the ASPG executive officer for upload to the members only page on the ASPG website.

Intensive maintence and cover crop rotations continue in both of the BRF long-term trials along with a range of soil sampling, (nematode surveillance screening, physical soil properties, microarthropods and NTF). The second harvest of the Extensive trial is scheduled for the 7th of March 2022. Results from the second commercial harvest of the Intensive trial block showed that the nematicide treated blocks produced a higher mean number of roots per treatment, but the organic amended plots had a higher mean root weight per treatment. The incidence of wireworm damage was significantly higher in the organic matter treatment than all other treatments, but this requires further monitoring before any definite conclusions can be determined. The nil treatments (control plots) had a significantly higher incidence of pimpling that all other treatments. The nematicide treated or amended plots were not significantly different from each other.

The intensive survey throughout the major Australian production regions is ongoing. Nematodes, both plant parasitic and free living, are being monitored in selected on-farm blocks over time. This intensive survey will continue for the life of the project to understand how on-farm practices influence nematode populations. Diagnostic sampling is also available for growers who want ad hoc information about nematode numbers in particular blocks.

Host range and pathogenicity trials continue. As results become available, they are distributed to growers and added onto the cover crop resistance list. An updated summary of cover crop resistance and a grower handout explaining the treatments in the long-term trial and key project findings are also attached to this milestone report.

The nematicide trial was harvested in January 2022 and results are currently being collated. The third commercial sweetpotato harvest of the intensive trial will commence on the 7th March 2022. Harvest of the long-term pot trial to investigate RKN damage to two commercial sweetpotato cultivars is scheduled for the 9th of March.

Achievements

Update on long term farming system trials

Report to industry on performance of cover crop pot trials.

Update including metagenomics data and soil biology data.

Round 3 Nematicide trials commenced.

Project Reference Group meeting(s) held and minutes provided.

Update on long-term farming system trials

Bundaberg field day

A project update and field day were held on the 20th of October 2021 at the Bundaberg Research Facility. This was originally planned to occur in August, but due to Covid restrictions, was postponed to October where a face-to-face update and field walk could be delivered rather than a virtual update. A flyer was distributed to industry via the ASPG secretary (Attachment 1). The event was attended by 17 growers and industry representatives and facilitated by ASPG's executive officer, Peter Long. Project team members delivered updates on changes in soil parameters, nematode, NTF and microarthropod populations and yield data in the Intensive and Extensive, long-term farming systems trials in Bundaberg (Figures 1 and 2). Results of recent herbicide trials and cover crop screening experiments to determine susceptibility to nematodes were also presented with the latest data on long term on farm nematode surveys (see Appendix 1). A handout to explain the long-term trial and assessment process was developed for attendees (Attachment 2). Guest speakers Tony Pattison and Hazel Gaza delivered presentations on soil health and the development of a soil health toolkit. The event concluded with a field walk to the long-term trial site (Figure 3). A future grower update is planned for Autumn 2022.

Figure 1. Left, Wayne O' Neill discusses the changing RKN populations in the plots with differing amendments in the long-term trials. Right, Mary Firrell explains the changes in carbon levels resulting from organic amendments.

Figure 2. Left, ASPG executive officer Peter Long facilitates a Q & A panel with Rachael Langenbaker, Sandra Dennien and Wayne O'Neill. Right, Jennifer Cobon presented the results from pathogenicity screening trials.

Figure 3. Rachael Langenbaker, trial manager describes the organic amendments used in the of the long-term farming systems trial at the DAFs Bundaberg Research Facility.

Report to industry on performance of cover crop pot trials.

As reported in previous milestones, due to long running drought conditions over most sweetpotato cropping areas during 2019 and 2020 leaving growers with reduced water availability for commercial crops let alone cover crops, this part of the project was deferred to 2021. Growers were supplied with 4-8kg bags of seed of Sunnhemp, signal grass and White french millet to try on farm in small plots. A cover crop trial was completed in 2021 and reported in previous milestones. An area is currently under cover crops in preparation for an on-farm field trial to assess cover crop susceptibility to *R. reniformis* in spring of 2022. A suitable site is currently being negotiated at GRF to trial several mixed species of RKN resistant winter cover crops in the coming months to evaluate growth habits, water requirements and biomass production.

Update including metagenomics data and soil biology data.

As per milestone 105, soil has been collected at critical points during the long-term farming systems trial for metagenomic analysis. Samples are stored at -20^{o} for future reference. Negotiations continued for some time in relation to the USQ request for either increased funding or removal of metagenomic activities from the proposed subcontract. Pricing from alternative suppliers was presented to PRG as requested. Information from soil health experts on the practicality, interpretation of data and usefulness of this approach to the project aims was also presented to the PRG. Subsequently the PRG decided not to go ahead with developing metagenomic sweetpotato assays under PW17001. Soil samples will continue to be stored at -20^{o} in case requirements change in the longer term.

Round 3 Nematicide trials commenced.

Similar to cover crop trials, as reported in previous milestones, due to long running drought conditions over most sweetpotato cropping areas during 2019 and 2020 this part of the project was also deferred to 2021. This decision was not only based on the fact that there was a lack of available water but there was also a steep decline in nematode numbers throughout sweetpotato cropping areas. Despite sampling multiple on-farm blocks with previously high populations, no suitable sites could be found with high enough nematode numbers to run trials. Private research businesses contracting to chemical companies were in the same situation.

A suitable site was identified in January 2021, however sampling returned very low RKN numbers. After a return of rainfall around April, the block was sampled again and numbers had increased, though were still not ideal. A decision was made to go ahead with the first nematicide trial in partnership with Mitchell Feint of AgPD, who was leasing the block. The Bundaberg site was planted with sweetpotato cultivar Orleans in May 2021.

Figure 4. the nematicide trial block in Bundaberg, December 2021.

The trial investigated the effects of commercial nematicides Metham, Vydate and Nimitz. on root-knot nematode populations in sweetpotato. Routine soil samples were collected and analysed for RKN, free living nematodes, microarthropods and NTF evaluation. The scheduled December harvest of the Nematicide trial had to be postponed due to wet weather so this was postponed to mid-January 2022. Unfortunately, the rescheduled harvest date then coincided with a spike in Covid 19 infections in QLD. Increased safe work protocols had to be developed and departmental permissions approved to conduct this group activity. Staff from Mareeba and ESP were also unable to attend.

The block was top chopped on the 6th of January 2022, thanks to Russ McCrystal of McCrystal Ag. Plants from the 1m buffer zones were removed and roots were dug on the same day. The sweetpotatoes were given 4 days in wet conditions to harden before being harvested on the 10th of January 2022. The roots were transported to Gatton Research Facility where they were washed and assessed. The sweetpotato were assessed over the week of the 17th – 21st of January 2022. The results of the assessment are still being analysed.

Figure 5. Top chopping the nematicide trial block in Bundaberg, December 2021.

Figure 6. Removing the buffer plants by hand, nematicide trial January

Harvested roots were washed in a chlorine solution using a standard butternut pumpkin washer. Over the duration of 9 days, the 15 000 roots were individually weighed and assessed into eight size categories; extra small, small, small medium, medium, medium large, large, jumbo and three marketability grades, first or premium grade, second grade and non-marketable. A categorisation system was designed to capture 18 common defects found in commercial sweetpotato production. As the range and types of skin lesions than may or may not be attributed to nematode infection either directly or indirectly is unknown, all defects were recorded. Each root underwent close visual scrutiny and was evaluated using this system. Data is currently being collated before forwarding onto a DAF biometrician for analysis.

Figure 7. Roots from the nematicide trial undergoing assessment, January

Figure 8. Covid safe protocols were followed by the assessment team, January 2022.

Nematicide Trial Nematode Counts

The nematicide trial was sampled to assess plant parasitic nematode numbers in May, June, August, October, and at harvest in January. The information presented below is based on mean nematode counts; analysis to determine statistical significance is currently underway in consultation with statisticians.

Root-knot nematode counts at the start of the trial averaged around 30 per 200g dry soil across all plots when treatments were applied in May 2021. The Metham treatment had a rapid effect on plant-parasitic nematodes. No root-knot nematodes and very low numbers of other plant-parasitic species were recovered from Metham treated plots when the trial was sampled approximately two weeks after application.

When the trial was again sampled in June and August, root-knot nematode numbers had declined to undetectable levels in almost all plots (including untreated controls), likely due to limited root mass in the young crop and slow reproduction in the cooler months. However, by the October sampling, root-knot nematode numbers had increased dramatically in most treatments, with a mean of over 2000 RKN/200g dry soil in the untreated controls. Nimitz (normal application) had the lowest mean root-knot nematode count at this point in the trial, but Vydate had the lowest numbers of total plant parasitic nematodes (spiral and reniform nematodes were the other abundant plant-parasites).

Table 1. October 2021, Nematode Data – Mean Counts/200g Dry Soil

	RKN	Total Plant Parasitic nematodes
Nimitz	25	762
Vydate	118	174
Metham	512	902
Nimitz trickle	532	903
Nil	2287	2943

At the January 2022 harvest, mean root-knot nematode counts were high for all nematicide treatments as well as the nil control. Vydate treated plots had the highest RKN and total plant parasite counts; the reasons for this are unclear and further analysis will determine if the results are statistically significant. Reniform nematode numbers were high in some plots, but its distribution was patchy in the trial (mainly confined to the southeast corner) so it is hard to draw any conclusions about the effectiveness of particular nematicides towards this species.

Table 2. January 2022, Nematode Data – Mean Counts/200g Dry Soil

	RKN	Total Plant Parasitic nematodes
Nimitz trickle	1746	3328
Metham	1910	2342
Nil	1914	3828
Nimitz	1953	2884
Vydate	3798	4358

Analysis of yield and quality data will give an indication of whether or not nematicides gave enough control during the growth of the crop to provide a commercial benefit. The site where this trial was located has a sandy loam soil which may be more conducive to rapid build-up of root-knot nematode populations than some other soil types.

