Advanced Agronomic Practices to Maximize Wheat and Feed Barley Yields and Harvestability

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Photo Credit: Victor Gauthier

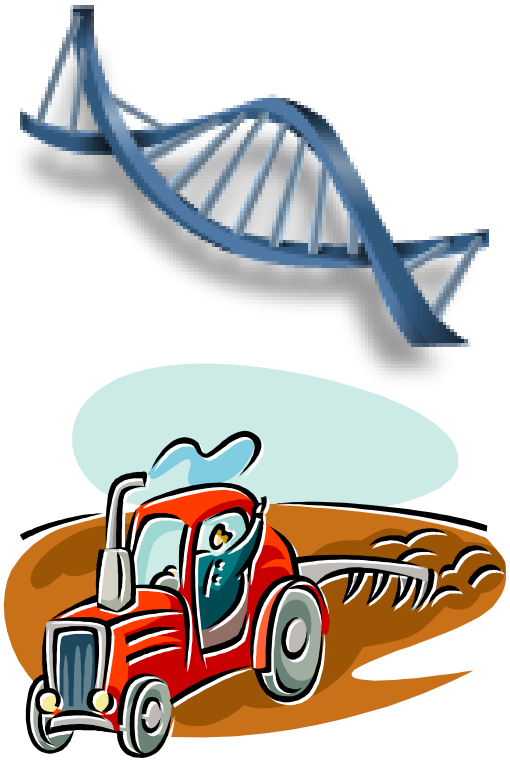
The Role for Crop Scientists and farmers in Feeding the World

- Wheat provides 20% of humanity's total calories[1]
- World population to stabilize in 2050 at 9B[2]
- The predicted increase in:
  - Wheat demand = 1.7% per yr[3]
  - Wheat productivity = 1.1% per year[3]
  - Western Canadian productivity increasing at 1.4% per yr[4]
- Need to increase cereal yields from 3.2t/ha to 4.3t/ha[5]
- How ???[2]
  - Some increases in cultivated land
  - Bridging current yield gaps
  - Breeding stress resilient varieties
  - Increase yield potential of current varieties via breeding
  - Adopt improved crop management practices and intensive agriculture

[1]FAO, 2010. FAOSTAT 2010. Available at http://faostat.fao.org/site/368/DesktopDefault.aspx?PageID=368#anchor
[2]Singh, B.B. (2013) World food security in the 21st century: challenges and opportunities for crop scientists. ASA, CSSA & SSSA International Annual Meetings. Tampa, Florida. Nov 3-6, 2013.
[3]Rosegrant and Agcaoili. 2010. Global Food Demand, Supply and Price Prospects to 2010. International Food Policy Research Institute, Washington, DC, USA.
[4]Thomas and Graf. 2014. Rates of yield gain of hard red spring wheat in western Canada. CJPS. 94:1-13.
[5]Bruinsma. 2009. How to Feed the World in 2050. FAO Expert Meeting, June 24-26, 2009. Rome.

Background

- Increased wheat yields are attributed to:
  - **Breeding** (21% in Asia and Latin America[1]; 28% in NW Mexico[2]; 90% in the UK[3]). i.e. Semi-dwarfs, disease resistance.
  - **Improved agronomic practices** (33%-48% in NW Mexico[2,3]). i.e. Fertilizer, irrigation, mechanization, early seeding, weed management.
- 10yr provincial average for spring wheat 44.9 bu/acre[4] (2.4t/ha)



[1]Evanson and Gollin, 2003.Assessing the Impact of the Green Revolution, 1960 to 2000. Science. 300: 758-762.
[2]Evans and Fischer, 1999. Yield Potential: Its Definition, Measurement, and Significance. Crop Science. 39:1544-1551.
[3]Fischer and Edmeades, 2010. Breeding and Cereal Yield Progress. Crop Science. 50:S85-S98.
[4]Alberta Agriculture and Rural Development. Source: Statistics Canada. 2014. Alberta 2013 Crop Season in Review. Available at: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sdd4191.

Advanced Agronomic Practices - Background

Supplemental Urea Ammonium Nitrate (UAN)

- To maximize yield, N fertilizer should be available at the time of maximum crop uptake.
  - In cereal crops, this is from the start of elongation until heading (Bauer et al., 1987).
  - Delayed N applications (at anthesis) tend to increase grain protein content without increasing yield (Rawluk et al., 2000).
- Karamanos et al. (2005) found post-emergent N applications could increase Hard Red Spring (HRS) wheat yields in high moisture or irrigated conditions.

Bauer, A., Frank, A. B. and Black, A. L. 1987. Aerial parts of hard red spring wheat. I. Dry matter distribution by plant development stage. Agron. J. 79: 845-852.
Karamanos, R. E., Flore N. A. and Harapiak, J. T. 2005. Effect of post-emergence nitrogen application on the yield and protein content of wheat. Can. J. Plant Sci. 85: 327–342.
Rawluk, C. D. L., Racz, G. J. and Grant, C. A. 2000. Uptake of foliar or soil application of 15N-labelled urea solution at anthesis and its affect on wheat grain yield and protein. Can. J. Plant Sci. 80: 331-334.

Plant Growth Regulators (PGRs)

- In western Canada, Manipulator was recently registered (for wheat) and a 2nd PGR is in the process of registration (for wheat).
- These PGRs produce shorter (2-15cm), thicker & stronger stems which reduce lodging in intensive management systems (Syngenta, 2013; Taminco, 2013).
- The primary use of PGRs is as a harvest management aid.

Syngenta. 2013. Palisade2EC Label. Accessed November 27, 2013. Available online at: http://www.syngentacropprotection.com/Labels/p-1197/Palisade_2EC
Taminco. 2013. Manipulator Technical Data Sheet. Accessed November 27, 2013. Available online at: http://www.taminco.com/

Foliar Fungicides

- Foliar fungicides increase wheat yields by 5.5-44%. Largest increases on cultivars with less genetic resistance to fungal pathogens (Ransom & McMullen, 2008).
- In-crop fungicide applications must protect the upper canopy leaves to permit a longer period of grain filling, leading to higher grain yield, kernel weight, plumpness & test weight (Turkington et al., 2011a).

Ransom, J.K. and M.V. McMullen. 2008. Yield and disease control on hard winter wheat cultivars with foliar fungicides. Agron. J. 100: 1130-1137.
Turkington, T.K., H.R. Kutcher, K. Xi, K.N. Harker, J.T. O'Donovan. 2011a. The impact of fungicide and herbicide timing on barley leaf disease severity, weed management and crop productivity. Abstract. The American Phytopathological Society Meetings in Honolulu, Hawaii, August 6-10, 2011.

Seeding Rate

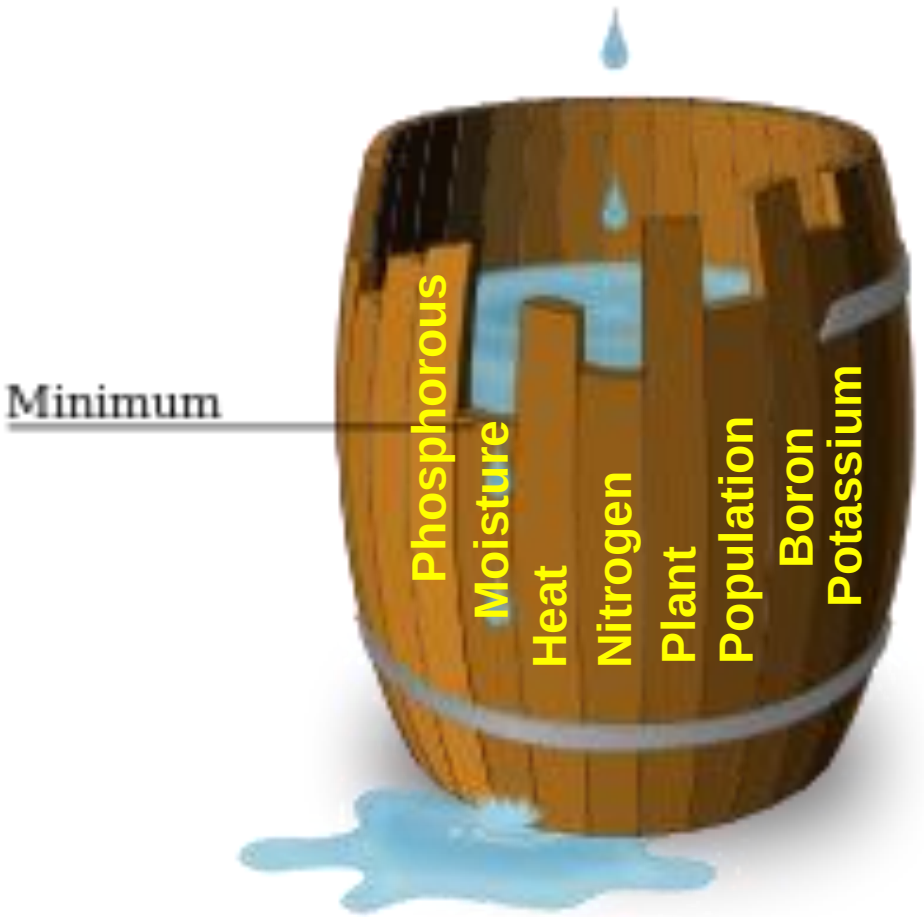
- **Yields are often stable over a wide range of seeding rates, but in some instances yield increases are observed**
- **High seeding rates:**
  - **Accelerate maturity**
  - **Reduce tiller number per plant**

Desired plant population		
	per square meter	per square foot (range)
Barley 2 row	210	22 (16 - 30)
Barley 6 row	210	22 (16 - 30)

Jedel and Helm, 1994. Agronomic response to seeding rate of two- and six-rowed barley cultivars in central Alberta. CJPS. 75: 315-320.
http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex81?opendocument#target

Liebig's Law of the Minimum

"Growth is controlled not by the total amount of resources available, but by the scarcest resource (limiting factor)."



http://en.wikipedia.org/wiki/Liebig's_law_of_the_minimum

Basic Agronomic Practices

- Direct seed into canola stubble
- Vibrance XL seed treatment
- High target seeding rate – 35 plants/ft^2
- Heat + Glyphosate pre-seed burnoff
- Seeding as early as possible
- Early weed control with Stellar + Axial
- Fungicide applied with 80L/ac water volume

Systems Approach to Testing Agronomic Practices

- The yield & agronomic benefits associated with advanced agronomic practices have been studied.
- However, there is very limited research testing the COMBINED EFFECTS of these agronomic practices.
  - Ontario research found that combined agronomic practices had synergistic yield benefits (Johnson, 2013).
  - Olesen et al. (2003) found enhanced disease under high N fertilizer rates, emphasizing the need to test fungicides under varying rates of N fertilizer.
- This research uses a systems approach to pin-point combinations of agronomic practices that result in the largest synergistic yield, agronomic & economic benefits.

Johnson, P. 2013. Breaking Yield Barriers – the Production Package to Hit 150 bu/ac Wheat. FarmTech 2013.
Olesen, J.E., J.V. Mortensen, J. Petersen, and L.N. Jorgensen. 2003. Effects of rates and timing of nitrogen fertilizer on disease control by fungicides in winter wheat. 2. Crop growth and disease development. Journal of Agricultural Science. 140:15-29.

Advanced Agronomic Practices in Wheat, Barley and Pea to Maximize Yield and Harvestability

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KL Nelson and KWS – UK
Kittle Farms Ltd.
Lefsrud Seed & Processors Ltd.
McNelly Seed Farms Ltd.
N. Jonk Seed Farms
Don Schmermund
Stony Plain Seed Cleaning Plant
Trueblood Farms Ltd.
University of Alberta
Westlock Seed Cleaning Co-op Ltd.

