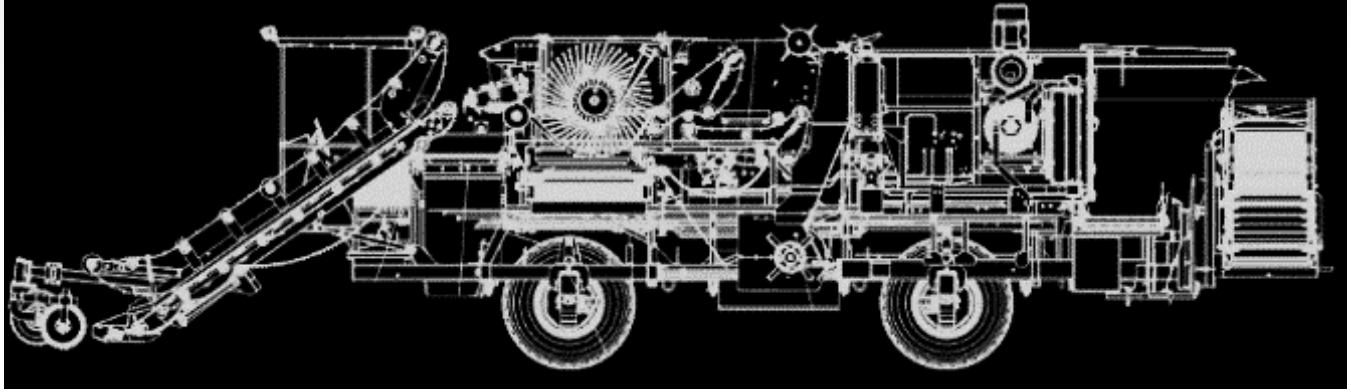


Field equipment sanitation to reduce spread of broomrape and other soil borne pests

Cassandra Swett, Justine Beaulieu, Kacey Zimmerman, Swett Lab et al., UCD Dept. of Plant Pathology

Brad Hanson, Pershang Hosseini, Hanson Lab, UCD Dept. of Plant Sciences

Zach Bagley, CTRI director

Numerous cooperators

AKA Team Clean Machine

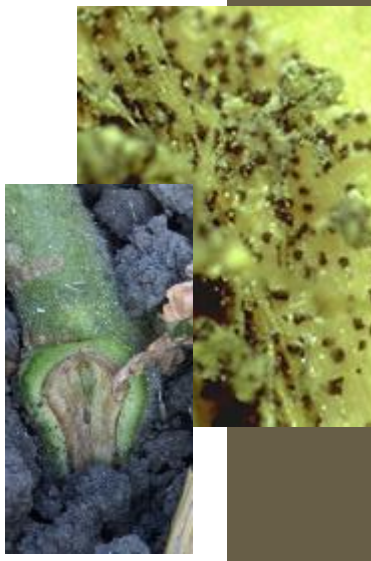
Soil-borne pathogens and other pests spread on field equipment to new fields

Broomrape

G. Miyao

Southern blight

Verticillium

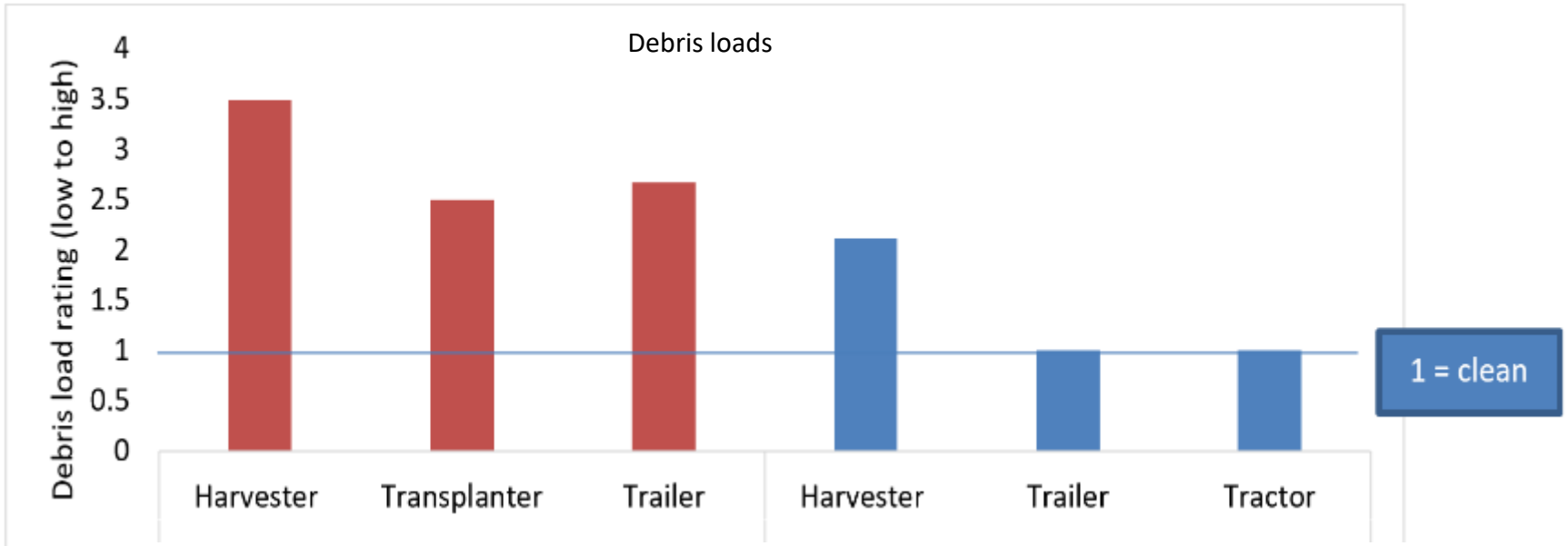


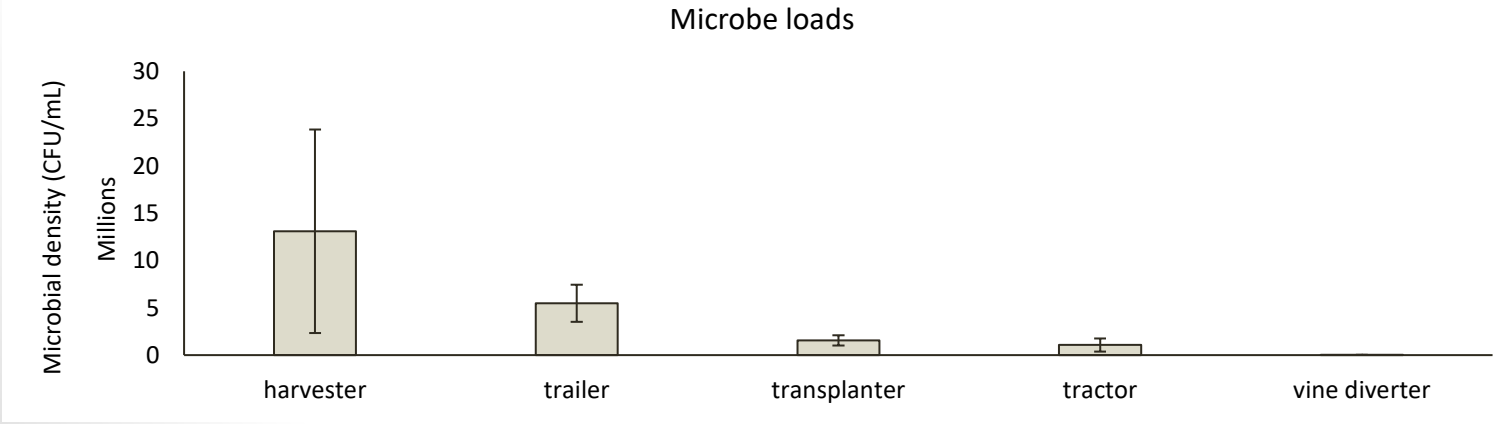
Fusarium wilt and rot diseases

Clavibacter (bac canker)

