Participatory Breeding and Testing Networks: A Maize Based Case Study for Organic Systems

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USDA
United States Department of Agriculture
National Institute of Food and Agriculture

Outline

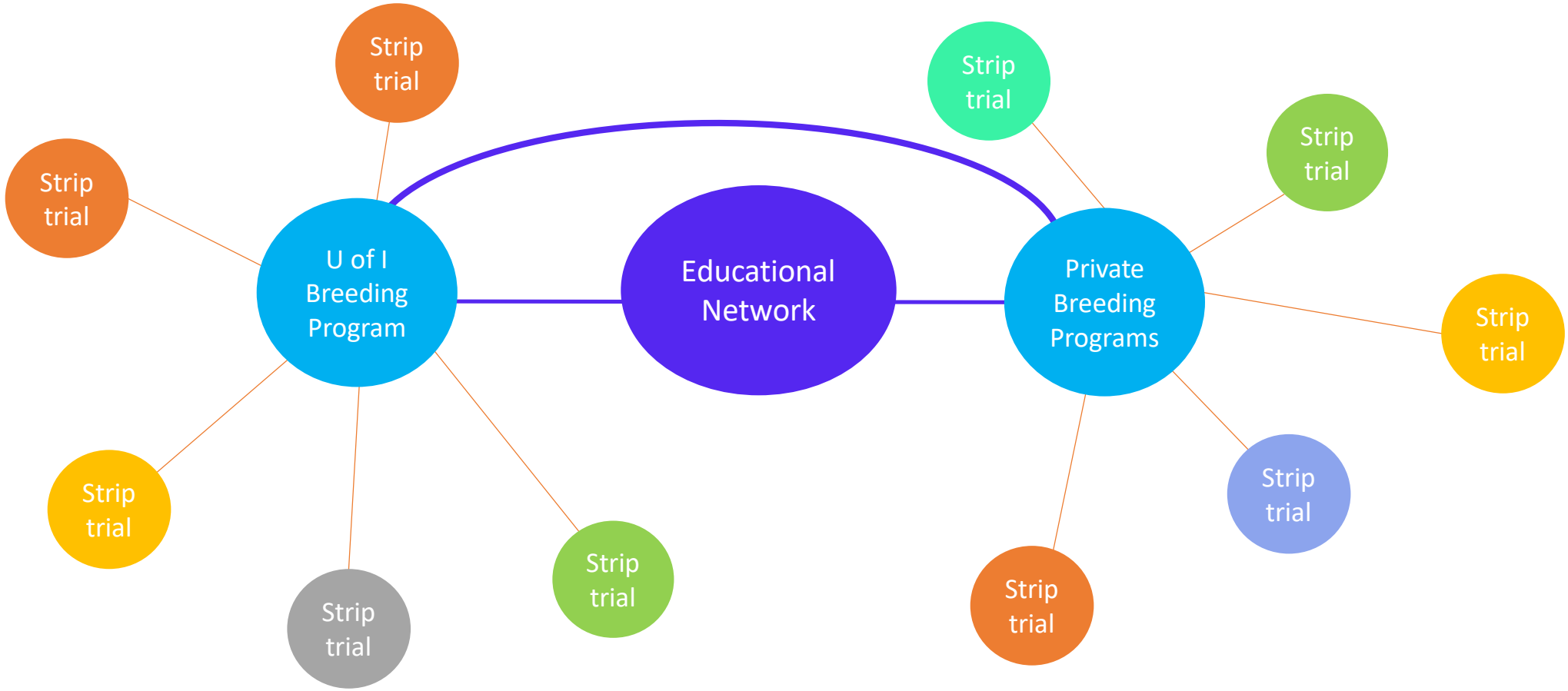
- Identified needs in the organic sector – Where my seed comes from?
- The CASH project
- Participatory testing network—on-farm strip trials
- Participatory testing network—on-farm replicated trials

Challenges

- Greater percentage of germplasm comes from conventional breeding programs under high input conditions
- The growing environment in organically managed systems is inherently more diverse
- Seed currently being used, is produced using organic guidelines, but the germplasm was generally developed in more homogenous environments

Luby et al. 2018

Participatory Breeding & Testing Network



Corn And Soil Health = CASH!

Participatory Network

Facilitate the exchange of needs/wants among producers, researchers, seed producers, and end users.

On-Farm Testing and Replicated trials

Screen materials for organic growing conditions.

Study weed and nutrient interactions with plant and soil health.

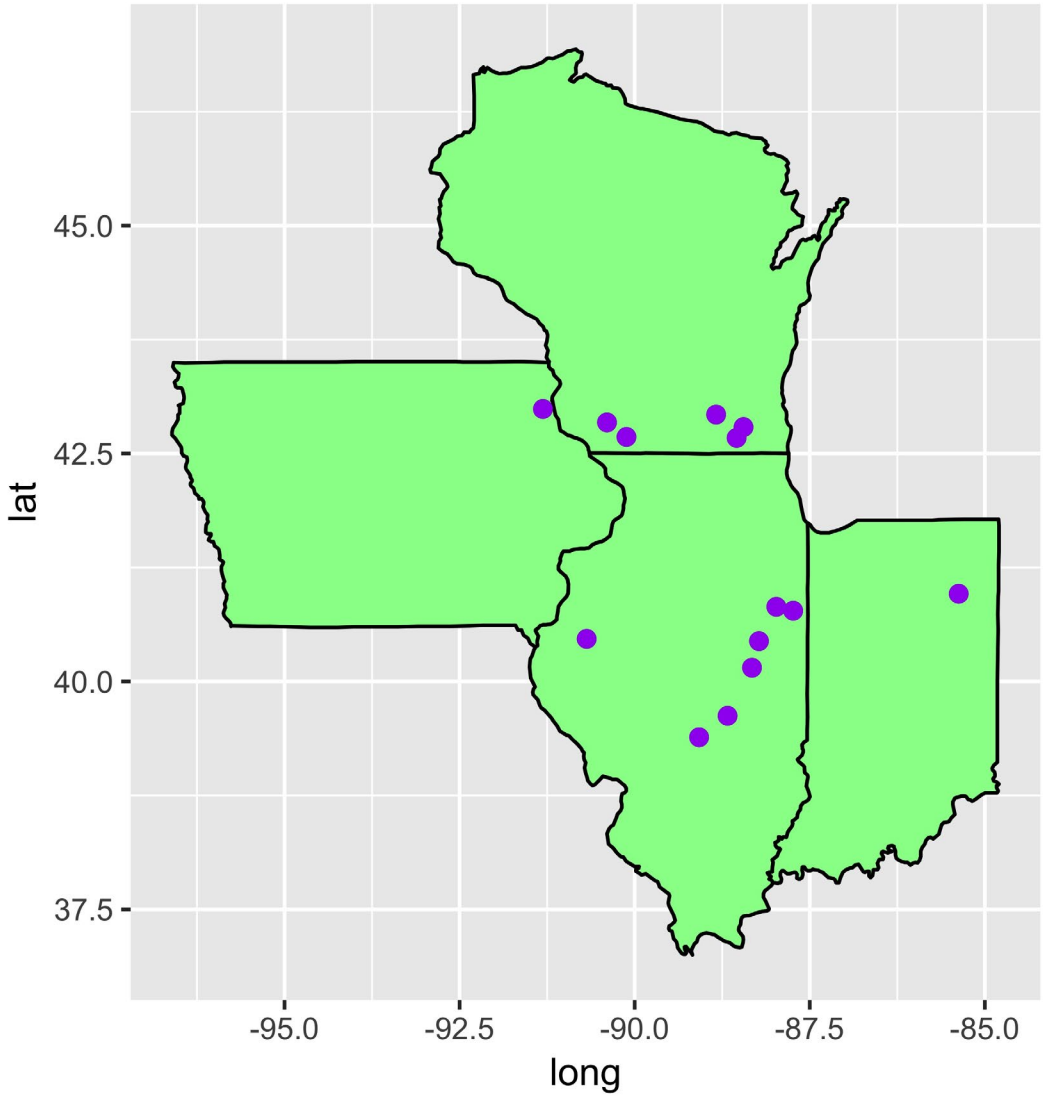
Business structure, sharing, and IP

Study business models, intellectual property, germplasm sharing structures that determine seed access.

