

Exploring gene sources for sustainable improvement of sugarbeet

Chenggen Chu*¹, Muhammad Tehseen², Lisa Preister¹, Barkan Bostan², Jolene Addington², Nathan Wyatt¹, Melvin Bolton¹, Karen Fugate¹, Vanitharani Ramachandran¹, Mark Boetel³, Eric Branch⁴, Emma Burt⁵, Mike Metzger⁵, Xuehui Li²

¹USDA-ARS, Sugarbeet Research Unit, Fargo, ND 58102,

²Department of Plant Sciences, North Dakota State University, Fargo, ND 58102,

³Department of Entomology, North Dakota State University, Fargo, ND 58102,

⁴Department of Plant Pathology, North Dakota State University, Fargo, ND 58102

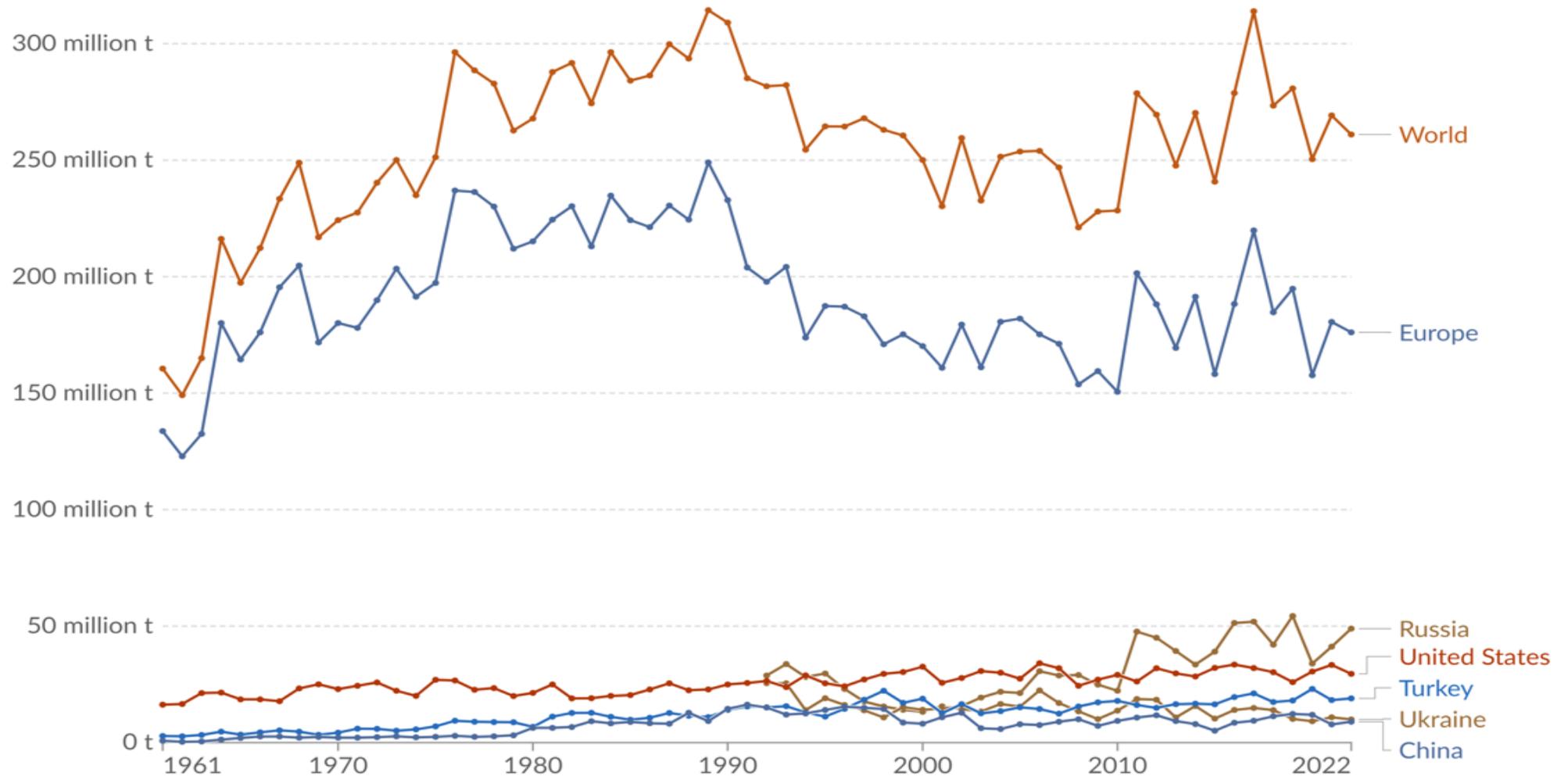
⁵Minn-Dak Farmers Cooperative, Wahpeton, ND 58075

Sugarbeet crop

Sugar beet production, 1961 to 2022

Our World
in Data

Sugar beet production is measured in tonnes.



Data source: Food and Agriculture Organization of the United Nations (2023)

OurWorldinData.org/agricultural-production | CC BY

Sugarbeet crop vulnerability

- **Important sugarbeet diseases and pests**

- Aphanomyces root rot
- Beet soilborne mosaic virus
- Cercospora leaf spot
- Curly Top
- Erwinia
- Fusarium yellows/wilt/stalk blight
- Powdery mildew
- Rhizoctonia root/crown rot
- Rhizomania
- Virus Yellows
-
- Aphids
- Beet army worm
- Cutworm
- Root knot nematode
- Springtails
- Sugarbeet root maggot
- Wireworm
- Sugarbeet cyst nematode
-

Sugarbeet crop vulnerability

- **Important sugarbeet diseases and pests**
- **Other main issues**
 - Sugar loss during post-harvest storage
 - Tolerance to abiotic stress (drought, cold)
 - Quality Improvement (metal ion content)
 - Sucrose content and impurities (non-sucrose soluble components)
 - Processing qualities
 - Sustainable improvement

Sugarbeet crop vulnerability

- Important sugarbeet diseases and pests
- Other main issues
- Narrow genetic diversity

Explore genetic resources for sustainable sugarbeet improvement

Sugarbeet evolution

Sea beet (*Beta vulgaris* ssp. *maritima*)



Cultivated beet (*Beta vulgaris* ssp. *vulgaris*)



Fodder beet



Leaf beet



Table beet (red beet, garden beet, root beet)

- Beta macrocarpa* Guss
- Beta patula* Aiton
- Beta atriplicifolia*
- Beta macrorhiza*
- Beta palonga*
- Beta procumbens*
- Beta webbiana*

How can we explore and utilize these genetic resources?

