Nematicide efficacy

Appendix 21 Final report PW17001 Integrated pest management of nematodes in sweetpotato

Brett Day, Rachael Langenbaker, Wayne O'Neill and Sandra Dennien

DAF project team:
Sweetpotato Research - Sandra Dennien, Mary Firrell, Rachael Langenbaker, Michael Hughes, Jean Bobby and Brett Day.
Nematology - Jennifer Cobon, Wayne O'Neill and Tim Shuey.

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Summary

The sweetpotato industry has limited nematicides and fumigants available for nematode control. In response to industry priorities, two trials were designed to evaluate the efficacy of currently registered nematicides for RKN control over the long winter growing period.

Trial one was conducted a sandy loam due to low nematode numbers at this site, a susceptible mung bean crop was grown prior to the trial to build numbers. Efficacy was assessed by monitoring nematode populations and crop yield and quality assessments at commercial harvest. The trial was planted to sweetpotato cultivar Orleans on 24th May 2021 in collaboration with Mitchel Feint of AgPD. The crop was grown to commercial crop standards with trial site maintenance conducted throughout the growth of the crop. The trial design was a randomised block with six replicates with five treatments: Nimitz (incorporated spray), Vydate, Metham Sodium, a Nimitz alternative application method and a nil control treatment. All nematicides were applied at recommended label rates and timing. The trial was harvested in January 2022, 231 days after planting.

All nematicide treatments had significantly higher marketable yield than the nil treatment. Metham Sodium and Vydate also had significantly higher total yield than other treatments. There were also significant differences for certain defects that can be associated with nematode damage. For example, all nematicide treatments also had significantly less barnacle lesions than the nil control. In the medium size category, all nematicide treatments also had significantly less blind pimple lesions compared with the nil treatment.

The nematicide trial was sampled to assess plant-parasitic nematode numbers in May, June, August, October, and at harvest in January. Findings are based on mean nematode counts for each treatment.

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 despite the large differences in mean counts, the results for root-knot nematode were not significantly different as there was high variation between replicates. Vydate had the lowest numbers of total plant parasitic nematodes (spiral and reniform nematodes were the other abundant plant-parasitic nematodes).

Mean count of microarthropods increased significantly over time, with the last two assessments having significantly higher mean counts. Decline of microarthropods on 29-Jun-21 may be attributed to nematicide application. Nematicides, pesticides and fertilizers, have proven to reduce microarthropods population and or the soil microbiological community (Winter et al 1990, Seymour 2006, Stirling 2016).

The site where this trial was located has a sandy loam soil which can be more conducive to rapid build-up of RKN populations than some other soil types. Despite this limitation, some of the nematicides seem to have given sufficient protection in the crucial early stages of the crop to allow increased yield and reduced defects, despite RKN rapidly increasing to high levels by the end of the trial.

Trial 2 was conducted at the Bundaberg Research facility on red soil. This trial included a bare fallow and alternative application methods of Nimitz and Salibro. The ran from autumn 2022 to spring 2023.To increase the RKN population, susceptible cover crop species and inoculated tomato plants cv. Tiny Tim were planted across the trial block in autumn and spring of 2022,followed by a crop of RKN susceptible Mung beans and Lab Lab in December 2022. The trial was planted in March 2023 to cultivar Beauregard and designed as a randomised complete block with eight treatments and six replicates. Soil samples were collected to assess plant-parasitic and free-living nematode numbers in March, May, August, and at harvest in October 2023.Roots were dug on the 30th of October at 238 DAP.

Outcomes

Trial 1

- All nematicide treatments had significantly higher marketable yield than nil.
- Metham sodium and Vydate had significantly higher total yield.
- Metham treatment had a rapid effect on plat-parasitic nematodes.
- Microarthropod count increased overtime.

Trial 2

- Vydate and Metham treated plots tended to produce a higher weight of total and medium sized roots and a higher number of roots.
- Nematode ….
- No treatment effect on microarthropods.

Nematicide Trial 1 - Sandy Soil

Introduction

Root-knot nematode (RKN) management is an integral step for sweetpotato growers as they pose a significant threat to the Australian sweetpotato industry. The damage that RKN are able to inflict on sweetpotato crops can result in high yield losses, with estimations that it costs the industry $20 m per year (ASPG per.com). Faced with the prospect of severe losses if left untreated, growers require effective and reliable products to treat RKN if pre-plant levels indicate losses are likely. The aim of this trial was to investigate the effects of currently registered commercial nematicides (Metham, Vydate and Nimitz) on RKN populations in a winter sweetpotato crop to gauge their efficacy.

Method

Due to long running drought conditions over most sweetpotato cropping areas during 2019 and 2020 this activity had to be deferred to 2021. This decision was not only based on the fact that there was a lack of available water but also an associated 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 contracted to chemical companies were in the same situation.

A suitable site with a mung bean crop in a sandy loam soil, conducive to rapid build-up of RKN populations was identified in January 2021, however sampling indicated very low nematode numbers. After a return of rainfall in April, the block was sampled again and numbers had increased, though were still not ideal. Despite this, a decision was made to proceed with the first trial and the Bundaberg site was planted with sweetpotato cultivar Orleans in May 2021.

Image 1 The nematicide trial block in Bundaberg, December 2021

The trial was designed to investigate the efficacy of three currently registered nematicides, Metham sodium, Vydate and Nimitz to control RKN populations in sweetpotato. Routine soil samples were collected to extract RKN and other plant-parasitic species, free living nematodes, microarthropods and nematode trapping fungi (NTF). The trial design was a randomised block with six replicates of five treatments. The treatments were Nimitz (standard spray application), Vydate, Metham, a Nimitz alternative application method and a nil control treatment with no nematicide. All nematicides were applied at recommended label rates and recommended timing.

The trial site was a 19.5 m x 50 m block consisting of 6 datum rows, each bordered by a single buffer row for a total of 13 rows (Figure 1). The plots were 10 m long comprising 8 m of datum and 1m buffer at each end with five plots per lineal row. The total trial area was 0.0974 hectares. The total datum area was 360 m^2, or 0.036 hectares.

The trial was scheduled for harvest in December 2021, but had to be postponed to mid-January 2022 due to wet weather. Unfortunately, the rescheduled harvest date coincided with a spike in COVID-19 infections in QLD. COVID safe work protocols were developed and the required departmental approvals were obtained to conduct this group activity. With movement restrictions around locations with active cases in place, project staff from Mareeba and Ecosciences precinct were unable to attend and assist in the assessment.

The block was top chopped on the 6th of January 2022, and roots from the 1m buffer zones were removed. The sweetpotatoes were given 4 days to harden before harvest on the 10th of January 2022.

Image 2 Top chopping the nematicide trial in Bundaberg, January 2021.

Image 3 Removing the buffer plants by hand.

Harvested roots were washed in a chlorine solution using a standard butternut pumpkin washer and assessed from the 17th – 21st of January. Over 8000 roots were individually weighed and sorted into eight size categories: extra small, small, small medium, medium, medium large, large and jumbo. Roots were then placed into one of three marketability grades, first or premium grade, second grade and non-marketable. Defects were recorded using the categorisation system developed for the Intensive and Extensive trials designed to capture 18 common defects found in commercial sweetpotato production. Each root underwent close visual scrutiny and was evaluated using this system.

Image 4 Roots from the nematicide trial undergoing assessment, January 2022.

Image 5 Covid safe protocols were followed by the assessment team in 2022.

Results - Nematode population monitoring

The nematicide trial was sampled to assess plant-parasitic nematode numbers in May, June, August, October, and at harvest in January. Findings are based on mean nematode counts for each treatment.

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 despite the large differences in mean counts, the results for root-knot nematode were not significantly different as there was high variation between replicates. Vydate had the lowest numbers of total plant parasitic nematodes (spiral and reniform nematodes were the other abundant plant-parasitic nematodes).

Table 1. October 2021 and January 2022, Mean Nematode Counts/200g Dry Soil.

	RKN		Total Plant Parasitic nematodes	
Treatment	October 2021	January 2022	October 2021	January 2022
Nil	2287	1914	2943	3828
Metham	512	1910	902	2342
Vydate	118	3798	174	4358
Nimitz	25	1953	762	2884
Nimitz trickle	532	1746	903	3328

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 parasitic nematode counts, although the reasons for this are unclear. 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 to control this species.