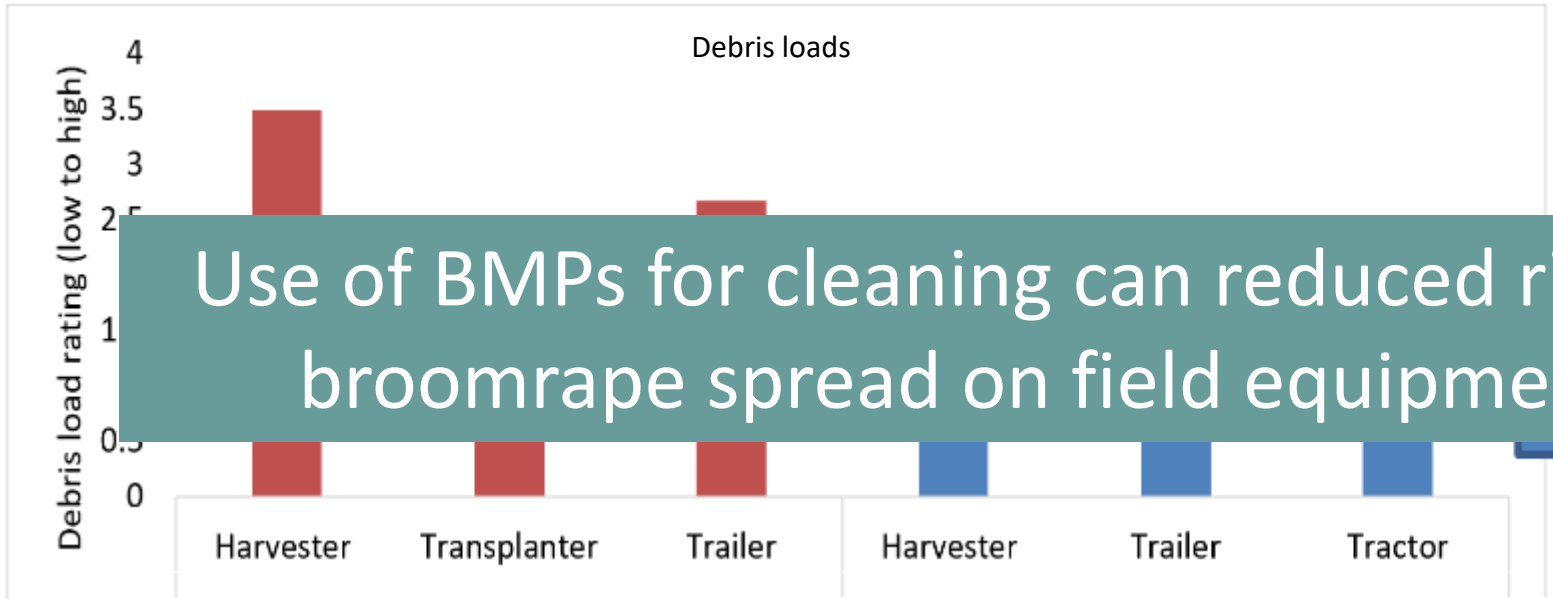
Root knot nematode

There are many kinds of equipment that can spread broomrape and other pests

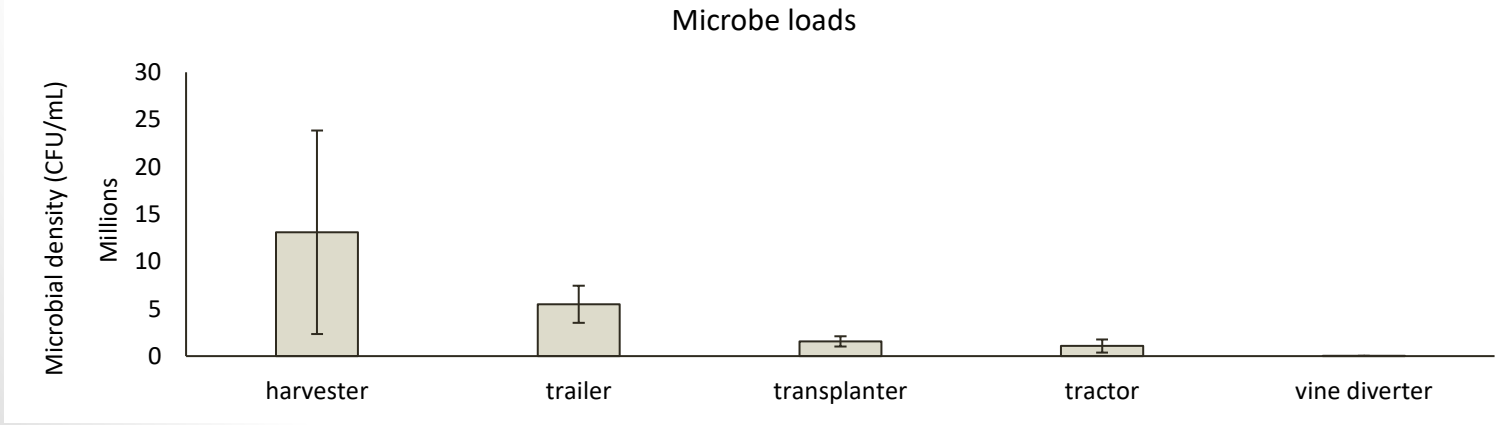




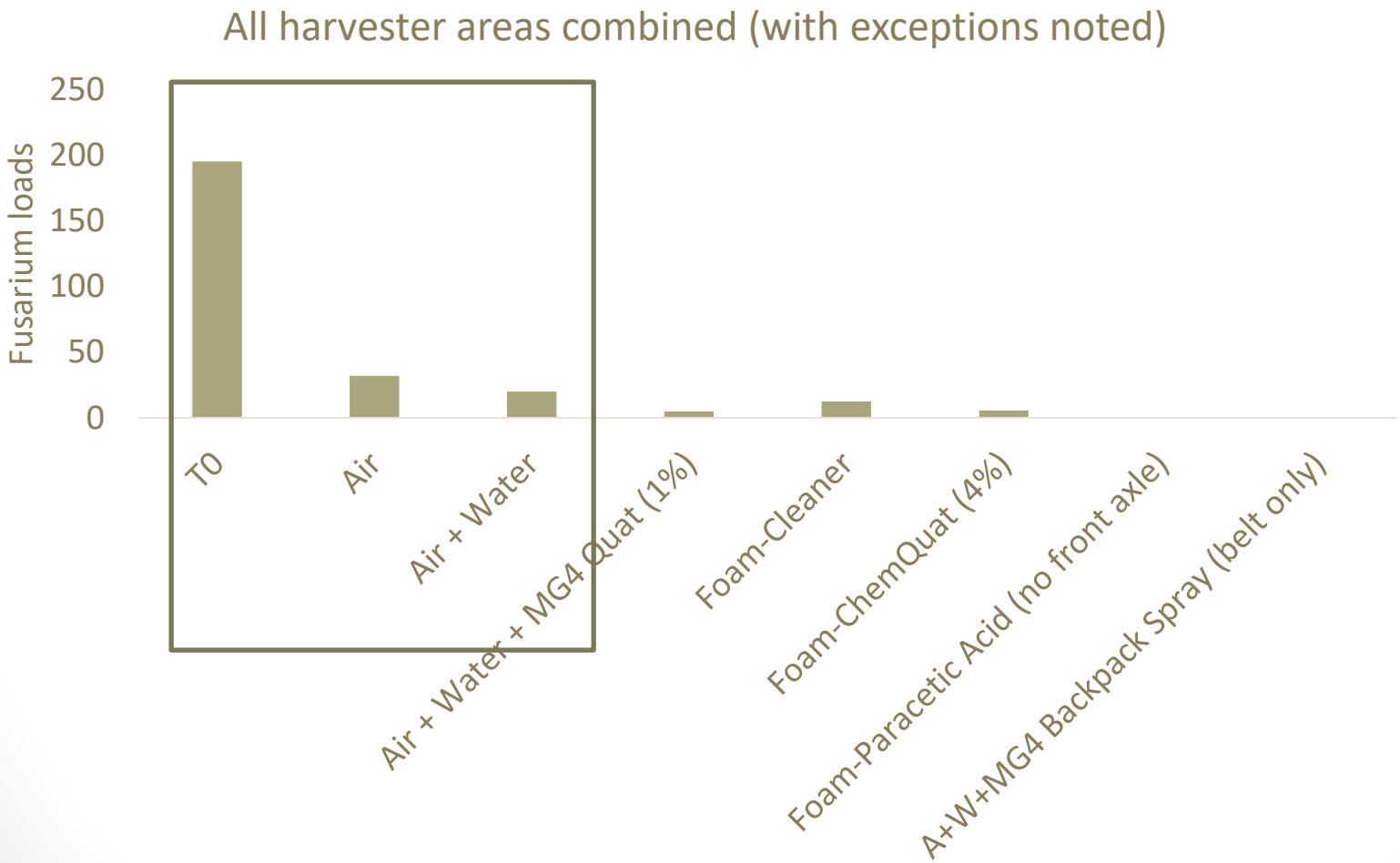
There are many kinds of equipment that can spread broomrape and other pests



