



Evaluating Genetics of Soybean Host Plant Reaction to Soybean Gall Midge Infestation

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Soybean Plant Reaction to Gall Midge Infestation



Evaluations 2020, 2021

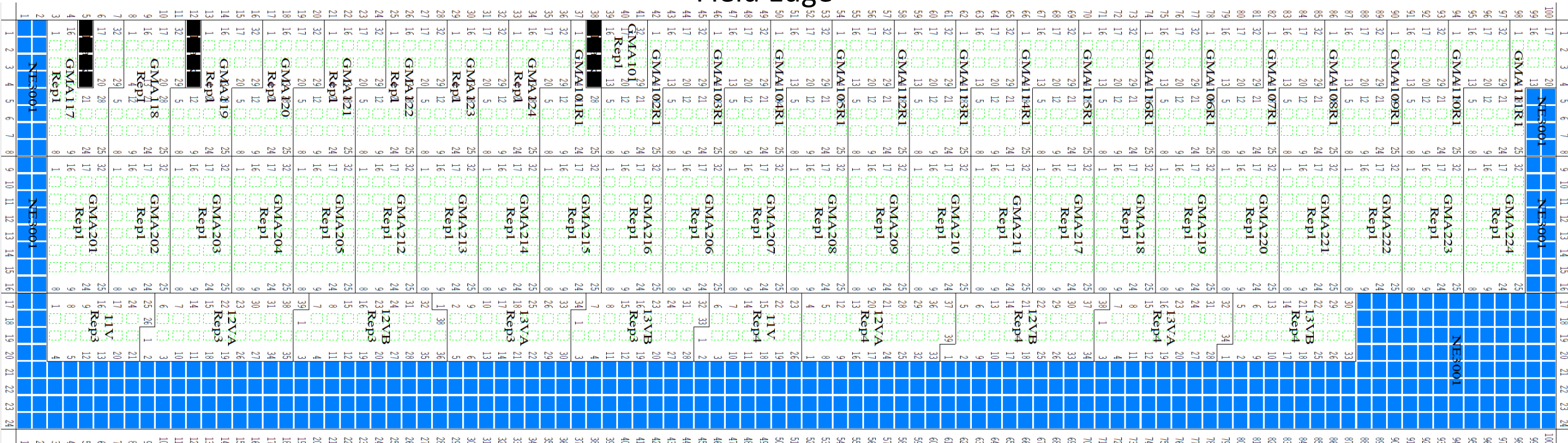
Set of genetically diverse accessions from USDA Soybean Germplasm Collections

- 713 Accessions – represent complete genetic diversity in the collection in MG I-IV
- Evaluated in 2 reps, 3 locs
- Larval presence/absence
- Injury score



Map of SGM plots on field edges

500 ft
Field Edge



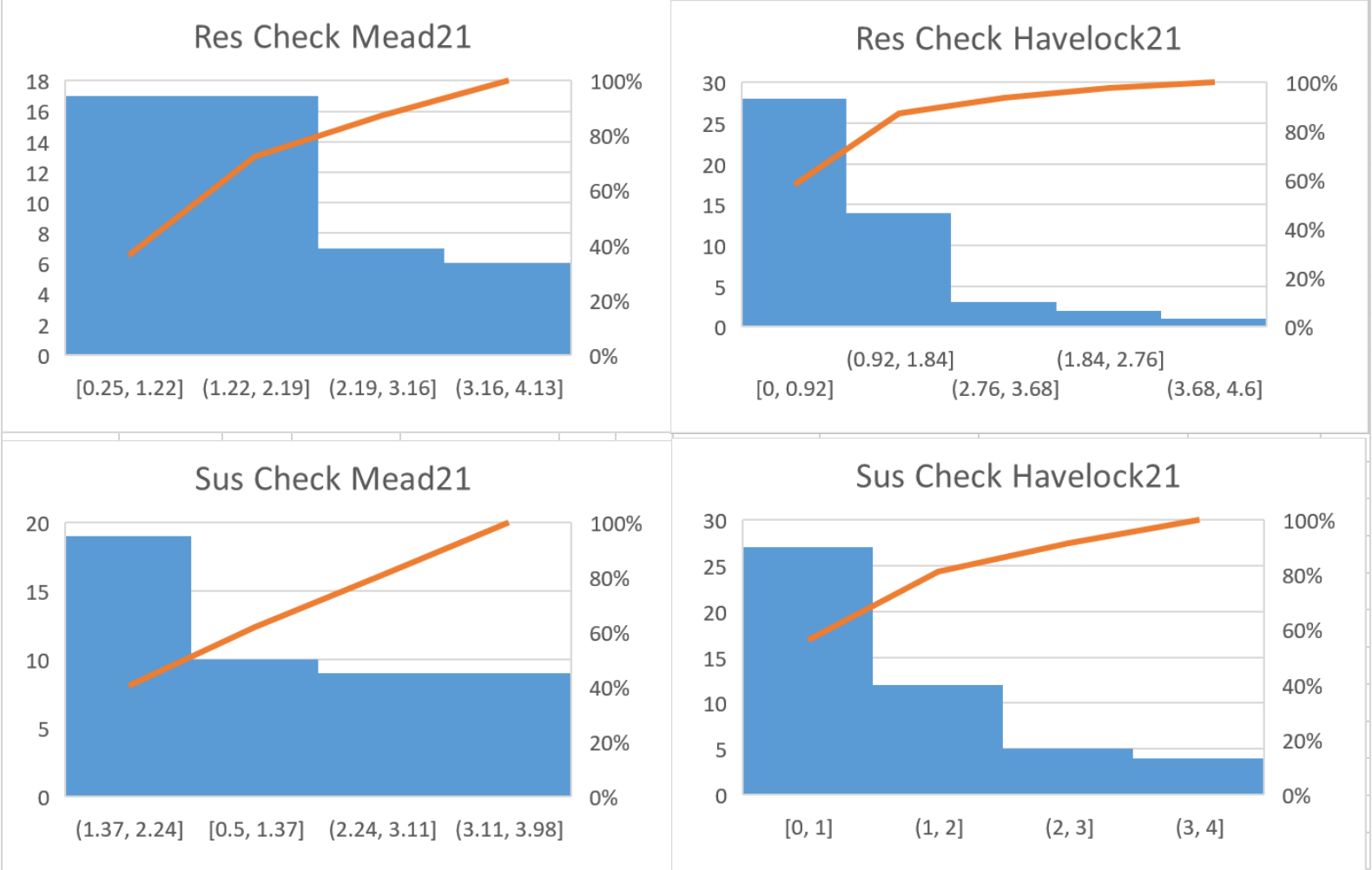
- Plots planted in long strips along field edge
- 500+ ft long, 50 ft into the field from edge

Soybean Plant Reaction to Gall Midge Infestation

	Mead21				Havelock21			
Strain	Min	Max	Mean (n=47)	Min	Max	Mean (n=48)	Combined Mean	
Res Chk	0.25	3.75	1.69	0	3.75	0.91	1.30	
Sus Chk	0.5	3.75	2.09	0	3.75	1.32	1.71	

Field Experimental Design 2020-2021

- Augmented Incomplete Block
- 24 Blocks of 32 Entries
 - 30 new lines
 - 2 common checks



Soybean Resistance to Gall Midge

- Evaluation of **713** genetically diverse soybean accessions from the USDA Soybean Germplasm Collection

- **3 Env, 2 Reps/Env**

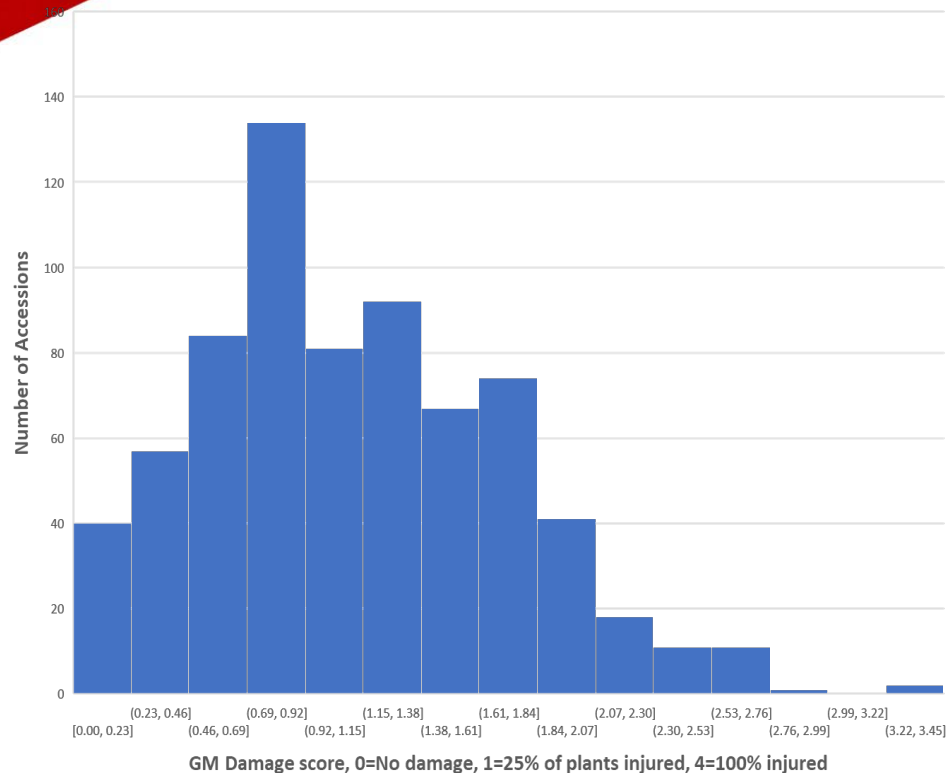
Environments are Mead, NE 2020, Mead, NE 2021, Havelock, NE 2021

- **Injury Score 0=No injury, 1=25% injured, 4=100% injured**
- ***Injury*** means dead or wilted plants due to GM infestation

- Distribution shows predominance of more resistant reactions = **Good News**

- **40** accessions with mean injury score **<0.25**
- **114** with mean score of **0.50 or less**
- **350** with mean score of **1.0 or less**
- **15** accessions with mean score of **2.50 or higher**