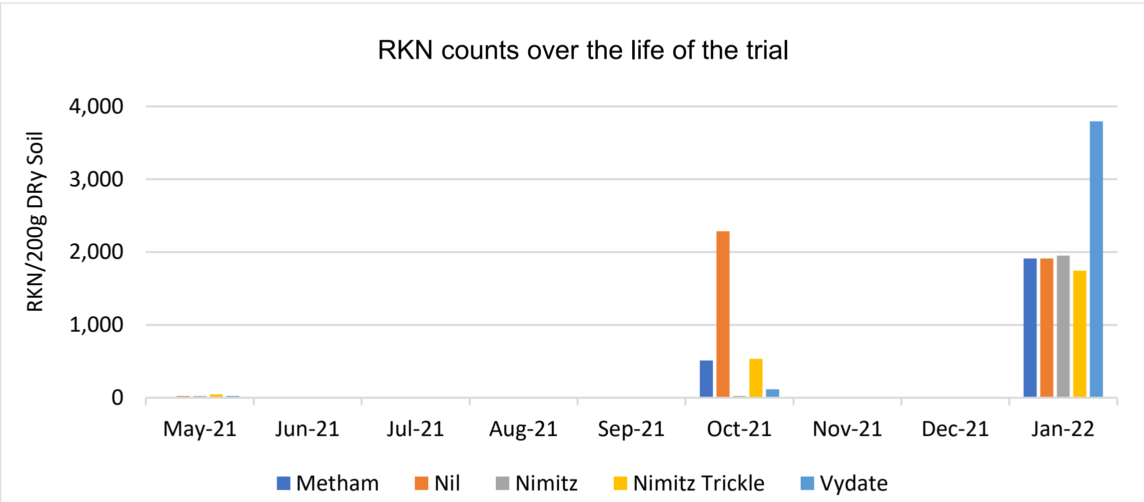

Figure 1 RKN counts over the life of the trial.

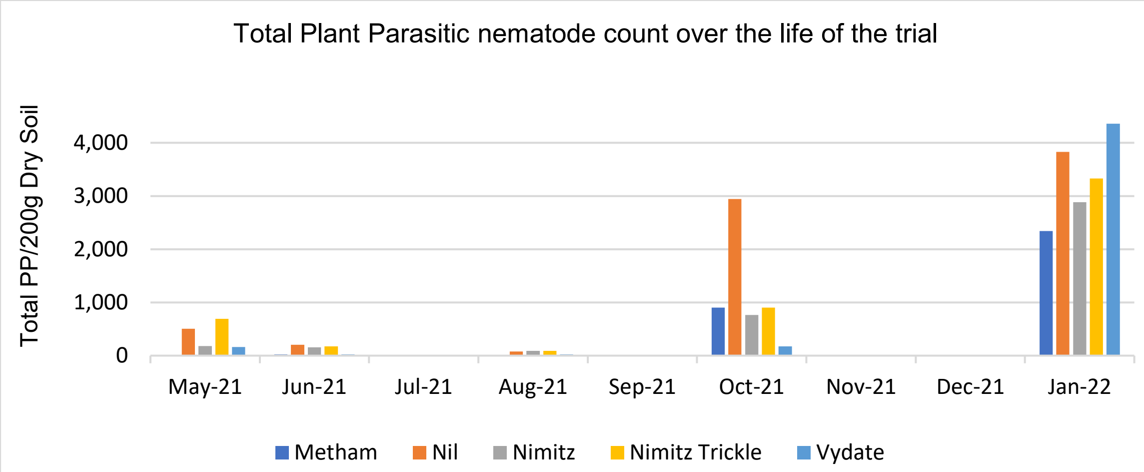

Figure 2 Total Plant Parasitic nematode counts over the life of the trial.

Results - Nematode trapping fungi and microarthropod monitoring

Data was collected on counts of microarthropods and nematode trapping fungi (NTF) and conidia. Data was collected on 5 occasions: 26/5/2021, 29/6/2021, 8/8/2021, 21/10/2021, 6/6/2022. A single count of microarthropods was recorded for each treatment plot, while the presence of NTF was recorded for 4 plates from each plot.

The counts of microarthropods were analysed using both a GLMM (generalised linear mixed model) and an ANOVA (analysis of variance). All significance testing was performed at the 0.05 level and where a significant effect was found, the 95% least significant difference (lsd) was used to make pairwise comparisons.

Microarthropods

Microarthropod data was analysed in several different ways to obtain a complete understanding of the results. Timepoint assessments were analysed together to investigate any temporal effects and then each assessment was analysed separately. A square root transformation was applied to the data prior to ANOVA in the combined assessment analysis to improve the normality assumption.

The results from the combined analysis suggest there is a significant main effect of collection date ($p < 0.001$), but the main effect of treatment was not significant ($p = 0.334$), nor was the interaction of collection date and treatment ($p = 0.893$). This indicates that there was no significant negative effect of any of the nematicide treatments on microarthropod populations in the sweetpotato crop, compared with the untreated control. Mean count of microarthropods increased significantly over time, with the last two assessments having significantly higher mean counts (Table 2).

Table 2 Mean microarthropod counts overtime.

Date collected	Means
26-May-21	0.767b
29-Jun-21	0.383b
08-Aug-21	0.717b
21-Oct-21	1.610a
06-Jan-22	1.703a

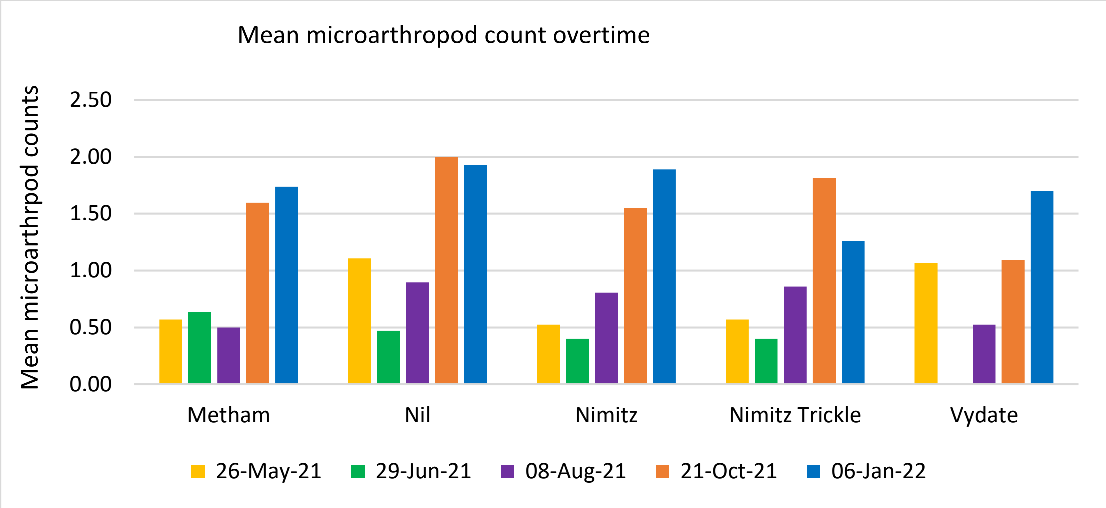

Figure 3. Interaction of collection date and treatment. Mean microarthropod counts increased overtime.

Nematode Trapping Fungi (NTF)

Nematode trapping Fungi (NTF) data was collected from 1gm of soil sample cultured on ¼ strength Corn Meal Agar. Count data was collected on five occasions. A total of 600 plates were assessed for the five occasions of sampling. Only 16 plates out of 600 had nematode trapping fungi present: 3 Vydate, 3 Metham, 4 Nimitz, 2 Nil and 4 Nimitz trickle. No conidia were recorded on any plate therefore this data has not been analysed.

Results – Sweetpotato yield and quality.

Data was analysed using Genstat statistical software package (19th edition). Linear mixed models (REML) were used to analyse continuous variables (root diameter, root length and total root weight), whilst generalised linear mixed models (GLMM) were used to analyse count variables (total number of nodes and total number of roots). Treatment means and differences between varieties were deemed significant at the 0.05 level. Pairwise comparisons were performed using the 95% least significant difference (LSD) on significant effects.

