



Anaerobic Soil Disinfestation and Biofumigation in Perennial Strawberry Systems:

Will It Help?

New England Vegetable and Berry Growers
Northhampton, Massachusetts
January 5, 2024





- Why is this topic important?
- What are the specific problems?
- How can growers improve the situation?
- Where do we get information and support?
- Who should consider these approaches?



“12 year effect”

Not New!



Strawberry farms evolving

Matted Row



Plasticulture, protected culture –
perennial and annual systems



Root problems are caused by:

- Disease
- Nematodes
- Insects
- Cultural problems



Stress can make problems worse!

- Winter damage
- Poor vigor
- Poor nutrition
- Poor site selection
- Poor pest management





Verticillium Wilt - *Verticillium dahliae*

- resembles drought stress
- occurs primarily in 1st year
- interveinal and marginal leaf necrosis
- inner leaves retain green color
plants **wilt** under stress
- randomn distribution in field



Black Root Rot – *Rhizoctonia*, *Pythium* *spp.*, *Fusarium*

- Fine feeder roots dry up
- Dark lesions develop and the outside of root turns black
- Interior root core eventually turns brown
- Severely infected plants collapse
- Partially infected plants wilt during drought, or while plant is fruiting or rapidly growing



Red Stele – *Phytophthora fragariae*

- Infected plants are stunted
- New leaves are bluish-green and wilted



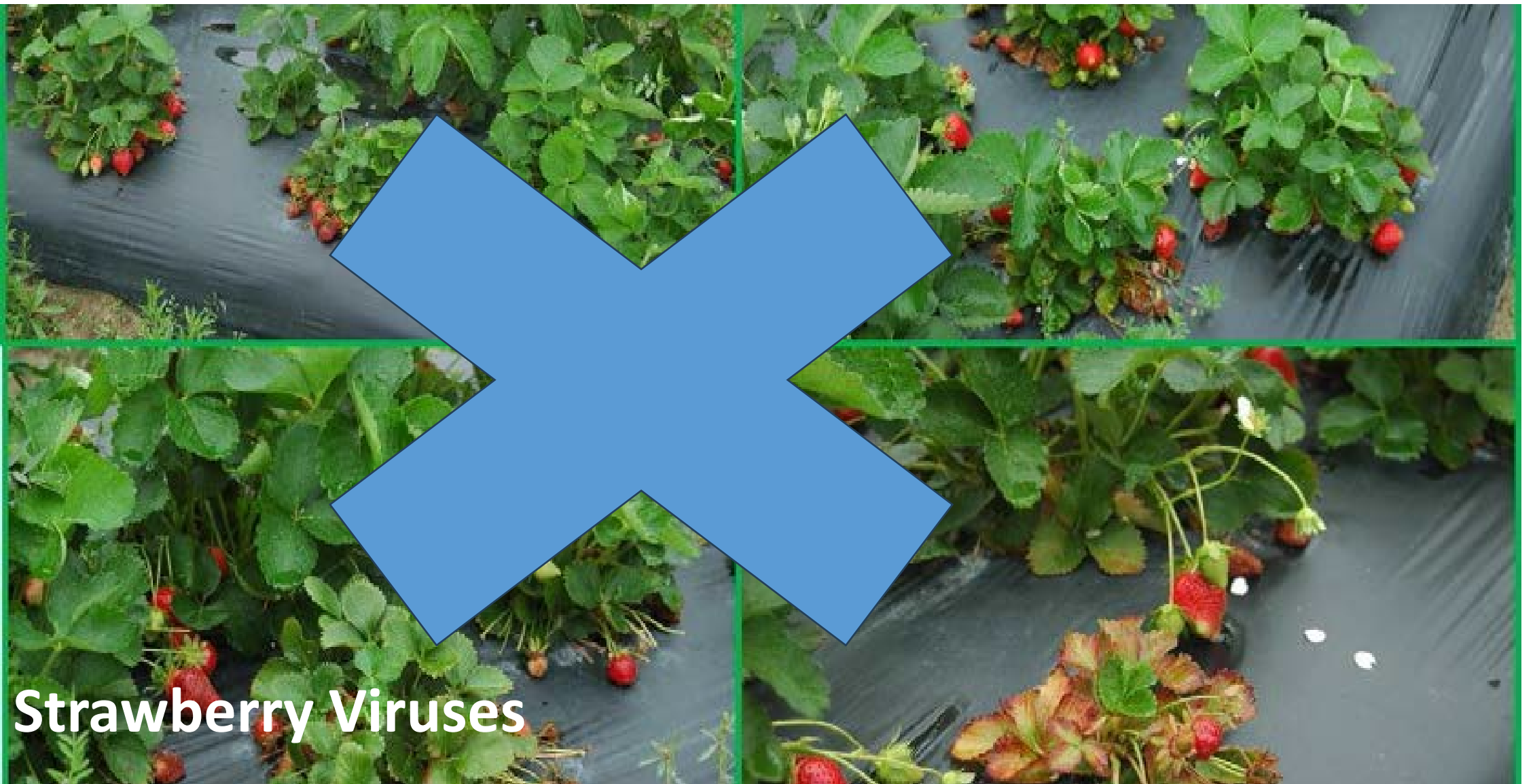
- Root rot
- Late rot
- Infection
- Wilt



Anthracnose - *Colletotrichum fragariae*, *C. acutatum*, and *C. gloeosporioides*

- may cause daughter plants to die
- outer leaves die prematurely
- the plant may collapse from crown rot





Strawberry Viruses

- Strawberry Mild Yellow Edge Virus
- Strawberry Vein Banding Virus
- Strawberry Mottle Virus



Neopestalotiopsis Disease - *Neopestalotiopsis rosae*

- Aggressive, new disease
- Primarily in Southeast, but found as far north as PA
- Originally plant borne, but now found in soils
- Persistent in southern soils



Images from UF/IFAS

Charcoal Rot

Macrophomina phaseolina

- Soil borne
- Favors dry and warm soil
- Causes plant collapse
- has been isolated in eastern NY – Found on plasticulture June Bearing field that had DN planting the year prior



Image from OSU Plant Clinic

Nematodes

Symptoms

Reduced growth
Yellow foliage
Excessive wilting
Reduced yields

May predispose plant to invasion of soil fungi such as *Fusarium*, *Pythium*, *Rhizoctonia*, *Verticillium*

Stubby-root nematodes
Root-knot nematodes
Lesion nematodes



A close-up photograph of a white grub (larva) in dark soil, positioned near a plant root system. The grub is C-shaped, with a yellowish-brown head and a white body. It is surrounded by dark brown soil and some plant roots. The background is slightly blurred, showing more soil and roots.

White Grub Complex

- June Beetles, Japanese Beetles and Chafers
- Adults nocturnal
- larvae are C-shaped, with six legs
- Stunted growth and plant dieback
- First year plantings most susceptible



Strawberry Rootworm

Paria fragariae

- Adults are nocturnal and shy
- Larvae are white and can be found in soil – root feeders
- Adults do the foliar feeding damage resulting in **distinctive**, ragged appearance

Root weevils, *Otiorhynchus* spp.

