New Approaches for the Sunflower Pathology Program at USDA-ARS

Bill Underwood
Research Plant Pathologist
USDA-ARS
Northern Crop Science Laboratory, Fargo ND

About Me

- Originally from southern Indiana (Madison, on the Ohio River between Louisville and Cincinnati).
- Grandparents farmed tobacco, corn, soybeans.

About Me

- 2001: BS Biology – Indiana University
- 2006: PhD Genetics – Michigan State
- 2007-2010: NIH Postdoctoral Fellow –
  Carnegie Institution for Science (Stanford) then UC Berkeley.
- 2010-2015: Staff Scientist – UC Berkeley
  Energy Biosciences Institute
  Dept. of Plant & Microbial Biology
- July 2015: Joined ARS Sunflower & Plant Biology in Fargo

Energy Biosciences Institute

USDA ARS

Topics

- Overview of major recent advances in Plant Pathology Research
- *Sclerotinia*
- *Phomopsis*
- Downy mildew / Rust

Advances in Plant Pathology Research In the Past Decade

- Insights into pathogen effector – host target dynamics that drive outcomes of plant-microbe interactions.
- Explosion in number of sequenced plant and phytopathogen genomes.
- Expanded understanding of R gene-mediated resistance, how NB-LRRs provide immune system surveillance.
- Insights into inverse gene-for-gene relationships in necrotroph pathogenicity.

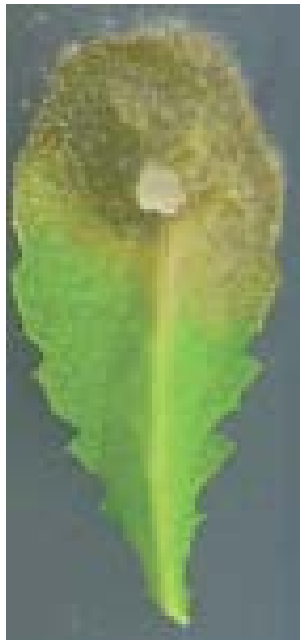
Pathogen Lifestyles Influence the Research Agenda