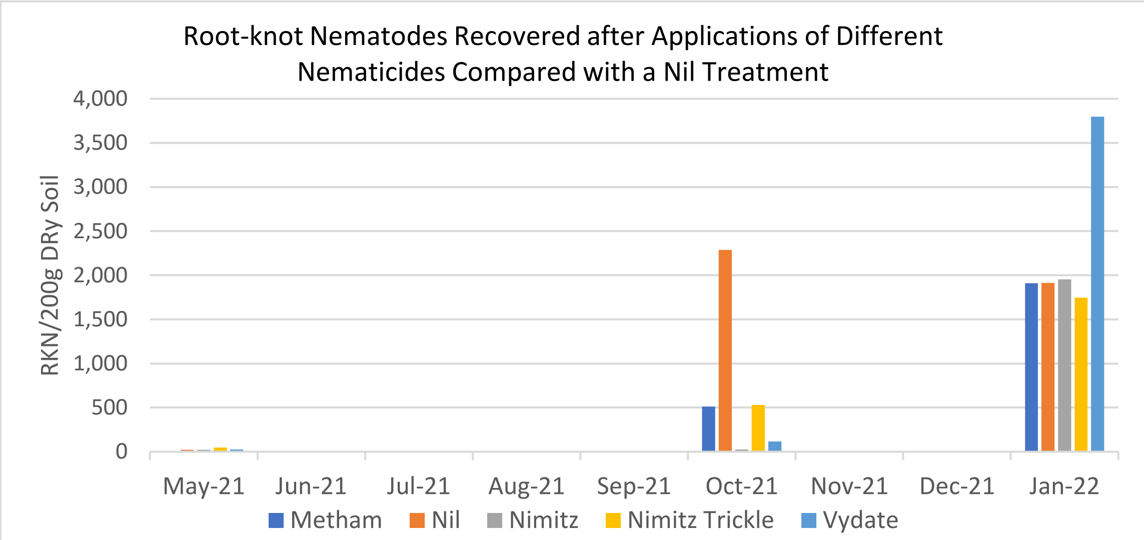


Figure 9. Mean Counts for Root-knot Nematode Over Time

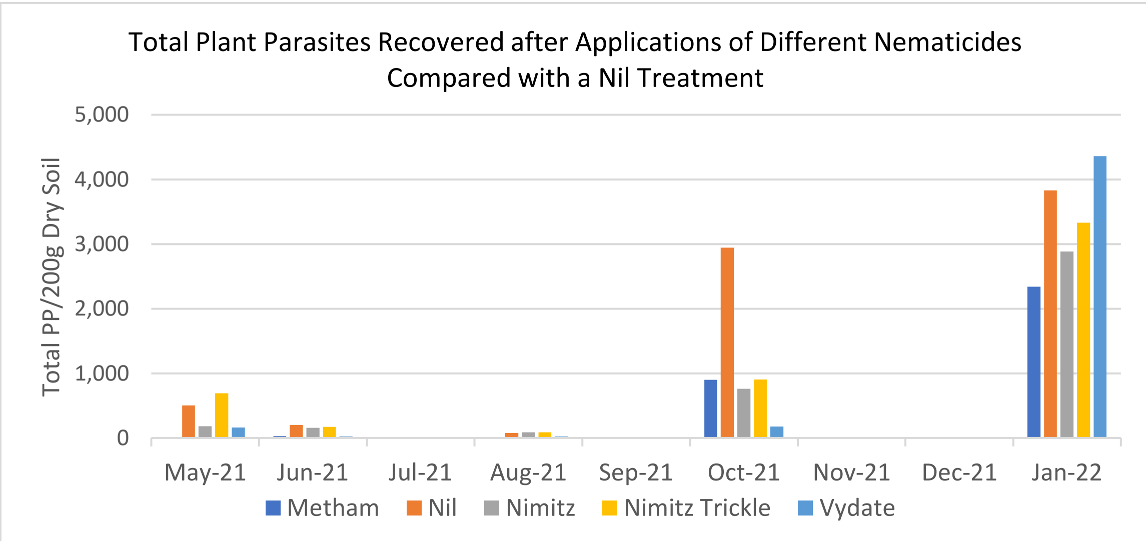


Figure 10. Mean Counts for total plant-parasitic nematodes over time

Project Reference Group meeting(s) held and minutes provided.

A Project Reference Group meeting was held in Bundaberg on the 20th of October 2021. This was attended by 3 PRG members in person and one joining via Microsoft Teams. Minutes have been provided to Hort Innovation.

Additional Achievements

Pathogenicity experiments

Resistance pot trials to assess potential rotation crops and sweetpotato varieties

Resistance to plant-parasitic nematodes is determined by the capacity of the nematode to multiply on a plant, with high multiplication rates indicating susceptibility and low multiplication rates indicating resistance. Levels of resistance or susceptibility were determined by inoculating plants with a known number of root-knot nematode eggs (initial population density Pi), measuring final population density (Pf) and then making the following calculation: Reproduction Factor (RF) = Pf/Pi (Table 1).

Since not all eggs in inoculum are capable of hatching and invading roots, a conservative figure of 1/10 of the Pf was used as Pi, i.e. 1,000 as each plant was inoculated with 10,000 eggs of either *Meloidogyne incognita* or *M. javanica*.

Table 3. Resistance categories

	Resistance Rating
> 100	Highly Susceptible (HS)
10 - 100	Moderately Susceptible (MS)
1 - < 10	Slightly Susceptible (SS)
0.1 - < 1	Resistant (R)
< 0.1	Highly Resistant (HR)

Rotation/Cover crops

Experiment 15 & 16

Plant species soybean (cv. Stuart, Hayman, Moonbie, A6785 and Soy791), cowpea (cv. Ebony and Caloona) and peanut (cv. Alloway), butterfly pea and burgundy bean were inoculated with two species of root-knot nematodes (*Meloidogyne incognita* and *M. javanica*) to determine the host status of these cultivars.

- Burgundy bean is highly susceptible to both *M. incognita* and *M. javanica*
- **Butterfly pea is resistant to *M. incognita*,** but slightly susceptible to *M. javanica*
- Caloona cowpea is slightly susceptible to *M. incognita* and highly susceptible to *M. javanica*
- Ebony cowpea is highly susceptible to *M. javanica.*
- Alloway peanut is highly resistant to both *M. incognita* and *M. javanica*
- Soy 791 is slightly susceptible to *M. incognita*

Ebony cowpea was repeated in another experiment because of the inconclusive results with *M. incognita* (see EXP 19). Soy791 soybean was repeated in another experiment because of the inconclusive results with *M. javanica* (see EXP 19).

Experiment 17

Plant species barley (cv. Harpoon, Moby), triticale (cv. Crackerjack2), sunflower (cv. Greystripe), millet (cv. Jap, Shirohie, Maxa), vetch (cv. Popany), Brassica nigra, snail medic, lucerne (cv. Alfacut) and chicory (cv. Commander) were inoculated with two species of root-knot nematodes (*Meloidogyne incognita* and *M. javanica*).

- Harpoon barley is moderately susceptible to *M. javanica*
- Moby barley is moderately susceptible to both *M. incognita* and *M. javanica*
- Crackerjack2 triticale is moderately susceptible to *M. javanica*

- Greystripe sunflower is highly susceptible to both *M. incognita* and *M. javanica*
- Millet (Japanese, Shirohie, Maxa) are all moderately susceptible to both *M. incognita* and *M. javanica*
- Popany vetch is moderately susceptible to both *M. incognita* and *M. javanica*
- Brassica nigra is slightly susceptible to *M. incognita* and moderately susceptible to *M. javanica*
- Snail medic is moderately susceptible to *M. incognita*
- Alfacut lucerne is moderately susceptible to *M. javanica*
- Commander chicory is moderately susceptible to *M. incognita* and highly susceptible *M. javanica*

Harpoon barley, Crackerjack2 triticale and alfacut lucerne are being repeated in other experiments because of the inconclusive results with *M. incognita* (see EXP 22 - next report). Snail medic is being repeated in another experiment because of the inconclusive results with *M. javanica* (see EXP 22 - next report).

Experiment 18

Plant species sorghum (cv. Banker, Lantern), sweetcorn (cv. Messenger, Acceleration, Inception, SV1446SD) and maize (cv. Monsoon8) were inoculated with two species of root-knot nematodes (*Meloidogyne incognita* and *M. javanica*).

- Banker sorghum is slightly susceptible to both *M. incognita* and *M. javanica*
- Lantern sorghum is highly susceptible to *M. incognita* and moderately susceptible *M. javanica*
- Messenger sweetcorn is highly susceptible to both *M. incognita* and *M. javanica*
- Acceleration sweetcorn is highly susceptible to *M. incognita* and moderately susceptible *M. javanica*
- Inception sweetcorn is highly susceptible to both *M. incognita* and *M. javanica*
- SV1446SD sweetcorn is highly susceptible to both *M. incognita* and *M. javanica*
- Monsoon8 maize is highly susceptible to *M. incognita*

Monsoon8 maize is being repeated in another experiment because of the inconclusive results with *M. javanica* (see EXP 22 - next report).

Experiment 19

Plant species soybean (cv. A6785, Hayman, Moonbie, Soy791, Stuart) and cowpea (cv. Ebony, Red Caloona) were inoculated with two species of root-knot nematodes (*Meloidogyne incognita* and *M. javanica*).