Use of BMPs for cleaning can reduced risk of broomrape spread on field equipment

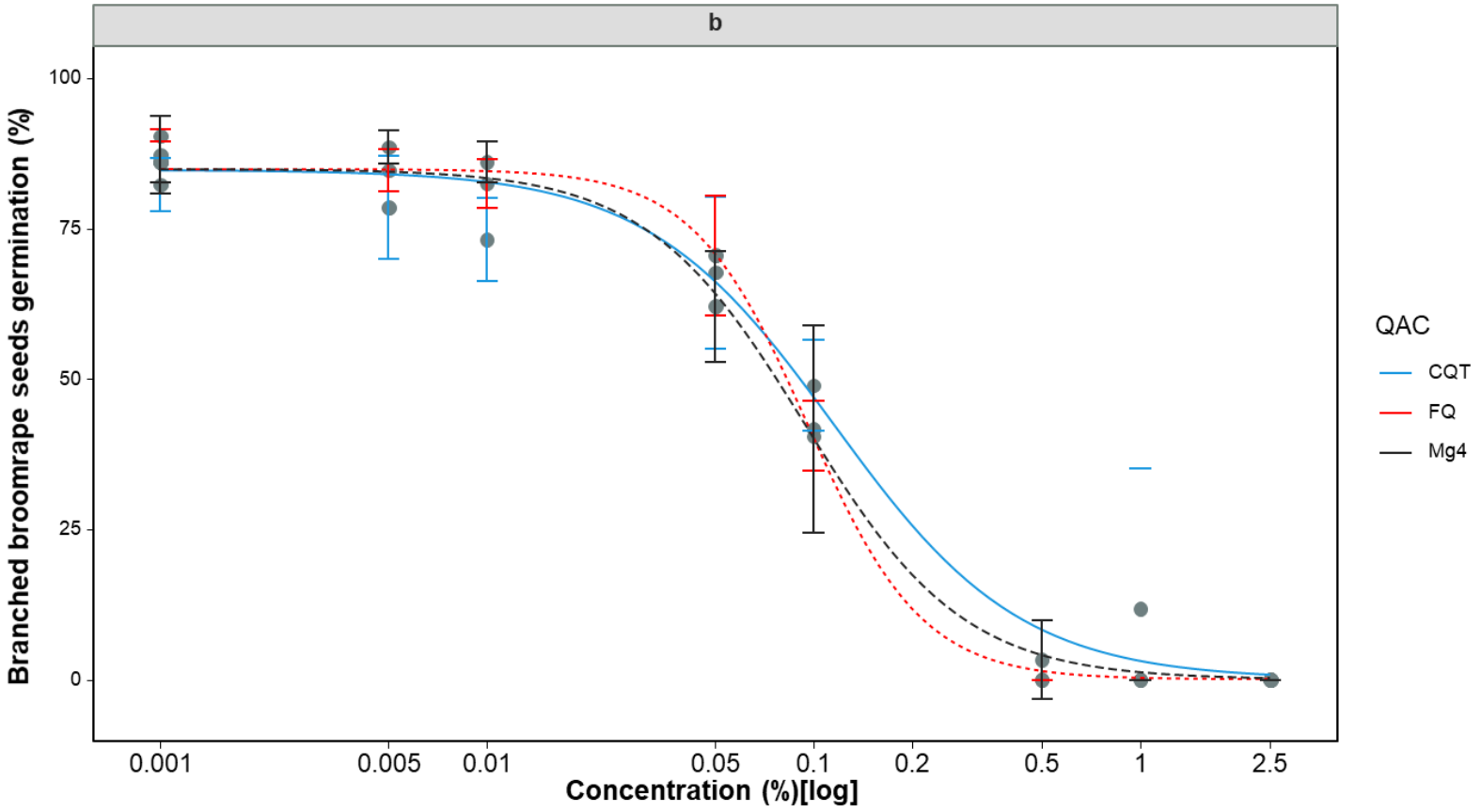


Air alone reduce loads by ~83%; Pressure wash increased to 90%

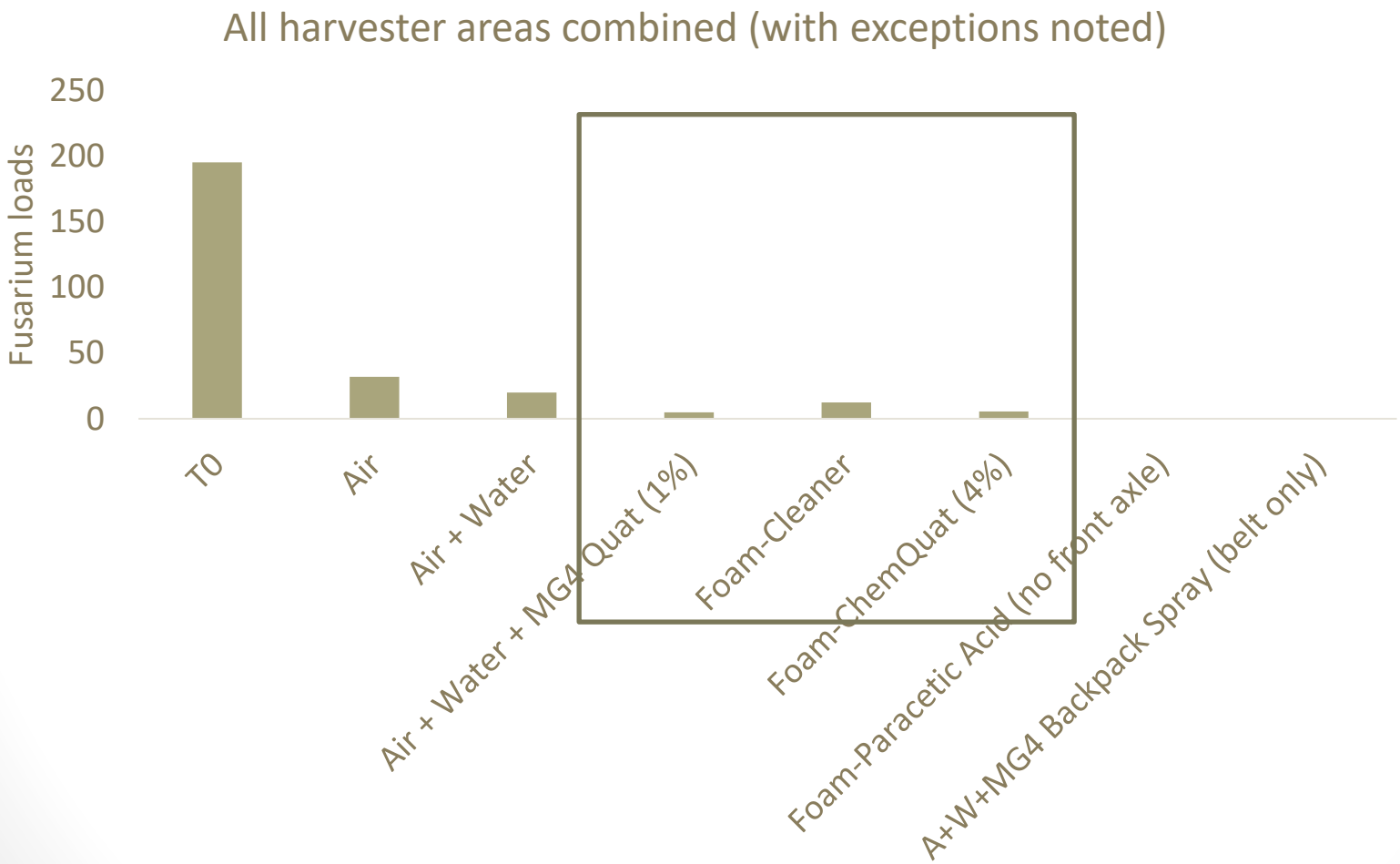


Commercial quaternary ammonium sanitizers are effective against broomrape

Evaluated: MG4-Quat (Mg4), Flo-Quat (FQ), and Cleaner QT-185 (CQT)

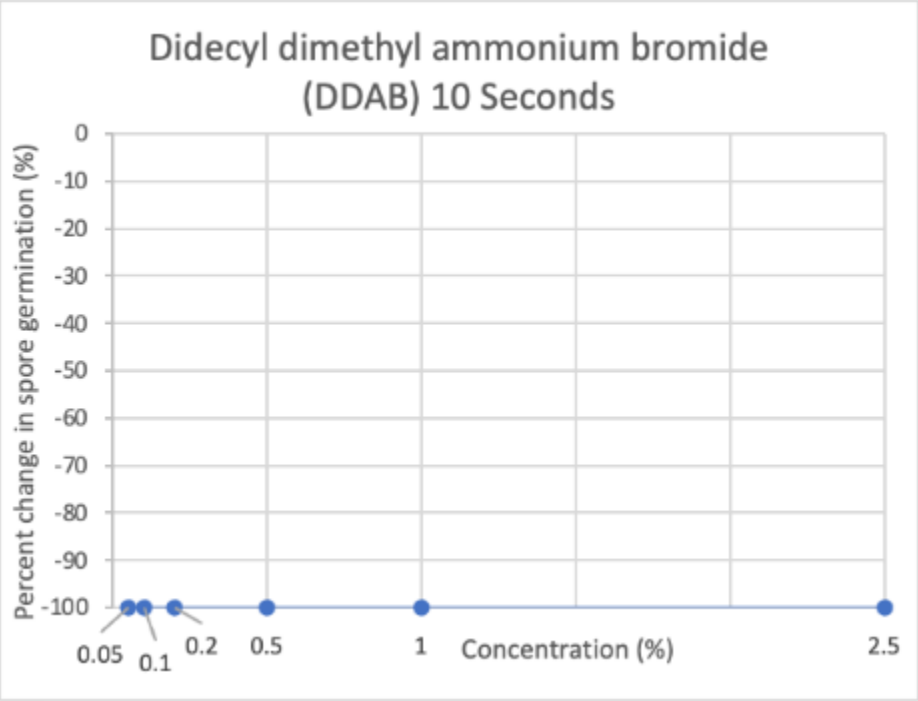


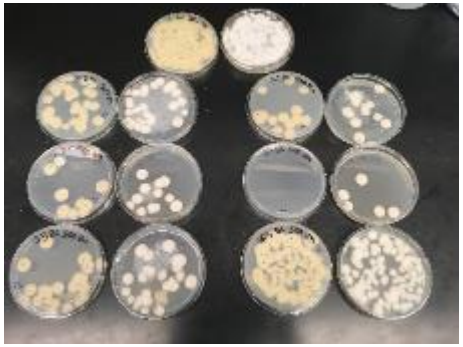
QAC compounds reduced loads by 97%



QACs are also effective against Fusarium

Can be used for co-management with Fusarium diseases (and potentially other diseases)





Across comparable locations, sanitizer in foam was more effective-may increase residency time of QAC

Harvester Sanitation Best Management Guidelines (version 1.2)

