# Organic Sweet Potato IPM: from prevention to prescription

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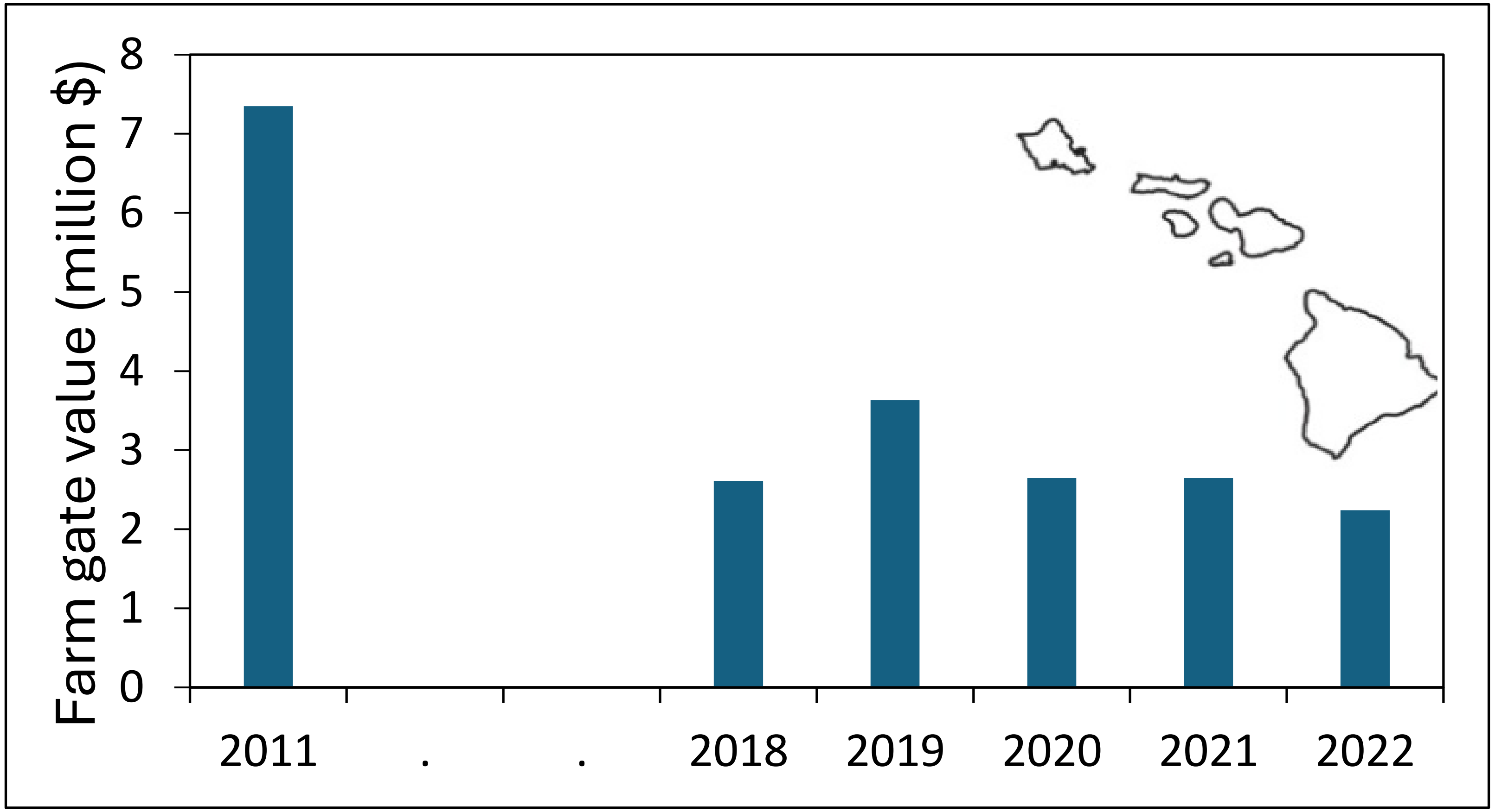


## Hawaii Sweetpotato Production on a decline

Heavy tillage destructive to soil health| intense pest pressure| labor intensive| Organic production is challenging

# Objectives

Develop Organic IPM strategies :

1) against key insect pests
2) against key plant-parasitic nematodes, and
3) to improve soil health properties (prescription & prevention)

# Weevil-Stem Borer Complex



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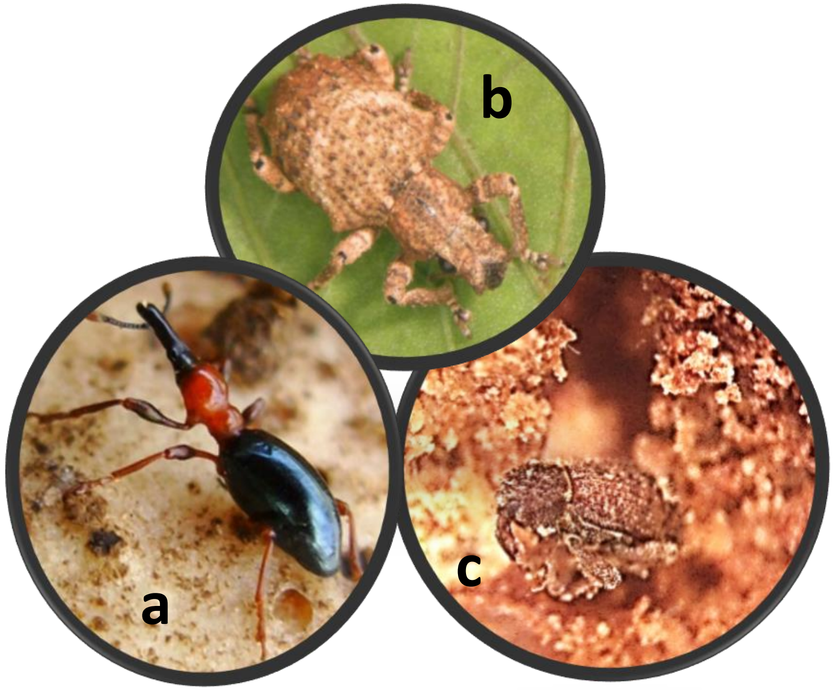
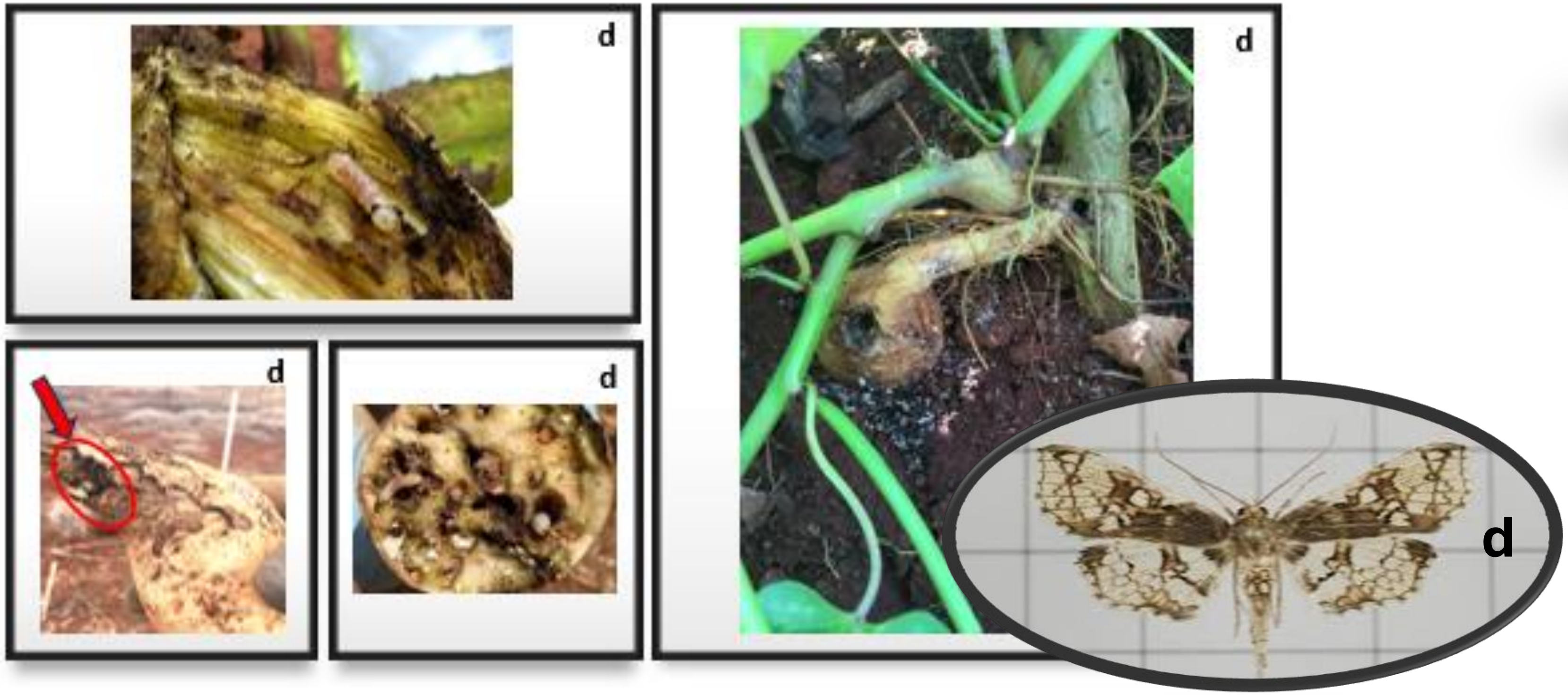


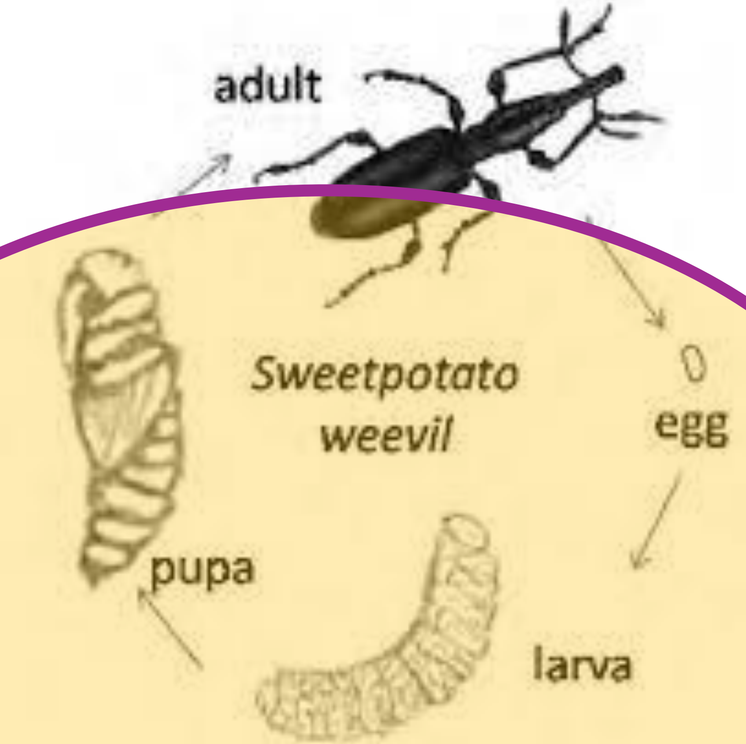




a. Sweet potato weevil (*Cylas formicarius*)
b. Rough sweet potato weevil (*Blosyrus asellus*)
c. West Indian sweet potato weevil (*Euscepes postfasciatus*)
d. Sweetpotato stem borer (*Omphisa anastomosalis*)

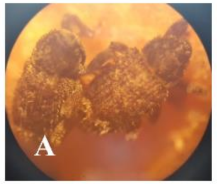
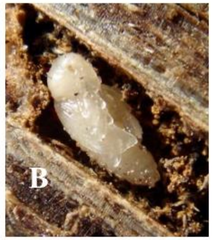
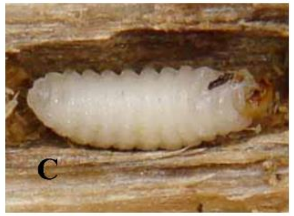
# Sweet potato weevil

(*Cylas formicarius*)

47 days from eggs to adult, adult can live for 42 days.




**Bore inside sweet potato roots/stems**

| Weevil | Adult | Pupa | Larva |
|---|---|---|---|
| *Euscepes batatae* |   |   |   |
| *Cylas formicarius* |   |   |   |

(Fatiaki et al., 2018)

(Stathers et al., 2018 by International Potato Center CIP)

(HDOA, 2011)

# Rough sweet potato weevil

(*Blosyrus asellus*)

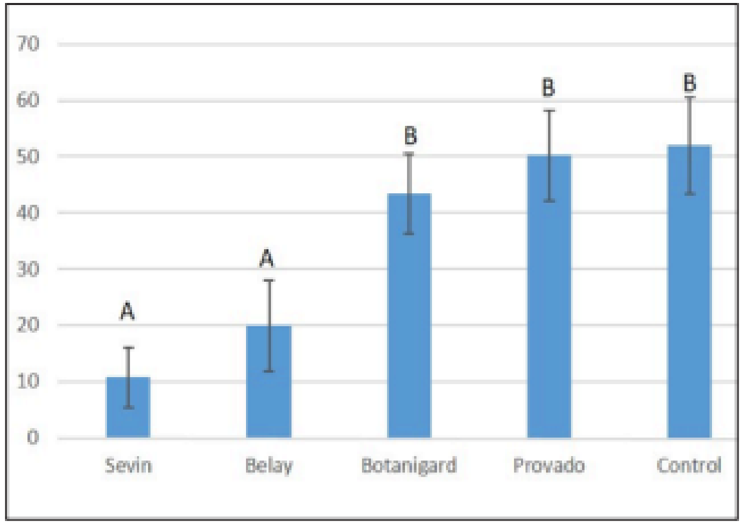



**Figure 4. Percent of all tubers with characteristic damage caused by rough sweetpotato weevil (RSW) after treatment with four insecticides and a control. Bars denoted by same letters are not significantly different.**

**Table 1. Mean ± SE of percentage of tubers damaged by RSW based on the grade of tubers.**

| Treatment | RSW-damaged marketable tubers, % | RSW-damaged off-grade tubers, % |
|---|---|---|
| Sevin | 10.6 ± 7.2¬¬A | 10.8 ± 4.6A |
| Belay | 26.2 ± 5.5A | 5.4 ± 1.6A |
| BotaniGard | 48.8 ± 9.5BC | 31.2 ± 7.2B |
| Provado | 56.8 ± 10.1C | 30.2 ± 2.1B |
| Control | 60.8 ± 10.1C | 25.2 ± 6.3B |

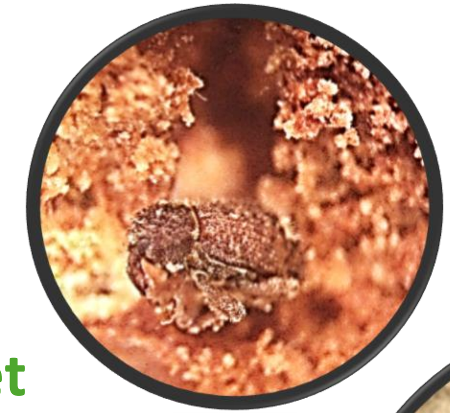
**Note: Figures followed by the same letters are not significantly different.**

Long residue chemical is effective, but not the biopesticide commercially available in Hawaii.