- A6785 soybean is resistant to *M. incognita* and slightly susceptible *M. javanica*
- Hayman soybean is slightly susceptible to *M. incognita* and moderately susceptible to *M. javanica*
- Moonbie soybean is slightly susceptible to *M. incognita* and moderately susceptible to *M. javanica*
- Soy791 soybean is slightly susceptible to *M. incognita* and moderately susceptible to *M. javanica*
- Stuart soybean is slightly susceptible to *M. incognita* and moderately susceptible to *M. javanica*
- Ebony cowpea is moderately susceptible to both *M. incognita*
- Red Caloona cowpea is slightly susceptible to *M. incognita* and highly susceptible to *M. javanica*

Further to Experiment 15 & 16

- Ebony cowpea is moderately susceptible to *M. incognita*
- Soy791 soybean is moderately susceptible to *M. javanica*

An update on nematode resistance ratings of cover/rotation crops trialled to date has been provided to ASPG for the website. Further glasshouse experiments to determine host range resistance of more rotation crop species are presently underway.

Growers intensive survey

At the beginning of the project in 2018, field surveys were conducted throughout the major cropping regions to gain an understanding of region-specific nematode species occurrences and identify any potential biosecurity issues. Over 90 survey samples have been processed with plant-parasitic nematodes being the main focus. Free-living nematodes were also identified to give an overall indication of the soil's biological status.

Further sampling of selected growers' fields across the different growing regions took place in 2020 and 2021 to gain a better understanding of plant-parasitic nematode dynamics under the different management systems undertaken by the growers.

Intensive surveys of growers' fields have been undertaken in the three growing regions. Four sites in Cudgen, seven sites in Bundaberg and four sites in Rockhampton have been resampled for the intensive grower surveys from 2018 -to 2021. Growers participating in the intensive grower survey have been provided with the nematode identification results for all years of sampling for their consideration and so they can make comparisons.

A table of results showing numbers of the two most important plant-parasitic nematodes in sweetpotato production together with the free-living nematode numbers follows. No apparent trends were obvious, but for individual growers where numbers of either root-knot nematode or reniform nematode have changed drastically, further analysis of the data, together with an in-depth investigation of the growers' practices, is being undertaken.

Table 4. Main plant-parasitic nematodes in sweetpotato production from intensive growers surveys together with the free-living nematode numbers

		Plant-parasitic nematodes/200 g dry soil		**Free-living nematodes/200 g dry soil**
Sample ID	**Year**	**Root-knot *Meloidogyne* spp.**	**Reniform *Rotylenchulus reniformis***	**Various species**
EC01	2018	20	0	736
EC01	2020	157	0	4051
EC01	2021	28	0	3728
EC04	2018	1611	0	379
EC04	2020	388	0	1983
EC04	2021	57	0	2311
RL02	2018	394	0	390
RL02	2020	63	0	4496
RL02	2021	3	0	2443
RL03	2018	264	23	904
RL03	2020	592	0	3032
RL03	2021	3	0	1157
RL03	2021	0	0	3899
RL04	2018	453	0	254
RL04	2020	2133	0	225
RL04	2021	100	0	1182
RL06	2018	0	35	549
RL06	2020	20	2	120
RL06	2021	1220	8135	794
RL09	2018	506	0	413
RL09	2020	40	0	1351
RL09	2021	530	0	1767
RL11	2018	0	15	308
RL11	2020	2	2156	1396
RL11	2021	0	1573	1633
RL13	2018	587	0	914
RL13	2021	0	2	1839
RL15	2018	4	19	1129

RL15	2020	4	125	3285
RL15	2021	411	411	451
RL16	2018	6	799	870
RL16	2020	2	147	2564
RL16	2021	3	9	2825
RL21	2018	14	0	515
RL21	2020	44	0	1562
RL21	2021	1848	365	1471
RL24	2018	1	0	870
RL24	2021	0	0	431
RL35	2018	0	0	962
RL35	2020	0	0	437
RL35	2021	0	0	3939
RL39	2018	162	0	1197
RL39	2020	0	0	1084
RL39	2021a	17	0	2374
RL39	2021b	15	0	2431

An update on nematode resistance ratings of cover crops trialled to date was distributed to growers via the ASPG secretary in February 2022. Further glasshouse experiments to determine host range resistance of more rotation crop species are presently underway.

Long term RKN pot trial

A novel long-term pot trial to assess the susceptibility of Beauregard and Bellevue storage roots to RKN species *M. javanica* has been established in the BRF plant house. The randomised complete blocked experiment includes two treatments (RKN and Nil/control), two commercial sweetpotato cultivars (Beauregard and Bellevue) and four replicates. It is hoped that this experiment will provide increased knowledge on types of damage inflicted by *M. javanica* on storage roots of the two cultivars.

The experiment was planted on the 24th of September 2021 with PT seedbed cuttings. The pot trial uses 24, 100 litre pots filled with pasteurised field soil. Twelve pots were inoculated with *M. javanica,* with the remaining twelve being the control group. This experiment is scheduled for harvested in early March 2022.

Figure 11. The long-term pot trial at BRF February 2022.

Future project activities

- The third commercial sweetpotato harvest from the Intensive trial block will be harvested on the 7th of March 2022, weather permitting.
- The long-term pot trial will be harvested in early March 2022.
- A further long-term pot trial to investigate the effects of *Rotylenchulus reniformis*, is planned for spring 2022.
- A further herbicide trial to investigate the plant back effects of Sempra on sweetpotato planting vines is planned to take place in spring of this year.

Outputs

- Two project team meetings conducted.
- Field day and project update conducted in October 2021 in Bundaberg.
- Harvest of nematicide trial completed in January 2022.
- An update on nematode resistance screening distributed to growers in February 2022.

Outcomes

- Growers now have 24-hour access to project documents on ASPG members only website.
- Growers have greater understanding of the long-term farming system trials.
- Researchers have new knowledge on the effects of organic amendments on nematode control, crop growth and insect occurrences.

Issues and risks

The recent flare up of COVID across the country once again impacted scheduled field days and movement of project staff to on farm experiments and assessments. This also made intensive grower sampling by Qld project staff in NSW impossible. A contingency plan was established with an agronomist in NSW many months ago with an arrangement in place for him to collect soil samples for processing in QLD. This has allowed for basic sampling to continue in the interim. It is hoped that the team can now access all major production areas to collect samples and discuss results with growers on farm and in person.

Other information

No additional information to report

Appendices

Appendix 1 - Bundaberg field day, October 20, 2021.

Appendix 2 - Long term farming system trials, Intensive and Extensive

Appendix 3 - Soil analysis results in the long-term trial.

Appendix 4 - Microarthropods and NTF Results in the long-term trial.

Appendix 5 – Intensive trial harvest results, second harvest.

Attachments

Attachment 1 – Bundaberg field day industry flyer.

Attachment 2– Hand out Bundaberg filed day and project update, October 20, 2021, Bundaberg.

Attachment 3– Updated summary of resistance' February 2022'.

Appendix 1

Bundaberg field day

Bundaberg field day, October 20, 2021.

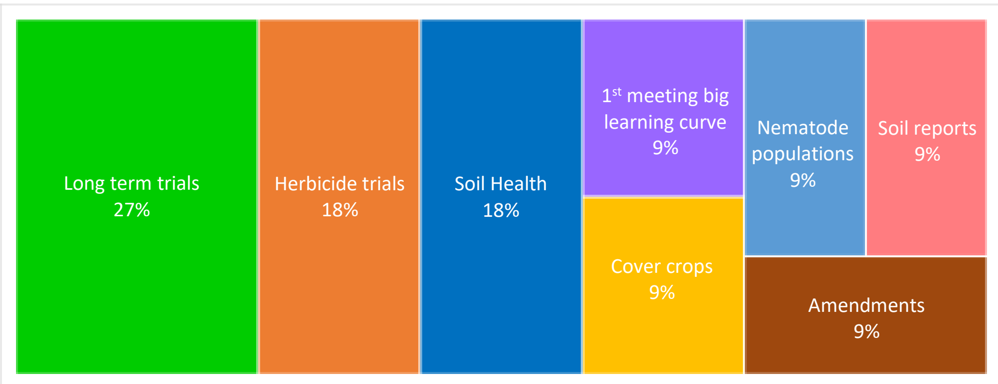
Table 1

Start time	Talk duration	Questions/ mins	Topic
2.00	10	Peter Long, ASPG Executive officer	Welcome, outline
2.10	10	Sandra Dennien	Project outline, long term field trial harvest assessment - lesion data
2.20	10	Rach Langenbaker	Long term field trial - yield data, Nematicide trial
2.30	10	Wayne O'Neill	Nematode population trends in the long term field trial
2.40	10	Sandra Dennien	NTF and microarthropod trends, long term field trial
2.50	15	Key messages and questions	
3.00	15	15 minute break	
3.15	10	Mary Firrell	Changes in soil parameters in the long term field trial
3.25	10	Jenny Cobon	Cover crop susceptibility screening, ongoing farm surveys
3.35	10	Michael Hughes	Herbicide trials
3.45	15	Key messages and questions	
3.55	20	Guest speaker Tony Pattison	Soil health
4.20 - 4.50pm	30	Field walk	
		Rach Langenbaker & Brett Day	Field walk
		Guest speaker Hazel Gaza	Soil health tests
	15	Questions	

Feedback form attendees

Feedback from attendees indicated that 55% of attendees rated the quality of the presentations as being excellent and 45% rated the talks as good. Over 27% said that it was highly relevant to their business and 73% of attendees considered the update was mostly relevant. When asked which topics attendees liked the most, many selected multiple options. The long-term trials were the most liked topic with herbicide trials and soil health topics the second most liked at 18%. The remainder of topics were each liked by 9% of growers.

Table 2. What topics did you like the most about the project?



Appendix 2

Long term farming system trials

Intensive Trial

Intensive trial plan

- Four Sweetpotato crops (cultivar Beauregard) in 5 years with shorter rotation breaks.
- Five treatments - combinations of organic amendments vs nematicide vs nil.
- Organic matter/compost incorporated at bed formation or in a furrow prior to planting.
- Crop rotations incorporated at bed formation.
- 25 plots (5 replicates).