WHERE TO CLEAN?

- A designated area for equipment cleaning, within the field perimeter, should be assigned and solely utilized.
- This area will be an at-risk location for future broomrape emergence if there was seed in the debris removed from the equipment and should be monitored carefully in future crops.

TIME TO CLEAN?

- The time needed for effective cleaning may require restructuring of harvest schedules.
  - Effective cleaning requires removing ALL debris and THEN applying a sanitizer—a process which typically takes 3-4 hours with a standard crew.
  - 1-2 hours of cleaning, no matter how efficient your crew is, is not likely to effectively reduce your risk of pest spread.

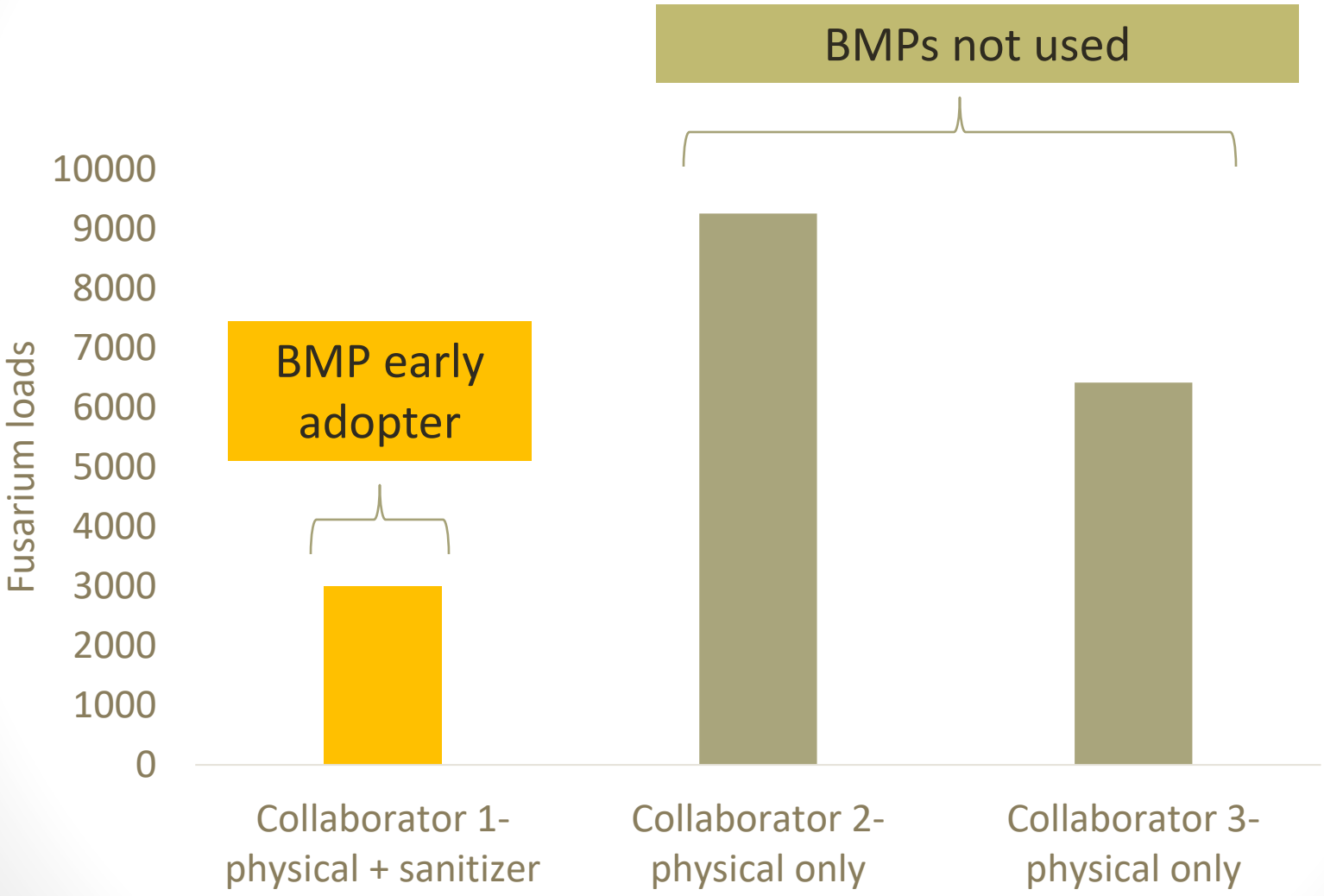
CLEANING STEPS:

1. **Remove loose debris –**
   a. Soil and plant debris should be removed from all equipment using compressed air, scrapers, and pressure washers. Any visible plant or soil debris has some risk of containing broomrape seed or fungal spores.
   b. Pay particular attention to the areas that accumulate a lot of debris or are difficult to access.
      - Axles and frame members, suction fan, fan duct, and chipper are all areas that accumulate a lot of debris, are hard to clean, and are of high risk of moving seed or pathogens.
      - In high-risk fields, it may be necessary to remove the fan duct for thorough cleaning.
2. **Pressure wash –**
   a. Remove fine debris, caked-on plant and soil materials, and greasy areas that can harbor seed and pathogens and also inactivate chemical sanitizers.
   b. This is the most important step in the cleaning process. Areas that contain debris when the sanitizer is applied will not be sanitized, since debris deactivates the sanitizer.
3. **Sanitize –**
   a. AFTER CLEANING, apply chemical sanitizers which can kill broomrape seed and fungal or bacterial pathogens.
   b. Quaternary ammonium, NOT BLEACH, is the sanitizing agent which is proven to kill broomrape seed.
      - Locally this can be bought under the labels: Clorox Pro Quaternary, Chem quat, Flo San or MG 4-Quat.
      - A solution of at least 1% is necessary for efficacy and should be used to spray down the equipment after soil and plant debris has been knocked off and pressure washing is completed.
   c. Apply sanitizers to surfaces still wet from pressure washing, or rewet the surfaces before sanitizing to increase contact time and improve efficacy.
4. **Do not rinse** – To provide maximum activity on seed or pathogens, washed and sanitized equipment should be left to dry, not rinsed with water or other cleaning agents.

REMEMBER:

- If seed is underneath or within soil or plant material no cleaning agent, including quaternary ammonium, will be completely effective in killing seed or pathogens.
- No amount, or % of active ingredient, will make up for poorly-cleaned equipment with significant amounts of plant debris and soil. Debris you can see is debris which can and will harbor pests and deactivate your sanitizer.

Use of BMPs is improving harvester sanitation efficacy



Currently working to expand BMPs to include specific guidelines for a wider of field equipment

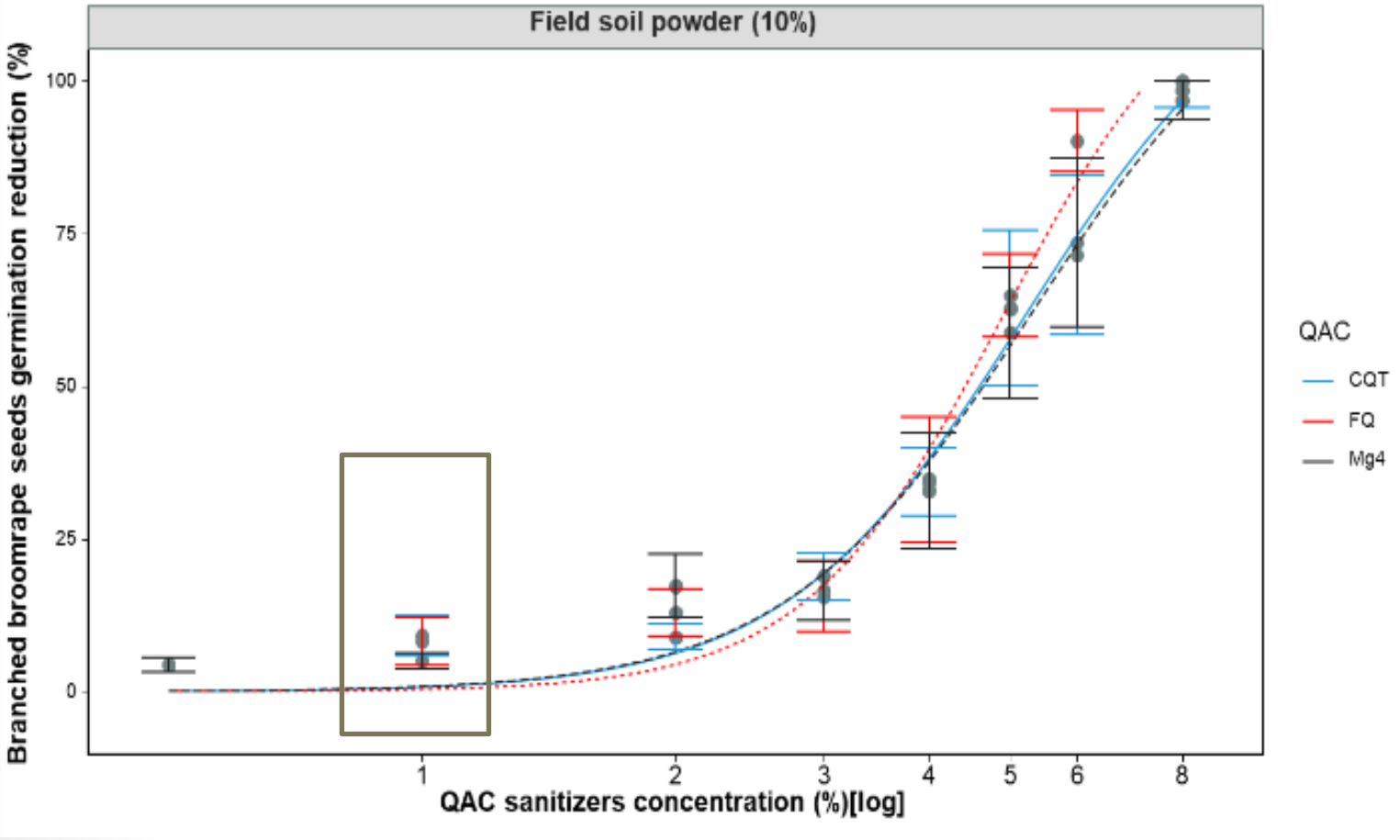
Use	Specific equipment	Function	Risk from			Number to evaluate
			Frequent between-field movement	Shared use	Moves large amounts of soil	
Various uses	**Tractor**	Pulls various equipment	X	X		4 to 6
Off season field preparation	**Incorporator-Tunnels**	Incorporates plant material into soil			X	2 to 3
	Subsoiler 16' 9-Shank	Soil tillage			X	2 to 3
	Triplane	Levels field			X	2 to 3
	Row lister	Forms rows				2 to 3
	Wilcox eliminator	Plant material incorporation + tillage + bed formation			X	2
	Cultivator-Performer	Removes weeds, forms beds				2 to 3
Planting	**Transplanter-standard**	Transplants tomatoes	X	X		3
	Transplanter-mechanical	Transplants tomatoes	X	X?		2
During season	**Vine trimmer/trainer**	Trims/trains vines	X	X		3 to 4