Objectives

1.Using a systems approach, determine synergistic benefits of stacking multiple agronomic practices: PGRs; supplemental UAN; Agrotain; and/or foliar fungicides to increase yields & economic returns of wheat & feed barley.

2.Compare small plot results from objective 1 with “Wheat 150” & “Barley 180” field scale trials to develop statistical tools to allow producers to effectively analyze field research.

3. Determine if wheat or feed barley cultivars respond differently to the intensive agronomic practices listed in objective 1.

4. Using a systems approach, determine which agronomic practices (PGRs, inter-row seeding) improve field pea harvestability.

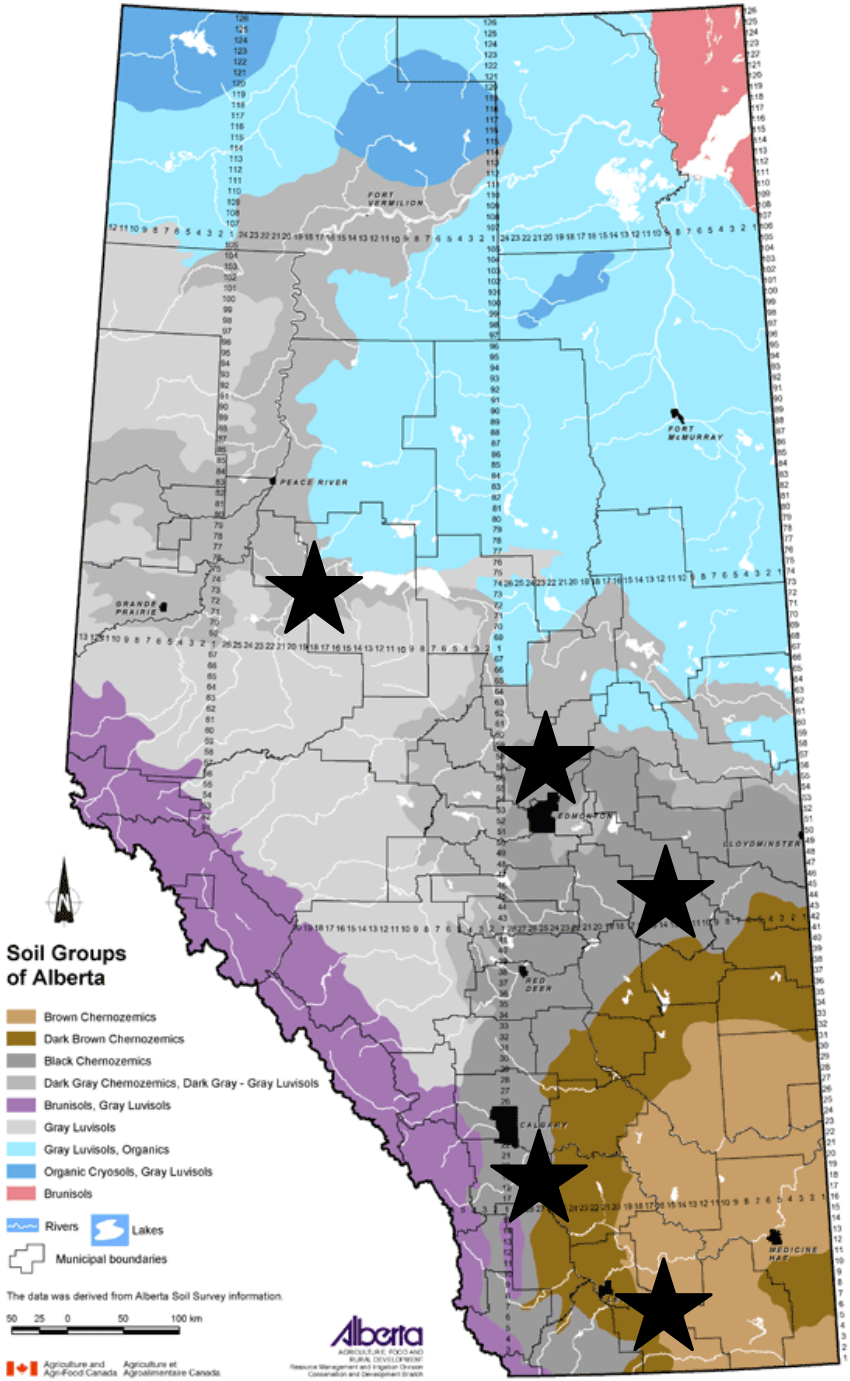
5. Determine the benefits of various fungicide modes of action & application timings for use on feed barley.

When?

- 3 years (2014-2016)

Where?

- Magrath (irrigated)
- High River
- Killam
- Bon Accord
- Fahler



Prepared by Laurel Perrott, MSc. Student

Precipitation - 2014

	Magrath		High River		Killam		Bon Accord		Falher	
	mm	inches	mm	inches	mm	inches	mm	inches	mm	inches
May	33	1.3	57	2.2	24	0.9	40	1.6	18	0.7
June	221	8.7	130	5.1	106	4.2	60	2.4	50	2.0
July	67	2.6	28	1.1	54	2.1	40	1.6	28	1.1
August	58	2.3	35	1.4	40	1.6	13	0.5	4	0.2
Sept	46	1.8	75	3.0	39	1.5	42	1.7	0	0.0
Total	425	16.7”	325	12.8”	263	10.4”	194	7.6”	101	4.0”
LTA	226	8.9”	245	9.6”	258	10.2	295	11.6”	238	9.4”
Soil Moisture @ Seeding (0-6”)					22%		29%		Good/excellent	
Seeding Date†	May 15, 2014		May 21, 2014		May 16, 2014		May 8, 2014		May 20, 2014	
Harvest Date	Sept 16, 2014		Sept 17, 2014		Sept 23, 2014		Sept 19, 2014		Sept 6, 2014	

Growing Degree Days - 2014

	Magrath	High River	Killam	Bon Accord	Falher
May	136	89	114	148	81
June	225	231	259	280	284
July	431	383	387	410	414
August	380	337	348	372	374
September	86	77	145	113	42
Total	1257	1116	1252	1322	1203
Long Term Average	1276	1094	1267	1249	1024
Seeding Date	May 15	May 21	May 16	May 8	May 20
Harvest Date	Sept 16	Sept 17	Sept 23	Sept 19	Sept 6

Wheat Stacked Management

(comparing 48 management practices)

Yield Response

Comparing 48 management practices

REP 1													
	UAN C	UAN C ONLY	CCC	CCC + Fungicide @ Time A	CCC + Fungicide @ Time B	CCC + Fungicide @ Time A+B	PGR B	PGR B + Fungicide @ Time A	PGR B + Fungicide @ Time B	PGR B + Fungicide @ Time A+B	Fungicide @ Time A	Fungicide @ Time B	Fungicide @ Time A+B
		1	2	3	4	5	6	7	8	9	10	11	12
		137	138	139	140	141	142	143	144	145	146	147	148
	UAN B	UAN B ONLY	CCC	CCC + Fungicide @ Time A	CCC + Fungicide @ Time B	CCC + Fungicide @ Time A+B	PGR B	PGR B + Fungicide @ Time A	PGR B + Fungicide @ Time B	PGR B + Fungicide @ Time A+B	Fungicide @ Time A	Fungicide @ Time B	Fungicide @ Time A+B
		1	2	3	4	5	6	7	8	9	10	11	12
		125	126	127	128	129	130	131	132	133	134	135	136
	UAN A	UAN A ONLY	CCC	CCC + Fungicide @ Time A	CCC + Fungicide @ Time B	CCC + Fungicide @ Time A+B	PGR B	PGR B + Fungicide @ Time A	PGR B + Fungicide @ Time B	PGR B + Fungicide @ Time A+B	Fungicide @ Time A	Fungicide @ Time B	Fungicide @ Time A+B
		1	2	3	4	5	6	7	8	9	10	11	12
		113	114	115	116	117	118	119	120	121	122	123	124
	0 UAN	Control	CCC	CCC + Fungicide @ Time A	CCC + Fungicide @ Time B	CCC + Fungicide @ Time A+B	PGR B	PGR B + Fungicide @ Time A	PGR B + Fungicide @ Time B	PGR B + Fungicide @ Time A+B	Fungicide @ Time A	Fungicide @ Time B	Fungicide @ Time A+B
		1	2	3	4	5	6	7	8	9	10	11	12
		101	102	103	104	105	106	107	108	109	110	111	112

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Advanced Agronomic Management Treatments

In – Crop UAN		
Treatment	**Rate**	**Timing**
UAN 1.25x Yield Goal	30 lbs N/ac	Just prior to GS 30 (just before elongation) - June 13th in Bon Accord
UAN 1.25x + Agrotain	30 lbs N/ac + 3.4 mL Agrotain /lb UAN	
UAN 1.5x Yield Goal	60 lbs N/ac	
PGR x Fungicide Treatments		
PGR – CCC	0.73 L/ac (wheat)	GS 30-32 - June 18th in Bon Accord
PGR B	2.0 L/ac (wheat only)	
1st Foliar Fungicide Twinline	202 mL/ac	GS 39 Flag leaf fully unrolled - July 2nd, Bon Accord
2nd Foliar Fungicide Prosaro	320 mL/ac	Head Emerge ~ 2 weeks later - July 15th, Bon Accord

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Fertilizer Applied at Seeding - Wheat

Location	N	P_2O_5	K_20	S	Cu
Magrath	120 lbs N/ac* 100 lbs N/ac applied in fall 2013 20 lbs N/ac applied at seeding	49 lbs P_2O_5/ac	n/a	n/a	n/a
High River	85 lbs N/ac	22 lbs P_2O_5/ac	n/a	n/a	n/a
Killam – CPS, SWS, GP	81 lbs N/ac	25 lbs P_2O_5/ac	20 lbs K_2O/ac	5 lbs S/ac	n/a
Killam – HRS	90 lbs N/ac	25 lbs P_2O_5/ac	20 lbs K_2O/ac	5 lbs S/ac	n/a
Bon Accord – CPS, SWS, GP	96 lbs N/ac	50 lbs P_2O_5/ac	40 lbs K_2O/ac	n/a	n/a
Bon Accord – HRS	126 lbs N/ac	50 lbs P_2O_5/ac	40 lbs K_2O/ac	n/a	n/a
Falher	93 lbs N/ac	59 lbs P_2O_5/ac	18 lbs K_2O/ac	13 lbs S/ac	n/a

Yield Targets for:
Standard & Advanced Agronomic Management

	Magrath	High River	Killam	Bon Accord	Falher
			bu/acre		
HRS 1.0 x	90	45	65	79	60
HRS 1.25 x	113	56	81	99	75
HRS 1.5 x	135	68	98	119	90
CPS 1.0 x	100	55	80	87	75
CPS 1.25 x	125	69	100	109	94
CPS 1.5 x	150	83	120	130	113
SWS 1.0 x	112	77	75	98	83
SWS 1.25 x	139	96	94	123	104
SWS 1.5 x	167	115	113	147	124
Feed Barley 1.0 x	110	80	100	86	81
Feed Barley 1.25 x	138	100	125	107	101
Feed Barley 1.5 x	165	120	150	128	121
Malt Barley 1.0 x	110	70	90	97	83

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Wheat Stacked Management – Yield Response

comparison of 48 different management practices

	Lethbridge	High River	Killam	Bon Accord	Falher
Average Yield	115 bu/ac	80 bu/ac	119 bu/ac	94 bu/ac	70 bu/ac
			ANOVA F test		
UAN	**<0.0001**	**<0.0001**	0.1646	0.5364	**<0.0001**
Treatment†	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**0.0114**
UAN * Treatment†	0.6792	0.9455	0.6156	0.8781	0.9975
			Contrast F test		
No PGR vs PGR	0.1564	0.2627	0.1483	0.0614	0.1253
No Fungicide vs Fungicide	**<0.0001**	**<0.0001**	**<0.0001**	**0.0211**	0.5805
PGR vs PGR + Fungicide	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	0.1021
CV %	3.7%	8.0%	5.8%	6.5%	10.5%