A $\log_{10}$ transformation was required to improve the homogeneity of variance assumption. The two-way interactions of Treatment and Size ($p = 0.024$) and Size and Marketability ($p < 0.001$) were significant.

Treatment had no effect on the mean root weight for the small and medium sized roots. For the large roots, the mean root weight was significantly higher for the Metham and Nimitz trickle treatments compared to the Vydate and Nil treatments.

There was no significant difference between the mean root weight for the marketable and non-marketable within the small and medium classes, but the non-marketable large roots were significantly heavier than the marketable large roots.

Table 3 Back transformed means for root weight for all treatments.

Treatment	BT Means
Metham	371.5
Nil	358.4
Nimitz	363.8
Nimitz Trickle	365.8
Vydate	363.7

Blind pimples are thought to be associated with nematode infection. The mean percentage of Blind pimples in each treatment is shown in figure 3, below. The Nil treatment had significantly higher mean percentage of blind pimples in large and medium sized roots than Metham, Nimitz trickle and Vydate but was not significantly different to Nimitz.

Although nematicidal effects had broken down by end of trial, nematicides appear to have given sufficient protection during the growth of the crop to allow increased marketable yield and reduction of some defects associated with nematode infection.

For example, all nematicide treatments also had significantly less barnacle lesions than the nil control. In the medium size category,

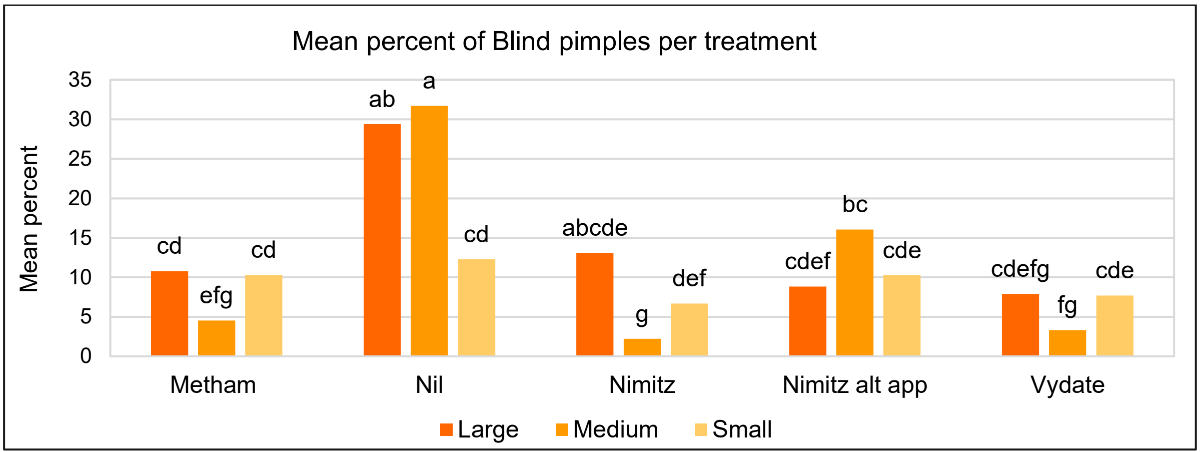

Figure 4 Mean percent of Blind pimples per treatment.

Nematicide Trial 2 – Red Soil

Introduction

Nematicide Trial 2 was conducted at Bundaberg Research facility on red soil. The aim was to investigate efficacy of currently available nematicides including alternative application methods of Nimitz and Salibro to control RKN in red soil. The trial ran from autumn 2022 to spring 2023.

Method

A Suitable site was selected at the Bundaberg Research facility. However, to increase the RKN population, the trial site was planted with a mixture of RKN susceptible cover crop species (Crimson Clover, Japanese Millet, Buckwheat Millet, Harpoon Barley, Chickpea and Jade Mung Bean) on May 10, 2022 before the trial. Species were chosen based on their suitability to the growing season, availability and susceptibility to RKN (Table 4).

Table 4. Cover Crop RKN Susceptibility.

Cover Crop	Root-k not Nematode Susceptibility	
	M. incognita	M. javanica
Buckwheat Millet	Moderately susceptible	Highly susceptible
Japanese Millet	Moderately susceptible	Moderately susceptible
Chickpea	Susceptible	Susceptible
Crimson Clover	Highly Susceptible	Highly Susceptible
Mung Bean	Susceptible	Susceptible
Harpoon Barley	Moderately susceptible	Moderately susceptible

Image 6. The Nematicide trial block planted to mixed cover crops, August 2022.

Over 800 highly susceptible tomato plants cv. Tiny Tim, were germinated in the plant house at BRF and another 800 in the glasshouse at GRF in April 2022. After plant establishment, pots were inoculated with 2000 RKN (*M. javanica*) eggs in May 2022. On the 22nd August the cover crops were mulched to a height of approximately 200 mm to allow for the transplanting of 728 RKN infested tomato plants across the trial block. The remaining 728 tomato plants were transplanted on 14th of September 2022. At the start of December 2022, the cover crops and tomatoes were slashed, and the block was sown with RKN susceptible Mung beans and Lab Lab.

Image 7. Tiny Tim tomatoes inoculated with RKN, June 2022.

Image 8. C1 block Nematicide trial site - planting Tiny Tim tomatoes, September 2022.

Image 9 The Nematicide trial site planted to a Mung bean and Lab Lab cover crop, January 2023.

The block was sampled on January 23 to determine if the RKN population had increased sufficiently for the trial to commence. The block was divided into subsampling zones according to the location of the replicates for the experiment. Root-knot and reniform numbers were high across the block, although root-knot numbers were substantially lower in replicate 4 area. This was thought to be due to irrigation issues in that corner of the block.

Table5. Nematicide Trial 2 Pre-plant Nematode Counts / 200g Dry Soil.

Sample	RKN	Reniform	Free-living
C1 Rep 1	7226	2625	4033
C1 Rep 2	9370	2322	5165
C1 Rep 3	7070	543	2773
C1 Rep 4	450	249	2738
C1 Rep 5	4744	423	2652
C1 Rep 6	2305	243	3718
C1 Weedy	2339	535	4120

The block was planted on the 6th of March 2023 to sweetpotato cultivar Beauregard and the soil was sampled the following day.

Image 10. The trial block with some of the bare fallow plots clearly visible.

There were eight treatments in the trial (table 5), each replicated six times and the trial was designed as a randomised complete block. The trial was sampled to assess plant-parasitic and free-living nematode numbers in March, May, August, and at harvest in October 2023.

Table 6 Nematicide treatments and application rates in trial 2.

Treatment	Application type	Application rate	Application date
Nil	Nil	N/a	N/a
Bare fallow	Nil	N/a	N/a
Metham	Fumigation	As per label rate - 750 L/Ha	Prior to bed formation on 9th January 2023,
Vydate	Via trickle tape	As per label rate - 18Lha, followed by 4 applications of 2L/ha every 2 weeks'	After planting, 18L/Ha on 15th March 2023 2L /ha on: 29th March 2023, 12th April 2023, 27th April 2023 and 9th May 2023
Nimitz	Standard	As per label rate - 8L/Ha	Prior to incorporation and bed forming on 23rd February 2023
Nimitz alternative	Via trickle tape	As per label rate - 8L/Ha	After planting on 15th March 2023, 17th April 2023
Salibro	Via trickle tape	As per label rate - 2L/Ha per application	After planting on 15th March 2023 and 29th March 2023
Salibro alternative	Via trickle tape	As per label rate - 2L/Ha per application	After planting on 15th March 2023, 29th March 2023, repeated on 17th April 2023, and 9th May 2023

Soil Monitoring

Soil samples were collected on the 6th March at planting, on the 22nd of May,23rd of August and the 30th of October 2023. Samples were sent to the project team nematologists for nematode extraction and to GRF for extraction of soil biologicals, microarthropods and Nematode trapping fungi (NTF). Results from these samples will allow investigation into correlation between soil characteristics, RKN populations and soil biology.

