Biological monitoring as indicator of soil health

Appendix 17 Final report PW17001 Integrated pest management of nematodes in sweetpotato

Jean Bobby, August 2023

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The Department of Agriculture and Fisheries proudly acknowledges all First Nations peoples (Aboriginal peoples and Torres Strait Islanders) and the Traditional Owners and Custodians of the country on which we live and work. We acknowledge their continuing connection to land, waters and culture and commit to ongoing reconciliation. We pay our respect to their Elders past, present and emerging.

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Intensive trial- biological monitoring as an indicator of soil health

Summary

Microarthropod population and presence of Nematode Trapping Fungi (NTF) as indicators of soil health were collected at pre-plant and pre-harvest stage of the crop including during cover crop or rotation crop for the life of the trial (see full report at Appendix 17).

Statistical analysis of the microarthropod data showed significant effects of collection date ($p<0.001$) and treatment ($p<0.001$). Mean microarthropods per plot fluctuate over time. The highest mean was recorded on the second collection date (4-Feb-2021) after which it declined but increased slightly on 6-Jun 2022 before declining again in later assessments. The high counts in February 2021 can be attributed to the build-up of litter from amendments and a rotation crop (White French Millet/Jumbo Sorghum) prior to planting of first commercial sweetpotato crop. The decline in mean microarthropod count on 28-Jun-2021 and further decline in 27-Jan-2022 can be attributed to high rainfall; chemicals from pesticide, herbicide, nematicide and fertilizer application.

Organic matter treatment had a significantly higher mean microarthropod count than all other treatments followed by V Furrow amendment, which was significantly better than the nematicide treatment but not the compost and nil treatments.

Nematode trapping fungi have a significant effect of collection date ($p<0.001$). Mean proportion of plates with NTF decreases significantly after the first assessment. This may be attributed to build-up of plant litter and organic matter in the soil prior to first planting, an environment favorable for NTF to be prevalent. However, the decline in preplant (04-Feb-21 & 27-Jan-22) may be related to tillage as well as environmental factors such as rainfall, heat, and agronomic practices such pesticide and herbicide application. NTF proportions increased again on 09-Dec-22 at preplant and reasonably high on 28-Apr-23 (pre-harvest) after a period of rotation crop. Mean proportion of plates with NTF is generally high for preharvest assessments (02-June-20, 28-Jun-21).

Presence of conidia was significant for collection date ($p<0.001$), higher at the first collection date (2-Jun-20) and the last two (9-Dec-22 & 28-Apr-23) collection dates. The decline in mean proportions on 4/02/2021 to 6/06/2021 may be a resulting effect of agronomic practices such as tillage, chemicals from pesticide, herbicide, nematicide and fertilizer application as well as soil environment.

Outputs

1. Soil health Masterclass, grower updates and report.

Outcomes

The outcome of the biological monitoring as indicator as indicator for both trials (Intensive & Extensive) is that it increases grower knowledge on role of microarthropod and Nematode trapping fungi and their importance to soil health. It also increased grower knowledge on use of amendments and which amendments promotes soil health in a sweetpotato farming system (intensive and extensive)

Take home message/key findings

1. Cover cropping promotes buildup of microarthropod population and promotes NTF in the soil.
2. Organic matter and V furrow Amendments ass seen in this trial promotes soil health in terms of microarthropod population and NTF.
3. Agronomic practices such as application of pesticide, herbicide, fertilizer as well as well tillage affects microarthropod population and NTF

Extensive Trial – biological monitoring as an indicator of soil health

Summary

Mean microarthropod count increased significantly over the first three collection dates before fluctuating over the rest of the collection dates, particularly for the double and incorporated amendment treatments. The increase can be attributed to build-up of plant litter and organic matter in the soil from application of amendments and cover crop (White French Millet followed by Soybean A6785 and Nemsol) prior to planting of first commercial sweetpotato crop.

Within treatment crops (grass/brassica and grass/legume), double and incorporated amendments have higher mean microarthropod count.

