Improving resistance to the major necrotrophic fungal pathogens of sunflower

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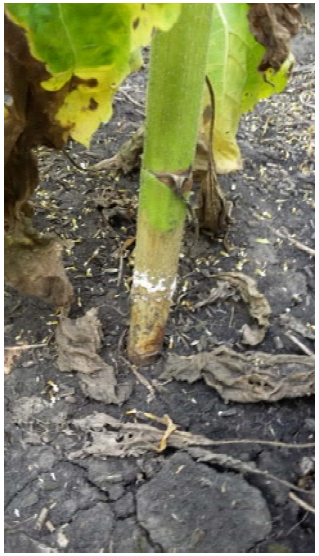
Sunflower Diseases

Downy Mildew
Oomycete
Plasmopara halstedii

Rust
Fungus
Puccinia helianthi

Sclerotinia Head Rot
Fungus
Sclerotinia sclerotiorum



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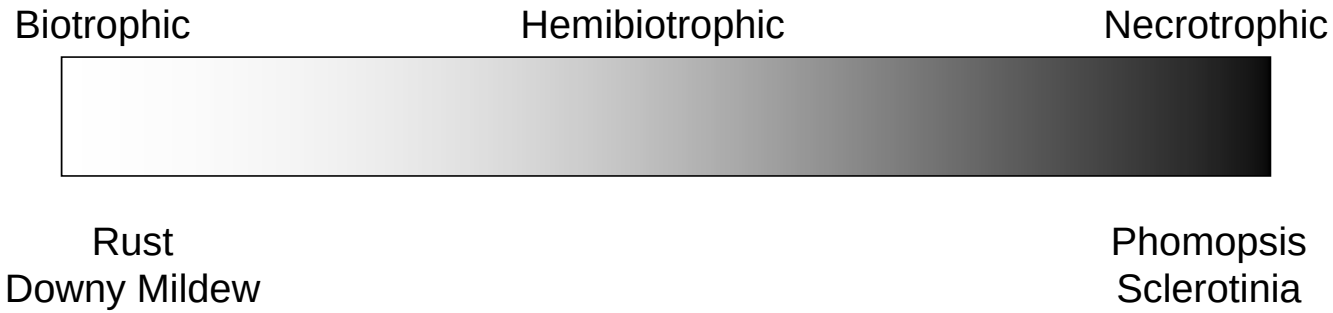
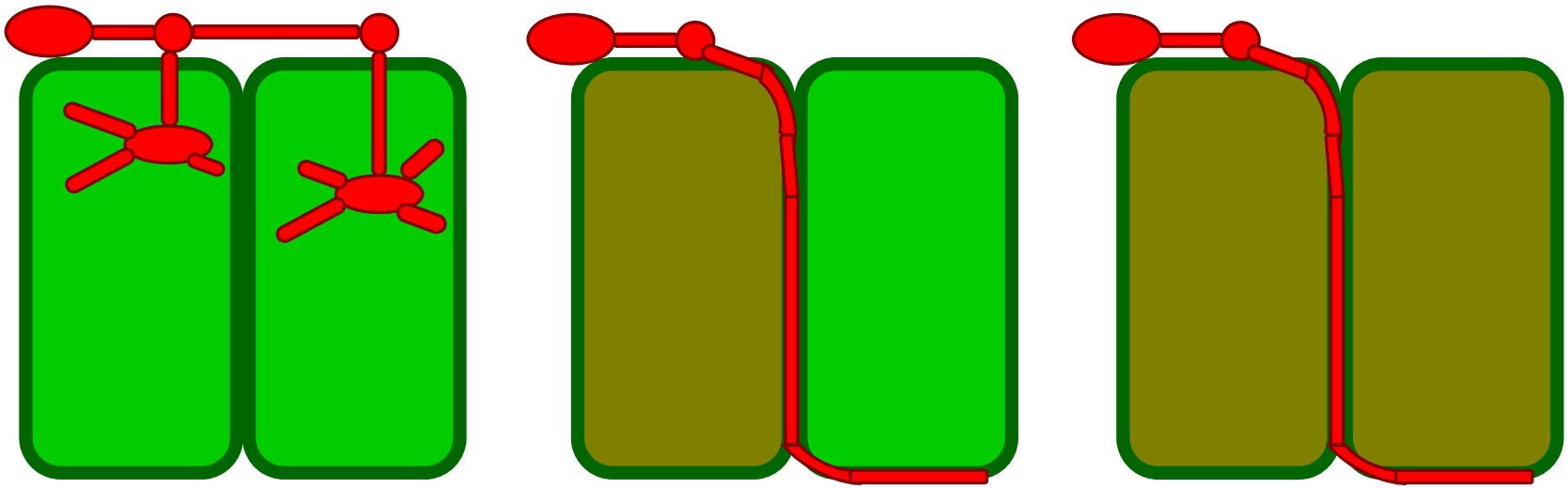
Phomopsis Stem Canker
Fungus
Phomopsis helianthi / Phomopsis gulyae

