

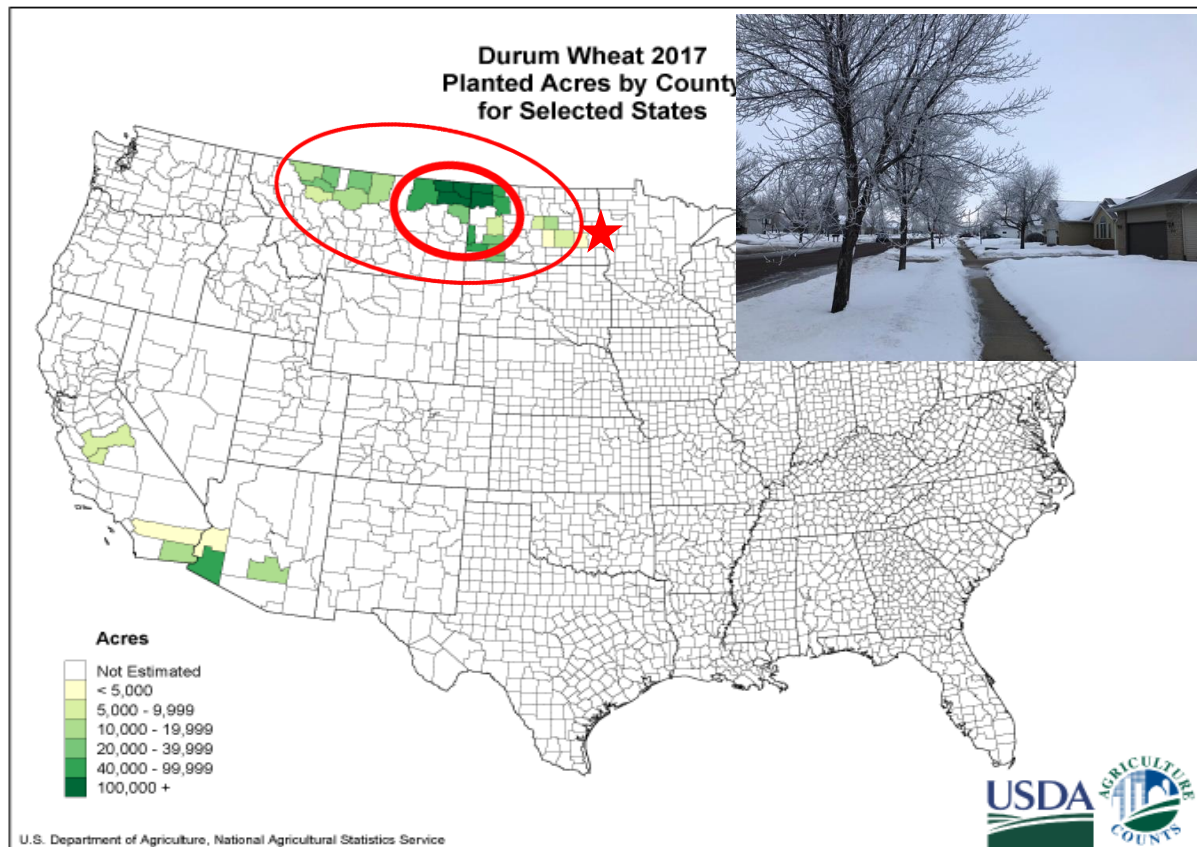
Genomic selection of grain yield and quality traits in the NDSU durum wheat breeding program

