ORGANIC SOYBEAN BREEDIN

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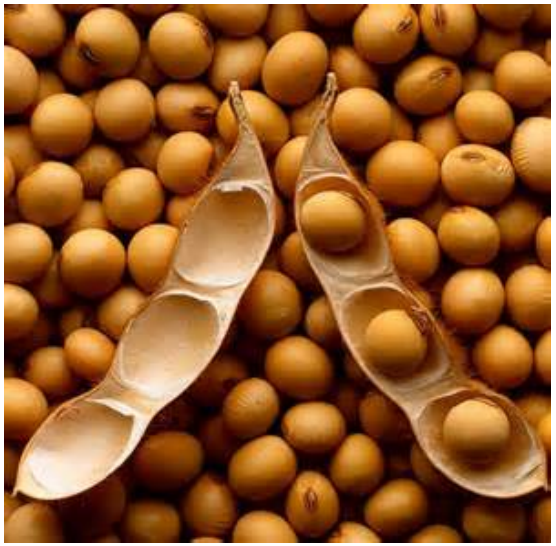
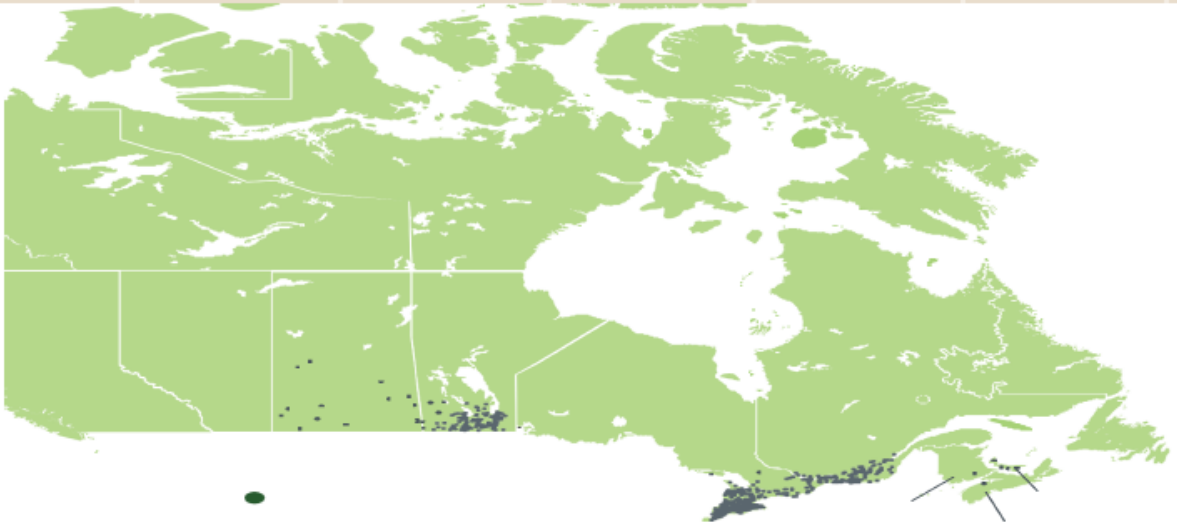


OUTLINE

- Canadian Soybean Production: GM vs. non-GM
- Organic Soybean Breeding Project
- Experiment 1: Cultivar Trial
- Experiment 2: Breeding Trial
- What have we learned?

Canadian Soybean Acres 2009 - 2015

Province	2009	2010	2011	2012	2013	2014	2015	Change ('09–'15)
Manitoba	415,000	520,000	575,000	800,000	1,050,000	1,270,000	1,330,000	220.48%
Maritimes	35,000	59,000	70,492	71,000	86,000	92,000	82,000	134.29%
Ontario	2,470,000	2,500,000	2,464,870	2,590,000	2,600,000	3,070,000	2,930,000	18.62%
Quebec	598,000	659,800	741,300	691,900	712,900	859,900	778,400	30.17%
Saskatchewan	0	0	0	0	170,000	270,000	300,000	–
Total	**3,581,600**	**3,738,800**	**3,851,662**	**4,152,900**	**4,618,900**	**5,561,900**	**5,420,400**	**51.34%**



	% Non-GM[1]				
Province	2010	2011	2012	2013	2014
Quebec	51.3%	50.0%	27.0%	20.0%	30.0%
Manitoba	5.0%	5.0%	5.0%	0.5%	0.75%
Ontario	35.0%	35.0%	25.0%	20.0%	25.0%
PEI	25.0%	16.0%	23.0%	23.0%	23.0%