Biotrophic

Golovinomyces cichoracearum

Hemi-biotrophic

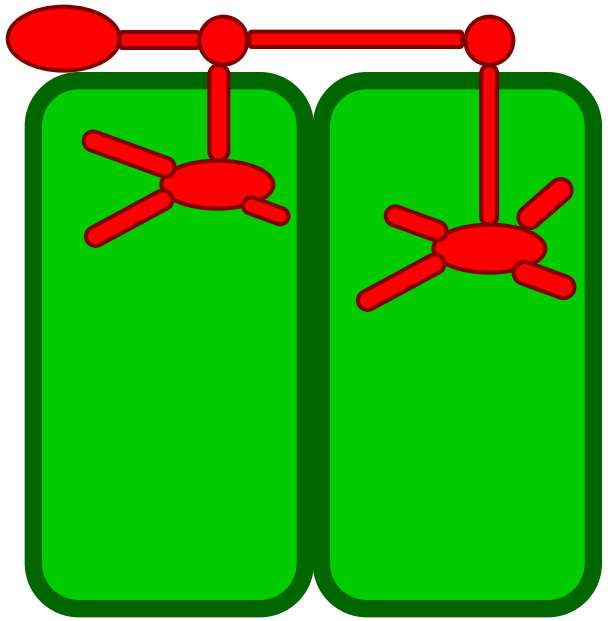
Pseudomonas syringae



Necrotrophic

Sclerotinia sclerotiorum

Pathogen Lifestyles Influence the Research Agenda

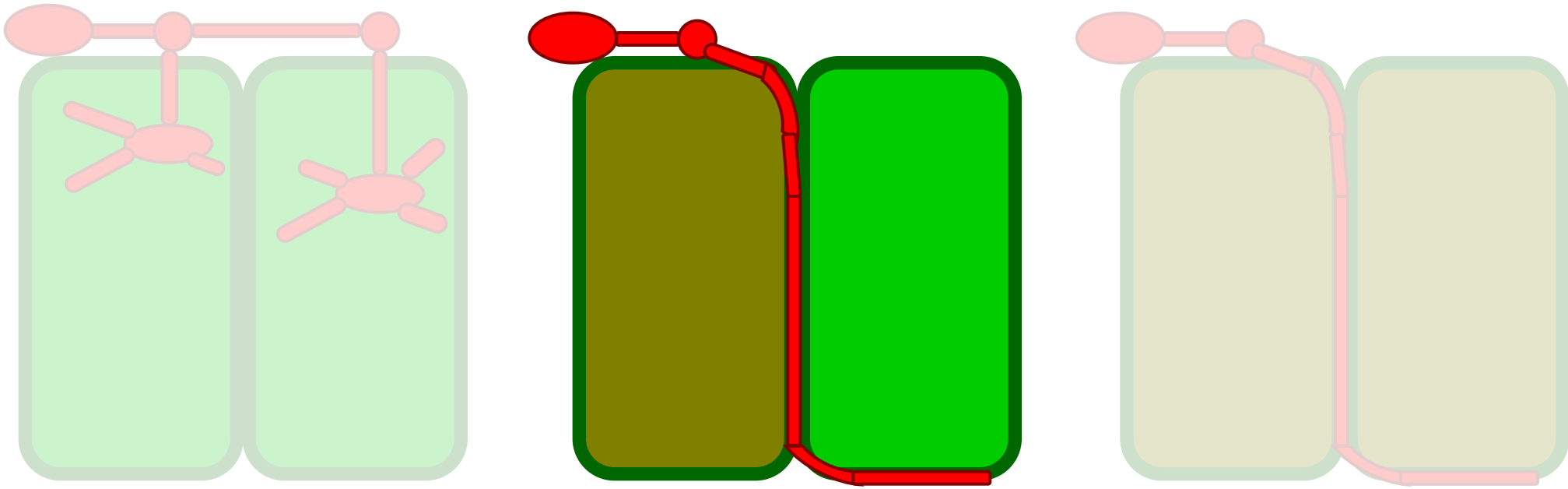


Biotrophic

Hemi-biotrophic

Necrotrophic

Pathogen Lifestyles Influence the Research Agenda



Biotrophic

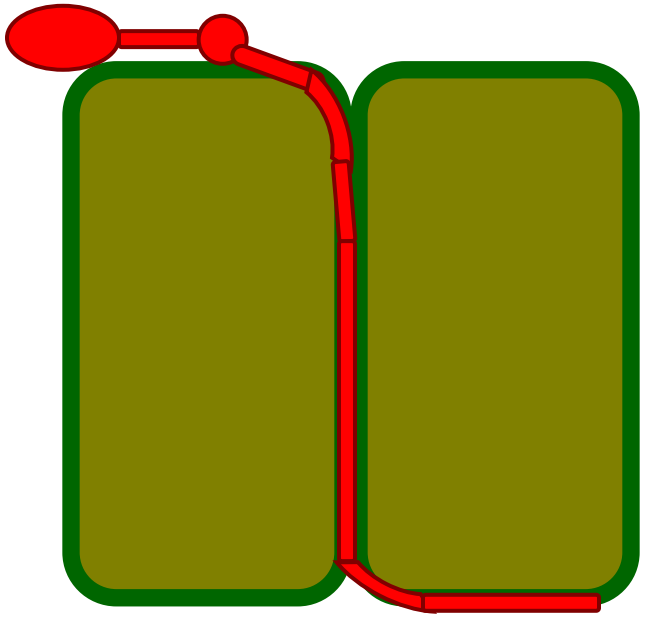
Hemi-biotrophic

Necrotrophic

Pathogen Lifestyles Influence the Research Agenda

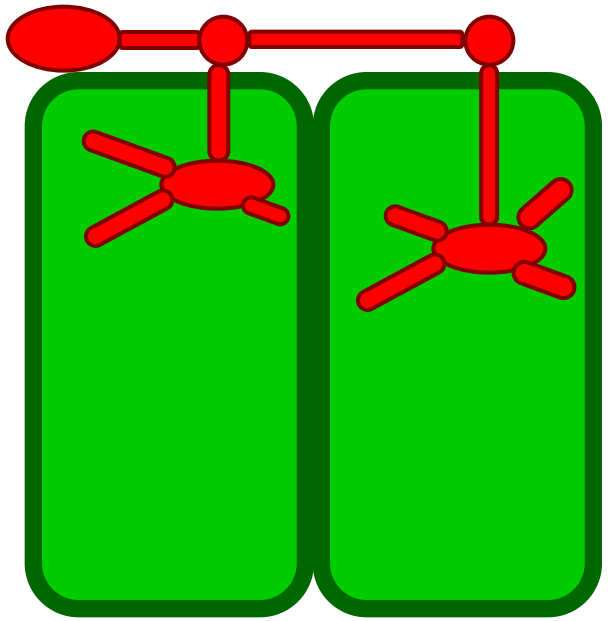
Biotrophic

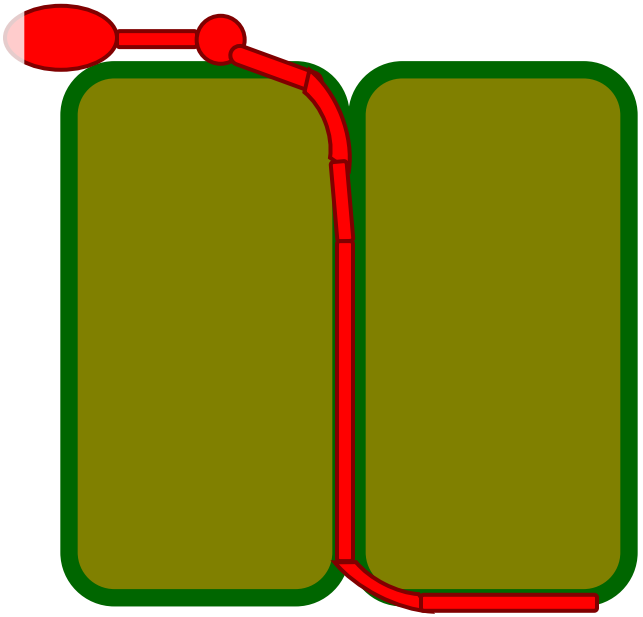
Hemi-biotrophic



Necrotrophic

Pathogen Lifestyles Influence the Research Agenda





Biotrophic

DOWNY MILDEW

RUST

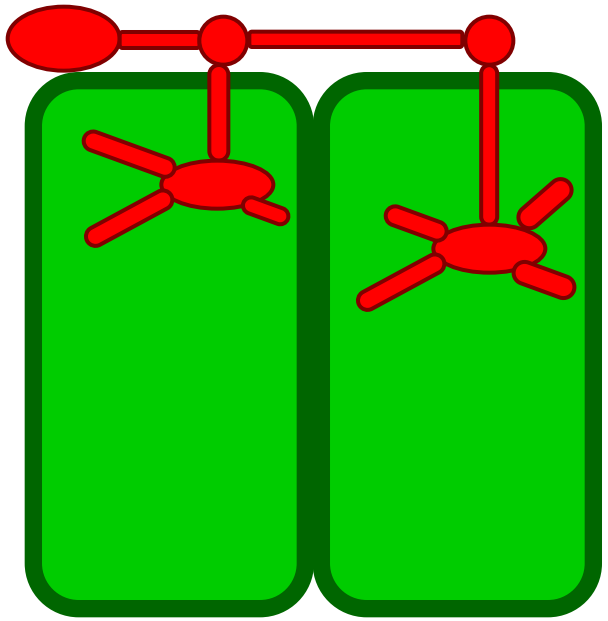
Hemi-biotrophic

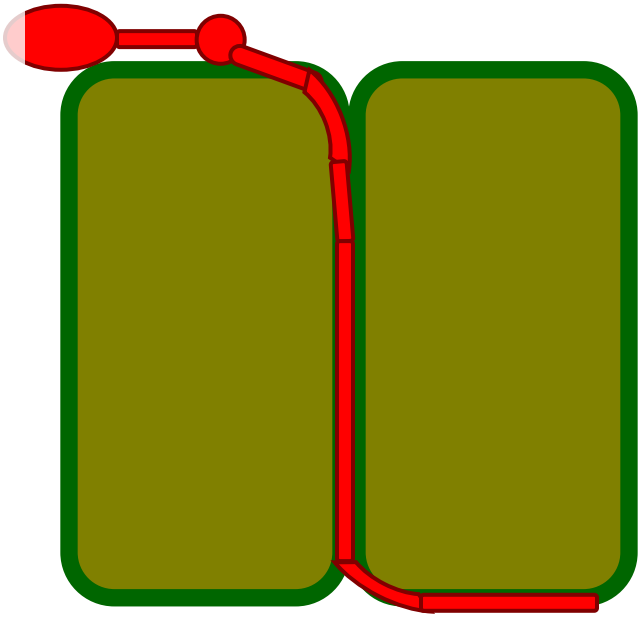
Necrotrophic

PHOMOPSIS

SCLEROTINIA

Pathogen Lifestyles Influence the Research Agenda





Biotrophic

- Qualitative, R gene-mediated resistance.
- Virulence effectors drive pathogenicity.

Hemi-biotrophic

Necrotrophic

- Quantitative, polygenic resistance.
- Toxins and necrotrophic effectors drive pathogenicity.

Sclerotinia

- No paradigm for broad host-range necrotrophic pathogens.
- Genetic variation for resistance among individuals within host species exists, but gene identities and resistance mechanisms are unknown.
- Genetic complexity of resistance hinders breeding efforts.
- Loci contributing to resistance have been identified through QTL mapping and association studies in many affected plants, but map-based cloning in crop plants with large, complex genomes remains prohibitive. No genes contributing to quantitative resistance cloned in any plant.
- No rational strategies for combining QTL from different sources.