(Pulakkatu-thodi et al., 2016)

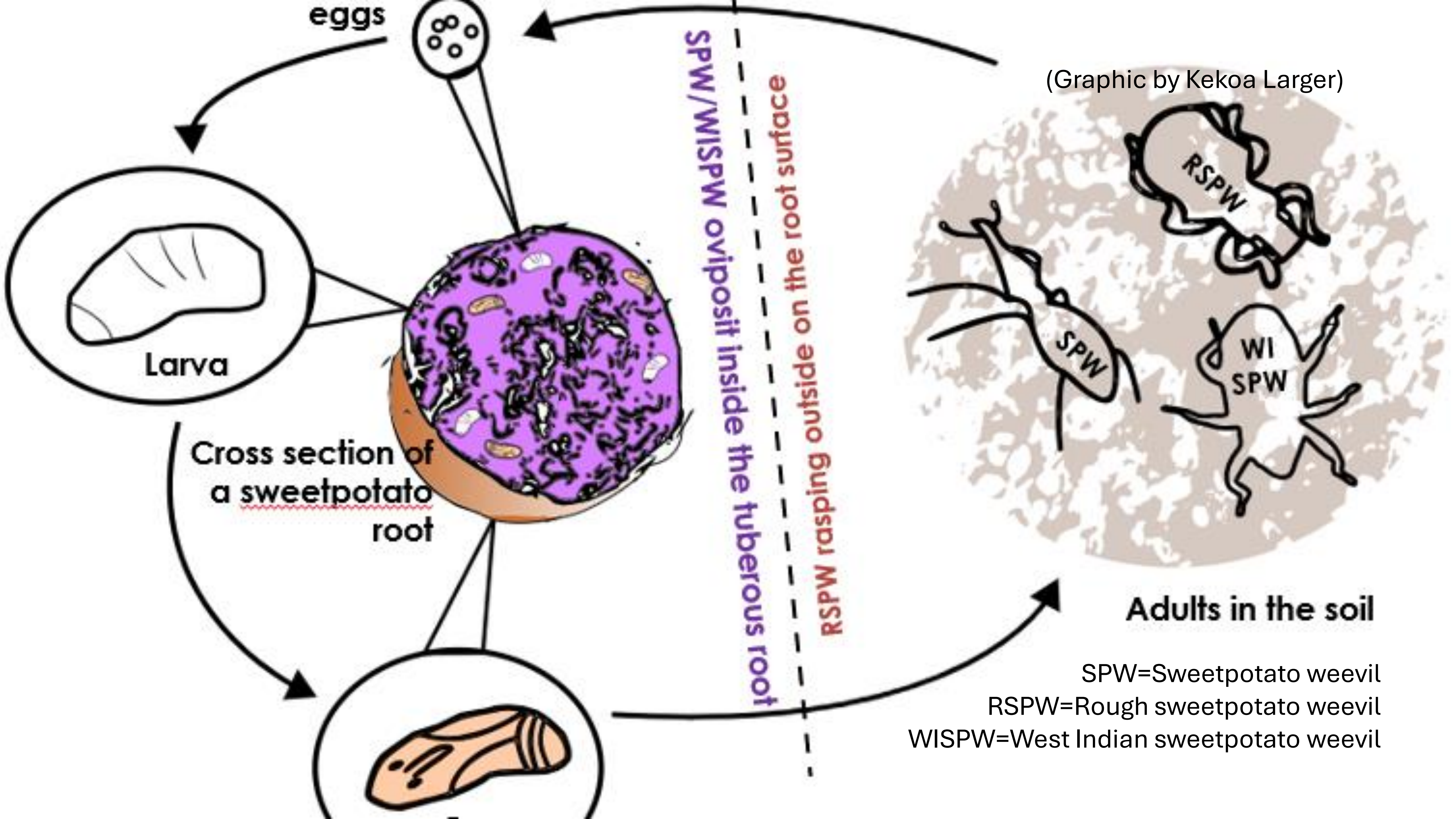
# West Indian sweet potato weevil

(*Euscepes postfasciatus*)



**Bore inside sweet potato roots**

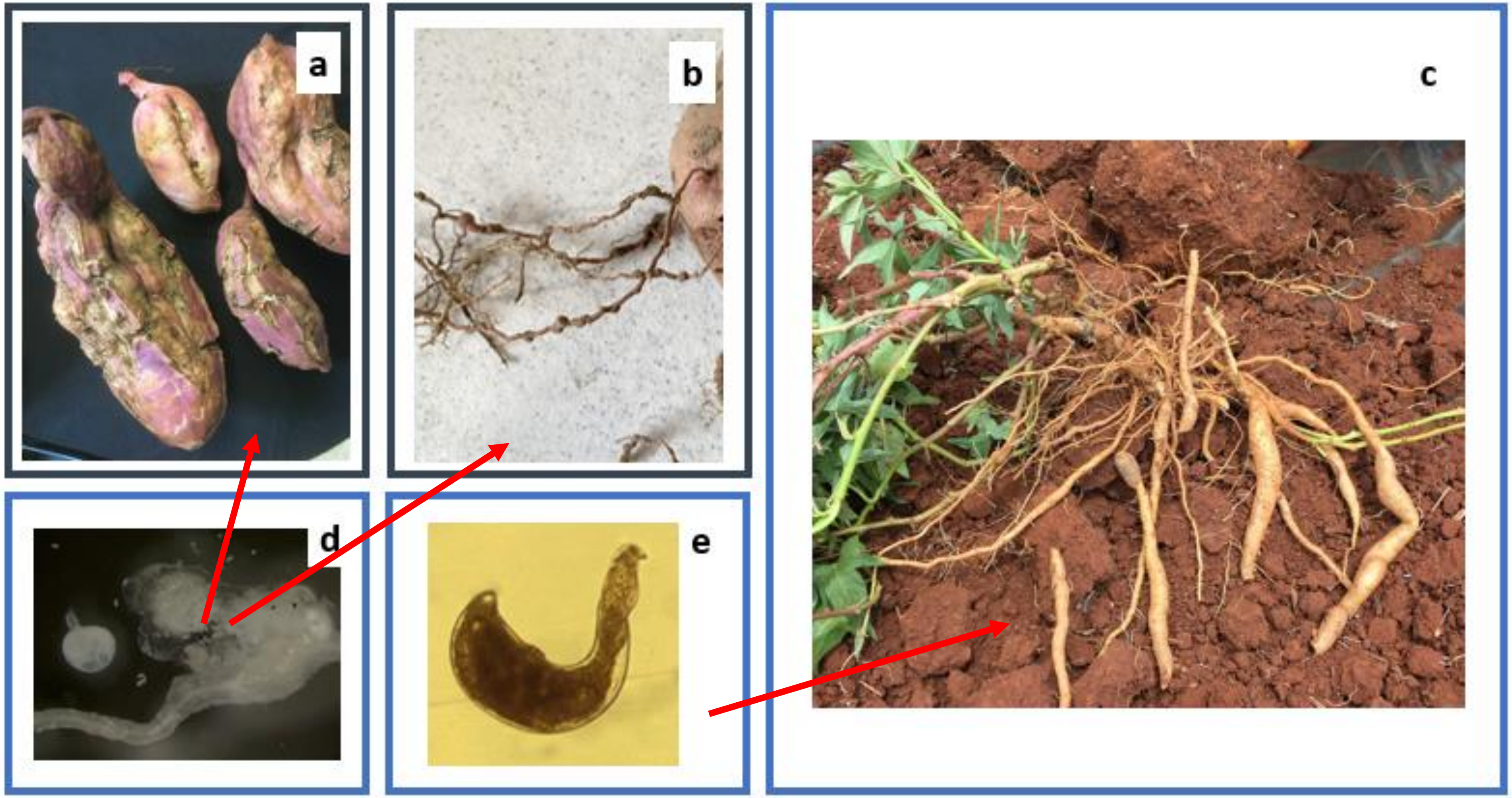
33 days from egg to adult, adult longevity is about 75-105 days (O'sullivan, ynd)




(Graphic by Kekoa Larger)

SPW=Sweetpotato weevil
RSPW=Rough sweetpotato weevil
WISPW=West Indian sweetpotato weevil

# Root-knot and Reniform Nematodes




Root-knot

Reniform

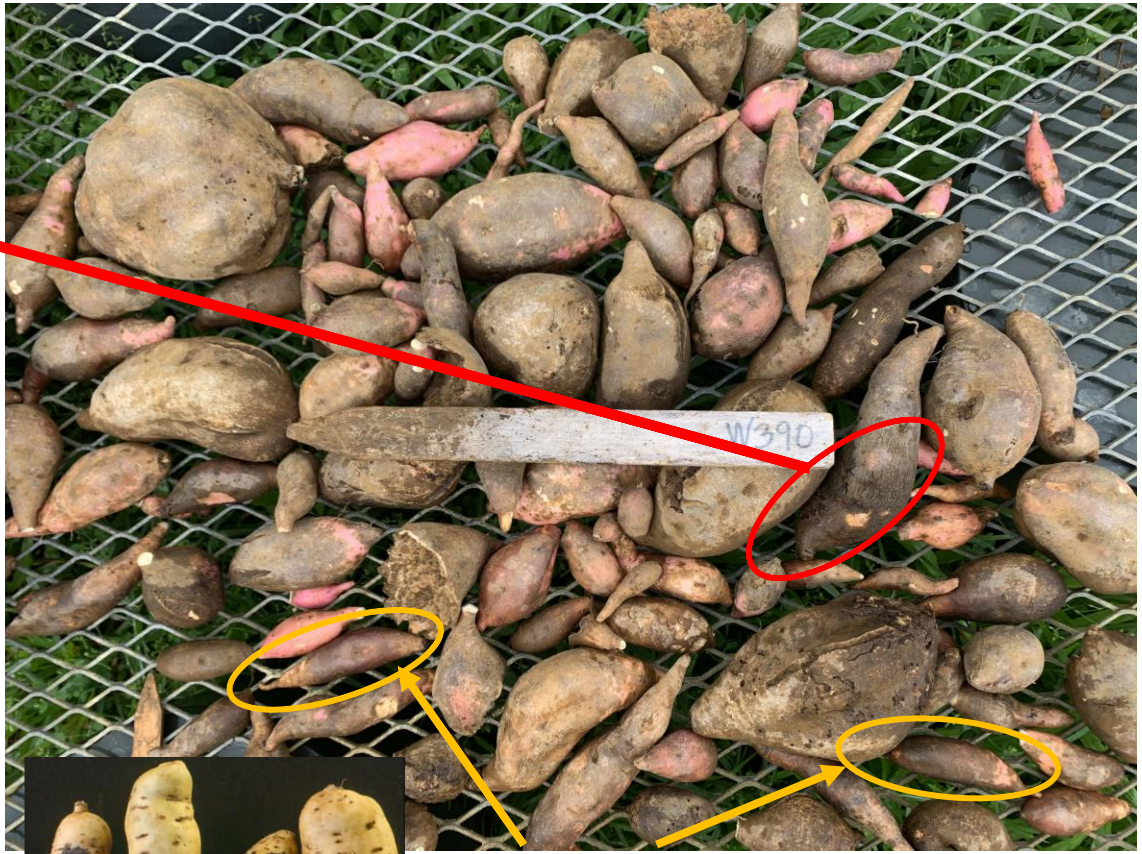
# Nematode Damage on Sweet Potato by root-knot or reniform nematodes

| PPN/symptoms | Healthy roots | Infected by nematodes | Yield loss (%) |
|---|---|---|---|
| **Root-knot nematodes**<br><br>Root cracking | <br> | <br> | Marketable yield = 81.6%<br><br>Total yield = 47.3% |
| **Reniform nematodes**<br><br>Delay storage roots development | <br>**Velum I** | <br>**Control** | Marketable yield = 35.6 %<br><br>Total yield = 36% |

(Waisen, Wang et al., 2019)

# *Fungal Pathogens*

***Java black rot***



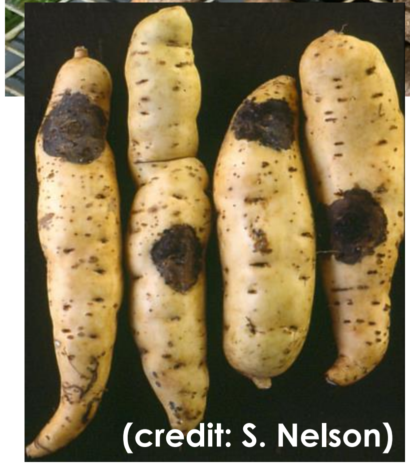

***Scurf***

(Pictured by Roshan Manandhar)

(credit: S. Nelson)


(Credit: R. Mandhar)

***Rhizopus soft rot***

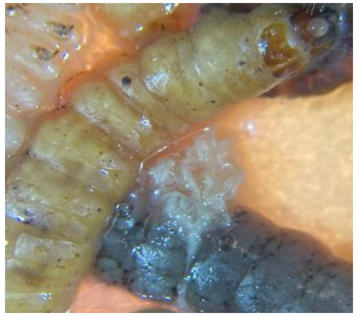


(credit: S. Nelson)

***Ceratocystis black rot***

# Integrated Pest Management (IPM)

- Pre-plant rotation
- ✓ Soil amendment/Bioinsecticide spray
- Post-plant drenching
- Host plant resistance/tolerance
- Integrated nematode and weevil complex  mgmt



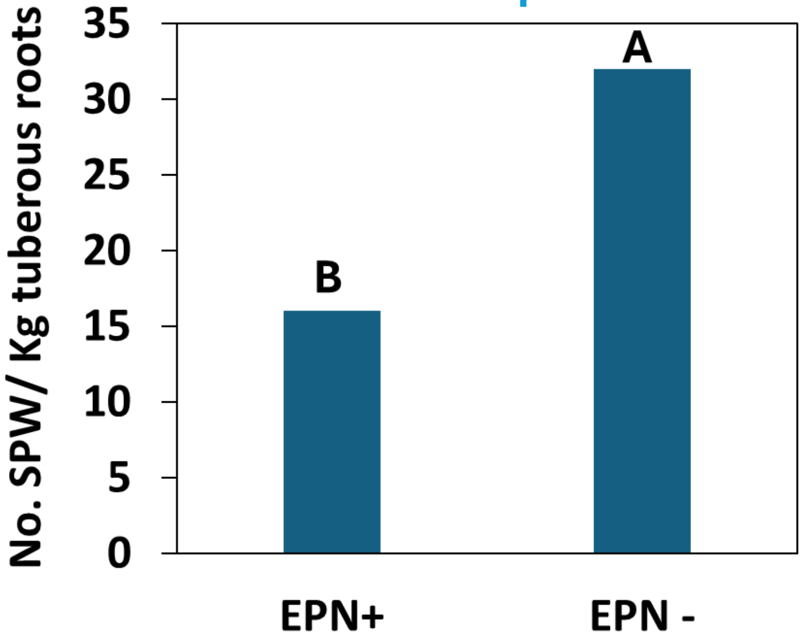
# Bioinsecticides

## Trial I (TwinBridges Farm)

Using an indigenous Entomopathogenic Nematodes (EPN), *Oscheius tipulae,* isolated from Hawaii reduced SPW numbers in tuberous roots. This field has more SPW than RSPW, and *Beauveria bassiana* did not have a significant effect.