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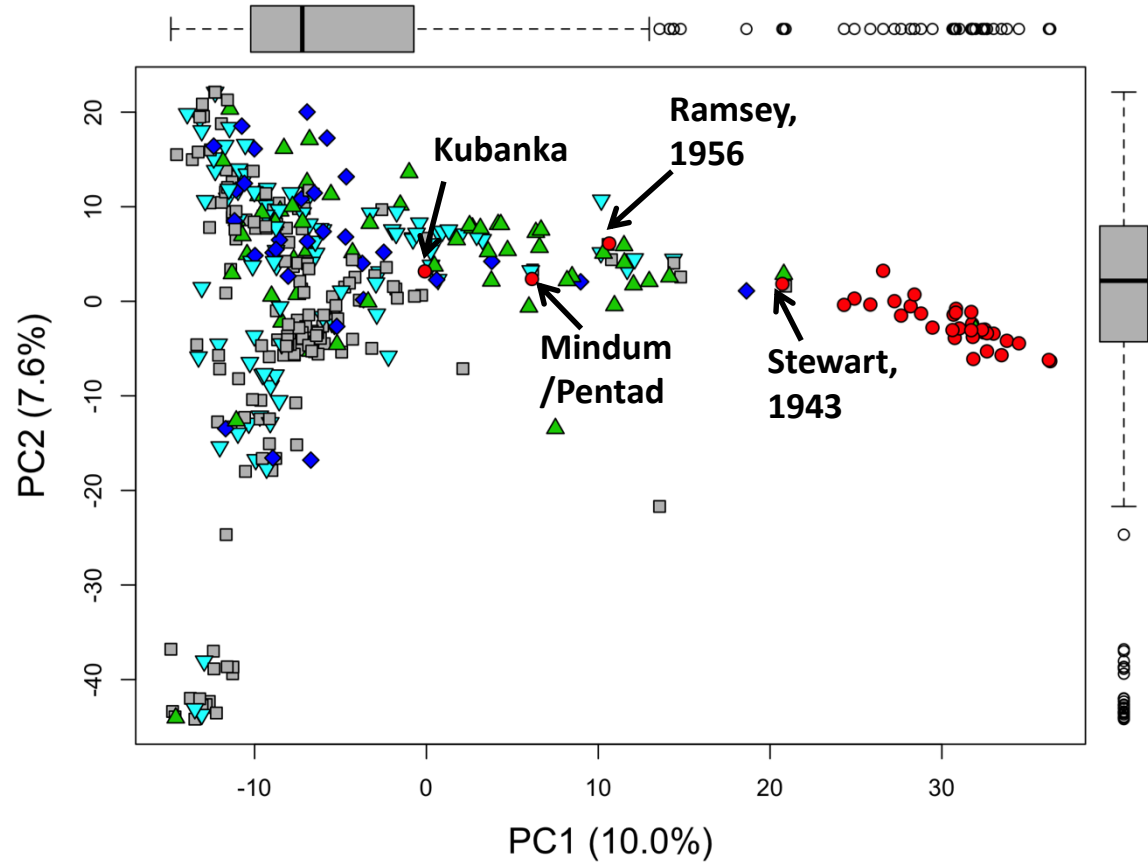
Durum wheat in Northern Great Plains, US

- ~1.5 million acres
- Rain fed, precipitation of 12-18 inches
- Over 90% acres planting the NDSU cultivars



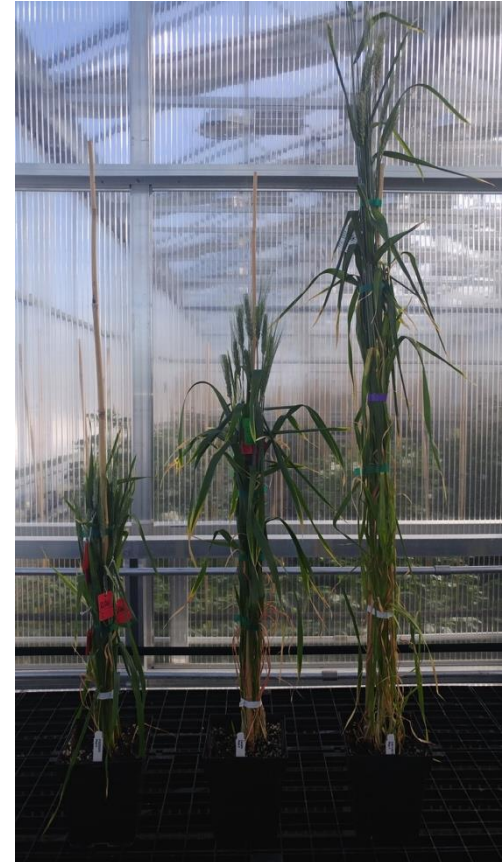
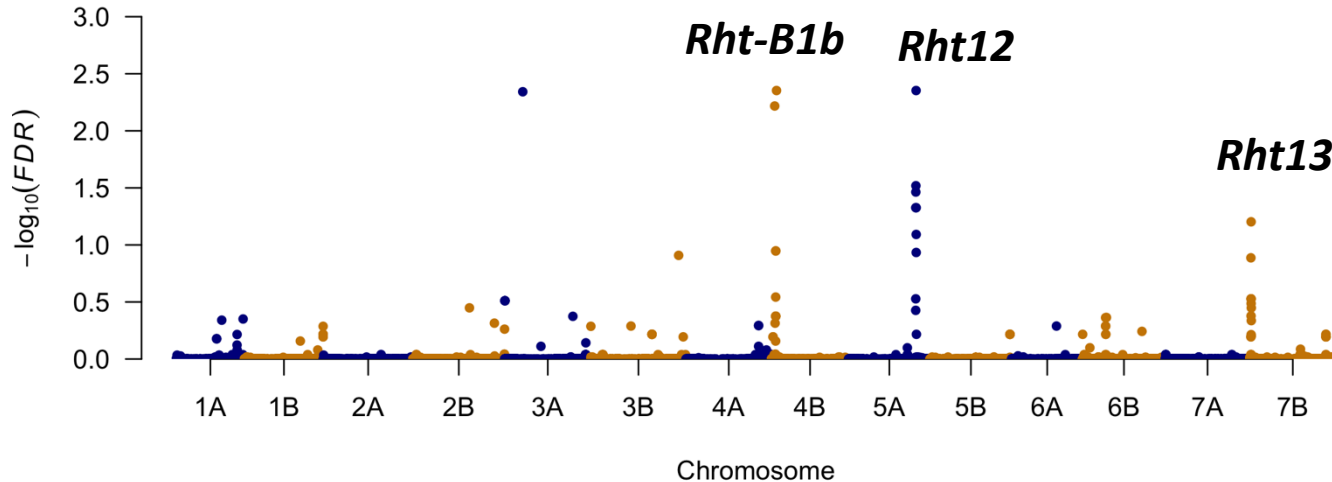
NDSU durum wheat breeding program

