Organic Sweet Potato IPM:

from prevention to prescription

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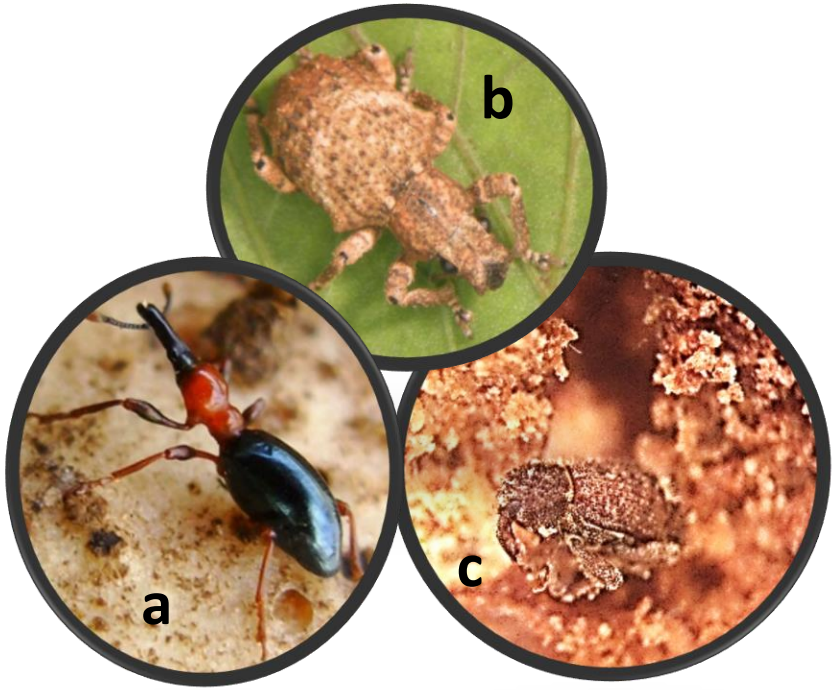
*USDA ARS PBARC

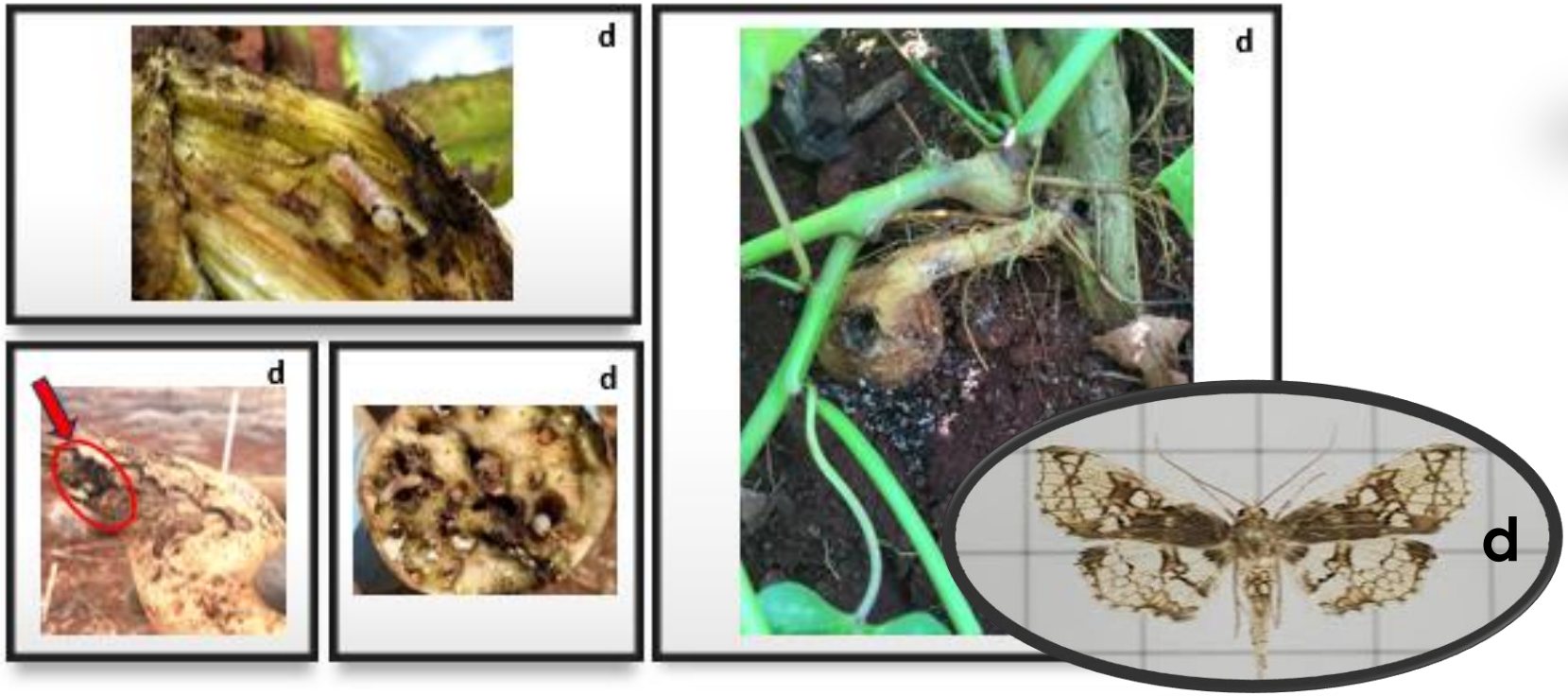
Objectives

Develop Organic IPM strategies :

1) against key insect pests
2) against key plant-parasitic nematodes, and
3) to improve soil health properties.

Weevil-Stem borer complex



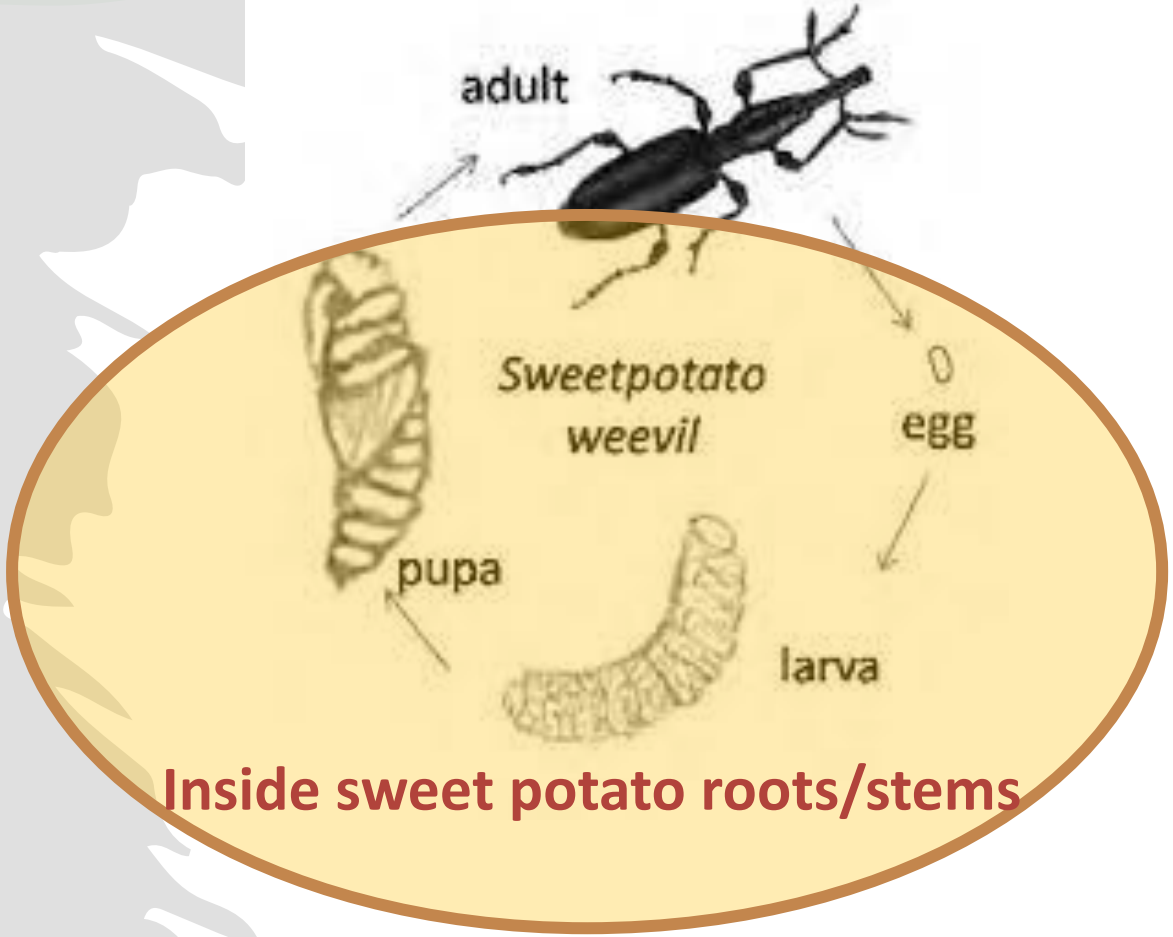


a. Sweet potato weevil (*Cylas formicarius*)
b. Rough sweet potato weevil (*Blosyrus asellus*)
c. West Indian sweet potato weevil (*Euscepes postfasciatus*)
d. Sweetpotato stem borer (*Omphisa anastomosalis*)

Sweet potato weevil

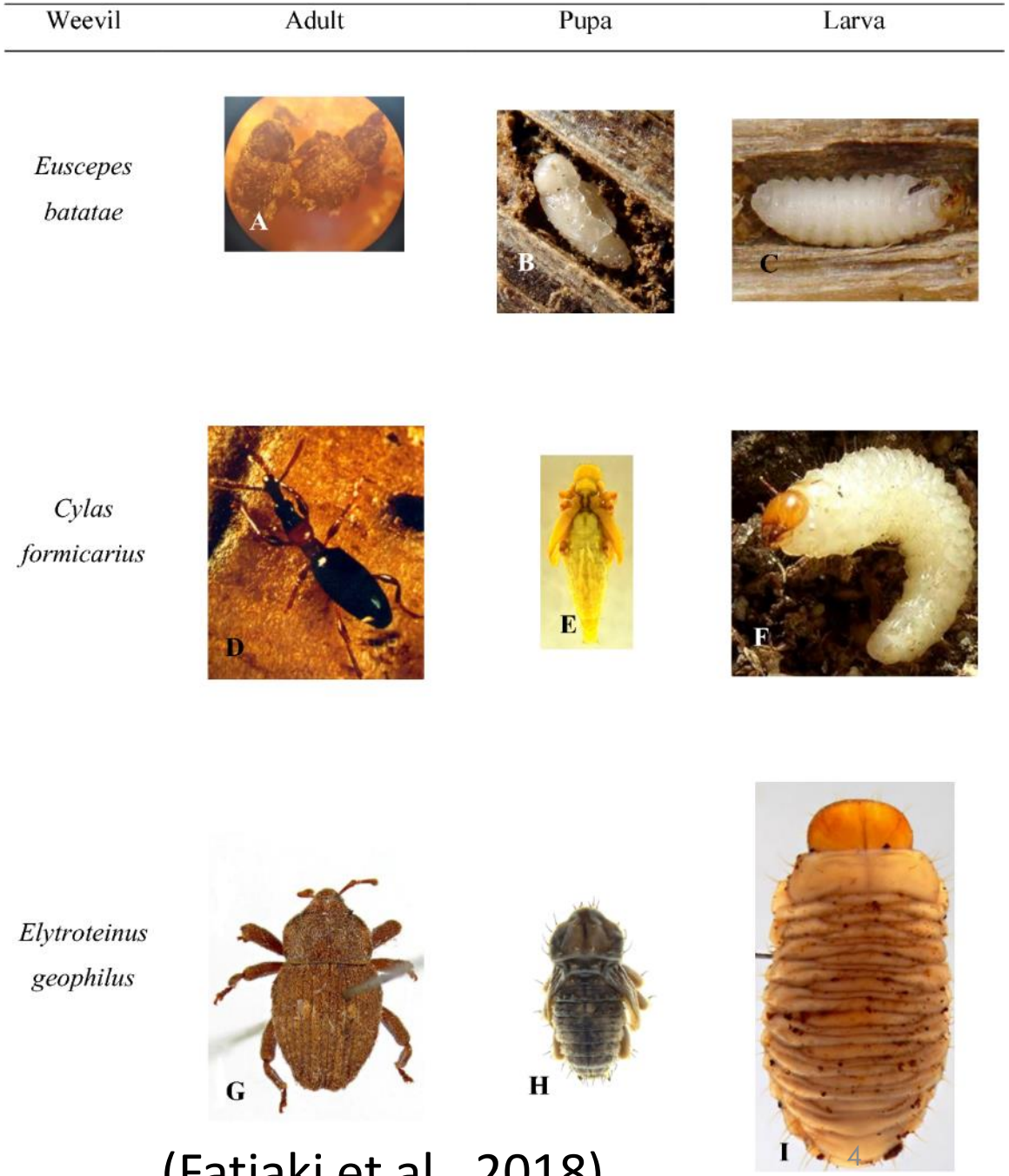
(*Cylas formicarius*)