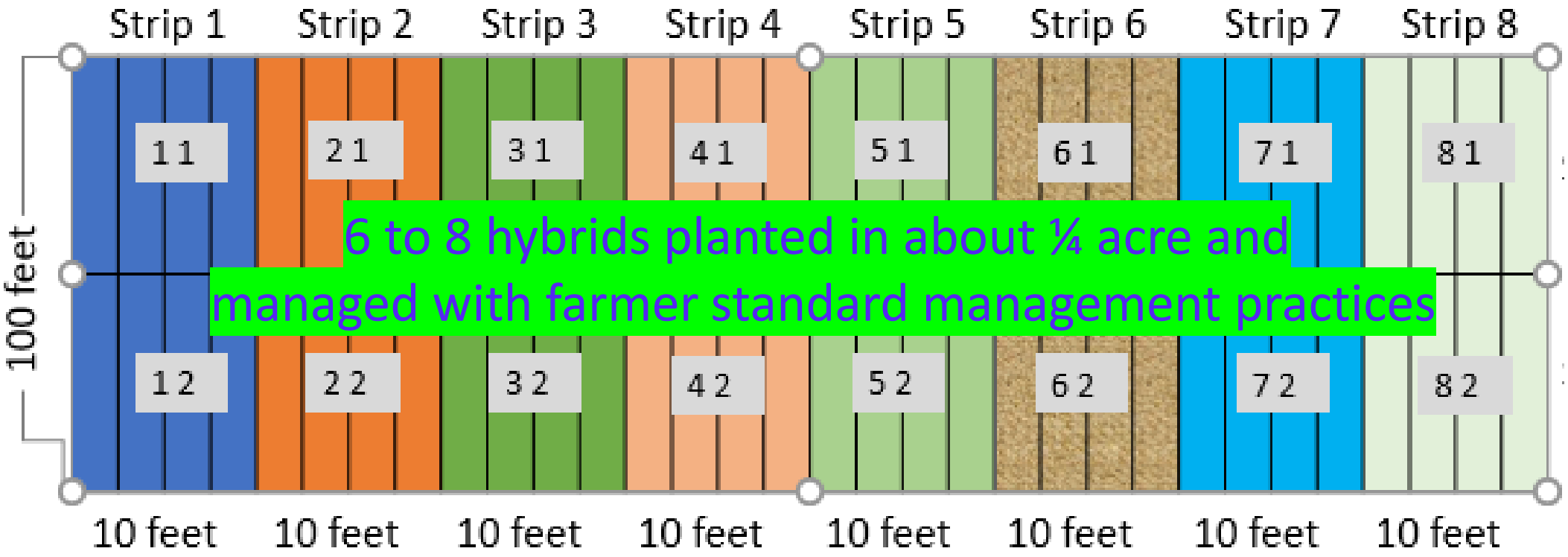
Why Strip Trials?

- Strip trials provide “real world” growing conditions
- To gather information about corn varieties of interest that have been identified by breeders in the network
  - Agronomic performance
  - Quality traits
- The information from the testing and educational networks is reported back to the breeders
  - Determine the future market potential of the tested corn varieties and,
  - Orient future breeding efforts (seed supply for the organic sector)

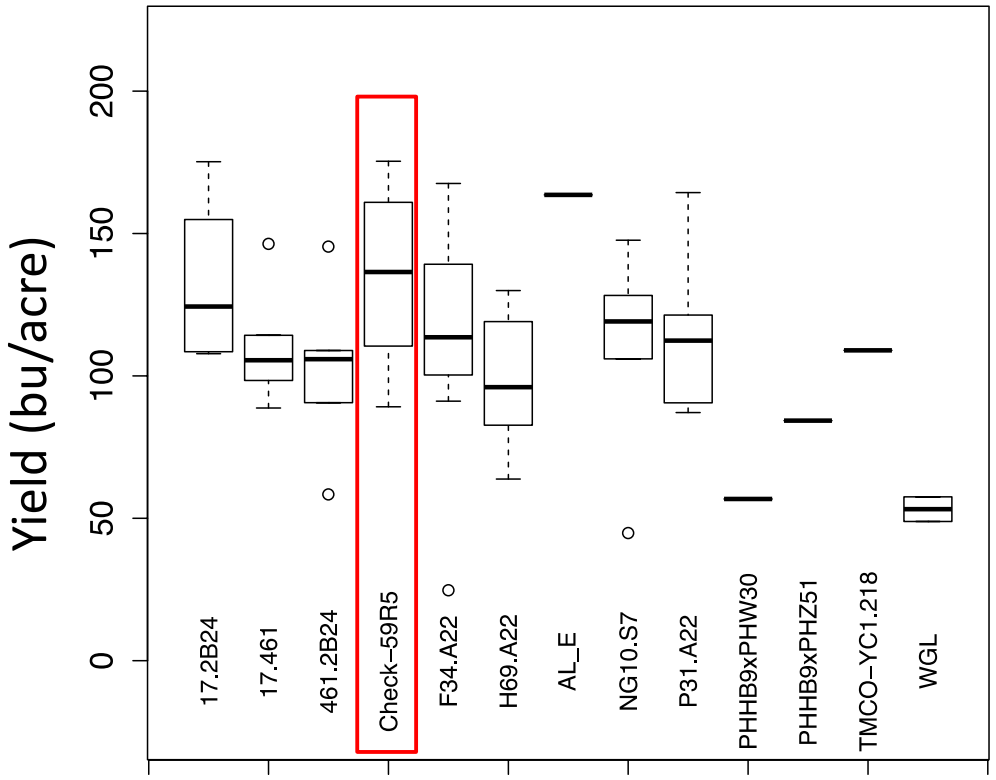
Strip Trials



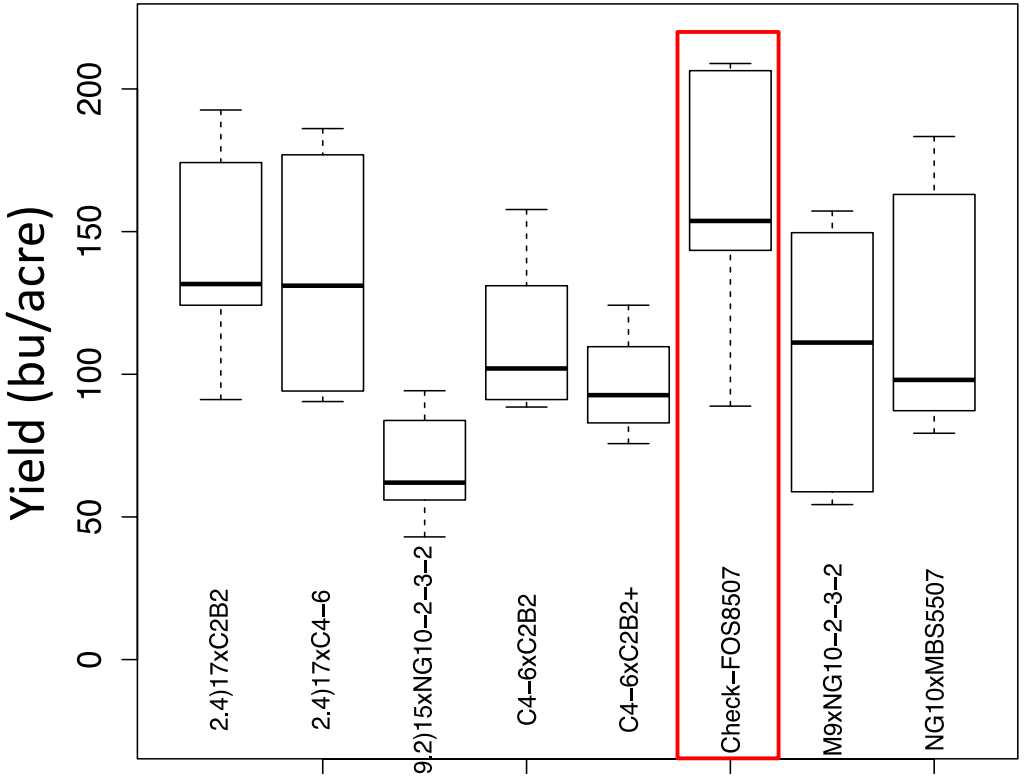
- 2018 offered 15 cultivars selected from the U of I collection and 2 private breeding programs
  - Food grade quality
  - High protein (methionine)
  - N efficiency
  - Good agronomic characteristics


Strip 1
Strip 2
Strip 3
Strip 4
Strip 5
Strip 6
Strip 7
Strip 8
11
21
31
41
51
61
71
81
12
22
32
42
52
62
72
82
100 feet
6 to 8 hybrids planted in about ¼ acre and
managed with farmer standard management practices
10 feet
10 feet
10 feet
10 feet
10 feet
10 feet
10 feet
10 feet