Sclerotinia

Goals

- Leverage functional genomics resources for *Arabidopsis thaliana* to identify, clone, and validate genes contributing to quantitative resistance.

- Identify important *Sclerotinia* virulence determinants (effectors) as a step toward reducing complexity.

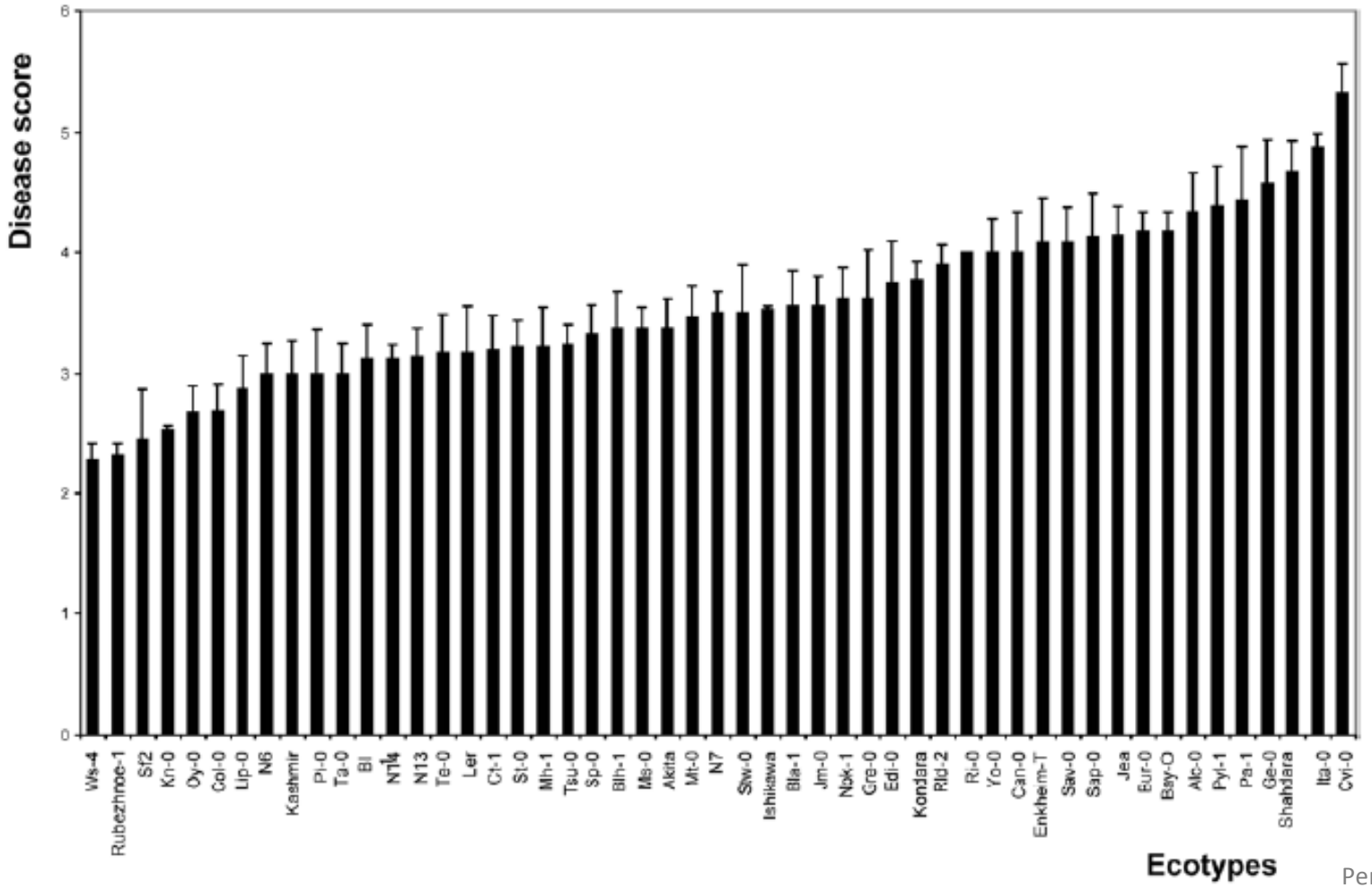
Sclerotinia

Why Use *Arabidopsis*?

- Association mapping is a powerful strategy to unravel the genetics of complex traits.
- *Arabidopsis* is a gold standard for association mapping.
- >1300 natural accessions genotyped to extremely high density (polymorphic marker every 500 bp).
- Extensive functional resources.