- Established in 1929 with a few landraces and breeding lines mainly from Russia
- ~90 years breeding selection made the NDSU durum breeding germplasm unique and with relatively narrow diversity



Breeding effort on plant height

- *Rht12* and *Rht13* were fixed in the NDSU durum wheat breeding pool, plant height 95-120cm
- The favorable alleles from an Australia cultivar “Heiti” introduced in 1940s (Joppa and Williams, 1988)



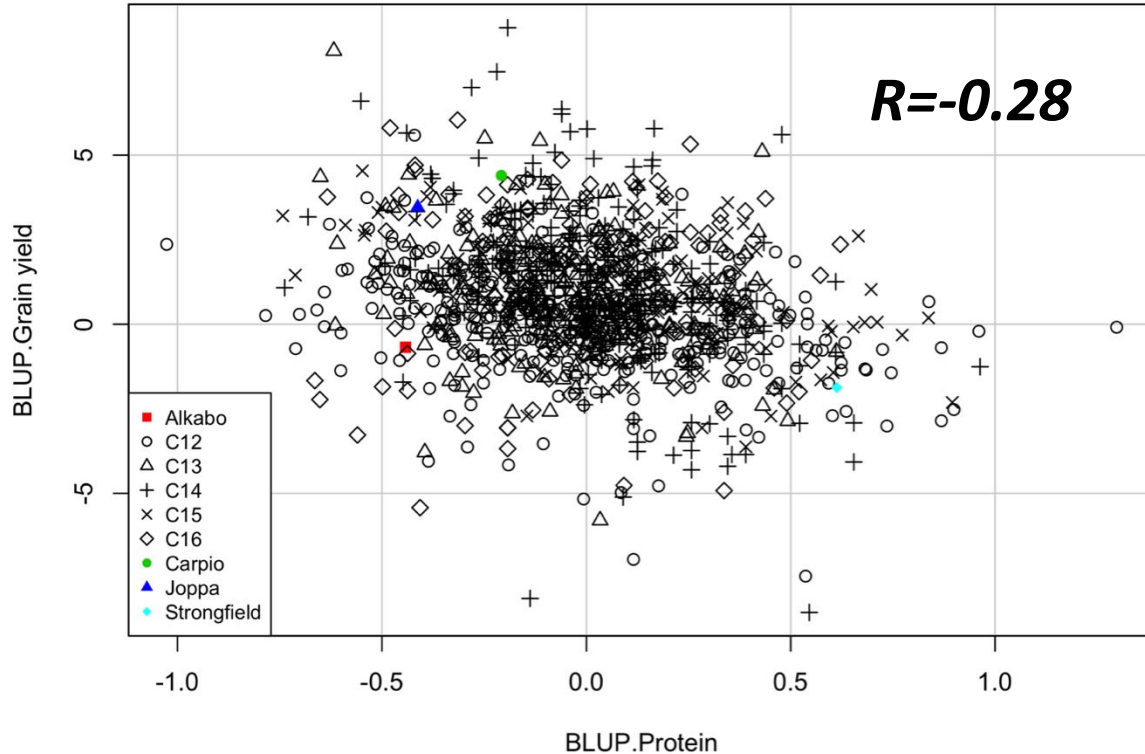
Breeding efforts on disease resistances and quality traits