Hybrid Performance Across Locations

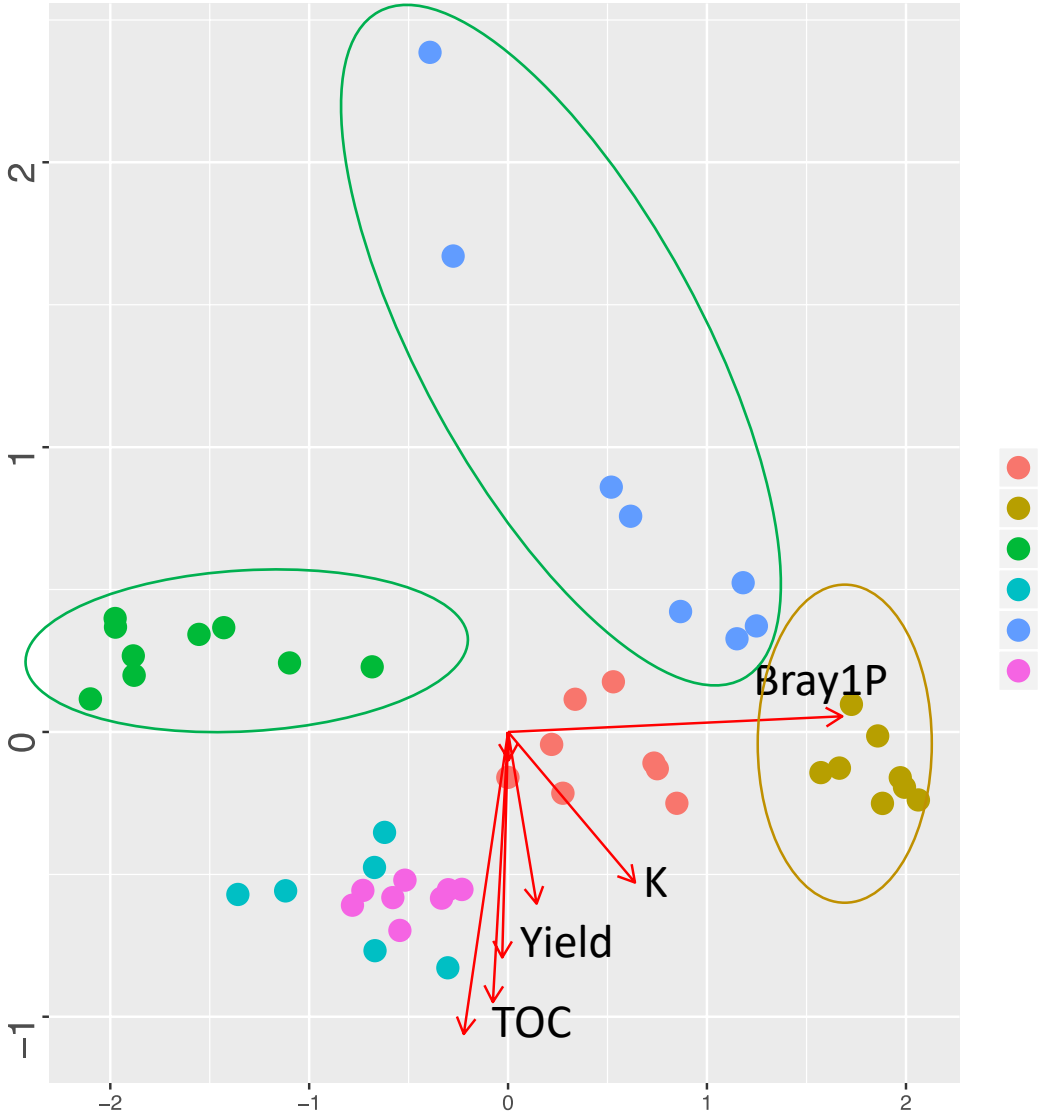


Illinois and Indiana

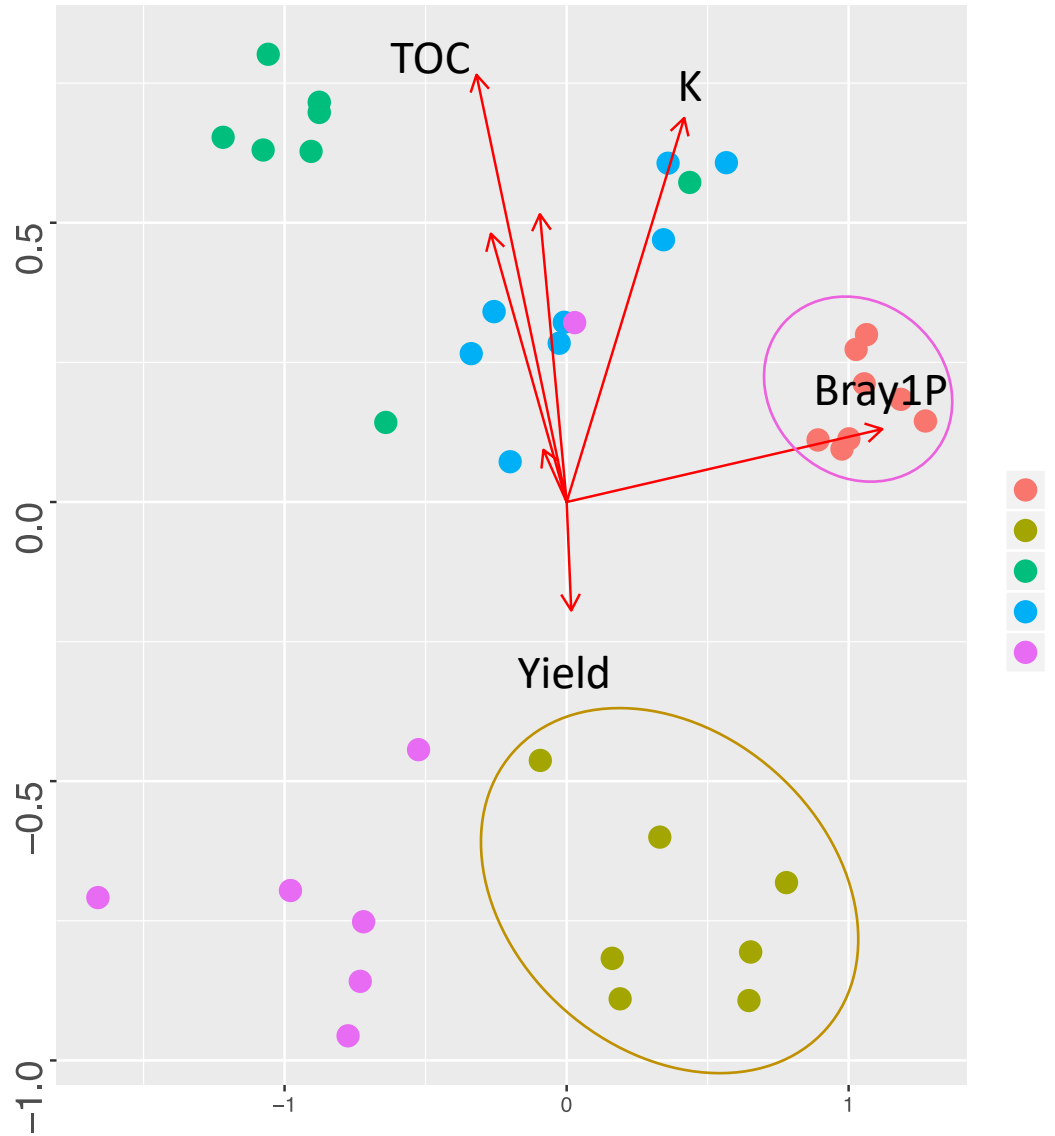


Iowa and Wisconsin

Illinois & Indiana



Wisconsin & Iowa

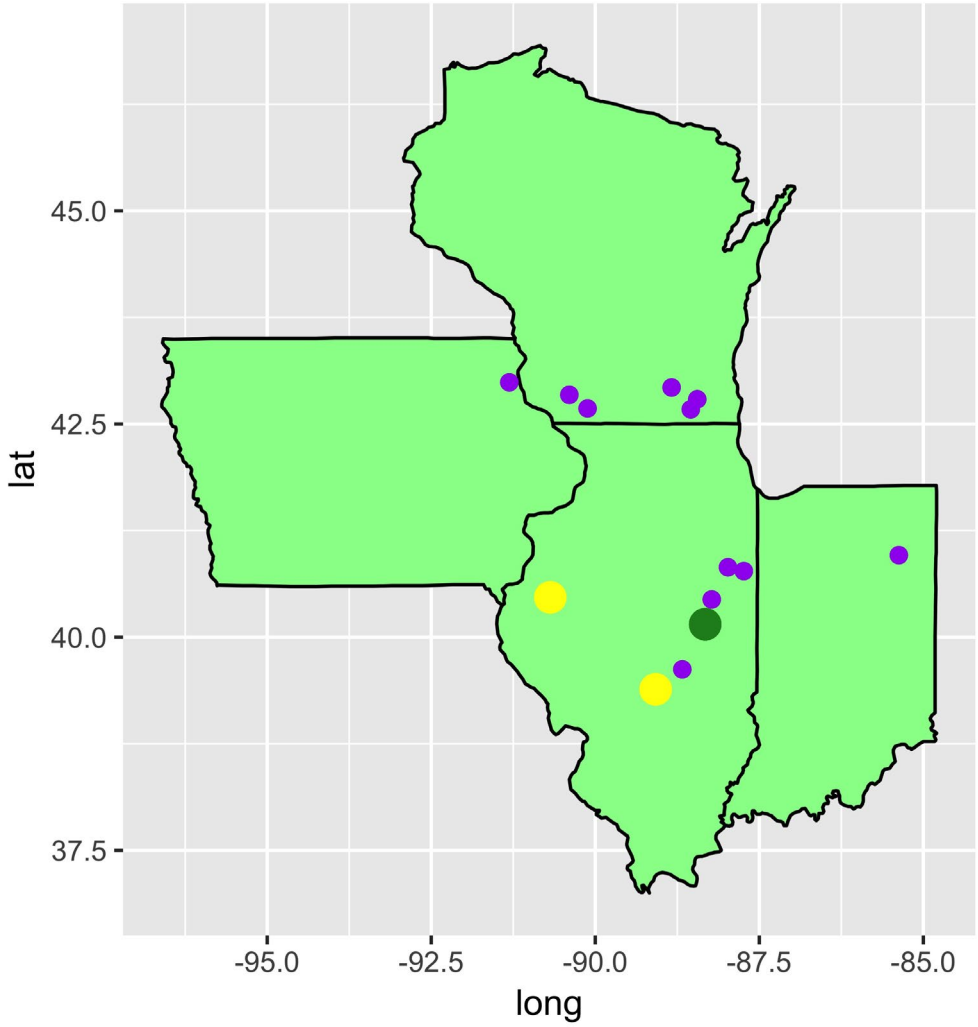


2018 Strip Trial Summary

- Sites had great variability in standard soil quality characteristics
- Across locations there were moderate to high yielding varieties
- Soils with improved levels of soil fertility had more stable yields
- Greater variability in yield performance was apparent in sandy soils
- Support the theory that ‘environment’ and soil quality characteristics should inform selection and testing of cultivars

Replicated Trials

- Investigate how corn cultivars respond to gradients of soil fertility and weed pressure
- Explore the effects of soil type and management on plant performance and soil health



Treatments

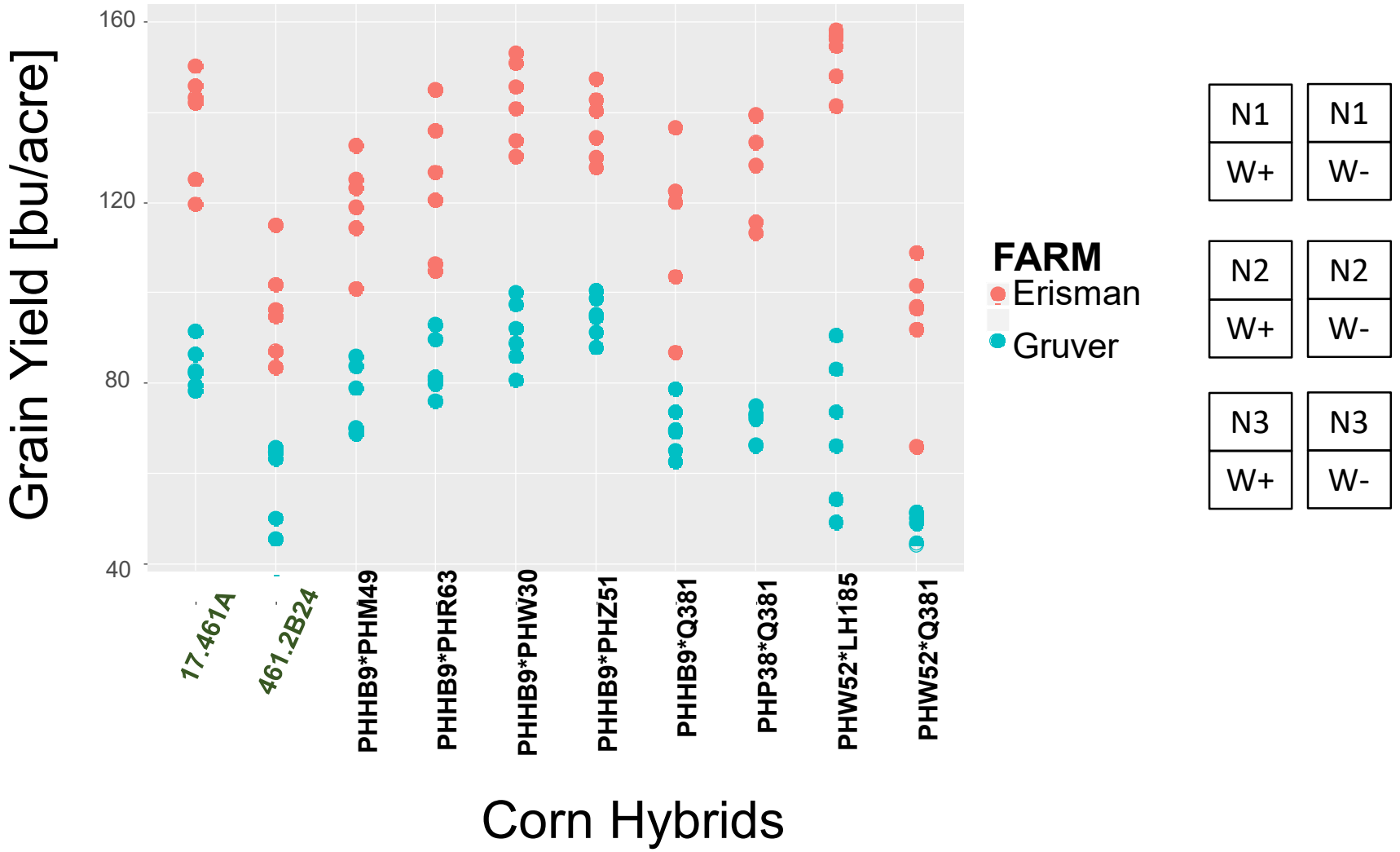
Replicated trial	Rep	CC trt	N trt										