Table 1 Treatments in the intensive trial

Treatment No	Intensive trial- 5 treatments x 5 reps
1	Organic matter (poultry manure and compost)
2	Compost
3	V furrow amendment
4	Nematicide (Nimitz)
5	Nil

During this reporting period the data collected from the second commercial harvest of sweetpotato, cultivar Beauregard, underwent analysis. The Intensive trial block was then hand sown with Jumbo sorghum in September 2021, at a rate of 20kg / Ha with a further 500g of seed sown in October 2021 to cover gaps in coverage. The sorghum crop was then slashed, and rotary hoed in preparation to prepare for the third commercial crop. Nutrient level, nematode, microarthropod, NTF and soil chemical monitoring followed amendment application on the 27th of January 2022. The organic matter plots received 22.4kg of chicken manure & 33.6kg of saw dust (total of 56kg per plot), incorporated at bed forming. The compost treatment plots each received 56 kg of compost, also incorporated at bed forming. The V furrow treatment plots each received 42.5kg of compost applied directly into a ‘V’ shaped furrow on top of the formed beds. The trial block was then planted to cultivar Beauregard on the 11th of February 2022. Nimitz was applied as per label rate at 8L / Ha. This block is scheduled to be harvested in early March 2022.

Figure 1. Jumbo sorghum in the Intensive trial block at BRF was slashed off in preparation for planting,

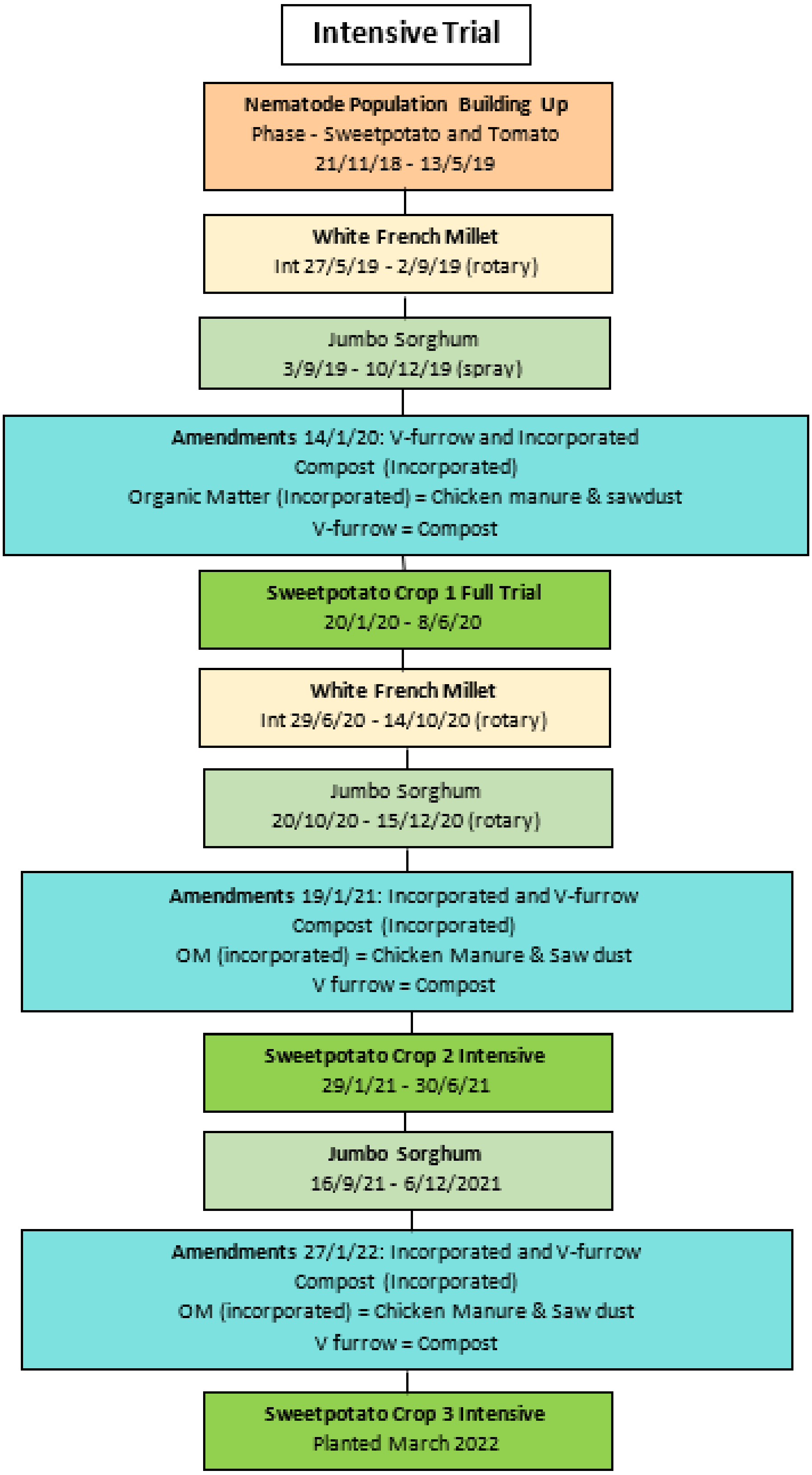


Figure 2. Intensive trial flowchart November 2018 to date.

Extensive Trial

Extensive trial plan

- Three sweetpotato crops (cultivar Beauregard) in 5 years with longer rotation breaks.
- 10 treatments - Combinations of organic amendments vs nematicide (Vydate) vs nil treatment.
- Early bed formation (soon after harvest).
- Amendments incorporated at early bed formation.
- 2 rotation crop treatments – Grass Brassica and Grass legume.
- Rotations sprayed out or cut/mulched.
- Amendments in a V-shaped furrow.
- 40 plots (10 treatments X 4 reps).

Table 2 Treatments in the extensive trial

Treatment No	Extensive - 10 treatments x 4 reps
1	Grass/brassica + Nematicide (Vydate)
2	Grass/brassica + Nil
3	Grass/brassica + V furrow amendment
4	Grass/brassica + Incorporated amendment
5	Grass/brassica + Double amendment
6	Grass/legume + Nematicide (Vydate)
7	Grass/legume + Nil
8	Grass/legume + V furrow amendment
9	Grass/legume + Incorporated amendment
10	Grass/legume + Double amendment

The Extensive trial aims to evaluate the efficacy of an unconventional sweetpotato farming system that combines low tillage, resistant cover crops and organic amendments to reduce plant parasitic nematode populations and enhance soil health. This trial is based around the novel concept of semi-permanent beds. These are GPS tracked and formed soon after harvest. RKN resistant cover crop rotations, either grass/brassica or grass/legume are then grown on top of the preformed beds for several months. A range of organic amendments are applied at bed formation and/or prior to planting. Sweetpotato cuttings are then planted directly into the earlier formed beds.

To prepare for the next commercial sweetpotato planting, the existing cover crop of Swan oats was sprayed out in September 2021. Any remaining plants were then slashed with a flail mower down to a height of 10-15cm taking care not to make contact with the preformed beds. The beds were last formed after the first sweetpotato harvest in June 2020. A sugarcane mulch and compost blend was incorporated at this time in the incorporated and double treatments.

By September 2021, the preformed beds had been in place for 15 months and had hosted four cover crops. This meant that the beds were also exposed to environmental effects causing some soil to wash off the beds and down into the furrows. In some places bed height dropped as low as 20cm. Traditionally beds are formed just prior to planting, however, the use of the low till, semi-permanent, preformed beds required a no/low till approach prior to planting in 2021. To re-form the beds rainmakers or ducks feet were used to bring the soil from the furrows back onto the hills and a lilliston cultivator was used to reform the bed exterior. A double disc opener was then used to achieve a v-furrow 15cm in depth through the 16 plots that required v-furrows (V-furrow and Double Amendment treatments) so that the amendments of sawdust and chicken manure could be added. The second commercial crop, (cultivar Beauregard) was then planted on the 23rd of September 2021. The Extensive Trial is due to be harvested and assessed in early March 2022.

Table 3 Amendments in the extensive trial

Treatment	Date applied	Amendment
Double Amendment	29/06/2020	Incorporated: Sugar cane mulch 28kg per row Compost 28kg per row
	14/09/2021	V-furrow: Chicken manure @ 22.4kg per row Sawdust @ 33.6kg per row
V-furrow	14/09/2021	Chicken manure @ 22.4kg per row Sawdust @ 33.6kg per row
Incorporated	29/06/2020	Sugar cane mulch 28kg per row Compost 28kg per row
Nematicide	29/09/2021	Trickle: Vydate @ 151.2ml per 8 rows Followed by 4 x fortnightly applications of Vydate @ 17ml per 8 rows
Nil	-	No treatment

Figure 3. Swan oats in the Extensive trial at BRF, August 2021.

Figure 4. Left, slashing the Swan oats in preparation for planting. Right, planting into the oat stubble, BRF, September 2021.

Figure 5. Scuffling to control weeds control and ensure integrity of hills post planting in the Extensive trial, BRF, October 2021. Note: oats trash still present on hills.

Figure 6. Commercial sweetpotato crop in the Extensive trial block at BRF, January 2022.