All treatments showed an increase in the overall mean microarthropod counts over the first three collection dates, before decreasing on 15/03/2022. The decrease can be attributed to March 2023's high rainfall (see appendix 17 for full report). All treatments except the nil and nematicide treatments then showed an increase followed by a decrease. Fluctuations in microarthropod population can be attributed to agronomic practices employed in the trial itself. For instance, tillage, application of chemicals as in pesticides, herbicides, nematicides and fertilisers (Winter et al 1990, Seymour 2006, Stirling 2016). Environmental factors such as temperature and rainfall (Winter et al 2006), acidity and Alkalinity of soil (measured as pH) also greatly influence population dynamics.

Nematode trapping fungi had significant effect of collection date ($p<0.001$). The proportion of NTF was highest on the first collection date. Mean proportion of plates with trapping decreases significantly over the first assessment before increasing and remaining reasonably stable. The interaction of treatment and collection date was significant (<0.001). The only sample with no significant difference was the collection on the 15-Mar-22. Only one plate has conidia. This collection date had high rainfall (see appendix 17 for full report).

When comparing treatments overtime, the only significant difference between the crops occurs for the double amendment on 14-Sep-21 and nematicide treatment on 29-Nov-22.

Intensive trial biological monitoring as an indicator of soil health

Introduction

Soil biota play major roles in the functioning of the soil and act as indicators of soil health. The two variables measured in the sustainable farming systems are: (1) Microarthropods (by count) & (2) Nematode Trapping Fungi (NTF) which is measured as presence of trapping (nematode is trapped by NTF) and presence of conidia. Conidia is produced by the *Arthrobotrys* species of nematode trapping fungi. Its presence is an indication of the presence of NTF as well as an identification key for the species of NTF present in the soil.

Methodology

Microarthropod extraction

Microarthropods were extracted using the Tullgren Funnel method. One hundred & twenty grams (120g) of soil from each plot (randomly sampled) was placed in a funnel attached to a collection tube containing 70% alcohol. Heat produced from lighting suspended in the Tullgren cabinet forced microarthropods to escape through the funnel. These microarthropods are trapped in the collection tubes containing 70% alcohol. The tubes are collected after 4-6 days and microarthropods counted under the microscope.

Image 1(a) Preparing soil for Tullgren (b) 120 g of soil in funnels with collection tubes attached (c) microarthropods under the microscope.

Identification of Nematode Trapping Fungi

To determine the nematode trapping fungi, 1g of soil from each plot is plated on quarter (1/4) strength cornmeal agar (CMA), incubated for 2-4 weeks to allow for fungal growth. The petri dish is observed under a bottom lit microscope. The two variables observed were trapping (actual trapping of nematodes by NTF) and the presence of conidia.

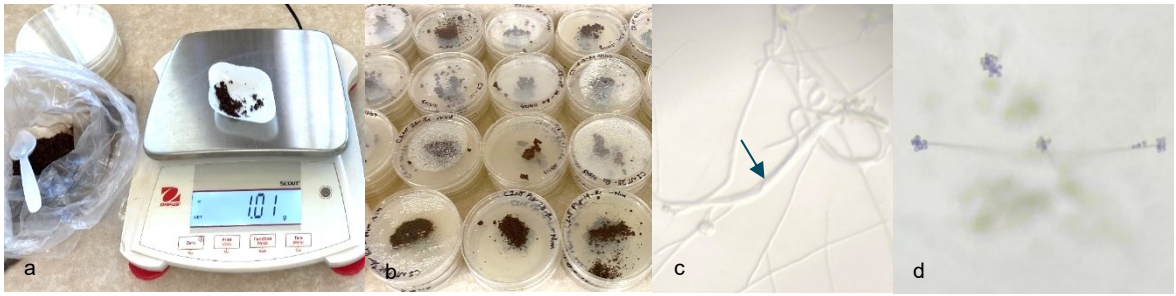

Image 2 (a) plating 1gm soil on ¼ strength CMA (b) incubating soil (c) trapped nematode (d) conidia under microscope.

The number of microarthropods per plot was counted. Count data for Nematode Trapping Fungi was based on presence and absence of trapping (actual trapping of nematode by NTF) & absence and presence of conidia. All data collected was analysed by the DAF biometrician. The counts of microarthropods were analysed using GLM/M and ANOVA and results for the model with the most

appropriate fit is reported. 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.