- ***Most of the non-GM soybeans are publicly developed cultivars***

Organic Soybean Breeding

KPU

Organic Production System

Ontario Organic Growers

Organic Plant Breeding

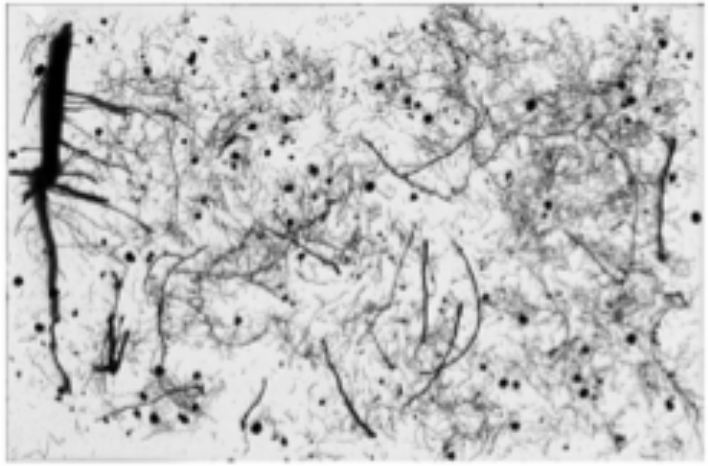
- Organic farmers are currently utilizing conventionally bred cultivar (Murphy et al., 2007)
- Crops in organic systems encounter more environmental stresses (Heckman et al., 2009)
- The organic environment causes differential performance of breeding lines and cultivars compared to conventional (Murphy et al., 2007; Reid et al., 2009)

- Organic farmers require cultivars which are adapted to the unique environment of their production systems (Lammerts van Bueren & Myers, 2012; Niggli et al.,

The Organic Soybean Ideotype

- Through the Process of a Literature review developed an organic ideotype
- We tested out this ideotype by conducting a cultivar trial and measuring traits theorized to be important for organic soybean cultivars to have

Rapid Canopy Coverage



Improved Nutrient Acquisition and Nodulation

Improved Nutrient Use Efficiency

QUESTIONS:

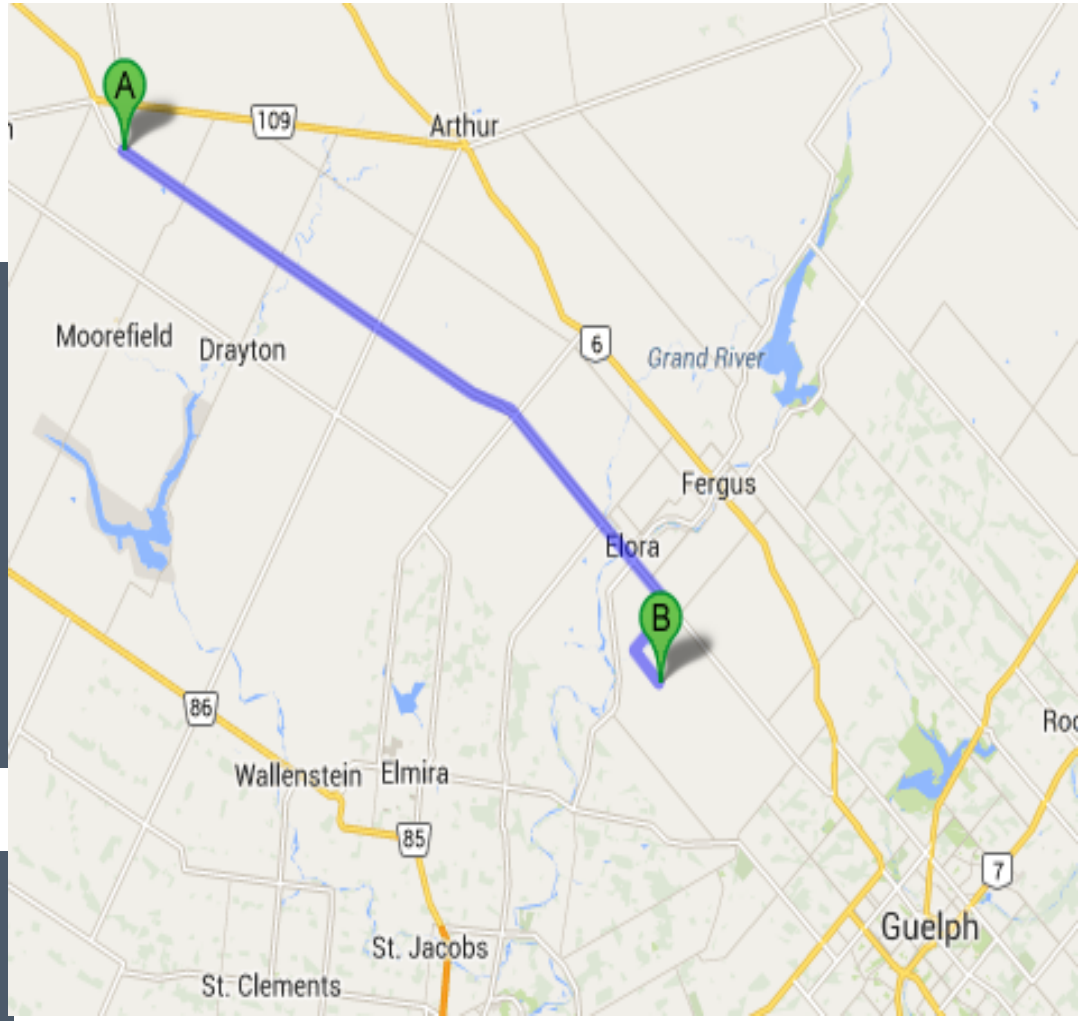
1) Is there genetic variation for adaptation to organic production system among cultivars developed exclusively under the conventional system?
2) Would selection in breeding populations result in different genetics?