Sunflower Diseases



Pathogenesis strategy



Biotrophic

Hemi-biotrophic

Necrotrophic

Qualitative Resistance

Quantitative Resistance

Sunflower Diseases

Single, dominant gene resistance

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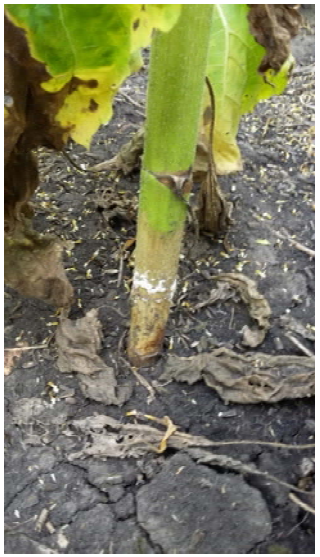

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Sunflower Diseases

Many mapped resistance loci

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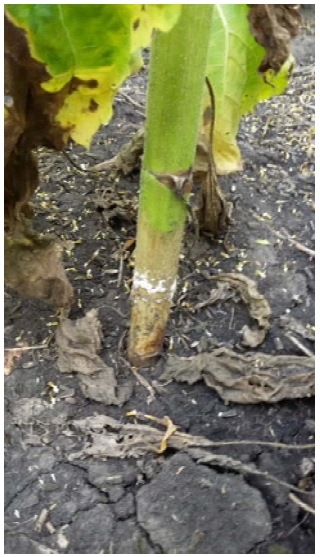

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Sunflower Diseases

Effective chemical control

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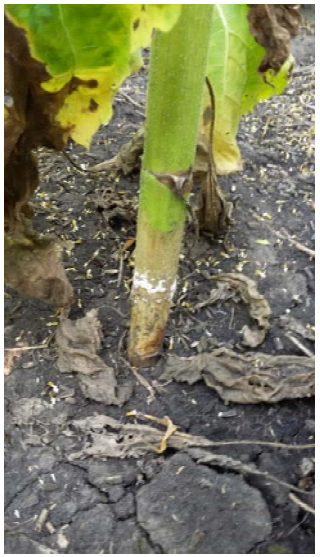

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Lab Focus Areas

- Sclerotinia basal stalk rot
  - Improvement of evaluation methods
  - Identification of highly resistant germplasm resources and genetic mapping (w/ Lili Qi)
  - Characterization of resistant lines
- Sclerotinia head rot
  - Genetic mapping of resistance loci (collaboration w/ Lili Qi)
- Mechanisms of resistance to Sclerotinia
  - *Arabidopsis* resources to identify genes and mechanisms for *Sclerotinia* resistance
- Sclerotinia pathogenicity
  - GWAS and bioinformatic prediction to identify Sclerotinia virulence factors
  - Functional characterization of virulence factors and host targets
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Evaluating Resistance to Basal Stalk Rot – Not Straightforward

- Simplest method – plant materials in infested field.
  - Low resolution, poor reliability.
  - Can only eliminate lousy germplasm.

- Field scale inoculation method developed.
  - Better resolution and reliability, but still not that good.
  - Still can't distinguish highly resistant lines from average lines.

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Developing and validating a greenhouse-based method for stalk rot evaluations

- Plants grown in deep sheet pots.
- Five-week-old plants inoculated with Sclerotinia-infested millet placed in the bottom of the pot.
- Evaluated for BSR/wilt daily for 4 weeks. Determine average days to plant death, AUDPC.