Results & Discussion

Microarthropods

Microarthropods and Nematode trapping fungi data reported in detail in Appendix 17. Statistical analysis using GLM/M and ANOVA showed a significant effect of collection date ($p<0.001$) and a significant effect of treatment ($p<0.001$). Pairwise comparisons using the 95% lsd suggest that mean microarthropods per plot fluctuate over time. The highest mean was recorded on the second collection date (4-Feb-2021) (figure 1) after which it declined but increased slightly on 6-Jun 2022 before declining again in later assessments. The rise of microarthropod counts can be attributed to the build-up of litter from earlier amendments before the first commercial planting. After harvest, the block was planted with a rotation crop (White French millet/Jumbo sorghum) followed by another application of amendments before the second planting. The slight increase on the 6-Jun-22 was during a period of rotation crop. Findings by Winter et al 1990 confirmed increased microarthropods when bromegrass was planted for 3-4 years following 15 years of conventional tillage. Stirling et al 2020 reported increase in biological community with rotation crop and amendments in sweetpotato farming system. The decline on the later assessments may be attributed to high rainfall.

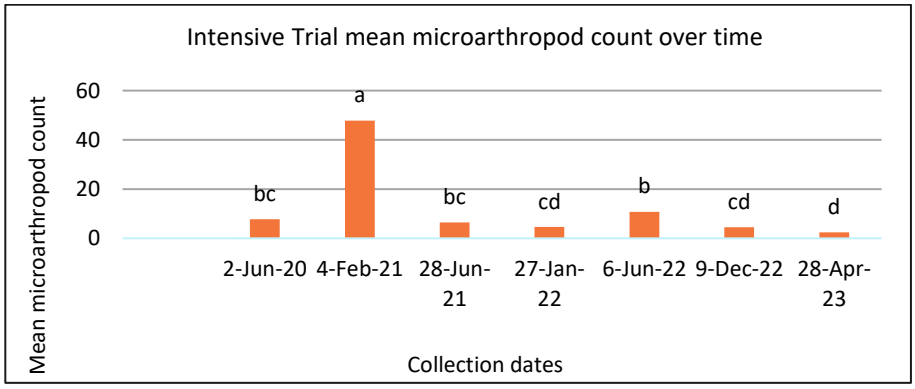

Figure 1 the mean microarthropod count at each collection date.

The organic matter treatments had a significantly higher mean microarthropod count than all other treatments followed by V Furrow amendment, which was significantly better than the nematicide treatment but not the compost and nil treatments. Microarthropods are decomposers of organic material, therefore the organic matter amendment provides a rich food source for them resulting in higher populations (Kautz 2006).

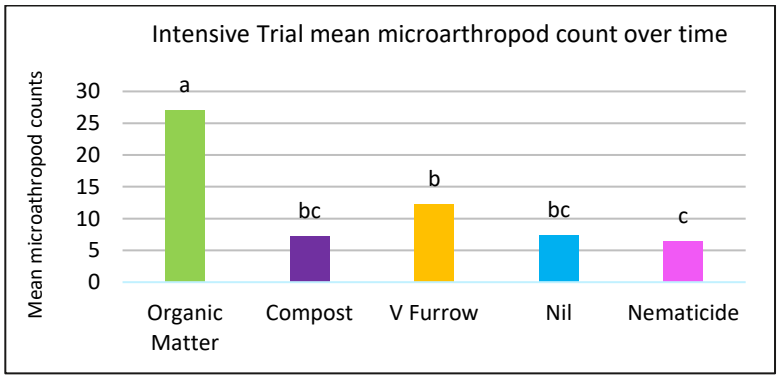

Figure 2 Mean microarthropod count per treatment over time.