Distribution of GM Injury Scores for 713 Germplasm Accessions

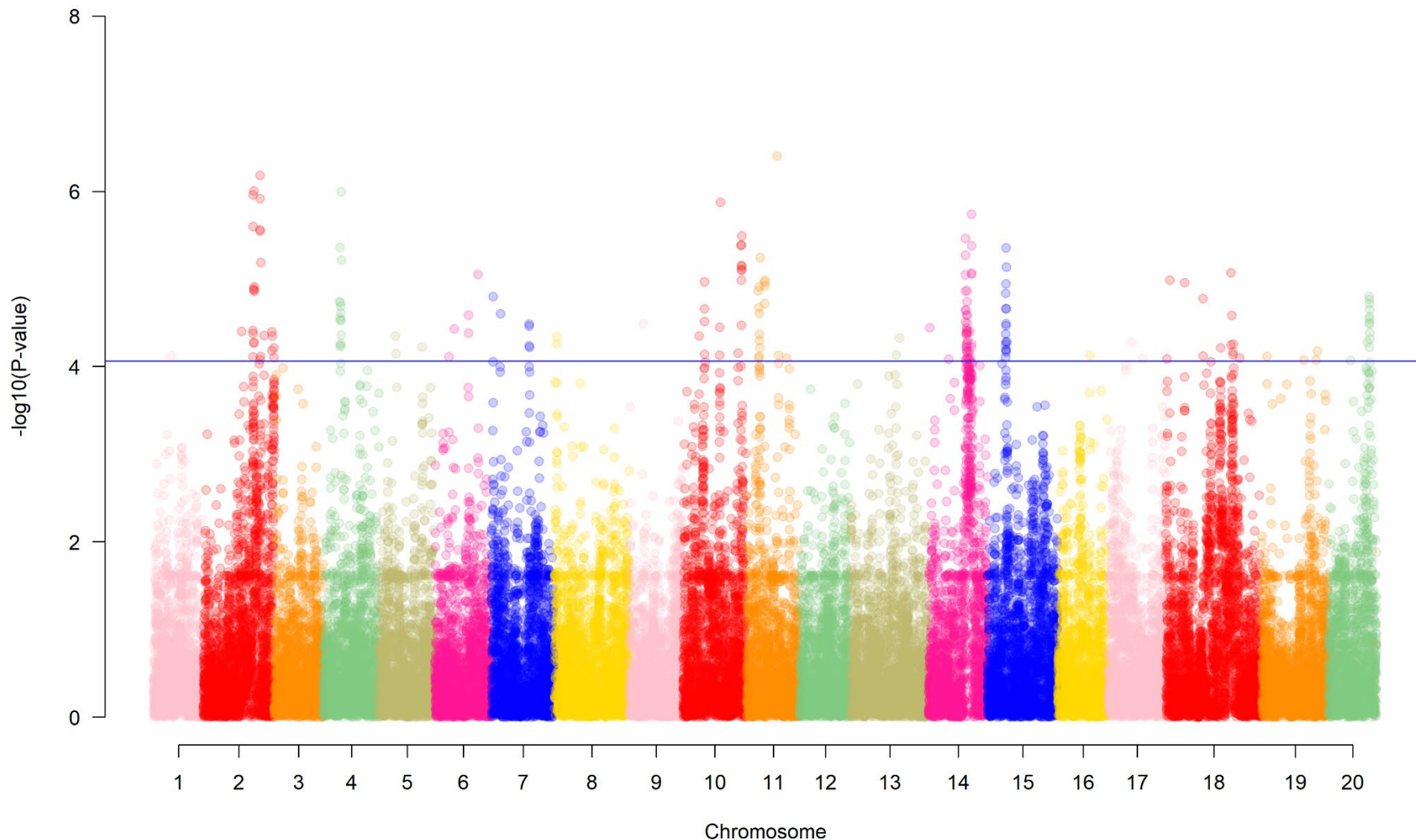


Soybean Gall Midge Genome-wide Association Mapping Preliminary analysis

GM All environments (3)

Manhattan plot from genome-wide association mapping of Gall Midge Injury Scores on 713 soybean accessions evaluated in 3 environments.

Significant SNPs are identified on all chromosomes except 1, 3, and 12.



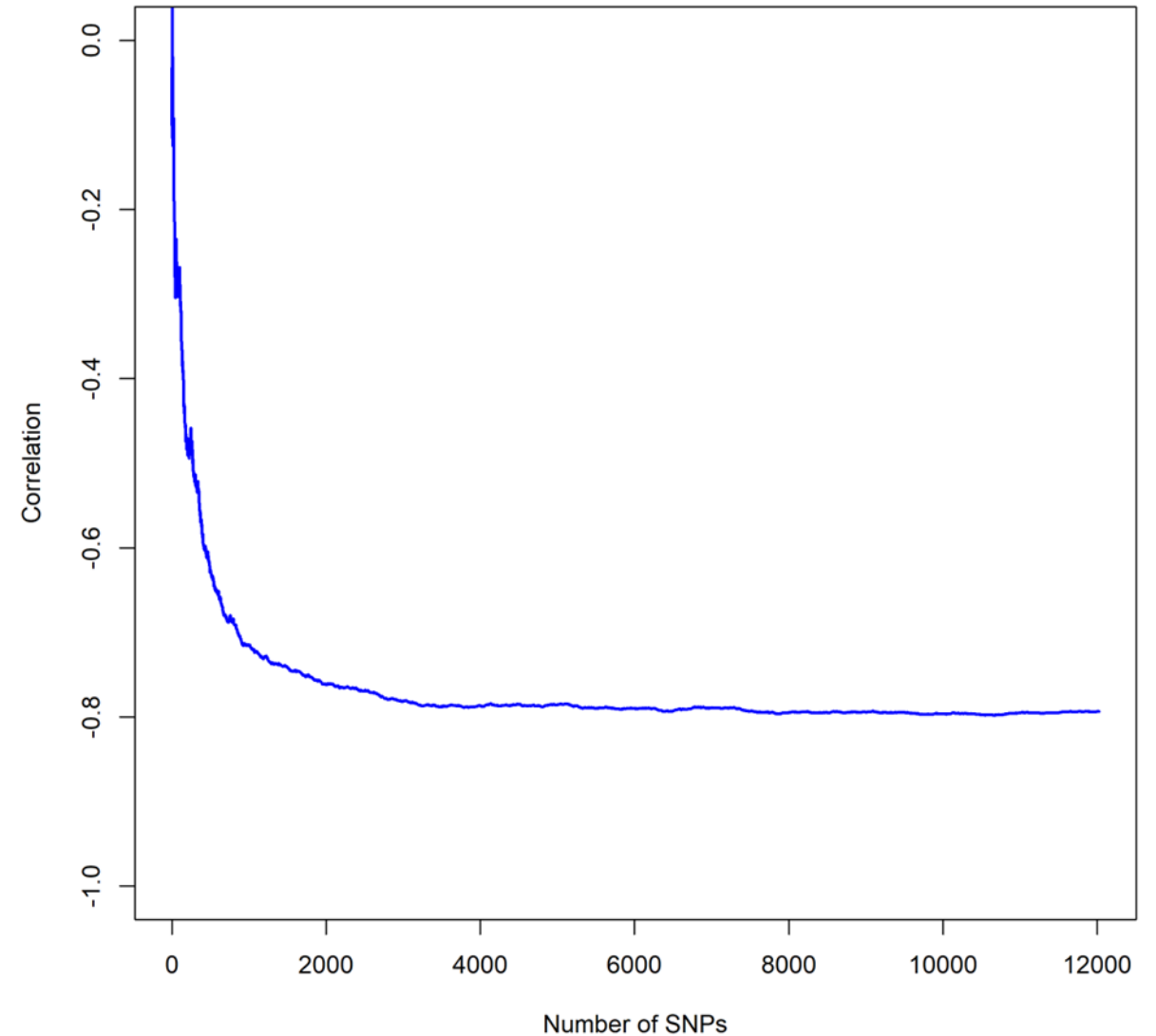
Diego Jarquin



Correlation between the **Estimated Injury** and the **Index $I=XB$** computed as the *product between the selected SNPs and their corresponding effects*. In this case, the SNPs were selected based on the estimated marker effects derived from the GWAS (top 10, 20, 29, 50, etc.)