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



Inside sweet potato roots/stems

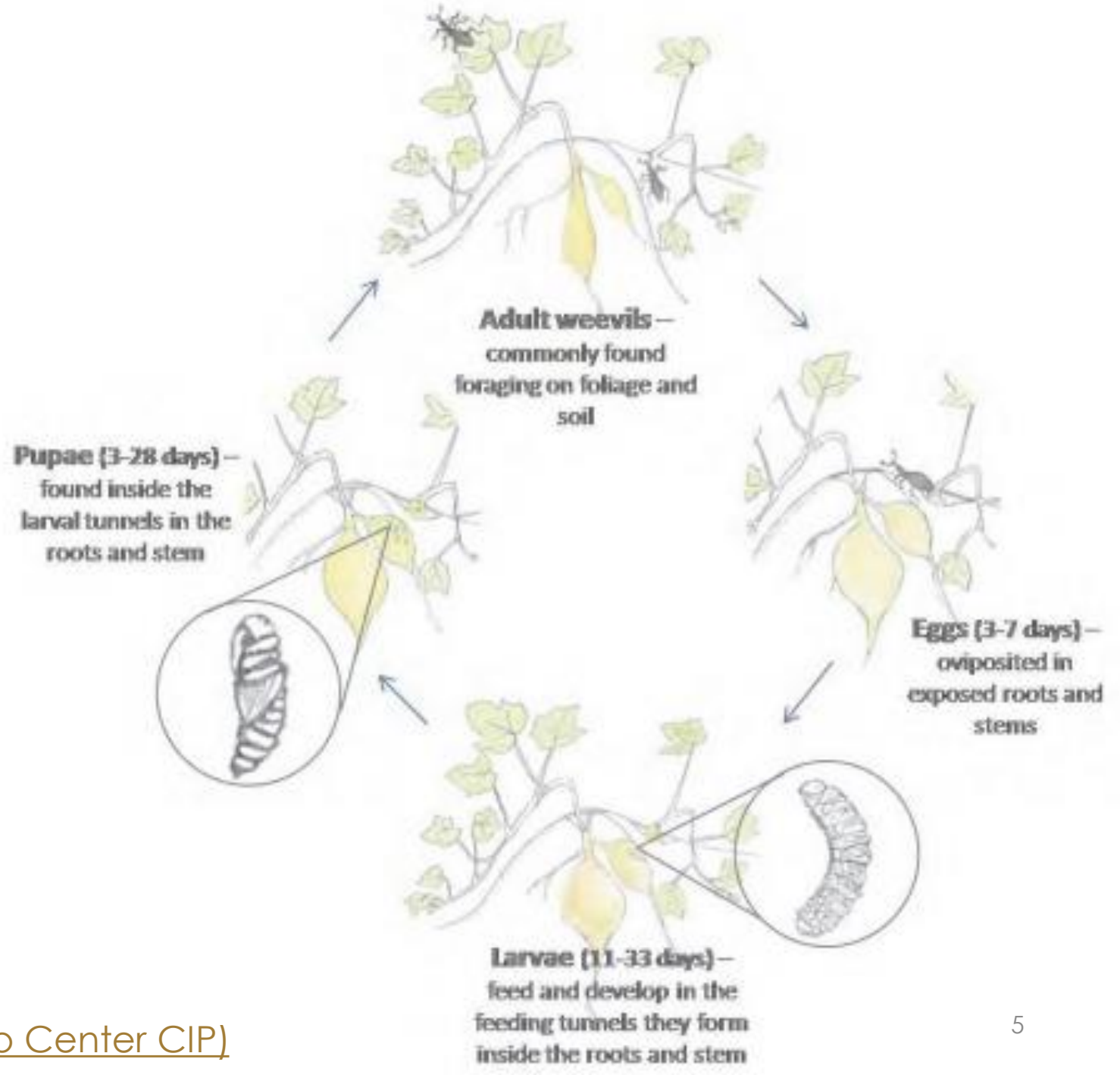
(Stathers et al., 2018 by International Potato Center CIP)



(Fatiaki et al., 2018)

Sweet potato weevil

(*Cylas formicarius*)



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

(HODA, 2011)

Rough sweet potato weevil

(Blosyrus asellus)

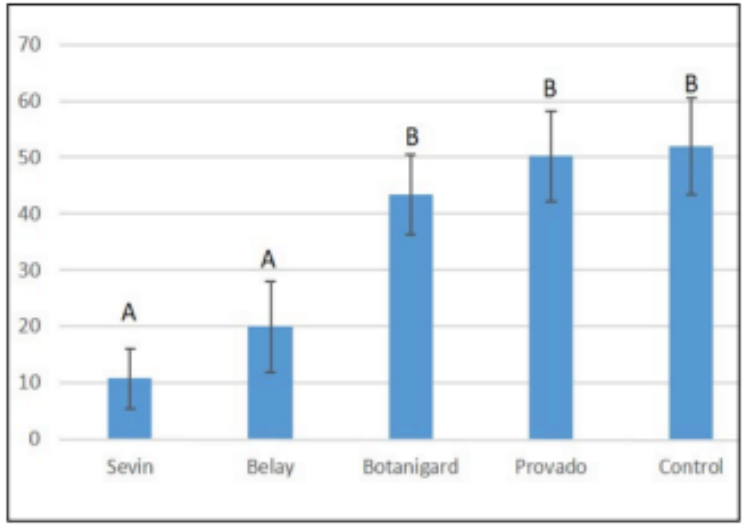


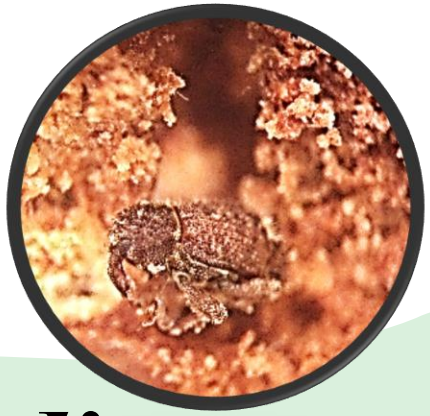
Figure 4. Percent of all tubers with characteristic damage caused by rough sweetpotato weevil (RSW) after treatment with four insecticides and a control. Bars denoted by same letters are not significantly different.

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 (Pulakkatu-thodi et al., 2016)

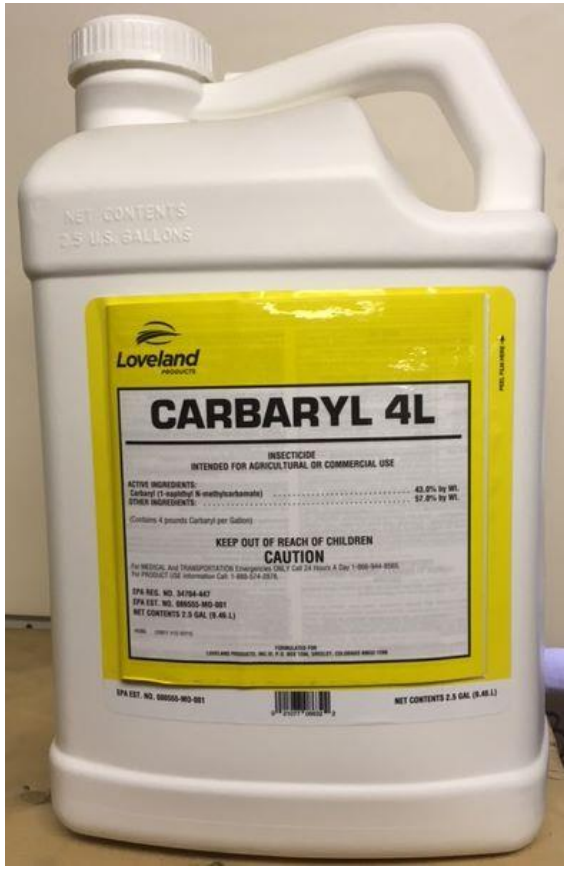


West Indian sweet potato weevil

(Euscepes postfasciatus)

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

Chemical Control

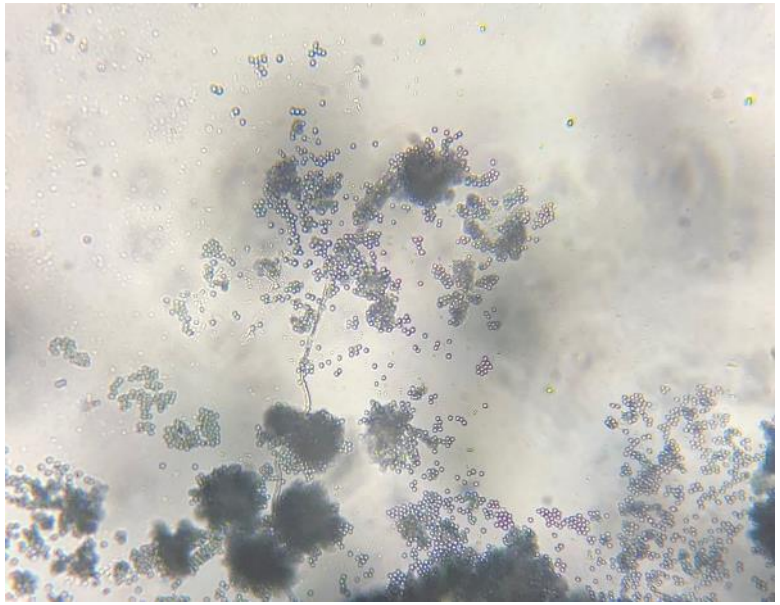


Organic Treatments

*Z*3-Dodecenyl-*E*2-butenoate

Entomopathogenic nematode (EPN)

Entomopathogenic fungi (EPF)



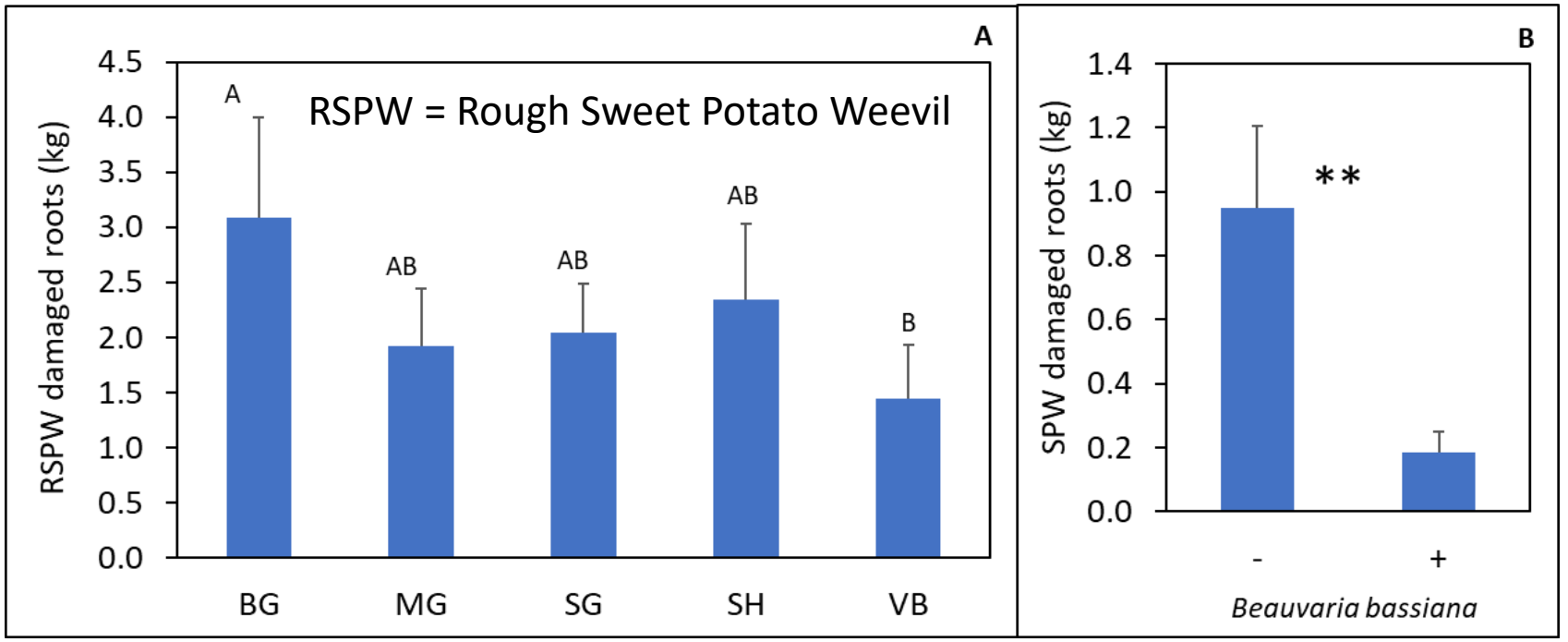
Pheromone trap
+ Cover Crops
+ Beauvaria bassiana

Alpha Scents, Inc.