	4	CC	N1		5	9	7	4	1	10	8	6	2	3
		noCC	N1		5	9	7	4	1	10	8	6	2	3
		CC	N3		5	10	3	8	9	2	7	1	4	6
		noCC	N3		5	10	3	8	9	2	7	1	4	6
		noCC	N2		8	3	4	5	2	9	1	6	7	10
		CC	N2		8	3	4	5	2	9	1	6	7	10
	3	CC	N3		3	5	8	6	4	1	10	9	7	2
		noCC	N3		3	5	8	6	4	1	10	9	7	2
		cc	N1		1	6	10	7	3	2	8	4	9	5
		noCC	N1		1	6	10	7	3	2	8	4	9	5
		noCC	N2		1	10	9	2	5	7	8	6	3	4
		CC	N2		1	10	9	2	5	7	8	6	3	4
	2	noCC	N2		8	10	5	6	3	1	4	7	2	9
		CC trt	N2		8	10	5	6	3	1	4	7	2	9
		noCC	N3		1	9	3	6	2	4	10	8	7	5
		CC	N3		1	9	3	6	2	4	10	8	7	5
		CC trt	N1		10	5	1	9	3	4	2	7	6	8
		noCC	N1		10	5	1	9	3	4	2	7	6	8
	1	CC	N3		5	6	3	8	1	2	10	7	4	9
		noCC	N3		5	6	3	8	1	2	10	7	4	9
		noCC	N1		9	4	10	7	6	2	5	1	3	8
		CC	N1		9	4	10	7	6	2	5	1	3	8
		CC	N2		4	3	10	7	6	5	8	2	1	9
		noCC	N2		4	3	10	7	6	5	8	2	1	9

4 row corn buffer

4 row corn buffer

- Nitrogen rates
  - O lbs N (N1)
  - 100 lbs N (N2)
  - 200 lbs N (N3)
- 10 corn cultivars
- Weeded pressure
  - No weed (W-)
  - Surrogate weed (W+)