- Reach plateau ~2000 most influential SNPs
- Indicates complexity of the trait

Correlation Index $I=XB$ vs. Estimated Injury



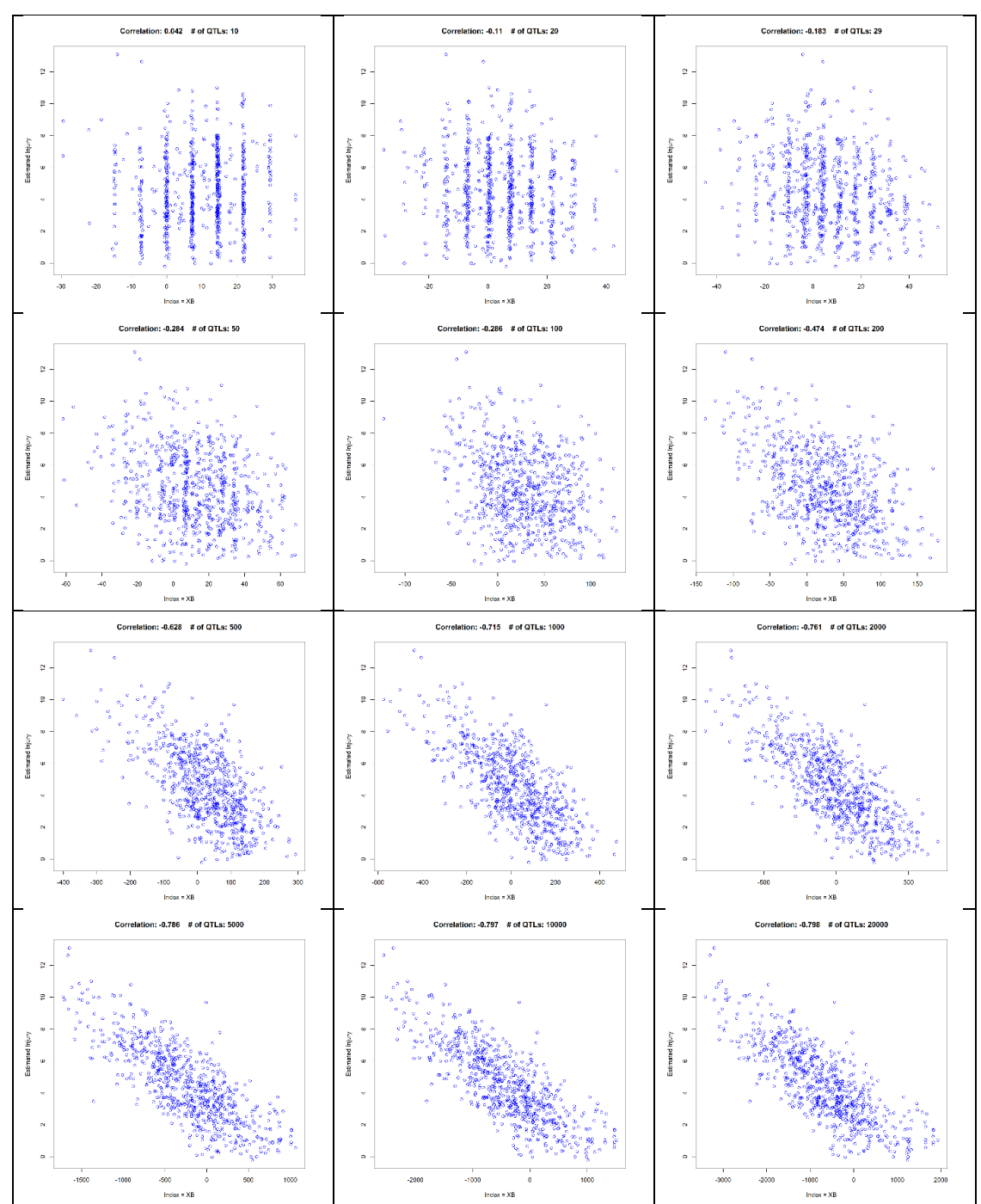
Diego Jarquin

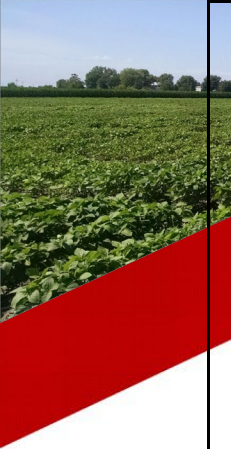


Scatter plot between the Estimated Injury and the Index $I=XB$ computed as the product between the selected SNPs and their corresponding effects. In this case, the SNPs were selected based on the estimated marker effects derived from the GWAS (top 10, 20, 29, 50, etc.)

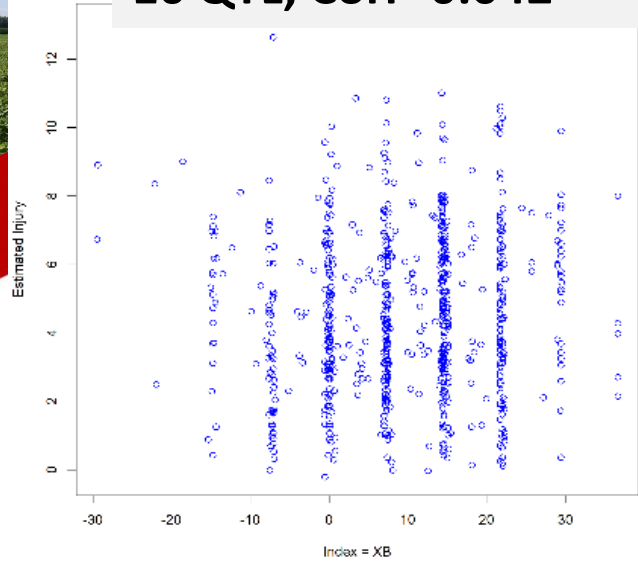


Diego Jarquin

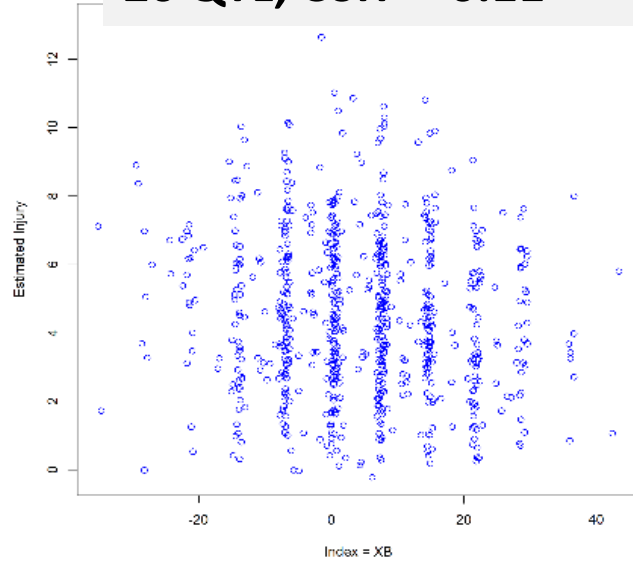




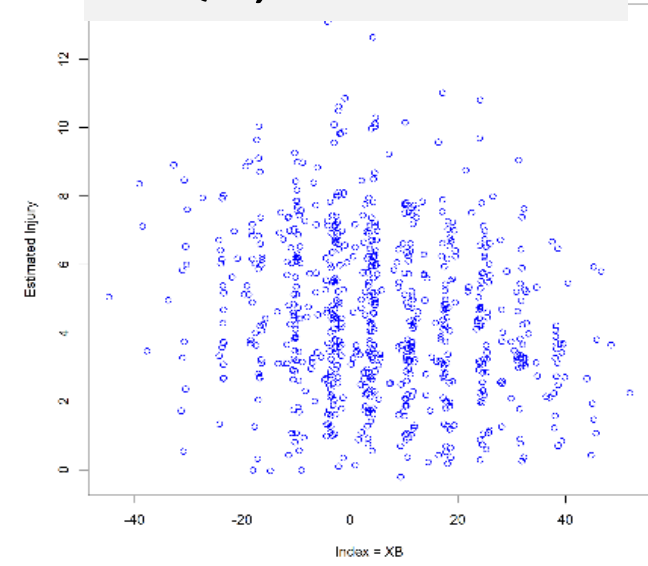
10 QTL, Corr=0.042



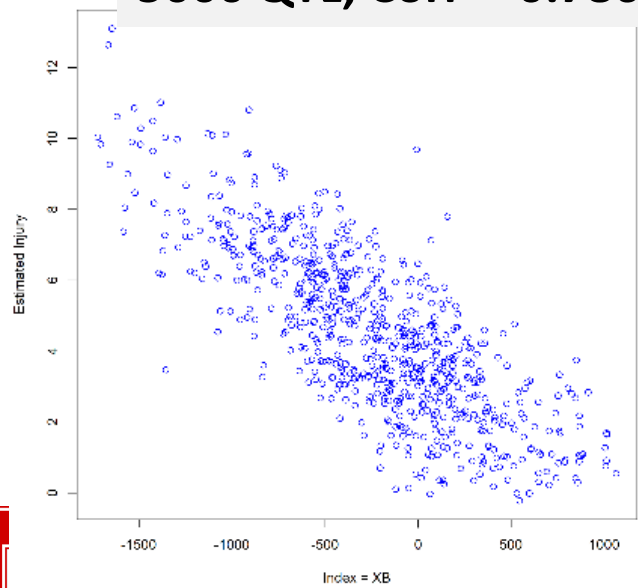
20 QTL, Corr= -0.11



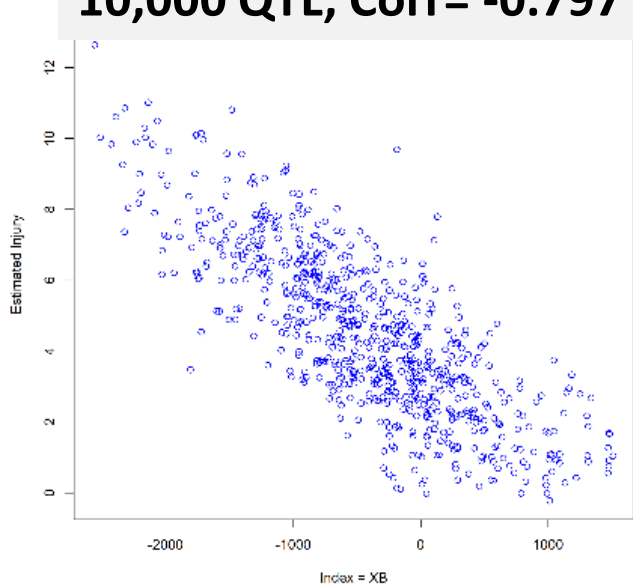
29 QTL, Corr= -0.183



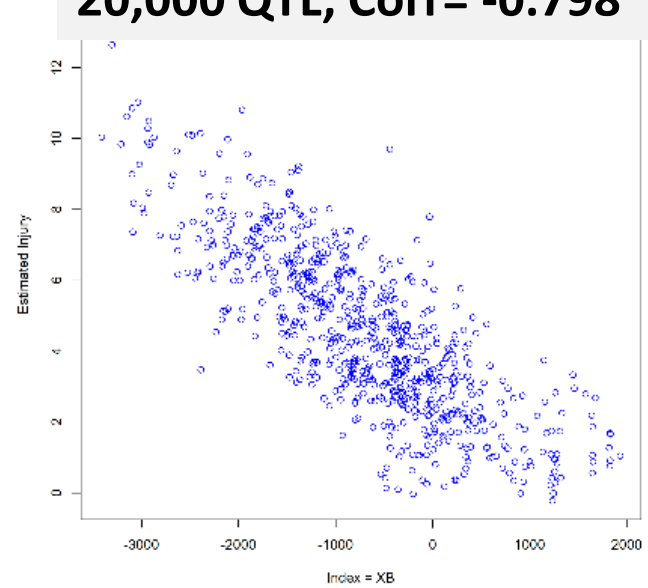
5000 QTL, Corr= -0.786



10,000 QTL, Corr= -0.797



20,000 QTL, Corr= -0.798



A photograph of a lush green soybean field under a clear blue sky, positioned in the top-left corner of the slide. A thick red diagonal line runs from the top-left towards the center, separating the image from the title and text.