Two Experiments:

Field locations

Organic Location (A)

Conventional Location (B)



Organic and Conventional Soil Test

Location	Year	Available K (ppm)	Available P (ppm) (1)	pH	OM 1 (%)	Precipitation (mm)2
Moorefield ***Organic***	2014	94	9.1	7.6	4.6	408.2
	2015	100	9.7	7.6	4.6	321.6
Elora ***Conventional***	2014	77	15	7.8	3.6	472
	2015	140	22	7.8	4	444.4

Experiment 1: Cultivar Trials

- 30 (2014) and 33 (2015) Ontario food grade non-GM soybean cultivars
- Planted in a RCBD
- Standard and "organic" traits were measured throughout development

Elora Research Station

Mapleton's Organic Farm

Cultivar Yield Trials

Field Observations Timeline

Early Season (VE-V5)

- Emergence
- Pubescence
- Flower color
- Leaf shape
- (1) Weed Suppressive Ability
  - Canopy Coverage

Mid Season (R5)

- Harvested whole plants
  - Nutrient Content
- (2) Root Morphology
  - Soil Cores
  - Roots/Nodules

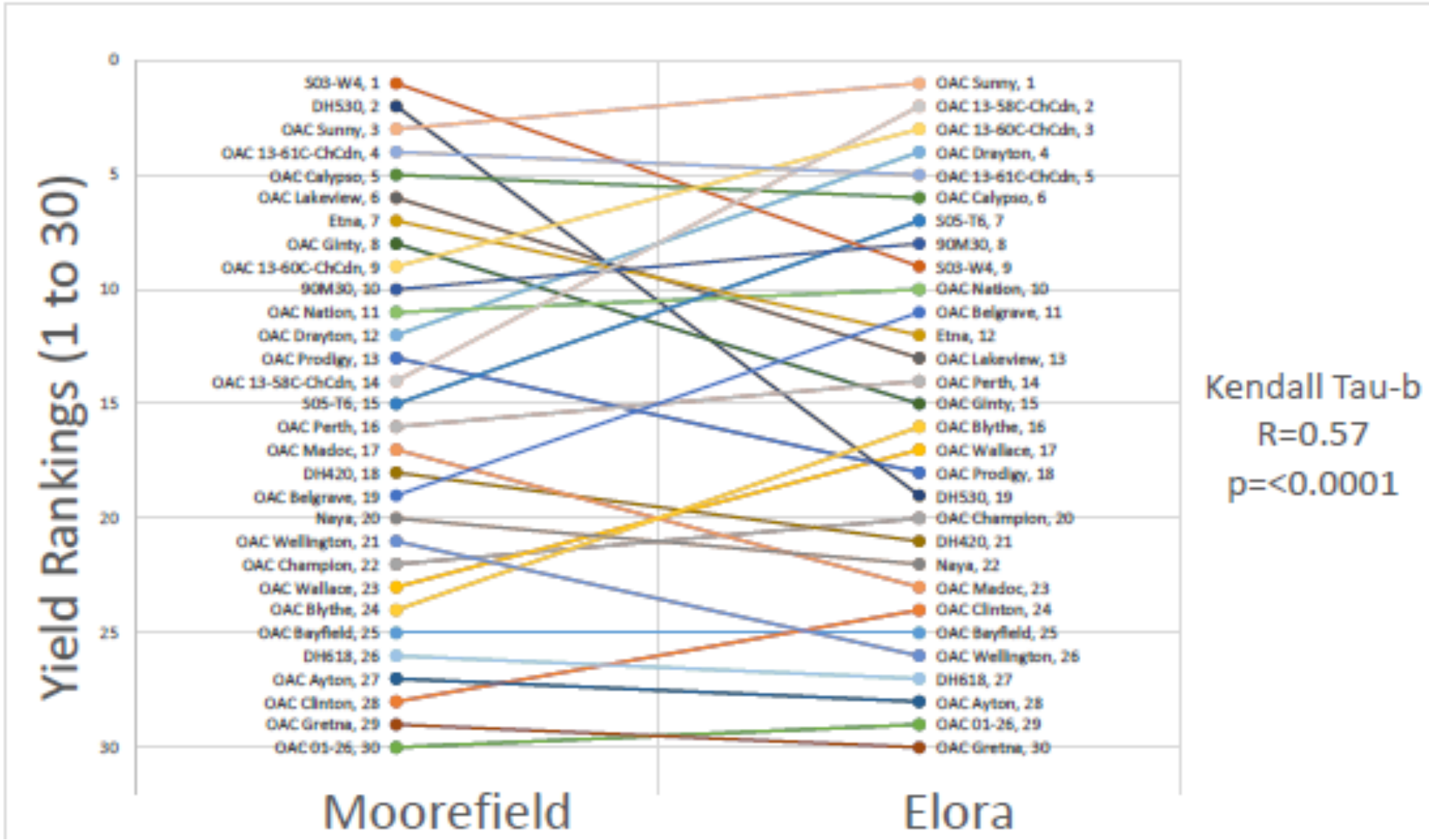
End Season (R8)