† Treatment = the 12 PGR x Fungicide treatment combinations

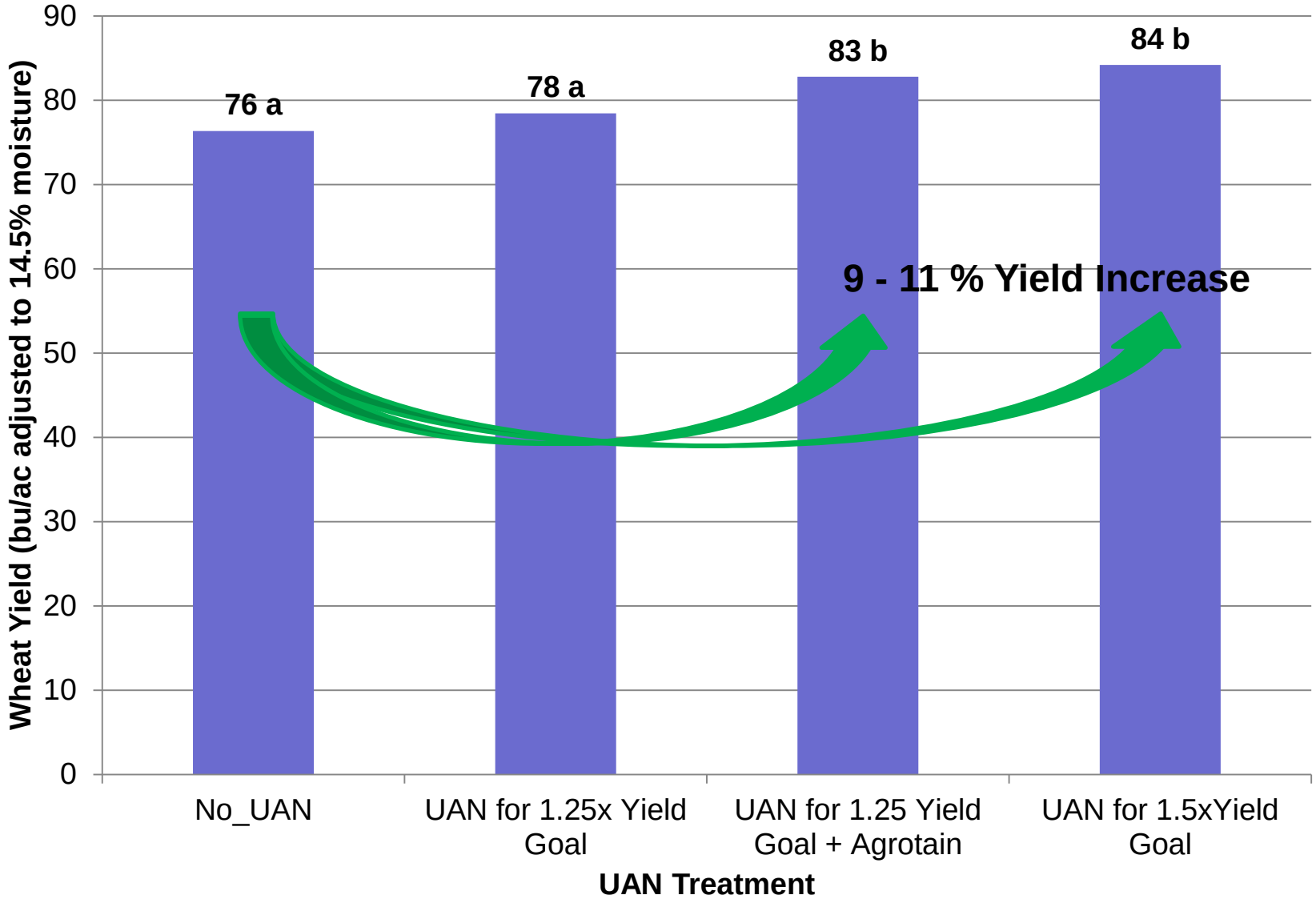
Wheat Stacked Management

(comparing 48 management practices)

Yield Response to UAN

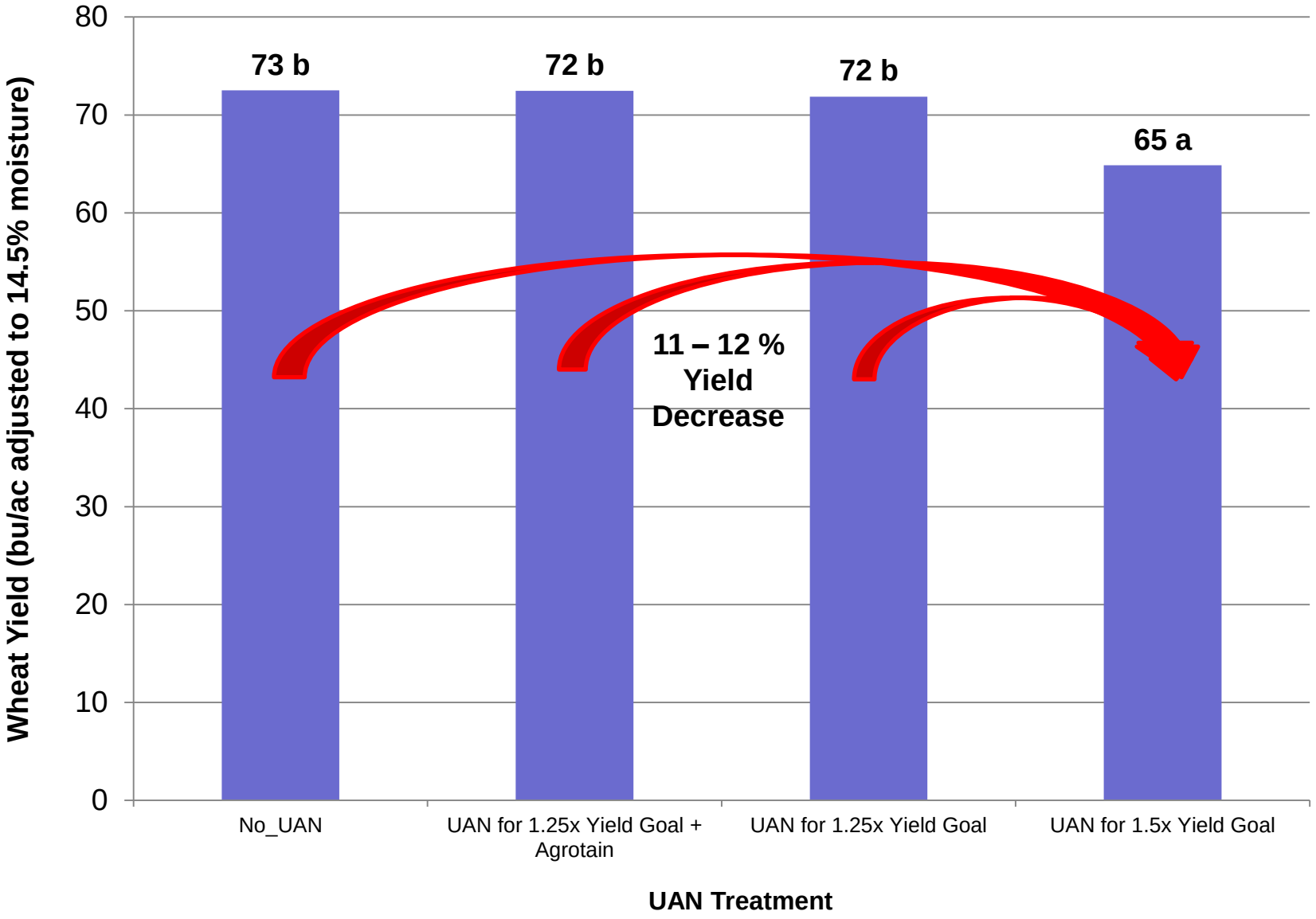
Positive Yield Response at 2 of 5 sites
(Lethbridge – Irrigated; High River)
Negative Yield Response at 1 of 5 sites
(Falher)