Soybean Plant Reaction to Gall Midge Infestation

- Use 2020-2021 injury score data and genotype info to predict injury score of remaining ~7,000 accessions in MG 0, I, II, III, and IV in the USDA Soybean Germplasm Collection
- **Selected 100 accessions: 90 most resistant, 10 most susceptible**
- Grew seed increase during 2022 for evaluation in 2023 field plots



Soybean Plant Reaction to Gall Midge Infestation

2022 Tests

- 120 selected lines from 2020-21 evaluation of 713 lines
- Yield test plots 4 locs – 2 NE, 1 IA, 1 SD
- Larval counts on yield test plot border rows at NE locs
- Damage scores on yield test plots
 - Included multiple ratings at NE locs, 5 dates, to generate severity progress curves (AUSPC)

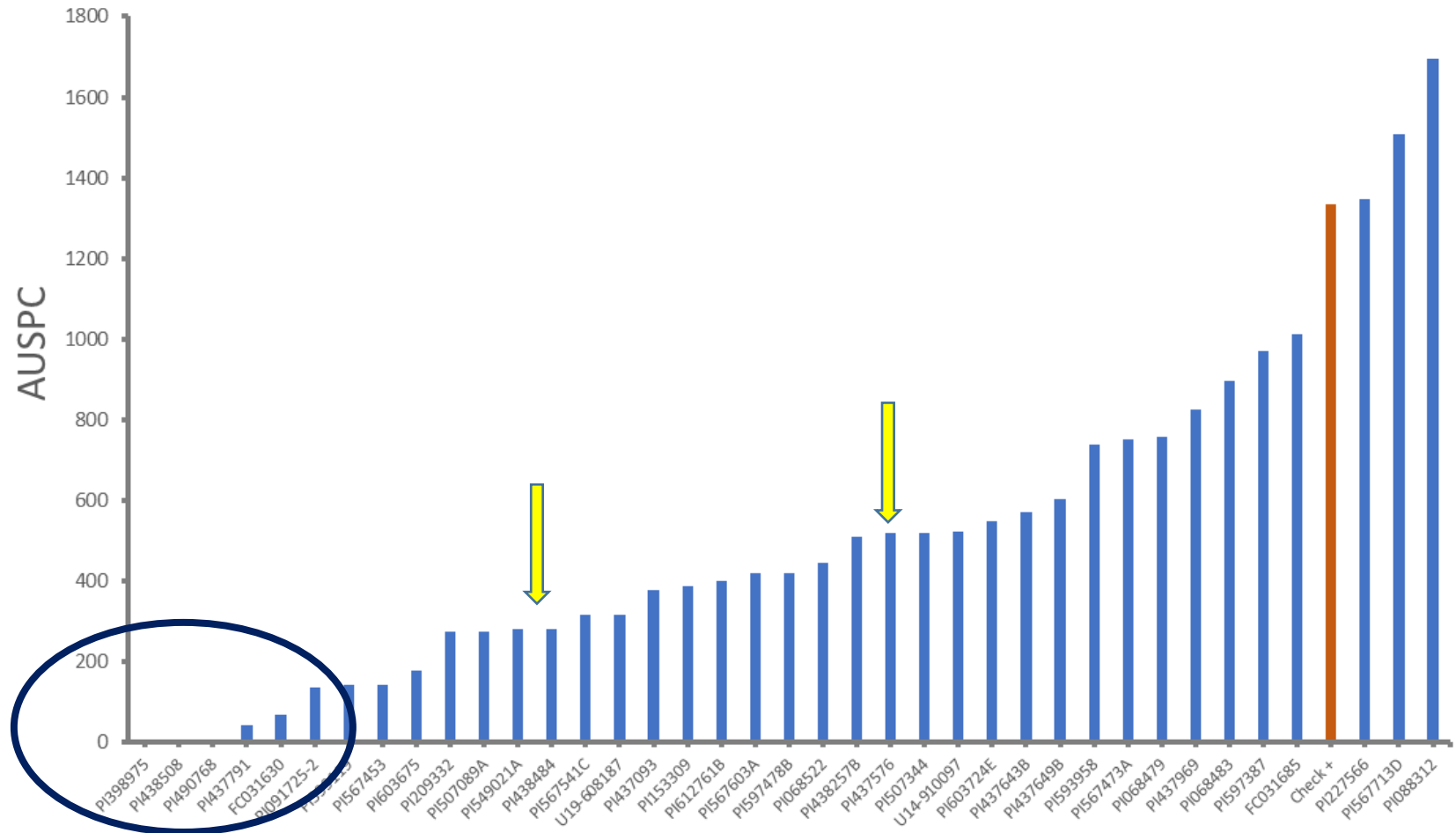


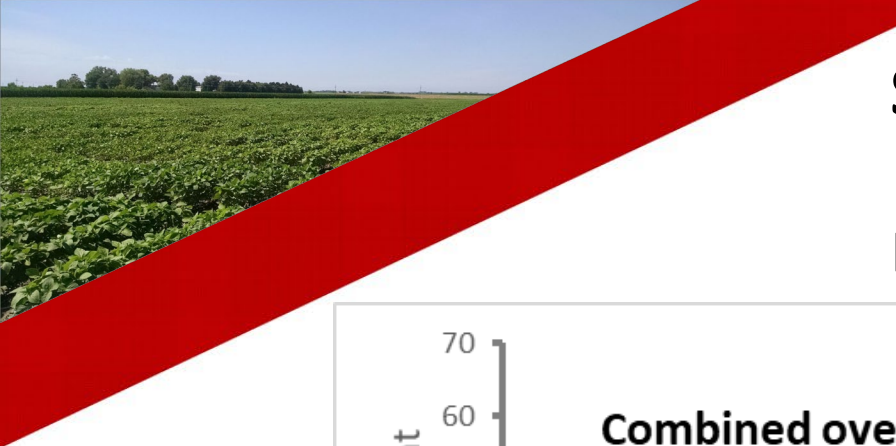
Genetics of Soybean Plant Reaction to Gall Midge Infestation -- Summary

- Damage severity scores made on
 - July 14, 26
 - Aug 5, 14, 24
- 3 PI lines with virtually zero damage
- 9 PI lines with minimal damage
- 2 elite Nebraska lines with lower damage vs. commercial susc. check



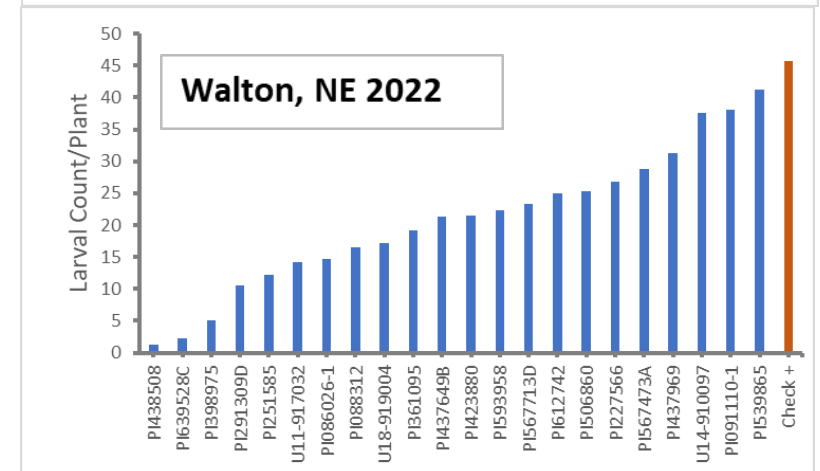
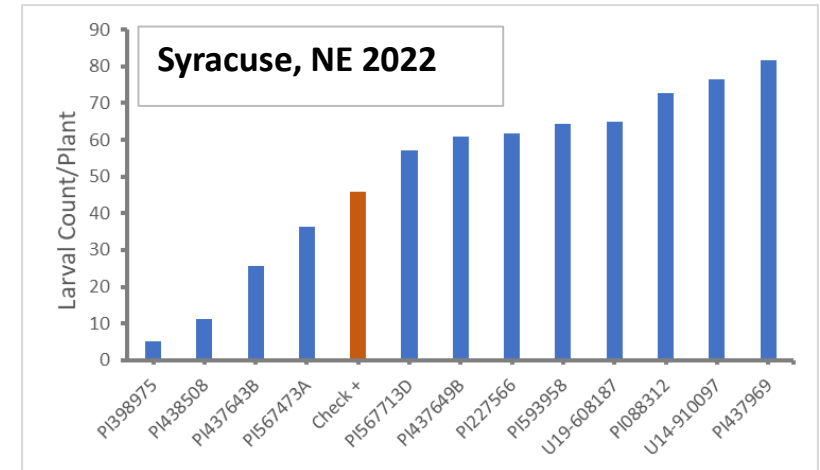
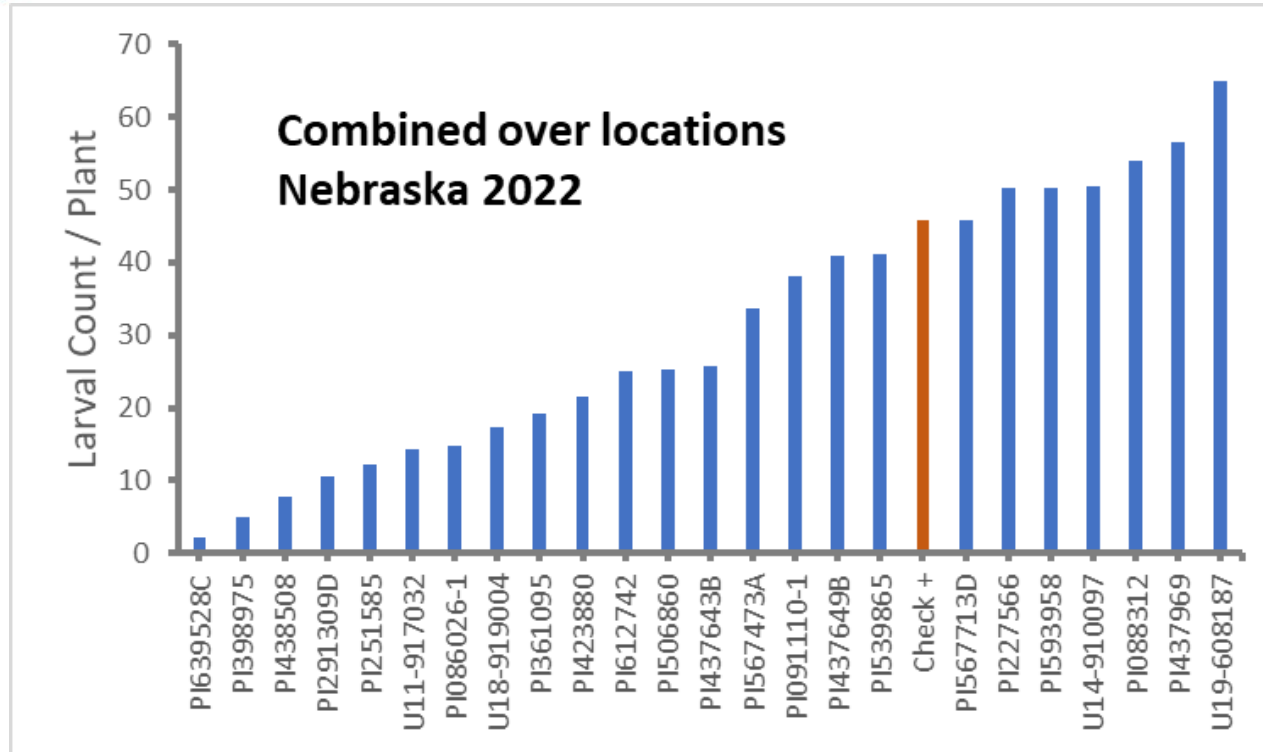
Area Under the Severity Progress Curve Syracuse, NE 2022