Developing and validating a greenhouse-based method for stalk rot evaluations

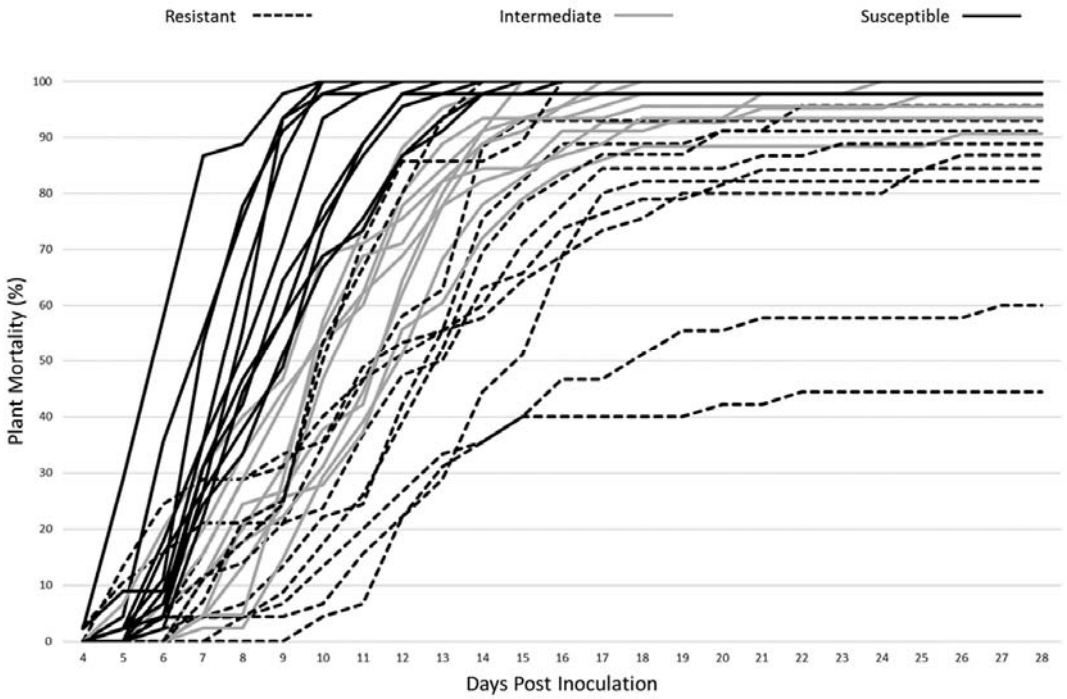
Validation panel:

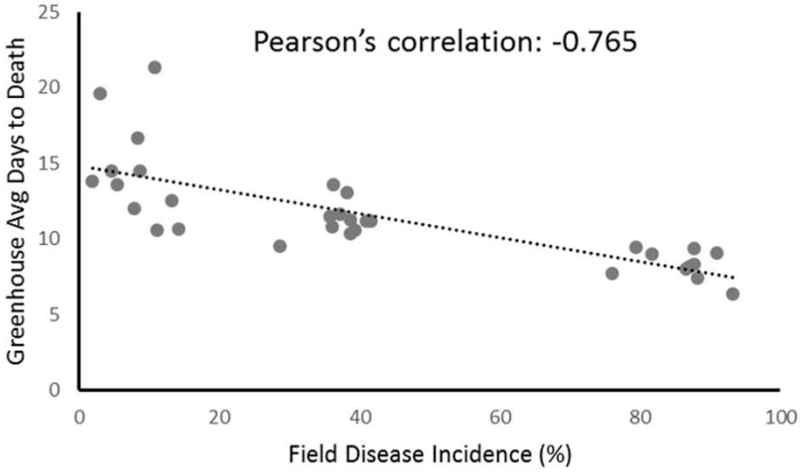
- 32 sunflower lines with extensive multi-year, multi-location field data from inoculated nurseries.
- 10 resistant, 10 intermediate, 10 susceptible, 2 inbred lines representing range of response in released inbred material.
- Evaluated for BSR/wilt daily for 4 weeks. Estimated average days to terminal wilt or whole-plant desiccation.