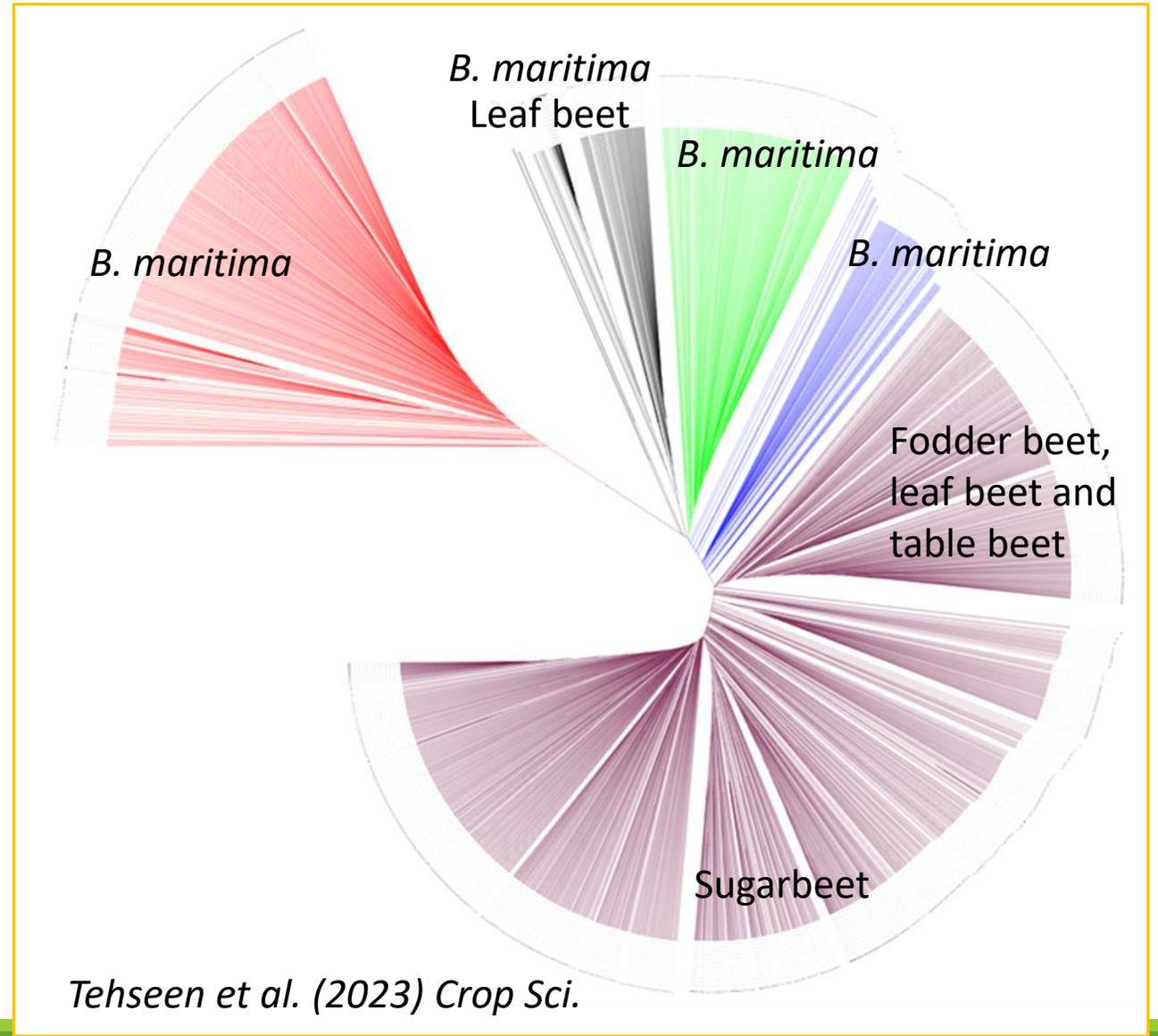


Objectives

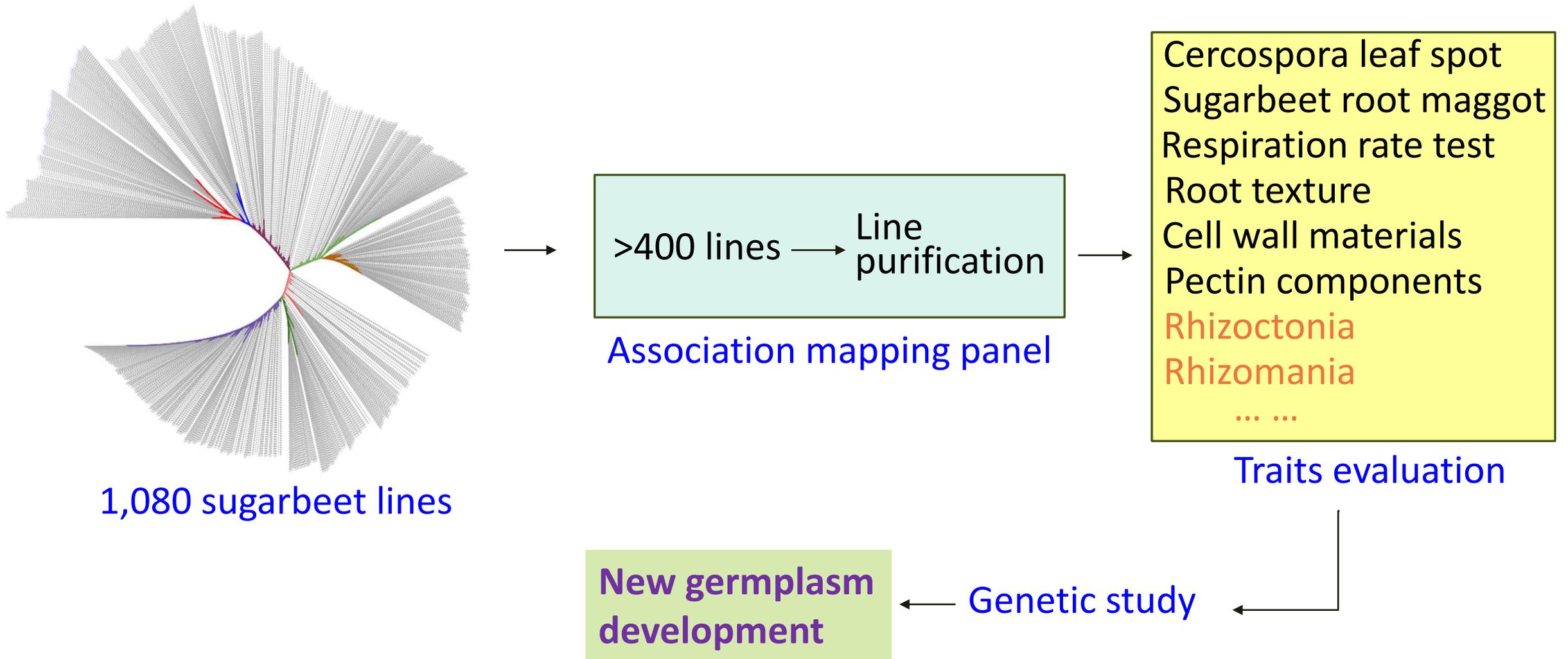
- ❑ Genetic diversity analysis in *Beta* germplasm
- ❑ Evaluate resistance to Cercospora leaf spot (CLS) and Sugarbeet Root Maggot (SBRM) (**resistance to others in future**)
- ❑ Traits related to post-harvest storage (respiration rate, tissue firmness, cell wall composition)
- ❑ Association mapping to identify beneficial genes and develop markers
- ❑ Marker-assisted trait introgression