High River Wheat Stacked - 2014 Yield



Preliminary Results - Trends must be supported with additional years of data

Falher Wheat Stacked - 2014 Yield



Preliminary Results - Trends must be supported with additional years of data

Wheat Stacked Management

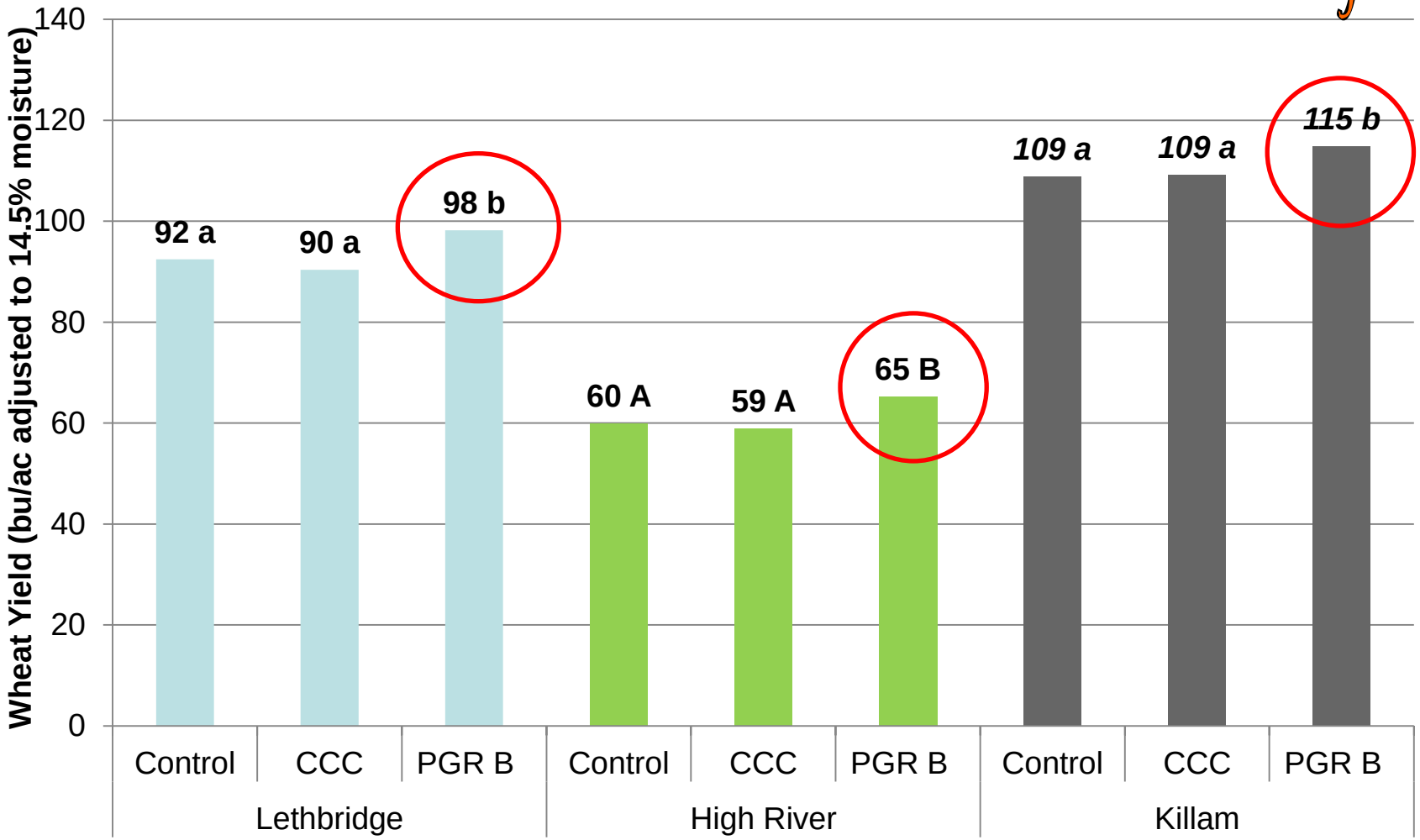
Yield Response to PGR

Significant Yield Responses at all locations

PGR B had significantly higher yields in high moisture environments

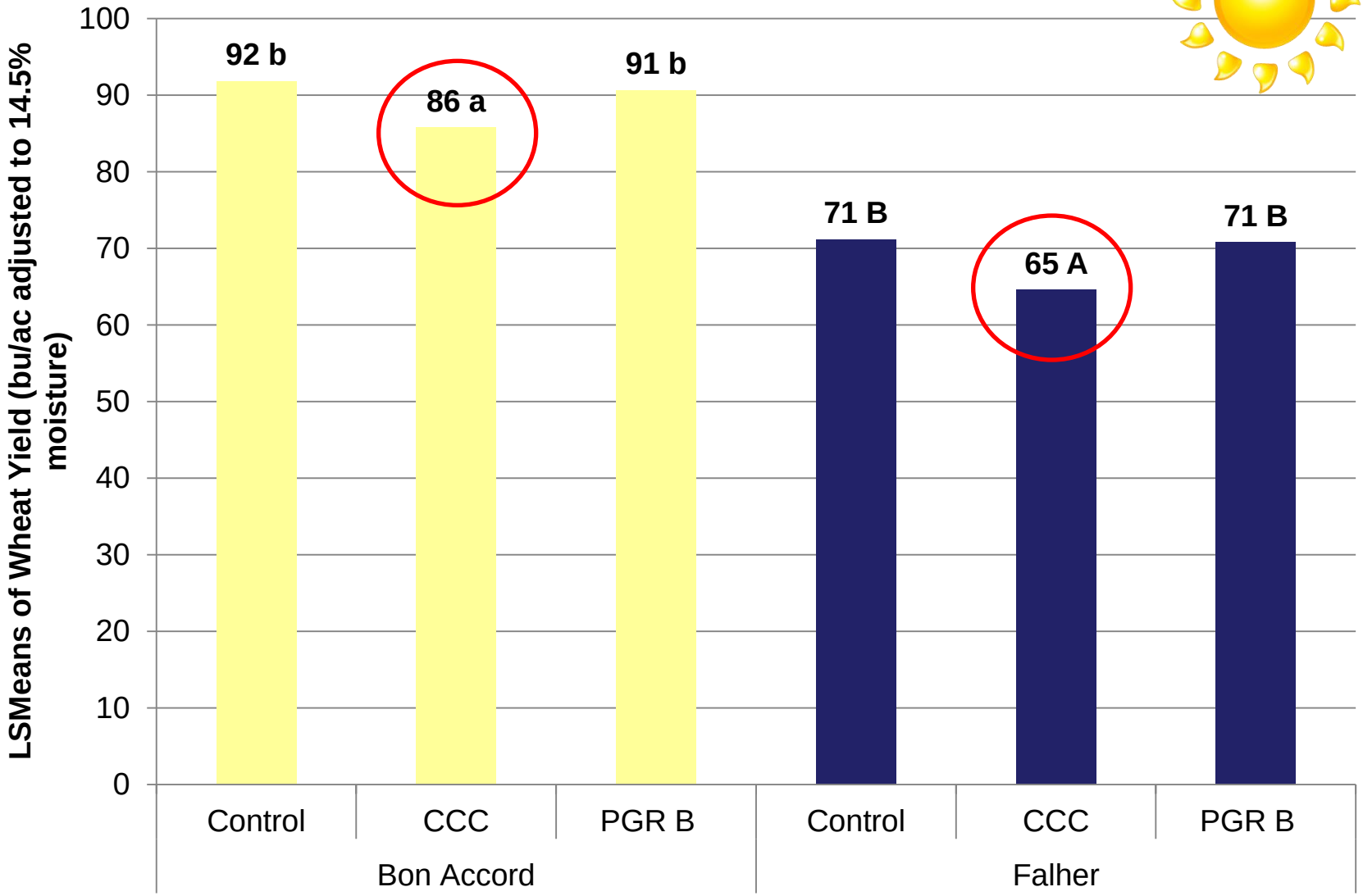
CCC had significantly lower yields in dry environments

Wheat Stacked 2014 - Yield Response to PGR at High to Adequate Moisture Environments



Preliminary Results - Trends must be supported with additional years of data

Wheat Stacked 2014 - Yield Response to PGR at Dry Environments



Preliminary Results - Trends must be supported with additional years of data

Wheat Stacked Management

Yield Response to Fungicide Treatments

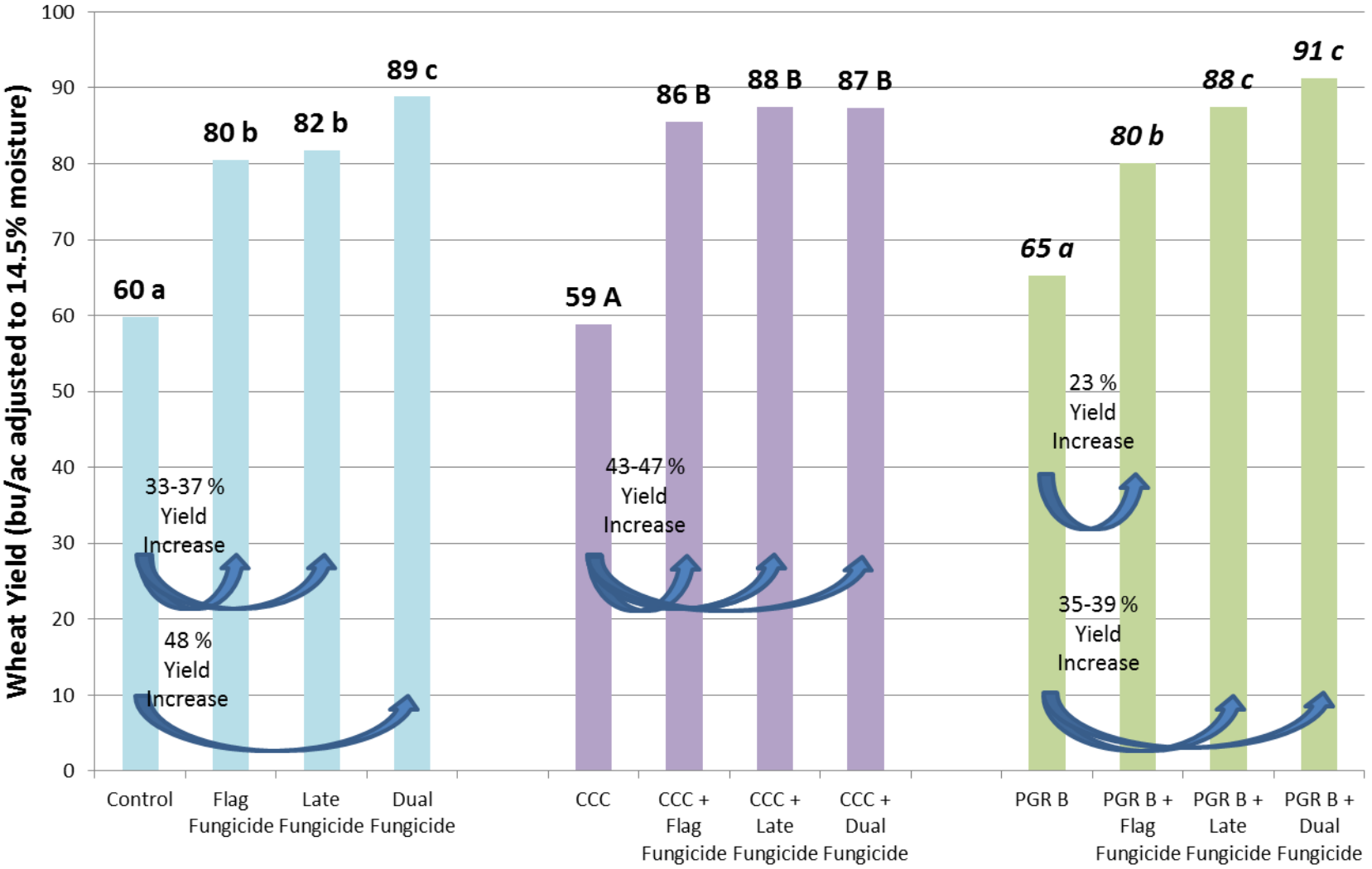
- Positive Yield Response at 4 of 5 sites

(Lethbridge, High River, Killam, Bon Accord)

Yield Response to PGR x Fungicide Treatments

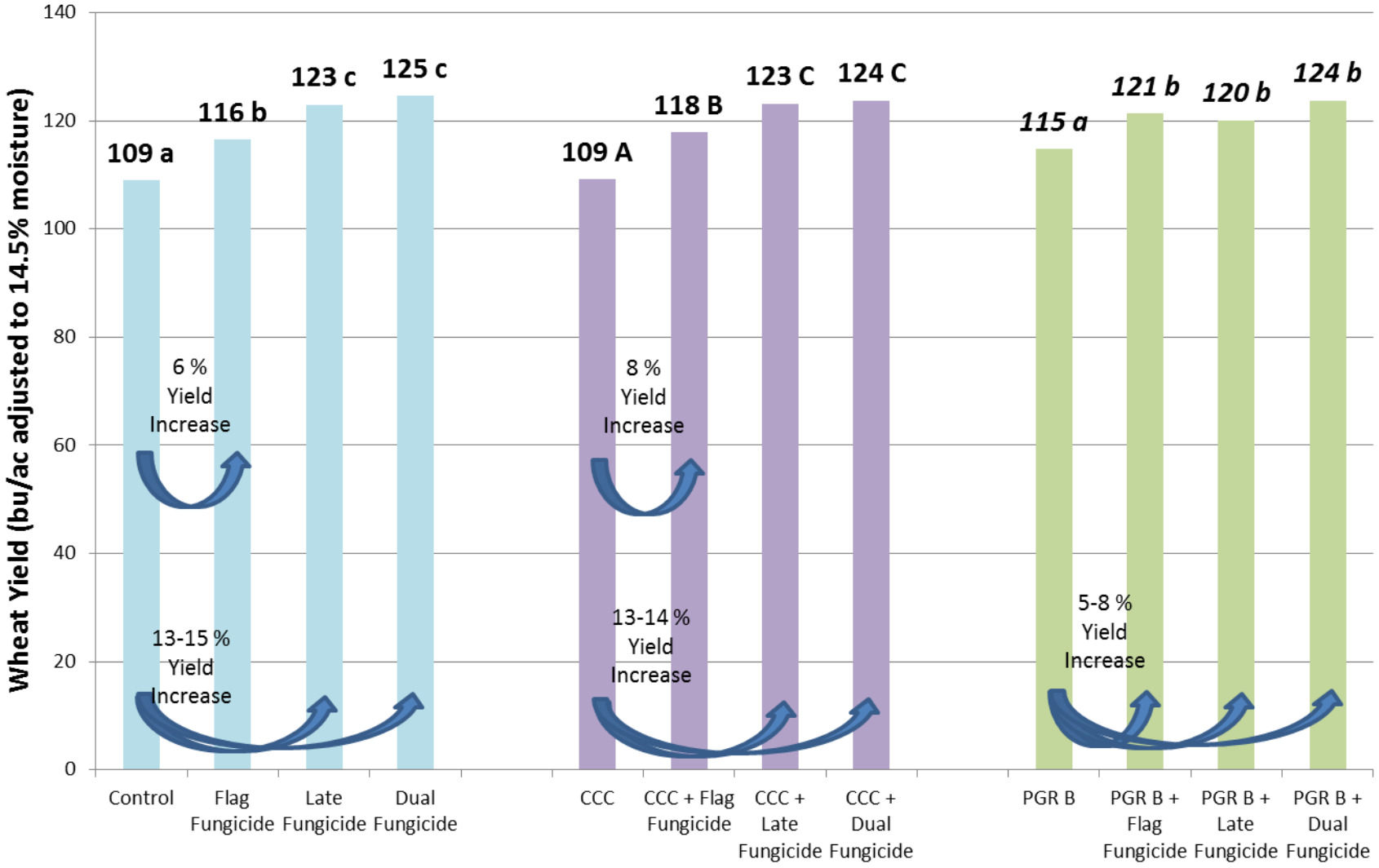
- Positive Yield Response at 4 of 5 sites
  - (Lethbridge, High River, Killam, Bon Accord)