11 days post inoculation

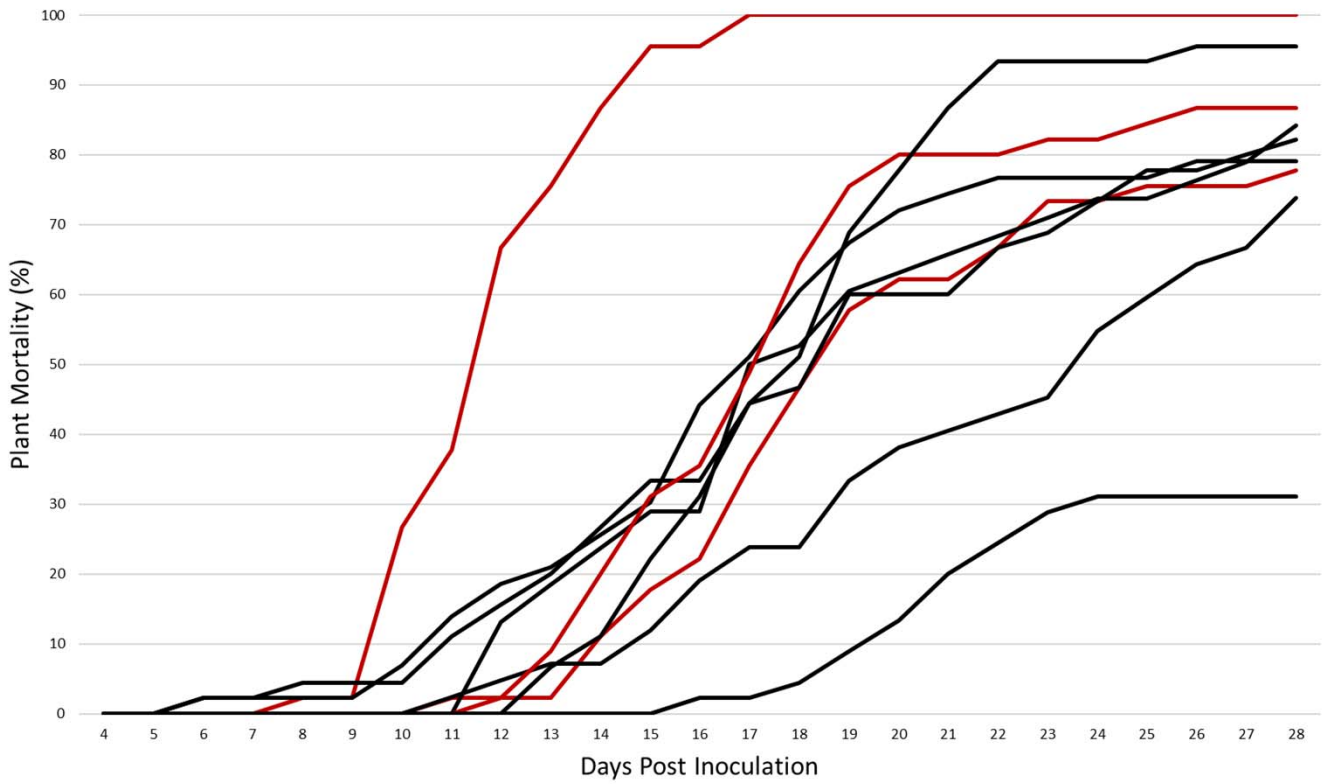
RHA 801 HA 89

Developing and validating a greenhouse-based method for stalk rot evaluations





Identifying sunflower lines with better resistance



HA 89 – susceptible control

Croplan 305 –resistant hybrid check

RHA 801 – previous “gold standard” resistant inbred line

HA 124 – highly resistant inbred line

Identifying sunflower lines with better resistance

- 60 lines with low incidence in field trials evaluated in greenhouse.
- 3 lines with resistance statistically superior to RHA 801.