Beta germplasm diversity analysis

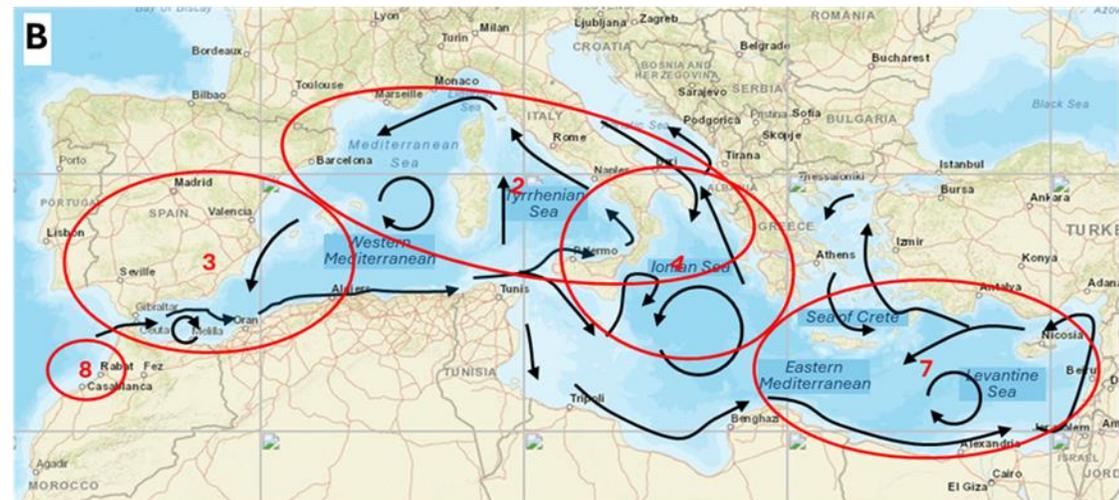
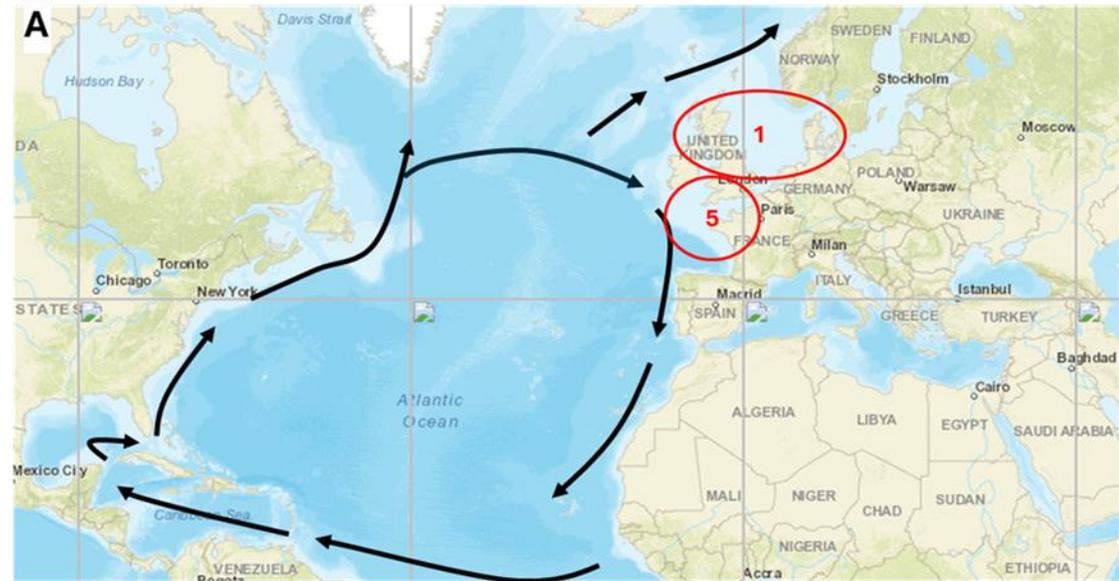
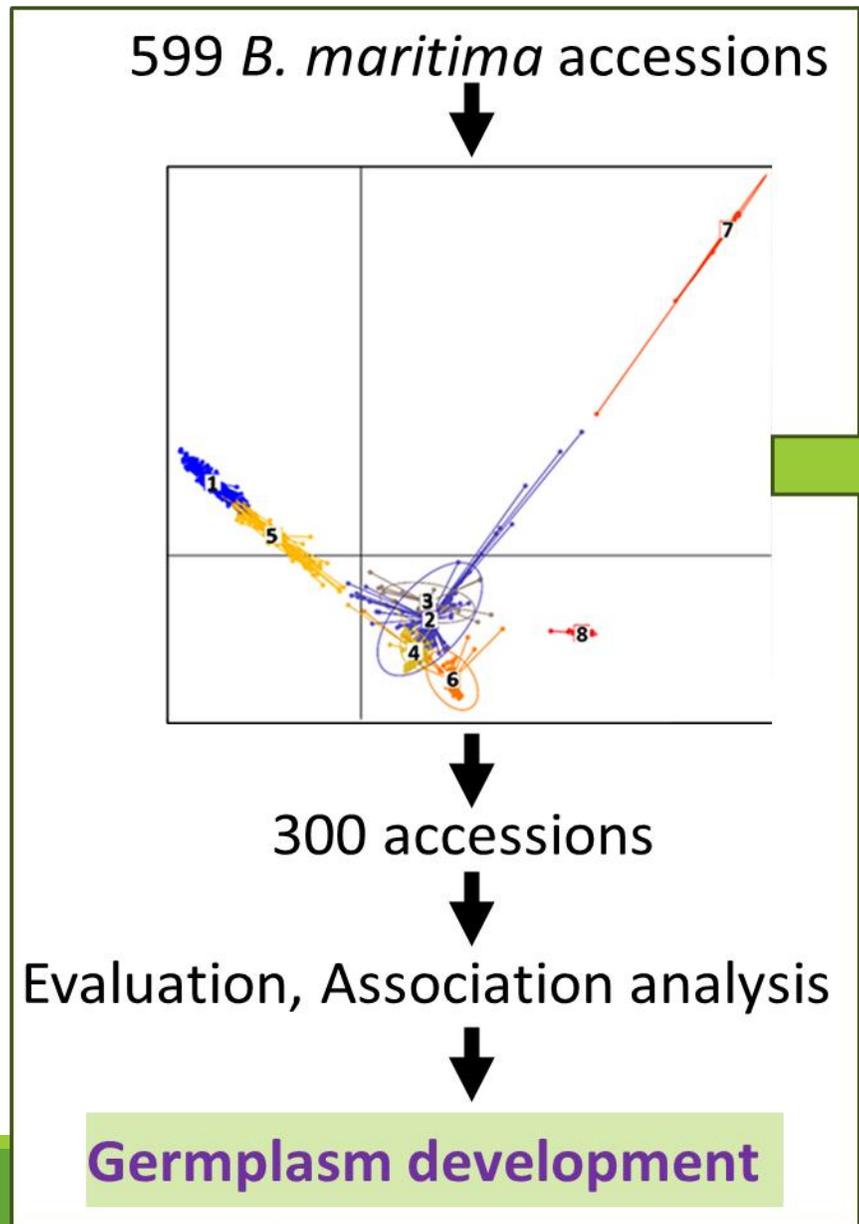
Sub-species	Number of accessions
<i>Beta atriplicifolia</i>	6
<i>Beta macrocarpa</i>	11
<i>Beta macrorhiza</i>	2
<i>Beta palonga</i>	1
<i>Beta patula</i>	3
<i>Beta procumbens</i>	1
<i>Beta webbiana</i>	1
<i>Beta maritima</i> L.	599
<i>Beta vulgaris</i> L.	1,315
Fodder beet	86
Leaf beet	67
Table beet	82
Sugarbeet	1,080
Total	1,939