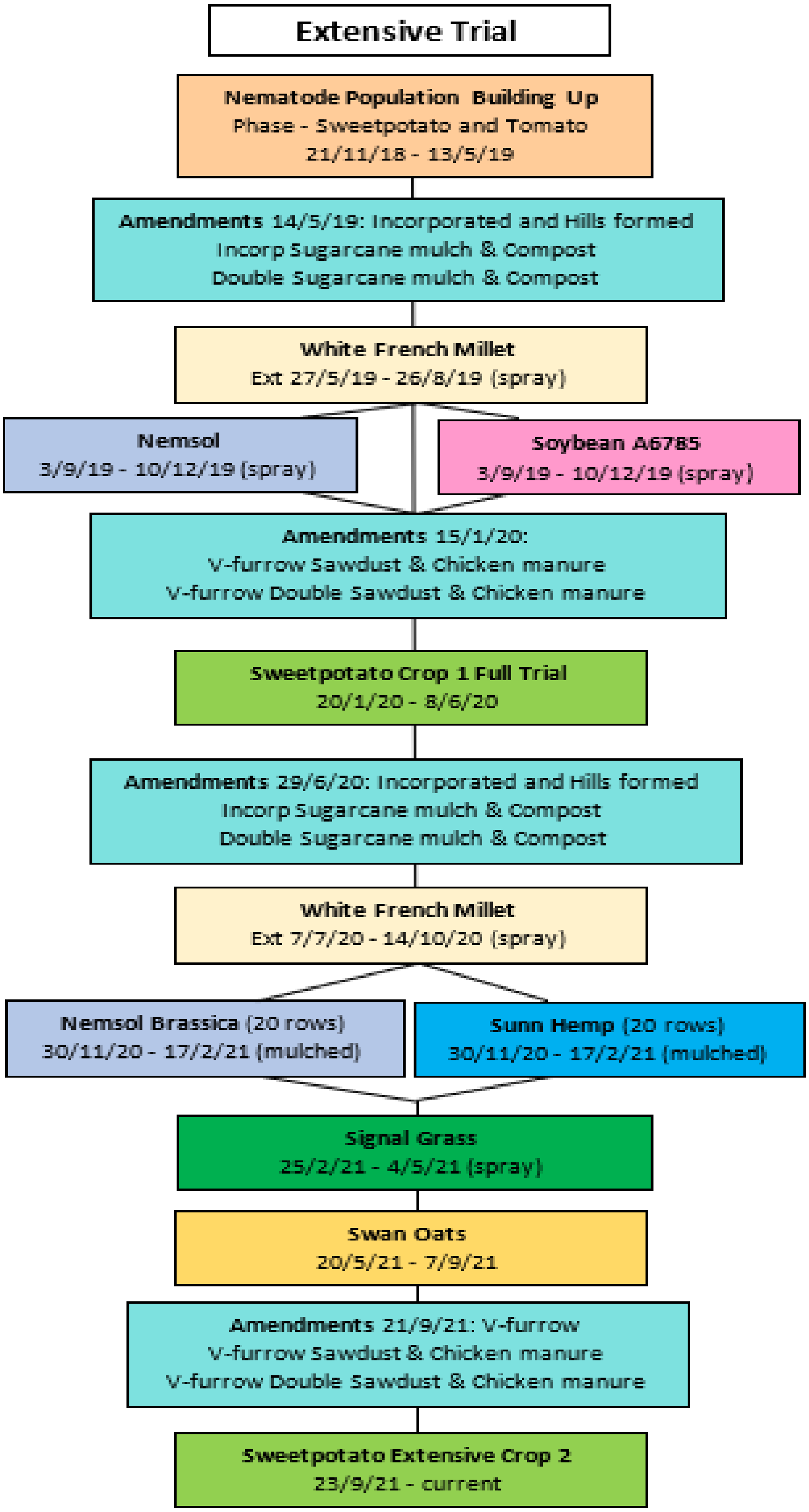


Figure 7. Extensive trial flowchart November 2018 to date.

Monitoring in the long-term trial blocks

There are two main reasons for regular monitoring tin the long-term trial blocks. Firstly, regular soil and leaf tissue samples are collected to monitor nutrient levels to allow for implementation of best practice protocols to ensure optimal growth of commercial sweetpotato crops and cover crops. Secondly, soil samples are collected at critical points in the trials, such as pre plant, pre harvest, post-harvest and pre and post rotation crop series. Analysis of these samples helps us to understand what effects that the varying farming systems and organic matter treatments may have on RKN control and soil health. From these samples we can determine, the populations of RKN, free living nematodes, microarthropods and NTF within the plots as well as chemical parameters such as carbon and nitrogen and in what form they are present.

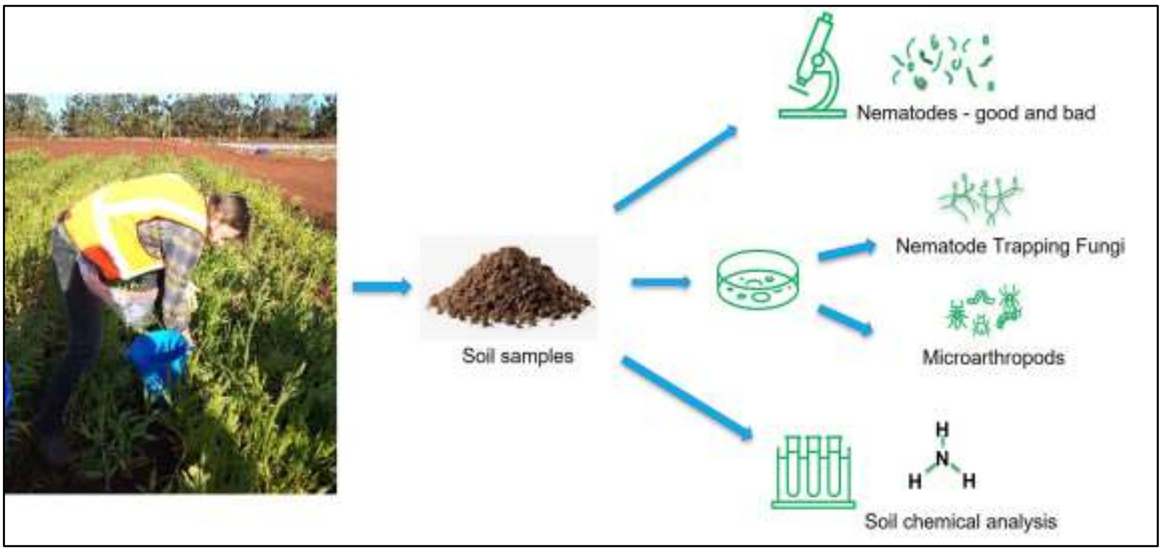


Figure 8. Soil collected from trial plots is split 4 ways; To determine RKN, free living nematode, NTF and microarthropod populations and chemical composition.

Nematode analysis from Bundaberg long term trial

This information was provided under the previous milestone (107). Pre plant and pre harvest samples were collected form the Extensive trial in September 2021 and February 2022 and the Intensive trial in January 2022. These will be analysed and compared to the respective harvest data in the coming months.

Appendix 3

Soil analysis in the long-term trials

Soil analysis - Extensive Trial

Soil samples taken from each plot in the Extensive trial, prior to the addition of amendments and planting of the second sweetpotato crop, were sent to the Department of Environment and Science, Chemistry Centre, for the same suite of analyses as previously tested.
As treatments in the trial were a combination treatment of cover crop type (either Legume or Brassica) with amendments (Incorporated, V furrow, Double Amendment, Nematicide or Nil) the data was analysed as 10 separate treatments.

Carbon

Total Organic Carbon (TOC) levels declined in both Double amendment treatments during the period from July 2020 to September 2021. This decline was also seen in the V furrow treatments. During this period, multiple field operations were completed. TOC levels improved in the Incorporated treatments. As expected, TOC % remained unchanged in the Nematicide and Nil treatments.

Table 1 Change in TOC in the Extensive Trial over a 26-month period

Change over time in Organic Carbon %					
Cover Crop	Treatment	July 2019	January 2020	July 2020	September 2021
Grass/Brassica	Double amendment	1.97	2.15	2.61	2.12
	Incorporated amendment	2.23	2.04	1.88	2.06
	Nematicide	1.66	1.66	1.59	1.56
	Nil	1.65	1.7	1.62	1.64
	V furrow amendment	1.64	1.68	2.00	1.73
Grass/Legume	Double amendment	2.12	1.96	2.55	2.21
	Incorporated amendment	2.29	2.01	1.88	2.07
	Nematicide	1.62	1.66	1.61	1.64
	Nil	1.64	1.67	1.63	1.65
	V furrow amendment	1.61	1.68	2.39	1.74

Testing for Potassium Permanganate Oxidisable Carbon (PPOC) can give an indication of 'active carbon' in the soil. The results of PPOC show that the double amendment treatments have a higher proportion of C in this active fraction. Results cannot be compared to earlier samplings as a change in PPOC methodology has recently occurred.

Table 2: TOC and PPOC Treatment Means

Extensive Trial sampled in September 2021		Treatment Mean %	Treatment Mean %
Cover crop	Treatment	TOC %	PPOC %
Grass/brassica	Double amendment	2.12	2.06
Grass/brassica	Incorporated amendment	2.06	1.97
Grass/brassica	Nematicide	1.56	1.25
Grass/brassica	Nil	1.64	1.27
Grass/brassica	V furrow amendment	1.73	1.44
Grass/legume	Double amendment	2.21	2.19
Grass/legume	Incorporated amendment	2.07	1.95
Grass/legume	Nematicide	1.64	1.27
Grass/legume	Nil	1.65	1.31
Grass/legume	V furrow amendment	1.74	1.48

Nitrate-Nitrogen

Total Nitrogen has declined in both Double amendment treatments during the period from July 2020 to September 2021. This decline was also seen in the V furrow treatments. TOC levels improved in the Incorporated treatments. As expected, TOC % remained relatively unchanged in the Nematicide and Nil treatments.

Table 3: Total Nitrogen % over a 26-month period

Total Nitrogen (mg/kg)					
Cover crop	Treatment	July 2019	January 2020	July 2020	September 2021
Grass/Brassica	Double amendment	1980	2100	2175	1925
	Incorporated amendment	2210	2000	1825	1900
	Nematicide	1640	1600	1525	1525
	Nil	1620	1600	1550	1525
	V furrow amendment	1600	1600	1825	1625
Grass/Legume	Double amendment	2050	1900	2100	2000
	Incorporated amendment	2110	2000	1775	1900
	Nematicide	1610	1600	1525	1500
	Nil	1580	1600	1550	1550
	V furrow amendment	1590	1600	1925	1675

The results of the Nitrate-Nitrogen analysis demonstrate increased levels from the use of a legume cover crop.