- Strawberry root weevil, *O. ovatus*
- Black vine weevil, *O. sulcatus*
- Rough strawberry root weevil, *O. rugosostriatus*,



Weeds

- Reduce plant productivity
- Harbor pests





Flumioxazin



Glyphosate

Herbicide Injury

Photos courtesy of OMAFRA:
<http://www.omafra.gov.on.ca/IPM/english/strawberries/herbicide-injury/index.html>



S-metolachlor



Terbacil



Winter Injury

- Brown flecking highlighted by creamy tissue
- Poor crown regrowth
- No signs of nematode issues
- Can occur at 10 degree F



Fertilizer injury

- Nitrate alone causes poor root growth
- Ammonium fertilizer alone is fine, but may be easily lost to leaching
- A mixture of two is best

Soil Testing Results

Measured Soil Textural Class: **fine**

Sand: --% - Silt: --% - Clay: --%

Group	Indicator	Value	Rating	Constraints
physical	Surface Hardness	146	57	
physical	Subsurface Hardness	189	84	
physical	Aggregate Stability	10.0	9	Aeration, Infiltration, Rooting, Crusting, Sealing, Erosion, Runoff
biological	Organic Matter	2.5	5	Nutrient and Energy Storage, Ion Exchange, C Sequestration, Water Retention
biological	Soil Respiration	0.4	22	
chemical	Soil pH	5.8	42	
chemical	Extractable Phosphorus	5.3	100	
chemical	Extractable Potassium	131.0	100	
chemical	Minor Elements Mg: 121.2 / Fe: 6.4 / Mn: 13.6 / Zn: 0.8		100	

Soil quality ranged from poor to excellent on Cornell Soil Health Tests

Common Issue Included:

- Aggregate stability
- Organic matter
- Soil respiration

Overall Quality Score: **58** / Medium

Distribution of 58 strawberry farms surveyed in Eastern NY

17 farms had disease as primary limiting problem

16 farms had weed pressure that limited production

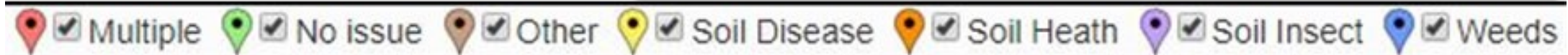
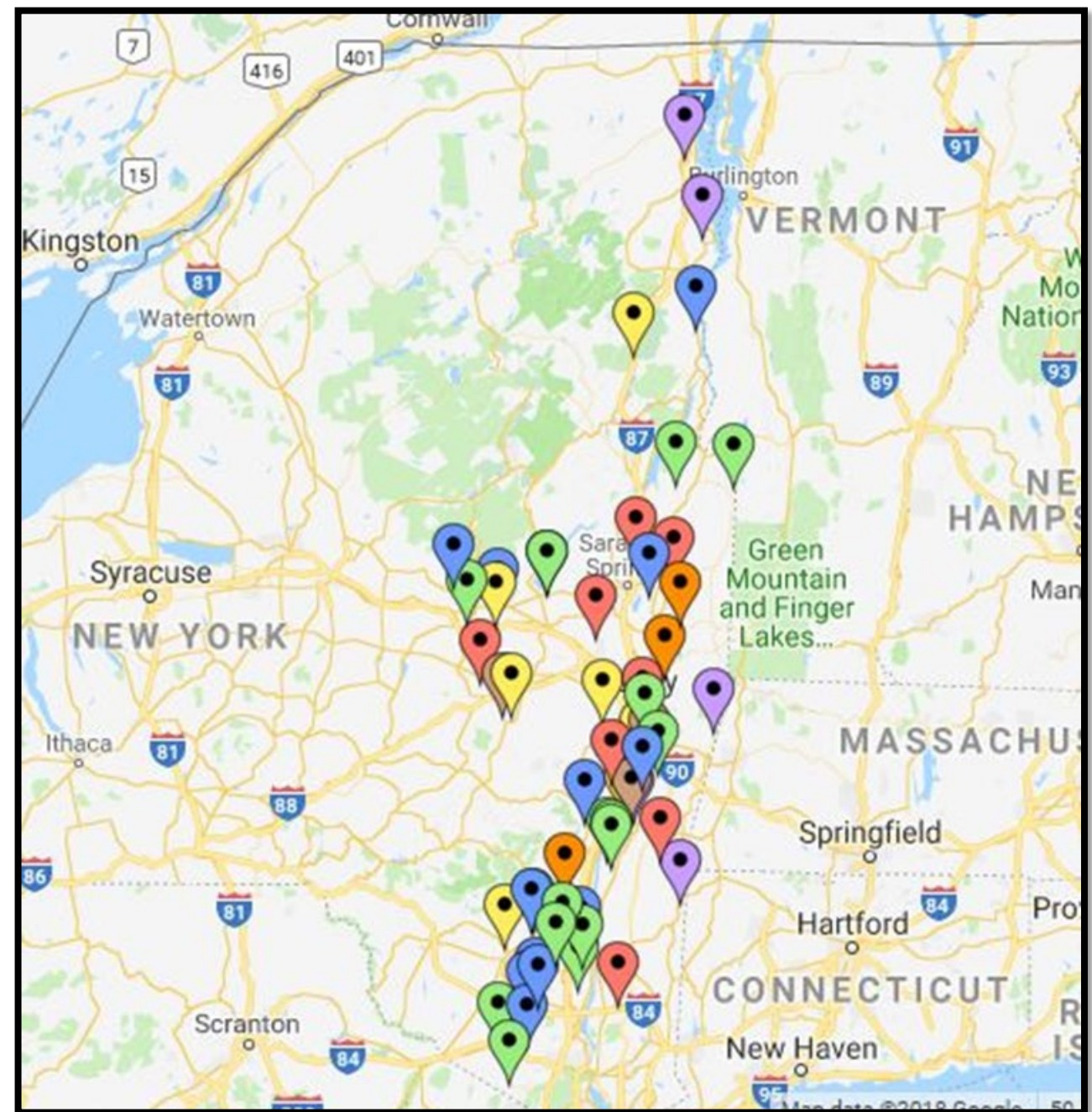
15 farms had abiotic damage

10 farms with overall soil health in 'poor' category

8 farms had limiting soil insect populations

4 farms had nematodes present

13 farms had no identifiable problems





How can farmers improve the situation?

- Move to annual culture
- Rotate fields intensively
- Incorporate cover crops
- Utilize predator species
- Chemical fumigants/fungicides
- Biofumigation
- Tarping
- Anaerobic Soil Disinfestation