OREI – Replicated Experiment Trial 2018



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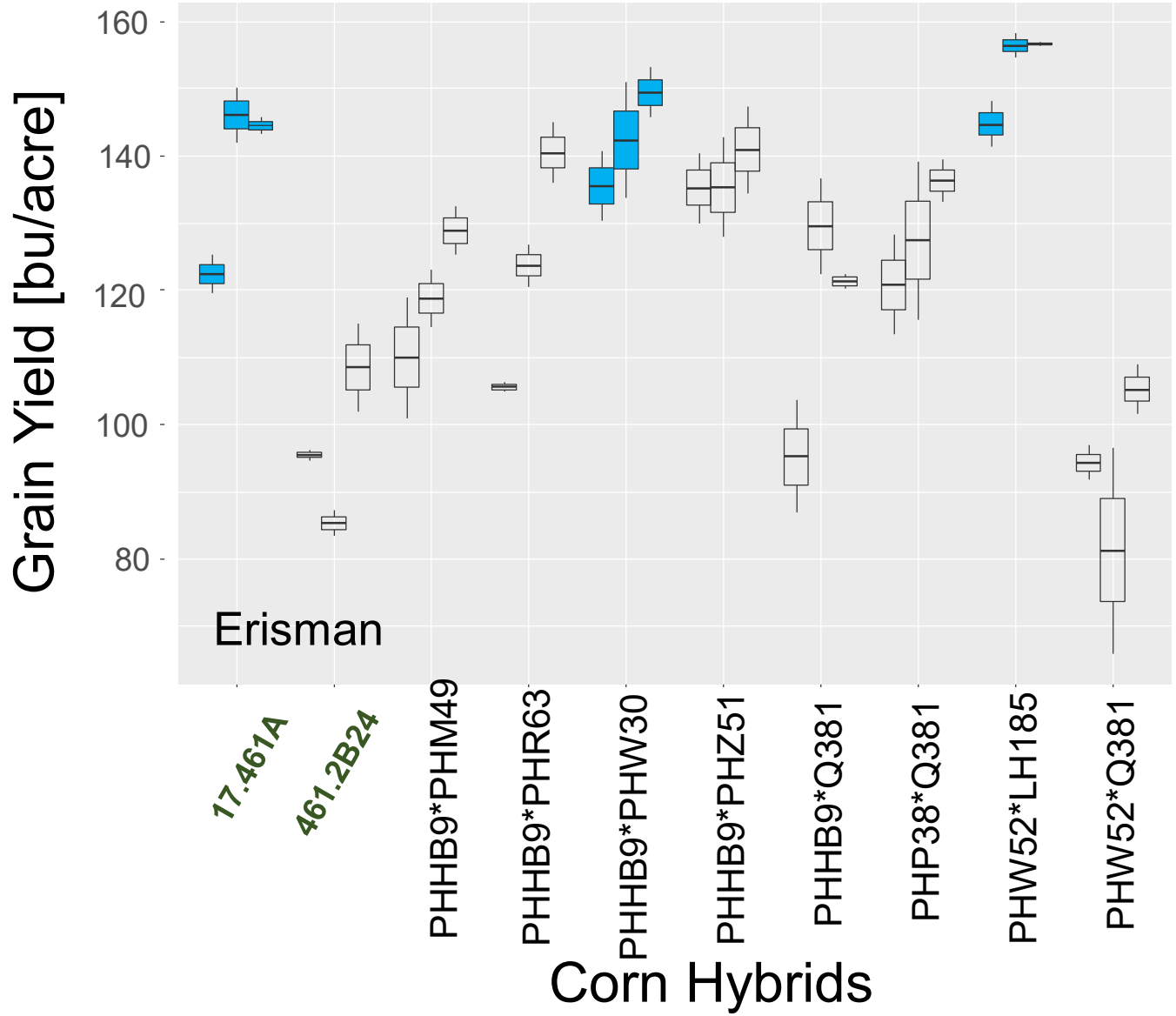
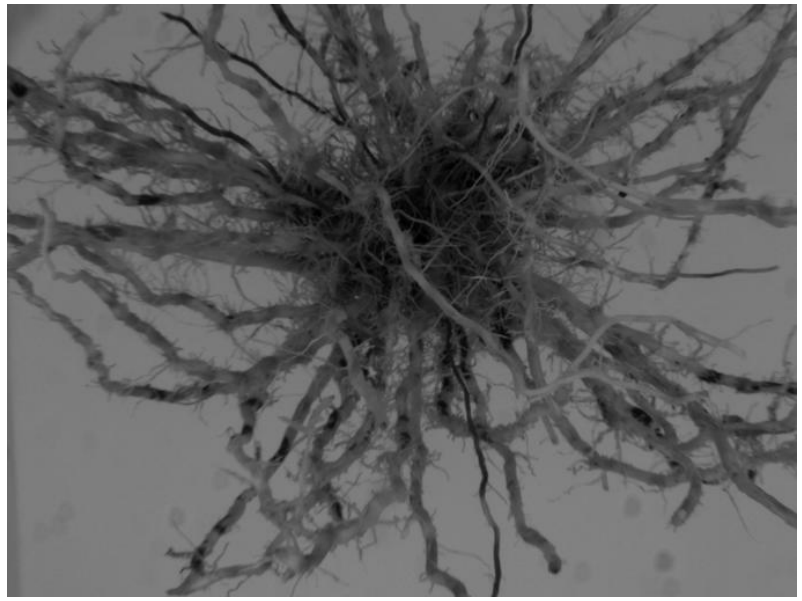
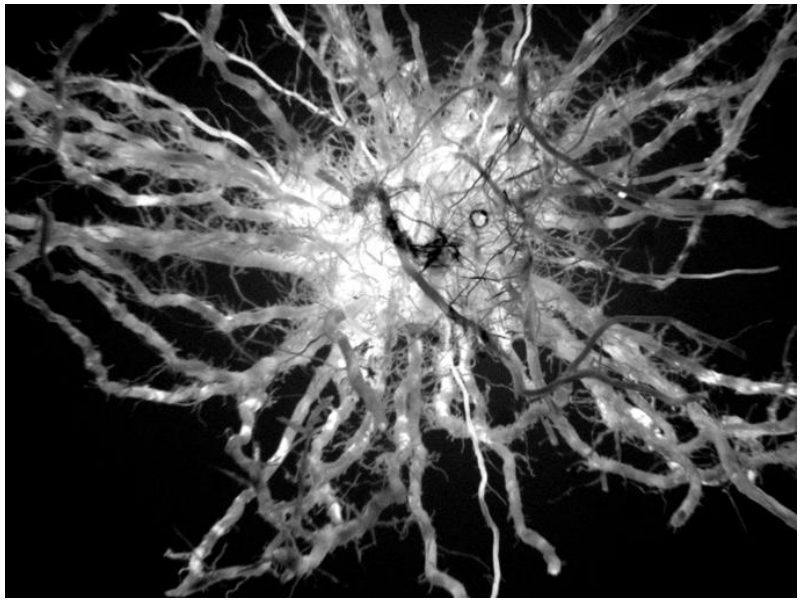
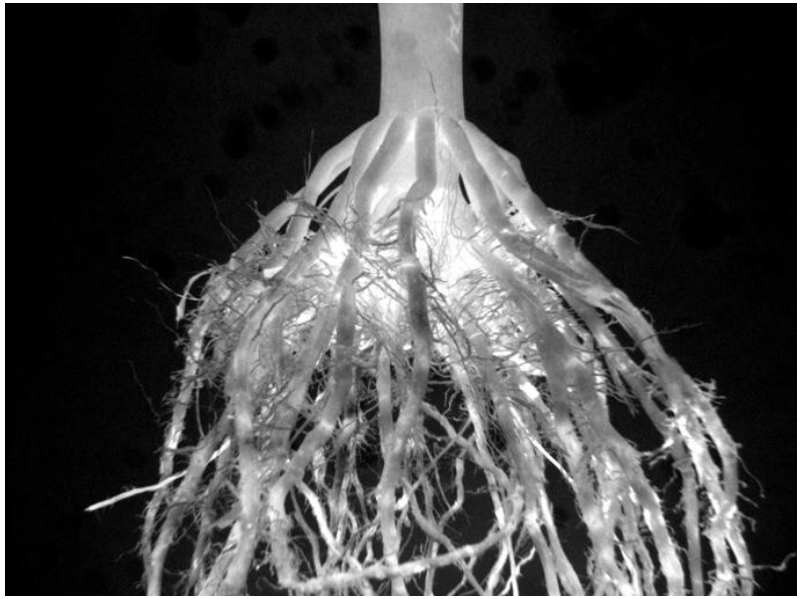