Identification and utilization of beneficial genes in sugarbeet lines

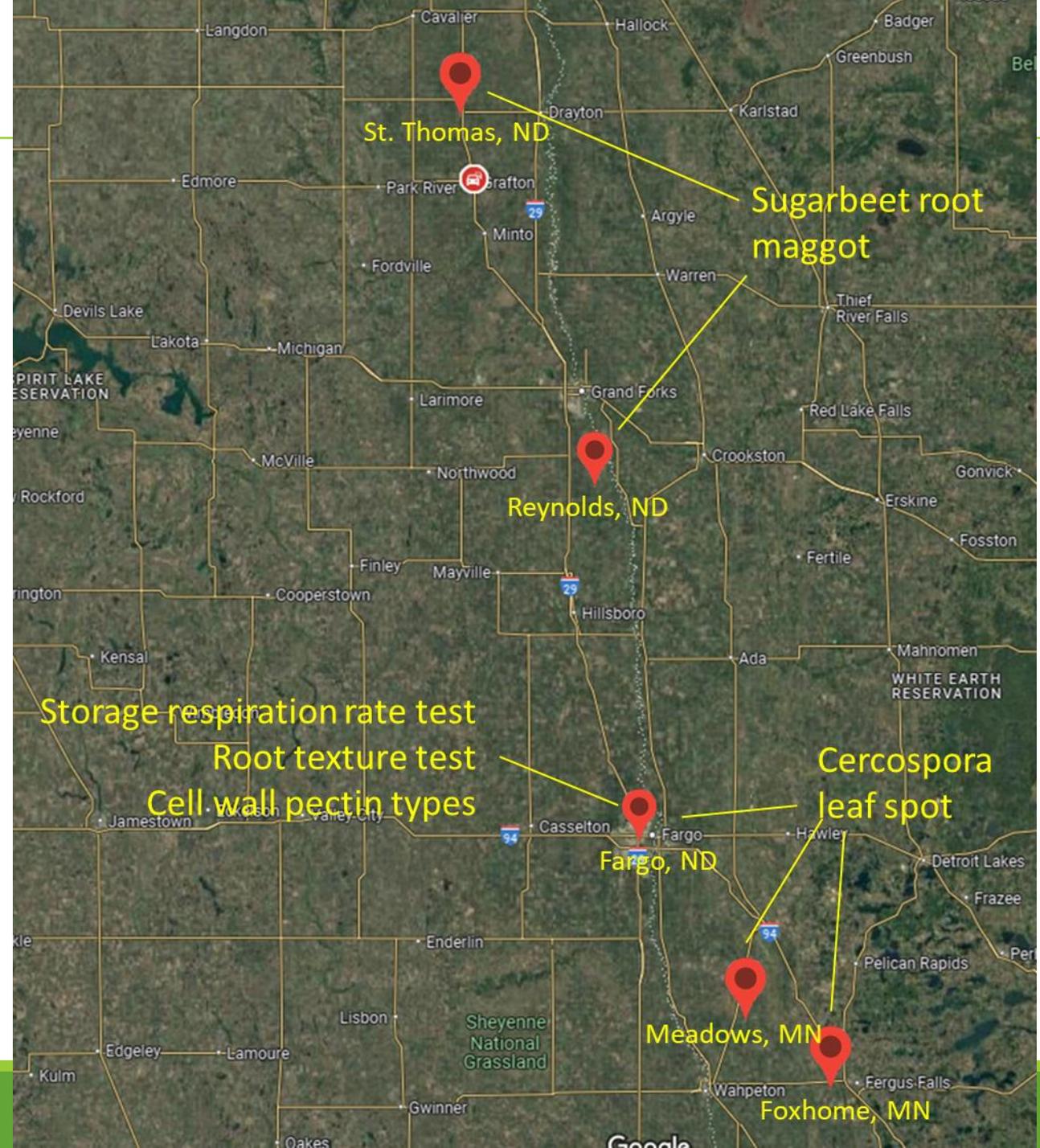


Identification and utilization of beneficial genes in sea beet lines



Trait evaluation

- Cercospora leaf spot (CLS)
- Sugarbeet root maggot (SBRM)
- Respiration rate during cold storage
- Root texture (puncture resistance and pressure resistance, dry matter)
- Cell wall pectin



Results

1. sugarbeet lines purification

410 sugarbeet lines



Results

1. sugarbeet lines purification

410 sugarbeet lines



Results

2. *B. maritima* purification

300 accessions Morphological selection → 393 plant types



Results

3. Cercospora leaf spot resistance evaluation

a) Sugarbeet lines



S

R



S

R



S

R

Results

3. *Cercospora* leaf spot resistance evaluation

b) *B. maritima*



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R



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R



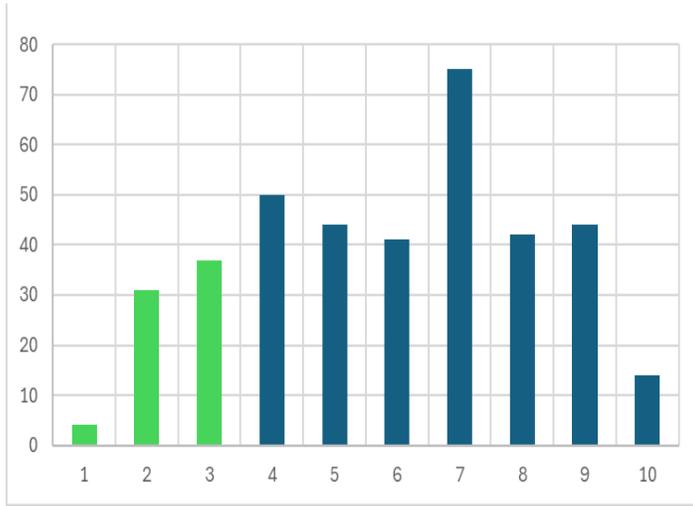
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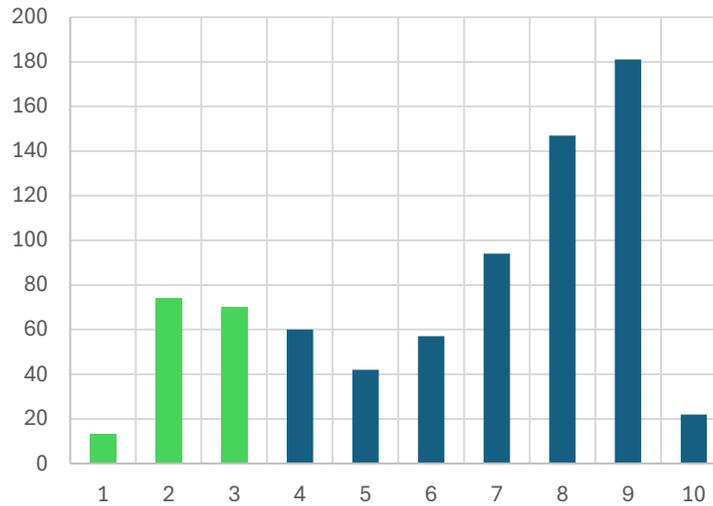
Results