Trial maintenance

A maintenance schedule was developed for the trial block in conjunction with the PRG, following best practice. Regular soil and leaf tissue samples were collected for laboratory analysis to monitor critical nutrients such as nitrate analysis. Scheduled fertiliser applications were made based on the results of the analysis. Crop maintenance included irrigation scheduling, scuffling along with regular weeding until row closure and regular weeding of the bare fallow plots. DAF designed weevil traps (project VG98002) containing pheromone attractant for sweetpotato weevil (Cylas formicarius) were installed at each corner of the block. Regular insecticide applications were carried out during the growth period based on weekly pest and disease monitoring.

Harvest

To monitor growth, three plants were dug up from the buffer rows at around 90 and 120 days after planting, to monitor root development. Prior to the harvest, the 2m buffer zones on the end of each row were hand dug and roots were removed. Rows were top chopped (pulversied) to remove the foliage and roots were left to harden for 1 week to prevent skinning during harvest. Roots were dug on the 30th of October at 238 days after planting (DAP). A potato harvester was used to lift the sweetpotato roots to the surface where they were manually hand-picked into hessian bags and placed into plastic half ton bins (image 7). Roots were freighted overnight to Gatton Research Facility (GRF) for assessment.

Roots were washed in a chlorine solution using a standard butternut pumpkin washer. Over 4000 roots were individually weighed and sorted into six size categories: small, small medium, medium, medium large, large and jumbo. Roots were then placed into one of three marketability grades, first or premium grade, second grade and non-marketable. Defects were recorded using the categorisation system developed for the Intensive and Extensive trials designed to capture 18 common defects found in commercial sweetpotato production as described in Appendix 18. Each root underwent close visual scrutiny and was evaluated using this system.

Results - Nematode population monitoring

1st Sampling

When the trial was sampled in March, sweetpotato vine had just been planted, Metham had been applied around 4 weeks prior and the standard Nimitz application around 2 weeks prior. At this point the Metham treatment had a significantly lower mean root-knot nematode count than all other treatments except the bare fallow.

2nd Sampling

At the second sampling in May, Metham, Nimitz alternative application, Vydate and the bare fallow all had significantly lower root-knot counts than the nil control.

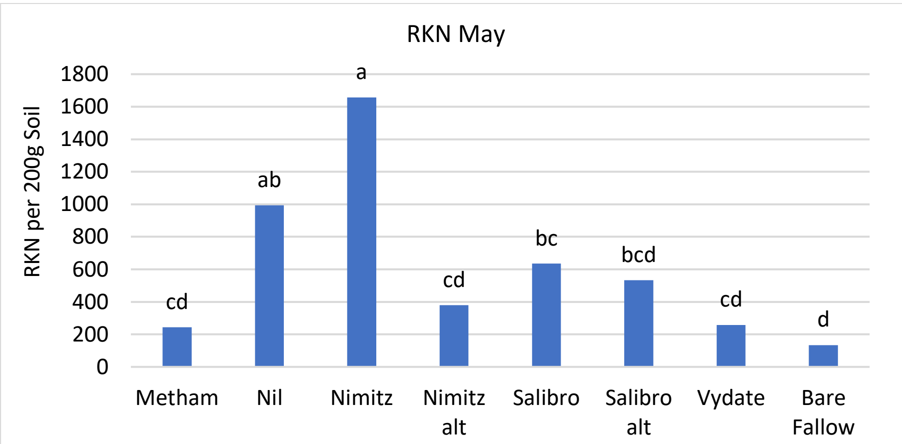

Figure 5 Mean root-knot nematode counts per 200g dry soil ($p < 0.001$)

All nematicides (except standard Nimitz) and the bare fallow had significantly lower reniform nematode counts than the nil control.

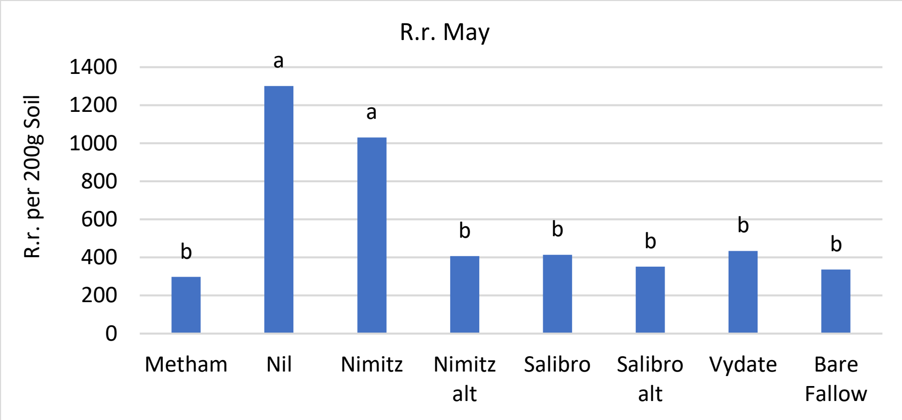

Figure 6 Mean reniform nematode counts per 200g dry soil (p = 0.003)

The Metham, Salibro alternative application and Vydate treatments had significantly fewer free-living nematodes in May, showing an impact by these nematicides on non-target organisms.

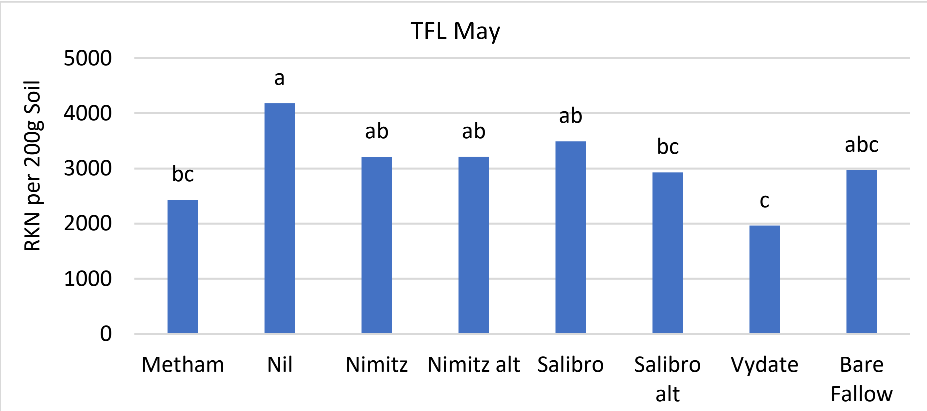

Figure 7 Mean free living nematode counts per 200g dry soil (p = 0.038)

3rd Sampling

In August, only the Nimitz alternative application and the bare fallow had significantly lower root-knot counts than the nil control.

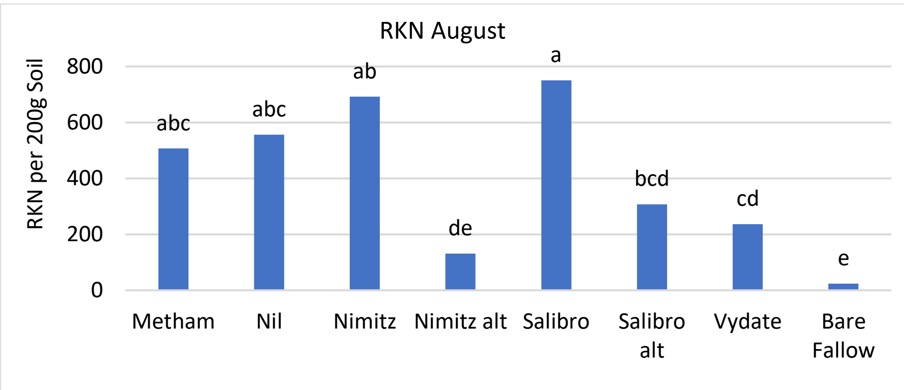

Figure 8 Mean root-knot nematode counts per 200g dry soil (p < 0.001)

The Nimitz alternative application, the alternative Salibro application, Vydate and the bare fallow had significantly less reniform nematode than control at this sampling.