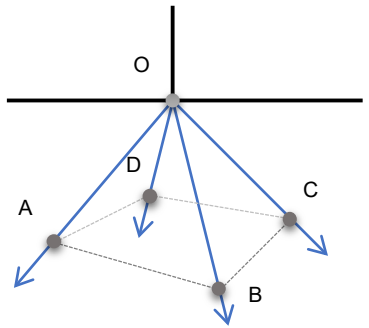
N1	N1
W+	W-
N2	N2
W+	W-
N3	N3
W+	W-

July 2017
Urbana, IL
MF1100

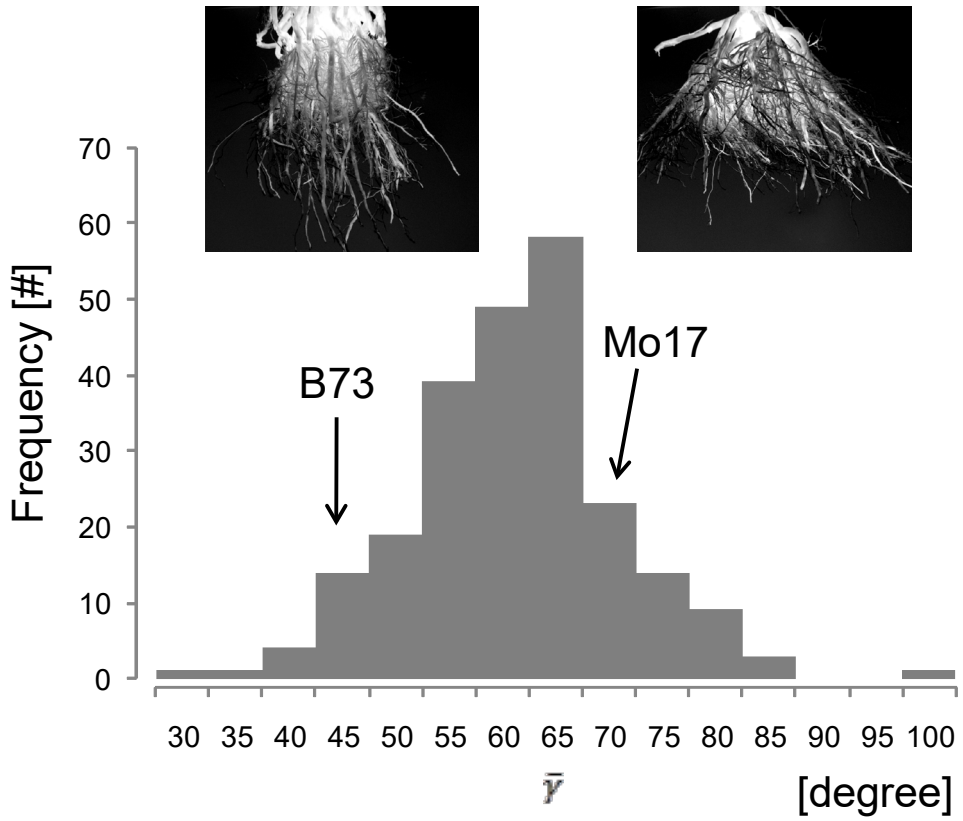




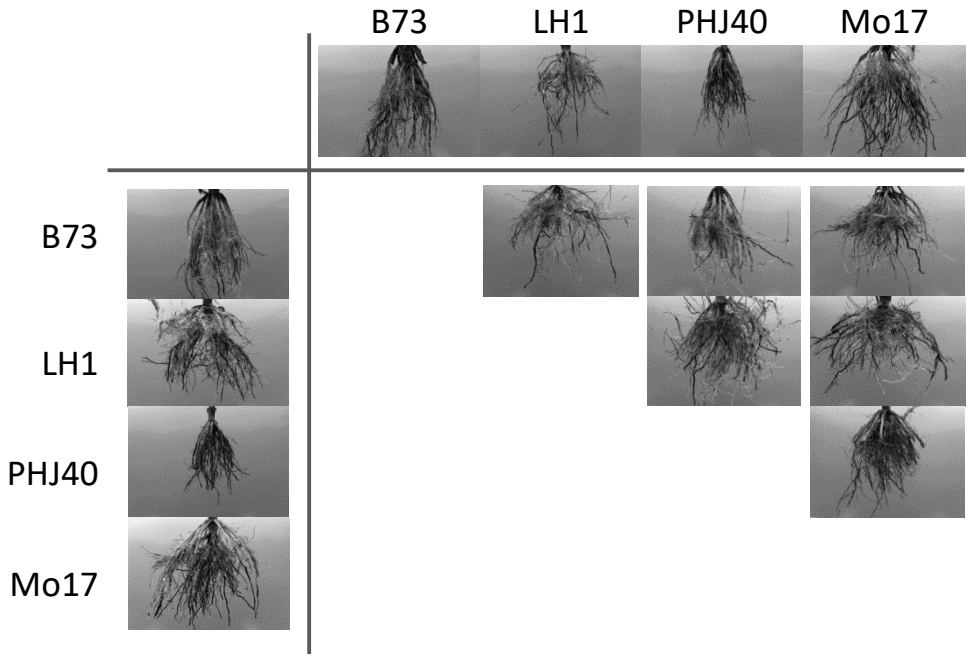




$$\gamma_1 = \angle AOB$$
$$\gamma_2 = \angle BOC$$
$$\gamma_3 = \angle COD$$
$$\gamma_4 = \angle AOD$$
$$\bar{\gamma} = \frac{1}{4}\sum_{i=1}^{4}\gamma_i$$