- The current NDSU durum germplasm are highly resistant to stem rust
 - *Sr9e* from “Vernal emmer” in 1940s (Joppa and Williams, 1988)
 - *Sr7a*, *Sr13*, and *Sr14* from “Khapli emmer” in 1950s (Joppa and Williams, 1988)
- Good resistance to tan spot
- “Heiti” was also used to improve spaghetti color
- Improvement of gluten strength in 1970s

Current major breeding goal

- Higher grain yield without loss of quality, disease resistance, and other agronomic traits

Negative correlation between grain yield and protein



Utilize new germplasm to improve grain yield

~250 worldwide collection lines evaluated with four-row plots at Williston, ND in 2017



Genomic selection to more efficient breeding

- Phenotypic selection on grain yield and quality, no more than 1,500 lines in F_6 and later generations
 - Due to high cost of phenotypic testing
 - Grain yield: \$15 per 4-row plot
 - Quality traits: \$63 per sample
- Genomic selection to pre-select promising lines from larger population at early generations (e.g., 10,000 F_4 lines) into yield trials, higher chance to develop a new cultivar with higher grain yield

Parents	30	Greenhouse
F_1	300	Greenhouse
F_2	600,000	ND
F_3	30,000	ND or Winter nursery
F_4	10,000	ND
F_5	3,000	

F_6 (PYT)	1,500	ND, Yield
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F_7 (AYT)	200	ND, Yield/Quality
F_8 (EYT)	60	ND, Yield/Quality
URYT	30	ND, Yield/Quality



Cultivar	<3	
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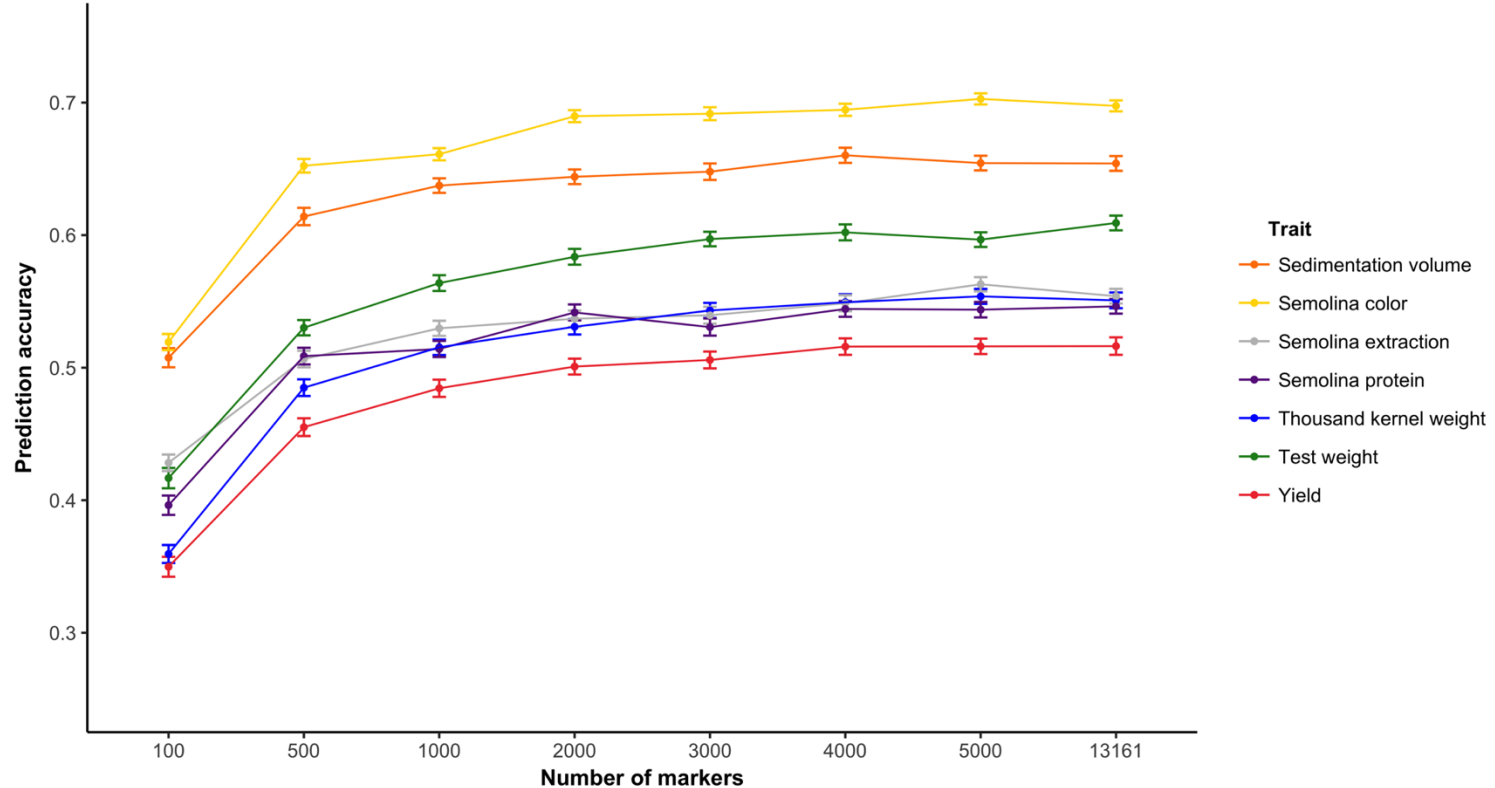
Training population to develop genomic prediction models