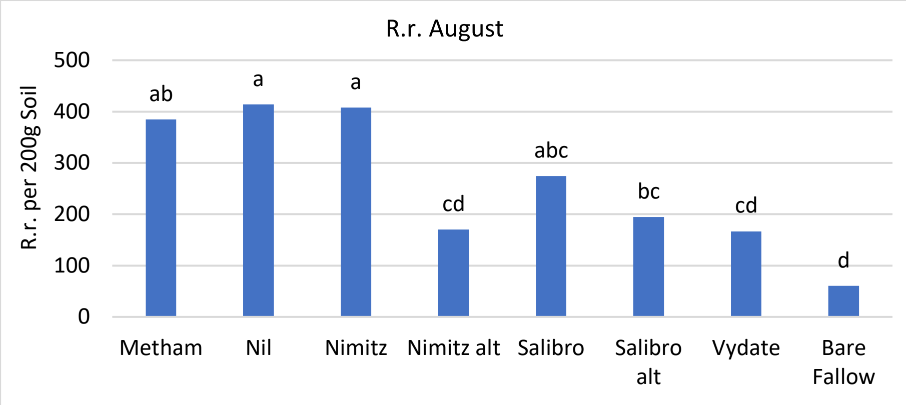

Figure 9 Mean reniform nematode counts per 200g dry soil ($p < 0.001$)

Vydate had significantly fewer free-living nematodes than all other treatments except Nimitz alternative application in August.

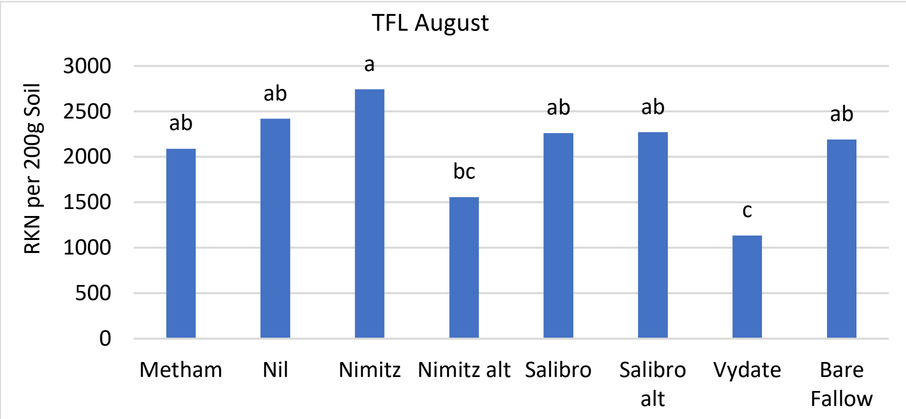

Figure 10 Mean free living nematode counts per 200g dry soil ($p = 0.033$)

4th Sampling

The final sampling was conducted in October, one week prior to harvest. The Nimitz alternative application, Vydate and the bare fallow had significantly lower mean root-knot nematode counts than Metham and Nimitz treatments and the nil control.

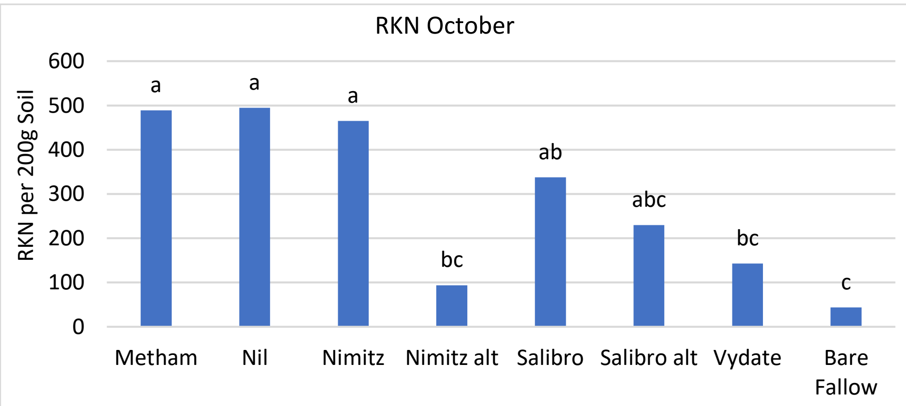

Figure 11 Mean root-knot nematode counts per 200g dry soil ($p = 0.008$)

The Nimitz alternative application, Salibro alternative application, Vydate and the bare fallow had significantly lower reniform nematode counts at the final sampling.

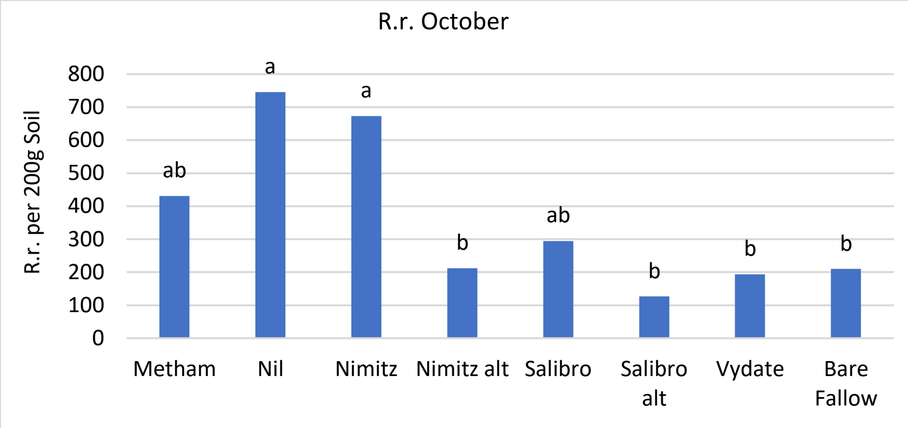

Figure 12 Mean reniform nematode counts per 200g dry soil (p = 0.032)

There were no significant differences in free-living nematode counts at the October sampling.

Having been applied almost a month prior to the first sampling, Metham Sodium had less root-knot nematode than all of the other nematicides and the nil control at the first sampling. By the second sampling, the Nimitz alternative application and Vydate also had lower levels of root-knot than the control. In August, the Nimitz alternative application was the only nematicide with lower mean root-knot counts than control, but at the final sampling both the Nimitz alternative application and Vydate were lower. So, for root-knot nematode, the Nimitz alternative application provided the most consistent control for the duration of the trial. Nimitz standard application, Salibro and the Salibro alternative application root-knot counts were not significantly different from the nil control at any of the 4 sampling points.

For reniform nematode, all nematicides except the standard Nimitz application had lower mean counts than control in May. At both the August and October samplings, Nimitz alternative application, the alternative Salibro application and Vydate had lower counts than control. So, as for root-knot, the alternative Nimitz application provided consistent control of reniform nematode. Vydate and the alternative Salibro application also provided control for much of the trial period.

Free-living nematode populations were impacted by some of the nematicides in the mid-trial period, with Vydate having the lowest counts in May and August. By the final sampling there were no significant differences between treatments for free-living nematodes. Most free-living nematodes have a very short life cycle, so can rapidly recover their populations when chemical effects have dissipated.

Without a susceptible host the root-knot nematode population dropped to low levels in the bare fallow treatment, as expected. Reniform nematode numbers also dropped but were still at relatively high levels (around 200 per 200g dry soil) at the final sampling, possibly reflecting the differing life cycles and survival strategies of the two species. Free-living nematode counts in the bare fallow treatment were not significantly different from those in the nil control sweetpotato crop.

Results – Biological monitoring

Microarthropod Counts

Data was collected on counts of microarthropods and nematode trapping fungi (NTF) from the Bundaberg nematicide trial. Data was collected at the replicate block level before planting (1/11/2022), at planting for the Nimitz plots before Nimitz application (7/3/2023) and for all plots after Nimitz application (7/3/2023, 28/8/203). Data was collected on the presence of NTF and conidia. Data was also collected from a single strip of weedy fallow at the southern end of the trial for comparison only.

The two assessments post Nimitz application (7/3/2023, 28/8/2023) were first analysed separately and then together to investigate any temporal effects. Analysis of the first assessment (7/3/2023) suggests there was evidence of over-dispersion. No significant treatment effect was detected at the first assessment on 7/3/2023 after Nimitz application ($F_{(7,35)}$ = 1.42; p = 0.227), but there was a significant treatment effect at the second assessment on 28/8/2023 ($F_{(7,35)}$ = 3.00; p = 0.014), (Table 7). Microarthropod population decreased.