Soybean Plant Reaction to Gall Midge Infestation

Larval count per plant at two Nebraska locations in 2022



- Significant differences in # of larvae per plant
- Illustrates differences in plant response to larval infestation
- Important information, along with damage scores, to ID target lines for next phase of research



Soybean Plant Reaction to Gall Midge Infestation

•2023 Field Evaluations

- Validation set: 100 PI Accessions

- **90 Resistant, 10 Susceptible**
- 3 Locations (2 NE, 1 IA; 3 reps/loc)
- Plant injury score. Plant injury scale (use 0.25 increments to fine-tune injury score)
 - 0 – 0% of plants wilting or dead
 - 0.25 – designated when any wilting or dead plants are found
 - 0.5 - 12.5 % wilting or dead plants
 - 1 – 25% wilting or dead plants
 - 2 – 50% wilting or dead plants
 - 3 – 75% wilting or dead plants
 - 4 – 100% wilting or dead plants
- Score ~ every 10-14 days to R6





Soybean Plant Reaction to Gall Midge Infestation

•2023 Field Evaluations

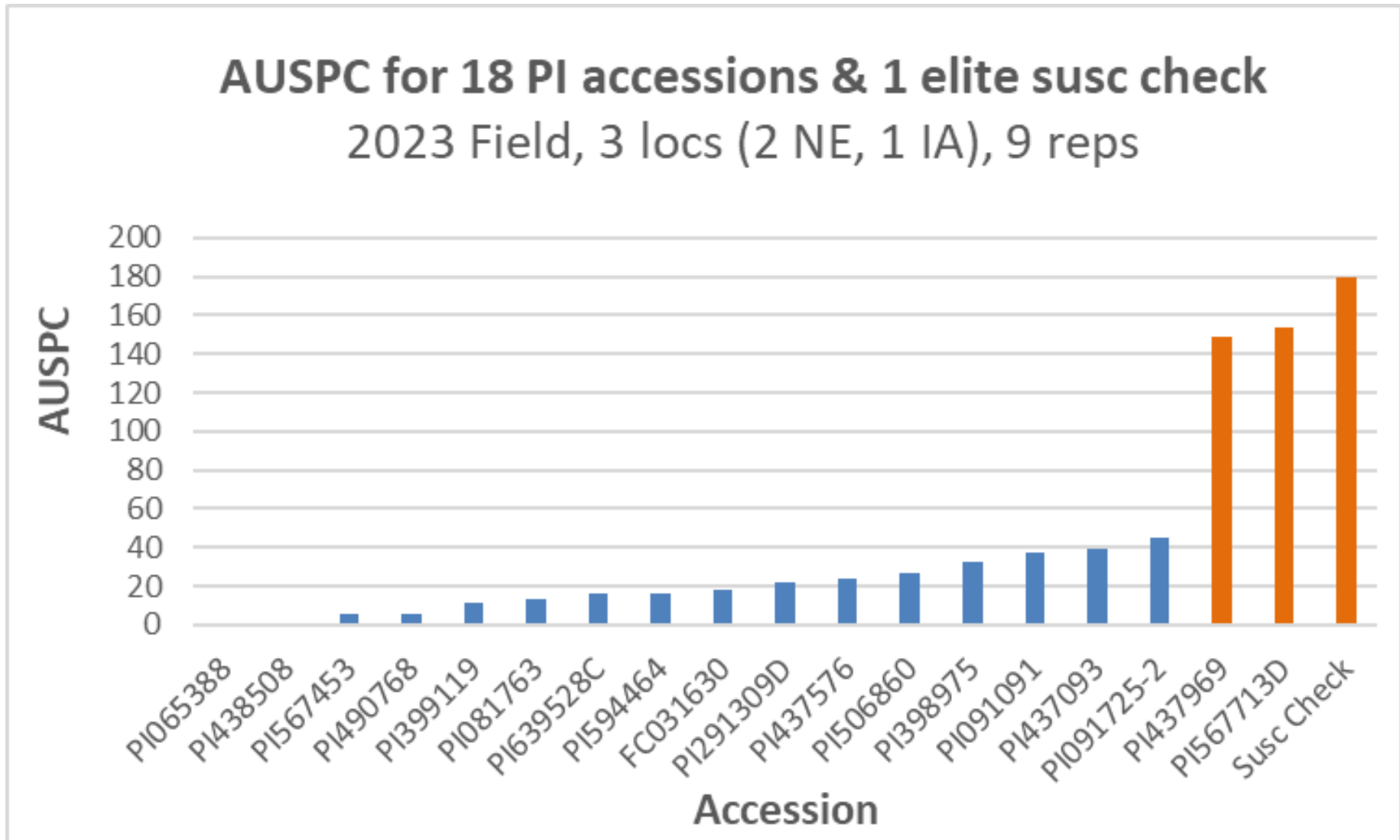
- Selected accessions from previous years for more detailed study
 - **18 accessions** – **16** more **resistant**, **2** most **susceptible**. Plus common susc commercial check
 - 4-row plots, 3 reps, 3 locations (2 NE, 1 IA)
 - Damage scores as above, AUSPC
 - Larval presence
 - Larval counts
 - Fissure +/-, fissure type
 - Surface, deep, above ground, below ground



Soybean Plant Reaction to Gall Midge Infestation

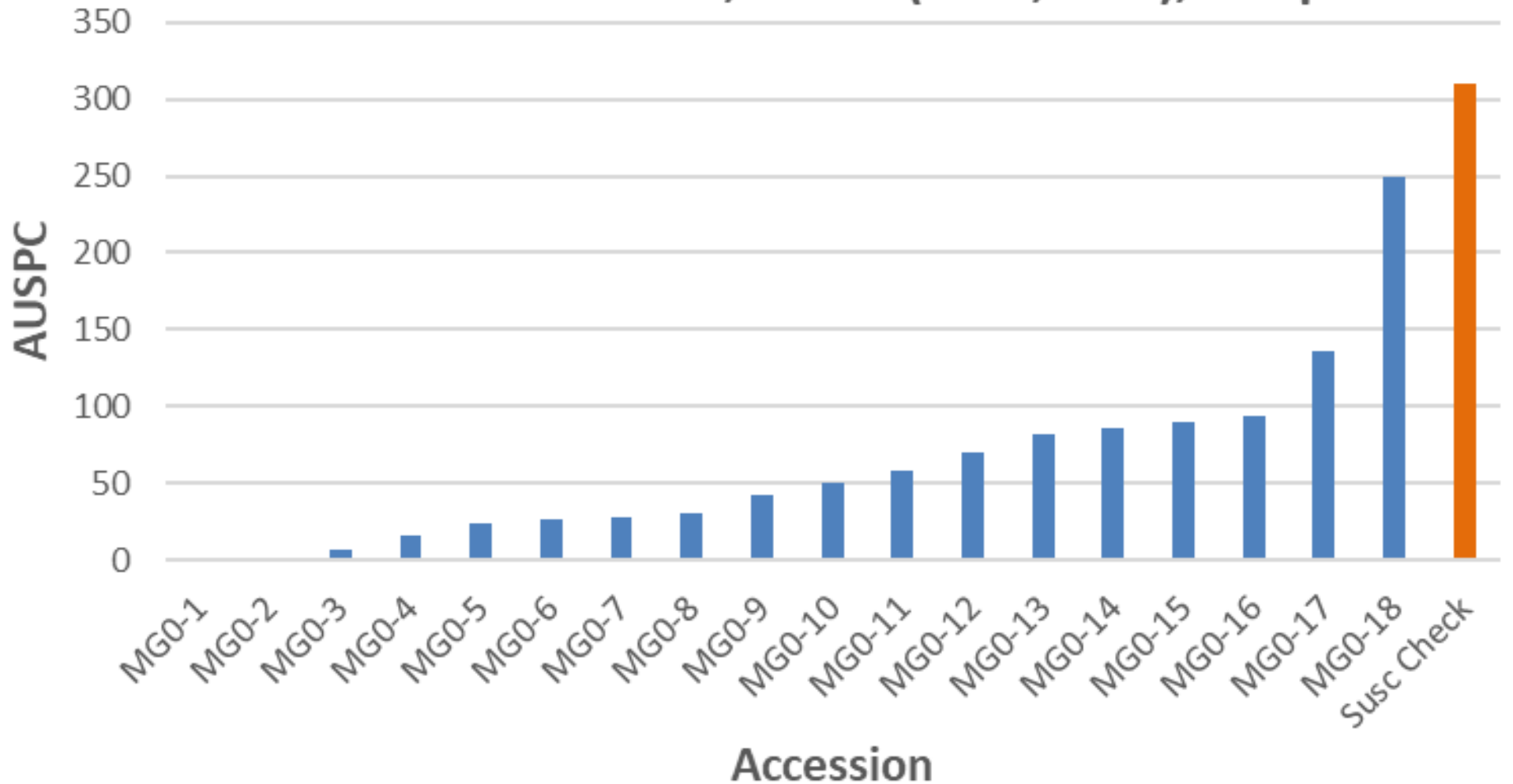


AUSPC for 18 PI accessions & 1 elite susc check
2023 Field, 3 locs (2 NE, 1 IA), 9 reps