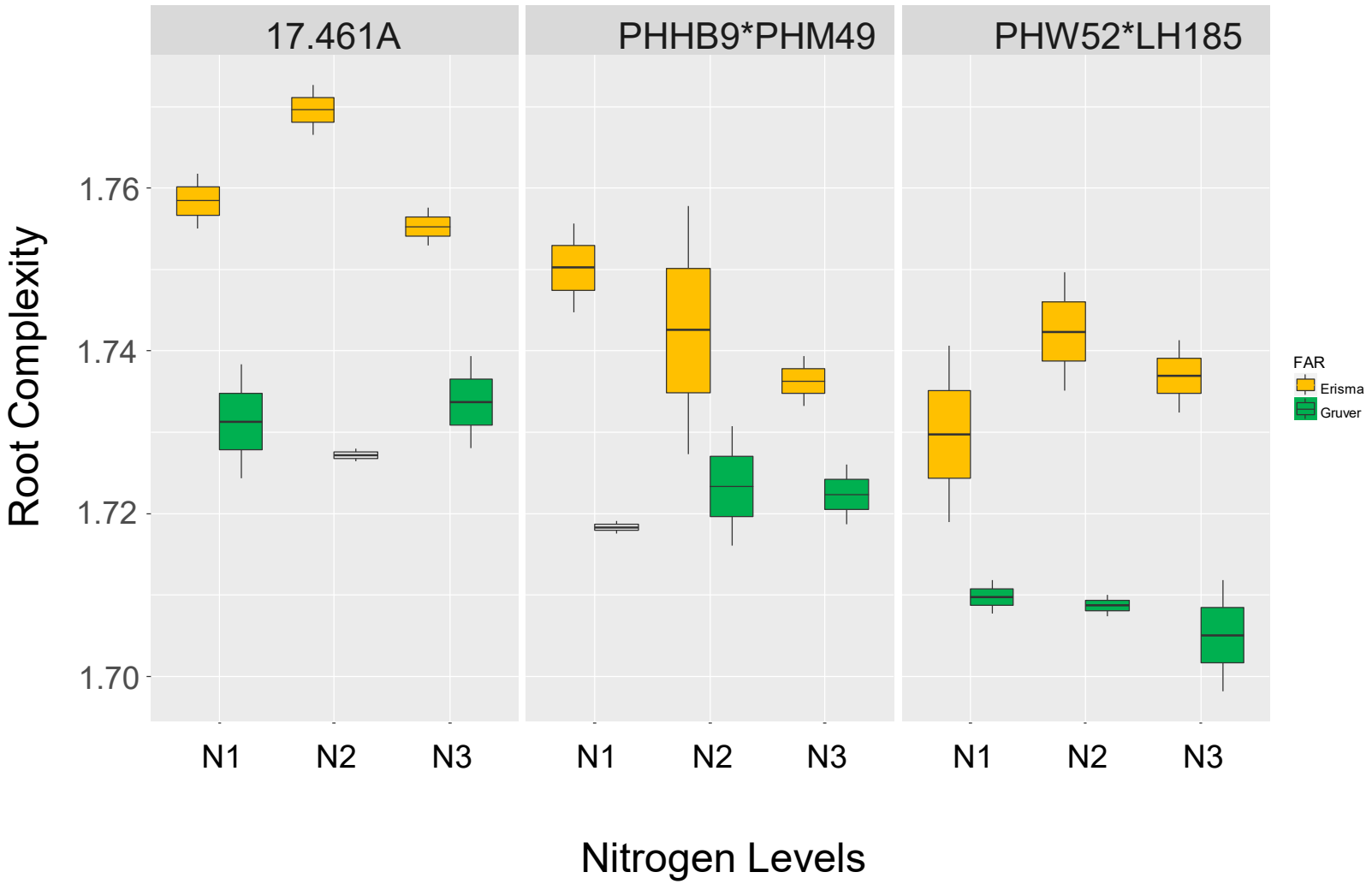
Heritability = 0.66



ANOVA

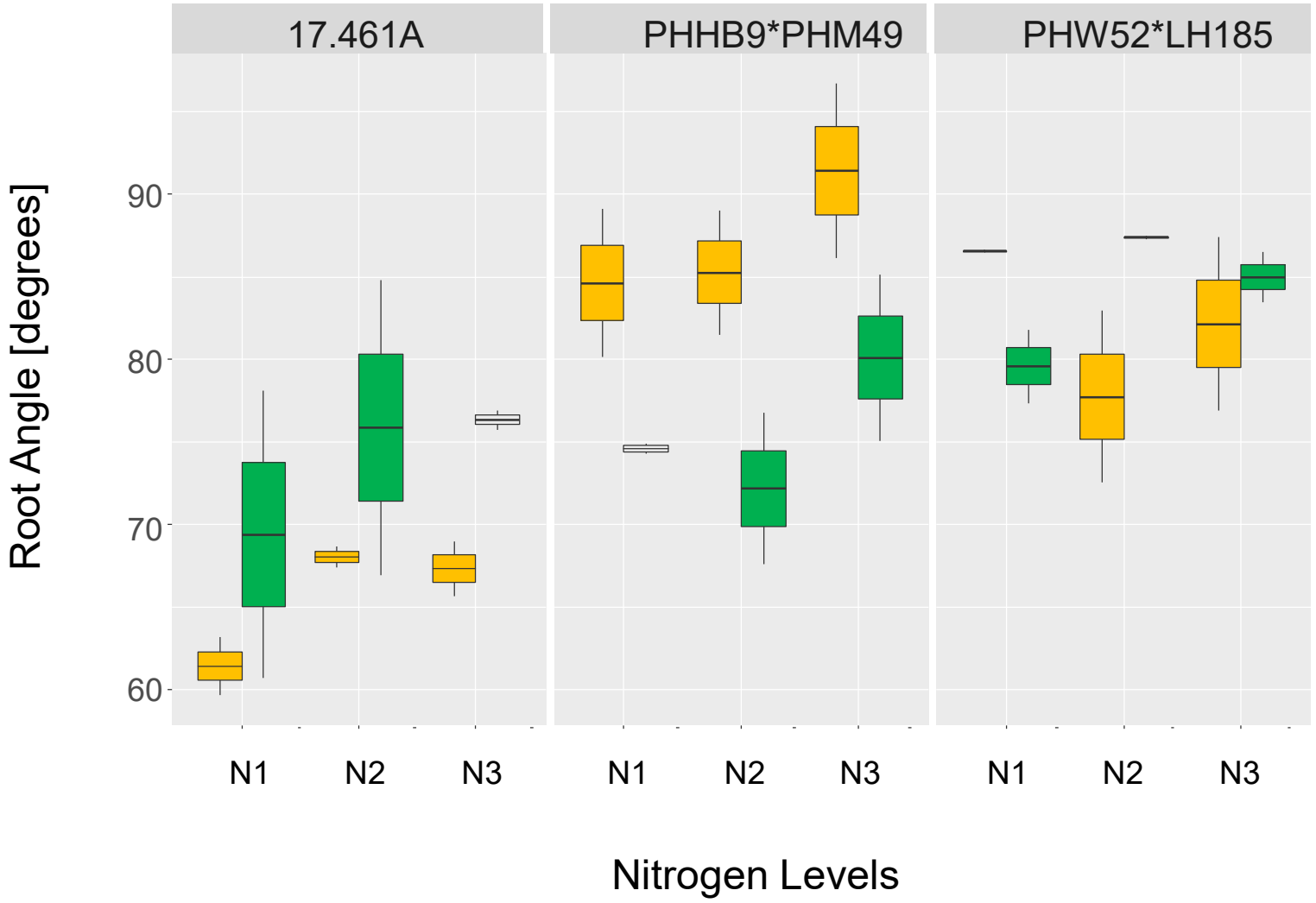
Effect	DF	Trait
ENV	1	***
Reps(ENV)	4	
Lines per se	11	***
GCA	11	
SCA	54	***
Checks (C)	7	**
Line×ENV	11	**
Heterosis×ENV	1	***
F1 vs. C×ENV	1	
C×ENV	4	*

OREI - Replicated Experiment Trial 2018



N1	N1
W+	W-
N2	N2
W+	W-
N3	N3
W+	W-

OREI - Replicated Experiment Trial 2018



N1	N1
W+	W-
N2	N2
W+	W-
N3	N3
W+	W-

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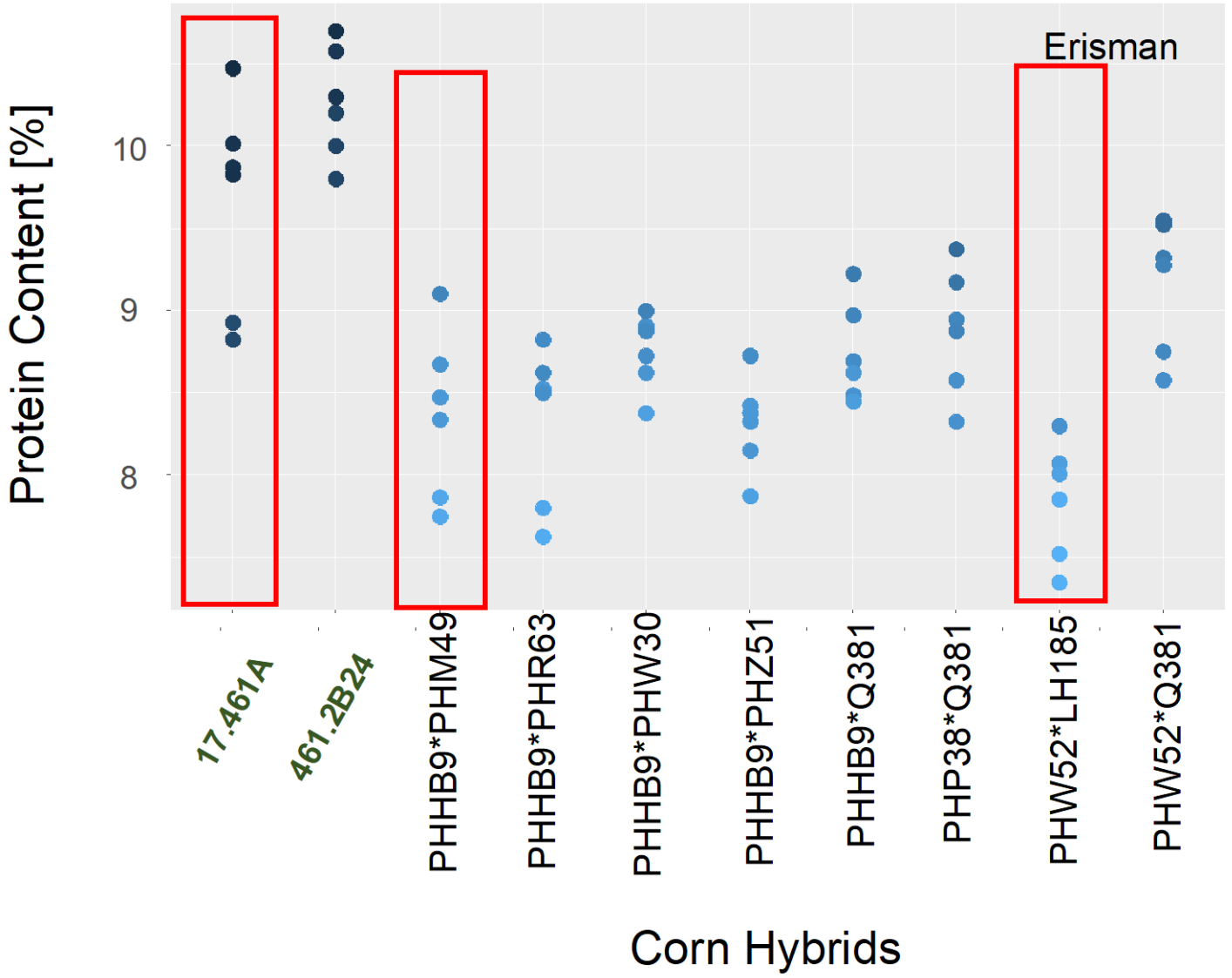

Starch [%]