Wheat Stacked 2014 - Yield Response to PGR x Fungicide Treatments - High River



Preliminary Results - Trends must be supported with additional years of data

Wheat Stacked 2014 - Yield Response to PGR x Fungicide Treatments - Killam



Preliminary Results - Trends must be supported with additional years of data

Wheat Stacked Management

Comparing PGR, Early Fungicide, Late Fungicide and Dual Fungicide vs Control

In high moisture environments (Lethbridge, High River & Killam)

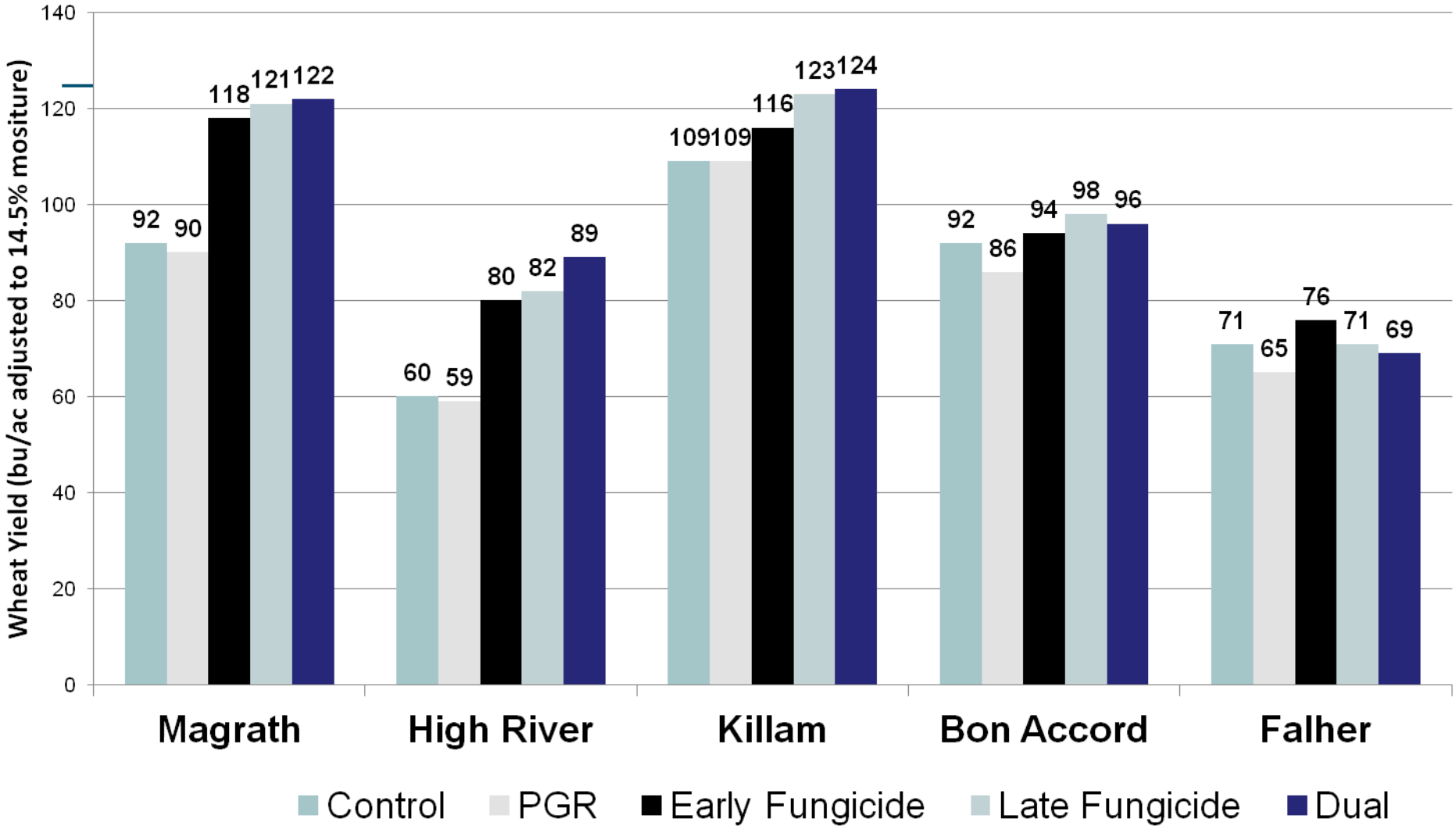
Early Fungicide, Late Fungicide and Dual Fungicide were all profitable

In dry environments (Bon Accord & Falher)

Most management practices resulted in a net loss.

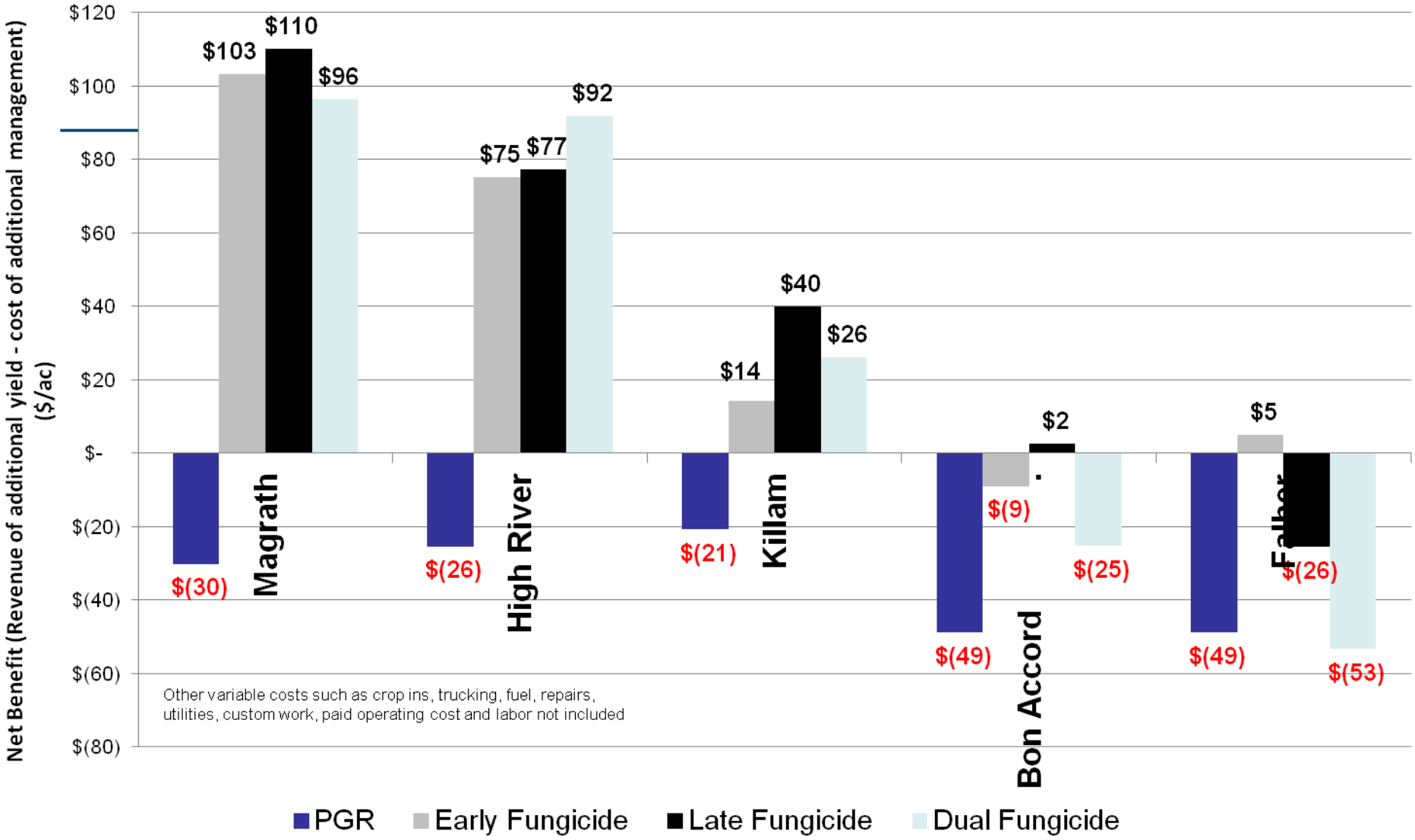
PGR applications resulted in a net loss at all locations

Wheat Stacked Management Yields @ 5 locations - Comparing 5 Management Practices



Economic Analysis Courtesy of:
***Rawlin Thangaraj*, Production Crops Economist**
Economics and Competitiveness, Economics Branch
Alberta Agriculture and Rural Development

Net Economic Benefit - Wheat @ $4.68/bu



Economic Analysis Courtesy of:
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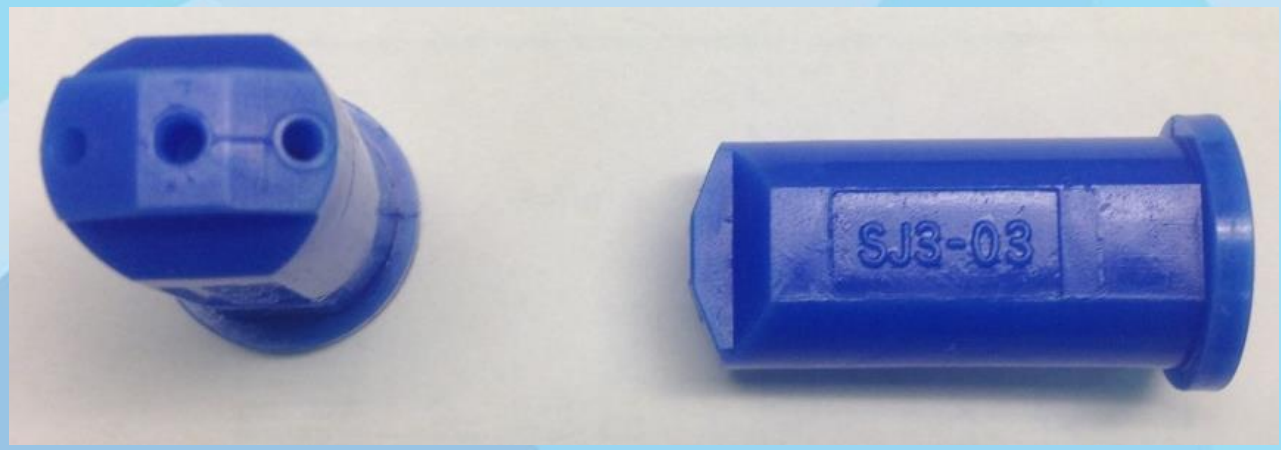
Economics and Competitiveness, Economics Branch
Alberta Agriculture and Rural Development