Accession Name	PI	Greenhouse Avg Days to Death	Statistical Grouping
A-1499	413050	20.6	a
HA 124	599775	20.2	a
No. 9121	175733	18.9	ab
Short Russian	650379	17.1	abc
Olea	650369	16.9	abc
Zelenka	650831	16.8	abc
FS-a-3	480471	16.6	abcd
HA 61	599771	16.5	abcd
Voshod Elite 7	650458	16.4	abcde
RHA 408	603989	16.4	abcde
VIR 160	497250	16.3	abcde
CMG-3	650400	16.3	abcde
Romsun V3355 AC	650498	16.0	bcdef
A-1405	380562	15.9	bcdefg
Lengyel A	531366	15.8	bcdefg
PO 6/4-2	431560	15.5	bcdefg
HZ.SM 27.208	531359	15.4	bcdefgh
VK-53	650468	15.4	bcdefgh
RHA 801	599768	15.2	cdefghi
Pioner Sibiri	497933	15.0	cdefghij
VIR 117	650485	14.2	cdefghijk
Polstar	650372	12.8	defghijk
VK-10	650464	12.4	defghijkl
Guaran	650810	12.3	efghijkl
HA 410	603991	12.2	fghijkl
D-75-11	431543	12.0	ghijkl
HA 89	599773	11.8	hijkl
Ostonne	650371	11.6	ijkl
Ames 102	490282	11.4	jkl
VIR 110	650536	10.5	kl
Cabure 1004	650798	8.8	l

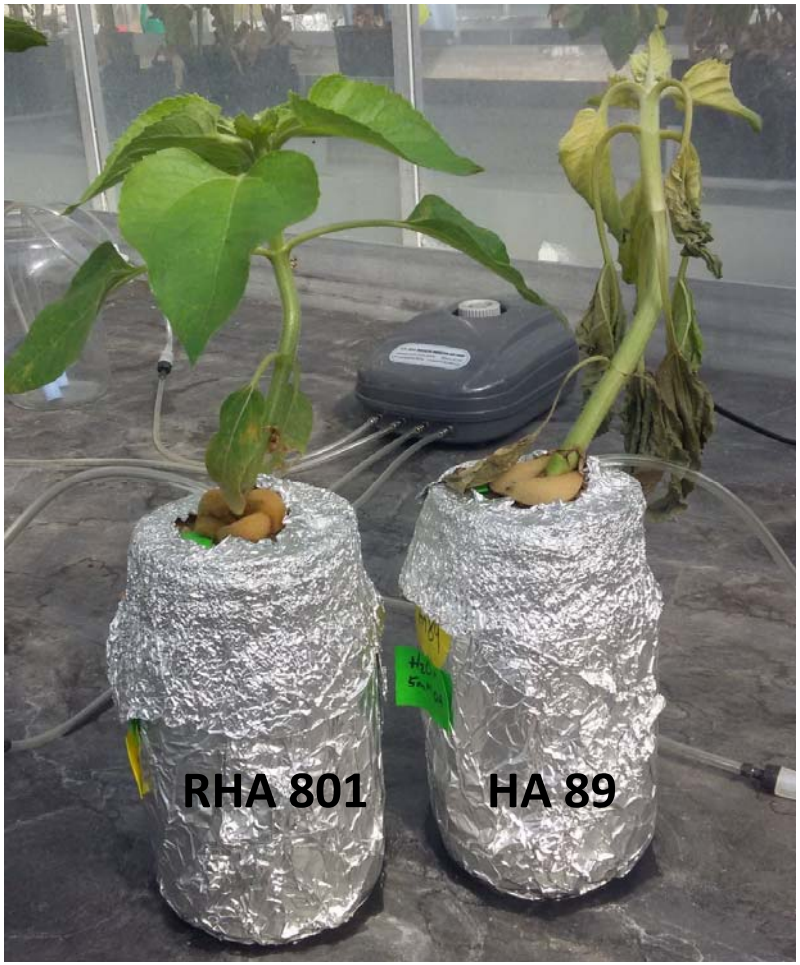
11 days post inoculation

RHA801 HA89

Mechanisms of resistance to basal stalk rot

- Treatment of roots with the Sclerotinia virulence factor oxalic acid recapitulates disease symptoms (wilting, stem streaking, leaf & meristem necrosis, eventual plant death).

- Some lines resistant to stalk rot show strong tolerance to oxalic acid.



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Mechanisms of resistance to Phomopsis

- Reported disease etiology –
  - Pathogen enters through hydathodes at leaf margin
  - Progresses through leaf tissue to petiole
  - Progresses through petiole to stem
  - Causes stem lesion and pith destruction resulting in early senescence, lateral wilting, necrosis of distal leaves, negative impact on yield, and potential lodging.