However, pairwise comparison of the treatment means suggest no treatments are significantly different to the Nil treatment. Hence, low microarthropod scores could be attributed to the change of cropping system. Diverse mix cover cropping established prior to build up RKN populations also favoured buildup of microarthropods. However, microarthropods decreased could be attributed to monoculture of young sweetpotato crop as well as high rainfall recorded during the growth stage of the sweetpotato crop (Winter et al 2006). Chemical application as herbicide, foliar and fertilizer can reduce microarthropod population as well (Winter et al 1990, Seymour 2006, Stirling 2016).

Metham, Nimitz Trickle + 2nd application had the highest mean counts and were significantly higher than bare fallow, Nimitz and the two Salibro treatments.

Table 7 predicted means, standard error (se), BT Mean for two assessment dates.

Collection date	7/3/2023			28/8/2023		
Treatment	Pred Mean	se	BT Mean	Pred Mean	se	BT Mean
Bare fallow	3.44	0.470	31.0	-0.44 b	0.690	0.64
Nil	2.04	0.496	7.7	0.25 ab	0.553	1.28
Metham	2.47	0.484	11.8	1.04 a	0.461	2.83
Nimitz	2.18	0.492	8.8	-1.36 b	0.993	0.26
Nimitz Trickle alternate	2.50	0.484	12.2	1.04 a	0.461	2.83
Salibro	2.65	0.481	14.2	-0.44 b	0.690	0.64
Salibro alternate	2.20	0.491	9.0	-0.95 b	0.838	0.39
Vydate	2.64	0.481	14.1	0.35 ab	0.539	1.41
	average 95% lsd = 1.073			average 95% lsd = 1.573		
Weedy fallow			24.0			2.0

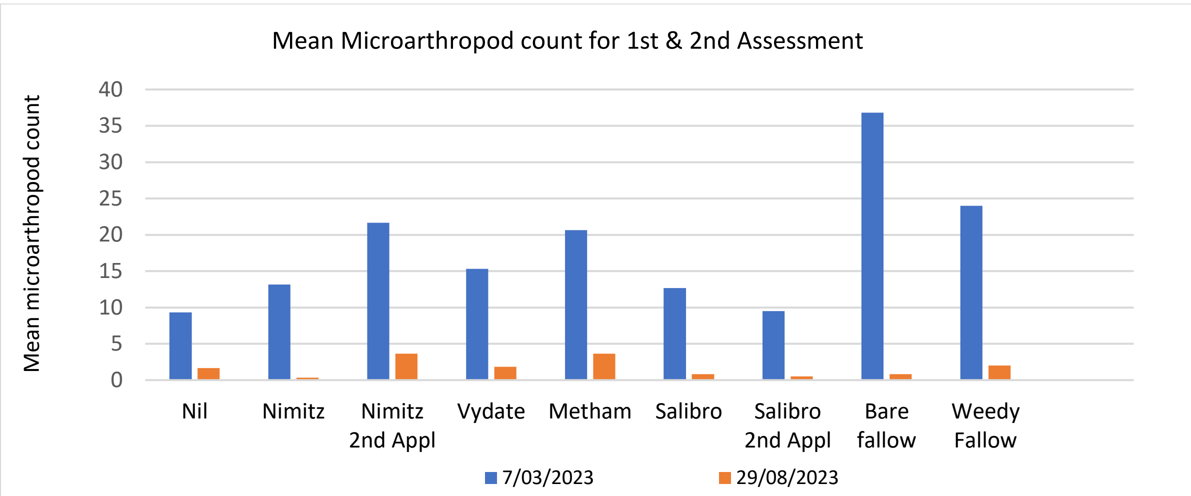

Figure 13 Significant treatment effect on second assessment.

Nematode Trapping Fungi

There were insufficient counts of NTF and conidia at the second assessment to enable a combined analysis. NTF were only detected on 4 plates at the 28/8/2023 sampling. These were 3 Vydate plates from the same plot and 1 Nil plate. This assessment date has not been analysed.

Results from the analysis of the first assessment on 7/03/2023 found no significant difference between the treatments ($F_{(7,35)} = 0.95$; $p = 0.483$), although only Metham and the standard Nimitz application had been applied prior to this sampling.

Conidia

Conidia were only observed on 4 plates from the 28/8/2023 sampling. These were 3 Vydate plates from the same plot and 1 Nil plate. This assessment date has not been analysed.

A third assessment on microarthropods and NTF was done on the 24/10/2023 (Table 8). The table is only based on average microarthropod count across all assessment dates. Microarthropod counts start increasing for Nil Treatments, Nimitz, Vydate and Sabilbro 2nd application as environment becomes conducive for population build up.

Table 8 Average microarthropod count for all treatments over time.

Assessment Dates	7/03/2023	29/08/2023	24/10/2023
Treatment no.			
Bare Fallow	36.83	0.83	0.66
Nil	9.33	1.66	2.16
Nimitz	13.16	0.33	2.83
Nimitz Trickle alternate	21.66	3.66	1.5
Vydate	15.33	1.83	2.16
Metham	20.66	3.66	0.83
Salibro	12.66	0.83	0.66
Salibro 2nd appl	9.5	0.5	1.16
Weedy Fallow	24	2	0

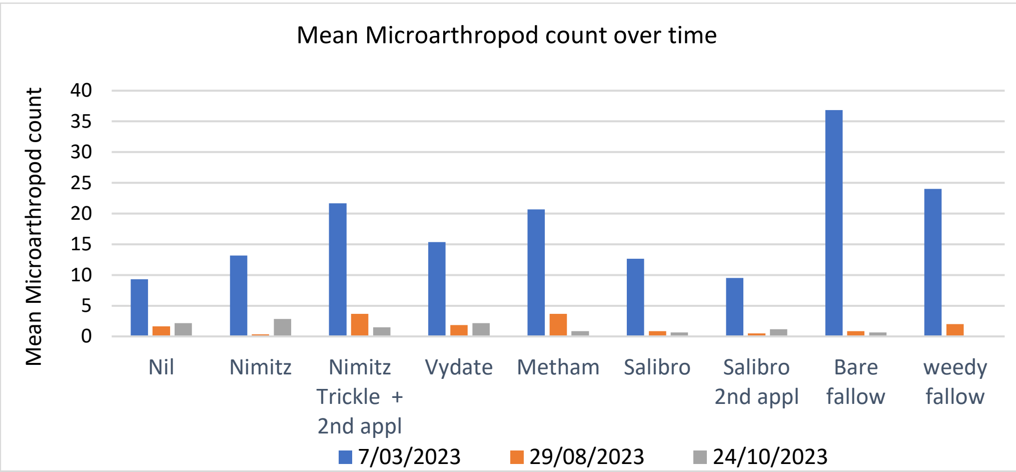

Figure 14. Mean microarthropod count over time.

Results - Sweetpotato yield and quality.

Figure 15 the project team conducting the yield assessment on the final harvest.

Root weight

Data was analysed by DAF biometrician Carole Wright. Root weight was analysed using analysis of variance (ANOVA), then a log10 transformation was applied to the total weight of marketable roots to improve the assumption of homogeneity of variance.

All roots with a weight of less than 150g were excluded from this analysis. In all instances below, the term “total roots” refers to small + medium + large roots.

Total roots (small + medium + large) and large roots grown in the Nil and Nimitz treated plots were significantly lower in weight overall than all other treatments except the Nimitz alternate treatment. The Vydate plots produced a significantly higher weight of roots per plot than the Nil, Nimitz and Nimitz alternate treatments, though this was not significantly different to plot weight in the Metham, Salibro and Salibro alternate treatments. Vydate plots produced roots with a significantly higher weight of medium roots than all other treatments except Metham.

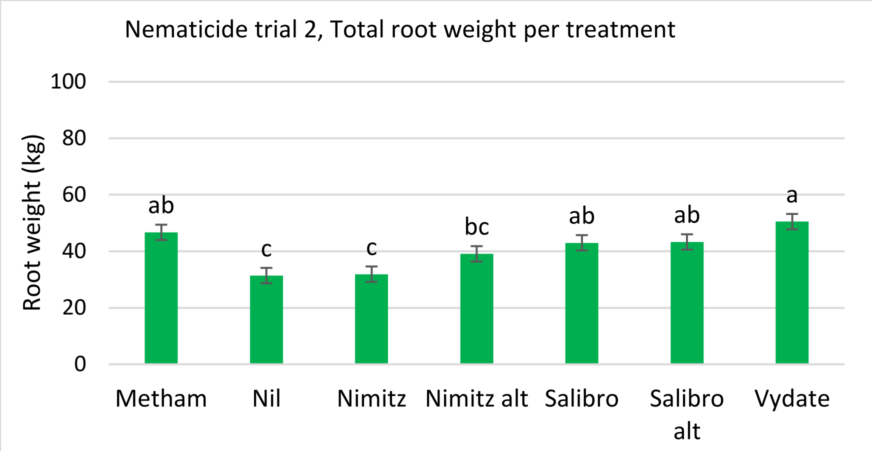

Figure 16. Total root weight per treatment.