***Beauveria bassiana***

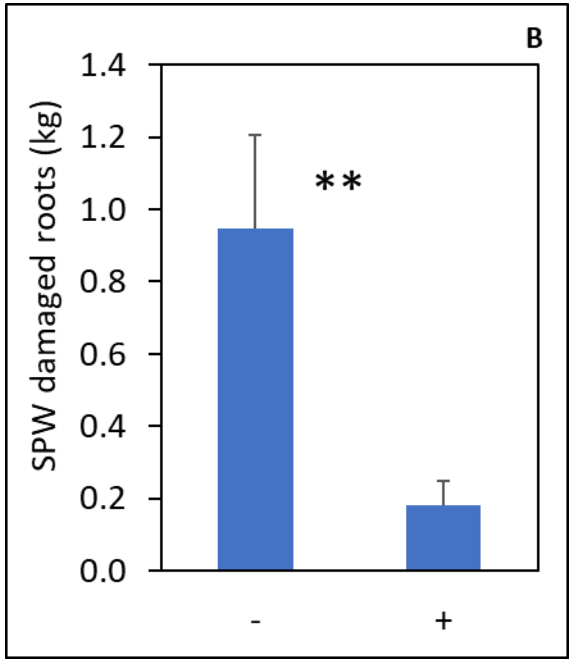

**A 5-month sweetpotato field trial**




EPN basal stem spray @ 2-week intervals

## Trial II (Pomoho Trial)

*B. Bassiana* did suppress SPW damage in a field dominated by RSPW, but did not reduce RSPW damaged roots.

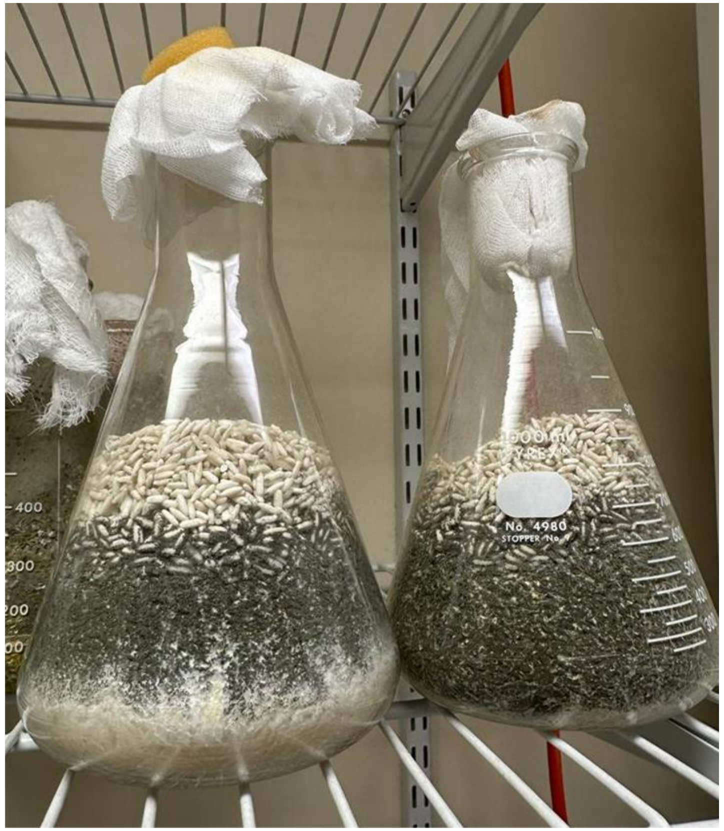



*Beauveria bassiana*

# *Metarhizium* Ko-002 and MetMaster®

MetMaster®
Foliar spray


Ko-002 cultured on rice
Inidgenous isolate from Oahu as soil amendment



*Metarhizium anisopilae*

# *Metarhizium*

## Kualoa Ranch Field trial

- **<u>Main plot</u>**:
  Ko-002 amended compost (+/-)
  1% amendment in the planting holes + velvet bean shredded mulch.

- **<u>Sub-plot:</u>**
  - MetMaster® (+/-) as basal stem spray started at 3 months after planting (sprayed twice)

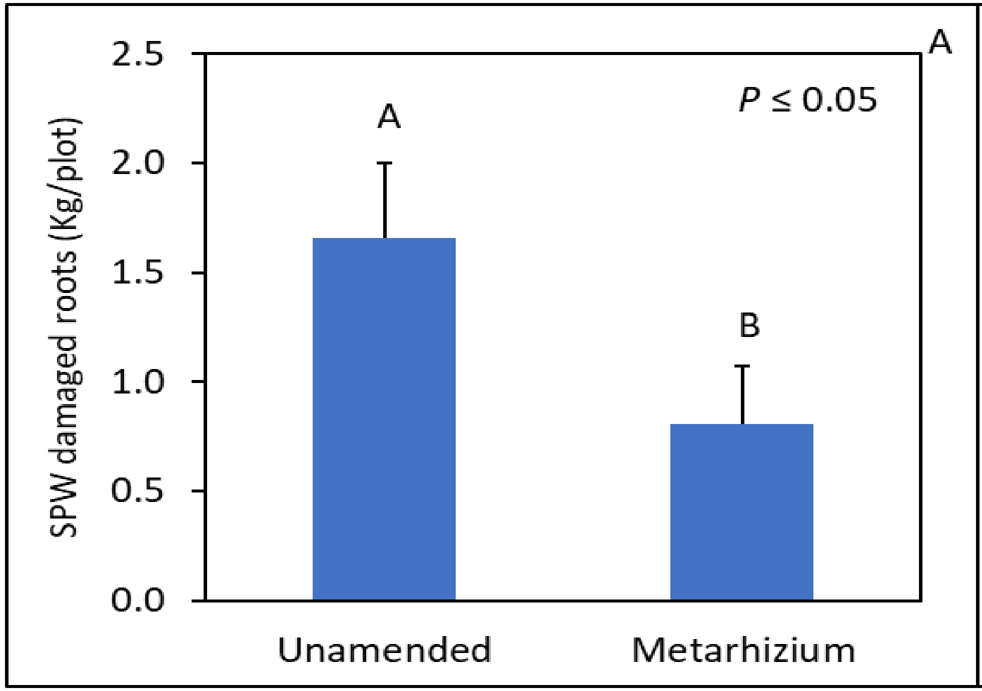
- Sweet potato for 5 months

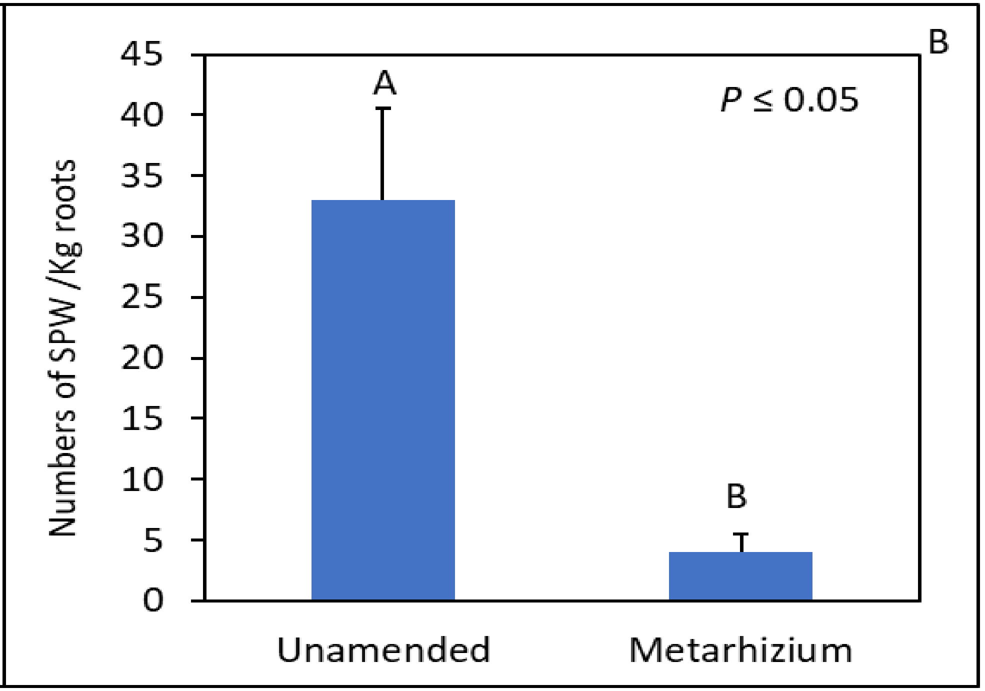
# *Metarhizium*

## Kualoa Ranch Field trial

MetMaster spray did not perform at all.

Ko-002 on mill run amended into soil @ 1% w/w assuming 250 g soil in the planting hole + velvet bean shredded mulch




Velvet bean mulch

Indigenous Metarhizium inoculated compost when amended into the soil reduced SPW no. and damaged roots.

# Metarhizium Amended Compost (1%)

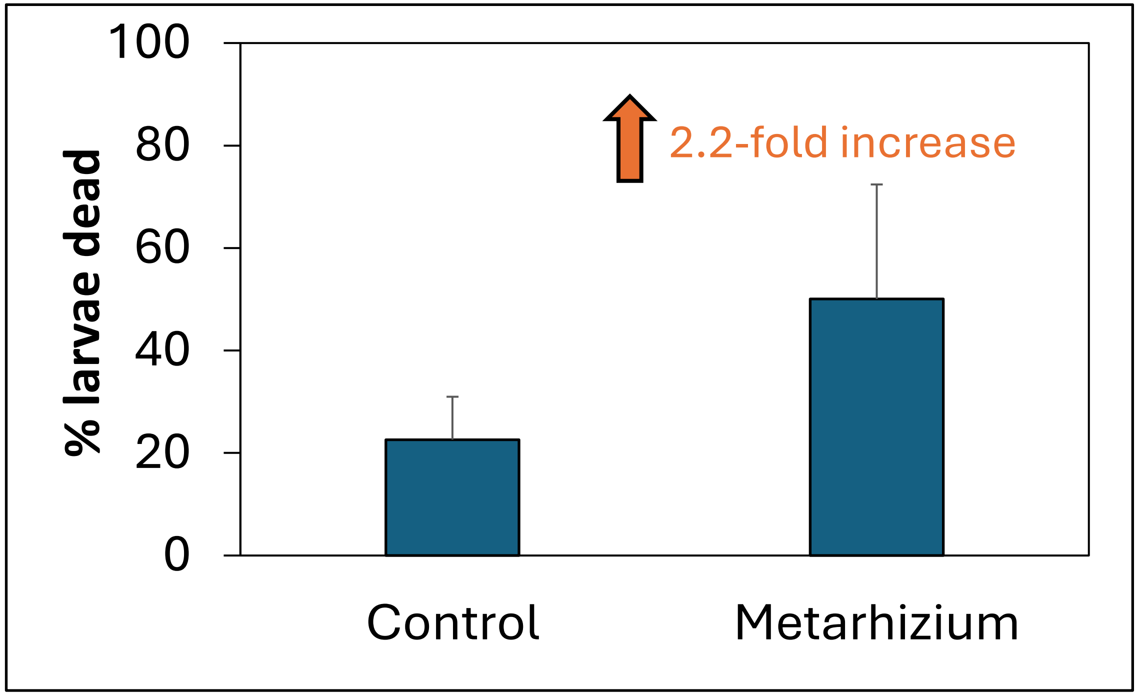
- Sweetpotato culls could harbor significant source of weevil pests in a field and affect next crop planting.
- Would amending indigenous *Metarhizium anisopilae'KO-002'* into field soil with cull sweetpotatoes help to reduce weevil pressure?

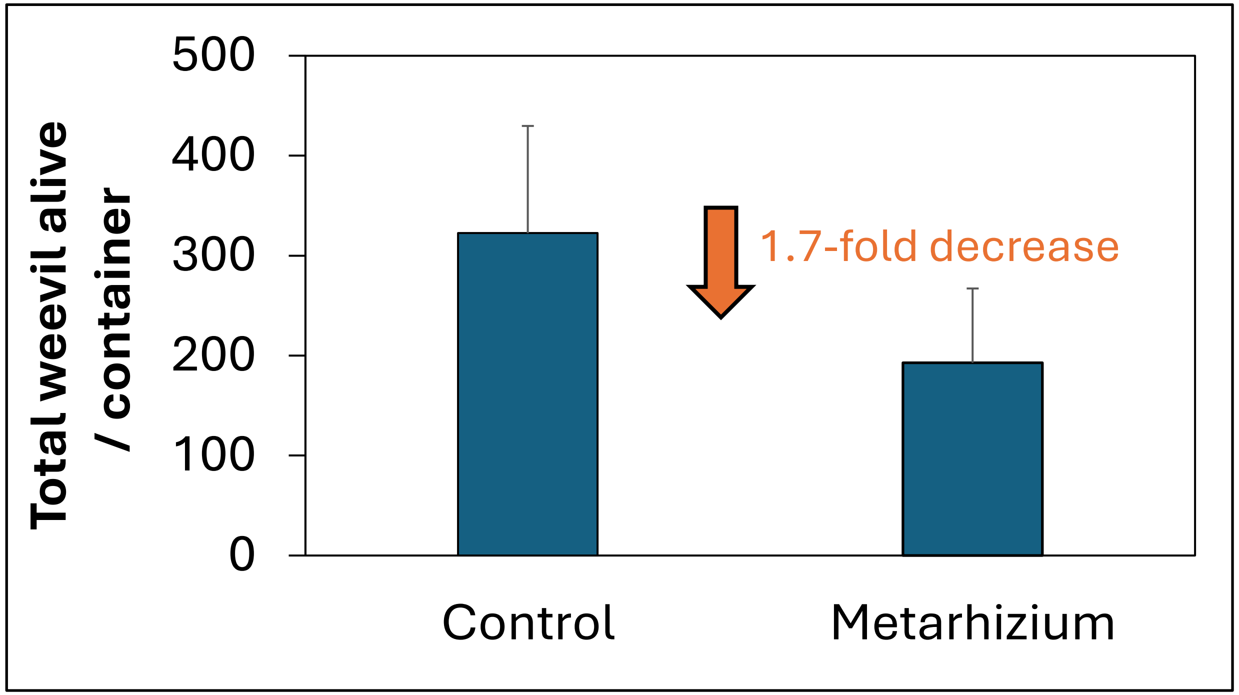
# Laboratory Experiment

Sweetpotato culls (750 g) were incubated in soil tubs with or without KO-002 inoculated mill run at 1% (w/w) for 1 month and checked for:

- weevil larvae, pupae and adults from 150 g subsample of chopped sweetpotato roots (~ 0.5 cm thick pieces)
- % mortalities were calculated.

# Metarhizium Amended Compost (1%) in tubs




- Though not significant, soil amended with Ko-002 increased % larvae dead and reduced the number of weevils (larvae of SPW, WISPW, and adults) in each tub.
- Thus, *Metarhizium anisopilae'KO-002* was showing potential to reduce weevil pressure in infested soil.