72
71
70
69

N1 W+	N1 W-
N2 W+	N2 W-
N3 W+	N3 W-

OREI - Replicated Experiment Trial 2018

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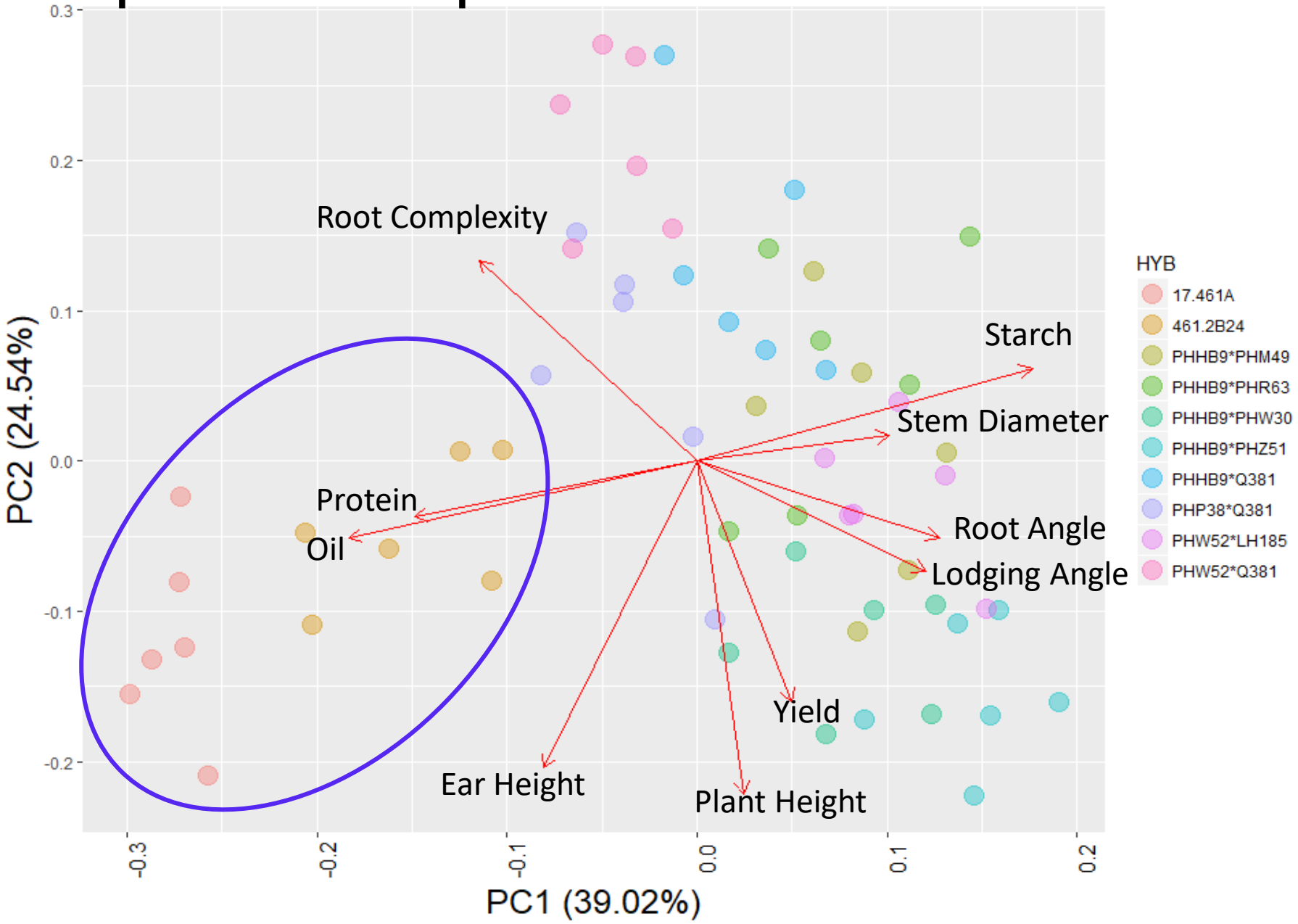
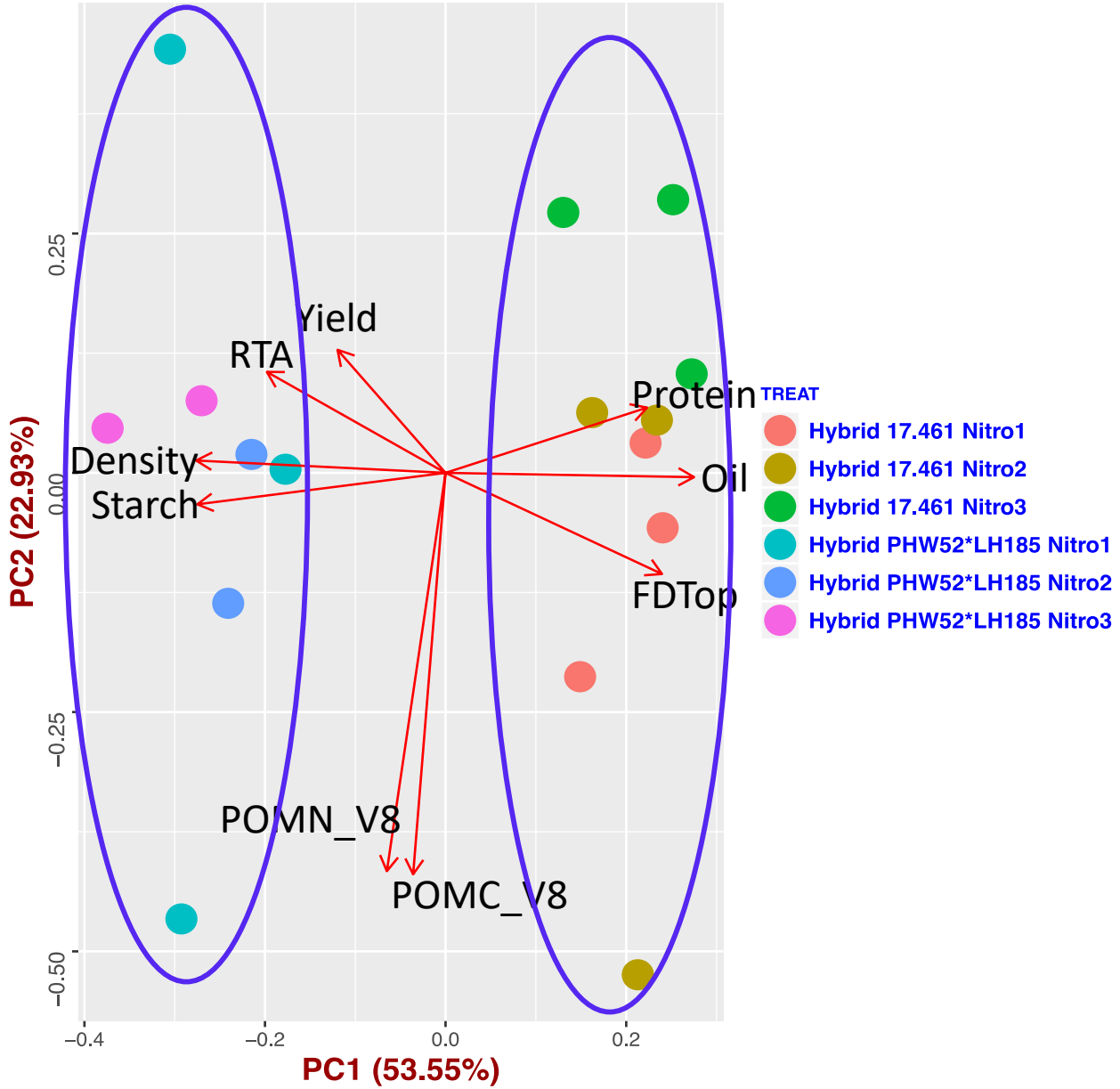


Soil Health & Plant Performance

- Food grade traits like grain density is more apparent in the U of I hybrid
- Density and starch are inversely related with protein content and root complexity
- Exploring the plant soil biotic interactions and their influence on fitness and grain quality of different corn varieties



Summary of Replicated Trials

- We observed significant difference between corn varieties for their response to varying nitrogen levels.
- All hybrids showed dynamic responses to improved levels of fertility. These responses were associated with characteristic changes in root architecture.
  - Across environments the top performing “organic hybrid” showed more complex and “steeper” root systems than all “conventional hybrids.”
- Organic hybrids showed high protein contents. Conventional hybrids were high in starch.
- Hybrids did not show significant performance differences between weed treatments.

Testing Network Moving Forward

- Receive continuous feedback from educational network—we welcome input from all players in the food system
- Evaluate and plan 2019 trials with current and new collaborators to expand the testing network—if interested talk to one of us
- Evaluate business models that address intellectual property and germplasm sharing issues

CASH

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