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

1 / 60 m (200 ft) diameter

Monthly or twice a month



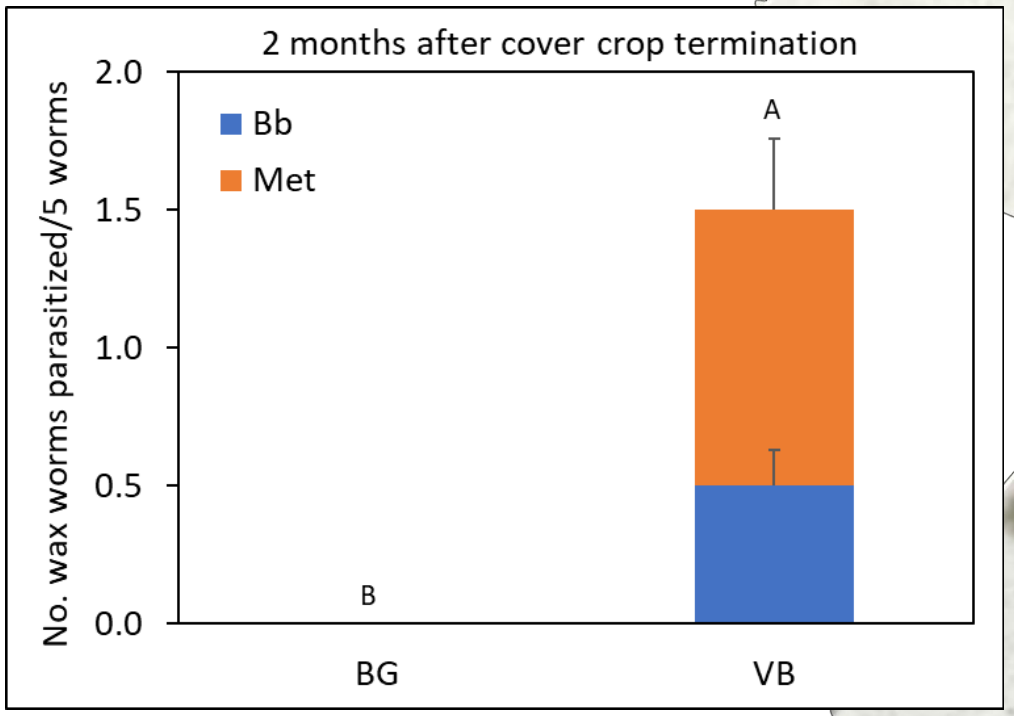
Hānai‘Ai 51

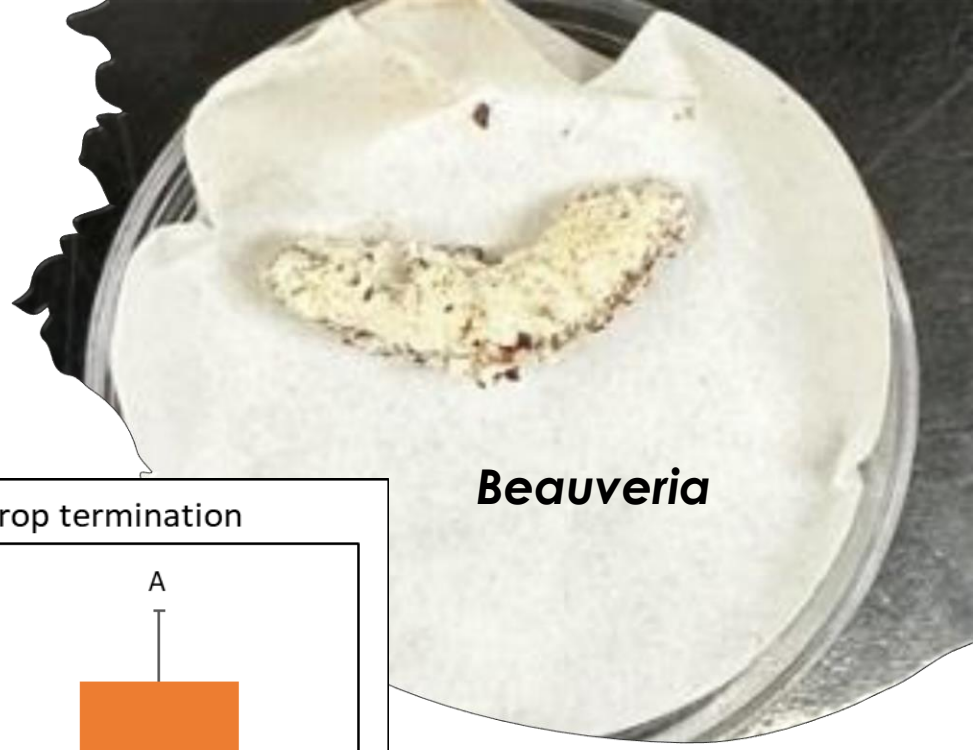
BG = Bare ground, MG=Marigold, SG=Sorghum, SH=Sunn hemp, VB = Velvet bean

Enhance Natural Enemies of weevils/ stem borers

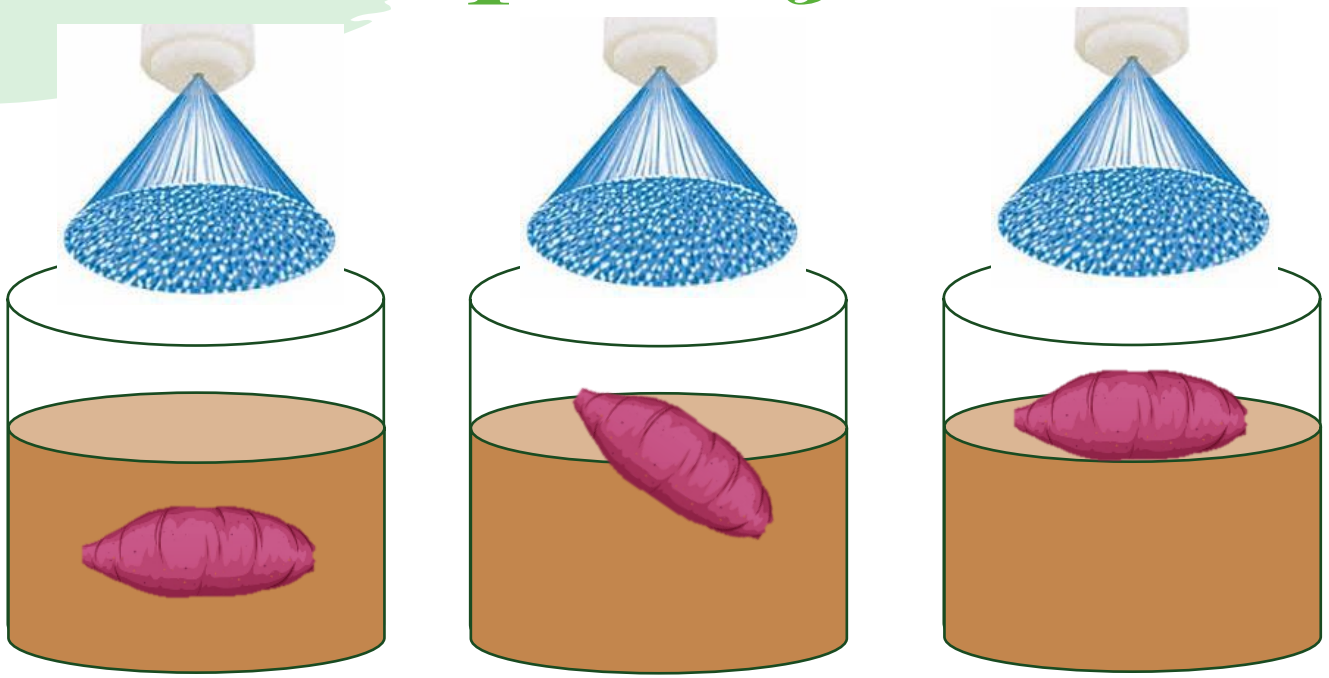
Entomopathogenic Fungi

- 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.





Entomopathogenic Nematodes



Soil tub bioassay of sweet potato roots (infested with SPW) treated with 1,000 or 10,000 *Heterorhabditis indica*