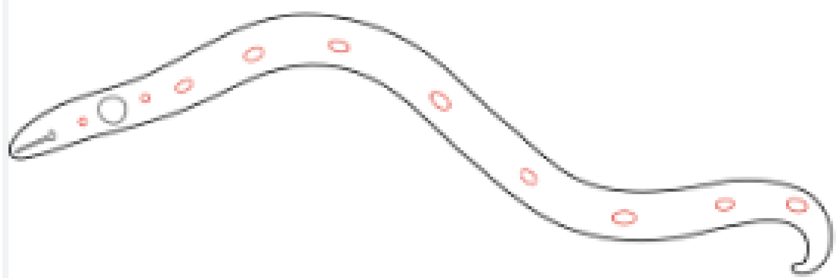
# Integrated Pest Management (IPM)

- Pre-plant rotation
- Soil amendment
- ✓ Post-plant drenching
- ✓ Host plant resistance/tolerance
- ✓ Integrated nematode and weevil complex  mgmt


# Molt-X
# a.i. = azadirachtin

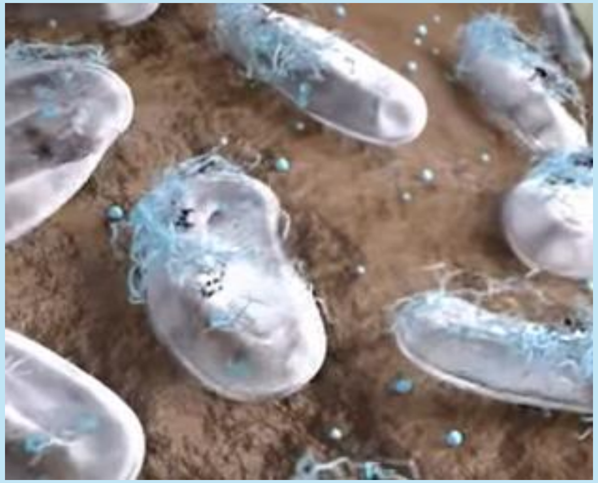
Mechanism of action are mostly studied in insects:

- Affect digestion, endocrine, and reproduction of insects (Mordue et al., 2005).
- Antifeedant activity on phytophagous insects.
- block the biosynthesis of insect growth hormones, such as ecdysteroids on the caterpillars.
- Inhibit the reproductive activities of the ovary and testis, thus reducing the fertility and fecundity of the adults (Lynn et al., 2010)



MeloCon® LC
BIOLOGICAL NEMATICIDE

OMRI
LISTED
For Organic Use



*Purpureocillium (Paecilomyces) lilacinum strain 251 – egg parasite*

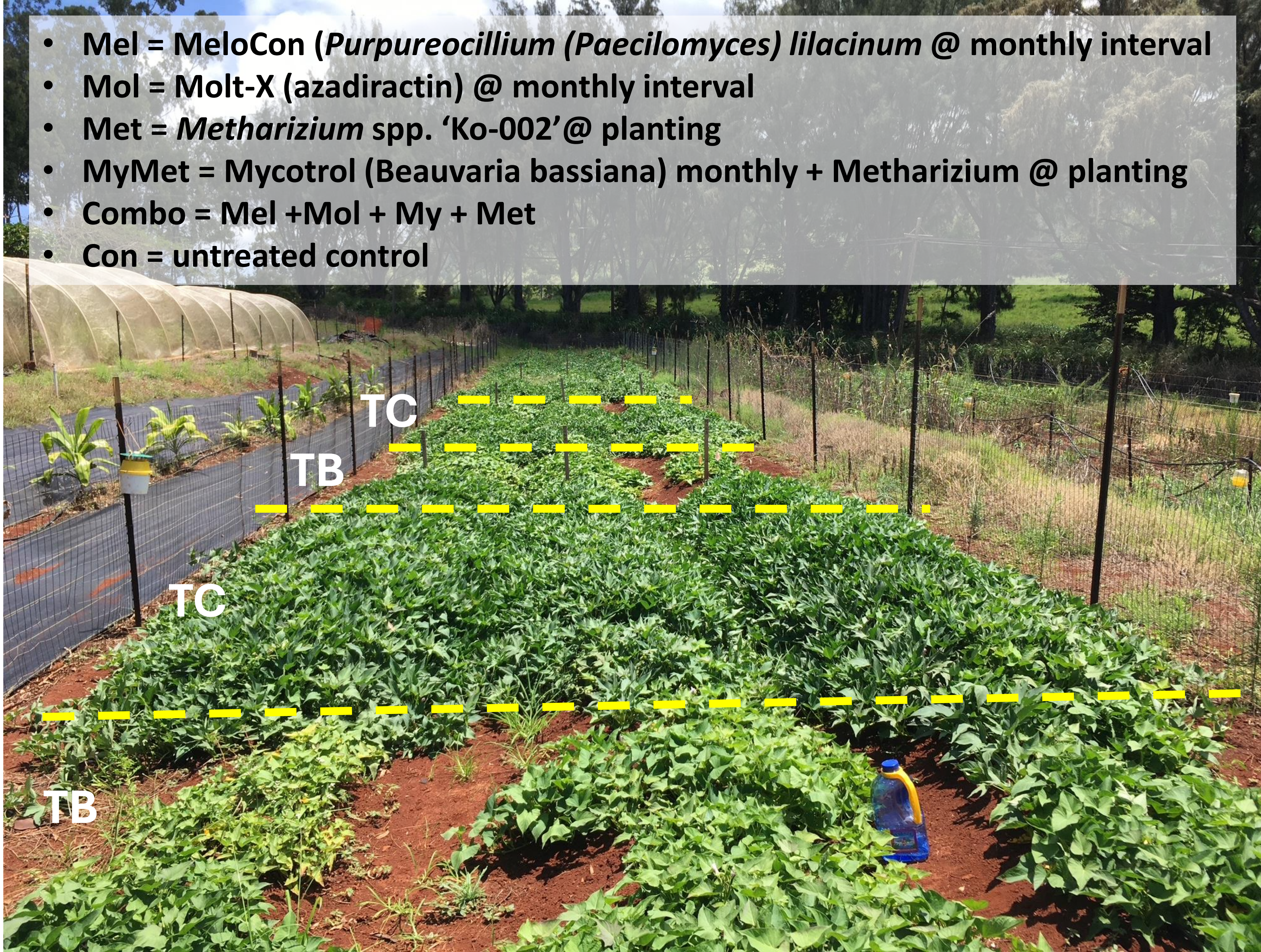
# Integrated Nematode Management (INM)

**‘Okinawan’ sweetpotato**

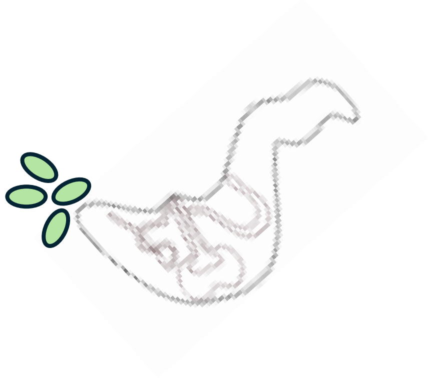
- **TwinBridge (TB)**
- **Tissue cultured (TC)**

In general, TC is more vigorous in growth, and thus also can tolerate more pest pressure.

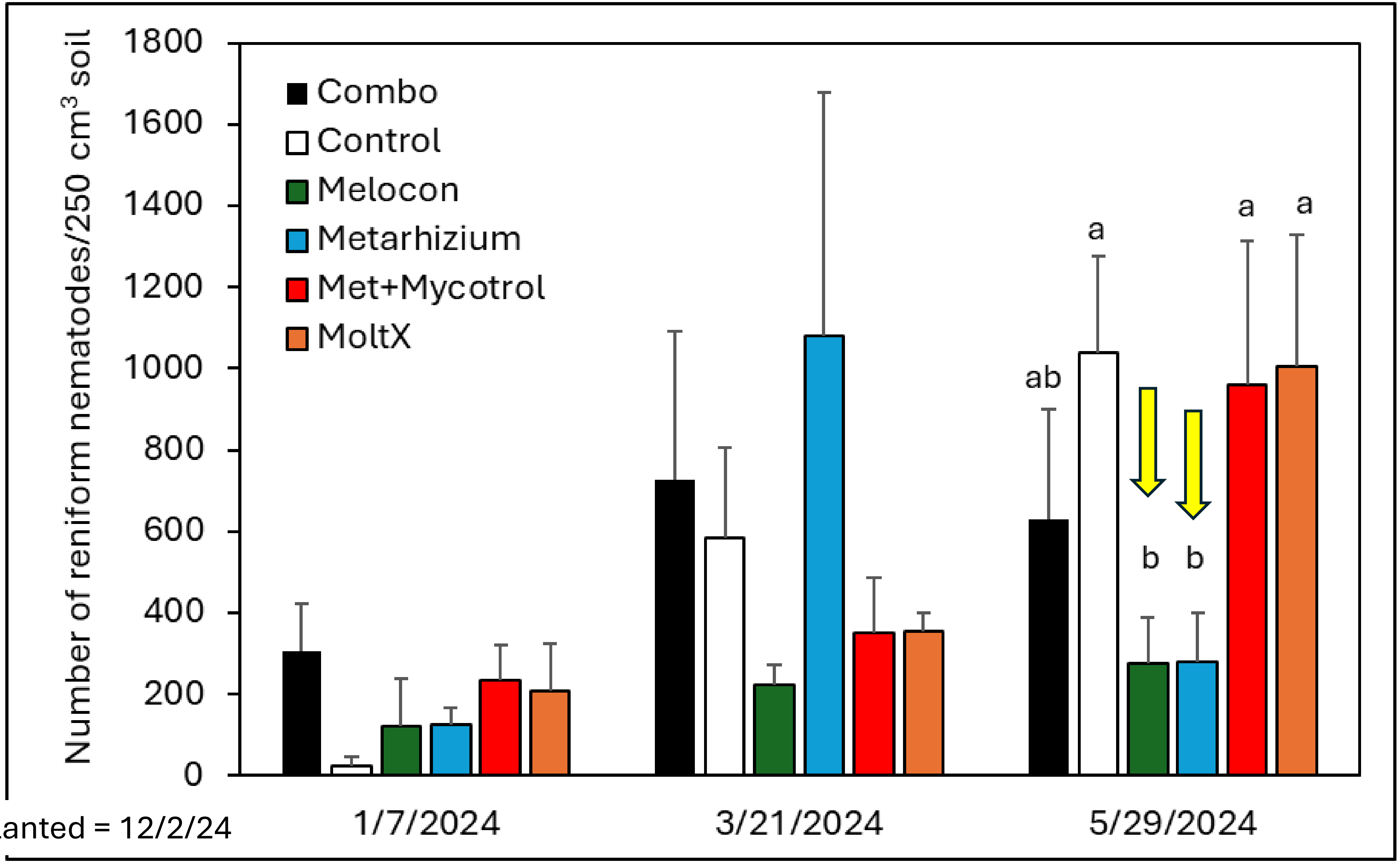
- **Mel = MeloCon (*Purpureocillium (Paecilomyces) lilacinum* @ monthly interval**
- **Mol = Molt-X (azadiractin) @ monthly interval**
- **Met = *Metharizium* spp. ‘Ko-002’@ planting**
- **MyMet = Mycotrol (Beauvaria bassiana) monthly + Metharizium @ planting**
- **Combo = Mel +Mol + My + Met**
- **Con = untreated control**



# MeloCon suppressed reniform nematodes

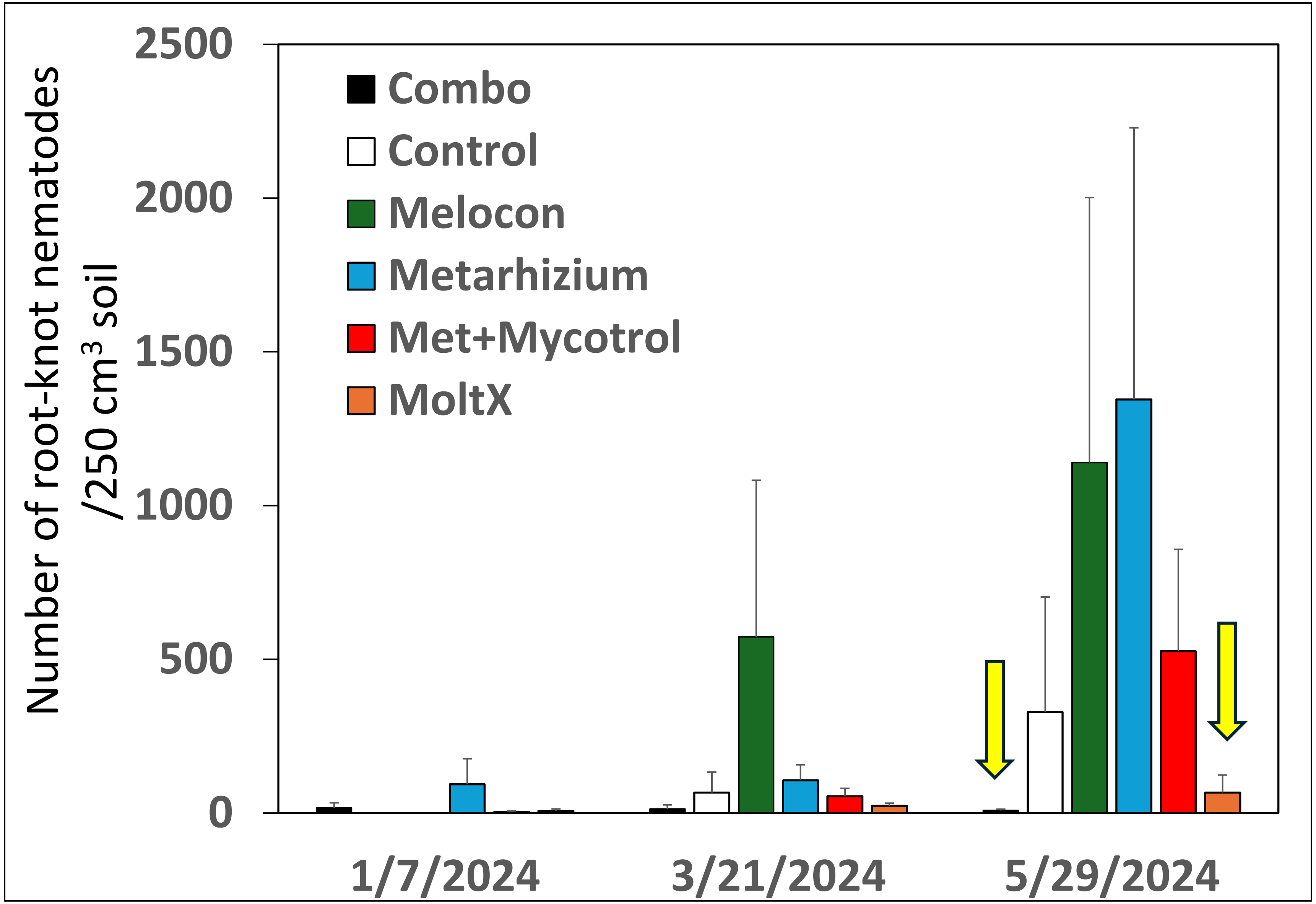


Surprisingly, soil amended with 'KO-002' also suppressed the number of reniform nematodes.