Wheat Stacked Management Trends

- **UAN**
  - **4-11% yield increase with 60 lbs N/ac @ 2 sites**
  - **11% yield decrease with 60 lbs N/ac @ Falher – dry site**



Preliminary Results - Trends must be supported with additional years of data

Wheat Stacked Management Trends

- PGR
  - In high moisture environments
    - PGR B resulted in a 4 – 8% yield increase vs control
  - In dry environments
    - CCC resulted in a 7 – 8% yield decrease vs control

Preliminary Results - Trends must be supported with additional years of data

Wheat Stacked Management Trends

- **Fungicide**
  - In moist environments (Lethbridge and High River):
    - Single fungicide applications increased yields by 28-37%
    - Dual fungicide applications increased yields by 33- 48%
  - In slightly drier environments (Killam):
    - Fungicide increased yields between 6-15%

Preliminary Results - Trends must be supported with additional years of data

Wheat Genetics x Management

Yield Response

Standard verses Advanced Management

Standard Agronomic Management		
Product	Rate	Timing
Supplemental UAN	n/a	Only N applied at seeding for area average yield goals
PGR	n/a	n/a
Foliar Fungicide	n/a	n/a

Advanced Agronomic Management		
Product	**Rate**	**Timing**
Supplemental UAN	30 lbs N/ac	Just prior to GS 30 (just before elongation). June 13th in Bon Accord
PGR - Manipulator	0.73 L/ac	GS 30-31. June 18th in Bon Accord
1st Foliar Fungicide Twinline	202 mL/ac	GS 39 Flag leaf fully unrolled. July 2nd, Bon Accord
2nd Foliar Fungicide Prosaro	320 mL/ac	2 weeks later . July 15th, Bon Accord

12 Wheat Cultivars Tested

Cultivar	Class	2013 Acres	% of acres	Height	Lodging	% Yield of Check	Distributor
AC Foremost	CPS	360121	7.1%	73 cm	VG	116%	SeCan
AAC Penhold	CPS	new	new	72 cm	Excellent	110%	SeCan
5700PR	CPS	187008	3.7%	75 cm	VG	122%	CPS Canada
KWS Sparrow	GP	new	new	90 cm	VG	113%	KWS
KWS Belvoir	GP	new	new	88 cm	VG	111%	KWS
Harvest	HRS	785530	15.5%	84 cm	VG	102%	FP Genetics
CDC Go	HRS	550664	10.9%	83 cm	G	110%	Public
Stettler	HRS	793134	15.7%	84 cm	G	112%	SeCan
CDC Stanley	HRS	153063	3.0%	87 cm	G	113%	CPS Canada
Thorsby	HRS	new	new	97 cm	2.7	105%	Canterra
Coleman	HRS	new	new	92 cm	1.9	105%	Public -
AC Andrew	SWS	11355	0.2%	79 cm	VG	100%	SeCan

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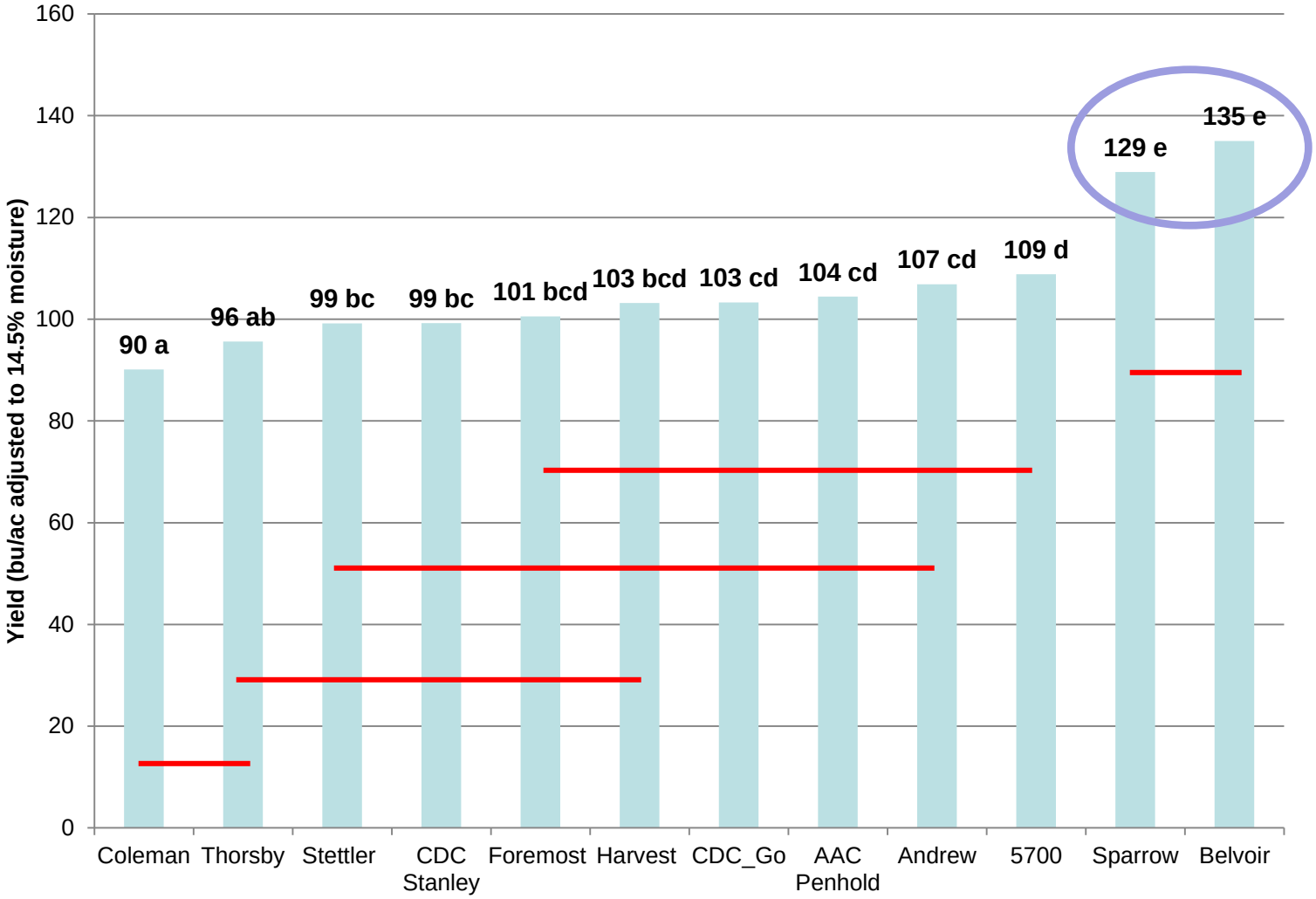
Yield Response to Cultivar

- Belvoir was the top yielding variety at 4 of 5 locations
- Sparrow was the 2nd top yielding variety at 3 of 5 locations

- Coleman was the lowest yielding variety at 2 of 5 locations
- Thorsby was the lowest yielding variety at 2 of 5 locations

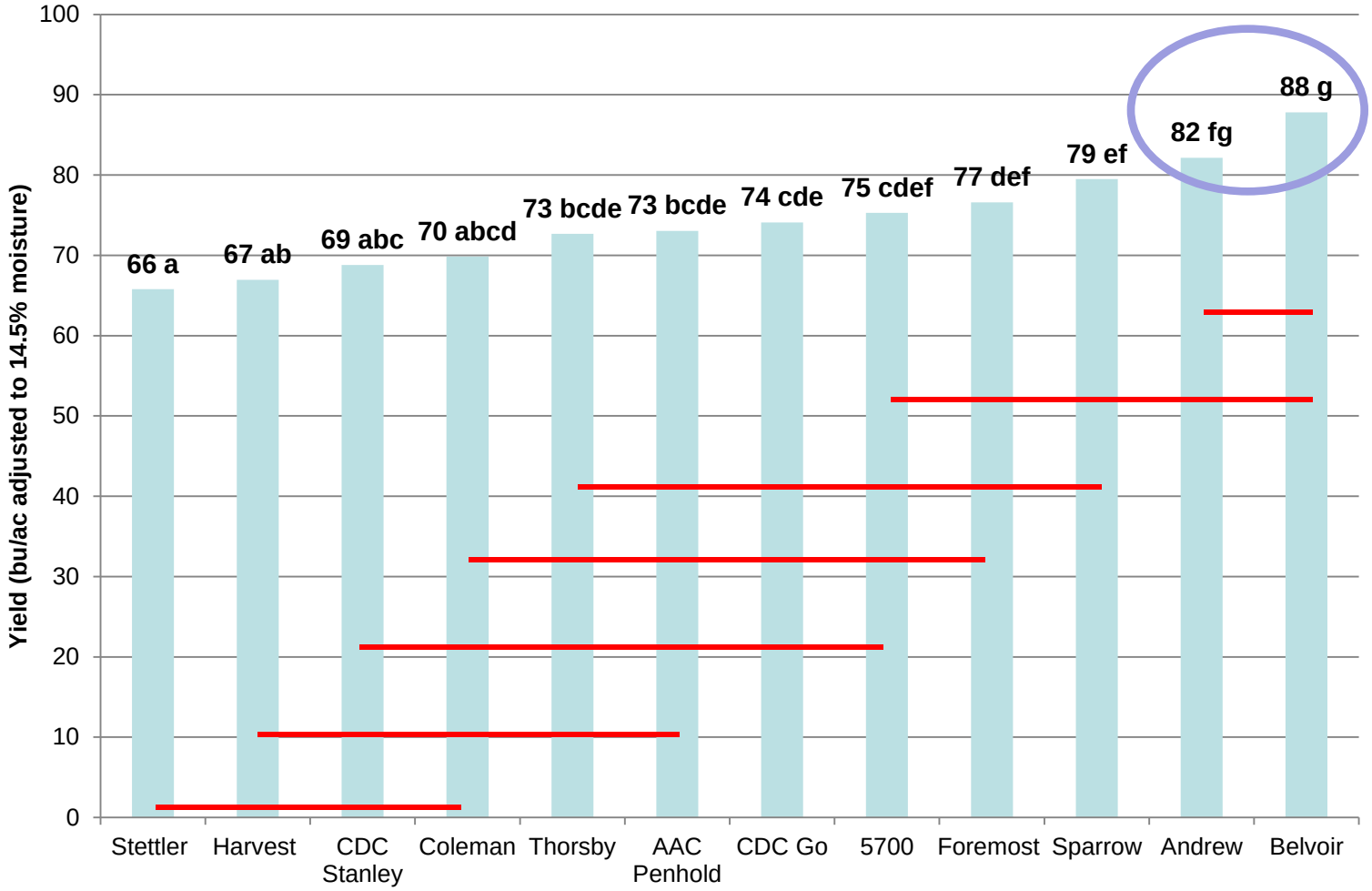
Magrath 2014 - Wheat Genetics x Management Yield