A. Infested tuberous root fully buried

B. Partially buried root

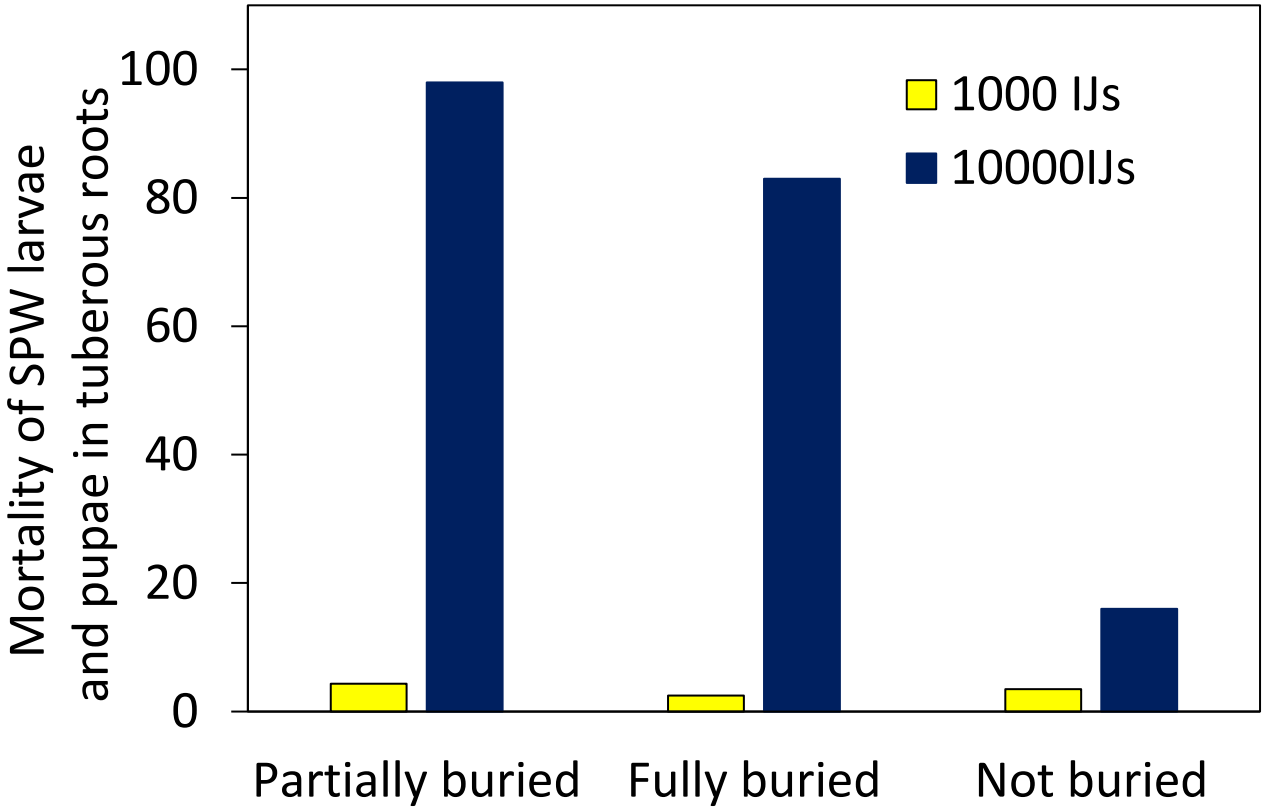
C. Root not buried

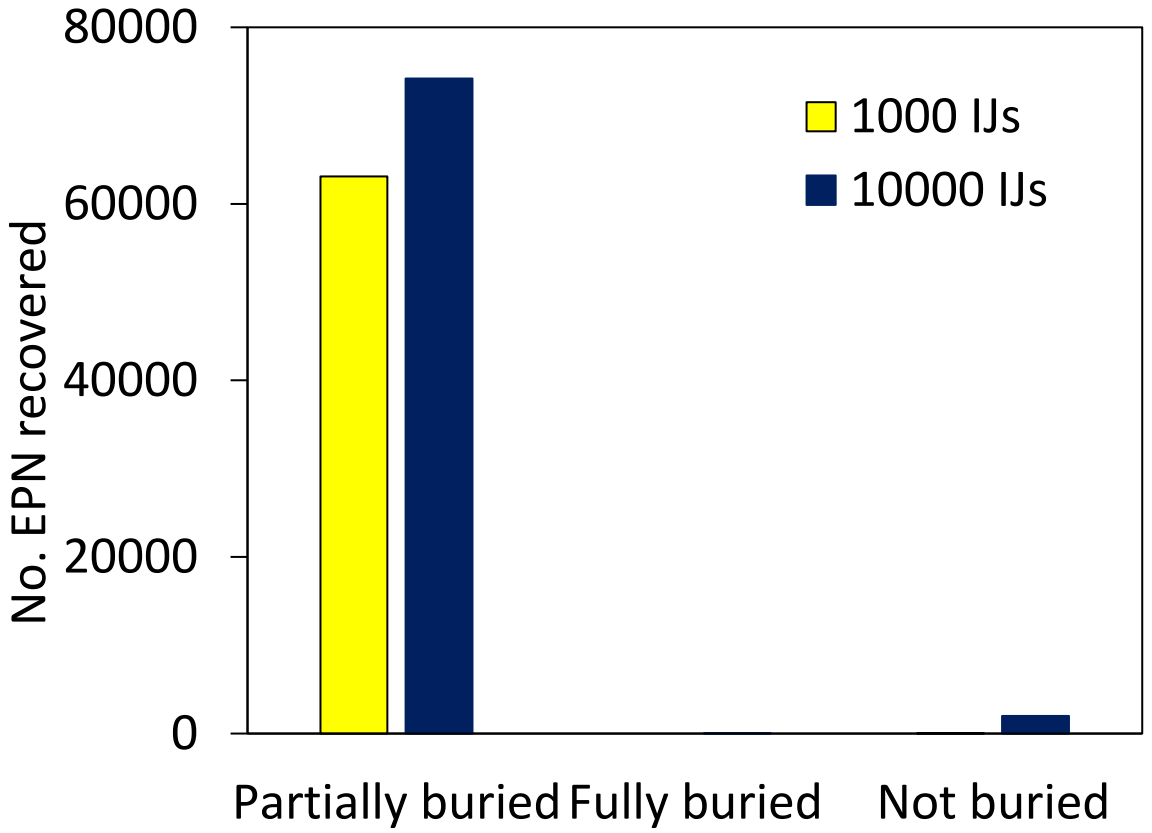
Hawaiian strain of *Heterorhabditis indica* on *Galleria mellonella* (wax worm)

(Roxana Myers, USDA ARS PBARC)

Entomopathogenic Nematodes (EPN)

Heterorhabditis indica 4 weeks after inoculation



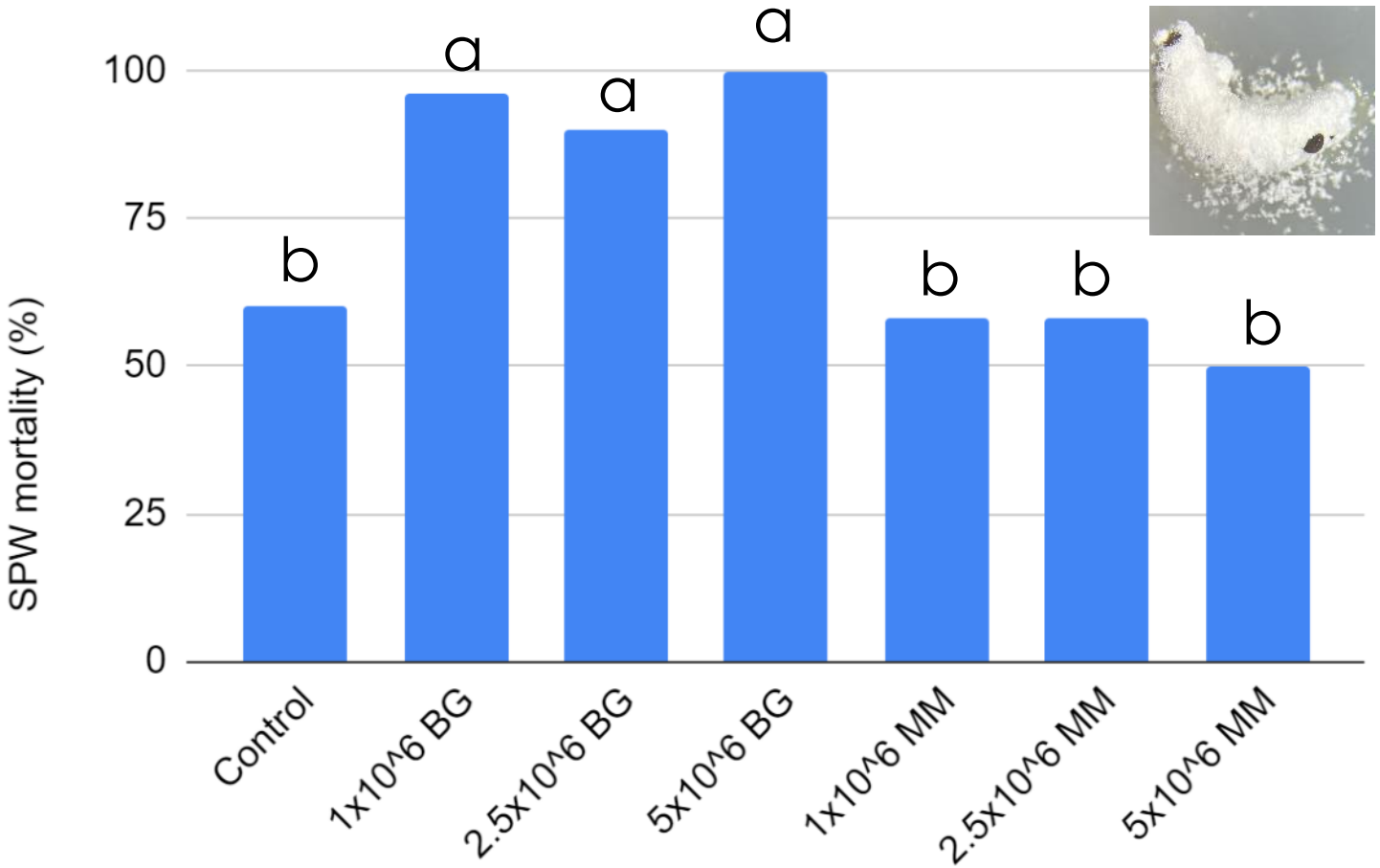


(Myers et al., 2020)

Myers: apply EPNs to field soon after harvest to reduce pressure on next crop

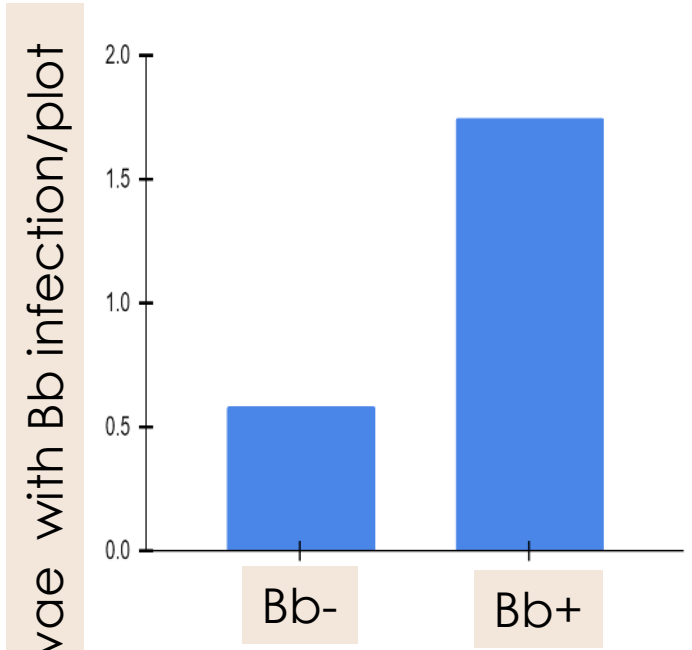
Remove cull sweet potato tuberous roots from soil surface before EPN application

Entomopathogenic Fungi (Botanigard® vs MetMaster®)