- Days to Maturity
- Height
- Yield
- Protein content
- Oil content
- Lodging
- (3) Nutrient Use Efficiency

Root Morphology Traits: Root Length and Surface Area; Nodule Mass

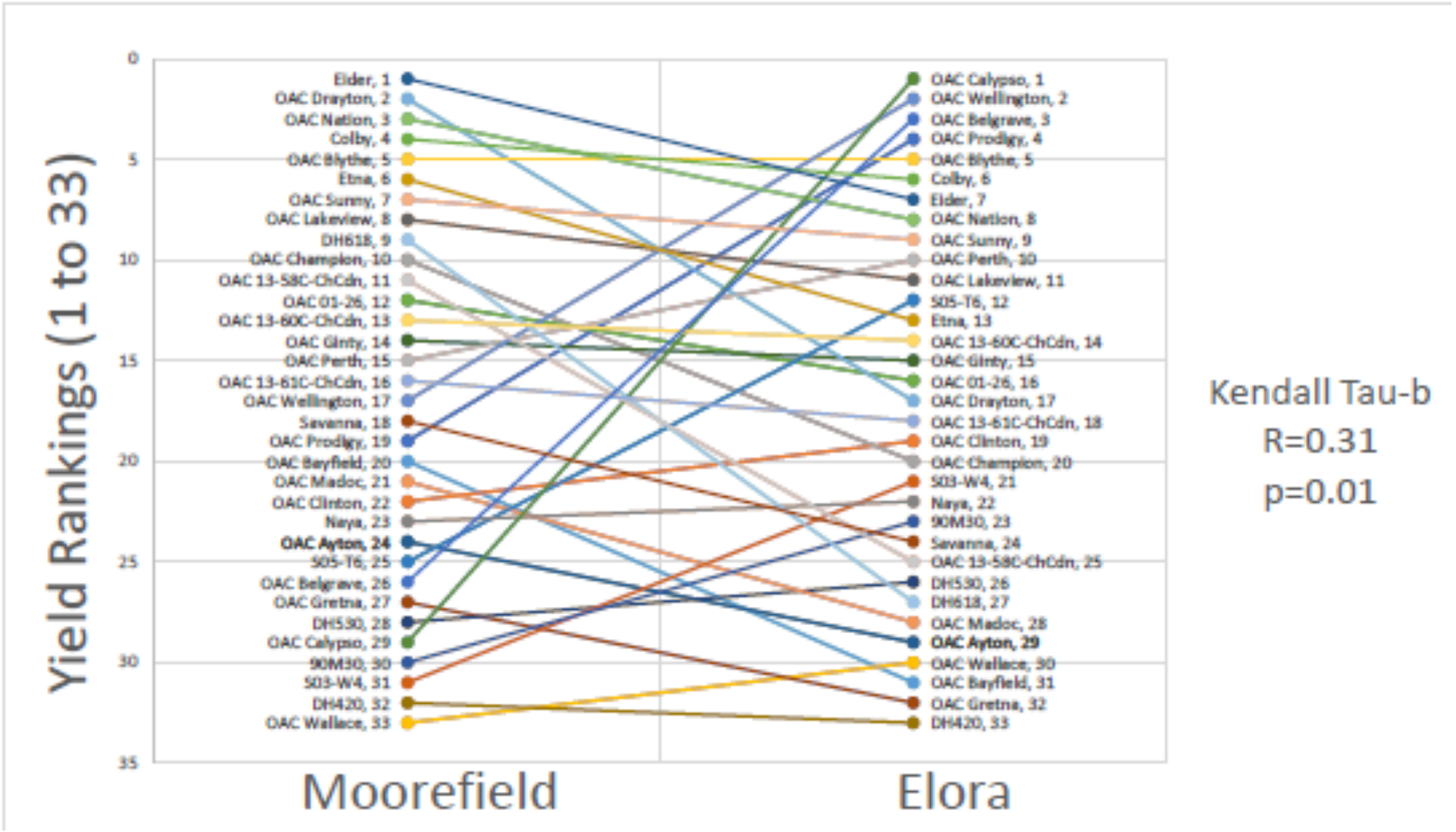
Conventional site	Organic site
•NO difference among the cultivars	•Significant differences among cultivars in both years