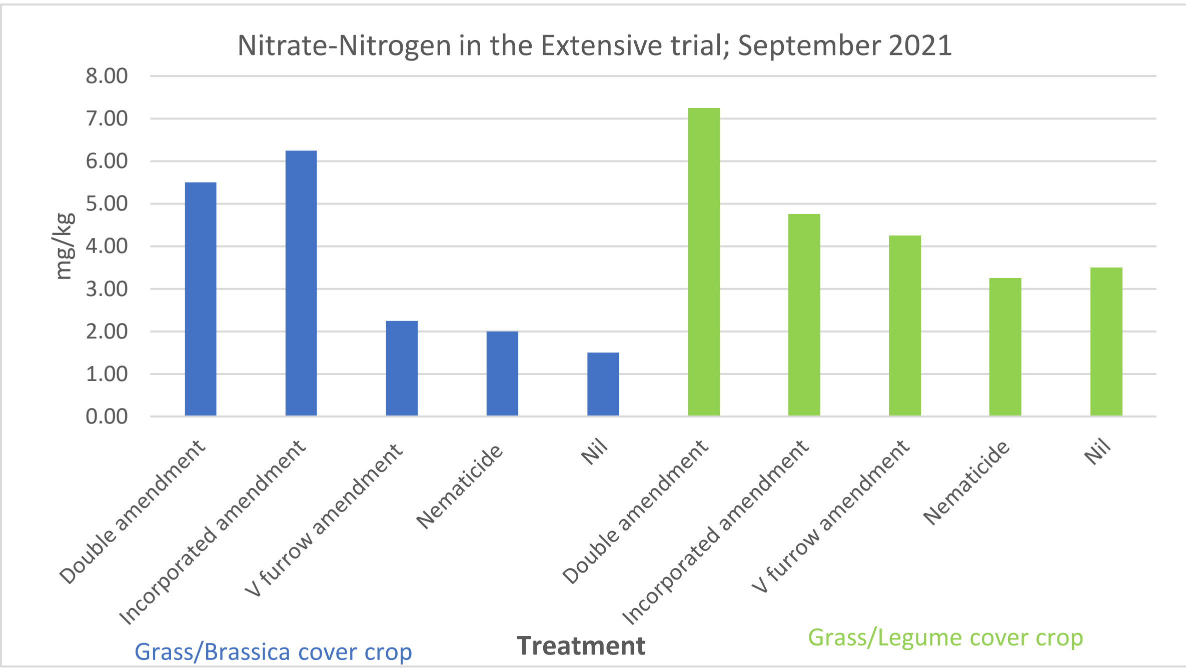


Figure 1. A snapshot of Nitrate Nitrogen levels from the different cover crops in the extensive trial September 2021.

Soil analysis - Intensive Trial

Soil samples taken from each plot in the Intensive trial, just prior to harvest of the second sweetpotato crop, were sent to the Department of Environment and Science, Chemistry Centre, for the same suite of analyses as previously tested.

Carbon

At the July 2021 sampling, Total Organic Carbon (TOC) levels were higher in the Organic Matter treatment and have steadily increased since the initial sampling in July 2020. TOC levels in the Compost treatments have remained relatively unchanged while those in the V furrow amendments have fluctuated during the sampling interval.
Treatments where no amendments were made (Nimitz and Nil treatments) have shown no increase in Carbon.

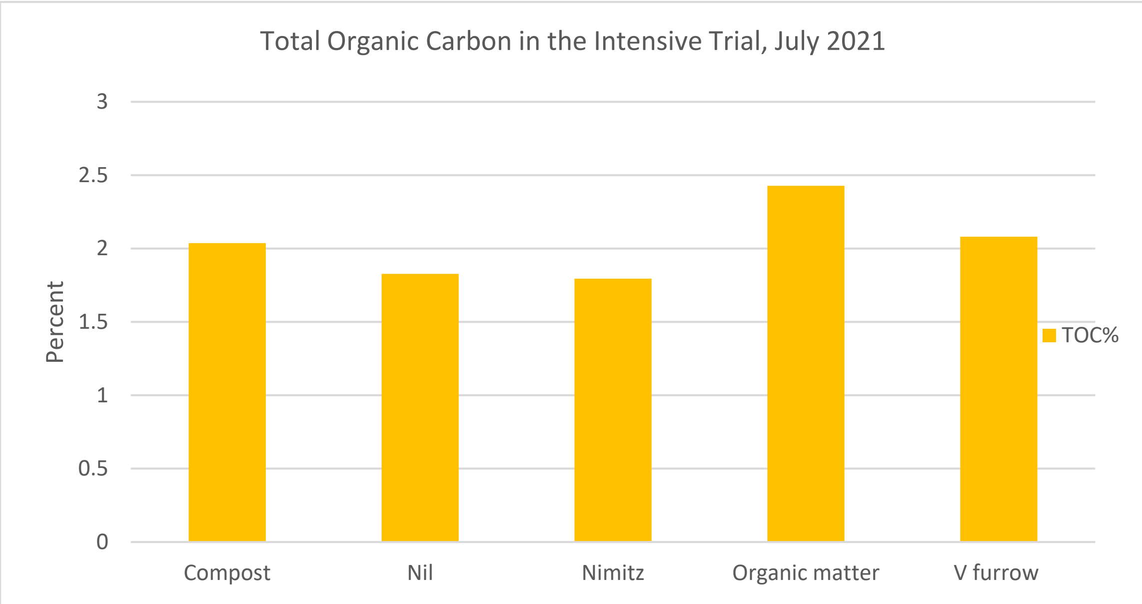


Figure 2. TOC levels in the Intensive Trial in July 2021.

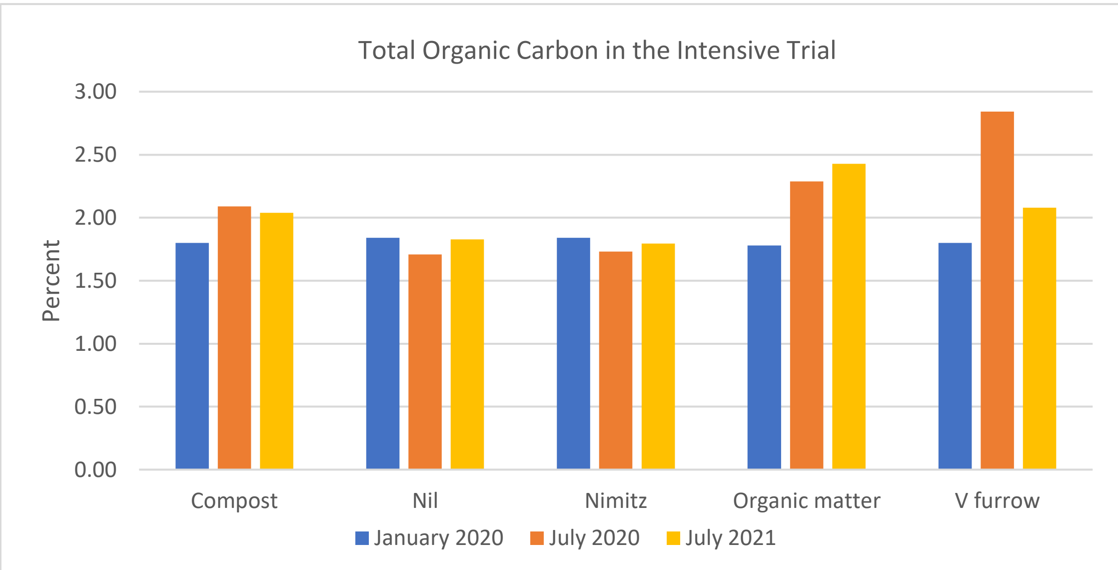


Figure 3 Change in TOC levels over time.

Nitrate-Nitrogen

Nitrate-Nitrogen (NO3-N) has increased in all treatments since the last sampling in July 2020 and has been greatest in the Organic Matter treatment. As the Nimitz and Nil treatments have also had increases in these levels, this may be due to the addition of synthetic fertilisers added to all plots, as per grower practice, during sweetpotato crop two. Individual plot data show marked variation within the treatment for Nimitz (5 – 24 mg/kg), Organic Matter (8-27mg/kg) and V furrow (4-28mg/kg) amendments. Data for the other analytes doesn't show this variability but as the NO3-N data is skewed, results from this sampling may be ignored when making final recommendations for the project.

The initial pre-trial soil tests returned a NO3-N result of <1 mg/kg across all treatments.