Nematode Trapping Fungi

Trapping & Conidia

Data was collected on seven occasions. Count data for Nematode Trapping Fungi was based on presence of trapping (actual trapping of nematode by NTF) and conidia. The resulting main effects model found a significant effect of collection date ($p<0.001$). Pairwise comparisons using the 95% lsd shows the mean proportion of plates with NTF decreases significantly after the first assessment. Mean proportion of plates with NTF is high for preharvest assessments (02-June-20, 28-Jun-21). The high proportion reading for 02-Jun-20 may be attributed to a build-up of plant litter and organic matter in the soil prior to first planting, an environment favorable for NTF to be prevalent. However, the decline in preplant (04-Feb-21 & 27-Jan-22) may be related to tillage or environmental factors such as rainfall, heat as well as agronomic practices such pesticide and herbicide application. NTF proportions increased again on 09-Dec-22 at preplant and reasonably high on 28-Apr-23 (pre-harvest) after a period of rotation crop.

Presence of conidia was significant for collection date ($p<0.001$). Mean proportions of plates with conidia present is higher at the first (2-Jun-20) and the last two (9-Dec-22 & 28-Apr-23) collection dates. A similar pattern to NTF the trapping as conidia is produced by NTF (Arthrobotrys spp). The decline in mean proportions on 4/02/2021 to 6/06/2021 may be a resulting effect of agronomic practices such as tillage and herbicide application.

Table 1 Mean proportions of NTF and conidia.

Collection date	Cropping stage	Mean of NTF	Mean of Conidia
02-Jun-20	Pre-harvest	0.240 bc	0.324 b
04-Feb-21	Pre-plant	0.020 d	0.042 c
28-Jun-21	Pre-harvest	0.190 c	0.117 c
27-Jan-22	Pre-plant	0.120 cd	0.050 c
06-Jun-22	Rotation crop	0.110 cd	0.097 c
09-Dec-22	Pre-plant	0.493 a	0.774 a
28-Apr-23	Pre-harvest	0.360 ab	0.372 b

Extensive Trial – biological monitoring as an indicator of soil health

Summary

Mean microarthropod count increased significantly over the first three collection dates before fluctuating over the rest of the collection dates, particularly for the double and incorporated amendment treatments. The increase can be attributed to build-up of plant litter and organic matter in the soil from application of amendments and cover crop (White French Millet followed by Soybean A6785 and Nemsol) prior to planting of first commercial sweetpotato crop.

Within treatment crops (grass/brassica and grass/legume), double and incorporated amendments have higher mean microarthropod count.

All treatments showed an increase in the overall mean microarthropod counts over the first three collection dates, before decreasing on 15/03/2022. The decrease can be attributed to March 2023's high rainfall (see appendix 17 for full report). All treatments except the nil and nematicide treatments then showed an increase followed by a decrease. Fluctuations in microarthropod population can be attributed to agronomic practices employed in the trial itself. For instance, tillage, application of chemicals as in pesticides, herbicides, nematicides and fertilisers (Winter et al 1990, Seymour 2006, Stirling 2016). Environmental factors such as temperature and rainfall (Winter et al 2006), acidity and Alkalinity of soil (measured as pH) also greatly influence population dynamics.

Nematode trapping fungi had significant effect of collection date ($p<0.001$). The proportion of NTF was highest on the first collection date. Mean proportion of plates with trapping decreases significantly over the first assessment before increasing and remaining reasonably stable. The interaction of treatment and collection date was significant (<0.001). The only sample with no significant difference was the collection on the 15-Mar-22. Only one plate has conidia. This collection date had high rainfall (see appendix 17 for detailed report).

When comparing treatments overtime, the only significant difference between the crops occurs for the double amendment on 14-Sep-21 and nematicide treatment on 29-Nov-22.

Introduction

Soil biota play a major role in the functioning of the soil and act as indicators of soil health. The two variables measured in the sustainable farming systems are: (1) Microarthropods (by count) & (2) Nematode Trapping Fungi (NTF) which is measured as presence of trapping (nematode is actually trapped by the hyphae of NTF) and presence of conidia. Conidia is produced by the Arthrobotrys species of nematode trapping fungi. Its presence is an indication of the presence of NTF as well as an identification key for the species of NTF present in the soil.