2014 Season Data



Kendall Tau-b
R=0.57
p=<0.0001

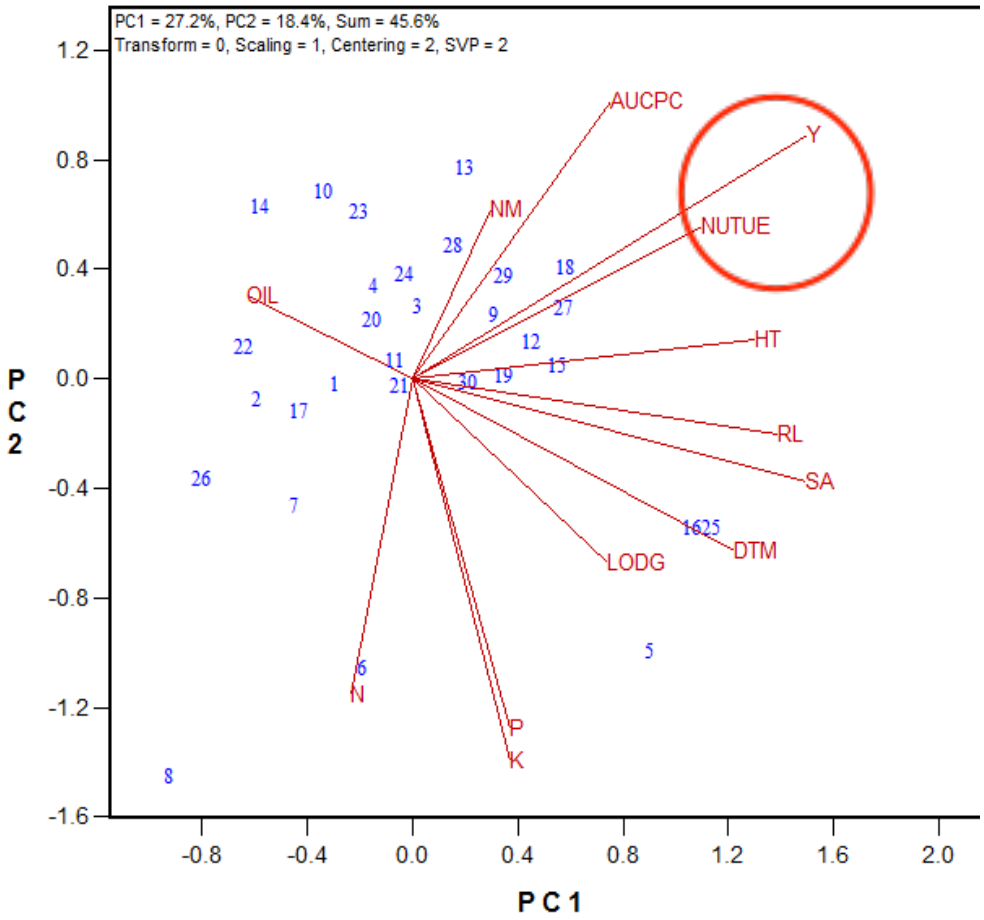
2015 Season Data



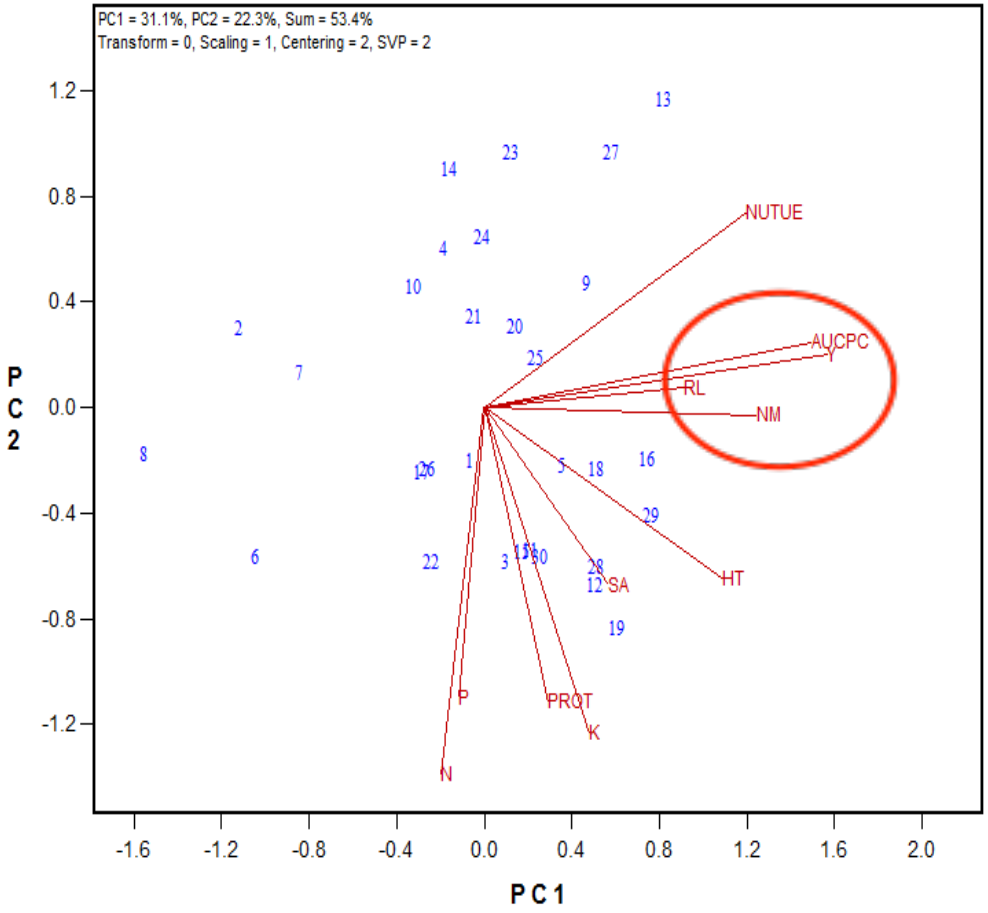
Kendall Tau-b
R=0.31
p=0.01

Principal Component Analysis: GxT Biplot

Elora: Conventional



Moorefield: Organic



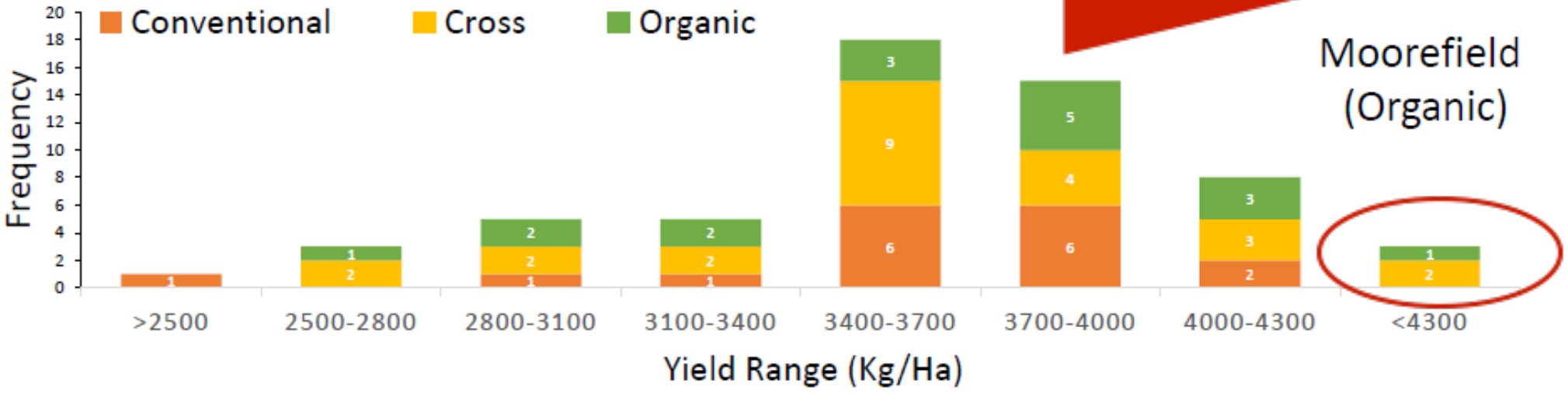
Experiment 2: Breeding Populations

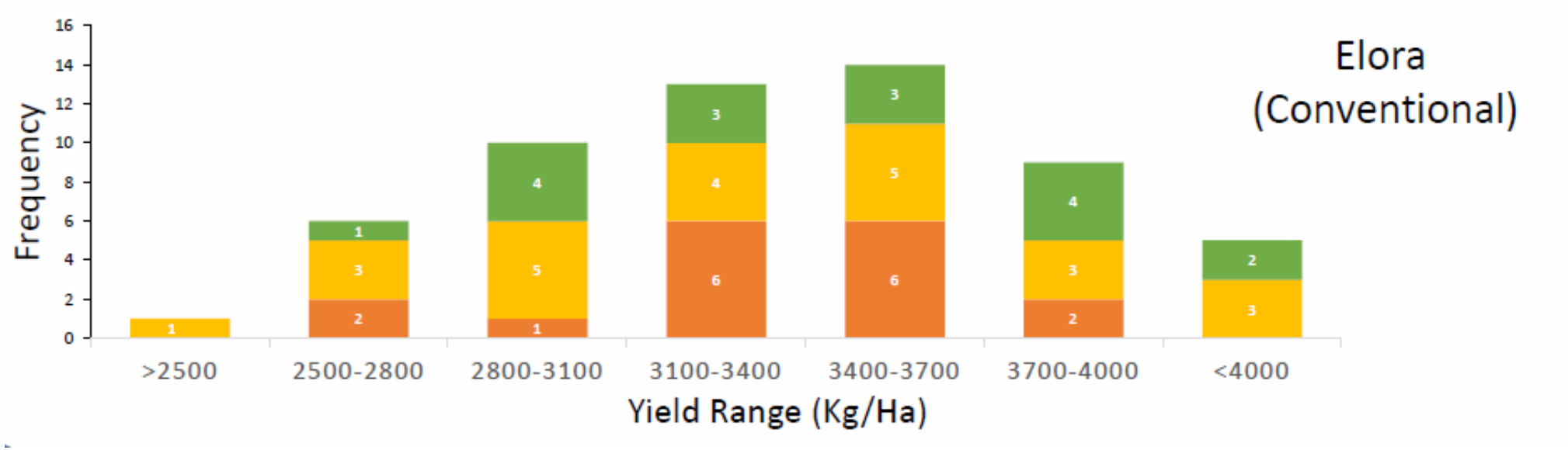
F5 Selection in Each Population

F6 Generation Yield Trials

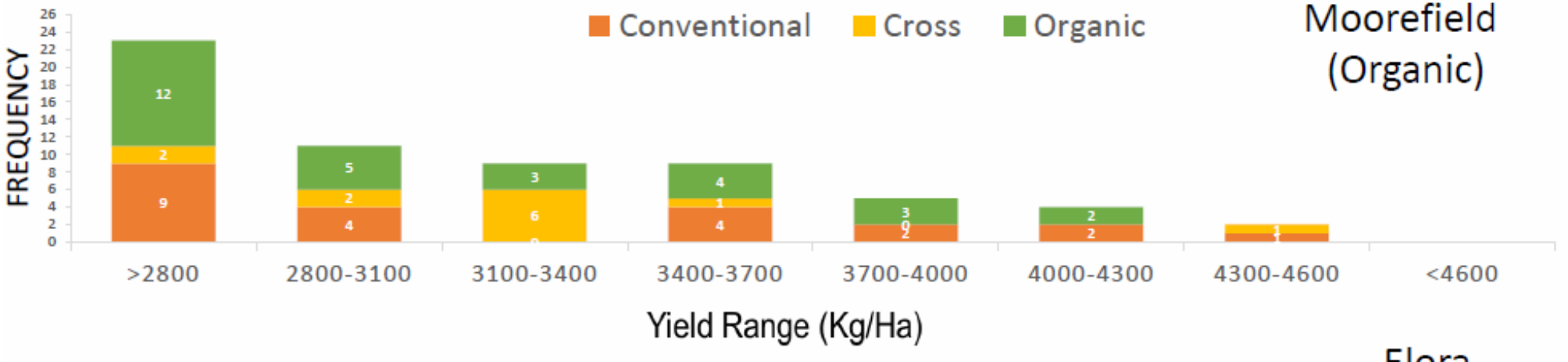
- Selections were planted in 4 row yield plots spaced 38cm apart in the F6 generation
- 5 replicated check cultivars were planted within each population (IR055 and IR062)