3. Cercospora leaf spot resistance evaluation

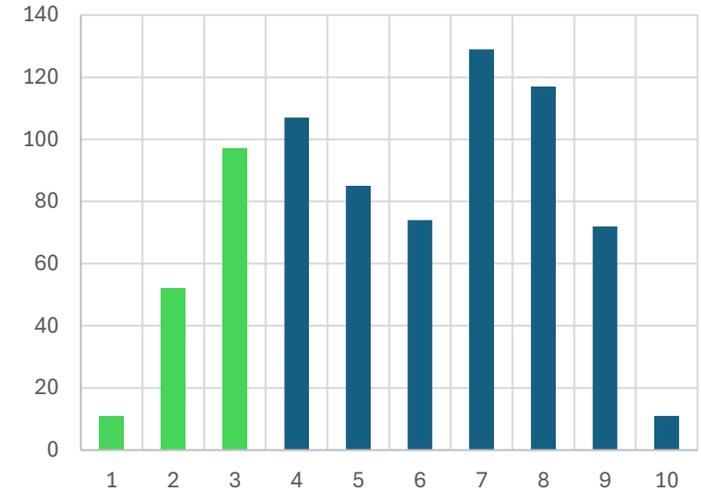
b) *B. maritima*



Fargo 2024



Foxhome 2024



Meadows 2024

53

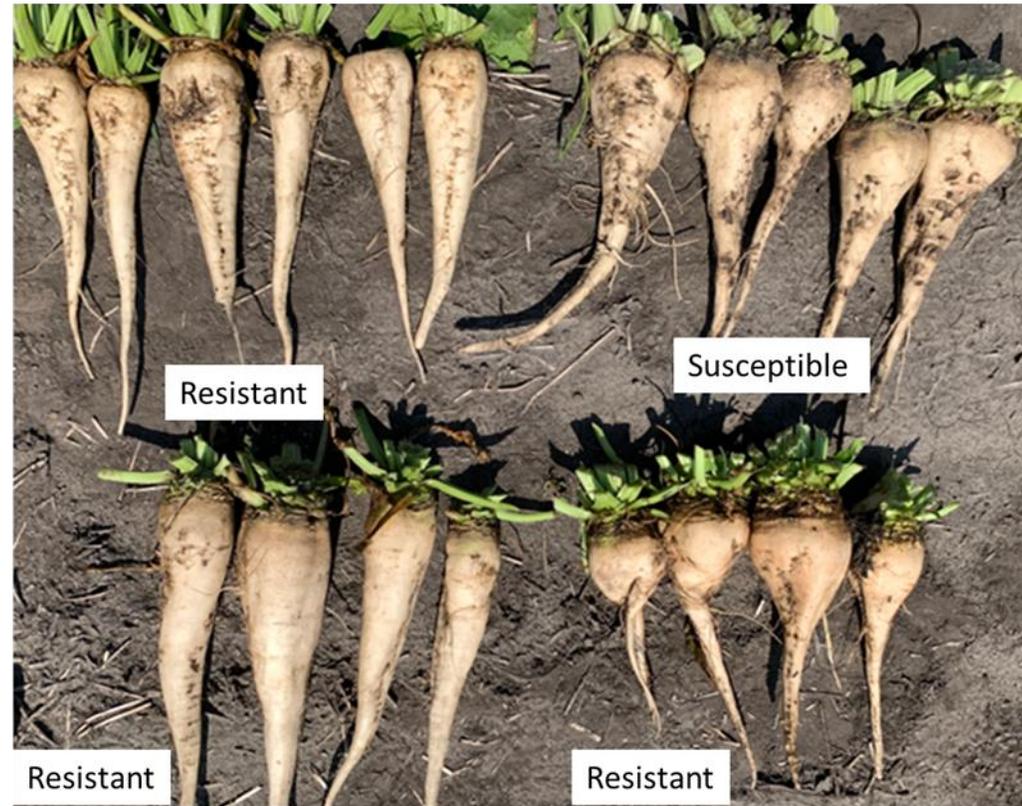
13

Pyramiding resistance from sugarbeet and *B. maritima* will lead to long last resistance.

Results

4. sugarbeet root maggot (SBRM) resistance

a) Sugarbeet lines



Results

4. sugarbeet root maggot (SBRM) resistance

b) *B. maritima*



Susceptible

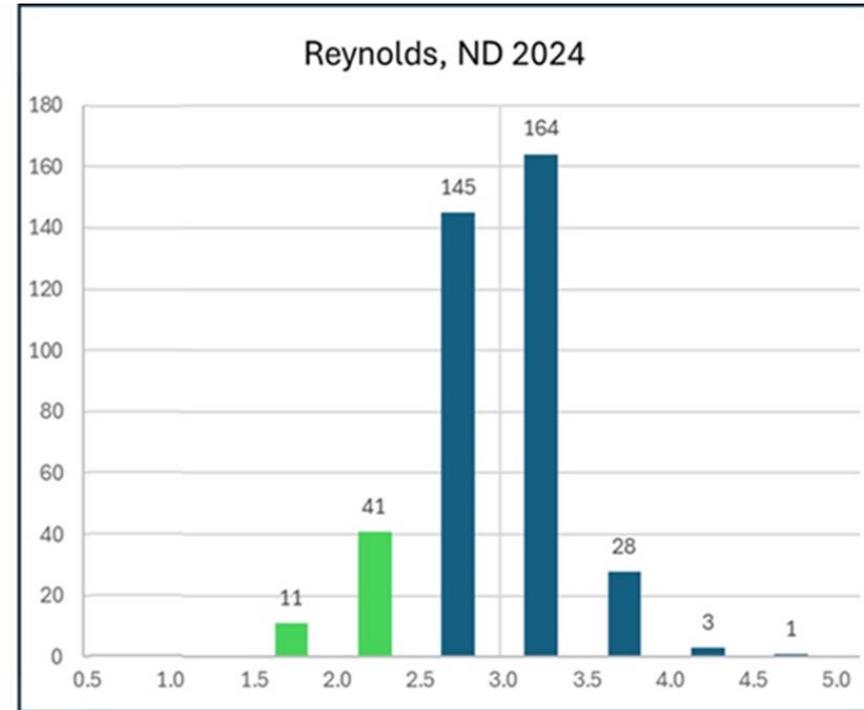
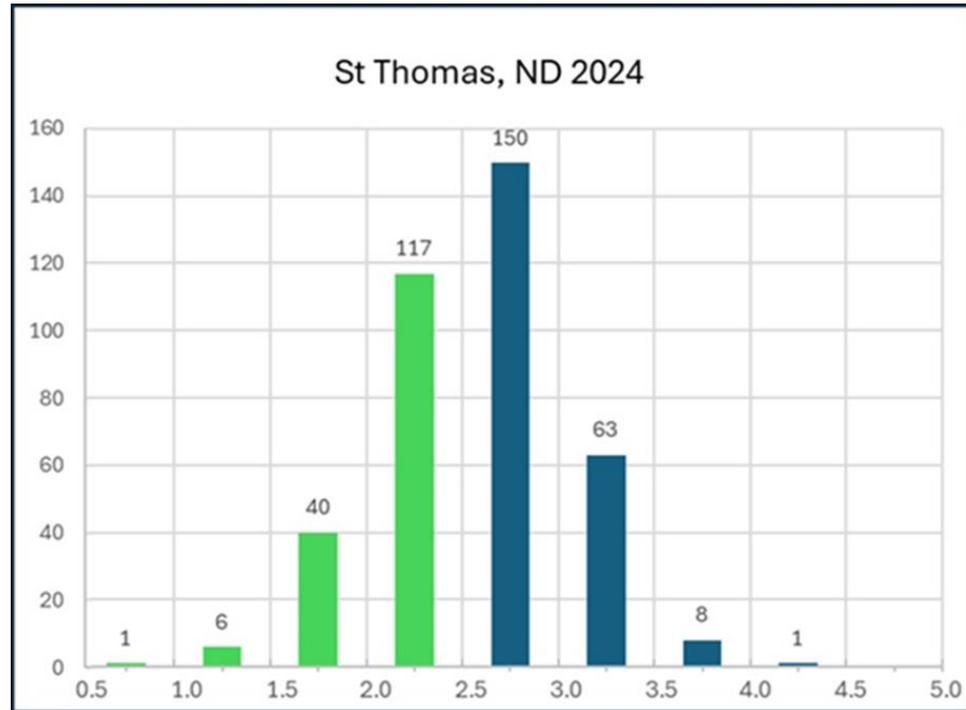