Methodology

Microarthropod extraction

Soil samples were collected on six occasions: At pre planting and pre-harvest stages of the sweetpotato crop and during a rotation or cover crop. Microarthropods counts were collected harvested from 120 grams of soil randomly collected from each plot and placed in the Tullgren funnel as previously described.

Nematode Trapping Fungi

To determine the nematode trapping fungi, 1 gm of soil from each plot is plated on quarter (1/4) strength cornmeal agar (CMA), incubated for 2-4 weeks to allow for fungal growth. The petri dish was observed under a bottom lit microscope. The two variables observed were trapping (actual trapping of nematodes by NTF) and the presence of conidia.

Results and Discussion

Microarthropods

Mean microarthropod counts increased significantly over the first three collection dates before fluctuating over the rest of the collection dates (see Appendix 17). Increase was more apparent for the double and incorporated amendments. The increase can be attributed to agronomic practices implemented prior to the first collection date. Amendments have been applied to double and incorporated treatment plots prior to the first planting of the commercial sweetpotato crop. The trial was also planted with a cover crop (White French Millet followed by Soybean A6785 and Nemsol). Amendments were then applied to the V furrows and double amendments before the first commercial planting. The soil had a build-up of plant litter and organic matter.

Table 2 Means for microarthropods overtime.

Date collected	Means	
2-Jun-2020	4.24	d
15-Feb-2021	11.12	b
14-Sep-2021	18.21	a
15-03-2022	5.55	cd
29-Nov-22	10.65	b
17-Apr-23	6.58	c

Within treatment crops (grass/brassica and grass/legume), the only significant difference was with nematicide and nil amendments of the grass/brassica treatments (figure 1) which have lower means than double and incorporated amendments.

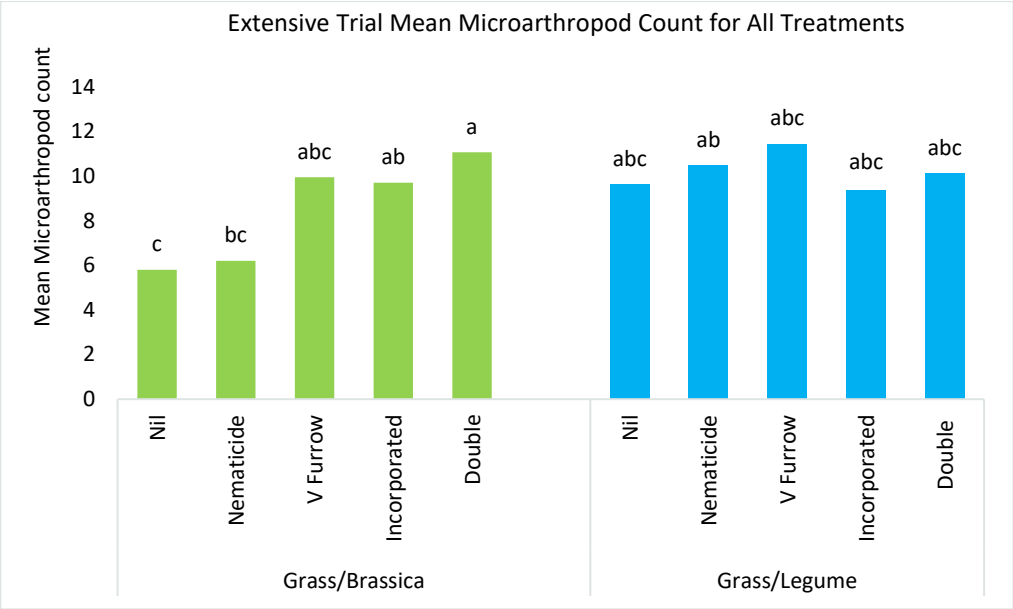

Figure 3 Graph of microarthropod means for treatment crops. No significant difference within Grass/Legume crop except for Nil & Nematicide in Grass Brassica treatment crop.

Table 3 Mean microarthropod count within each amendment over time. Letters of significance relate only to the column.