Soybean Plant Reaction to Gall Midge Infestation

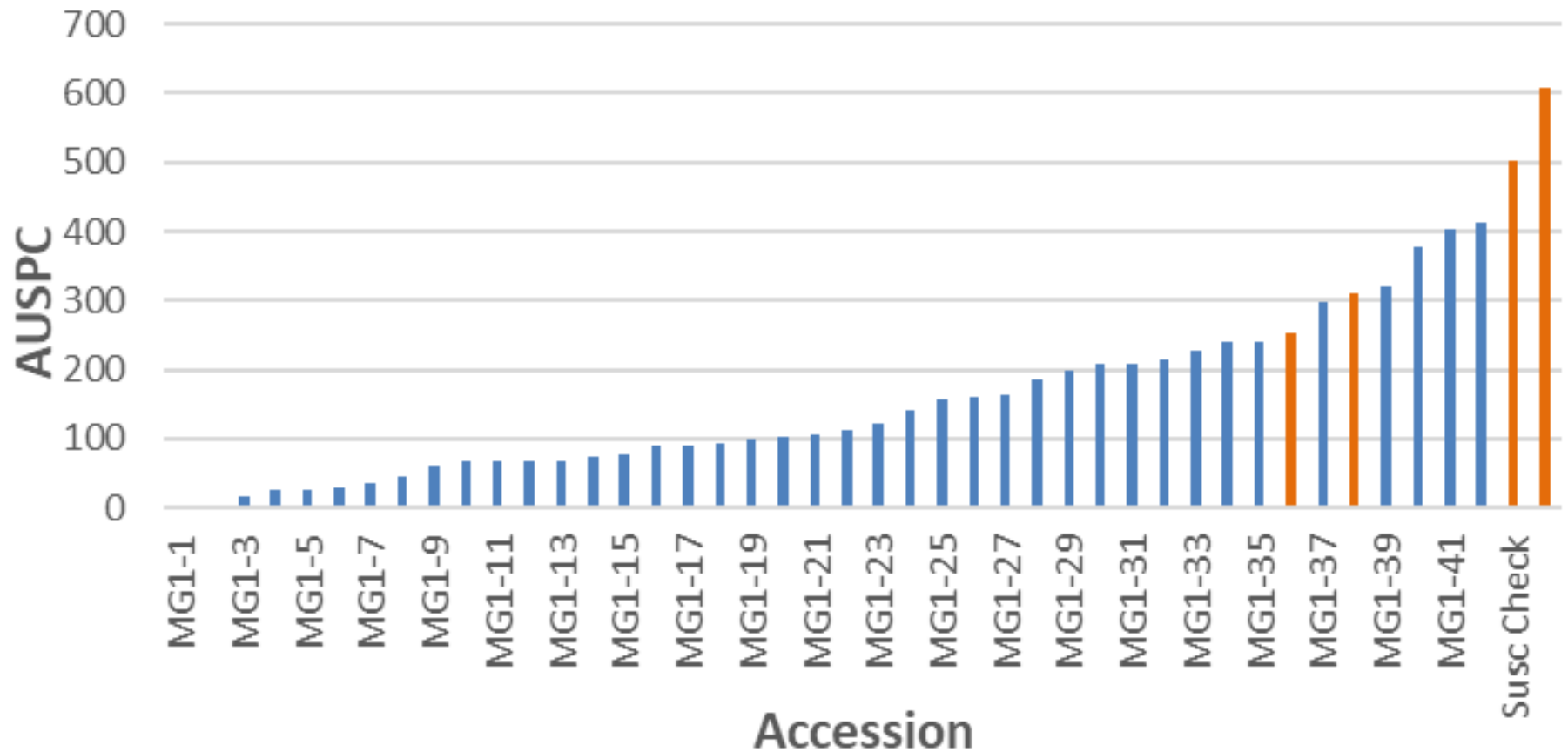
AUSPC for MGO accessions in the Validation Set
2023 Field Evaluations, 3 locs (2 NE, 1 IA), 9 reps





Soybean Plant Reaction to Gall Midge Infestation

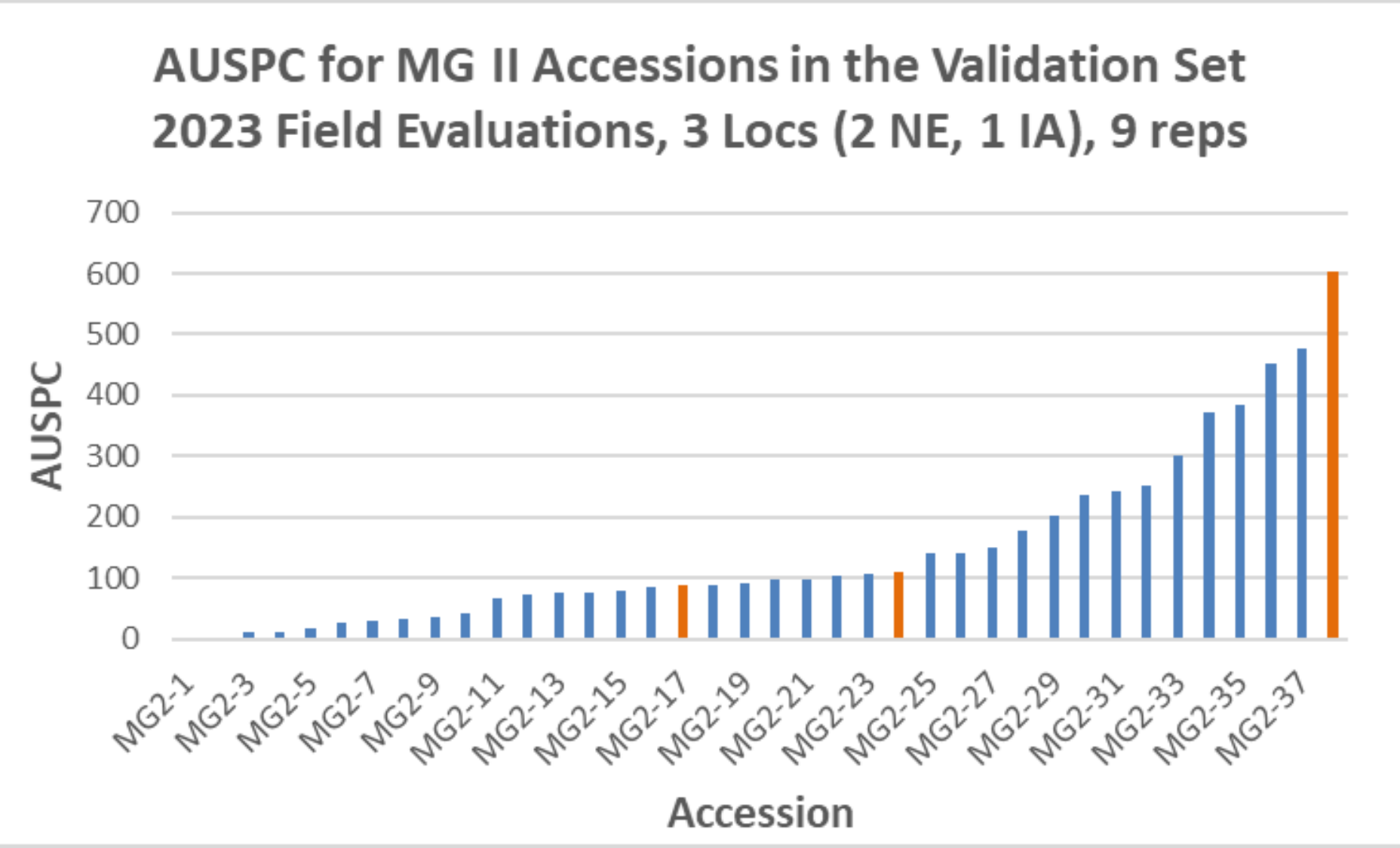
AUSPC for MG I Accessions in the Validation Set 2023 Field Evaluations, 3 locs (2 NE, 1 IA), 9 reps





Soybean Plant Reaction to Gall Midge Infestation

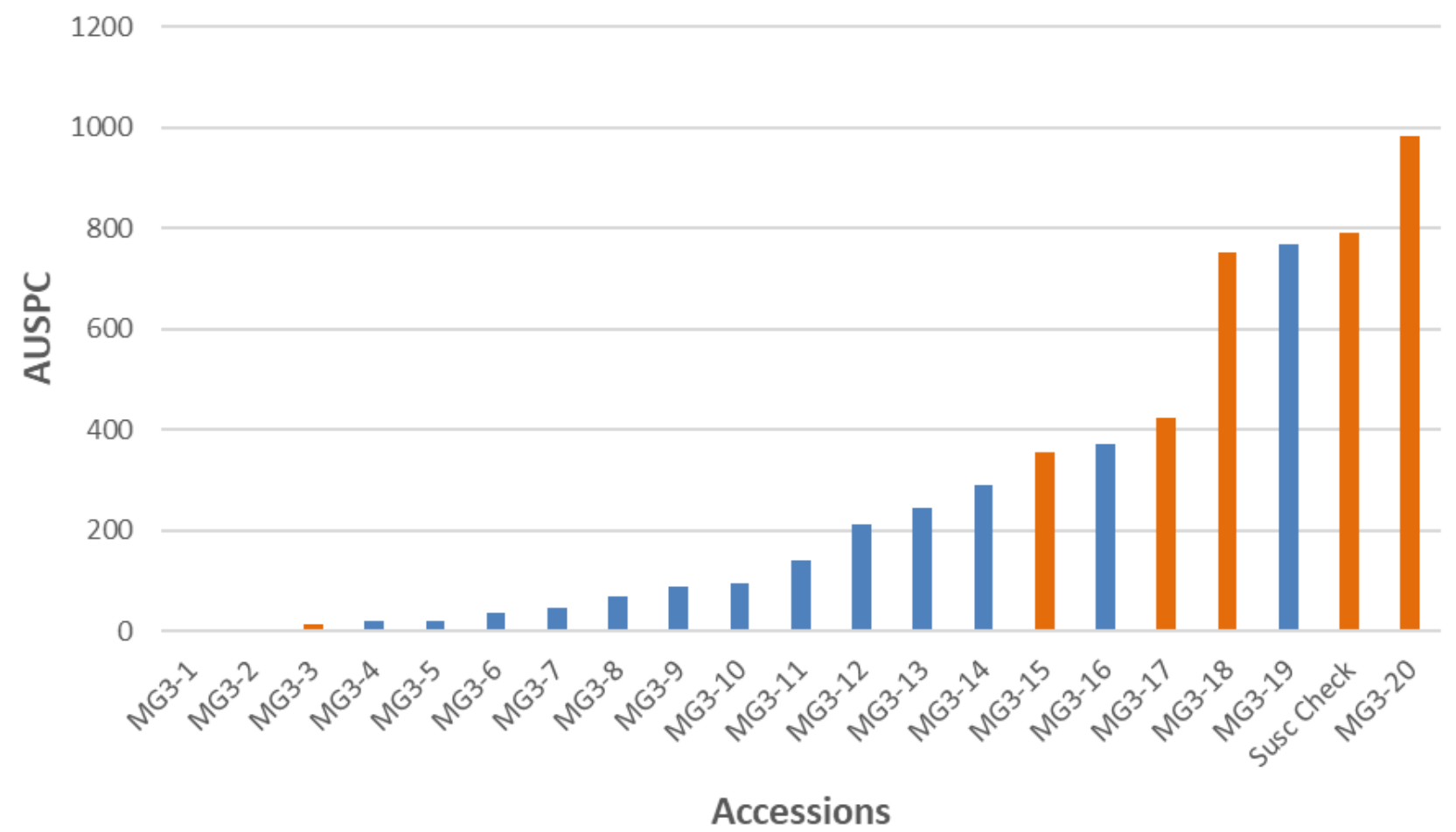
AUSPC for MG II Accessions in the Validation Set
2023 Field Evaluations, 3 Locs (2 NE, 1 IA), 9 reps





Soybean Plant Reaction to Gall Midge Infestation

AUSPC for MG 3 Accessions in Validation Set
2023 Field Evaluations, 3 Locs (2 NE, 1 IA), 9 reps



What about elite lines & cultivars? Is there “resistance”?