As a challenge to effective QAC use:

Field equipment can have high debris loads, even after washing

Debris affects QAC efficacy

At label rate of 1%, QAC sanitizers no longer work when soil is present

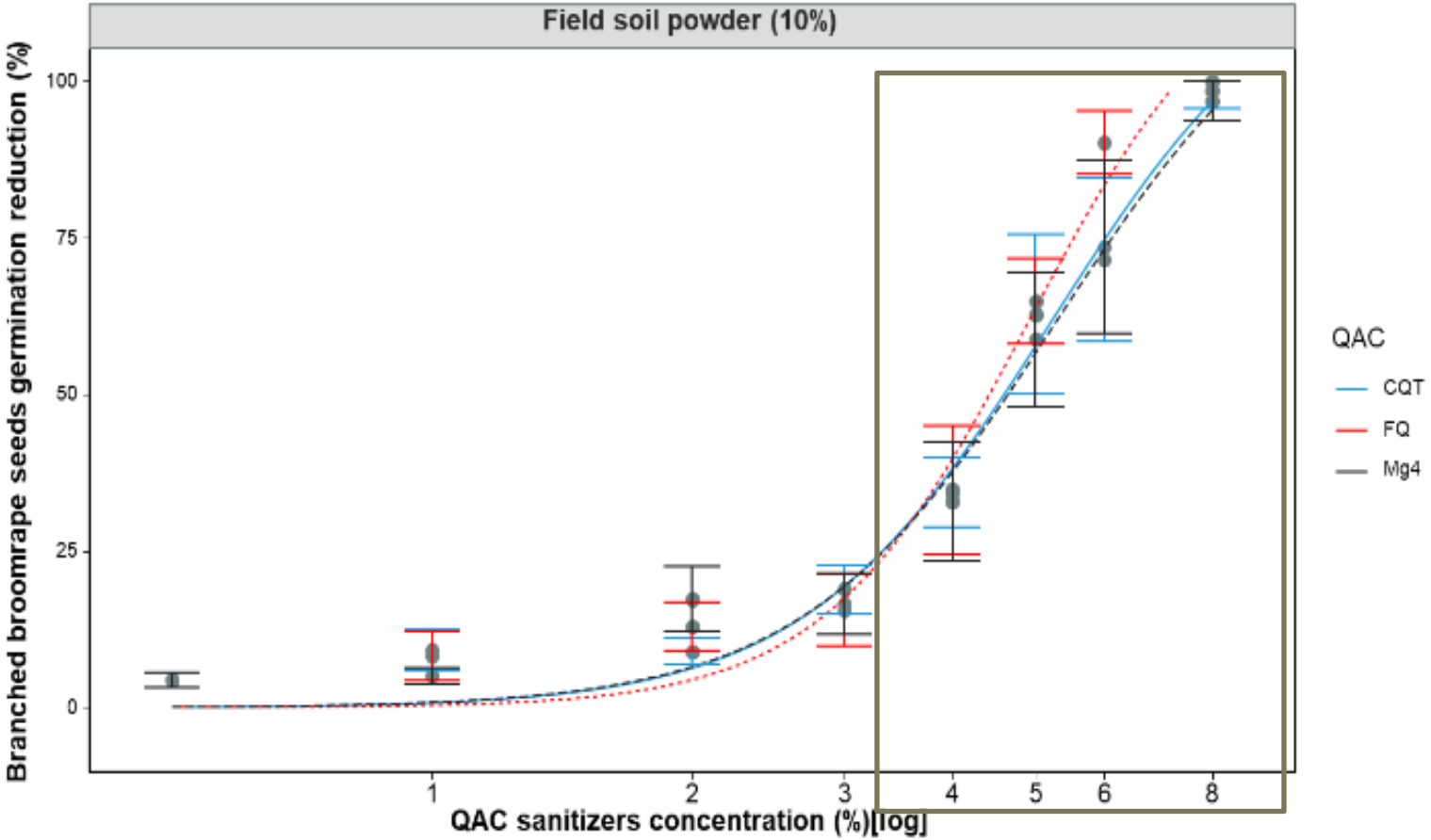


This is a dose-dependent relationship

Can regain efficacy in the presence of soil at higher QAC concentrations

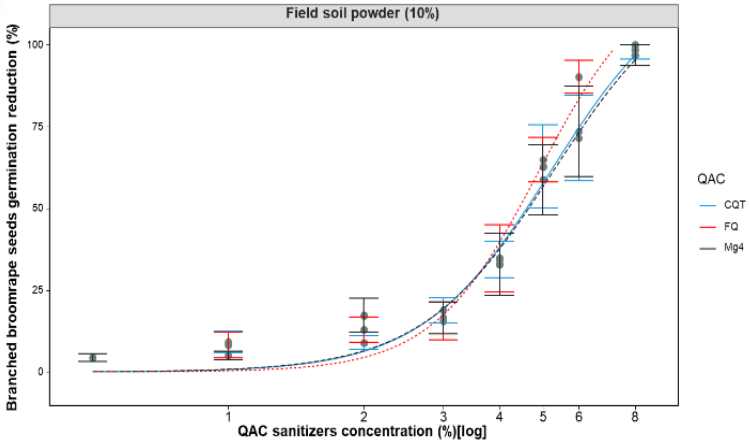
This is not a recommendation

We are currently investigating whether higher QAC rates are allowable