Root number

Root numbers were analysed using a generalised linear model with a Poisson distribution and a log link, except for total counts in the marketable and non-marketable categories. There was more variation than expected by the Poisson distribution and so a Negative Binomial distribution was assumed.

The Metham and Vydate treated plots produced a significantly higher number of roots than Nil, Nimitz and Nimitz alternative treatments but was not significantly different to the Salibro and Salibro alternate treatments. The Nil and Nimitz plots produced a significantly lower number of large roots than all other treatments. Vydate plots produced a significantly higher number of medium roots, but this was not significantly different to the number of roots produced in the Metham, Nimitz alternate and Salibro alternate treatments.

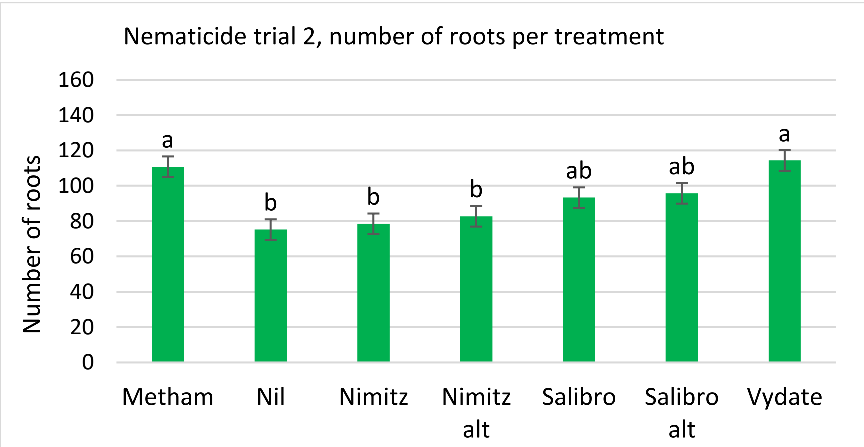

Figure 17. Number of roots produced in each treatment.

Defects

Incidence data was analysed using a generalised linear model with a Binomial distribution and complementary log-log link. The mean for incidence data is reported as a percentage.

Raised pimples

The incidence of raised pimples was too low to conduct an analysis across the treatments.

Black pimples

Image 11 Black pimples (circled) within a nematode crack indicating a later RKN infection.

Total roots (small + medium + large) from the Vydate treatment had a significantly lower incidence of Black pimples than all other treatments. This was also a significantly lower incidence of Black pimples when each of the size categories (small, medium and large) were analysed individually.

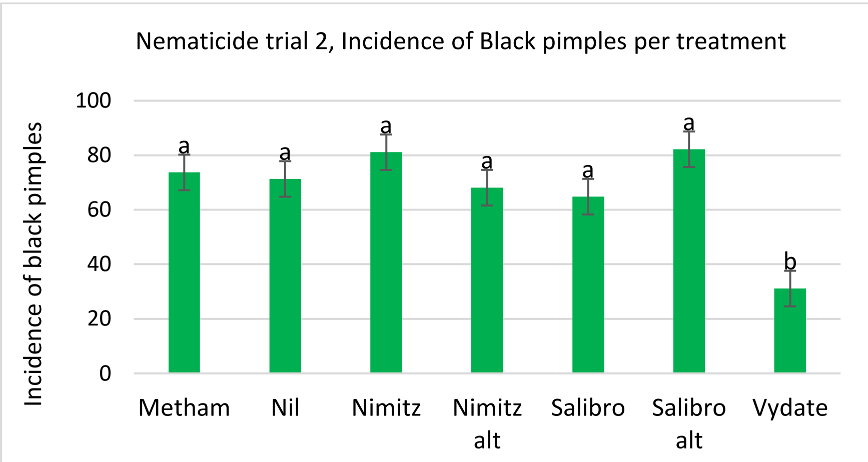

Figure 18. Incidence of Black pimples.

Nematode cracks

Image 12 Nematode cracks - a result of early RKN infection.

All roots (small + medium + large) grown in the Vydate treated plots had a significant lower incidence of nematode cracks than all other treatments. The Nil and Nimitz treatments produced roots with a significantly higher incidence of nematode cracks than all other treatments.

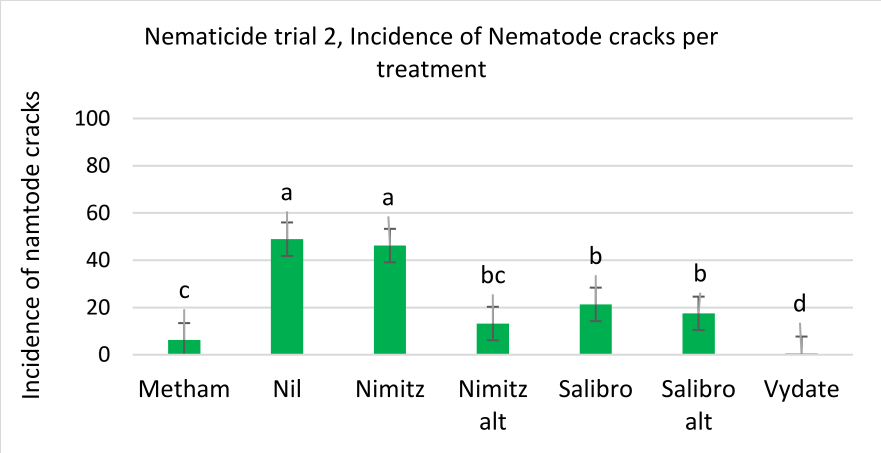

Figure 19. Incidence of nematode cracks.

Wireworm

All roots (small + medium + large) grown in the Metham treated plots had a significantly higher occurrence of wireworm damage than all other plots except Nimitz. A lower incidence of wireworm damage was observed on roots grown in the Nil, Nimitz alternate, Salibro, Salibro alternate and Vydate treatments though this was not significantly different to the Nimmitz treatment.

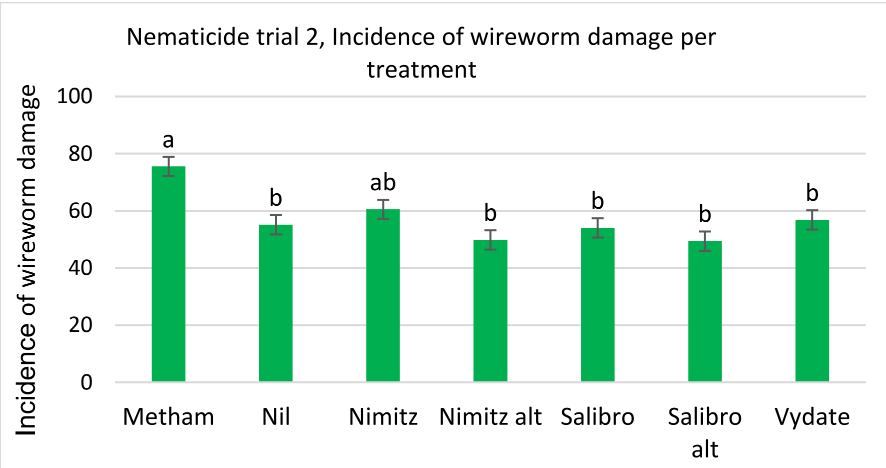

Figure 20. Wireworm damage on roots in each treatment.

Longitudinal grooves

Medium, large and the overall total roots (small + medium + large) grown in the Metham treated plots each had a significantly higher incidence of longitudinal grooves (LG) than all other treatments. However, this was not significantly different to the Salibro treated roots. The incidence of LG observed in large sized roots was not significantly different to that in the Nil or untreated plots.