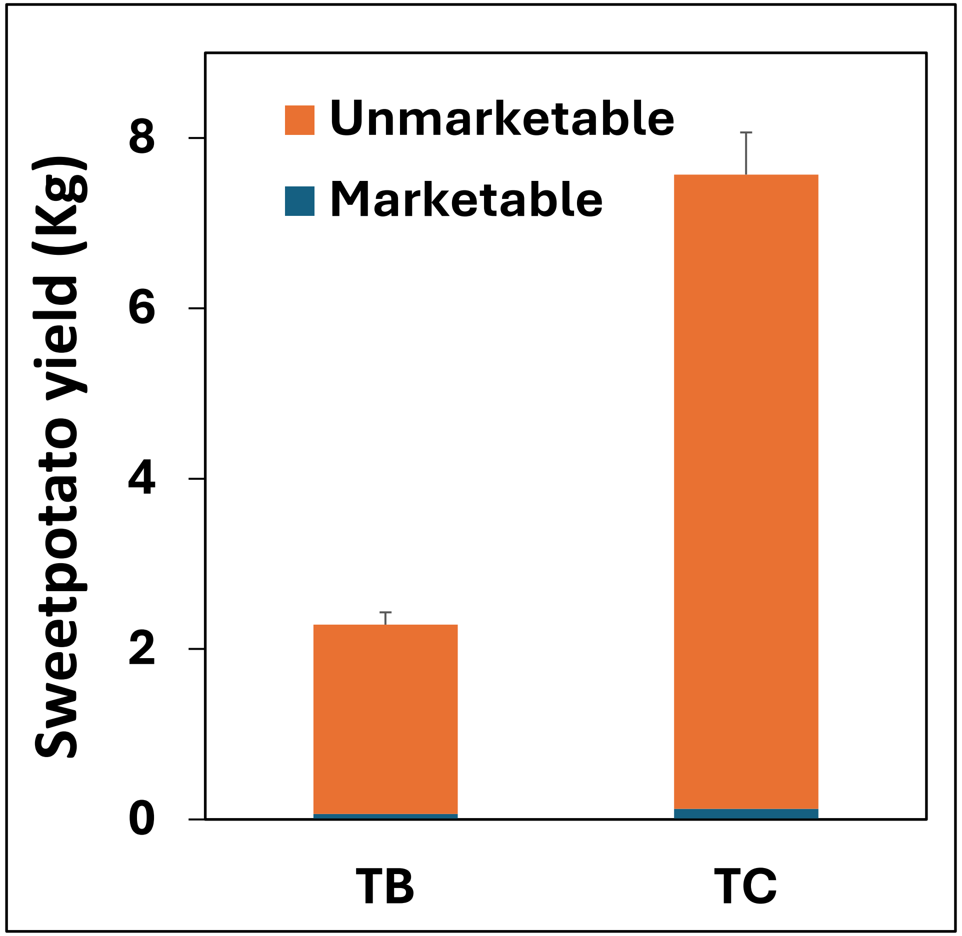


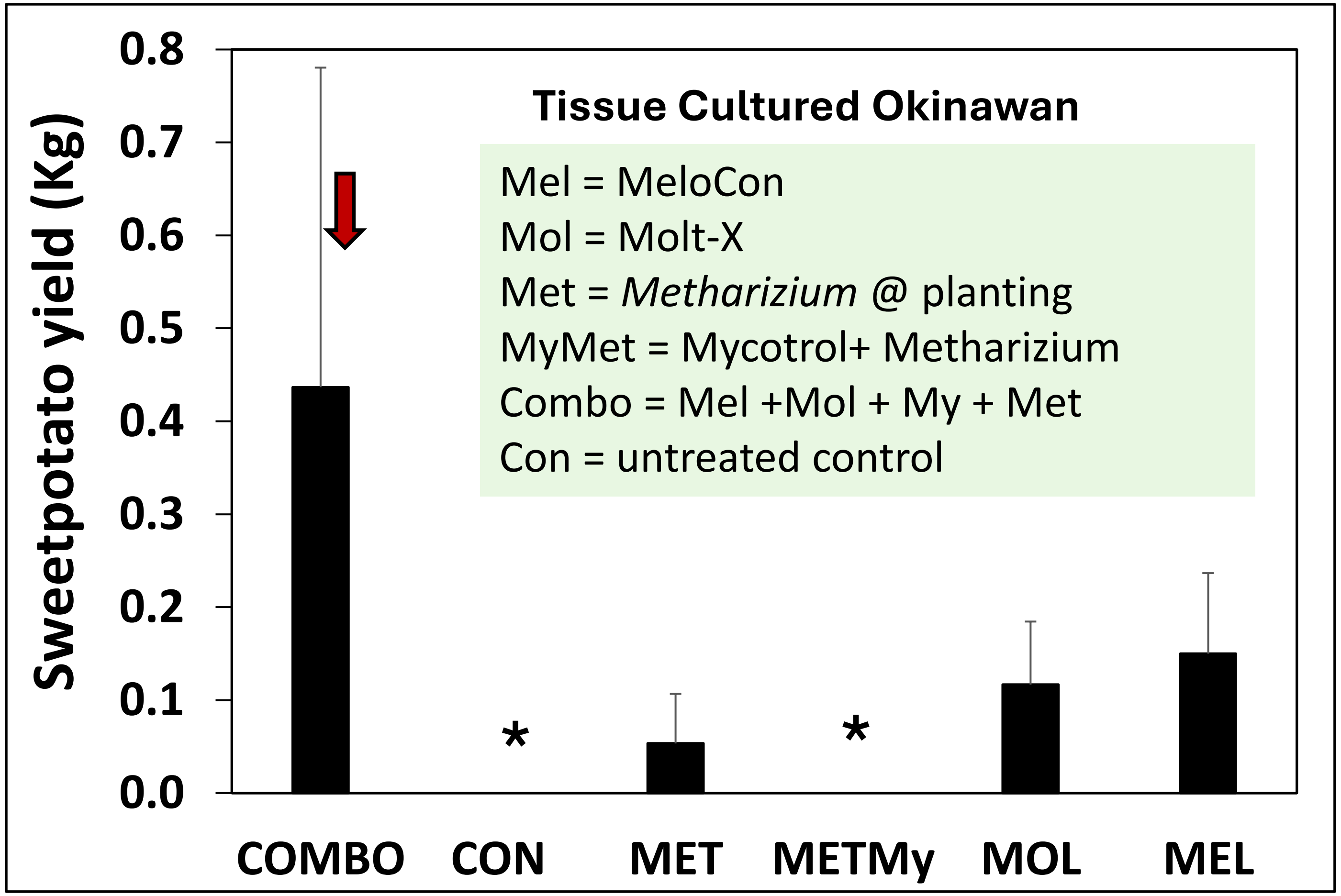

Sweet potato planted = 12/2/24

# Molt-X suppressed root-knot nematodes



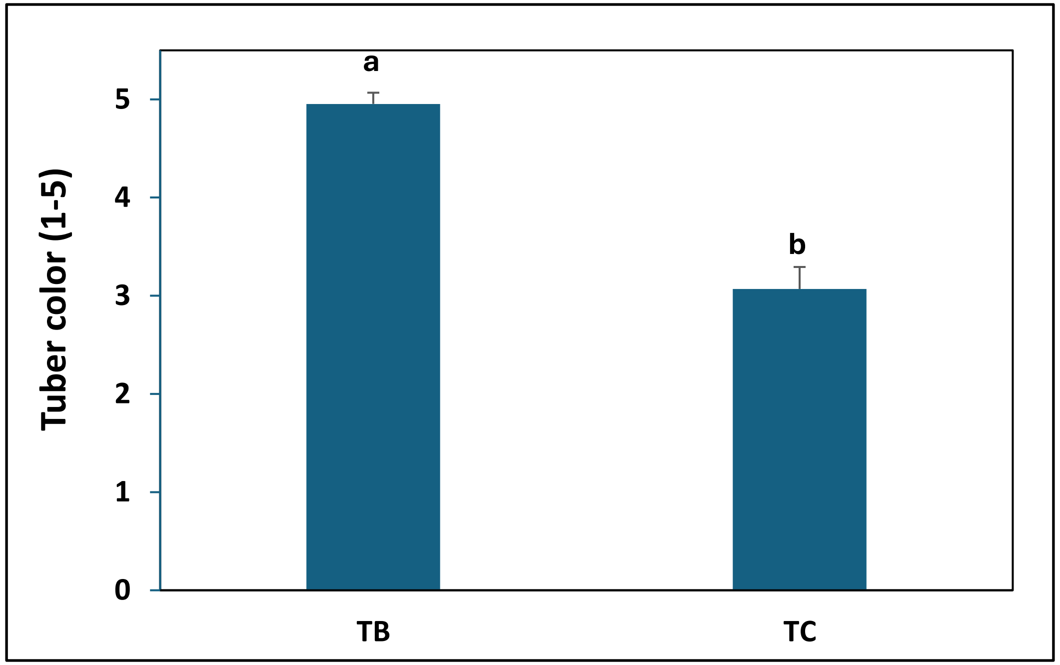
# Integrating Bioinsecticides and Bionematicides increased sweetpotato yield than individual treatment




'TwinBridge (TB)' Okinawan sweetpotato was very susceptible to stem borer damage and was harboring some virus, though the viral symptom was not apparent in the field. Tissu cultured (TC) Okinawan was more tolerant to pests.

Farmers in Hawaii still preferred darker color Okinawan sweetpotato, CTAHR Cooperative Extension is making effort to produce another tissue cultured 'Okinawan' sweet potato that are virus-free so that it is more vigorous in growth.

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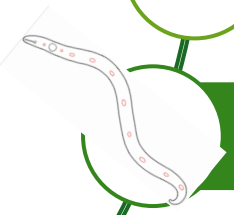
Principals of

# Sustainable Pest Management

- ✓ Enhance crop diversity (cover cropping)
- Support natural enemies
- Induce host plant resistance
- Improving plant health (tolerance)



- Targeting on vulnerable stages of nematodes

- Integrated with weevil complex management

(Wang and Uchida, 2014)

# *Cover Crops with Allelopathic against PPN*

Sunn hemp
*Crotalaria juncea*
*-- monocrotarine*

*T. erecta* and *T. polynema* are resistant to root-knot but very susceptible to reniform nematodes.

French Marigold
*Tagetes patula*
-- *$\alpha$-terthinyl*

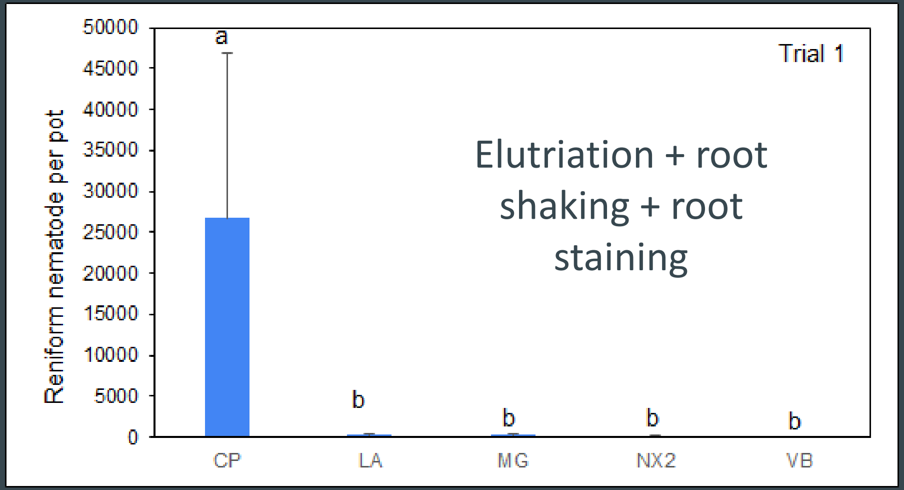
Brown mustard
*Brassica juncea*
-- glucosinolate

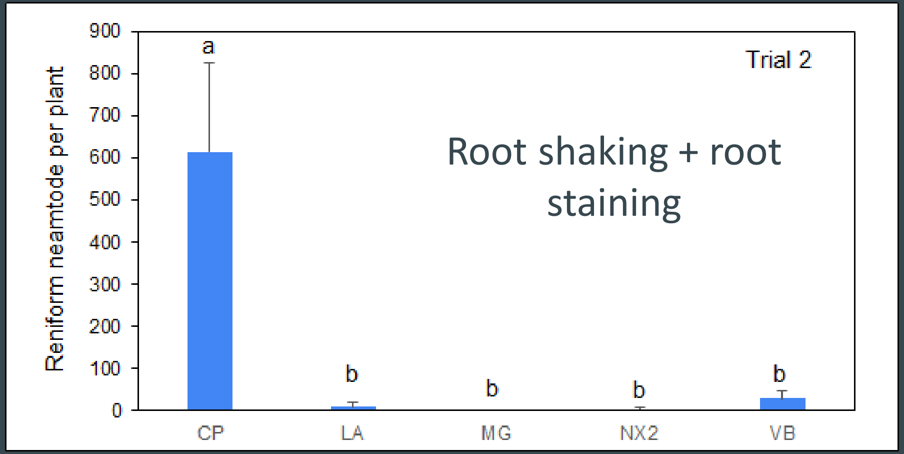
Sorghum-sudangrass
-- Dhurrin

*Velvet Bean (Macuna pruipriens)*
*-- L-DOPA*

# Greenhouse Experiment

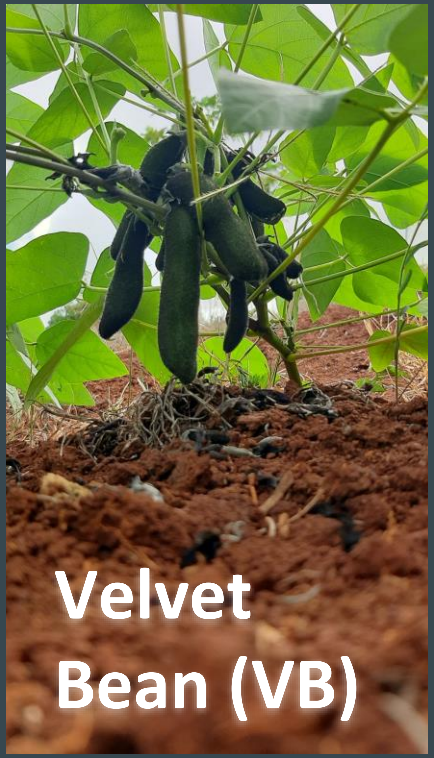
Initial population:
Trial 1 = 180; Trial 2= 400 reniform



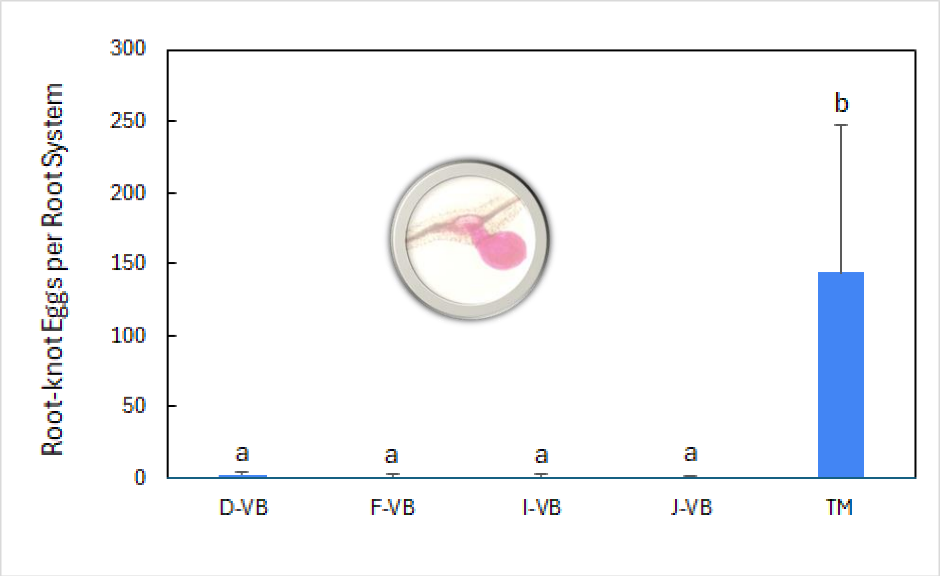



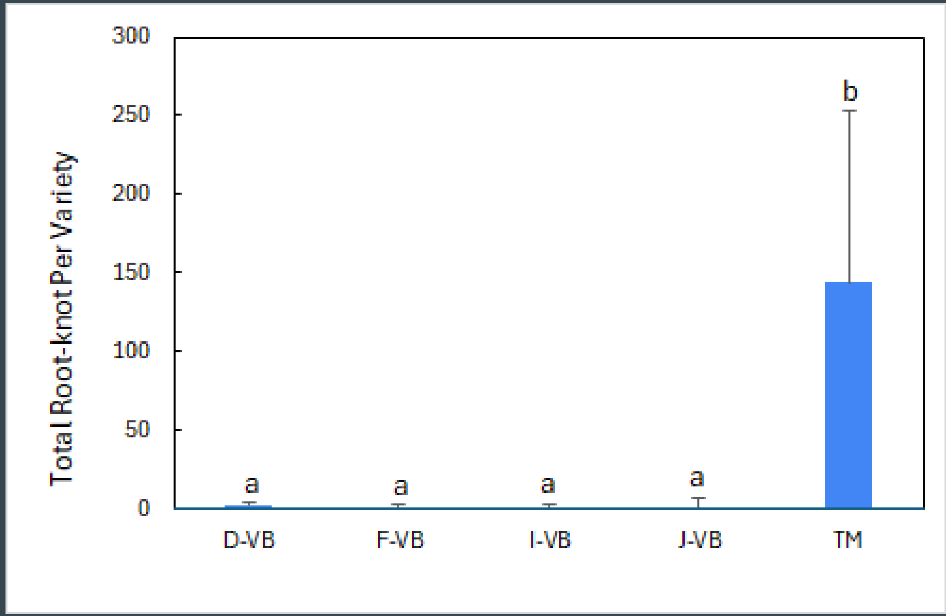

VB, MG and two sorghum varieties tested were resistant to reniform nematodes.