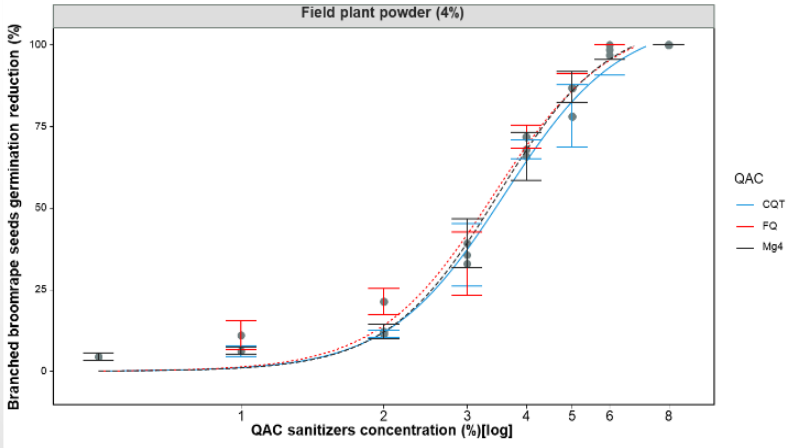


Different kinds of debris (soil vs plant) have similar effects

Soil



Plant

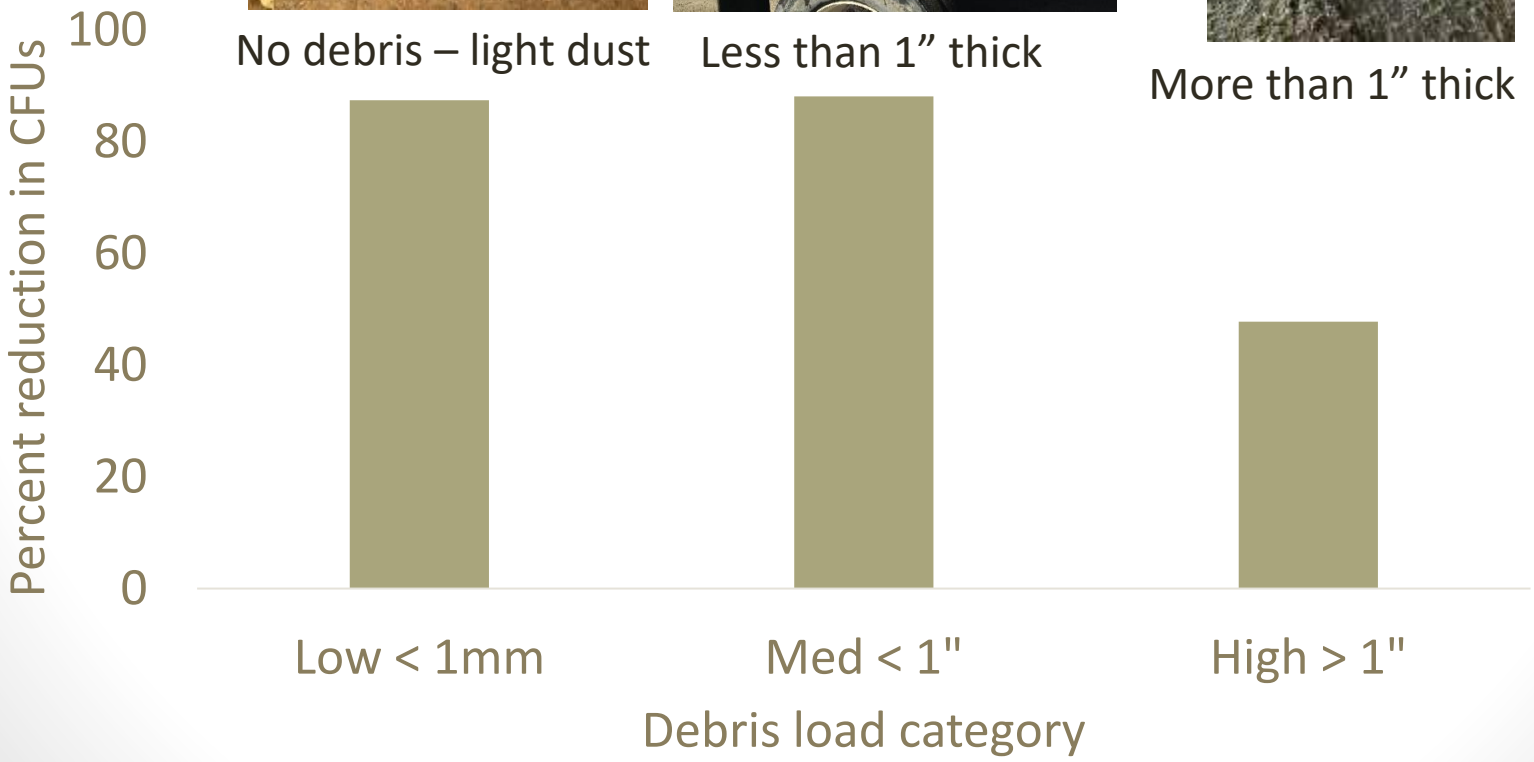


How clean does it need to be to effectively use a QAC?

No debris – light dust

Less than 1” thick

More than 1” thick



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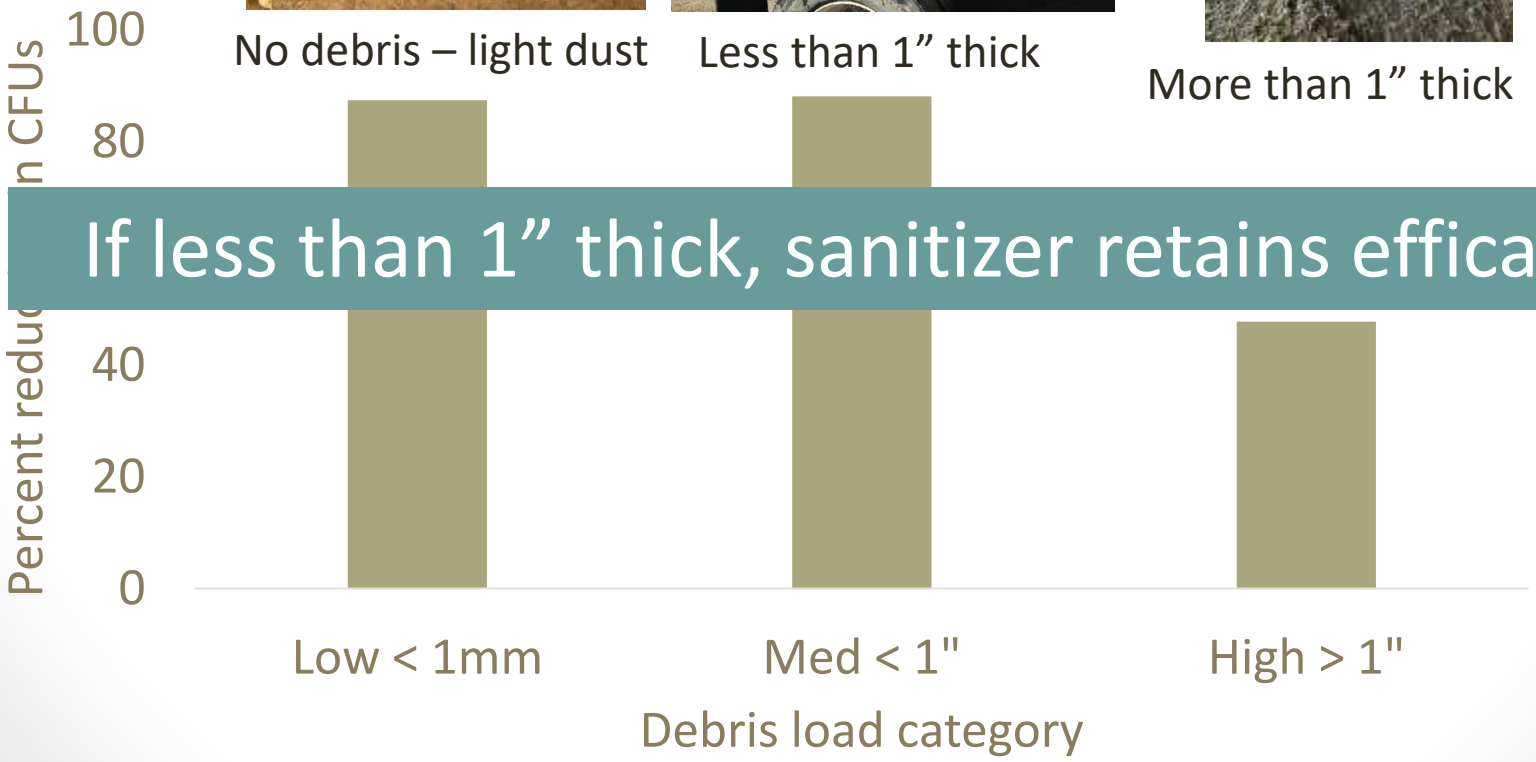
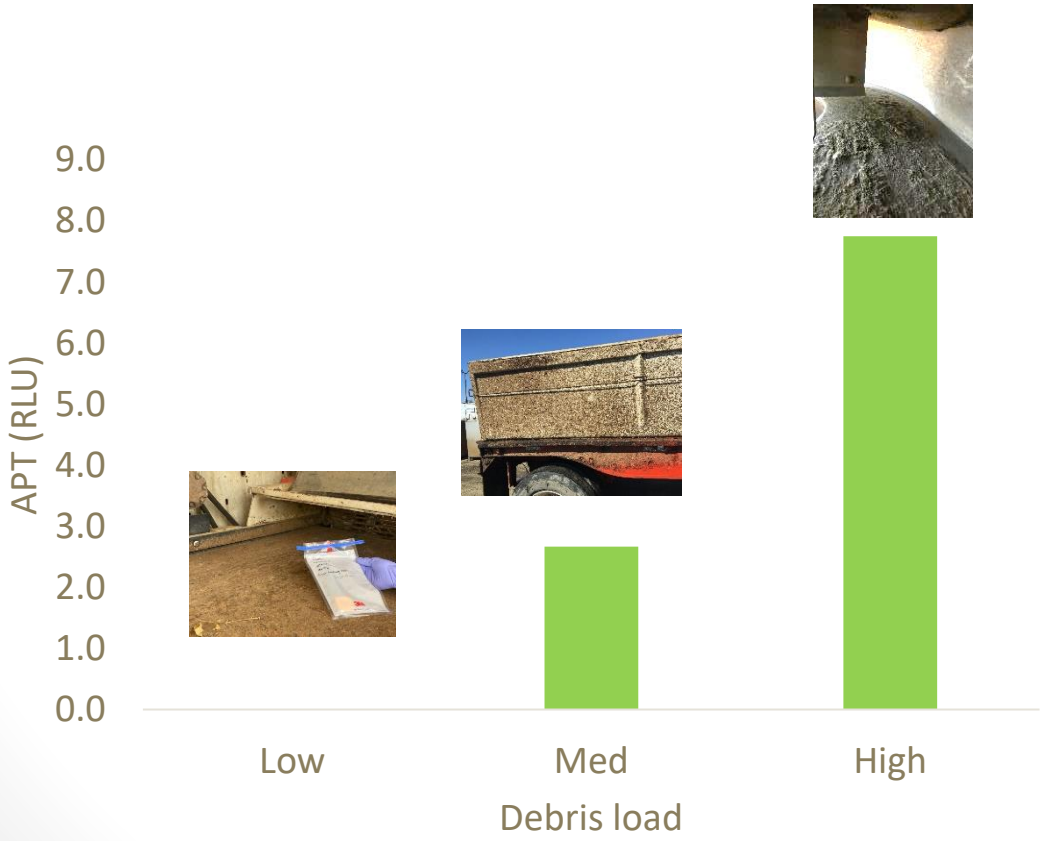
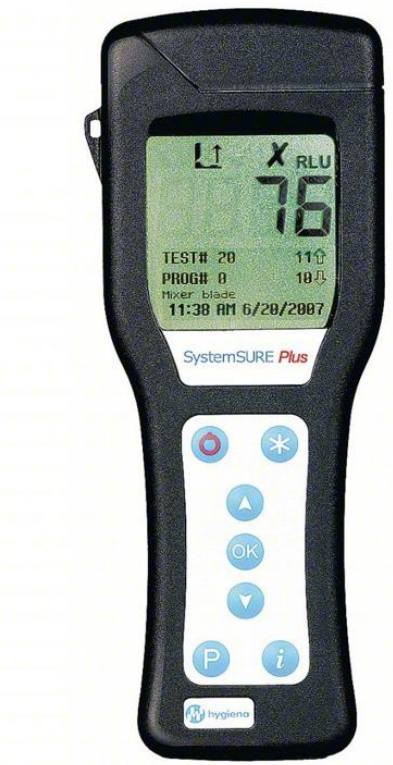