Sustainable, Effective Management Options

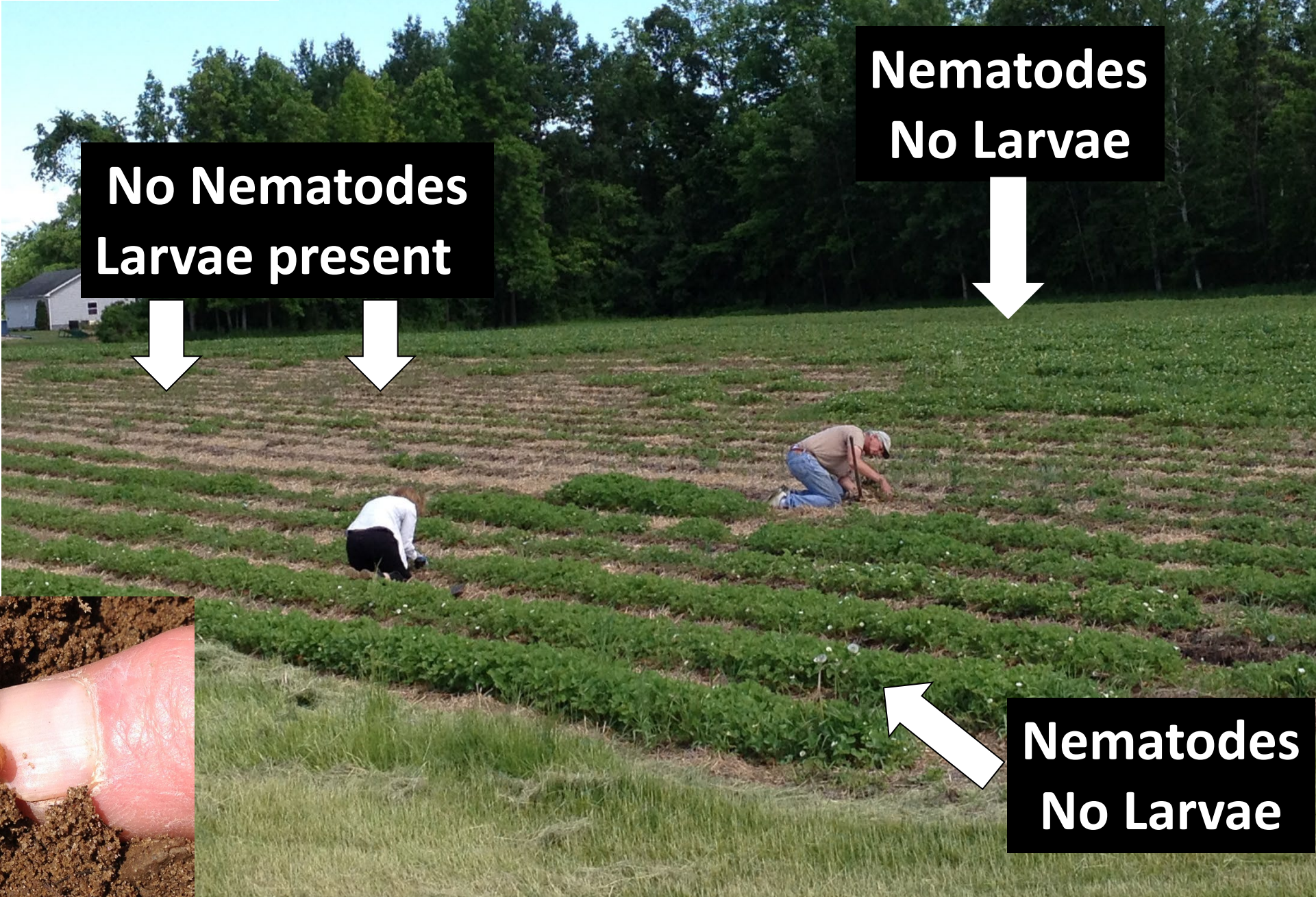
Crop Rotation
Cover Crops



Native EPN Application to control Vine Weevils in Strawberries
Sept 5, 2013



June 2014



**No Nematodes
Larvae present**



**Nematodes
No Larvae**



**Nematodes
No Larvae**



**Nematode
Infected
BVW
Larvae**





Fumigation

- Expensive and hard to find
- Scale limiting
- Incomplete control
- Unsustainable

Biofumigation

- Timing issues in strawberry systems
- Not a 'quick fix'
- Commitment to cover crops is necessary

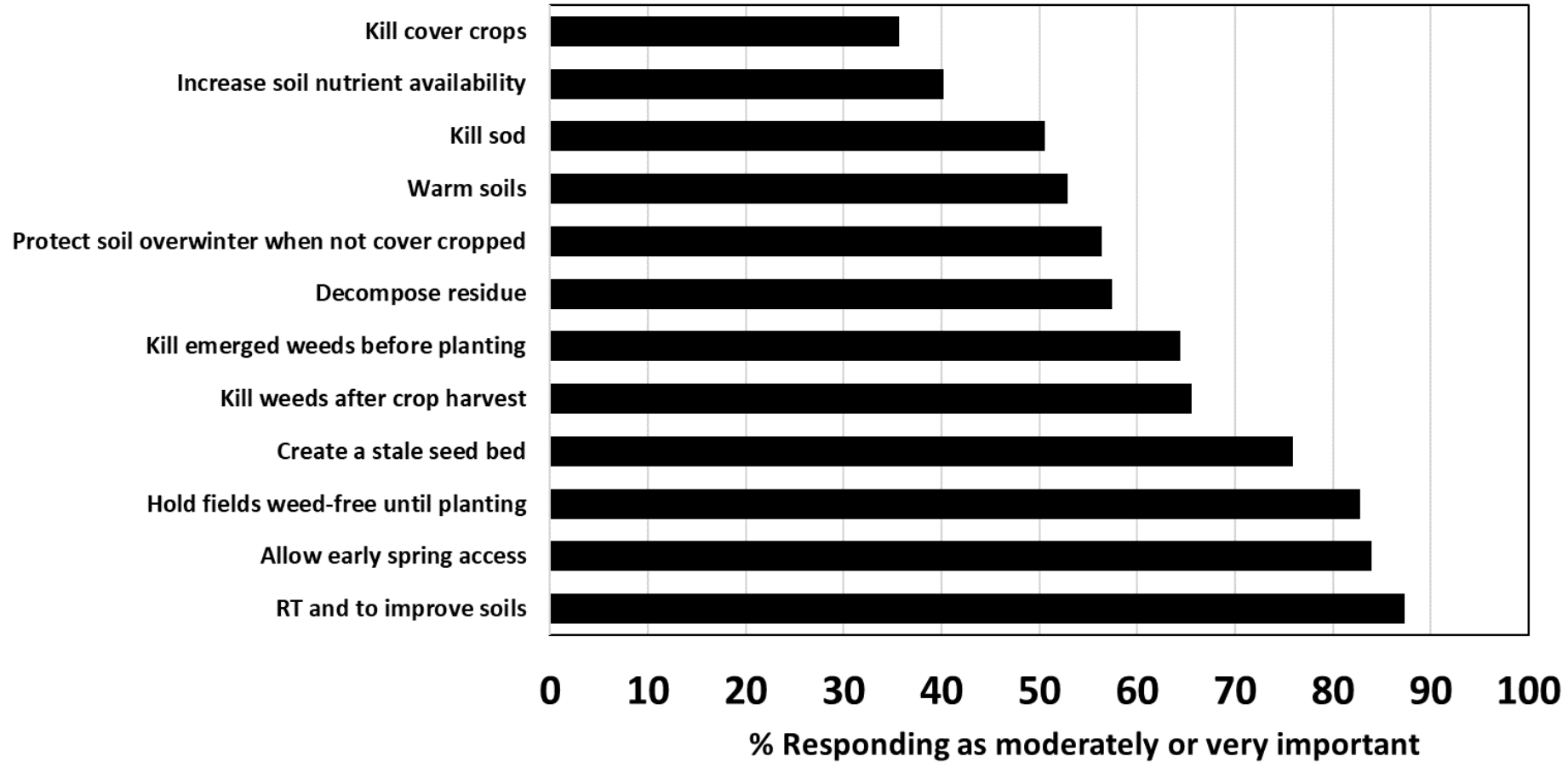




Fit tarping to the farm and field application.



A multifunctional tool...





Kill living weeds.



Manage pre-plant soil conditions.

- Warm soils
- Manage water





**Reduce the weed seed bank over the
long-term.**

Till

Tarp

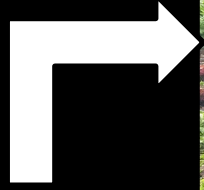


Terminate winter hardy cover crops



Nook & Cranny Farm, NY

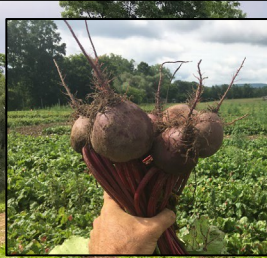
SPRING



SUMMER



Find tarping windows



WINTER



Use tarps as a tillage tool.