Preliminary Results - Trends must be supported with additional years of data

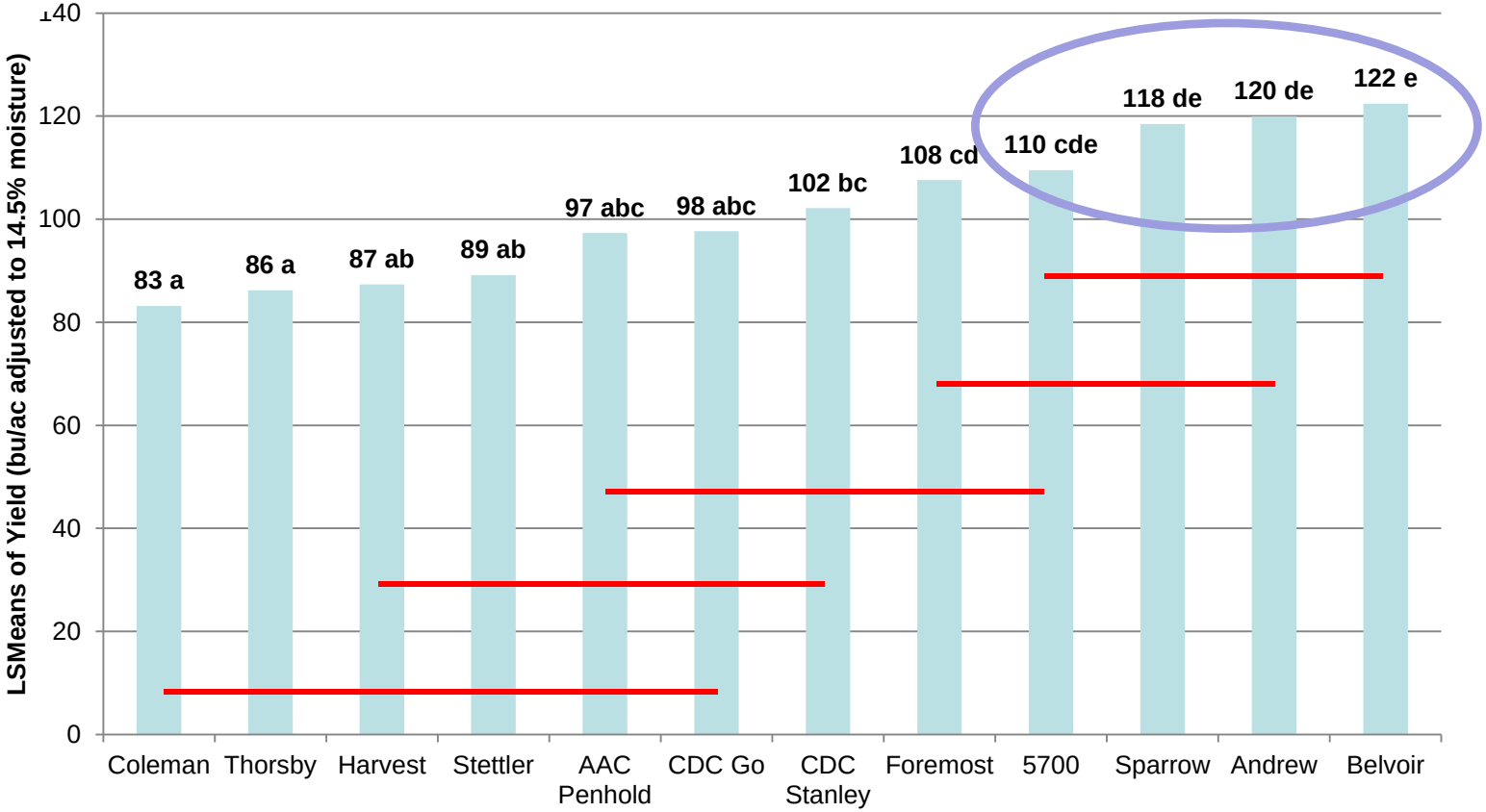
Alberta

High River 2014 - Wheat Genetics x Management
Yield



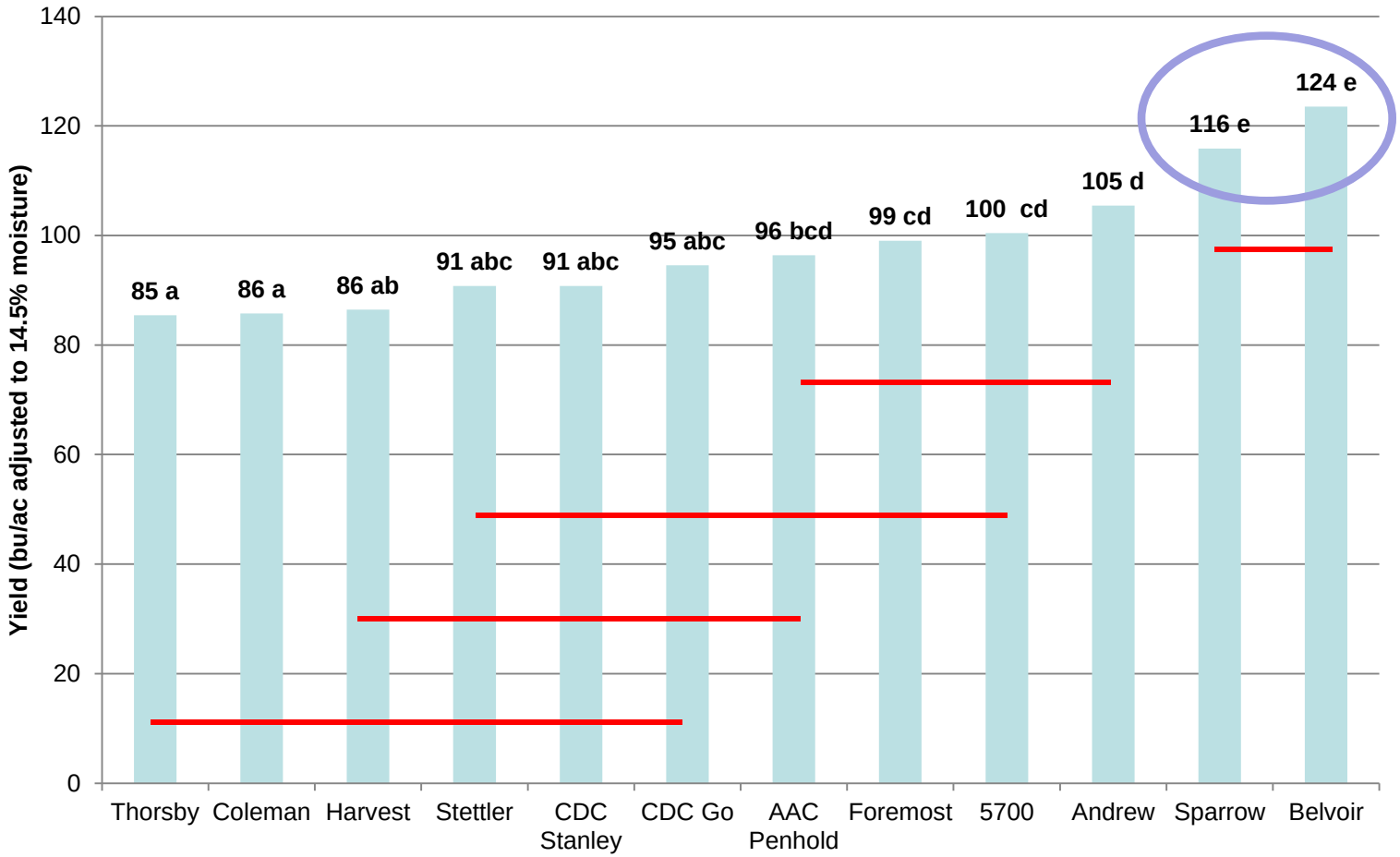
Preliminary Results - Trends must be supported with additional years of data

Killam 2014 - Wheat Genetics x Management Yield

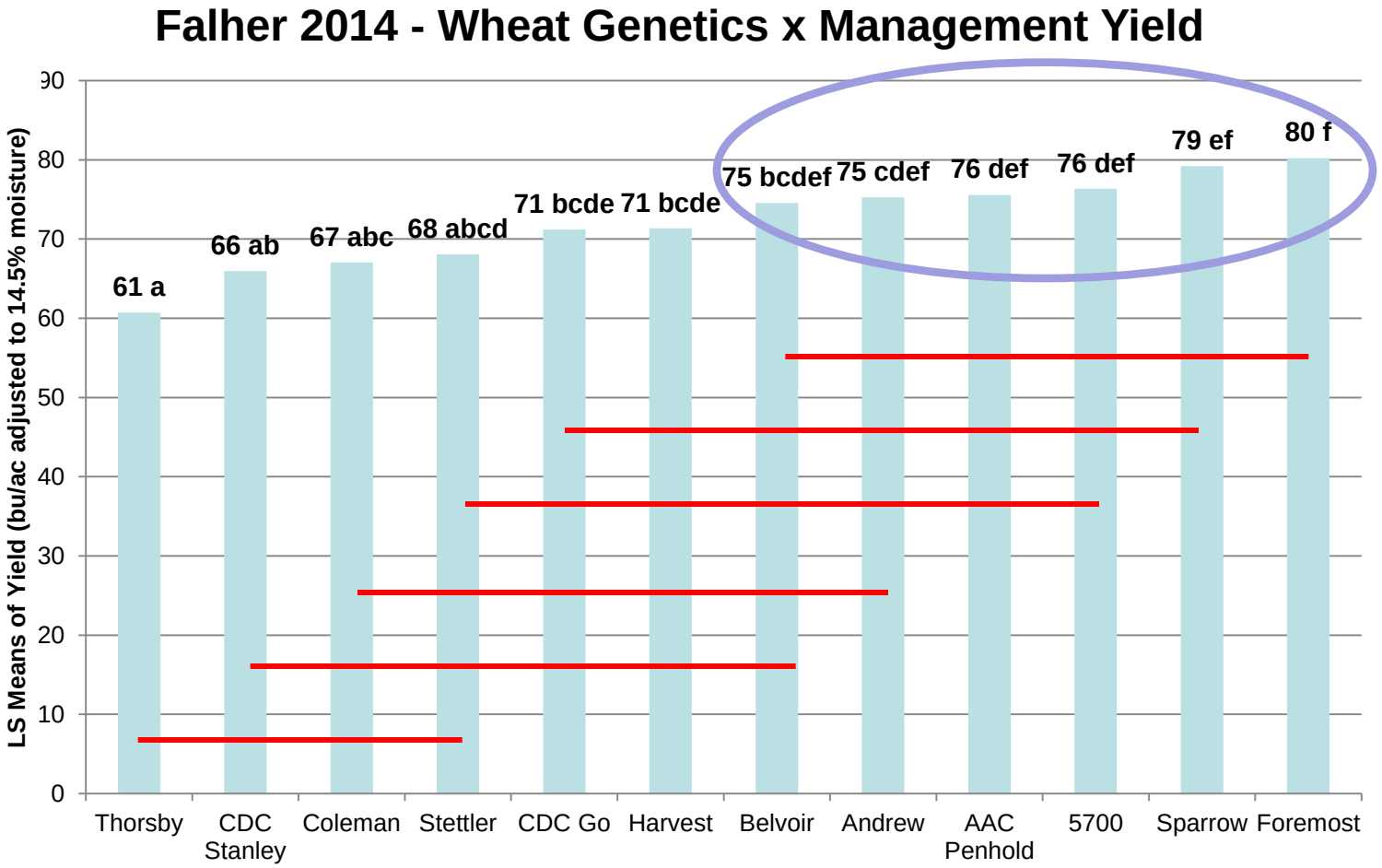


Preliminary Results - Trends must be supported with additional years of data

Bon Accord 2014 - Wheat Genetics x Management Yield



Preliminary Results - Trends must be supported with additional years of data



Preliminary Results - Trends must be supported with additional years of data

Belvoir – August 8th

Sparrow – August 8th

Coleman – August 8th

Thorsby – August 8th

Yield Response to Cultivar x Management

- 5700 and Foremost most often showed a yield response to advanced agronomic management