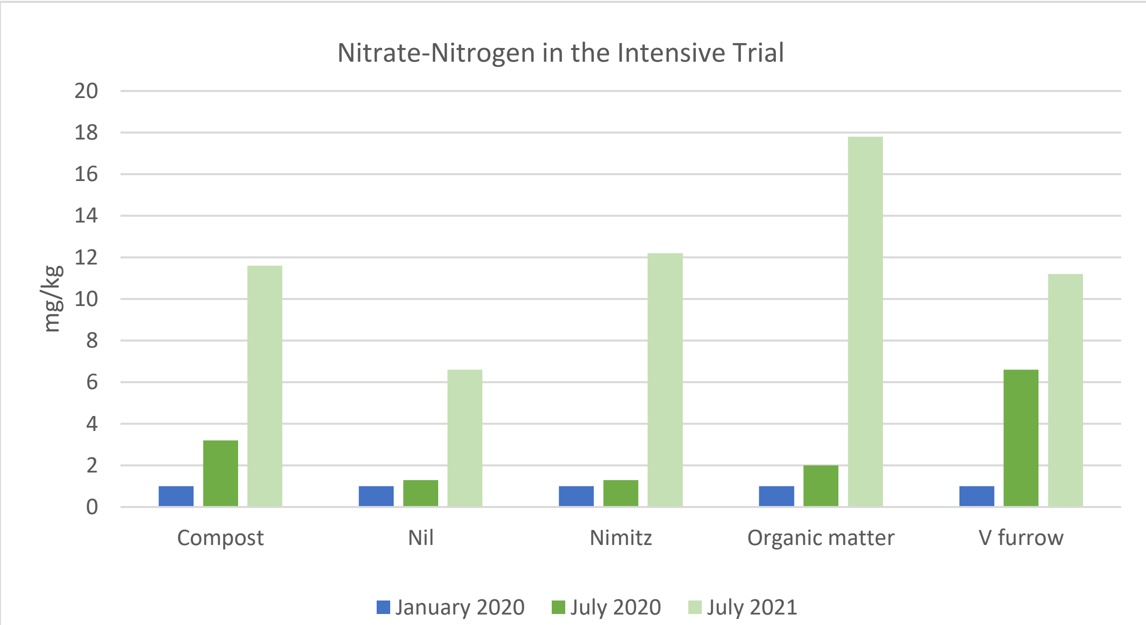


Figure 4.Change in N-NO3 levels over time.

We are currently awaiting results from DES on the last round of sampling in February 2022.

Appendix 4

Microarthropods and NTF in the long-term trials

Sampling method

The Tullgren Funnel method was used to extract microarthropods form the soil samples. Soil (120grams) was placed in a funnel attached to a collection bottle containing 70% alcohol. Microarthropods were forced through the funnel by heat produced from light tubes and trapped in the collection tube. Four replications are used for each treatment. To determine the presence of Nematode Trapping Fungi, soil is plated on agar and incubated for two to four weeks to allow for fungal growth. Two parameters were observed, the presence of conidia and the presence of traps (actual trapping of nematodes).

Extensive Trial

Microarthropod and NTF assessments were conducted for the Extensive trial of the Bundaberg long term trial on the 14th of September 2021. This trial, harvested in 2020, had amendments (sugarcane mulch & compost) incorporated into the soil and planted with a cover crop of French Millet for three months, sprayed out with Glyphosate and then planted with either a Brassica cover crop of Nemsol, or the Legume, Sunn Hemp for three months. These cover crops were then used to mulch the rows. Signal grass was then planted as cover crop for 3 months followed by Swan oats for three months before being sprayed out again. Soil samples were taken at this point before the next crop of sweetpotatoes was planted.

Under the Brassica cover crop system, the microarthropod count and presence of traps and conidia were highest in the incorporated amendment' (Figure 1). However, microarthropod numbers and percentage of trapping and conidia presence was highest in the Grass / Legume rotation with double amendment (i.e. incorporated amendment + V furrow) followed by Grass/Legume cover crop with incorporated amendments.

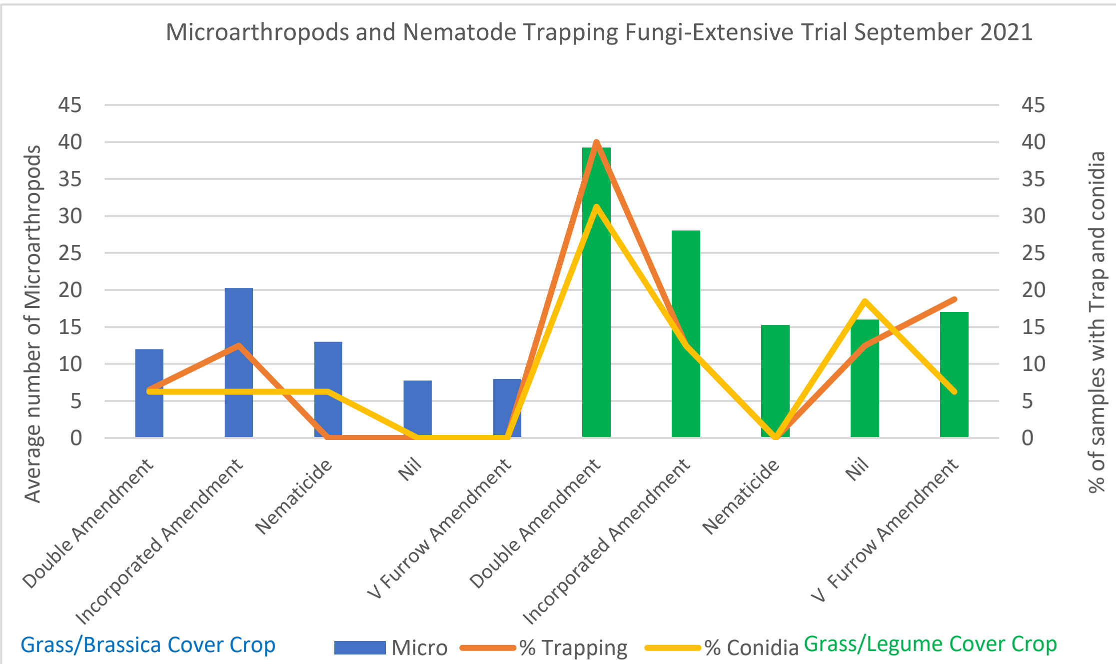


Figure 1. Microarthropod and Nematode Trapping Fungi in Extensive Trial September 2021.

Intensive Trial

After the first harvest in June 2020, the intensive trial was planted with a cover crop of French Millet for four months which was rotary hoed and followed with a cover crop of Jumbo Sorghum for two months, also rotary hoed into the field. Amendments (Compost, Organic Matter) were then applied prior to planting the next sweetpotato crop. After harvest in June 2021, Jumbo sorghum was planted. This block has since been planted with the third commercial sweetpotato crop. Soil samples were collected prior to planting in January 2022 for microarthropod and NTF monitoring.

In Figure 2, the microarthropod counts were highest in the organic matter and compost treatments. Trapping incidence was also highest in the organic matter, V furrow and nematicide treatments. but only for organic matter. The V furrow treatment also recorded highest percentage of conidia. In the nematicide treatment, microarthropod count was low. However, there was presence of conidia and high percentage of trapping.

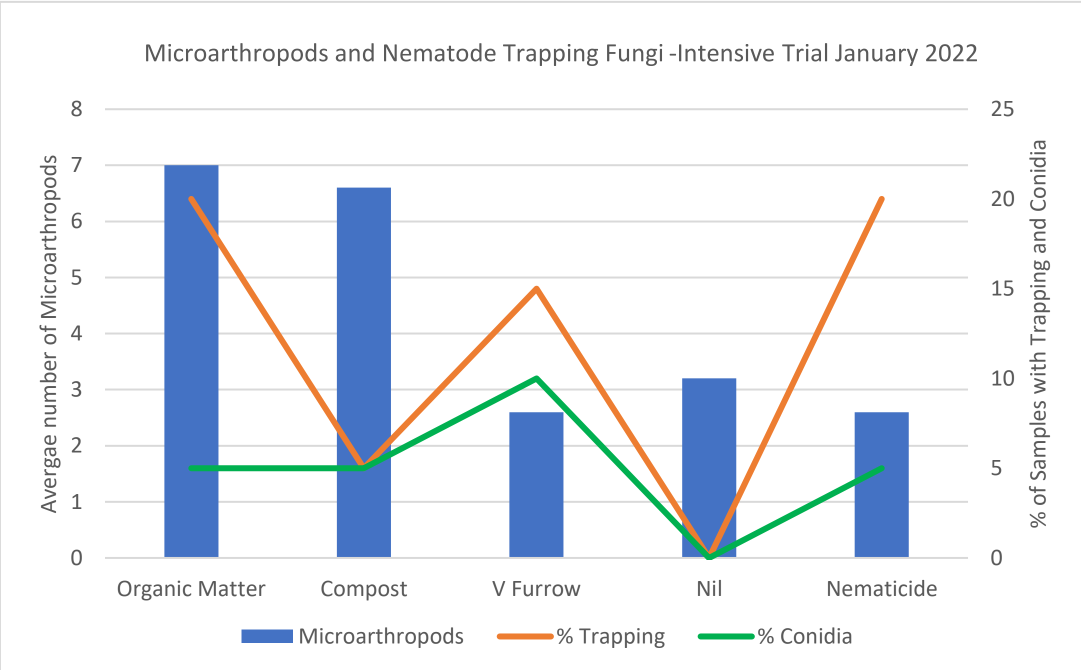


Figure 2. *Microarthropod and Nematode Trapping Fungi in Intensive Trial January 2022.*

Appendix 5

Intensive trial harvest results

The second Intensive trial 2021 harvest in June 2021, produced a total 6472 sweetpotatoes and a total of 2069kg from 250 metres of datum area. This is roughly the equivalent of 8.28kg per metre. Prior to harvest, the 2m buffer zones were hand dug and roots were removed from the field. All datum plots were then mechanically harvested and roots were then transported to GRF in half ton bins for washing and detailed assessment.
Unfortunately, Covid-19 lockdowns prevented project staff travelling form Bundaberg, Mareeba and ESP so local GRF staff from precision Ag and Entomology generously offer their time to assist and get the job done. Roots were washed in a chlorine solution using a standard butternut pumpkin washer.

Over the duration of 9 days, the 6472 sweetpotato roots were individually weighed and assessed into eight size categories; extra small, small, small medium, medium, medium large, large, jumbo and three marketability grades, first or premium grade, second grade and non-marketable. A categorisation system was designed to capture 18 common defects found in commercial sweetpotato production. As the range and types of skin lesions than may or may not be attributed to nematode infection either directly or indirectly is unknown, all defects were recorded. Each root underwent close visual scrutiny and was evaluated using this system.

Figure 1. Local GRF staff assisted GRF project team members to compete the assessment in June 2021.