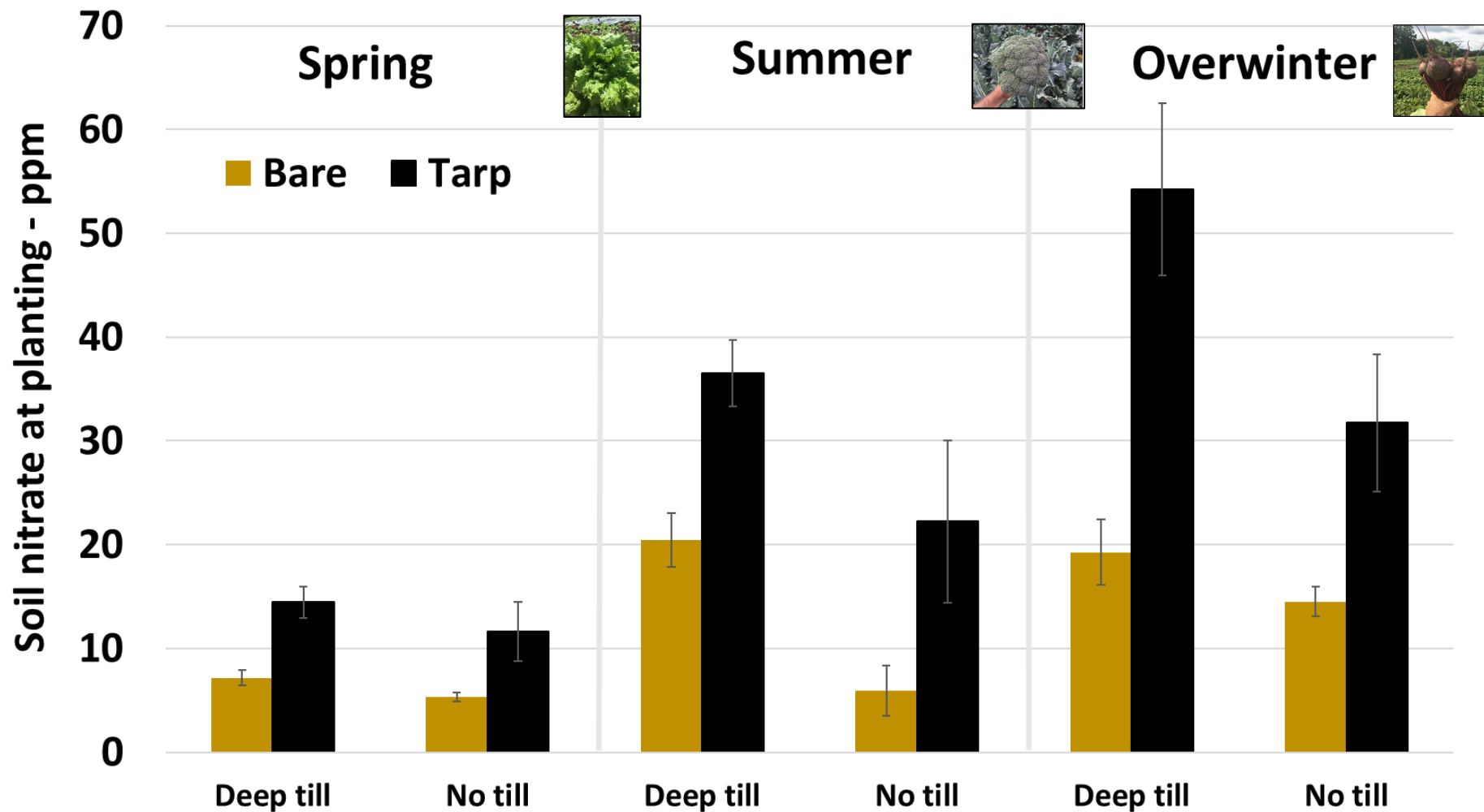


- **Make fewer passes**
- **Reduce intensity**
- **Try no-till**

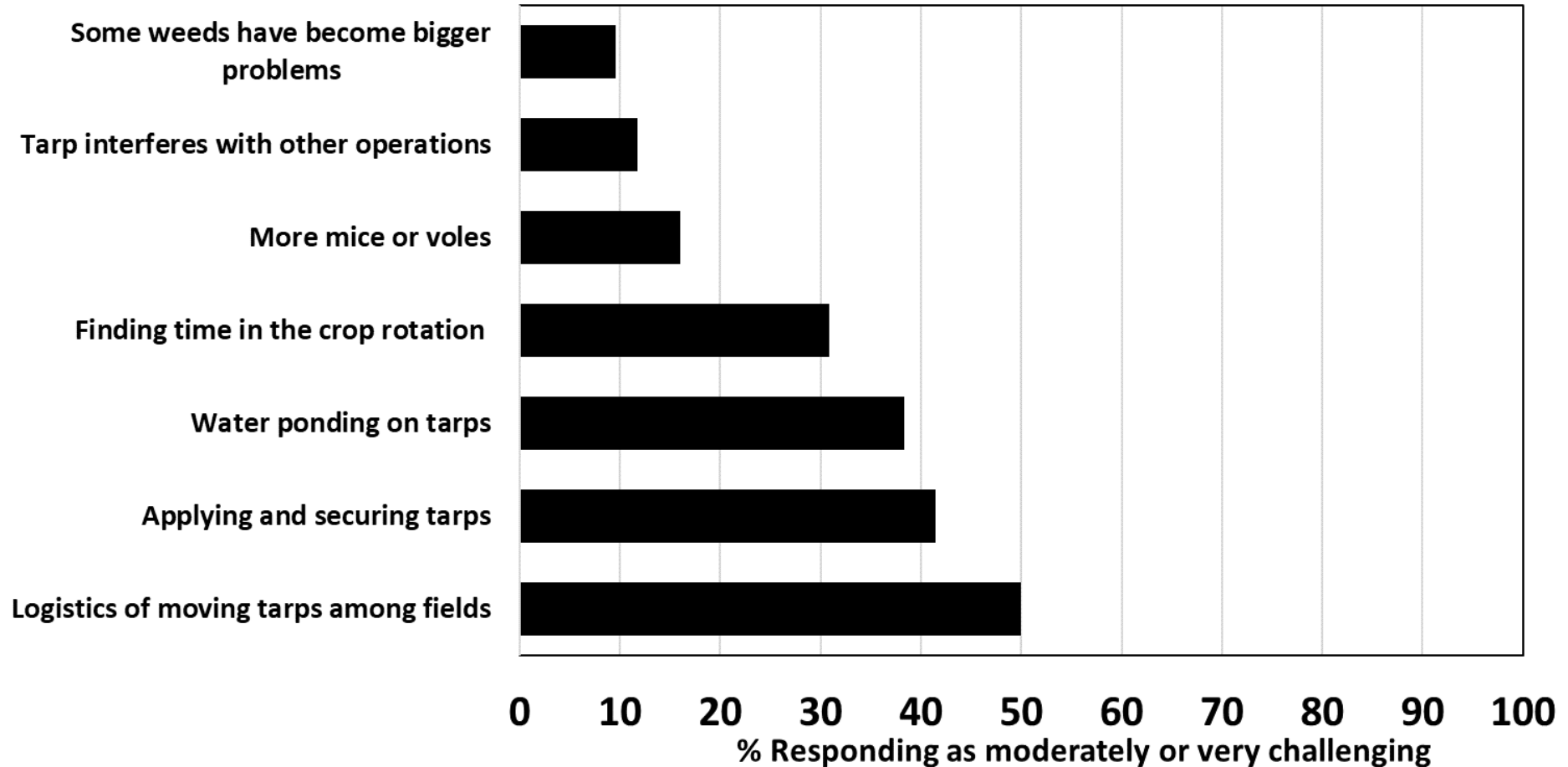




Increase plant-available soil N.



Logistical challenges



Anaerobic Soil Disinfestation

ASD 3 weeks/clear



Untreated/clear



9 ton/ac rice bran used in ASD

- Showing great promise in warm soil regions and in high tunnels
- Expensive
- Limited testing in cold regions

Hypothesis for northeast plasticulture and matted row JB strawberries:

- ASD will control
 - soil borne disease fungi
 - nematodes
 - weeds
- ASD will have no negative impact on soil health
- Carbon source will impact pest control.
- Cost vs. benefit of ASD should not discourage adoption





Methodology

- 4 Farms
 - 2 matted row - conventional
 - 1 plasticulture – conventional
 - 1 plasticulture, high tunnel - organic
- 3 carbon types
 - Alfalfa Meal (9 T/a)
 - Brassica Seed Meal (4.5 T/a)
 - Dried Molasses (9 T/a)
- Three varieties – Jewel, Cavendish, Galletta
- Additional treatments
 - Biofumigation – ‘Caliente’ Mustard
 - Chemical fumigant
 - Fungicide – Mefanoxam
- 3 years of plant and soil data
- 2 years of yield data