- 1,413 lines from 2012-17 AYT, 180-300 each AYT
- Phenotypic data
 - Grain yield from PYT, AYT, EDA, and URDN at three locations, ND
 - Grain and semolina quality traits including gluten strength, semolina extraction, semolina protein, semolina color, and test weight from AYT, EDA, and URDN
- 13,161 SNP markers via GBS

Genomic prediction accuracies, $r(GEBVs, Obs)$

Trait	Cross-validation	Predict 2012	Predict 2013	Predict 2014	Predict 2015	Predict 2016	Predict 2017
Grain yield	0.51	0.18	0.52	0.50	0.39	0.51	0.19
Semolina protein	0.55	0.36	0.36	0.30	0.44	0.55	0.58
Semolina extraction	0.55	0.24	0.28	0.53	0.53	0.52	0.30
Semolina color	0.70	0.62	0.42	0.60	0.59	0.62	0.65
Gluten strength	0.65	0.59	0.81	0.44	0.56	0.75	0.43
Test weight	0.61	0.42	0.33	0.43	0.51	0.48	0.38

2,000-5,000 markers are good enough to predict breeding values for all traits



Application and updating of the current GS models

- Amplicon-GBS to genotype (2,000-5,000 markers, \$6/sample)
 - 2,000 2017 F₅ lines
 - 2,000 2018 F₅ lines
- Update the GS models for grain yield and protein content
 - Grain yield data will be collected from PYTs and AYT_s in 2018-2019
 - Protein content of all the 4,000 F₅ lines will be evaluated using near infrared reflectance
- Low-cost genotyping to apply genomic selection in over 10,000 F₄ lines

Male-sterile facilitated recurrent genomic selection to speed up breeding population improvement

C_x : GS to select
best 100 from
1,000 F_1 plants

Best 10 F_1 plants:
Single-Seed Descent

Recurrent selection
population:
Ms3-Carpio to cross
20 elite cultivars and
breeding lines

C_{x+1} : GS to select
best 100 from
1,000 F_1 plants

Update GS models

Parents	30
F_1	300
F_2	600,000
F_3	30,000
F_4	10,000
F_5	3,000

Greenhouse

Greenhouse

ND

**ND or Winter
nursery**

ND

F_6 (PYT)	1,500	ND, Yield
F_7 (AYT)	200	ND, Yield/Quality
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URYT	30	ND, Yield/Quality

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 - Yuan Liu (Germplasm evaluation)