# Greenhouse Experiment


4 accessions of *Mucuna pruriens* var. utilis were tested.
Soil was inoculated with 100 *Meloidogyne incognita*/pot.
'Orange Pixie' tomato was included as a susceptible control.

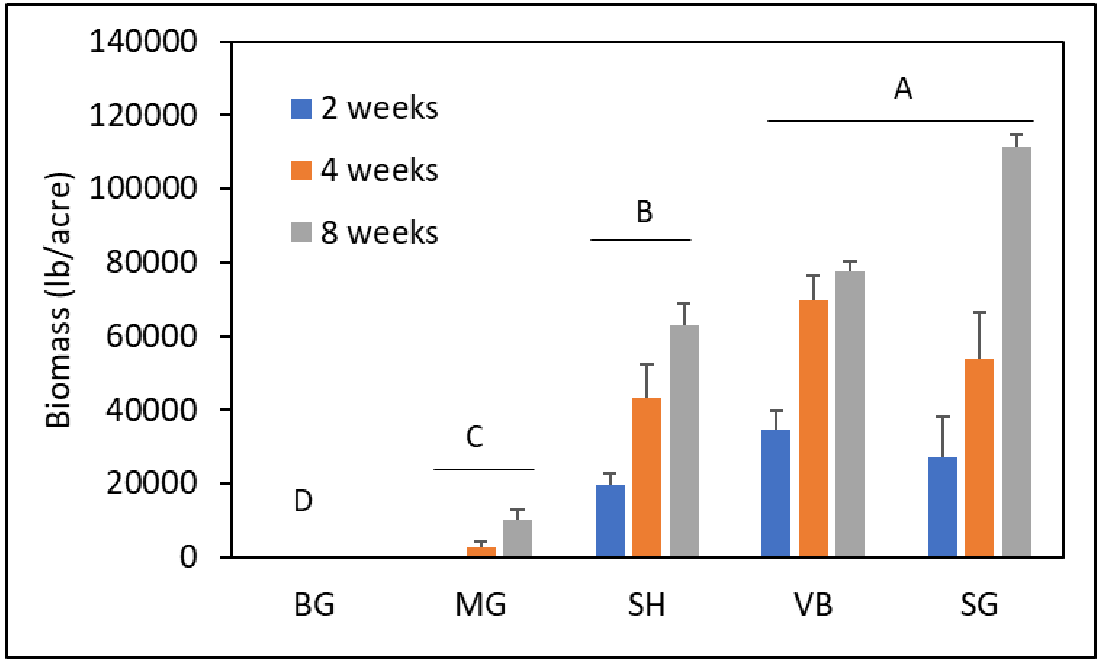
*Mucuna pruriens* var. *utilis* has less risk of becoming an invasive weed because it does not contain the irritating bristles of other *M. pruriens* varieties (Dissanayaka et al., 2024).

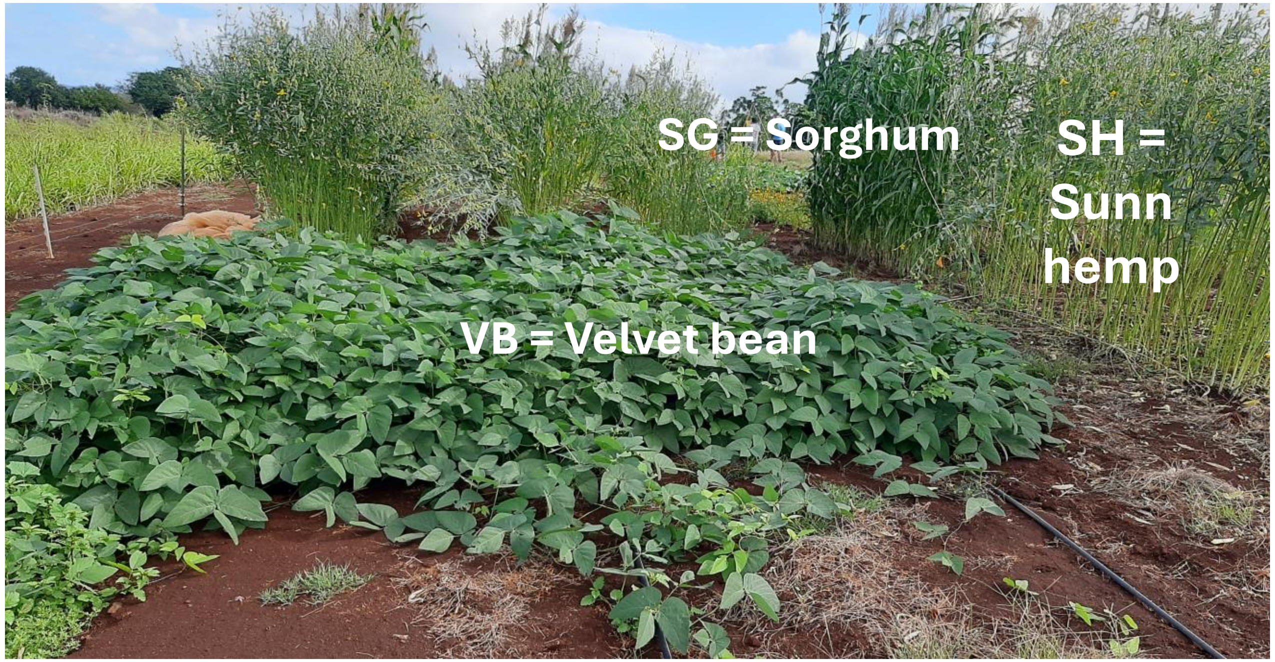
VB = Velvet Bean | TM = Tomato (n=4)

All accessions of VB were resistant to root-knot nematodes.

# Field Experiment

Irrigation regimes on cover crops




**Main factor:**

1) Sunn hemp **SH**
2) Sorghum **SG**
3) French Marigold, **MG**
4) Velvet bean **VB**
5) Bare ground **BG**

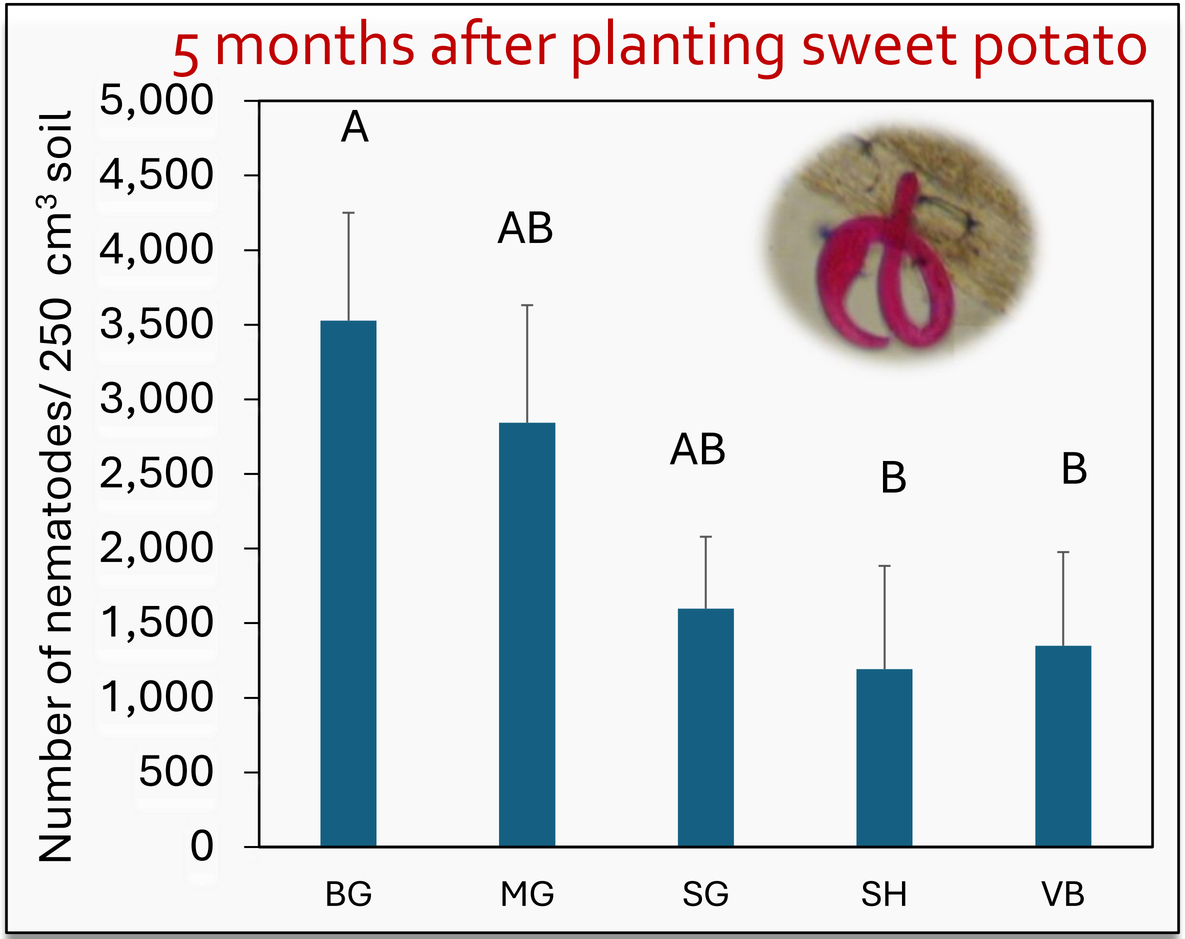
**Sub-factor (sweetpotato for 5 months):**
Beauvaria / no Beauvaria

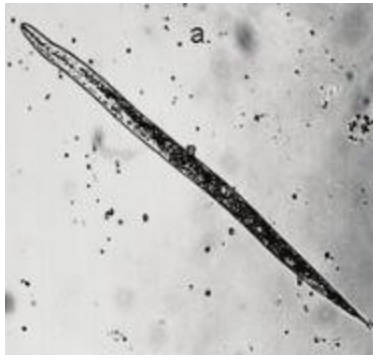
VB was drought tolerant, achieving similar biomass regardless of 4 or 8 weeks of rrigation.

Preplant rotation Velvet bean → Soil amendment → Post-plant drenching → Induce Systemic Resistance → Suppressive soil

# Velvet bean against reniform nematodes

**Year 1**




L-dopa, a neorotransmiter, paralyzed nematodes

BG = Bacre ground, MG=Marigold, SG=Sorghum, SH=Sunn hemp, VB = Velvet bean

## Principals of
# Sustainable Pest Management

- Enhance crop diversity (cover cropping)
- Support natural enemies
- Induce host plant resistance
- Improving plant health (tolerance)
- Targeting on vulnerable stages of nematodes

- Integrated with weevil complex management

(Wang and Uchida, 2014)

## *Natural Enemies of Plant-parasitic Nematodes*

- Occur naturally in soil, but they take time to build up their populations. They can be enhanced by cover crop residues.



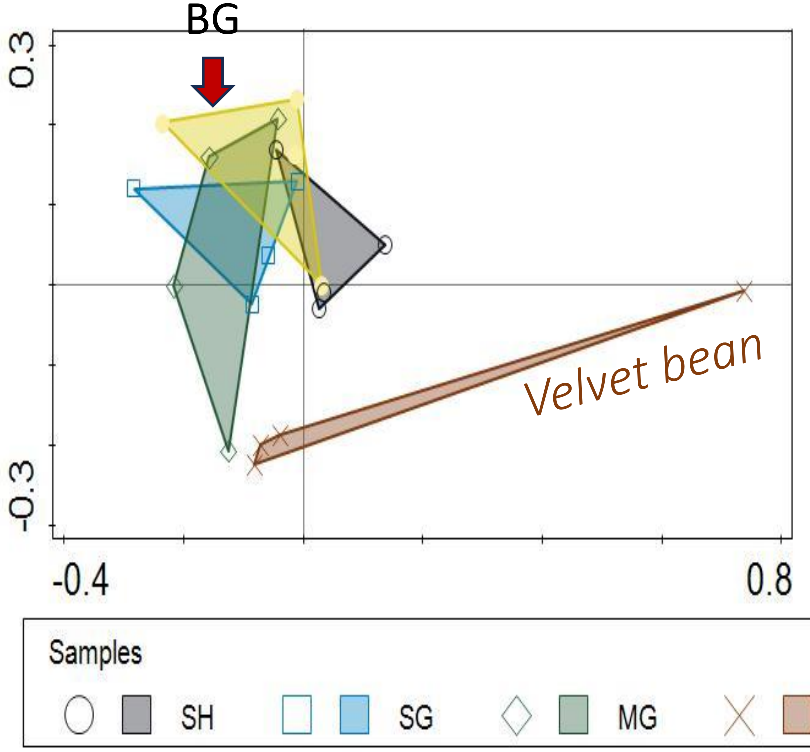

## 3 months after cover cropping & 4 weeks after soil incorporation

- ✓ VB increased arbuscular mycorrhizal fungi (AMF), saprophytic fungi (SF), and resulted in a higher fungi: bacteria (F/B) microbial biomass ratio.
- ✓ In the CCA scatter plot, soil health of VB was most segregated from BG.
- ✓ Increased soil C by 0.38%.