Resistant

Results

4. sugarbeet root maggot (SBRM) resistance

b) *B. maritima*



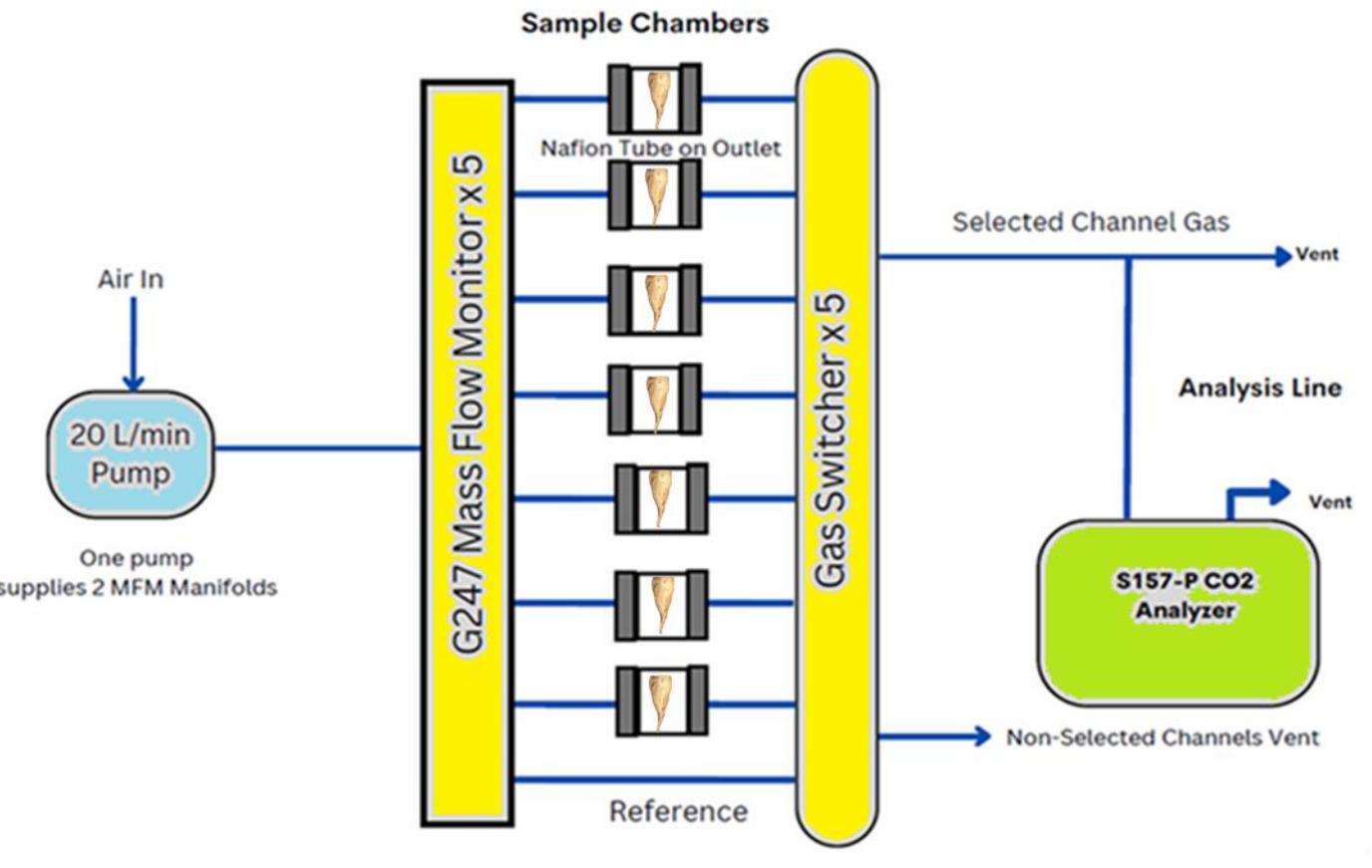
38 in common

Resistance from sugarbeet and *B. maritima* will be combined in future.

Results

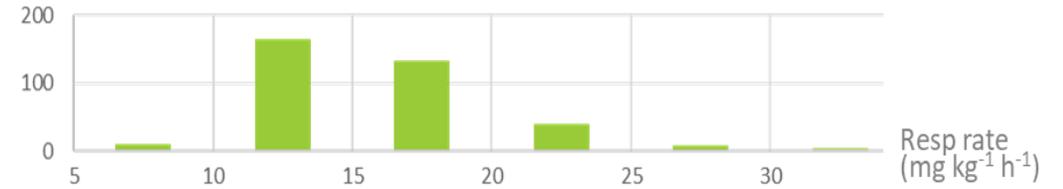
5. cold storage respiration rate in sugarbeet lines

40-Channel Root Respirometry System with S157 CO₂ Analyzer



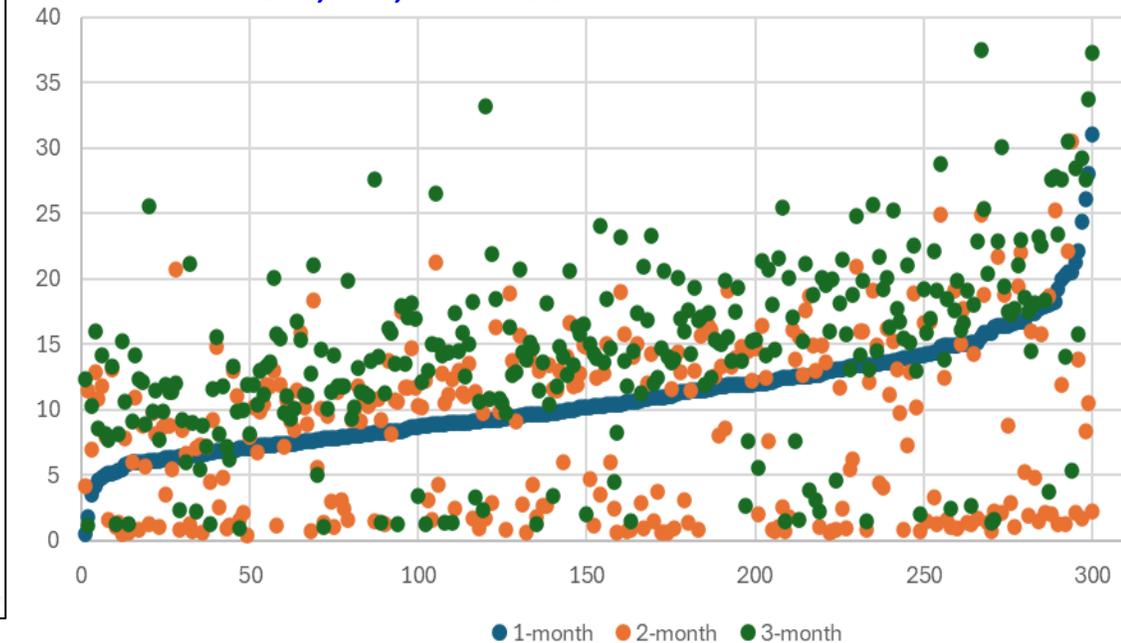
of lines

Tested when root cold stored within a month



Resp rate (mg kg⁻¹ h⁻¹)