Apply carbon



Incorporat



Wet soil to field capacity



Tarp for 2-3 weeks



Sustained soil temps of 68-85° F



Tarp removed – gas off for several days

Measurements

- Soil Health – 1x/year
- Plant vigor – 3x/year
- Yield – 2 years
- Fruit Quality – 2 years
- Weed infestation – 2x/year
- Plant health – 1x/year

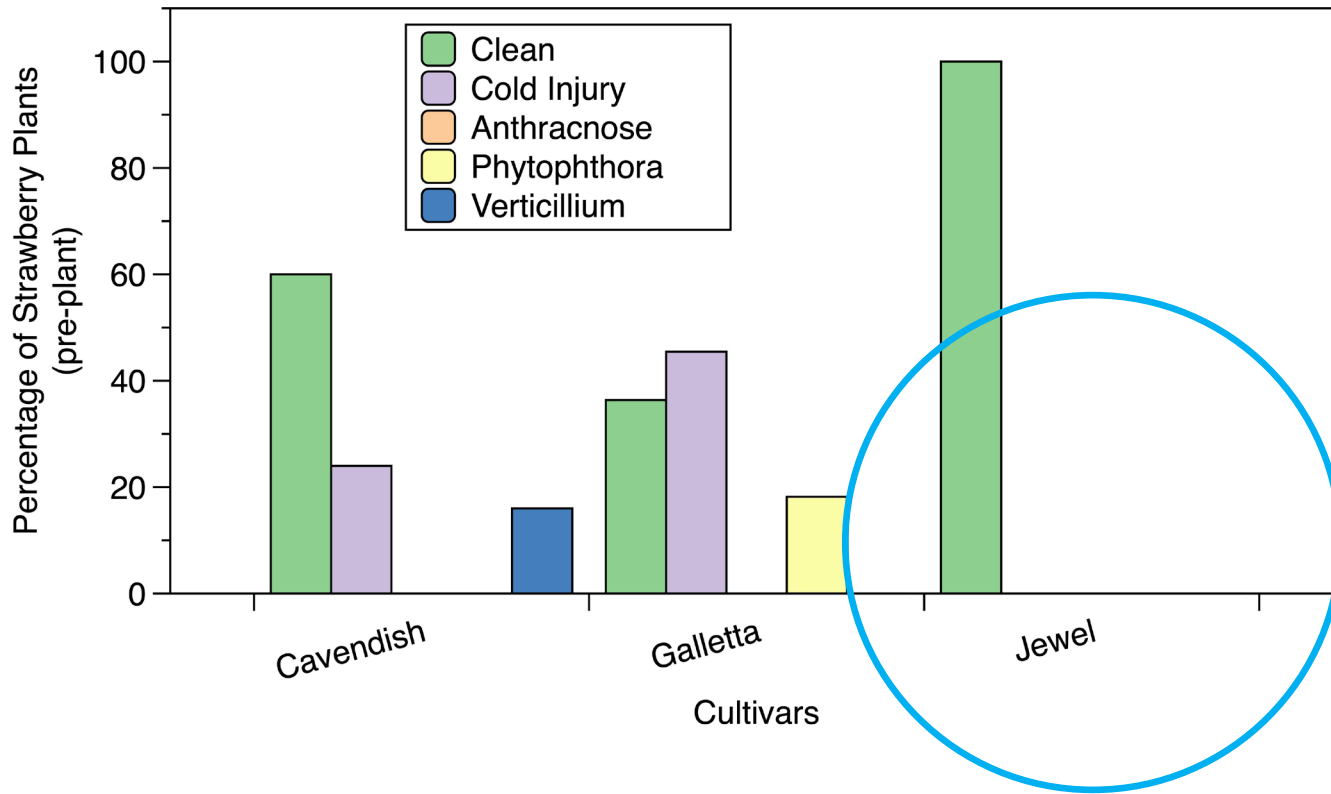
ASD **may be** more effective in suppressing weeds than tarping under aerobic conditions because:

- soil saturation enhances the decomposition of organic matter
- anaerobic conditions foster the accumulation of toxic volatile fatty acids and other organic acids in amended soil*
- lack of oxygen suppresses weed seed respiration
- anaerobic conditions result in changes in soil temperature and pH, which work synergistically with other factors to kill weed propagules.