- **Injury scores** are skewed to the low end in elite germplasm.
- **Good news**

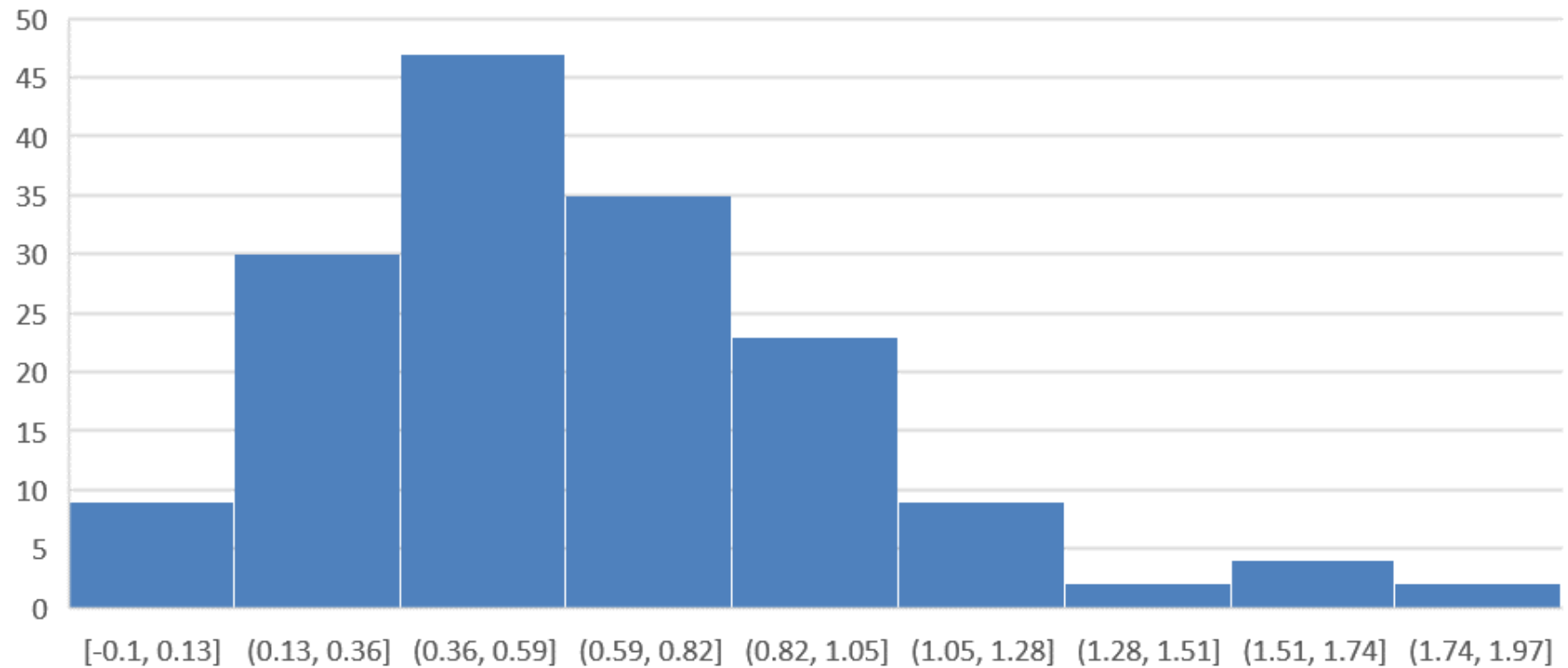
Injury Score

0=no injury,

1= 25% injured to

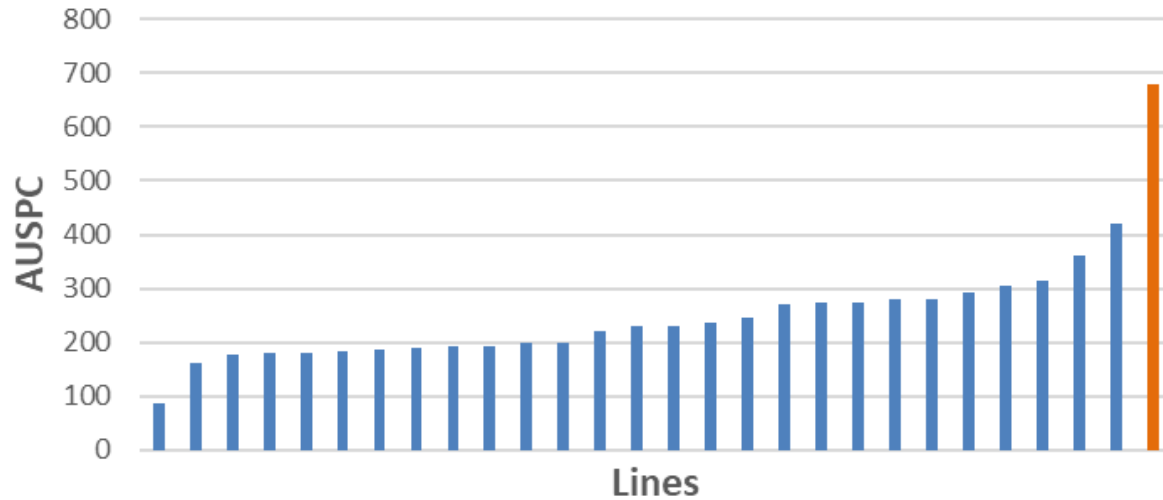
4= 100% of plants injured

Distribution of average GM Injury Score for 163 elite soybean lines from University of Nebraska Soybean Breeding Program
2-3 Env, 2 reps/Env 2020-2021

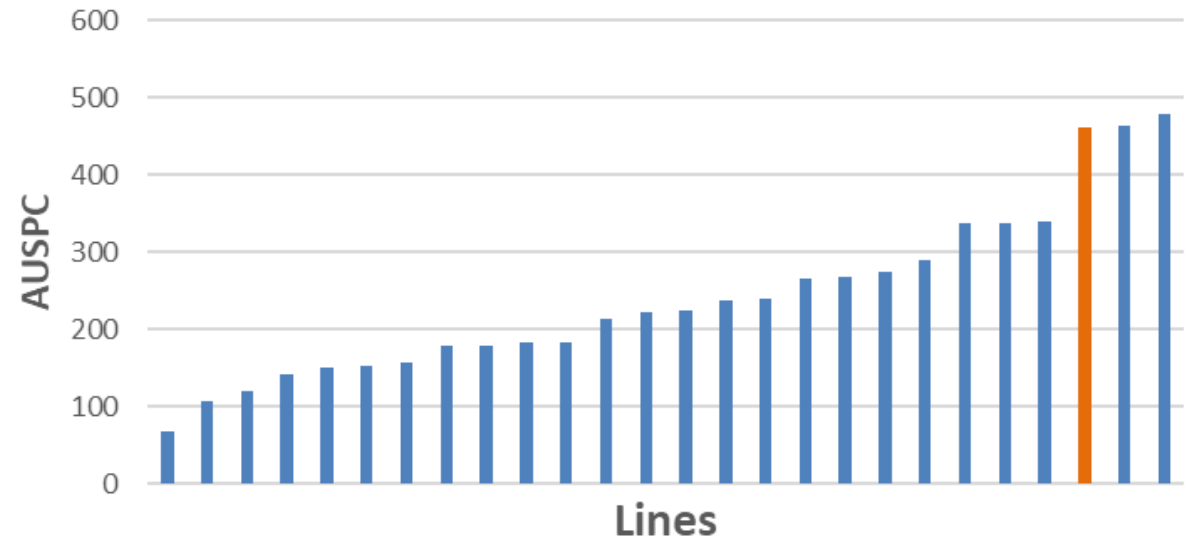


Soybean Plant Reaction to Gall Midge Infestation

AUSPC for Elite MG2 Lines
2023 Field, 2 NE locs, 6 Reps



AUSPC for Elite MG3 Lines
2023 Field, 2 NE Locs, 6 Reps



Elite MG2 & MG3 lines from the University of Nebraska soybean breeding program

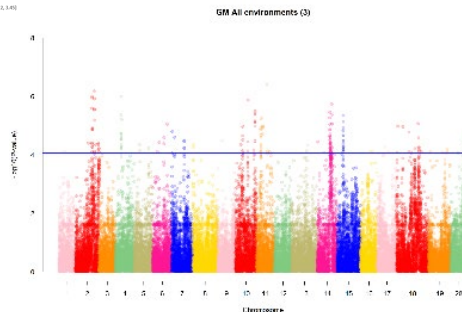
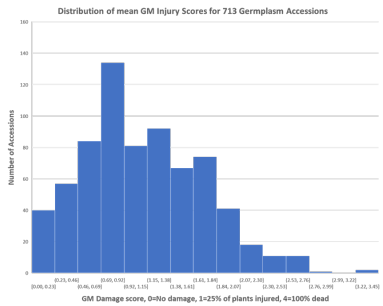