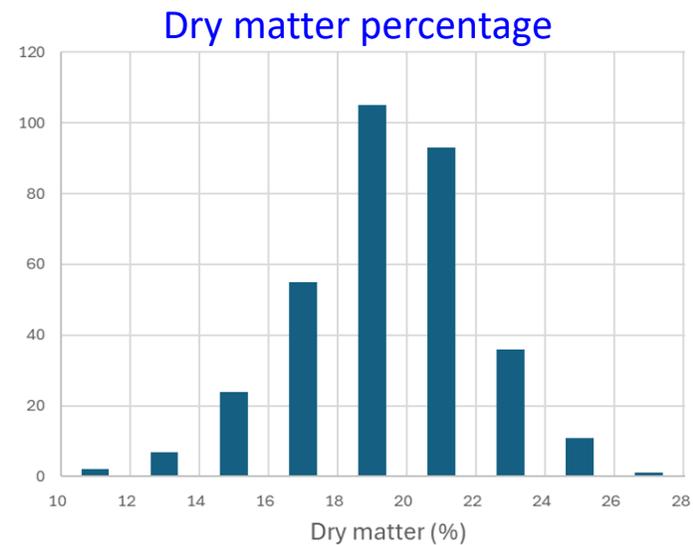
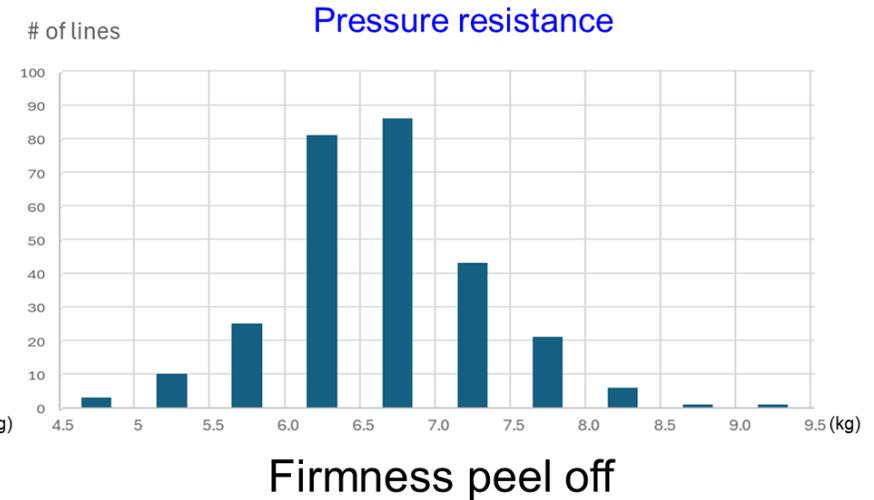
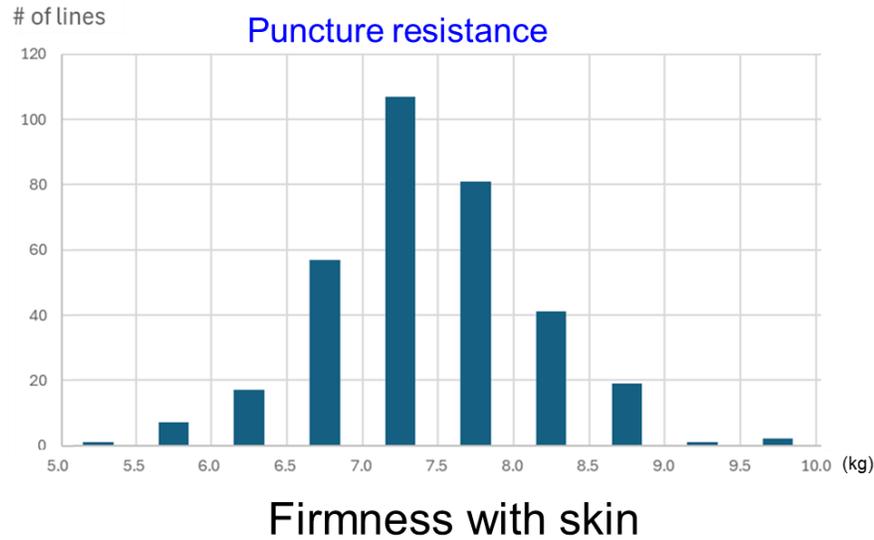
Comparison respiration rate cold stored for one, two, and three months



Results

6. tissue firmness test in sugarbeet lines

Cold stored less than 1 month



Correlations

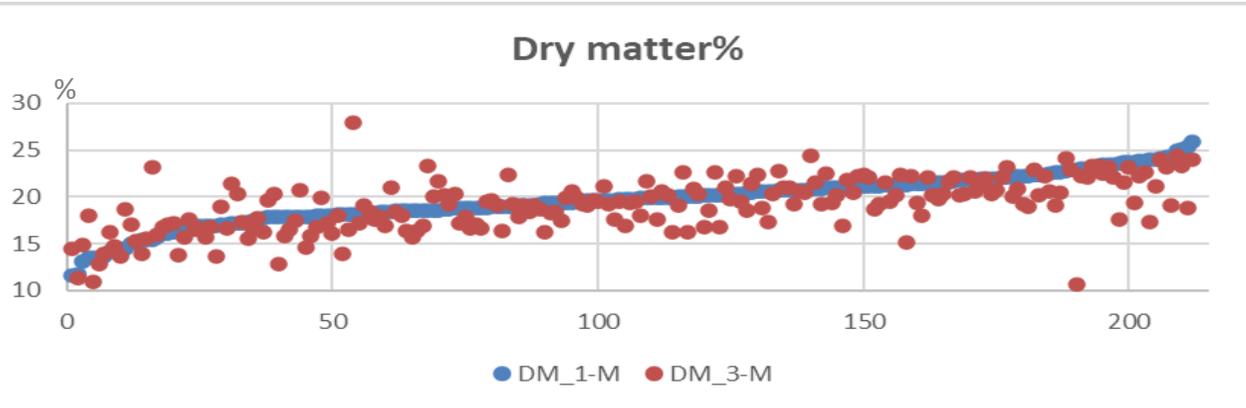
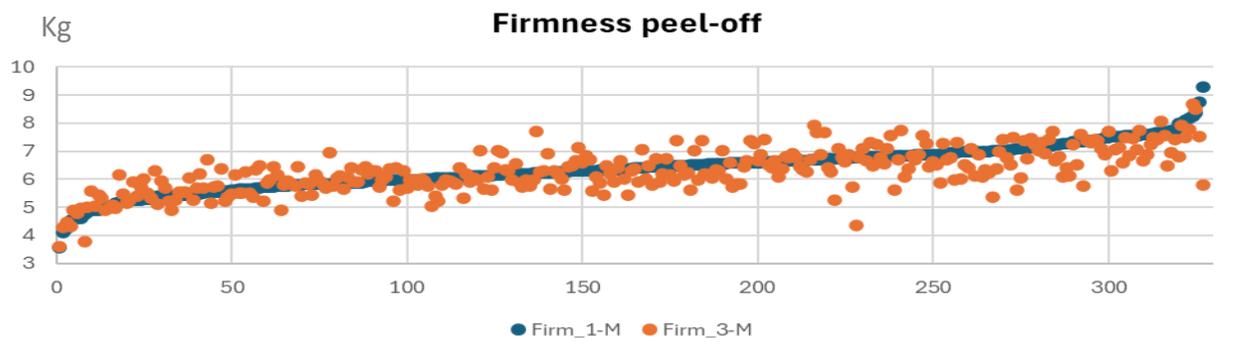
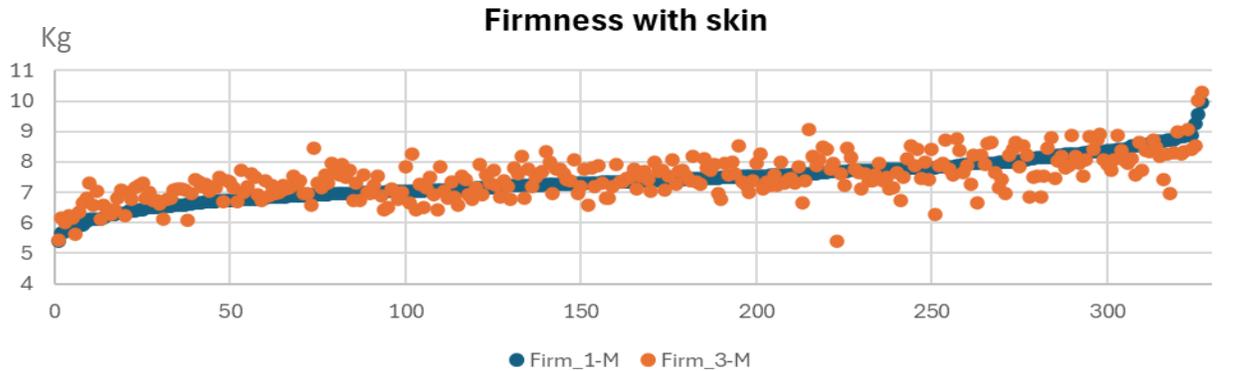
dry matter% ~
firmness with skin $r = 0.52^{***}$