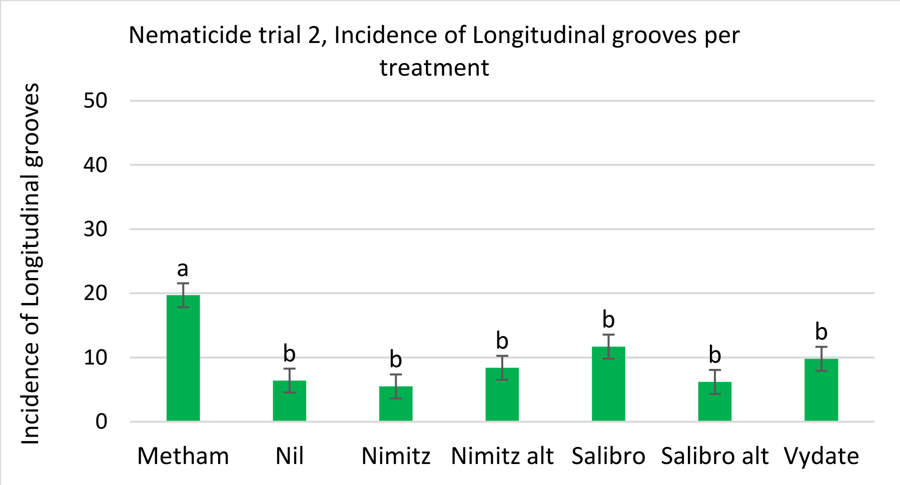

Figure 21. Incidence of longitudinal grooves per treatment.

Veining

When analysed as a group, total roots (small + medium + large) from the Metham treated plots displayed a significantly lower incidence of veining than roots grown in all other treatments. Roots in the Nimitz alternate treatment had a significantly higher incidence of veining that Vydate and Metham treated plots, but this was not significantly different to the Nil, Nimitz, Salibro and Salibro alternate treatments. When analysed separately by size category, the same significant differences were recorded across the small, medium and large size categories.

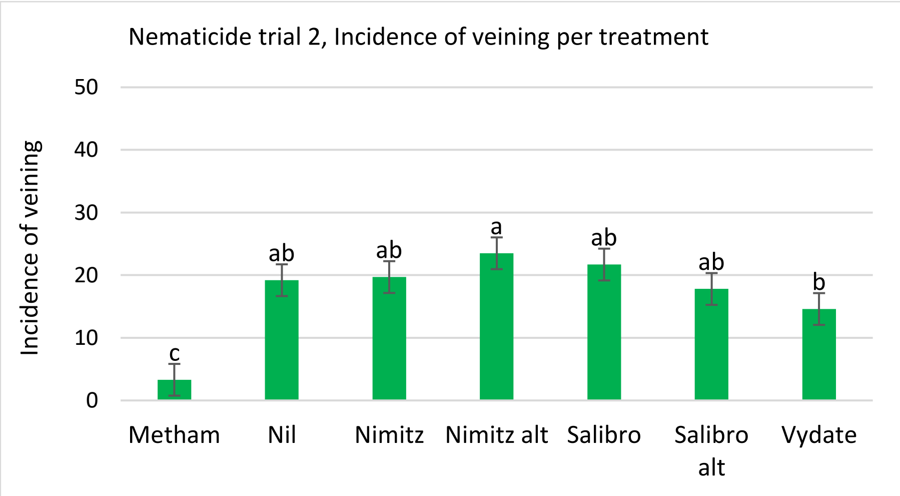

Figure 22. Incidence of Veining in each treatment.

Sunburn

Total roots (small + medium + large) from the Metham plots had a significantly higher incidence of Sunburn, however, this was not significantly different to Sunburn in roots from the Salibro and Vydate treatments. Roots in the Nimitz and Nimitz alternate treatments had a significantly lower incidence of sunburn, but this was not significantly different from roots in the Salibro alternate and Nil treatments.

Medium roots in the Metham, Salibro and Vydate treatments had a significantly higher incidence of Sunburn and this was not significantly higher than the Nil treatment. Small roots in the Vydate plots had a significantly higher incidence of Sunburn than all other treatments except Metham.

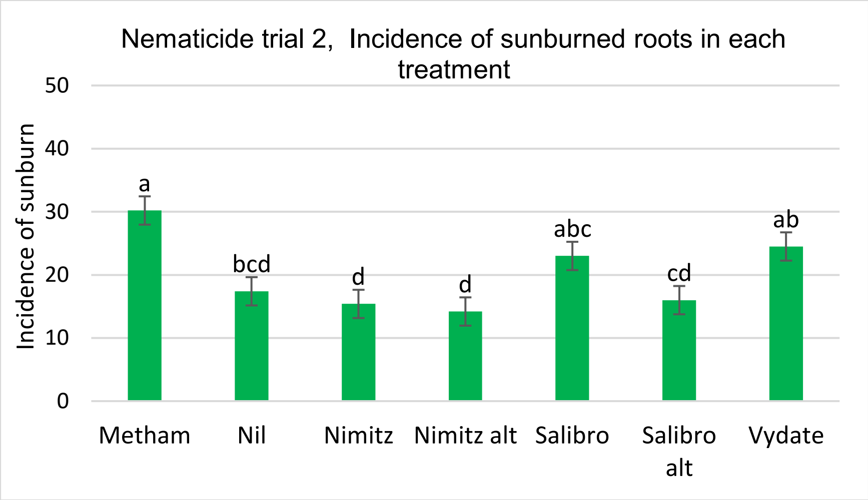

Figure 23. Incidence of Sunburned roots in each treatment.

Animal damage

Large roots in the Nil and Salibro plots had lowest incidence of animal damage though this was not significantly lower than the Nimitz, Nimitz alternate treatment, and Vydate. Roots in the Salibro alternate treatment had highest incidence of animal damage but this was not significantly different to those in the Nimitz and Metham treatments. There were no other significant differences.

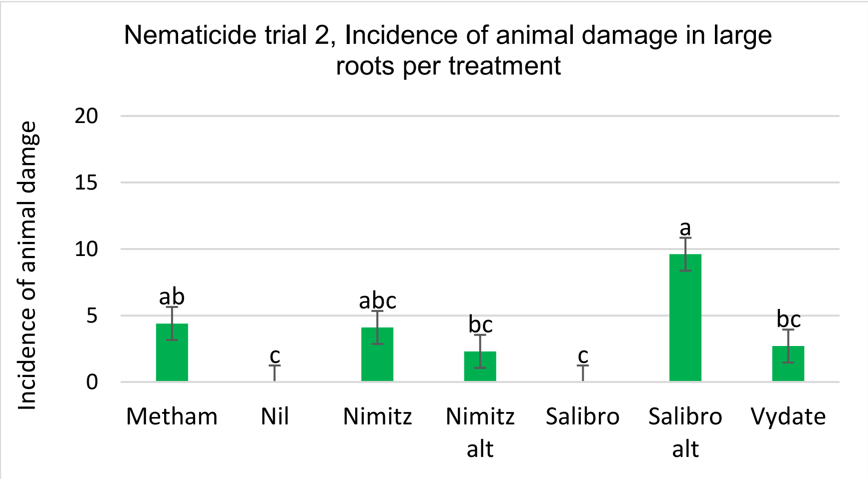

Figure 24. Incidence of Animal damage in large roots.

Other defects

There were no significant differences in any other defects.

Discussion

The Vydate and Metham treated plots tended to produce a higher weight of total and medium sized roots and a higher number of roots. Roots from the Vydate treated plots had a significantly lower incidence of nematode cracks and Black pimples. Roots grown in the Nil and Nimitz treated plots were lower in weight and number than all other treatments except the Nimitz alternate treatment.

Roots grown in the Metham treated plots had a significantly higher occurrence of wireworm damage, sunburn and longitudinal grooves, but a significantly lower incidence of veining. Sunburn occurs as roots push up above the soil surface and are therefore exposed. Any differences between treatments are unlikely to relate to efficacy of a chemical efficacy.

Large roots in the Nil and Salibro plots had lowest incidence of animal damage but roots in the Salibro alternate treatment had highest incidence of animal damage This may indicate that there was higher nematode pressure in the Nil and Nimitz plots affecting the development of large roots. Any differences between treatments are unlikely to relate to efficacy of a chemical in deterring animals.

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