Genetics of Soybean Plant Reaction to Gall Midge Infestation -- Summary



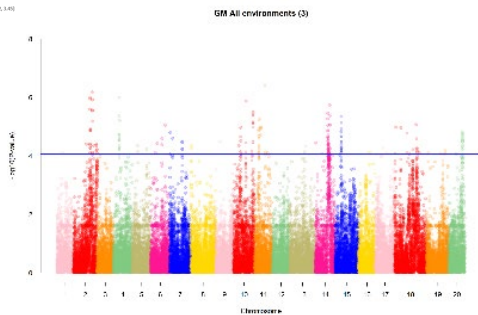
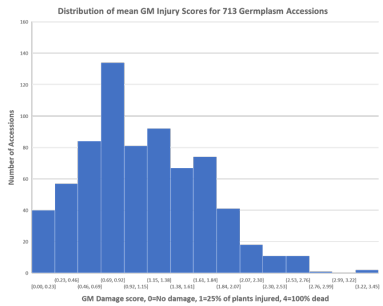
- Soybean lines show **differential response** to GM infestation
- There *are* **genotype differences**
- Identified **significant SNPs**
- Good results from **Validation Set** selected based on GEBVs for injury score
- ID'd several accessions with zero or very low AUSPC in both the initial set and validation set



Genetics of Soybean Plant Reaction to Gall Midge Infestation -- Summary



- There is **significant resistance** observed in **elite soybean germplasm** (based on evaluation of Nebraska breeding program elite lines)
- **Good news** for soybean farmers & companies => **can screen current elite germplasm** phenotypically and genotypically to **ID best lines** for SGM infested areas, breeding programs





Genetics of Soybean Plant Reaction to Gall Midge Infestation -- Summary

2024 tests and beyond

- Yield tests of elite lines in infested fields, with hilling or other treatments?
- Evaluate USDA Uniform Test entries using genotype information, ID and evaluate selected lines for reaction in infested fields
- Use selected most resistant lines in more detailed and controlled environment studies to help elucidate insect/plant interactions and genetics
- Develop cross populations for further genetic study

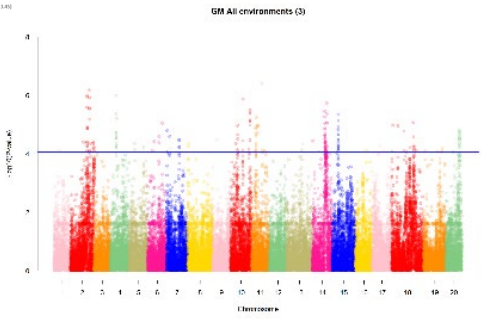
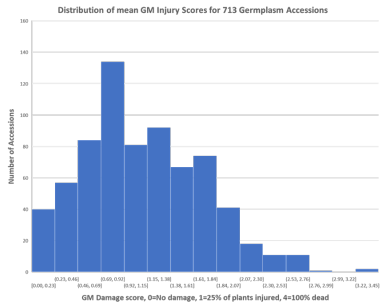




Genetics of Soybean Plant Reaction to Gall Midge Infestation -- Summary



Thank you



NCSRP NORTH CENTRAL SOYBEAN RESEARCH PROGRAM

The North Central Soybean Research Program, a collaboration of 12 state soybean associations, invests soybean checkoff funds to improve yields and profitability via university research and extension.



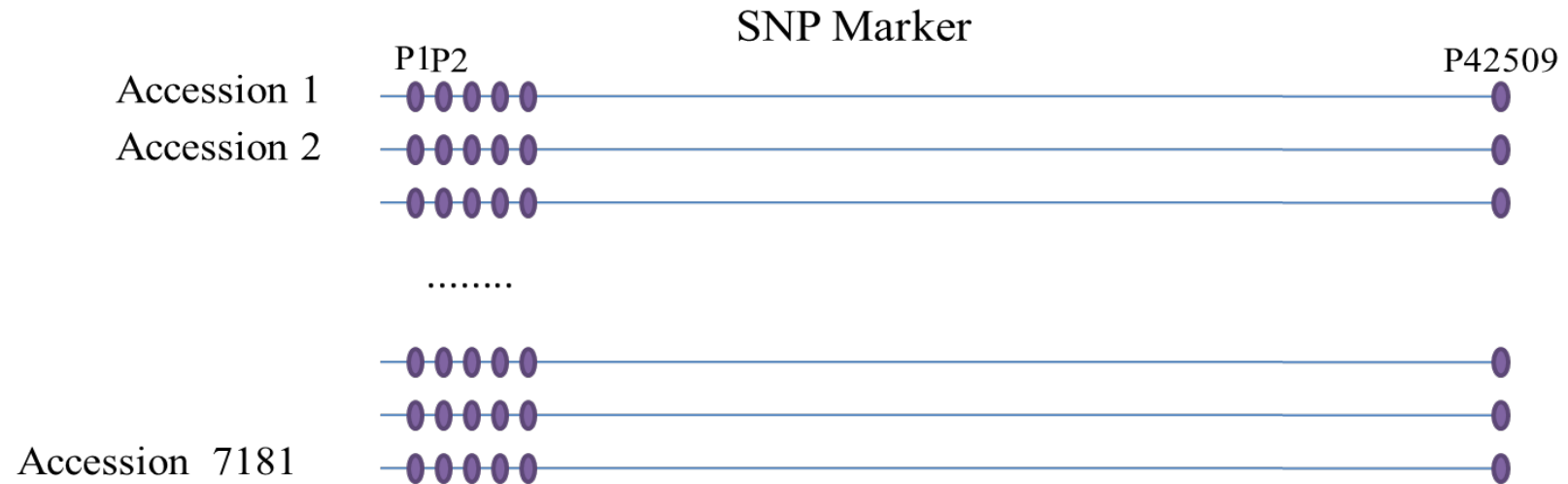
UNIVERSITY of NEBRASKA LINCOLN



Additional slides for possible inclusion or for questions



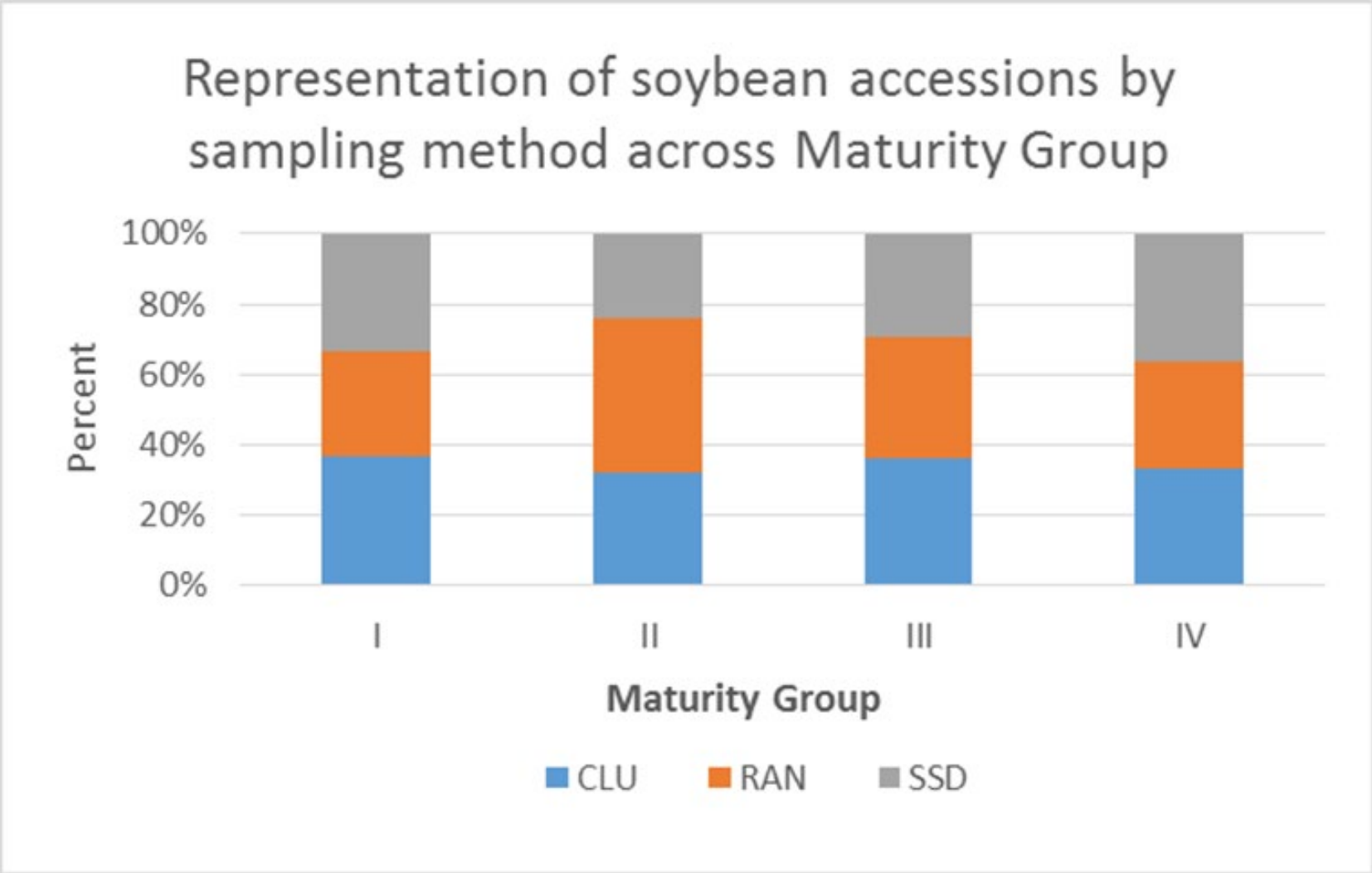
Data set for accessions & SNPs



- $n = 7181$ accessions MGI to MGIV
- $p = 42509$ SNP (single-nucleotide polymorphism) markers.
- Each of genotypes in the collection has a $1 \times p$ vector of genotypic binary marker information.
- **Reduced total SNPs to 19,356**
- **$m = 200 \ll P$ selected from total accessions**



Distribution of accessions across maturity group & sample method





Distribution of accessions sampled by each sample type

CLU(Blue)

SSD (Orange)

Random (Black)

Compare with Entire collection (Light Gray)

**Our sample represents the total genetic diversity in the USDA Soybean Germplasm Collection in MG I to IV*



PC plot – D. Jarquin