Petri dish assay

Beauveria Recovery at Sweet Potato Harvest



Bb = *Beauvaria basiana*

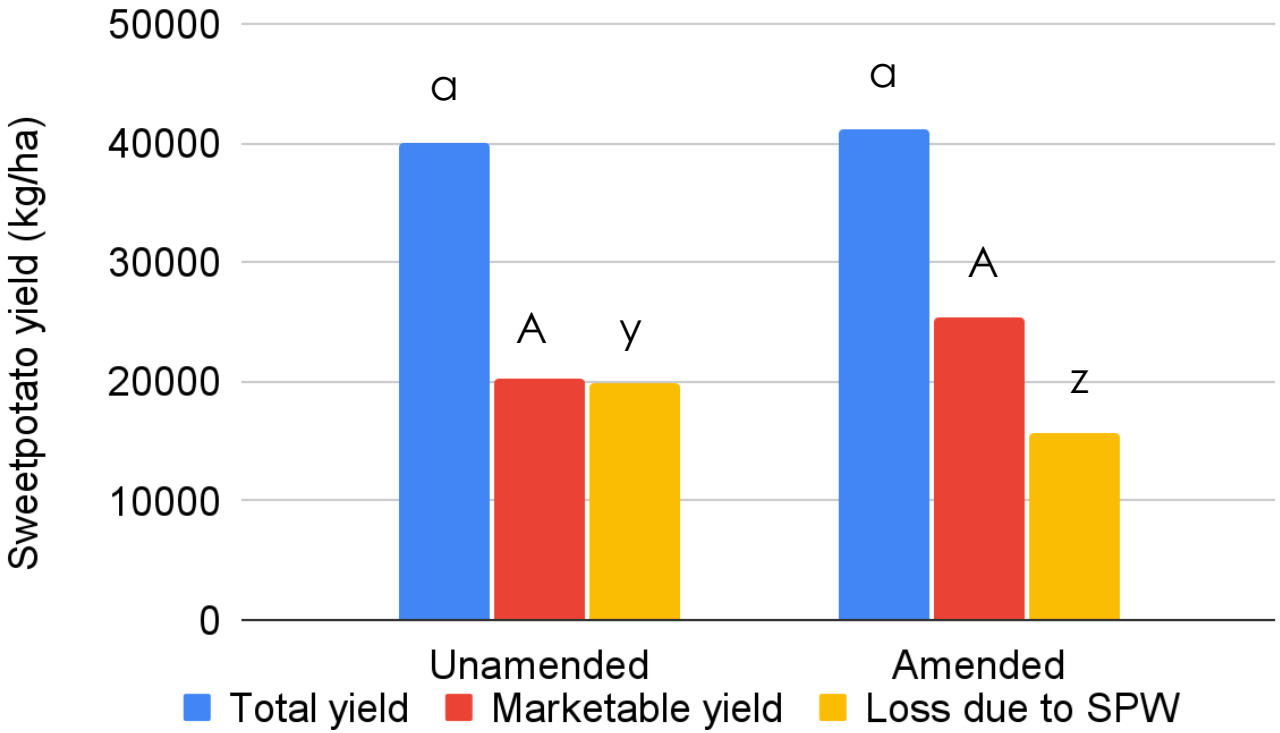
Field Trial

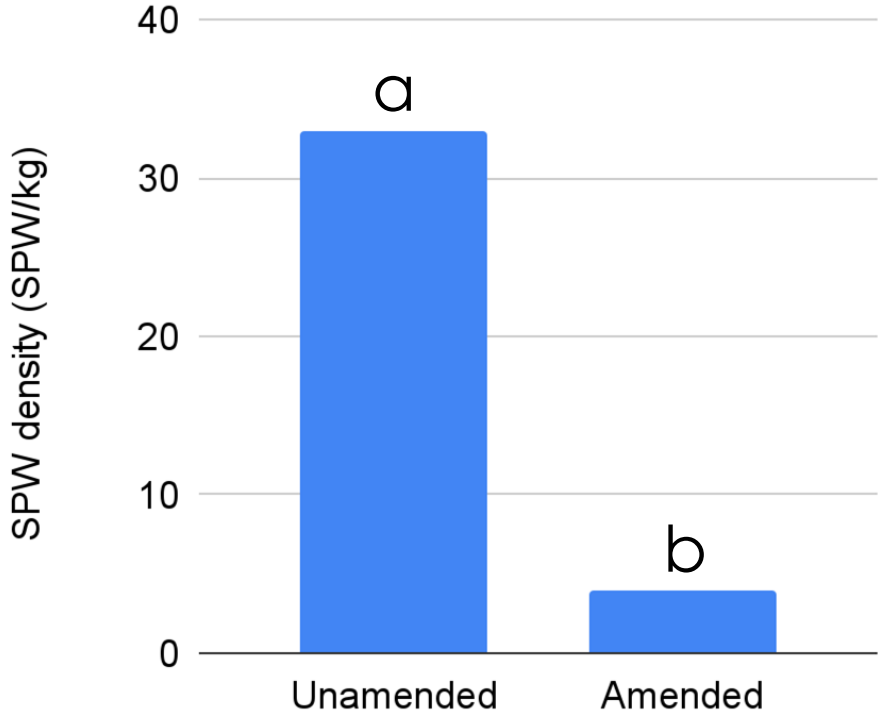
(Landon Wong, 2023)

Metarhizium Ko-002 Colonized mill run

Ko-002 on rice

Metarhizium Amended Compost





(Landon Wong, 2023)

Summary

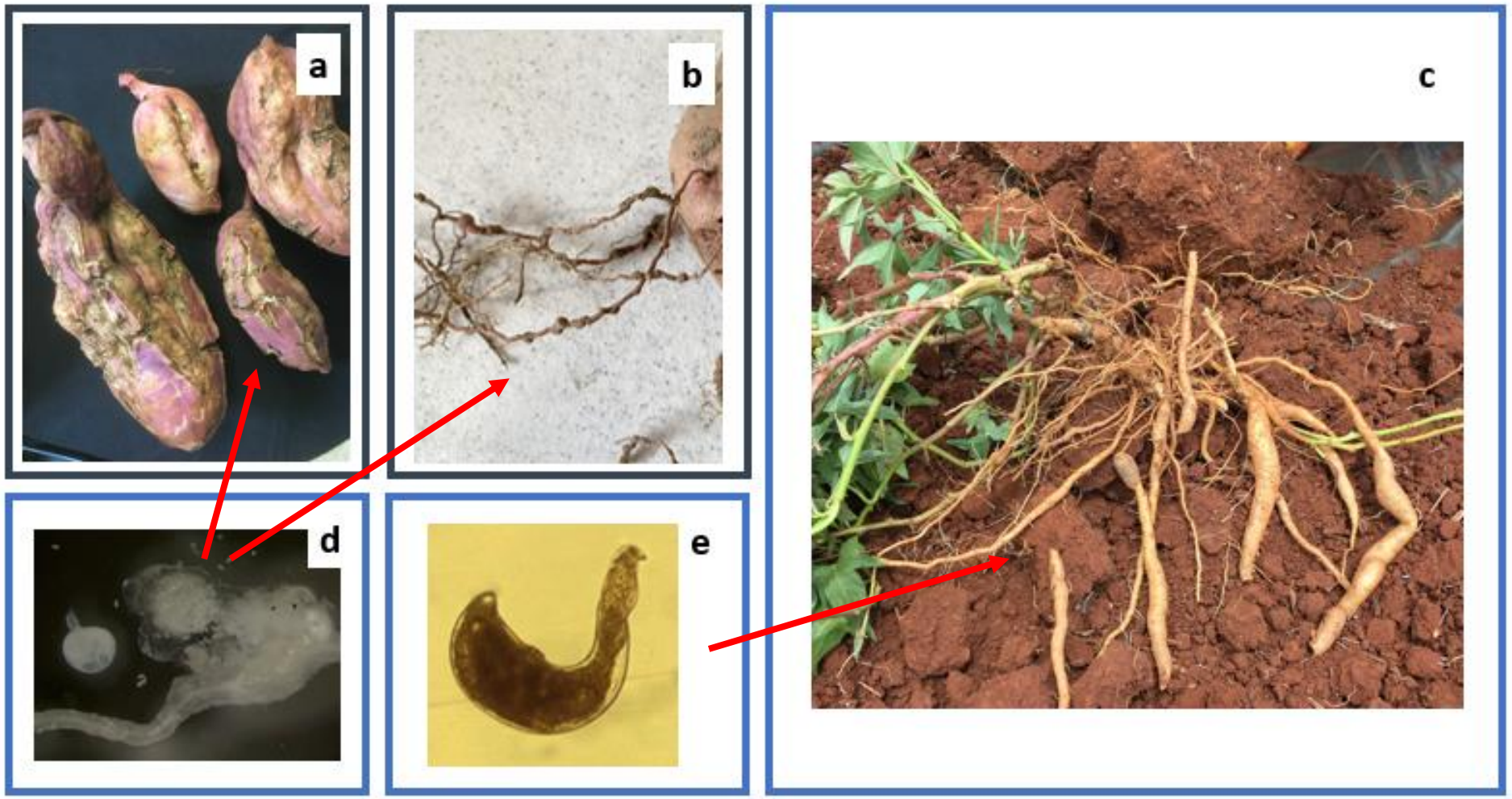
- Multiple arthropod pests especially weevils and stem borers are very damaging to sweet potato production in HI. Good news is they share similar natural enemies e.g. EPN, EPF.
- Commercial EPNs are regulated and not allowed to be imported into Hawaii, even though a few species can be imported, distributors are reluctant to import them due to short shelf life and lack of farmers buying them.
- Local strains of EPN and EPF (e.g. Metarhizium Ko-002) are viable and effective but needs to be cultured.
- Rotating sweet potato with velvet bean cover crop enhanced indigenous EPF in the soil that led to less rough sweet potato weevil damaged roots.
- Alpha Scent SPW lure keep SPW in check.
- Biweekly or monthly spray of *Beauvaria bassiana* is worth while to reduce pest pressure.
- Sanitation to ensure no weevil infested roots left on soil surface is recommended.

Objectives

Develop Organic IPM strategies :

1) against key insect pests
2) against key plant-parasitic nematodes, and
3) to improve soil health properties.

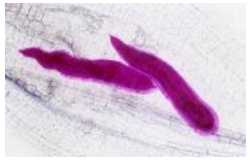
Root-knot and Reniform Nematodes



Root-knot nematode (*Meloidogyne* spp.)

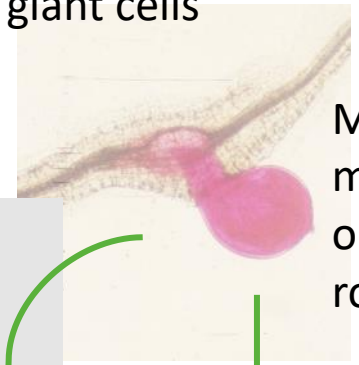
Sandy soil

根瘤线虫

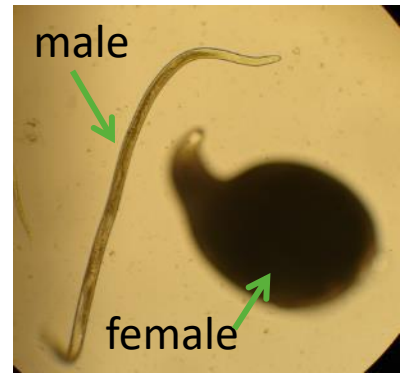


J3-J4
(sausage shape)

Feeding site undergoes hypertrophy and form giant cells



Male spends most time outside of the roots



Root-knot nematodes can produce eggs parthenogenetically (without sexual reproduction)

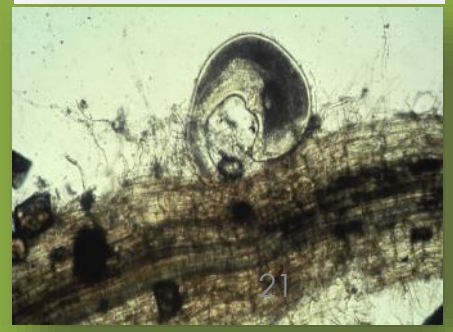
egg

J2
(infective stage)

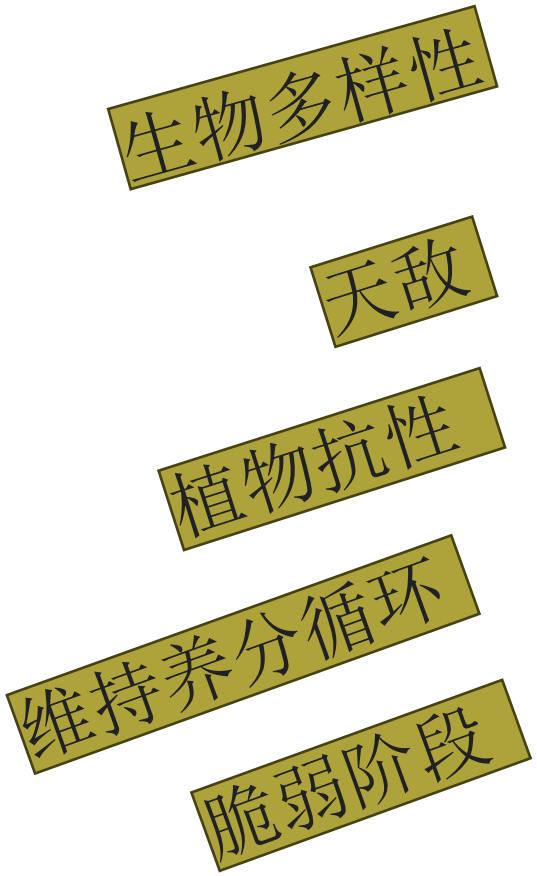
J2
(move inside root tissues until a feeding site is found)

High clay soil

Reniform nematodes
腎形線蟲



Integrated Nematode Management



1) enhancing high ***biological diversity*** through polyculture instead of conventional preference of monoculture systems;
2) increasing ecosystem community stability by promoting ***natural enemies*** of multiple pests and pathogens;
3) stimulating inherent ***plant defenses***;
4) improving plant health by maintaining nutrient cycling and energy flow; and
5) targeting on ***vulnerable stages*** of pests or pathogens through the understanding of their ecology.