Date Collected	02-Jun-20	15-Feb-21	14-Sep-21	15-Mar-22	29-Nov-22	17-Apr-22
Double Amendment	4.40 ab	13.07 a	22.79 ab	5.30 ab	11.25 ab	8.33 ab
Incorporated	1.84 b	15.28 a	16.11 ab	4.21ab	18.16a	5.06 ab
Nematicide	3.08 b	8.46 a	27.71 a	4.97 ab	7.96 b	3.86 b
Nil	2.70 b	7.53a	11.94 b	8.93 a	7.30 b	5.49 ab
V Furrow	9.81 a	11.40 a	11.63 b	3.56 b	8.69 ab	10.72 a

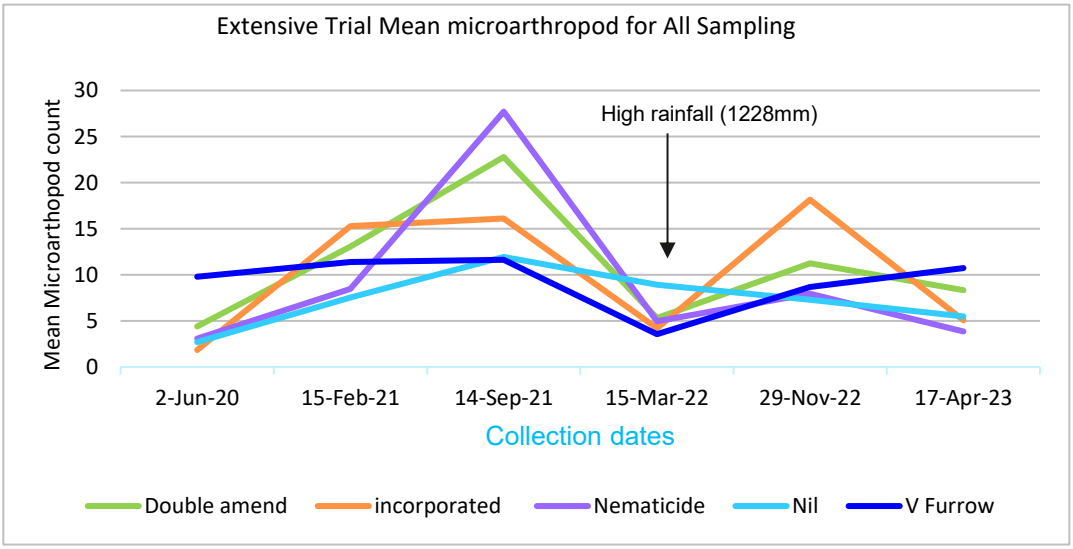

Figure 4 Graph of mean microarthropod count in each treatment over time.

All amendments showed an increase in the overall mean microarthropod counts over the first three collection dates, before decreasing on 15/03/2022. The decrease can be attributed to March 2023's high rainfall. All amendments except the nil and nematicide treatments then showed an increase

followed by a decrease.

Microarthropod populations in the amendment treatments fluctuated. This is proven to be affected by agronomic practices such tillage, application of chemicals (as in pesticides, nematicides and even fertilisers) (Winter et al 1990, Seymour 2006, Stirling 2016). Population fluctuations can be caused by environmental factors such as temperature and rainfall (Winter et al 2006), acidity and alkalinity of soil (measured as pH) Figure 3 presents an observation on mean microarthropod versus pH. Microarthropod population is inversely proportion to pH for different treatments. As pH increases, microarthropod populations decreased and vice versa.