Yield data

Sweetpotato harvest weights shown in Figure 2 illustrate the mean number of roots per treatment both marketable and non-marketable. The nematicide treatment had the highest number of roots overall (276) and the highest number of marketable roots (179), while the V-furrow treatments averaged 94 marketable roots. The nematicide, nil and Compost treated plots all had more marketable sweetpotato roots than non-marketable roots.

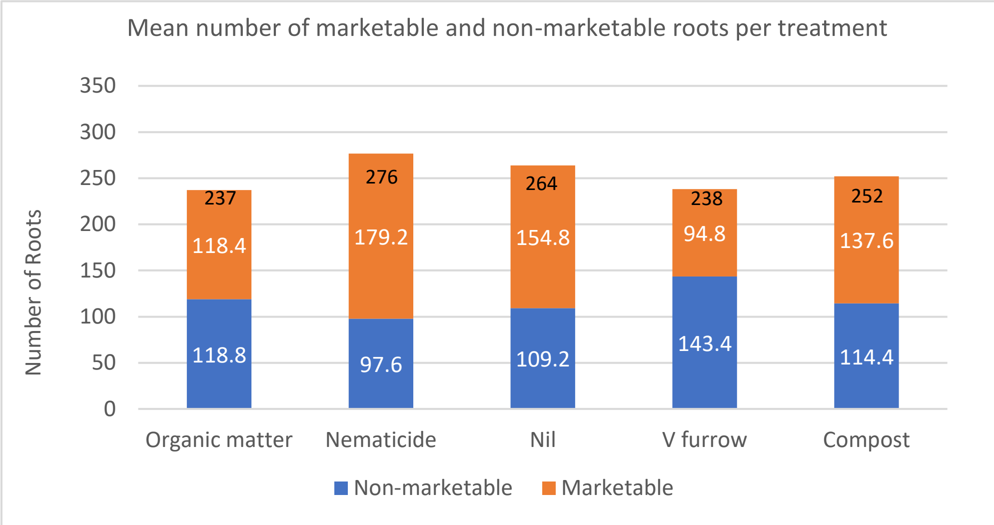


Figure 2. Intensive trial 2021, mean number of roots.

The mean total weight per plot in Figure 4 shows that the Organic Matter treatment had the largest mean weight of roots per plot but had the largest weight of non-marketable sweetpotato at 50.9kg. Nematicide had the largest marketable weight with 49.4kg. V-furrow had the smallest weight of marketable sweetpotato at 24.8kg. Compost had the smallest overall mean total weight of roots per plot.

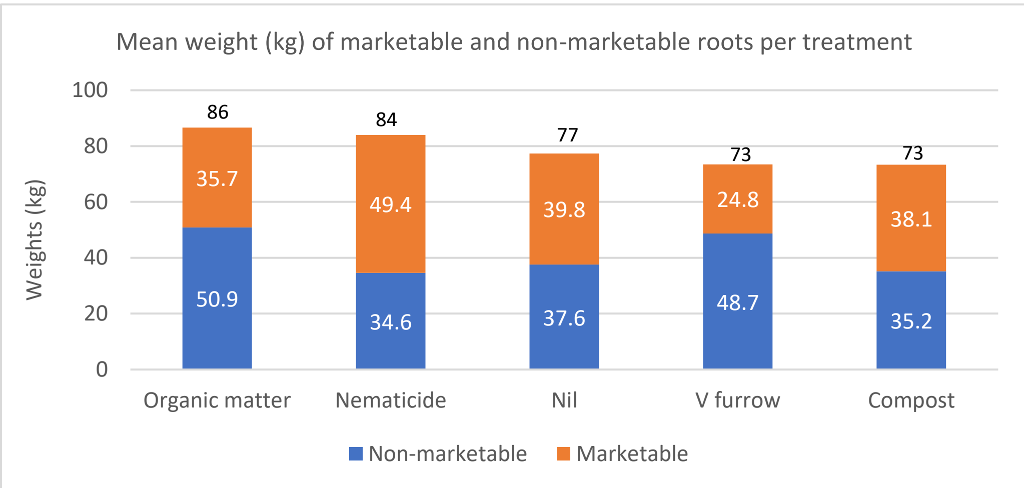


Figure 3 Intensive trial 2021, mean weight of roots.

Lesion data

Sweetpotato weevil were a problem initially with weekly pheromone traps collecting in excess of 200 weevils, despite regular chemical applications. Upon investigation, it was discovered that the spray equipment at Bundaberg Research Facility did not provide adequate coverage required for weevil control. Weekly weevil numbers in pheromone traps subsequently dropped to < 10 weevils. The organic matter treatment showed significantly more damage by wireworm than the other treatments. The nematicide treatment showed significantly less wireworm damage, although this was not significantly different to the nil treatments. The Nil, V furrow and compost treatments were all similar. Wireworms are known to feed on live vegetative material and decomposing plant material, with some debate on whether they feed on soil organic matter or not (McCrystal 2010, Barsics et al. 2013, Traugott et al. 2015). The incidence of wireworm damage in sweetpotato roots in the organic matter treatment needs to be monitored throughout the trial, to provide more conclusive evidence.

Barsics F., Haubruge E. and Verheggen F.J. (2013) Wireworms' management: an overview of the existing methods, with particular regards to Agriotes spp. (Coleoptera: Elateridae). Insects 4 (1), 117-152

McCrystal R. (2010) Improving the management of sweetpotato soil insects. Final Report, HAL Project VG05037. Horticulture Australia Ltd: Australia.

M., Benefer C.M., Blackshaw R.P., van Herk W.G. and Vernon R.S. (2015) Biology, Ecology and Control of Elaterid Beetles in Agricultural Land. Annual Review of Entomology. 60, 313-34

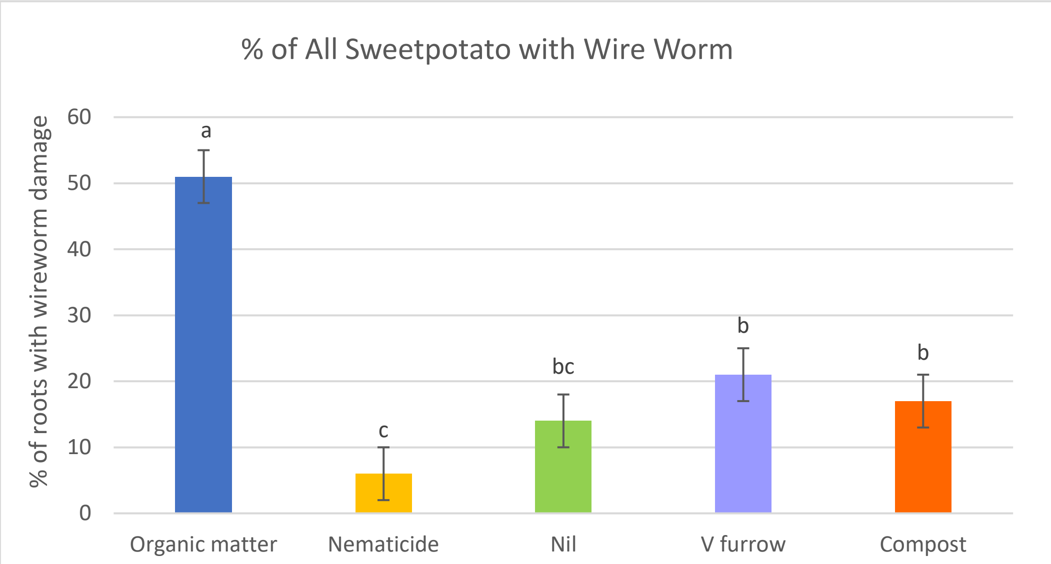


Figure 4 Intensive trial 2021, per cent of wireworm.

Traugott

There was a significantly higher incidence of blind pimples in the nil treatments. Blind pimples are documented globally to be direct result of RKN infection The incidence of blind pimples did not differ significantly within the remaining treatments, however the organic matter and Compost plots had a higher incidence of pimples.

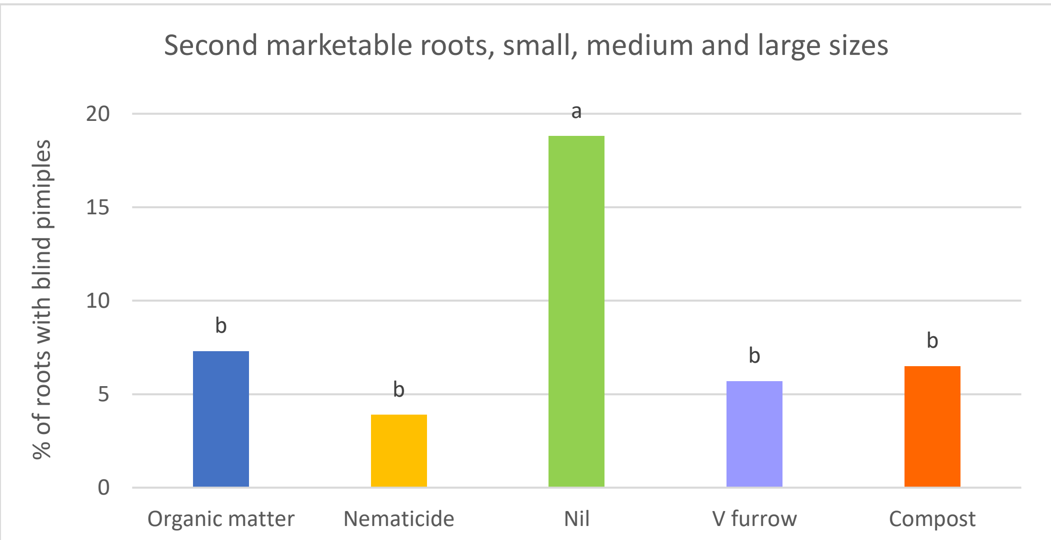


Figure 5 Intensive trial 2021, per cent of blind pimples.