- Potential types of resistance –
  - Leaf lesion resistance
  - Petiole resistance
  - Stem lesion resistance
  - Resistance to pith degradation

Resistance to stem lesioning

- Evaluated 80 lines in greenhouse experiments with stem-wound inoculation. Selected lines with some evidence of resistance in field trials under natural infection.
- Materials evaluated:
  - 29 lines showing resistance in MN and SD trials in 2011-2012 (Talukder, Hulke, Gulya).
  - 20 lines showing resistance in MN (Gulya) and Yugoslavia (Masirevic) trials in 1997-1999.
  - 31 lines acquired in germplasm exchange with Russia and showing resistance in Russian field trials.
- Goals:
  - Determine type of resistance.
  - Identify lines with best resistance of different types.

PI 650675 (CO-PB 39)

HA 410 (S control)

Resistance to stem lesioning

D. helianthi
Isolate Rothsay-2

Accession Name	PI	Disease Severity Index	Statistical Grouping
HA 410	603991	91.7	a
HA-R3	650754	91.7	a
AMM 683	526261	91.7	a
Kisvardai	531365	91.7	a
ZFA 3225	494857	89.6	ab
Penyigei E	531383	87.5	ab
Tournesol	181769	87.5	ab
Taiyo	650839	87.5	ab
V8883 4/1-1	431567	85.4	abc
ZM/A 5199	505653	83.4	abc
RHA 801	599768	83.3	abc
L1585U		82.1	abcd
3100399	507896	79.2	abcd
Abadsens	250085	77.1	abcd
Rannespely		77.1	abcd
Zelenka	650831	70.8	abcd
CO-PB 48	650681	68.8	abcde
Nyiregyhazi A	531377	66.7	abcde
TA-4181-8		66.7	abcde
Giza	433862	65.5	abcde
CM 214		64.6	abcde
HA 323	664232	60.4	bcde
3100397	507894	58.3	bcde
Slovenska siva	531389	58.3	bcde
AMM 608	526254	58.3	bcde
CO-PB 84	650699	56.2	cde
CO-PB 90	650703	56.2	cde
HA 378	561918	52.1	de
CO-PB 39	650675	50.0	de
CM 198		47.0	de

D. gulyae
Isolate N4

Accession Name	PI	Disease Severity Index	Statistical Grouping
HA 410	603991	91.7	a
CM 214		91.7	a
Rannespely		91.7	a
Taiyo	650839	91.7	a
Penyigei E	531383	91.7	a
ZFA 3476	494862	91.7	a
3100399	507896	89.6	ab
Abadsens	250085	89.6	ab
TA-4181-8		87.5	abc
Nyiregyhazi A	531377	87.5	abc
Tournesol	181769	87.5	abc
L1585U		86.9	abc
ZM/A 5199	505653	86.9	abc
HA-R3	650754	83.3	abc
Zelenka	650831	81.3	abc
Kisvardai	531365	81.3	abc
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AMM 608	526254	79.2	abc
3100397	507894	75.0	abc
Ames 10101	650657	75.0	abc
CM 198		75.0	abc
Giza	433862	68.7	abcd
Slovenska siva	531389	68.7	abcd
HA 421	618725	67.9	abcd
Ames 101	490281	65.5	abcd
RHA 354	509064	64.6	abcd
Ames 102	490282	64.6	abcd
CO-PB 39	650675	60.4	bcd
CO-PB 84	650699	58.3	cd
HA 378	561918	39.6	d

- Mapping population being developed for HA 378 (Lili Qi).
- PI 650675 (CO-PB 39) and PI 650699 (CO-PB 84) resistant to both *D. helianthi* and *D. gulyae*

- but -

Plants ~ 10 ft tall and flower after 7 months.

Ongoing and Future Work

- Sclerotinia basal stalk rot
  - Characterization of highly resistant lines.
  - Genetic and physiological evaluation of oxalic acid tolerance.
  - Aim is to break down genetically complex resistance into component parts to facilitate better mapping of contributing loci and improved knowledge of potential fitness trade-offs.

- Phomopsis
  - Identification of lines with leaf/petiole resistance.
  - Genetic mapping of resistance loci (w/ Lili Qi).
  - Characterization of *D. helianthi* genetic and pathogenic variation.

Acknowledgements

Sunflower Pathology

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QUESTIONS?

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