If less than 1” thick, sanitizer retains efficacy

Developing self assessment systems for training and efficacy evaluation

- Rapid measures of plant debris prior to sanitizer application using ATP sensors
  - Establishing ATP levels that correlate with QAC-inactivating debris loads

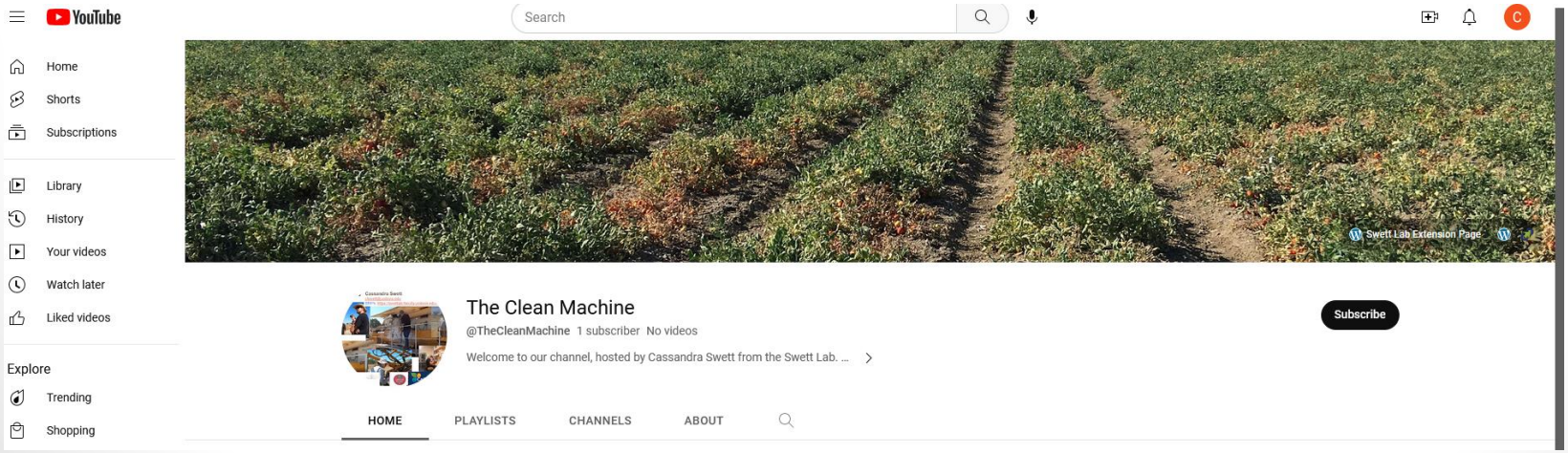




Developing self assessment systems for training and efficacy evaluation

- Training resources
  - You Tube videos
  - Updated BMPs
  - Train the trainer slide templates and trainings-with CE advisors
- Self audit system

https://www.youtube.com/@TheCleanMachineUCDavis-ss1is



Currently evaluating alternatives to QACs—equally effective but less debris-load sensitive?

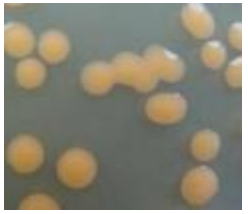
Type of sanitizer	Sanitizers	Product	Efficacy information	Corrosive (Y/N)	Citation
QAC	Benzalkonium chloride		Highly effective for many fungi		Bernardiet al. 2018
	Biguanide				Bernardiet al. 2018
Oxidizer	Peracetic acid		Not effective against broomrape but may be highly effective for fungi; remains stable in soil	No	Bernardiet al. 2018; Kitis 2004
	Peroxyacetic acid				
Gaseous	Aqueous ozone		Highly effective for bacteria and fungi	No	Martinelli et al. 2017; Epelle et al. 2022
Acid anionic surfacants	Phosphoric acid	Starsan	Effective against fungi and bacteria	No	Gaulin et al. 2011
	Dodecylbenzenesulfonic acid		Effective against fungi and bacteria	No	Gaulin et al. 2011
Oxidizer	Iodophors (iodine dissolved in surfactant and acid)	Io-STAR, Shebroson-D	Kills many types of microorganisms, organic matter has low influence on efficiency	Works best at lower pH so maybe	Kakurinov V. 2014.

Also working to expand to sanitation guidelines to wider range of soil borne pathogens

Fusarium wilt and rot diseases

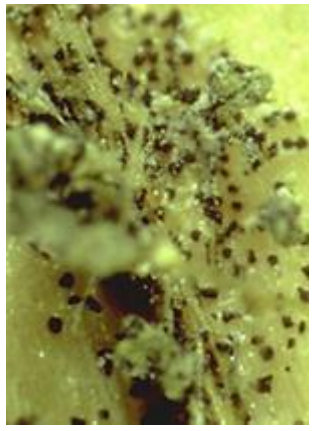
Bacterial pathogens

E.g. Clavibacter (bac canker)



Sclerotia-producing fungal pathogens

Southern blight



Verticillium

Outreach efforts aim to identify additional barriers and provide training

- Planning to do a harvester sanitation field day in 2024
  - English session
  - Spanish session

Questions?

Cassandra Swett
clswett@ucdavis.edu

BMPs: https://swettlab.faculty.ucdavis.edu/extension/

California Food Producers

California Tomato Research Institute