2 months

覆盖作物

线虫拮抗作用

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
-- α-terthinyl

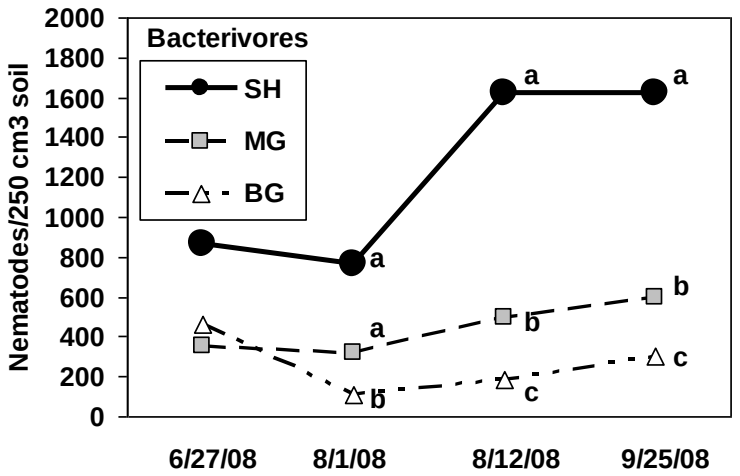
Brown mustard
Brassica juncea
-- glucosinolate

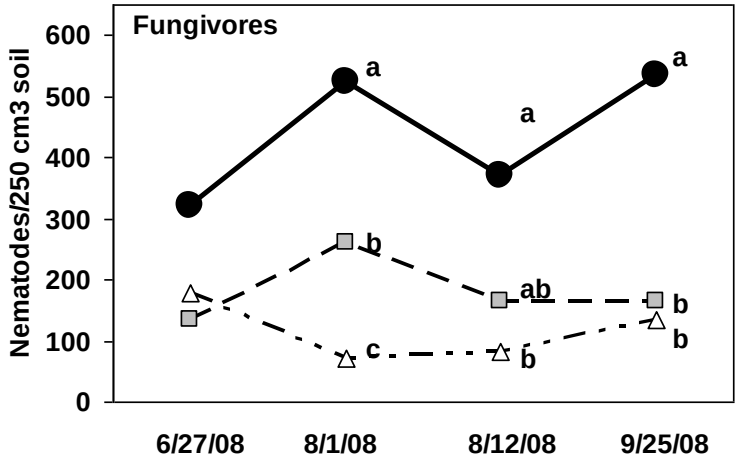
Sorghum-sudangrass
-- Dhurrin

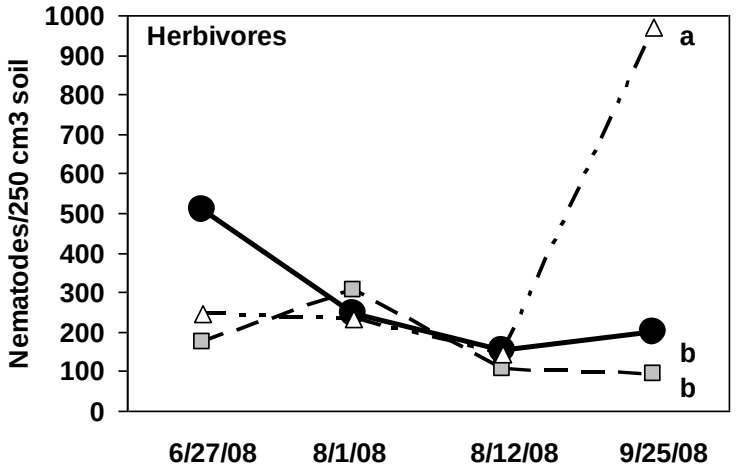
Velvet Bean (Macuna prupriens)
-- L-DOPA

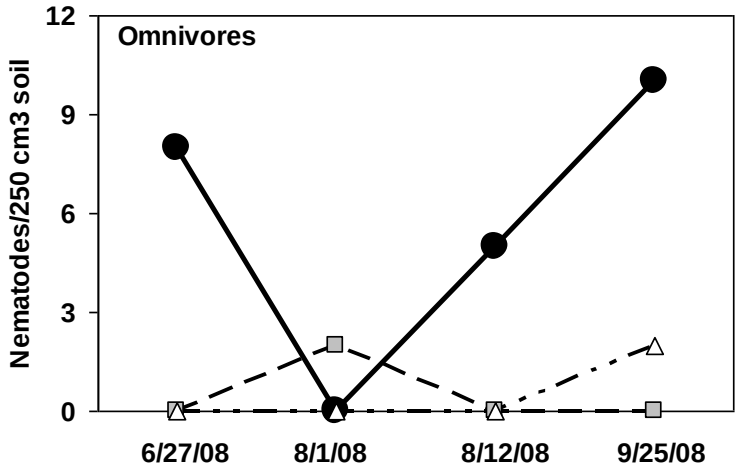
Sunn hemp Strip-Till Cover Cropping

- Preplant Treatment:
  - ❑ Sunn hemp (SH): 40 lb seeds/acre
  - ❑ Marigold (MG): 2.6 lb seeds/acre
  - ❑ Bare ground (BG): fallow with weeds









Sunn hemp + Molt-X chemigation

Zucchini

untreated

Sunn hemp + Molt-X

Tomato

untreated

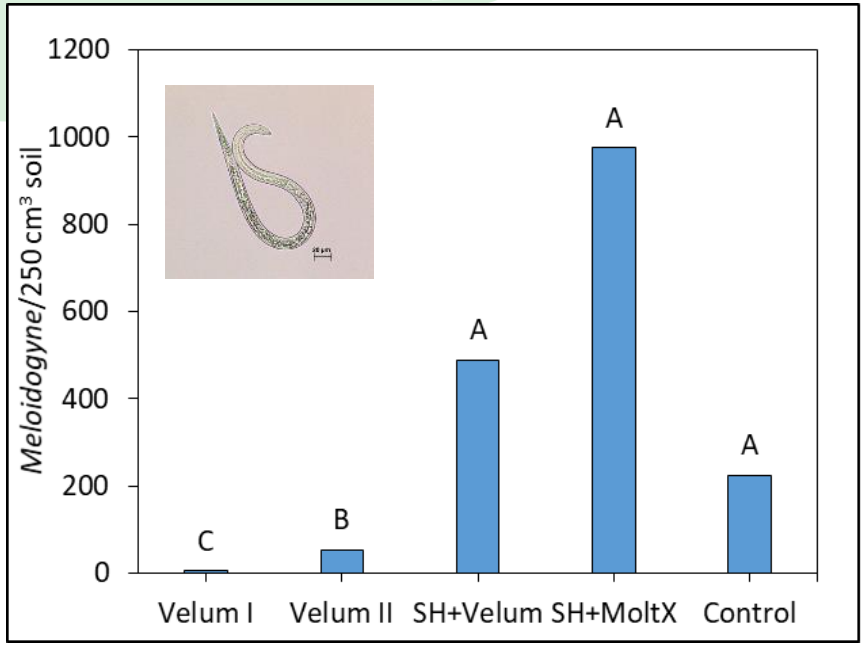
Sunn hemp + Molt-X

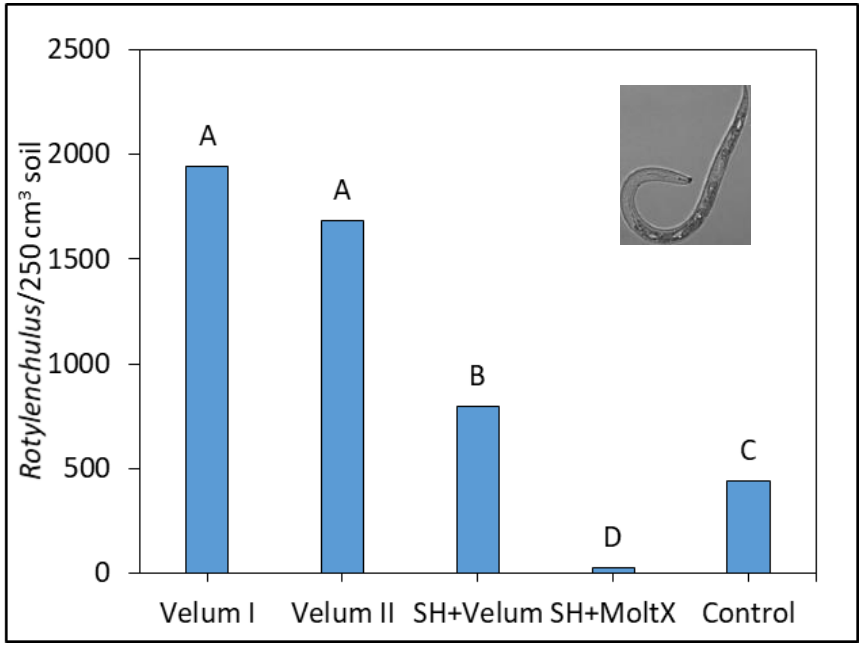
Sunn hemp

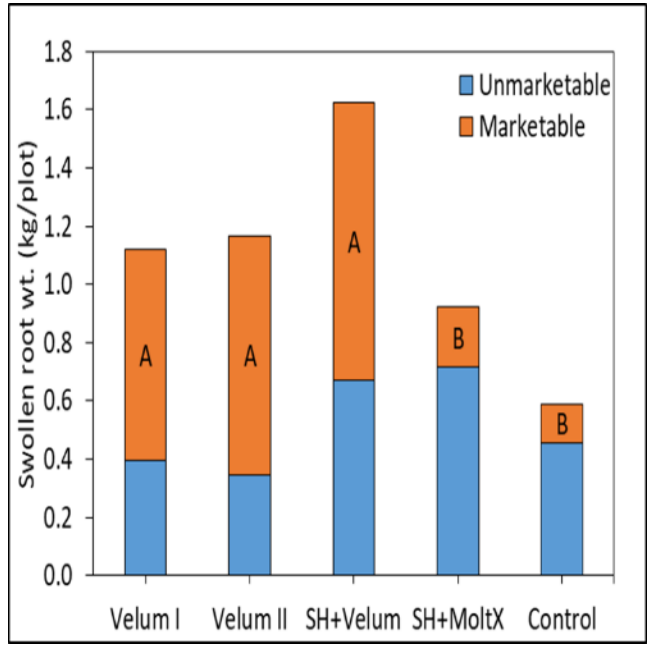
Molt-X (once a month)

Chemigation

Sunn hemp + Molt-X only effective against reniform nematodes







Velum 0 = apply at planting;
Velum 1 = apply 1 wk after planting;
SH +Velum = Preplant of sunn hemp (SH)+Velum at 1 wk;
SH+Molt-X = SH+ monthly injection of Molt-X
Control = no treatment

Velum suppressed root-knot, Molt-X suppressed reniform nematodes.

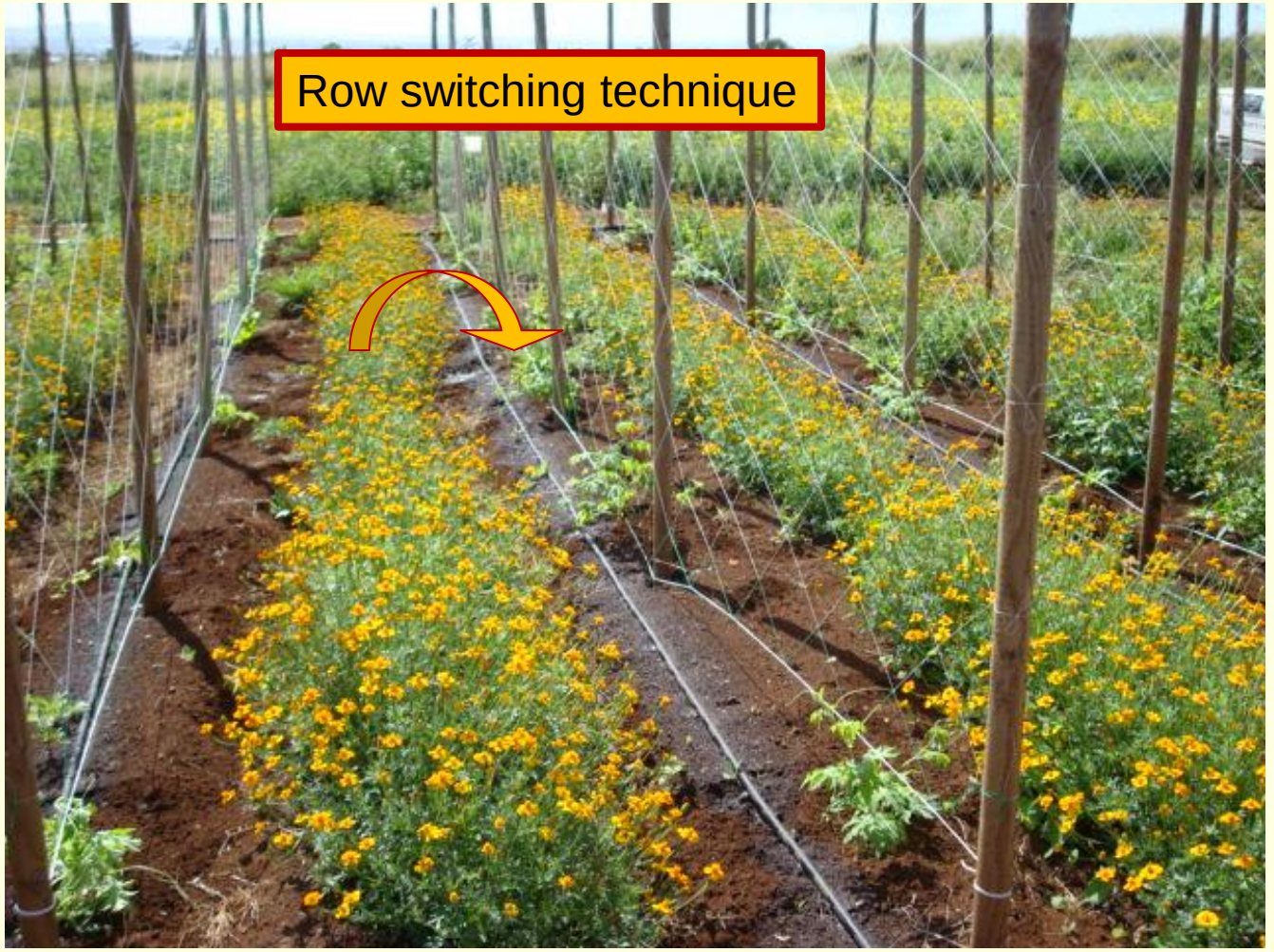
Velum One is not registered for sweet potato.