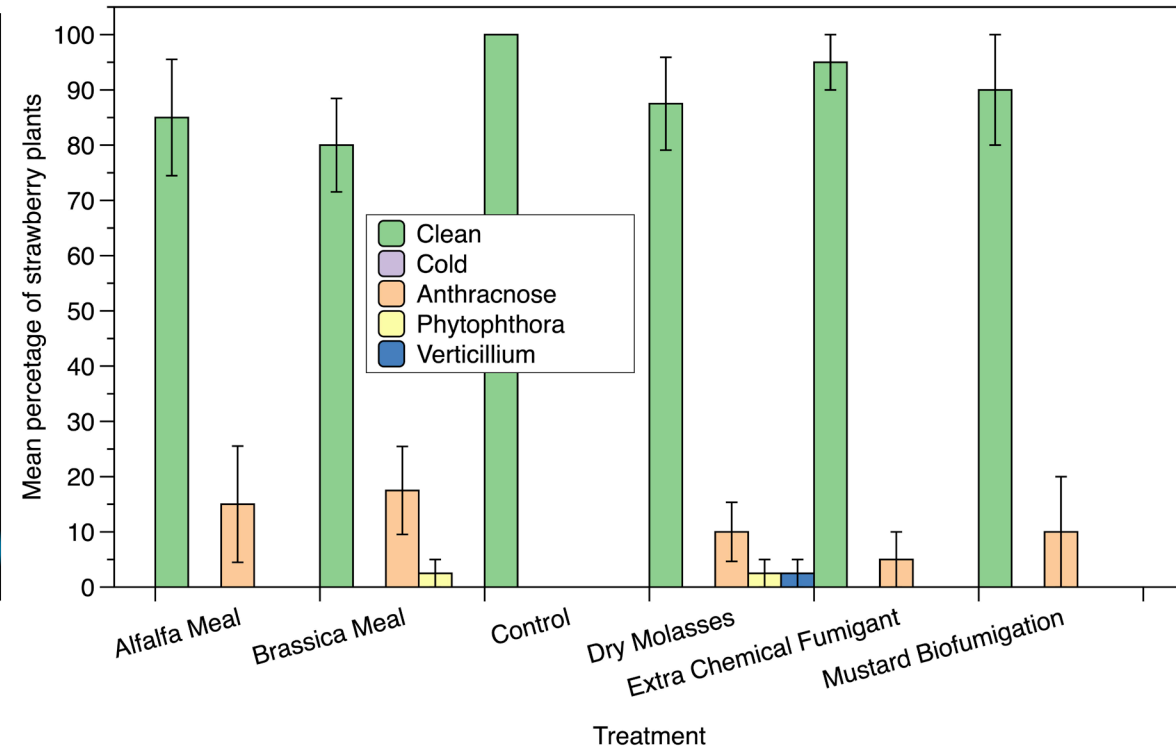
* Greenwood 1961

Strawberry ASD results

Pre-plant: All three cultivars



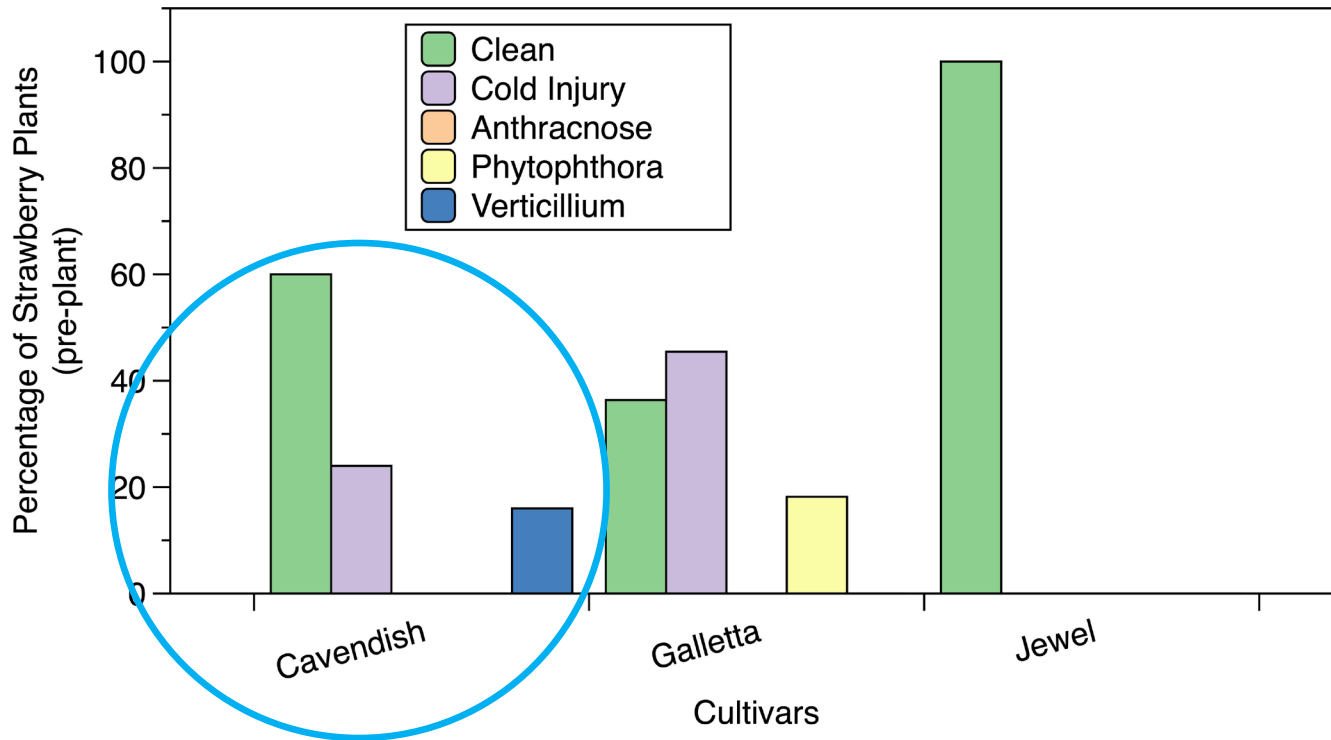
Post-plant: 'Jewel'



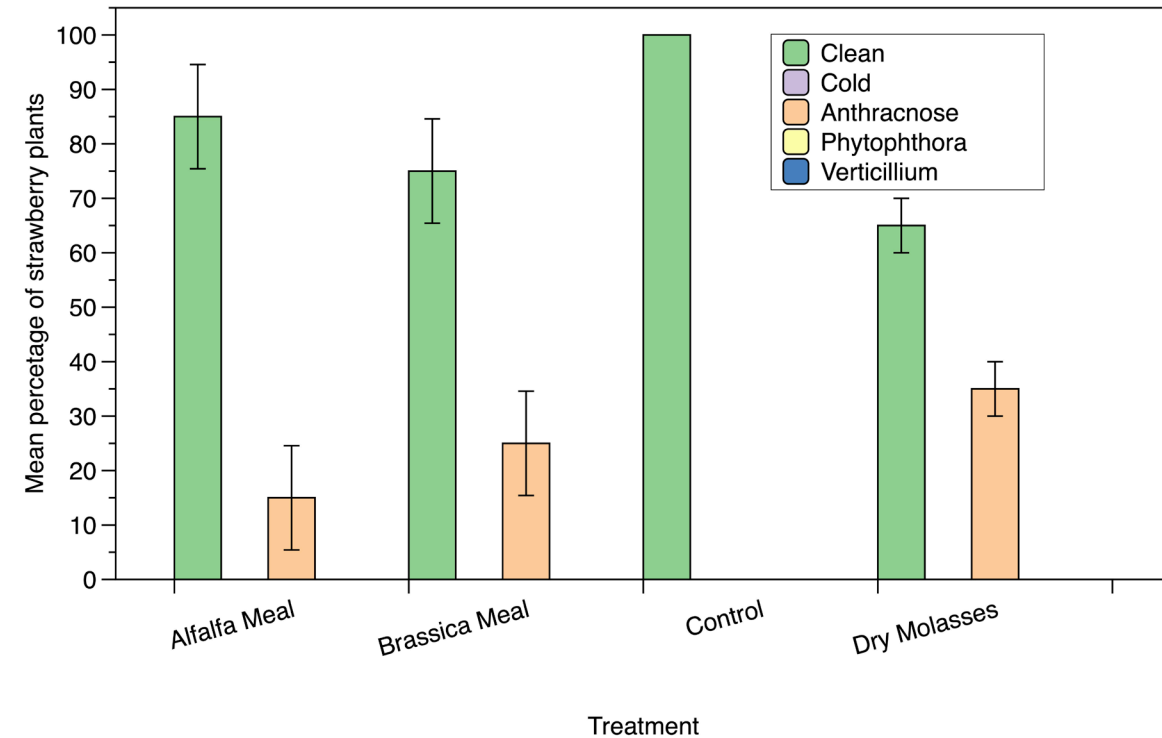
'Jewel' Clean pre-plant, picked up anthracnose in field?

Strawberry ASD results

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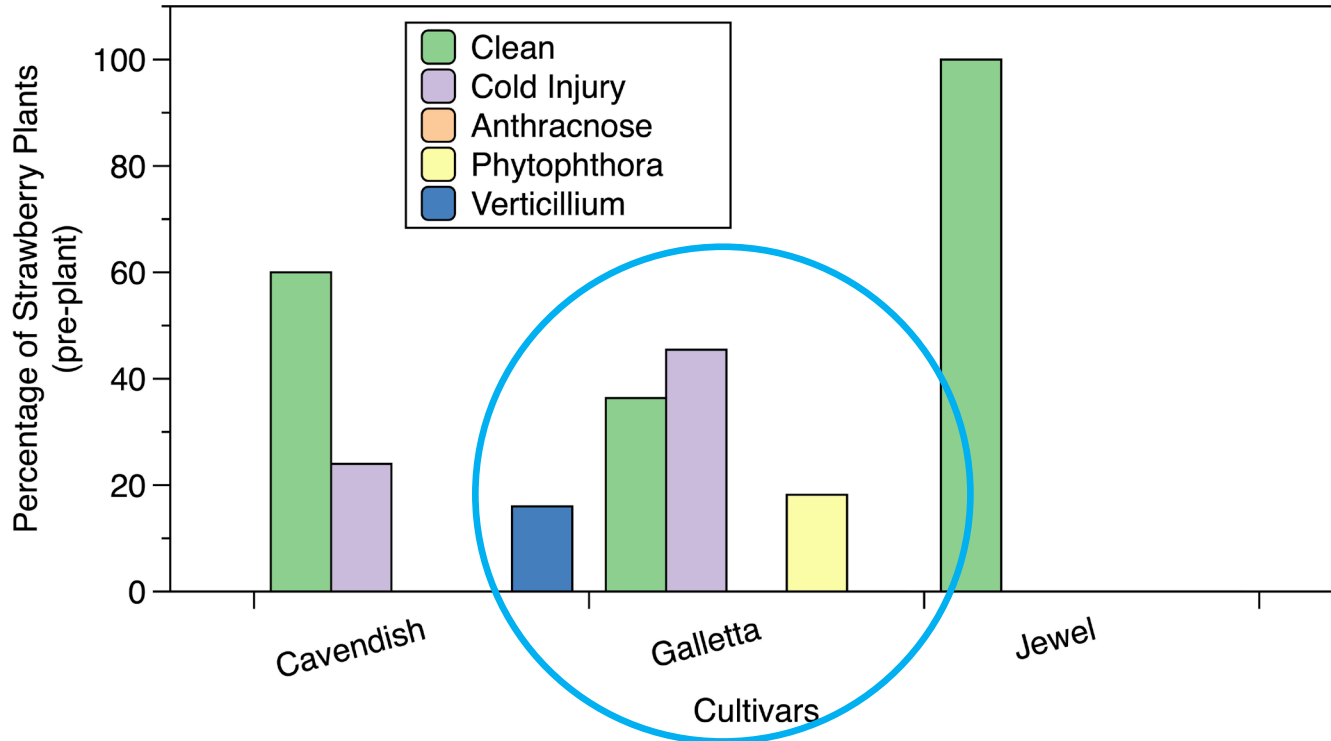
Post-plant: 'Cavendish'