Sclerotinia

Why Use *Arabidopsis*?



Perchepied et al., MPMI 2010

Sclerotinia

Goals

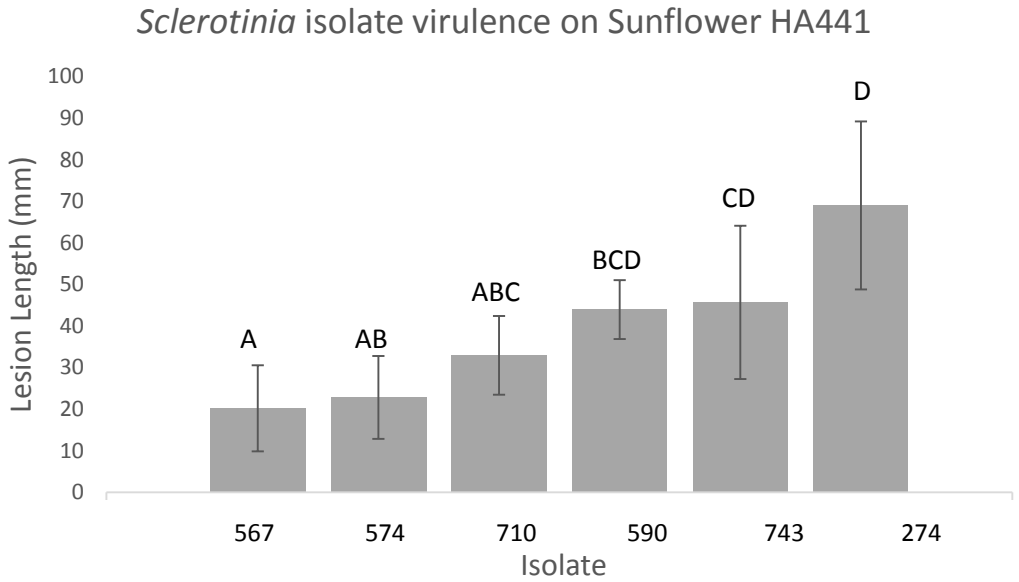
- Leverage functional genomics resources for *Arabidopsis thaliana* to identify, clone, and validate genes contributing to quantitative resistance.

- Identify important *Sclerotinia* virulence determinants (effectors) as a step toward reducing complexity.

Sclerotinia

- A sequenced genome, small genome size, and reduced costs of genotyping using high-throughput sequencing facilitate AM to identify virulence effectors.

- Collaborative effort w/ Bob Brueggeman (NDSU), Berlin Nelson (NDSU), and Jim Steadman (Nebraska).

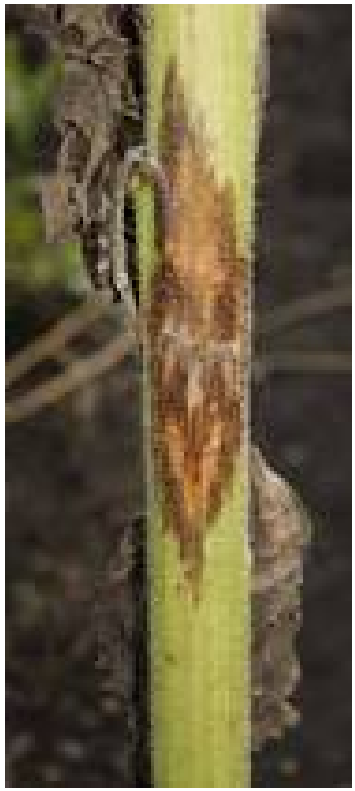


Phomopsis

Goals

- Identify and characterize toxins and/or necrotrophic effectors contributing to virulence.

- Evaluate diverse sunflower germplasm for insensitivity. Map responsible loci.



Downy Mildew / Rust

Goals

- Develop strategies to clone and validate NB-LRR resistance genes to facilitate improved deployment and stacking.

- Identify partial, race non-specific resistance to complement R gene-mediated resistance.

- Recent availability of *P. halstedii* genome makes effector-driven approaches feasible.

Overarching Goal

Determine identities and functions of genes involved in resistance of sunflower to economically important pathogens to improve efficiency and efficacy in deploying genetic resistance.

Acknowledgements

Chris Misar

Michelle Gilley

Mitch DuFour

Collaborators:

Robert Brueggeman (NDSU)

Berlin Nelson (NDSU)

Jim Steadman (Nebraska)

All of my colleagues and co-workers at the Sunflower and Plant Biology Research Unit

THANK YOU

Bill Underwood
William.Underwood@ars.usda.gov