- Root-knot affected sweet potato yield more than reniform nematodes.
- Sunn hemp improved yield in SH+Velum.

(Waisen and Wang, 2021 Journal of Nematology 53:1-15)

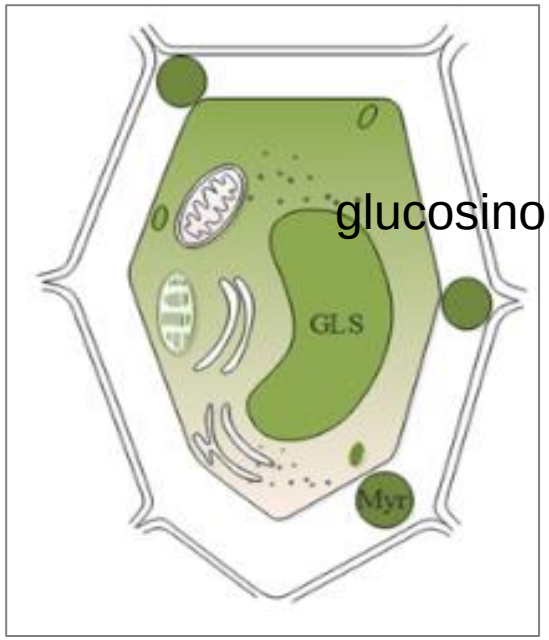
How to manage nematode efficiently using marigold?

萬壽菊



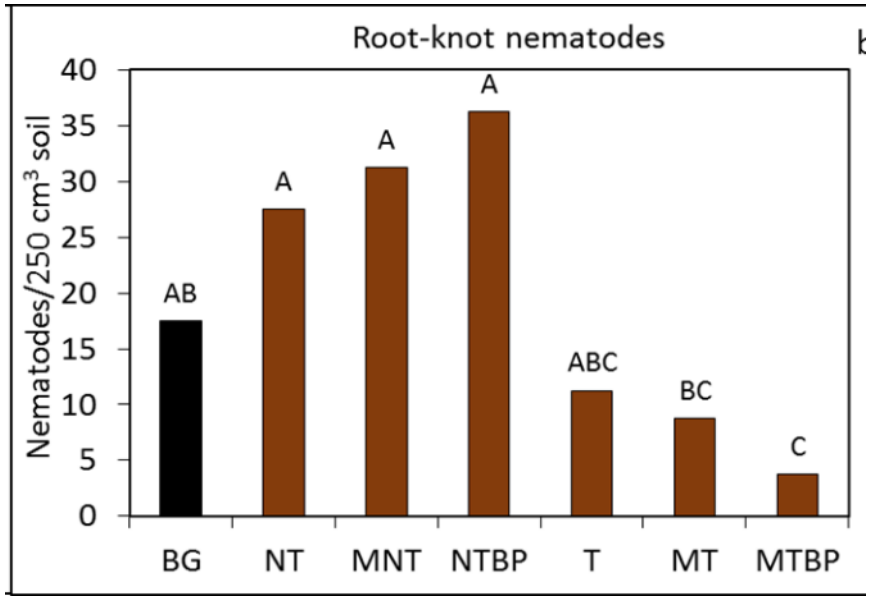
(Marahatta et al., 2012)

'Calientee 199' Brown Mustard Biofumigation



glucosinolate

Isothio cynate



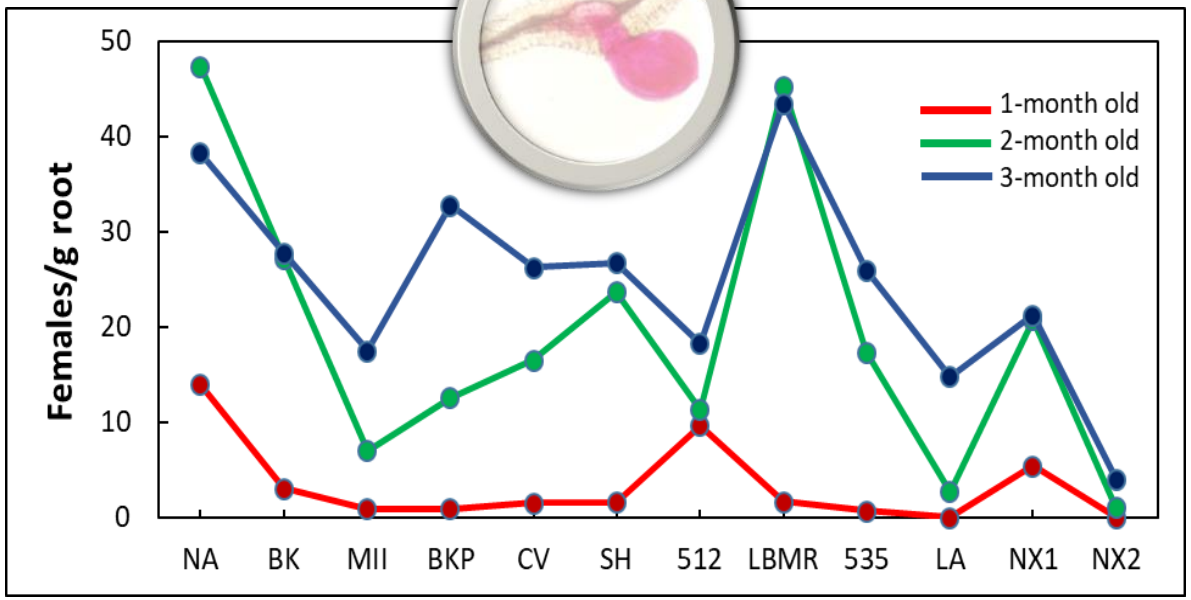
高粱 'NX-2' Sorghum

> 20 tons/acre in 2.5 months

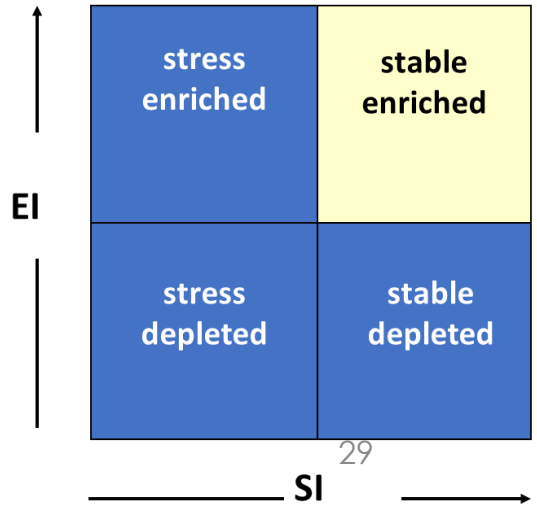
Flail mow and strip-till

Grow eggplant for 5 months

- Suppress root-knot female development



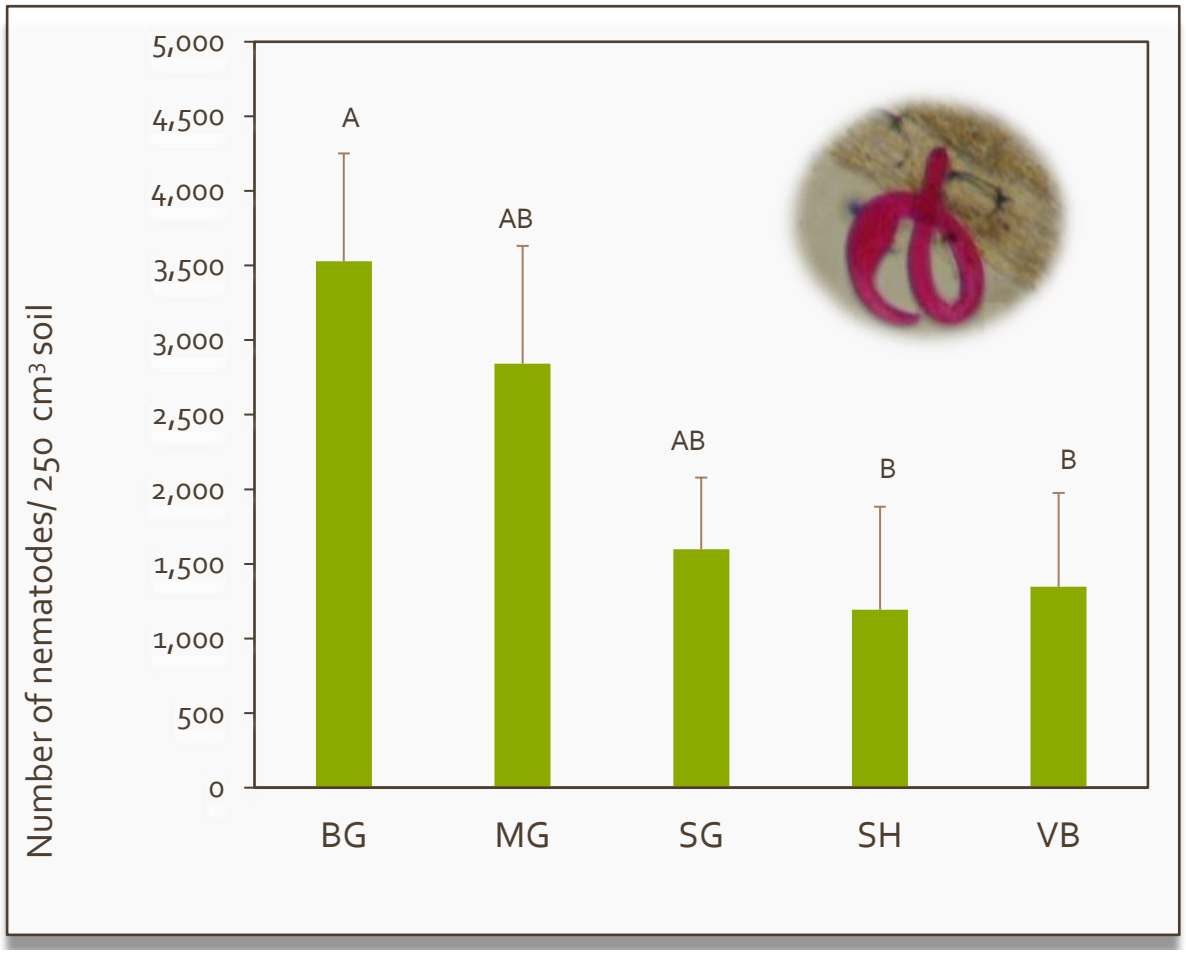
- Increased soil C in 1 year.
- Improved water infiltration in 1 year.
- Improved soil food web structure in 2 crop cycles.
- Improved soil aggregate stability in year 2.