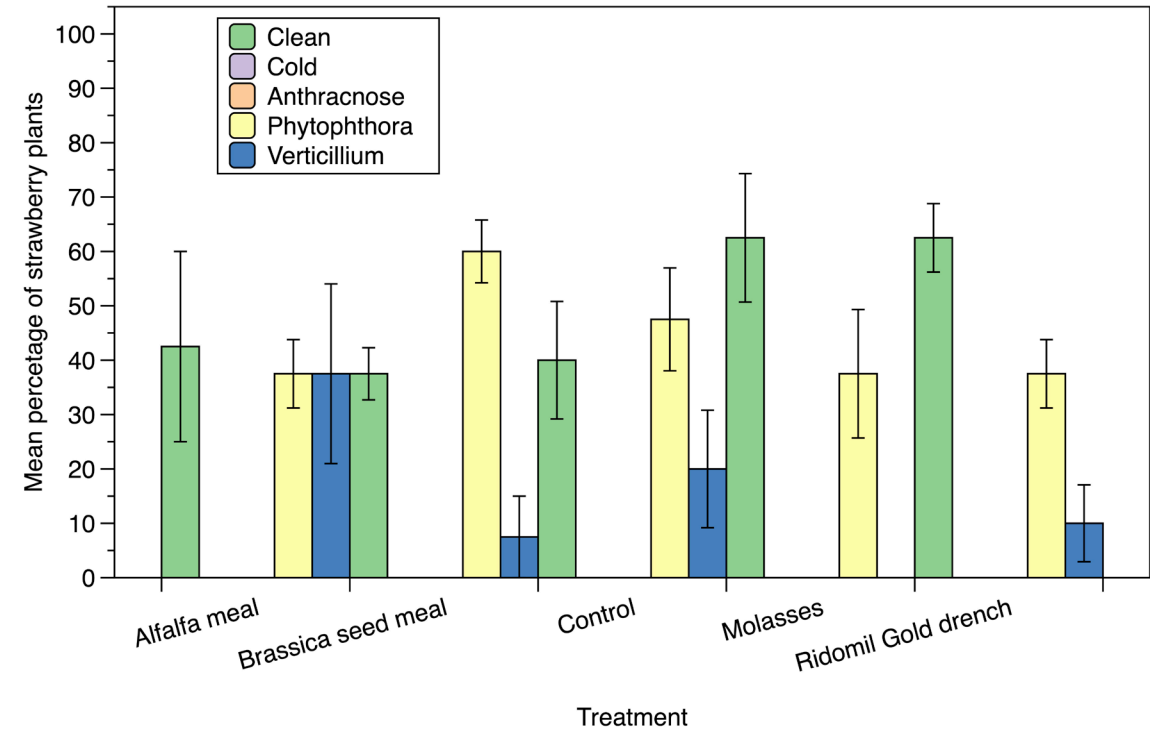
'Cavendish' Clean pre-plant, picked up anthracnose in field?

Strawberry ASD results

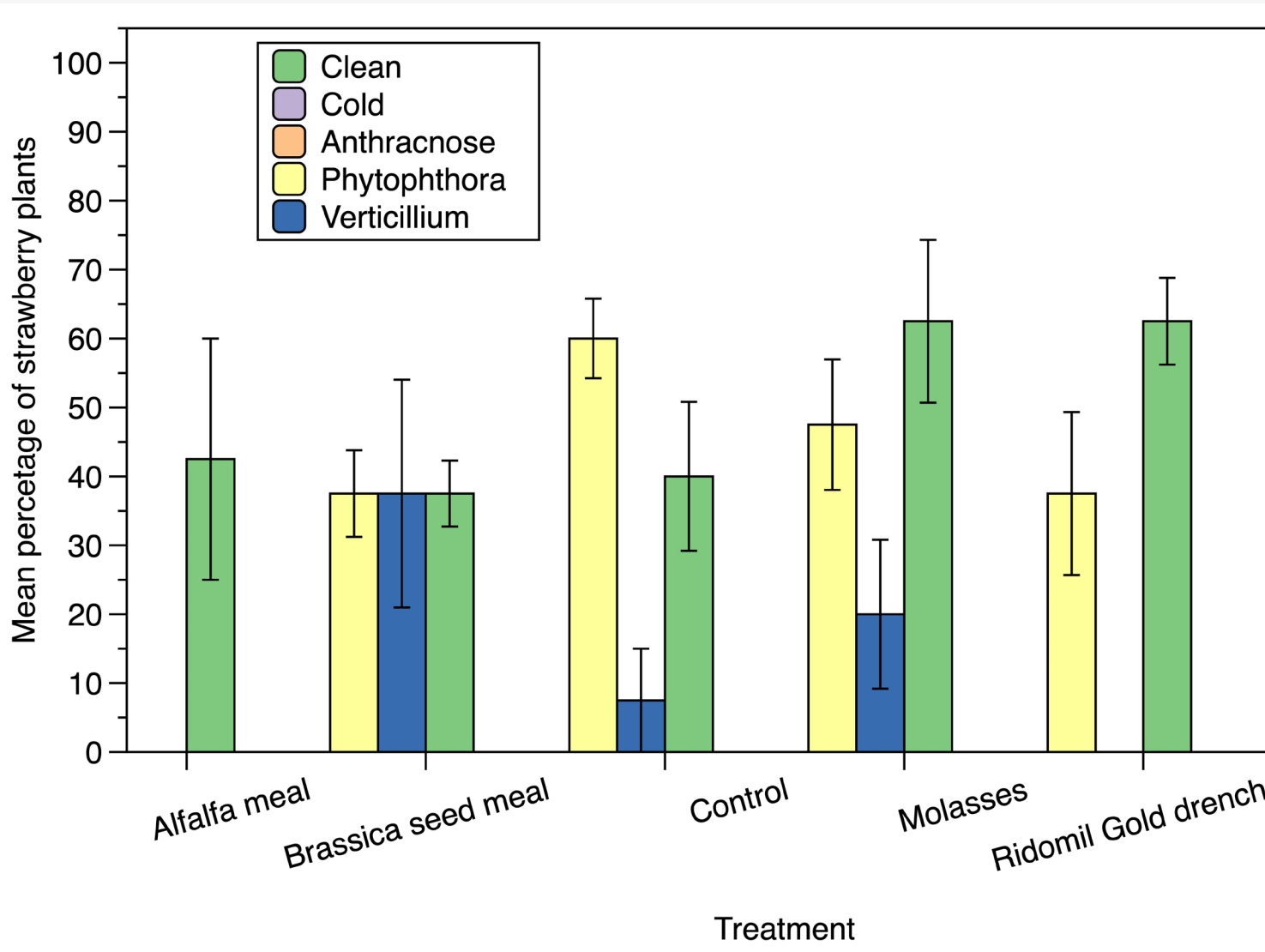
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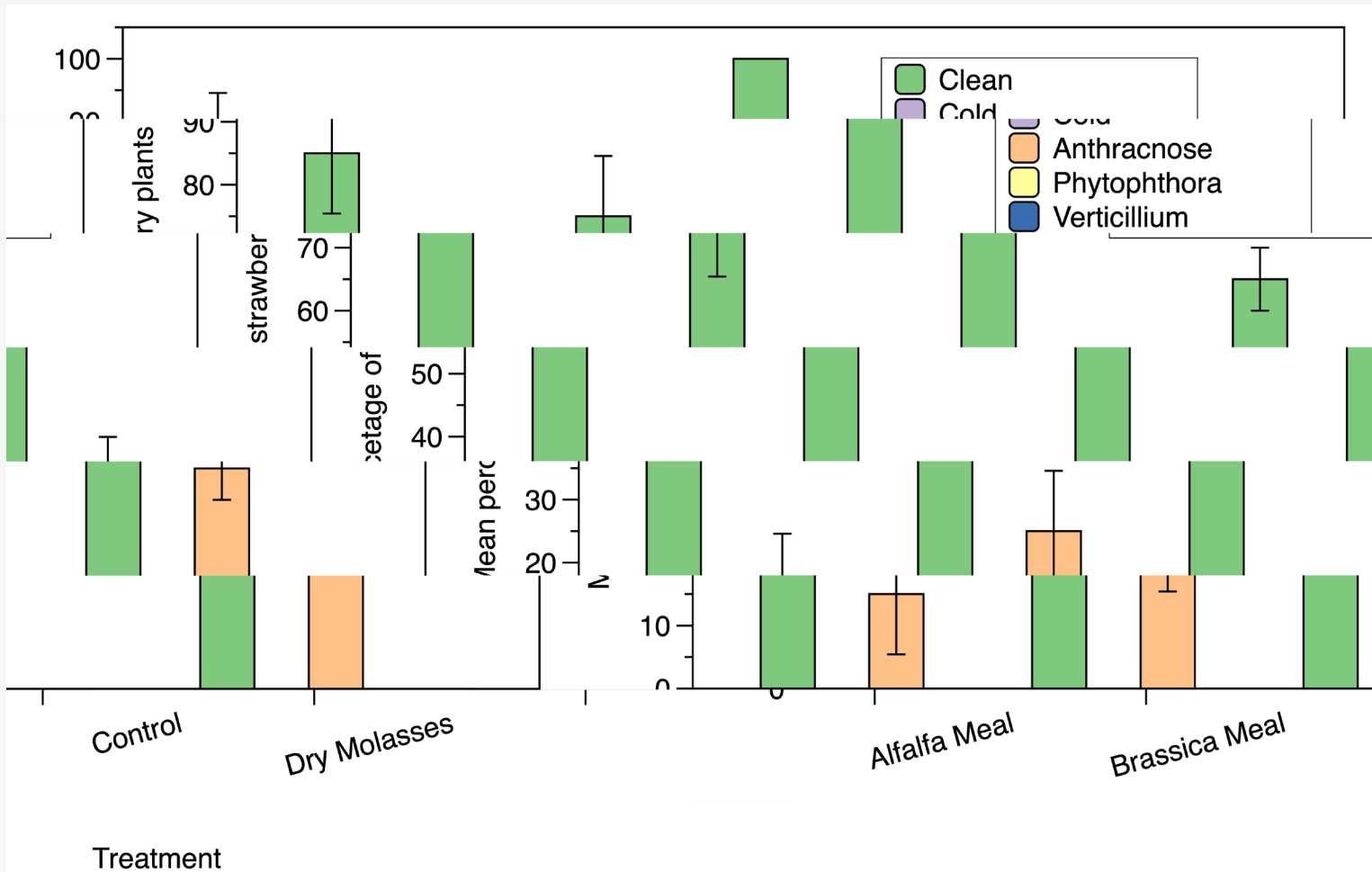
Post-plant: 'Galletta'