## Microbial biomass (PLFA assay)

| Trt | DIV | ACT (ng/g) | GN (ng/g) | Fungi (ng/g) | AMF (ng/g) | GP/GN | S/U | F/B |
|---|---|---|---|---|---|---|---|---|
| BG | 1.11 b | 140.51a | 120.28 b | 13.05 b | 0.00 b | 3.68 a | 9.16 a | 0.03 b |
| MG | 1.14 b | 132.43a | 145.73 b | 51.80 ab | 3.79 b | 3.53 a | 9.26 a | 0.06 b |
| SG | 1.16 b | 153.45ab | 217.39 ab | 27.96 b | 4.86 b | 2.43 ab | 5.91 ab | 0.04 ab |
| SH | 1.13 b | 157.60ab | 201.29 ab | 22.70 b | 0.40 b | 2.77 ab | 7.42 ab | 0.03 b |
| VB | 1.30 a | 141.66b | 288.49 a | 105.96 a | 33.06 a | 1.89 b | 4.17 b | 0.13 a |

Not stress but more fungal decomposition



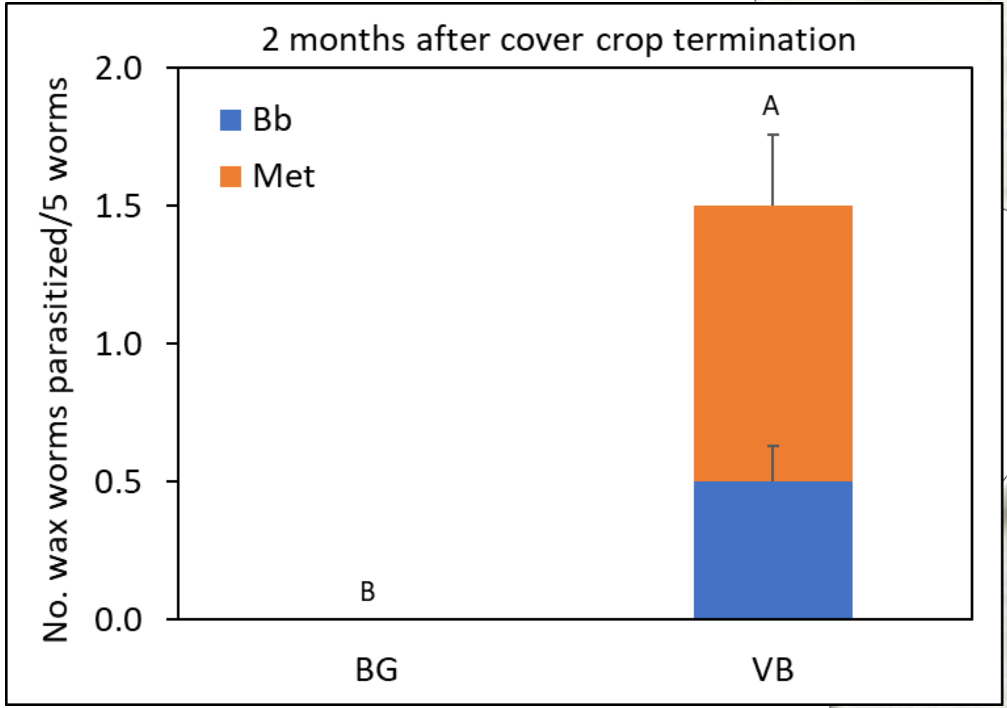

DIV = Diversity
ACT= Actinomycete
GN =Gram – bacteria
GP = Gram + bacteria
AMF = Arbuscular mycorrhizal fungi
S/U = Saturated/Unsaturated PLFA
F/B = Fungi/Bacteria PLFA

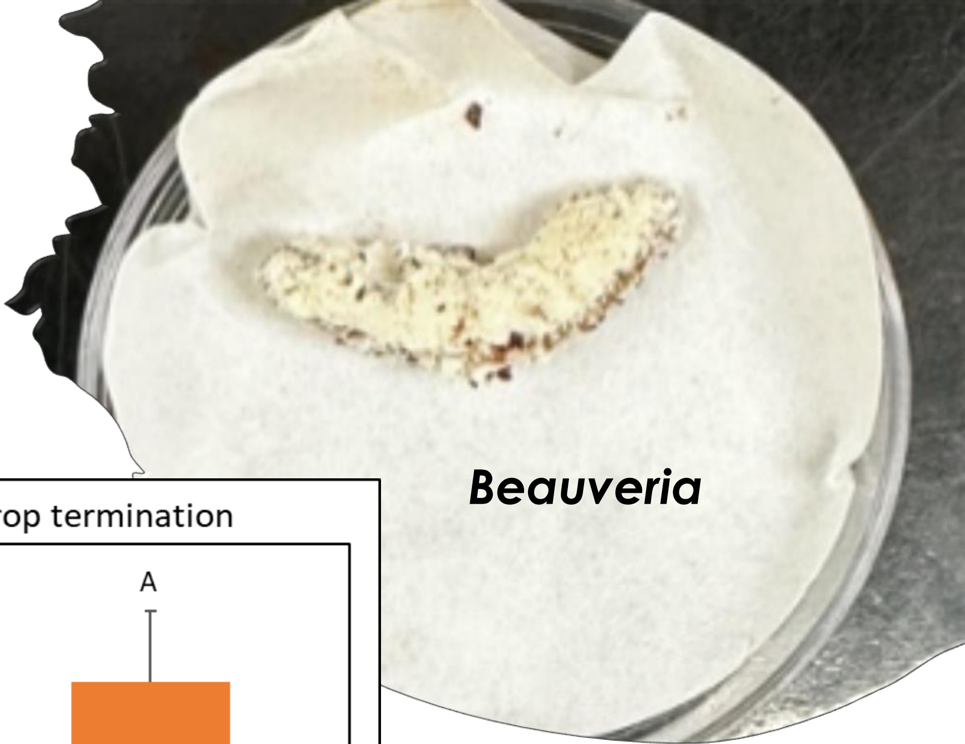
**First two canonical analysis explained 89.43% of variance**

# *Enhance Natural Enemies of weevils/ stem borers*

## Entomopathogenic Fungi

- Preliminary data shown that velvet bean (VB) residues also increased the frequency of waxworm baits colonized by *Metarhizium* and *Beauveria* in the sweet potato field. These are entomopathogenic fungi (EPF) that can parasitize insect pests including SPW, RSPW and WISPW.

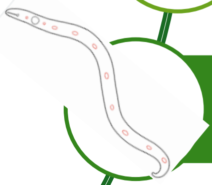



Principals of

# Sustainable Pest Management

- Enhance crop diversity (cover cropping)
- Support natural enemies
- Induce host plant resistance
- Improving plant health (tolerance)
- Targeting on vulnerable stages of nematodes

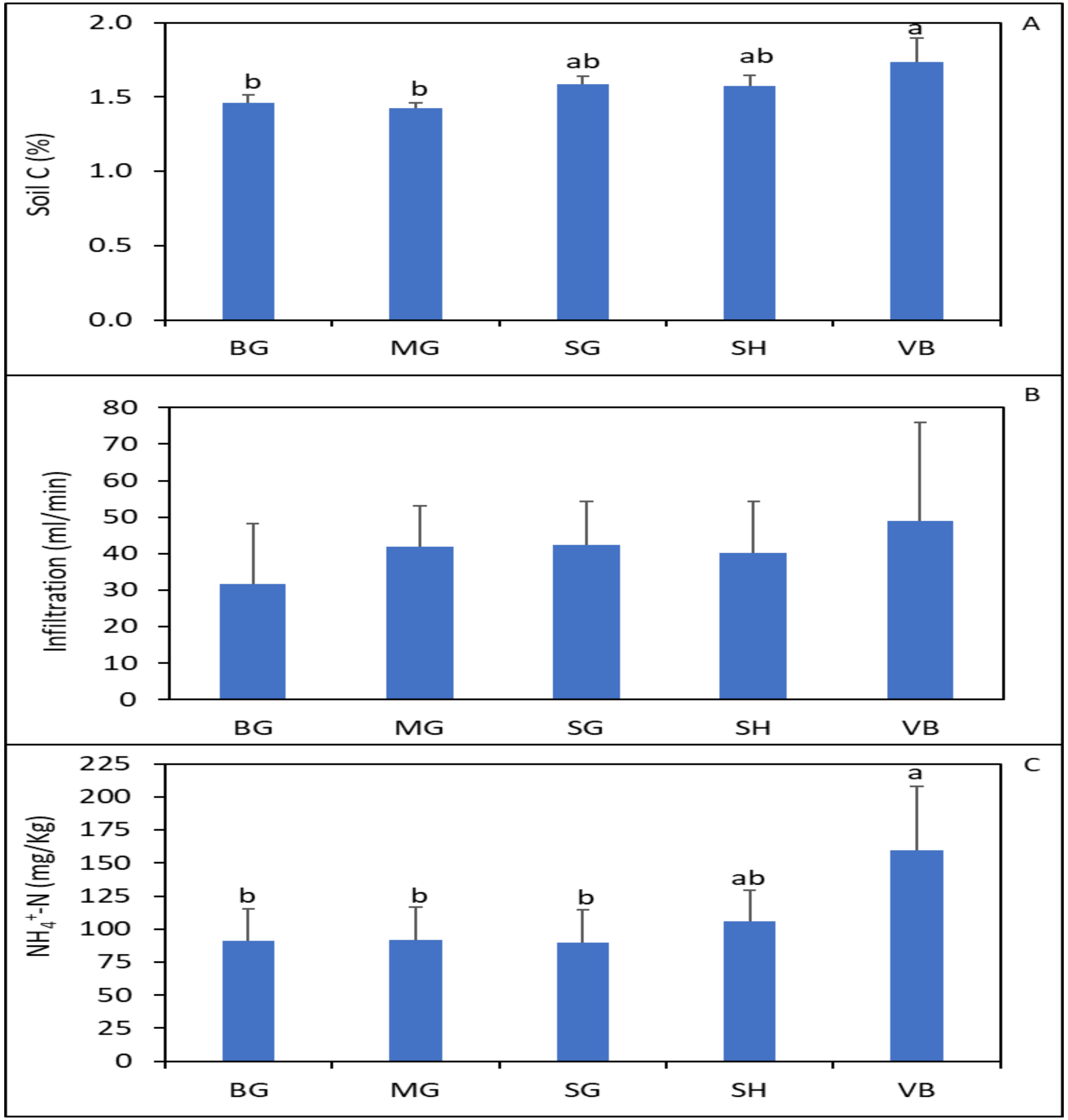


- Integrated with weevil complex management

(Wang and Uchida, 2014)

# Other Soil Health Properties

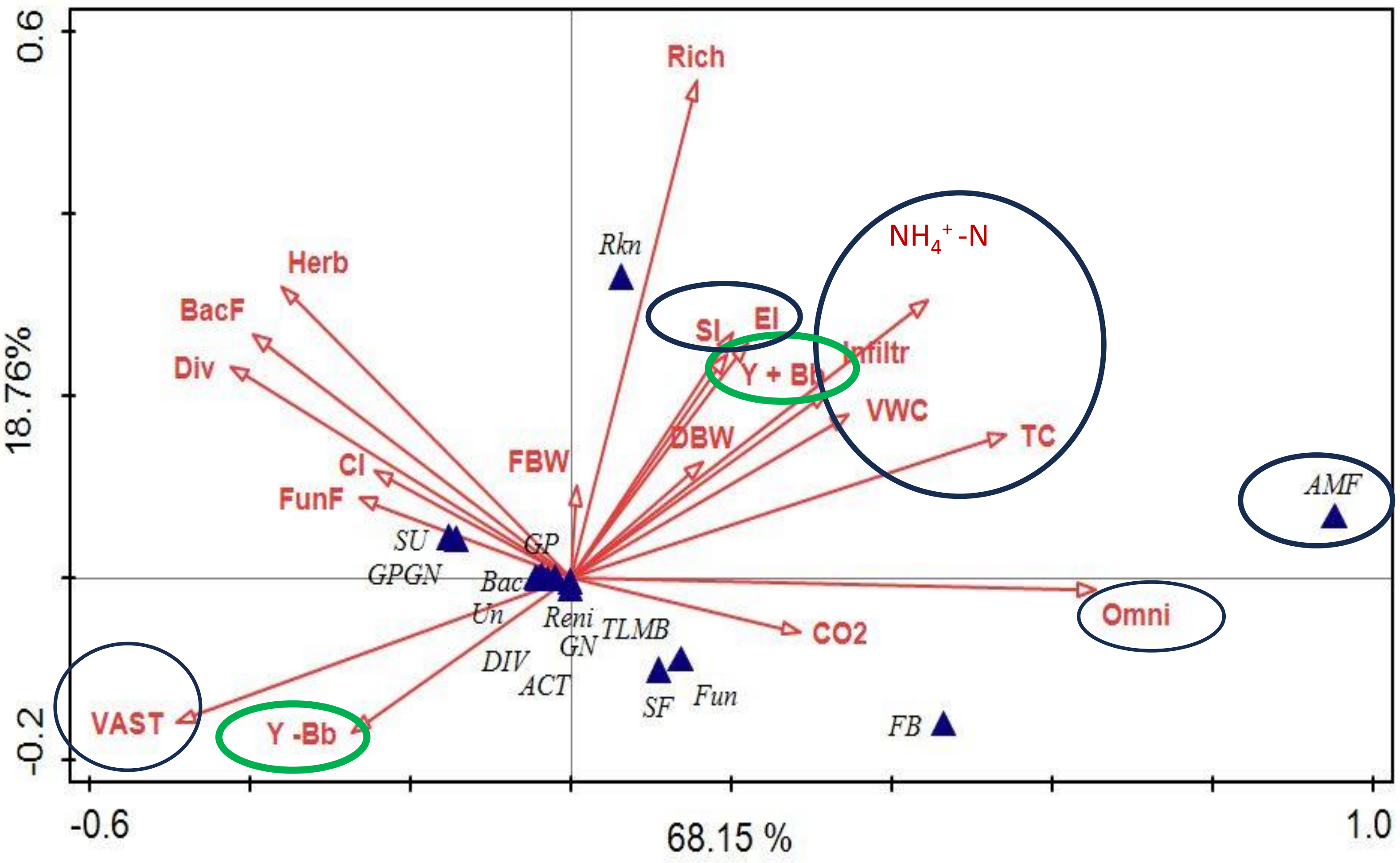
- VB increased total soil C at the end of cover cropping.
- VB resulted in a numerically higher water infiltration rate during sweetpotato growing period (2 sampling times).
- VB increased ammonia nitrogen in the soil at the end of sweetpotato growing season indicating more available nitrogen for plant growth.