絨豆

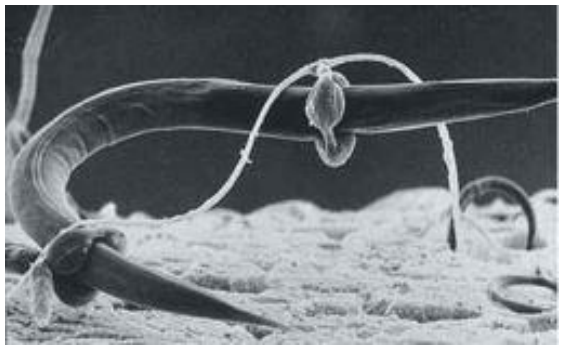
Velvet bean against renifrom nematodes 腎形線蟲

5 months after planting sweet potato



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

天敌 *Natural Enemies of Plant-parasitic Nematodes*



Nematode-trapping fungi
-- form constricting rings

Dactylaria ellipsospora
-form adhesive knobs

Arthrobotrys dactyloides

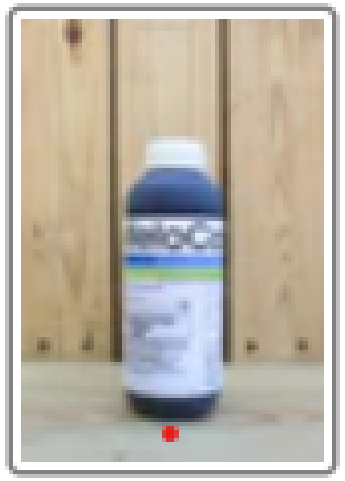
-form adhesive 3°nets

Pasteuria penetrans

- Occur naturally in soil, but they take time to build up their populations. They can be enhanced by cover crop residues.
- *Paecilomyces lilacinum* is a commercial product available from Symplot

Purpureocillium (Paecilomyces) lilacinum strain 251 – egg parasite

MeloCon® LC
BIOLOGICAL NEMATICIDE



OMRI LISTED
For Organic Use

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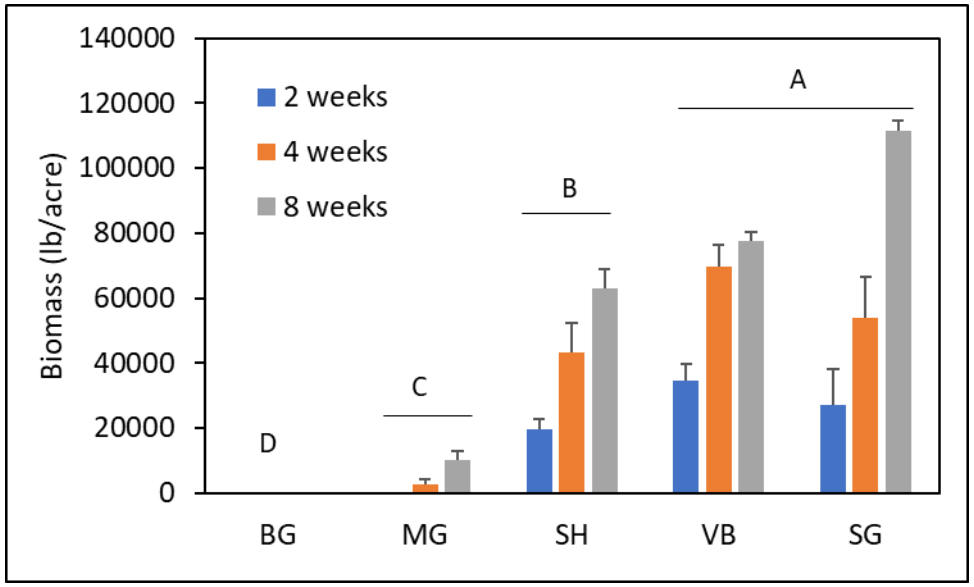
Irrigation regimes on cover crops



Velvet bean achieved similar biomass regardless of irrigated for 4 or 8 weeks. Thus, most water efficient.

Soil Microbial Biomass using Phospholipid Fatty Acid Analysis (PLFA) assay

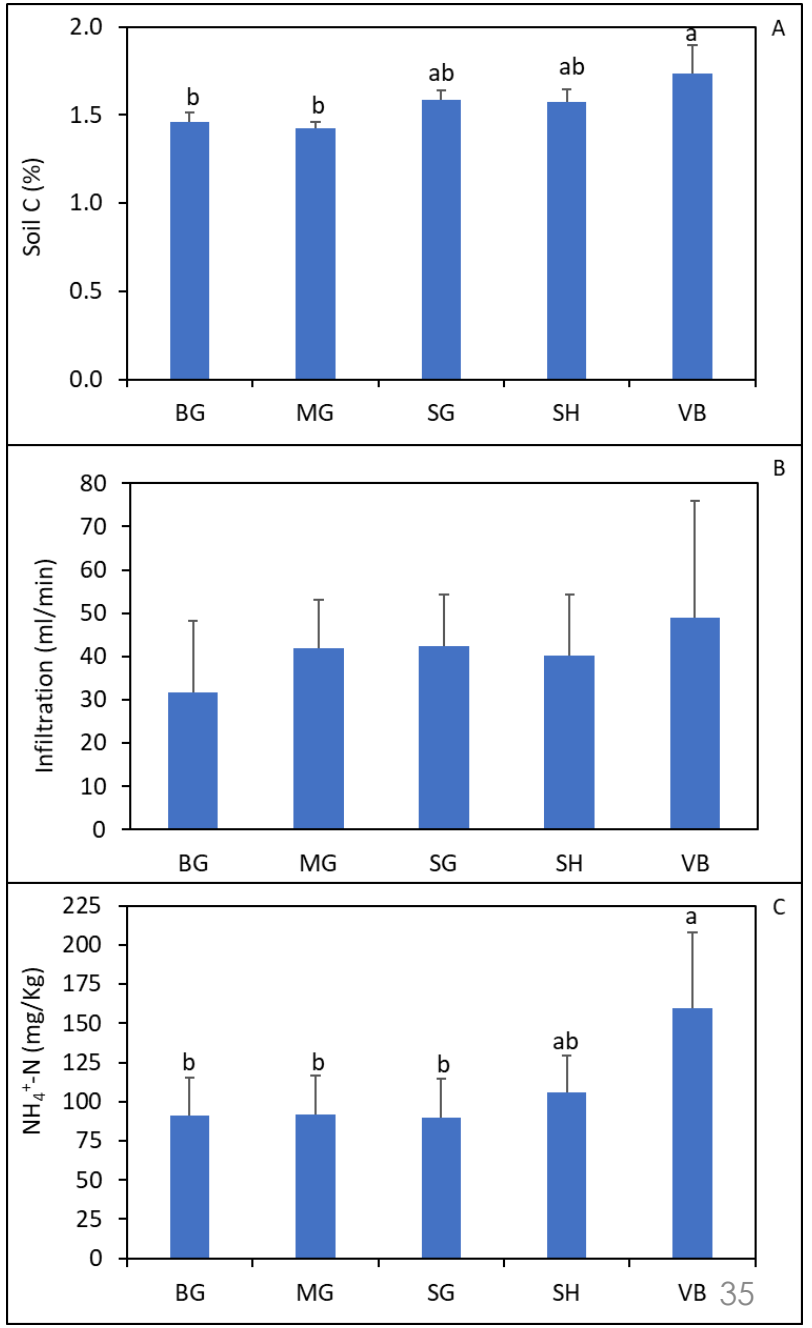
At 2-weeks after cover crop termination.

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

DIV = Microbial biomass diversity, **ACT** = Actinomycetes, **GN** = Gram negative bacteria, **AMF** = Arbuscular mycorrhizal fungi, **GP/GN** = Gram positive/ Gram negative bacteria, **S/U** = Saturated/ Unsaturated PLFA, **F/B** = Fungi/ Bacteria Ratio.

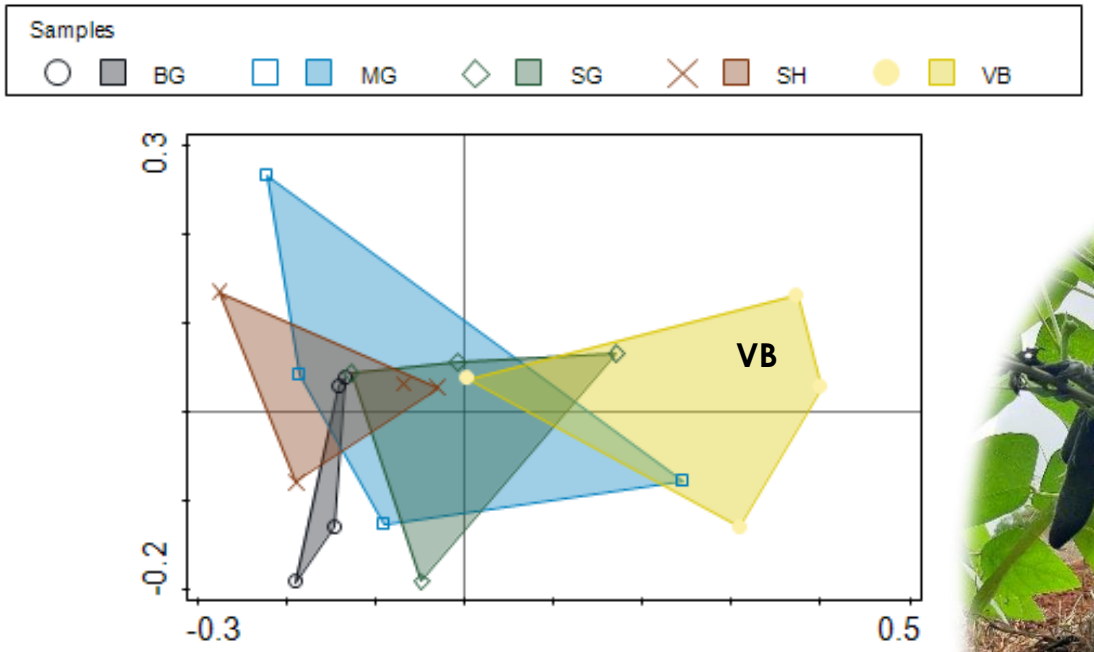
Other Soil Health Properties

- VB increased Soil C by 0.38% (at 3 months after cover cropping).
- Though not significant, VB plots had the highest water infiltration rate.
- VB also increased ammonia-N in the soil compared to BG indicating a higher pool of organic N that is potentially plant available (Solvita Labile Amino-Nitrogen (SLAN) test).



5 months after sweet potato planting (@ harvest)

- ✓ VB increased arbuscular mycorrhizal fungi (AMF), saprophytic fungi (SF), and resulted in a higher fungi: bacteria (F/B) microbial biomass ratio.
- ✓ VB increased soil C and NH_4^+-N in the soil = available organic form N.
- ✓ VB increased soil C by 0.38% was associated with increased in water infiltration, soil moisture content.



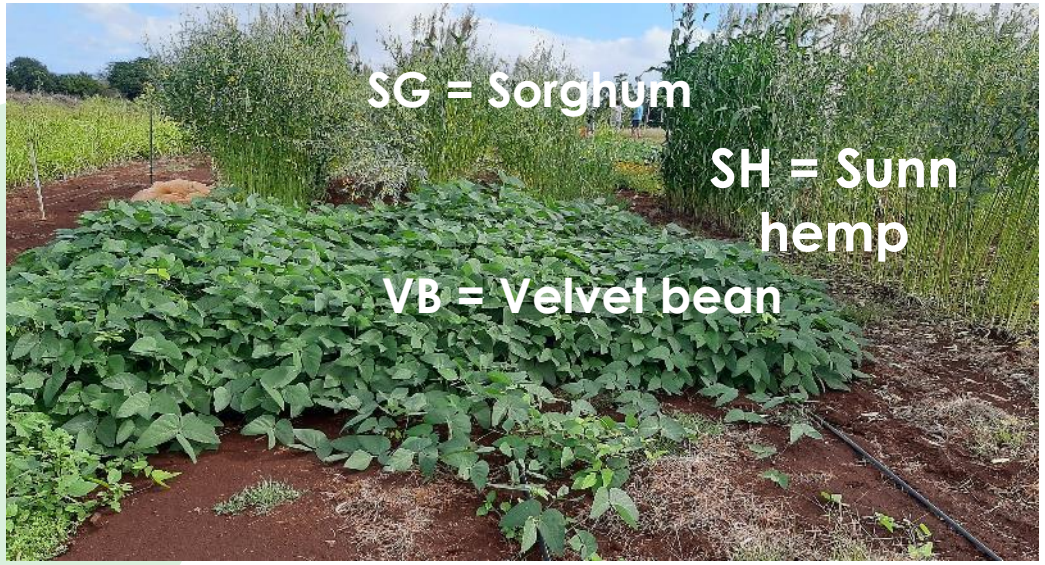
(first two axis explained 87.37% of variance)

Regenerative Agriculture

Happy Soil = Happy Farmers

Summary

- Velvet bean is drought tolerant and most effective in increasing soil C among the CC tested.
- Strip-till cover cropping allow allelopathic compounds from VB and SH to suppress reniform nematodes.



- induction of PGPR (G+ or G-) or AMF by strip-till cover cropping of VB might have an additional benefits of regenerative ag for nematode management.

SPM

Unitrap

Resources for farmers

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

Calculator

Prescription for Soil Health

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

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