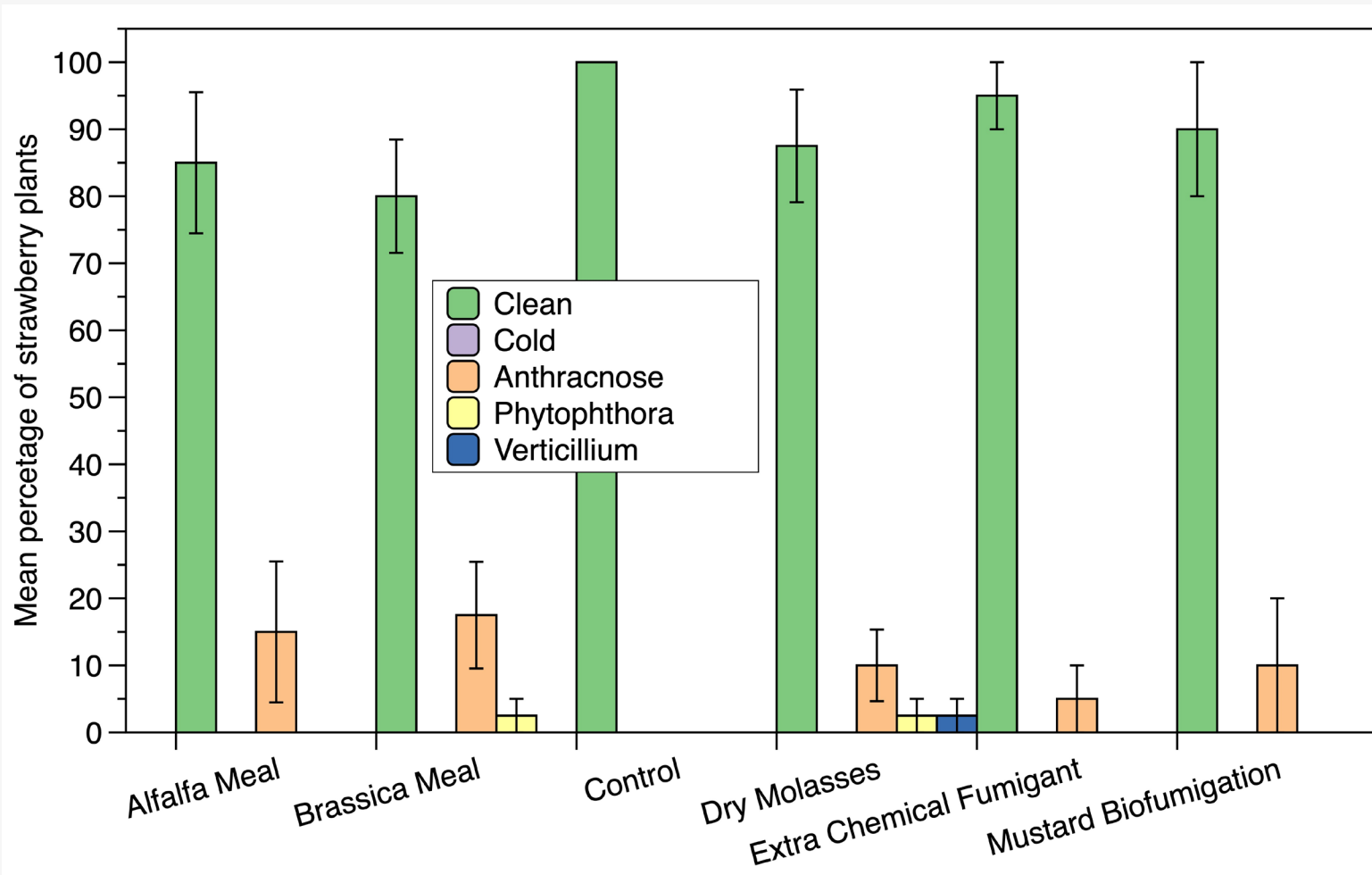
'Galletta' some diseases pre-plant, increased in some treatments, not alfalfa?



2022
 'Galletta'
 Black Plastic Mulch
 Conventional Farm



2022
 'Cavendish'
 Black Plastic Mulch
 Organic Farm



2022
 'Jewel'
 Matted Row
 2 Conventional Farms

With thanks to Cornell Cooperative Extension Student Interns Anita Minnifield and Cameron Fuhr for surveying work. Natasha Field, Chuck Bornt, Lindsey Pashow, Annie Mills, Jim O'Connell and Amy Ivy for support of past and current project(s), Caleb Goossen, Anya Osatuke and Kerik Cox for 'pandemic push' and Cornell Insect and Plant Disease Diagnostic Lab staff for their dedication to the cause!



Questions?

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