dry matter% ~
firmness with peel-off $r = 0.49^{***}$

Results

6. tissue firmness test in sugarbeet lines

Cold stored
for 3 months



Correlations

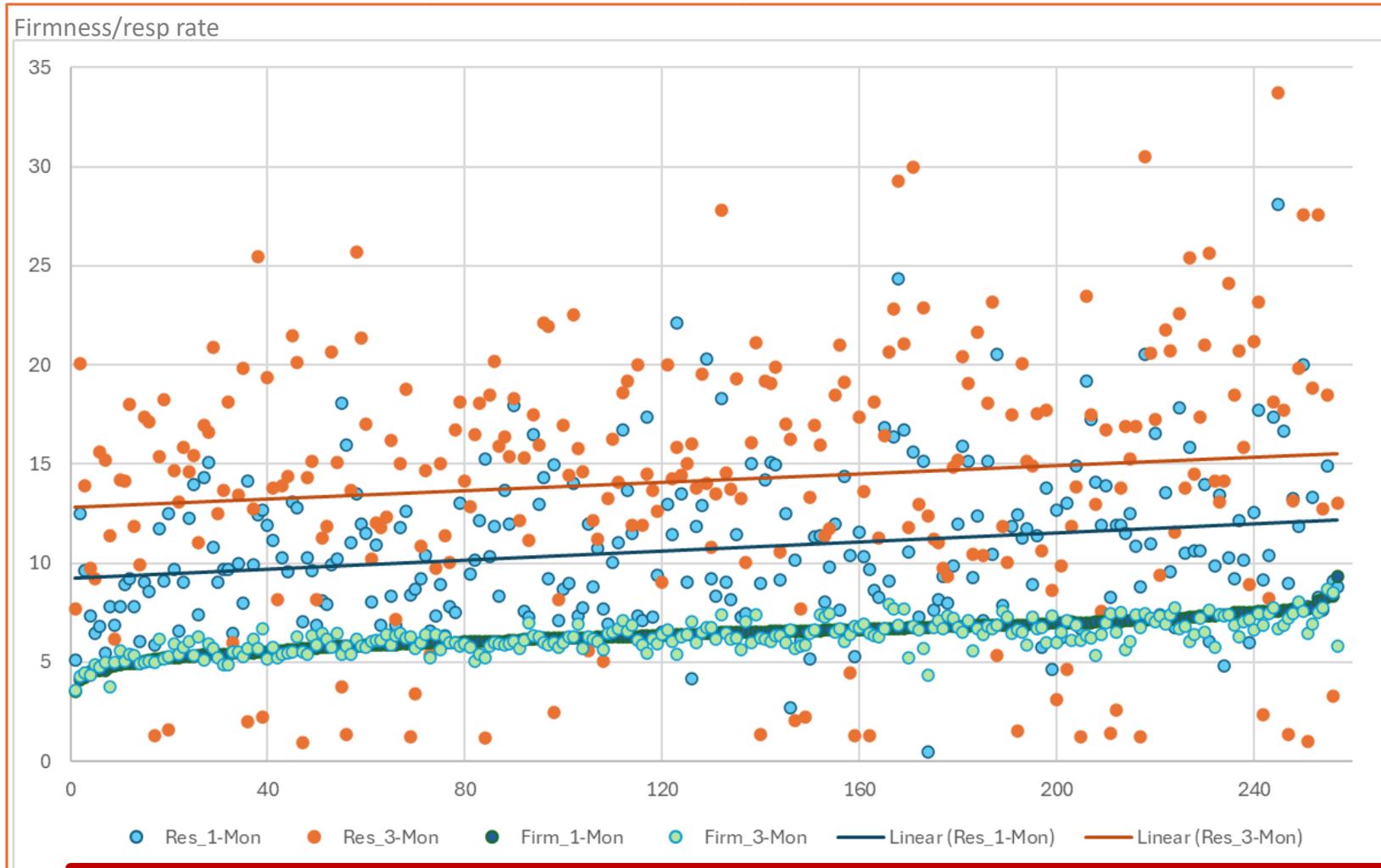
dry matter 1-M ~
firmness 1-M $r = 0.49^{***}$

dry matter 3-M ~
firmness 3-M $r = 0.43^{***}$

Results

6. tissue firmness test in sugarbeet lines

Possible relationship between respiration rate and tissue firmness



Respiration rate comparison

$$\overline{Res_1-M}_{\text{softer}} = 9.4$$
$$\overline{Res_1-M}_{\text{firmer}} = 12.1$$

$$\overline{Res_3-M}_{\text{softer}} = 13.7$$
$$\overline{Res_3-M}_{\text{firmer}} = 17.1$$

Correlations

$$r_{Res_1-M \sim Firm_1-M} = 0.22^*$$

$$r_{Res_3-M \sim Firm_3-M} = 0.16^*$$

Higher dry matter% → High sugar content → Firmer tissue → Higher respiration rate

Conclusions

- Genetic diversity analysis confirmed narrow genetic base in sugarbeet. Identification and application of diverse source of genes is important for sustainable sugarbeet improvement
- Wild sea beet accessions have great potential for bringing new valuable variations into sugarbeet
- Pyramiding resistance genes from different sources will lead to enhanced pest resistance
- Understanding sugarbeet root respiration rate and tissue firmness during cold storage will give us new breeding ideas to reduce post-harvest sugar loss
- Ongoing GWAS studies will identify genes associated with beneficial genes as well as develop markers for marker-assisted trait introgression

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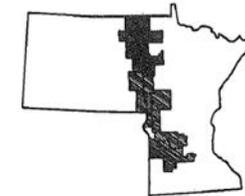
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Sustainable Sugar Beet Research Initiative



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Thank you!

chenggen.chu@usda.gov