- Two selection scenarios were examined in the populations at F6
  - 25% selection pressure
  - Selection of lines which out yield the mean of the replicated Checks

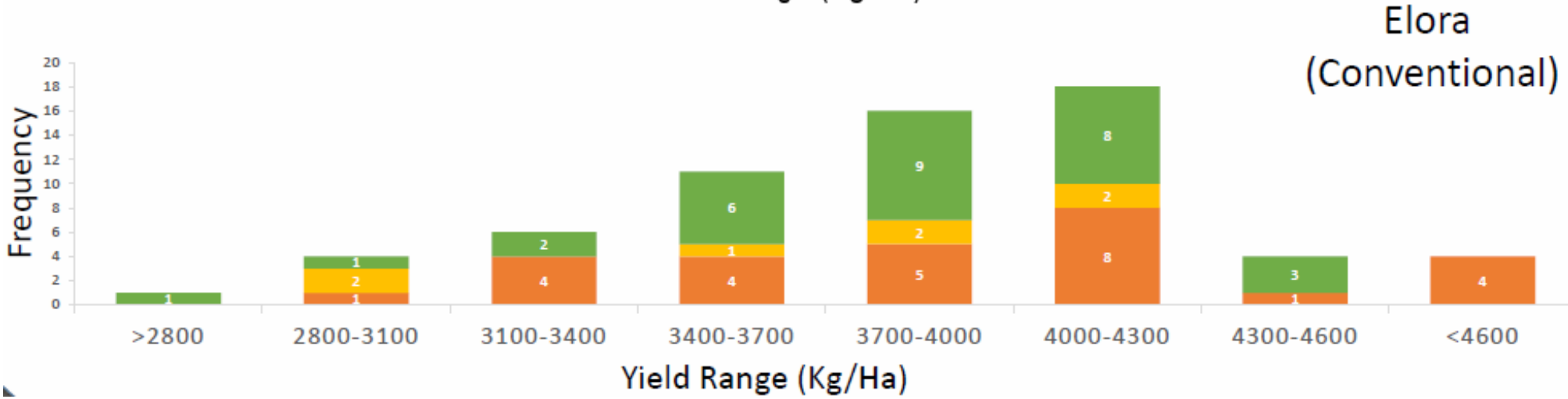
F6 Yield Distributions- IR055





F6 Yield Distributions- IR062





The Cross IR-055 was better adapted to Organic Production System than IR-062

- ***Only two*** F6 RILs beat the five checks in Elora
- ***48 (82%)*** beat the checks in Moorfield
- If the criteria were to advance lines that outperformed the checks, there would be too many selections
- *Possible solutions:*
  - 1) Select top 25% instead of everything that beats the checks
  - 2) Use checks adapted to organic environment

Conclusions for the Breeding Trial

- Selection pressure caused by the organic and conventional environments is population specific
  - IR055 was better adapted to the organic environment
  - IR062 was better adapted to the conventional environment
- High yielding lines in the conventional location do tend to rank within the top ten yielding lines in the organic location in the F6 generation
  - However, many of the best organic germplasm would likely have been lost at the F5 stage if the selection was only carried out at the conventional site

General Conclusions

- Our trials were limited in scope we only evaluated cultivars in a single organic and single conventional environment
- The established relationship between the canopy development, root morphology and yield should be examined across a larger number of organic environments
- The ***selections made in the early generations should be carried on into the Multiple Environmental Trials in organic environments to observe their performance***
- Needs to be done in the context of resources allocation within a breeding program

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Mapleton's Organic

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