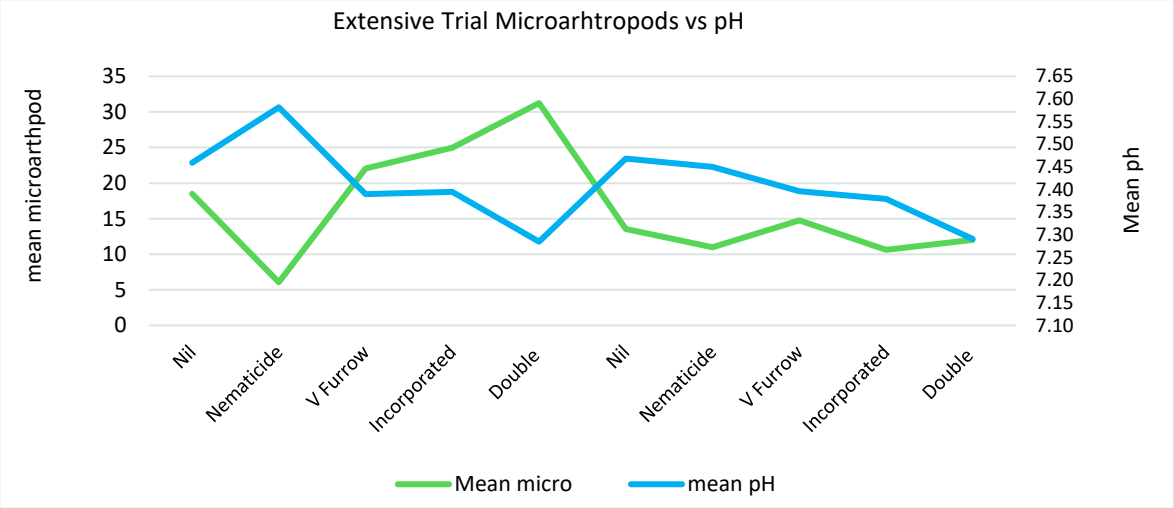

Figure 5 Graph of microarthropod vs pH for all treatments

Nematode trapping fungi

There was a significant effect of collection date ($p<0.001$) for NTF. The proportion of NTF was highest on the first collection date (01-Jun-20). The mean proportion of plates with trapping decreases significantly over the first assessment before increasing and remaining reasonably stable.

Table 4 Mean proportion for NTF for all collection date.

Date collected	Means	
1-Jun-2020	0.273	a
15-Feb-2021	0.000	d
14-Sep-2021	0.101	bc
15-Mar-2022	0.075	c
29-Nov-2022	0.131	bc
17-Apr-2023	0.159	b

The interaction of treatment and collection date was significant (<0.001). Table 6 presents a comparison between treatments within a date. The only sample with no significant difference was the collection on the 15-Mar-22. Only one plate has conidia. This could be attributed to high rainfall. Application of chemicals (herbicide, pesticide, nematicide and even fertilizer affects soil biology populations (Winter et al 1990, Seymour 2006, Stirling 2016).

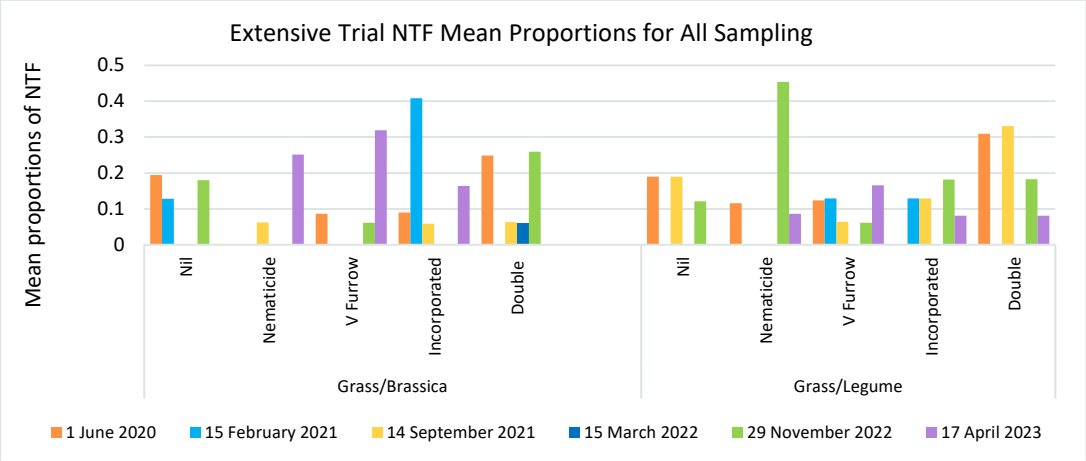

Figure 6 Graph of mean proportion of NTF for all sampling dates.

When comparing treatments overtime, the only significant difference between the crops occurs for the double amendment on 14-Sep-21 and nematicide treatment on 29-Nov-22.