# Relationships between Sweet Potato Yield with Soil Health Parameters

- Yield+*Beauvaria* (Y+Bb)
- Volumetric aggregate stability (VAST)
- Volumetric water content (VWC)
- Infiltration (Infiltr)
- Microbial respiration ($CO_2$)
- Total carbon (TC)
- Ammonia nitrogen ($NH_4^+$-N)

PLFA at 3 months Cover crop termination



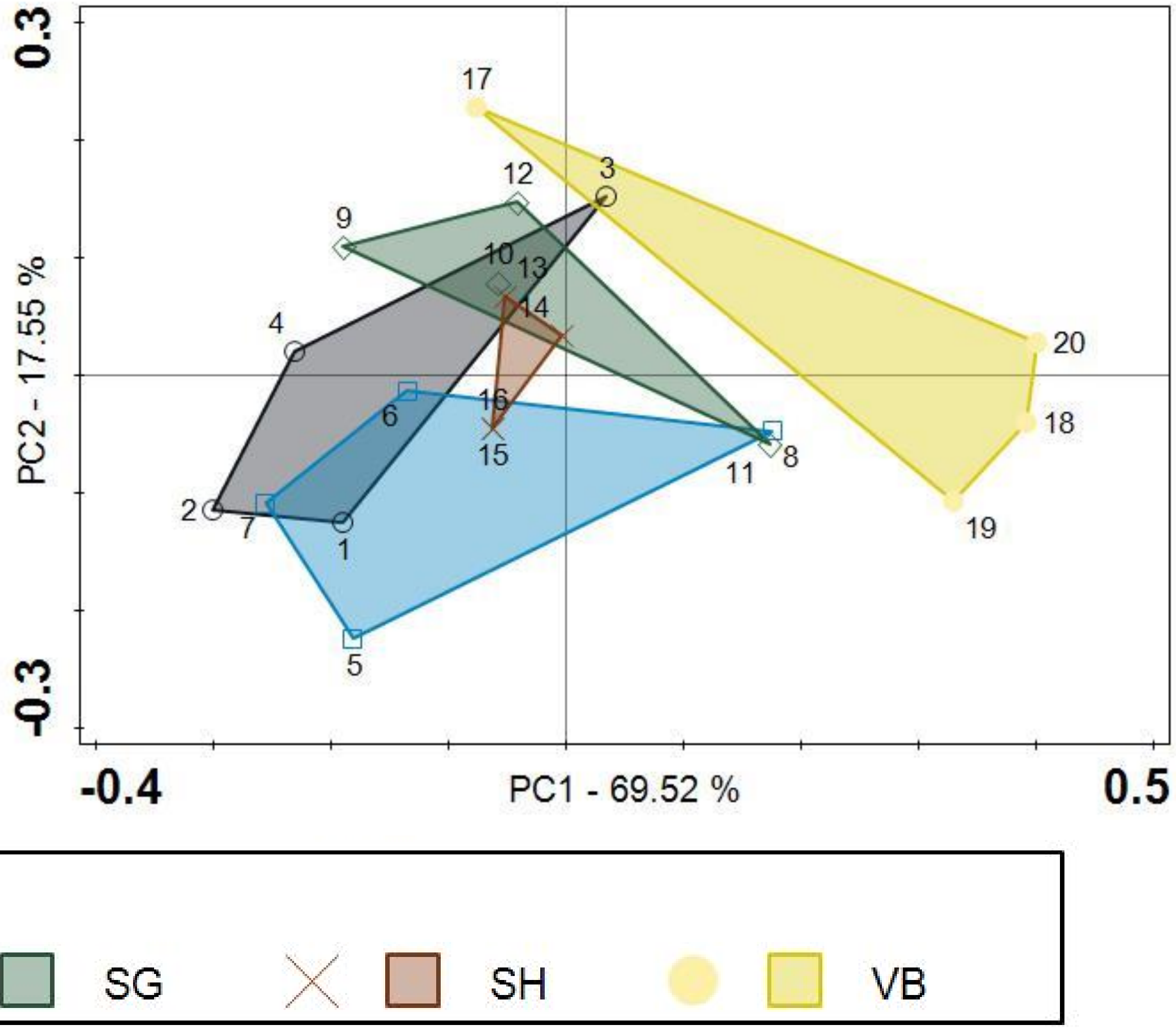

First 2 canonical axes explained 86.91 % of the variance.

- Cover crop dry biomass (DBM) was positively related to nematode Enrichment Index (EI), Structural Index (SI), infiltration (Infiltr), volumetric water content (VWC), total carbon (TC), ammonia nitrogen ($NH_4^+$-N) and also sweetpotato yield in *Beauveria* (Y+Bb) treated plots. (i.e. the higher the cover crop biomass, the better the soil health and plant health).
- But without Beauveria treatment, sweet potato yield lower with more cover crop biomass.

# Improving plant health (tolerance)

- VB resulted in soil health conditions most segregated from bare ground (BG), most likely because VB improved the soil health conditions from BG.
- Improvement of soil health by VB led to better performance of Beauvaria in suppressing weevil damage and improving yield.
- Thus, it is important to integrate vigorous and nematode suppressive cover crops like VB with the use of bioinsecticides for organic sweetpotato production.

5 months after sweetpotato was planted



Principals of

# Sustainable Pest Management

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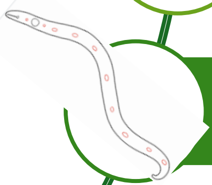


(Wang and Uchida, 2014)

# *Pheromone trap*
# +
# *Cover Crops*
# +
# *Beauvaria bassiana*

Monthly or twice a month


For more information, please read:

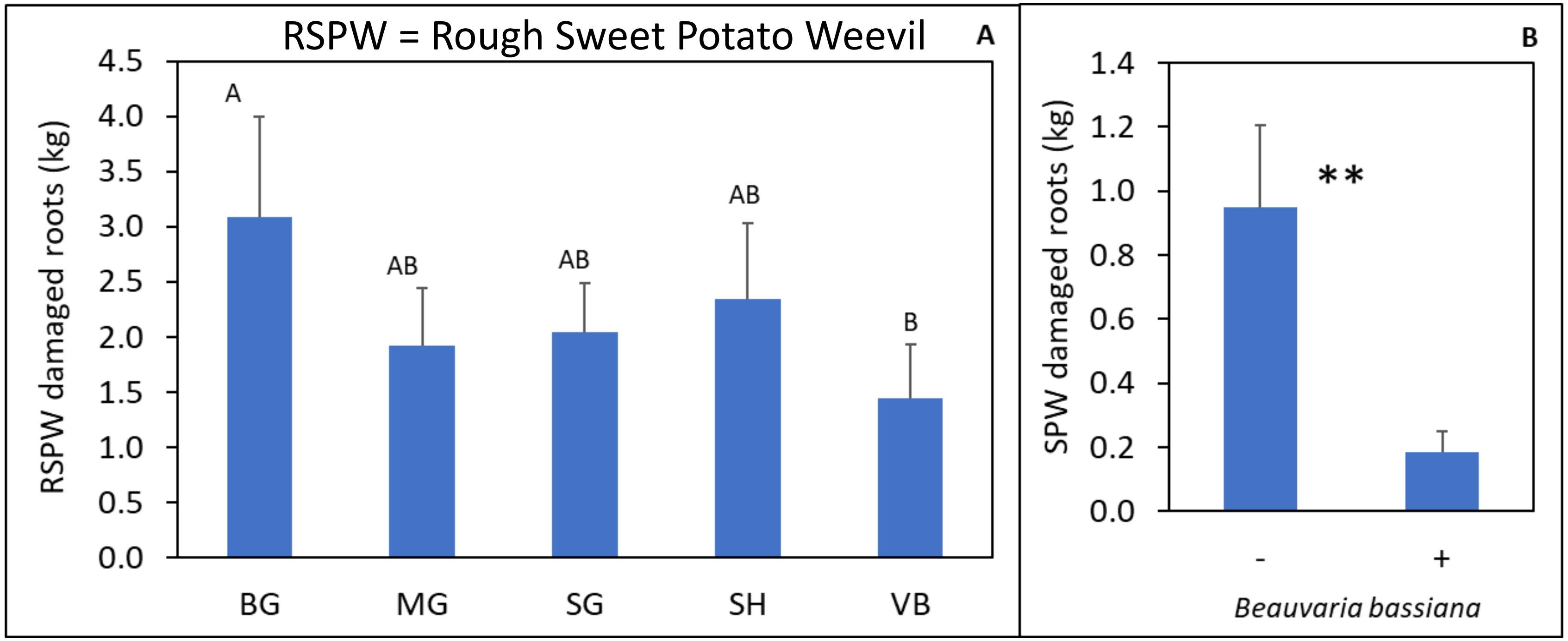
Hānai‘Ai 51

To order this lure, click this:

Alpha Scents, Inc.

*Z*3-Dodecenyl-*E*2- butanoate
Sweet potato weevil lure

1 / 60 m (200 ft) diameter

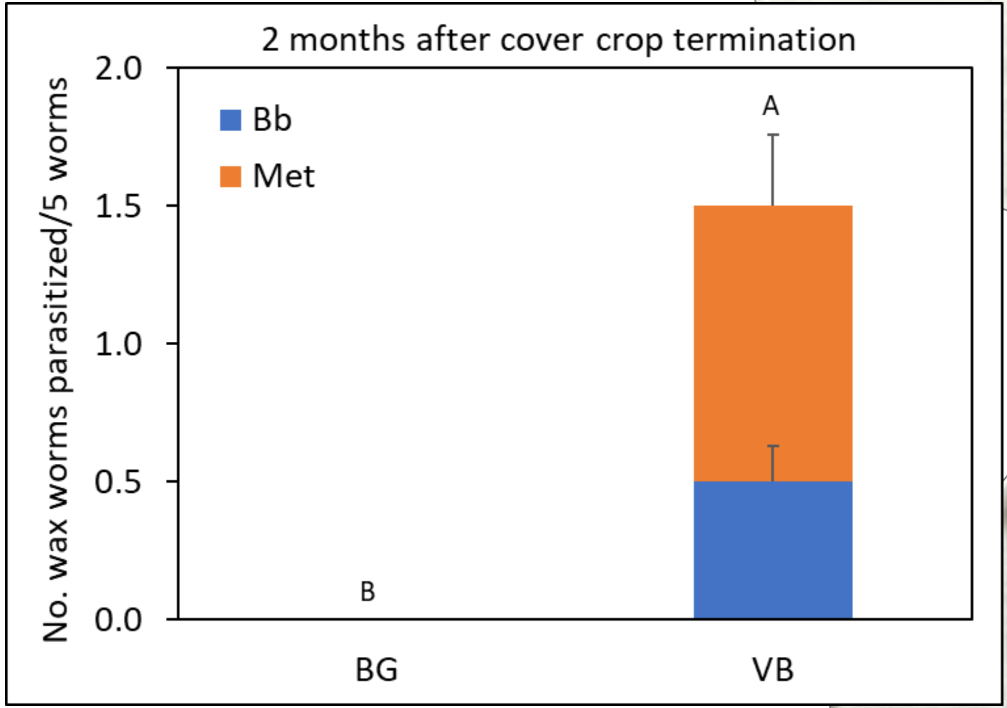


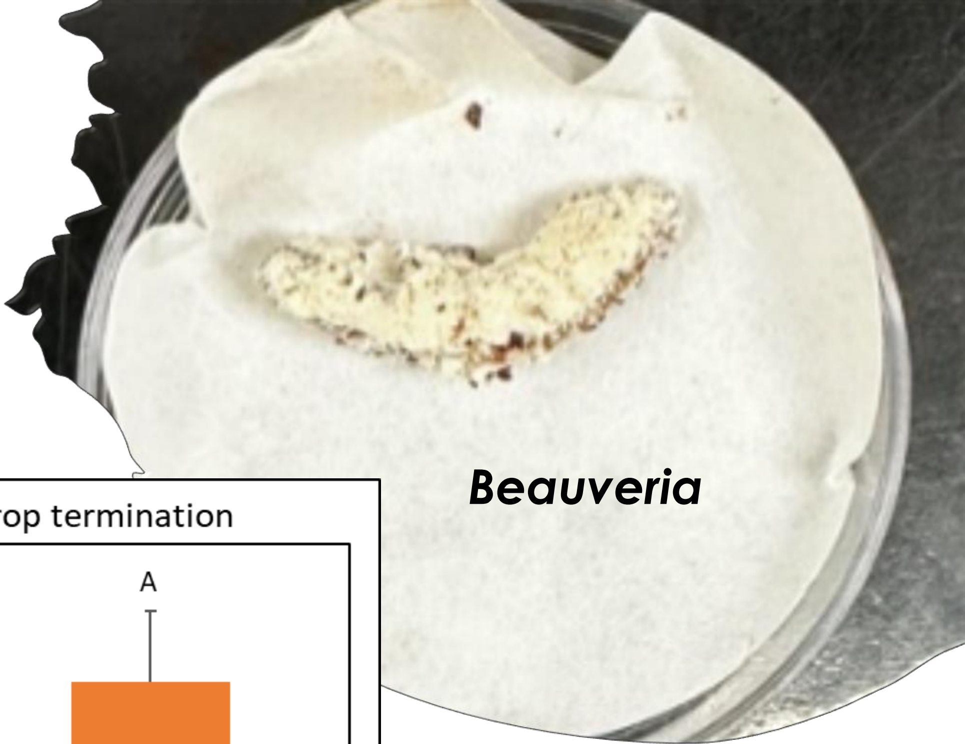

Pre-planting of VB cover crop reduced sweetpotato tuberous roots from RSPW damage. Basal stem spray of Mycotrol twice a month further reduced SPW damage. All were in conjunction with installing a SPW lure in the field.

# *Enhance Natural Enemies of weevils/ stem borers*

## Entomopathogenic Fungi

- Preliminary data shown that velvet bean (VB) residues also increased the frequency of waxworm baits colonized by *Metarhizium* and *Beauveria* in the sweet potato field. These are entomopathogenic fungi (EPF) that can parasitize insect pests including SPW, RSPW and WISPW.



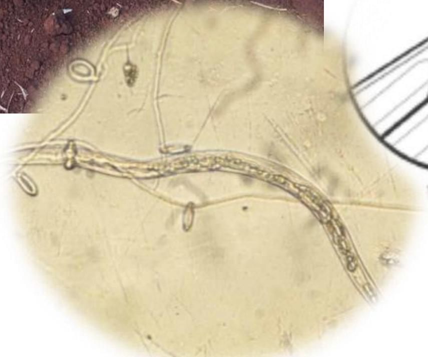





This explains why VB plots had lower RSPW damaged sweetpotato tuberous roots.

# Summary

Alpha Scents, Inc.




SPM

Unitrap

# Resources for farmers

Calculator

Prescription for Soil Health

1) Sustainable pest Management (SPM) for sweet potato
2) Entomopathogenic Fungi and Nematodes against sweetpotato weevil complex
3) Farmer driven sweetpotato weevil IPM using UNI-Traps. Hānai‘Ai 48: Newsletter
4) Cover crop plant-available nitrogen calculator
5) Prescription for soil health chart
6) Fact sheet on root-knot on sweet potato managed by different biological nematicides (Alabama)

Biological nematicides

# *Mahalo*


- NIFA OREI (HAW09705-G),
- NRCS CIG (NR1992510002G001 and NR2192510002G002).
- CTAHR Plan of Work (POW16-964), Multi-state (HAW09034-R) and Hatch (HAW09048-H).
- Roshan Paudel, Philip Waisen, Ben Wiseman, Lauren Braley, Jensen Uyeda, Josh Silva, Donna Meyer, Farm Crews from Poamoho Experiment Station, Koaloa Ranch.


Please complete a survey at:
https://docs.google.com/forms/d/e/1FAIpQLSc4p6-IDFZleX7zdkxpqD1ihxyqyqjch8OyKZ13VLe3_mYTZg/viewform

Video: Benefits of Cover Cropping (Chinese narration):
https://youtu.be/5l8m7F2f1G8


Dr. Koon-Hui Wang: Cover Crop Information (hawaii.edu)
koonhui@hawaii.edu