% Yield Increase with Advanced Management

Cultivar	Magrath	High River	Killam	Bon Accord	Falher	# of responsive sites
5700 (CPS)	18.2%	25.6%	8.8%	9.8%	5.6%	4
Foremost (CPS)	26.2%	36.4%	14.4%	12.9%	1.1%	4
Penhold (CPS)	7.7%	14.3%	14.8%	4.8%	-0.2%	3
Belvoir (GP)	9.6%	11.8%	8.3%	19.3%	-4.3%	3
Sparrow (GP)	8.3%	25.0%	10.4%	6.6%	-4.7%	3
Andrew (SWS)	2.7%	18.9%	7.8%	11.7%	-1.2%	2
CDC Go (HRS)	7.4%	26.5%	16.0%	6.7%	2.6%	3
Coleman (HRS)	13.4%	12.8%	8.0%	17.2%	1.2%	3
Harvest (HRS)	10.2%	22.5%	10.0%	16.9%	2.7%	3
Stettler (HRS)	6.0%	16.2%	28.8%	5.0%	-1.3%	2
Thorsby (HRS)	4.5%	21.4%	6.6%	11.2%	2.5%	2
CDC Stanley (HRS)	6.4%	12.0%	10.6%	6.8%	6.5%	3
Average	**9.9%**	**19.4%**	**11.7%**	**10.8%**	**0.7%**	**4**

Preliminary Results - Trends must be supported with additional years of data

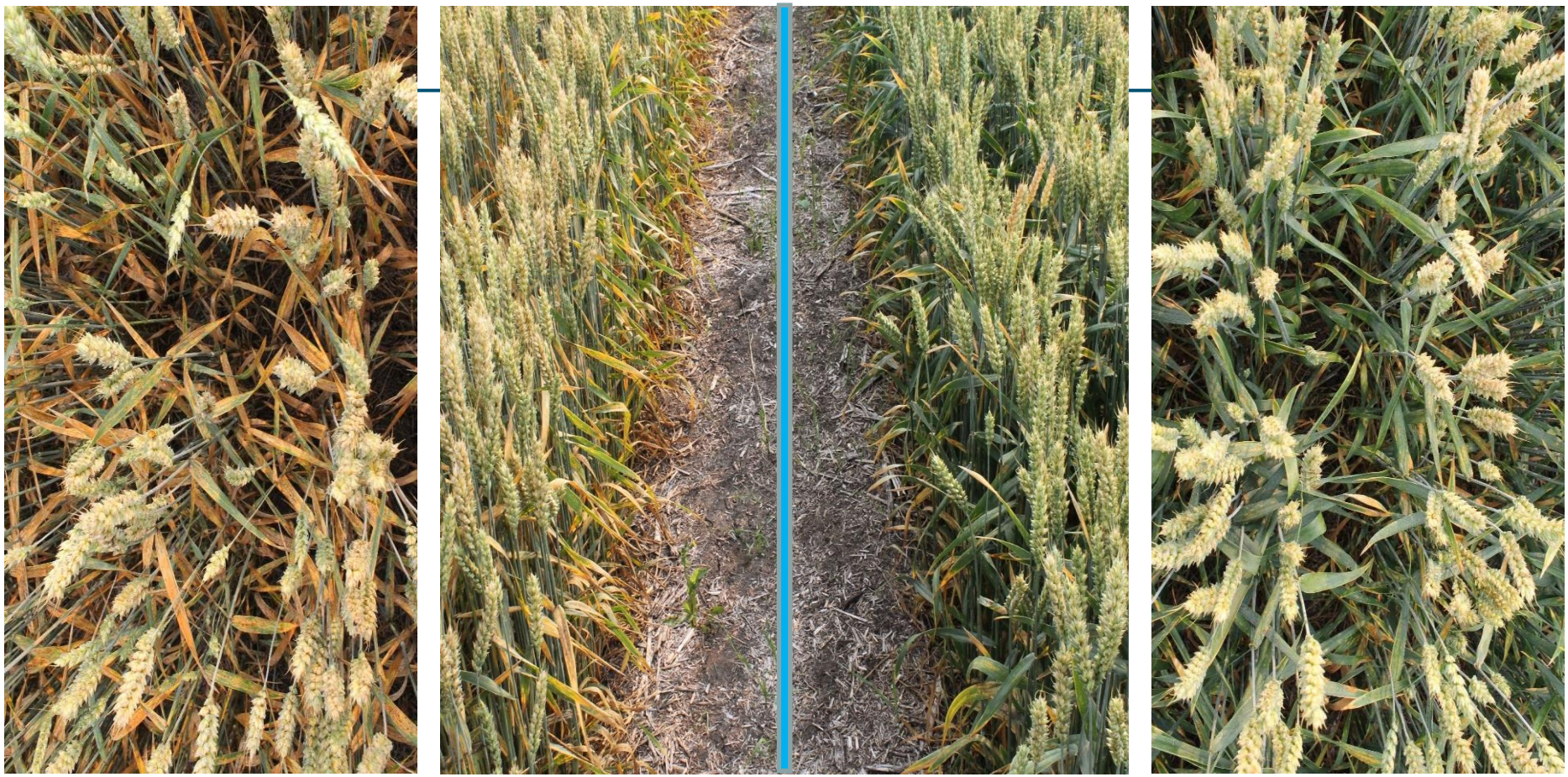
Belvoir @ Bon Accord, Aug 14, 2014

	Standard Agronomy		Advanced Agronomy	
Yield (bu/acre)	113 bu/acre	A	134 bu/acre	B
Height (cm)	80 cm	A	68 cm	B
Lodging	0	NS	0	NS
NDVI	0.50	A	0.58	B

Preliminary Results - Trends must be supported with additional years of data

Alberta

Belvoir @ Bon Accord, Aug 14, 2014



Standard Agronomy

Advanced Agronomy

Alberta

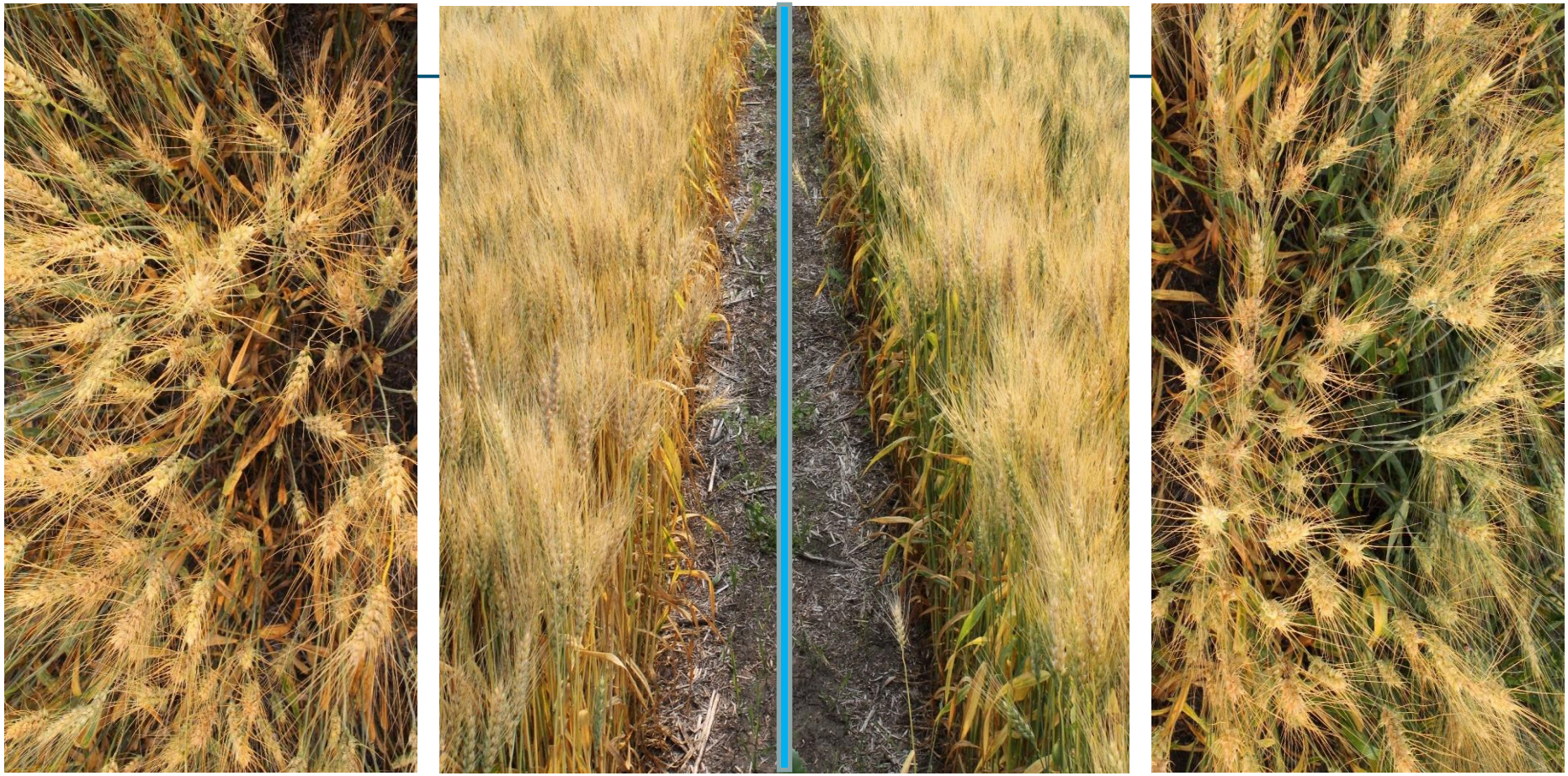
5700 @ Bon Accord, Aug 14, 2014

	Standard Agronomy		Advanced Agronomy	
Yield (bu/acre)	96 bu/acre	A	105 bu/acre	B
Height (cm)	77 cm	A	75 cm	A
Lodging	10	A	5	A
NDVI	0.45	A	0.51	B

Preliminary Results - Trends must be supported with additional years of data

Alberta

5700 @ Bon Accord, Aug 14, 2014



Standard Agronomy

Advanced Agronomy

Barley Stacked Management

(comparing 64 management practices)

Yield Response

Comparing 64 management practices

UAN C	Control 22 plants	CCC 22 plants	Flag Fungicide CCC 22 plants	Late Fungicide CCC 22 plants	Dual Fungicide CCC 22 plants	Flag Fungicide 22 plants	Late Fungicide 22 plants	Dual Fungicide 22 plants	Control 33 plants	CCC 33 plants	Flag Fungicide CCC 33 plants	Late Fungicide CCC 33 plants	Dual Fungicide CCC 33 plants	Flag Fungicide 33 plants	Late Fungicide 33 plants	Dual Fungicide 33 plants
	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164
UAN B	Control 22 plants	CCC 22 plants	Flag Fungicide CCC 22 plants	Late Fungicide CCC 22 plants	Dual Fungicide CCC 22 plants	Flag Fungicide 22 plants	Late Fungicide 22 plants	Dual Fungicide 22 plants	Control 33 plants	CCC 33 plants	Flag Fungicide CCC 33 plants	Late Fungicide CCC 33 plants	Dual Fungicide CCC 33 plants	Flag Fungicide 33 plants	Late Fungicide 33 plants	Dual Fungicide 33 plants
	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148
UAN A	Control 22 plants	CCC 22 plants	Flag Fungicide CCC 22 plants	Late Fungicide CCC 22 plants	Dual Fungicide CCC 22 plants	Flag Fungicide 22 plants	Late Fungicide 22 plants	Dual Fungicide 22 plants	Control 33 plants	CCC 33 plants	Flag Fungicide CCC 33 plants	Late Fungicide CCC 33 plants	Dual Fungicide CCC 33 plants	Flag Fungicide 33 plants	Late Fungicide 33 plants	Dual Fungicide 33 plants
	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132
NO UAN	Control 22 plants	CCC 22 plants	Flag Fungicide CCC 22 plants	Late Fungicide CCC 22 plants	Dual Fungicide CCC 22 plants	Flag Fungicide 22 plants	Late Fungicide 22 plants	Dual Fungicide 22 plants	Control 33 plants	CCC 33 plants	Flag Fungicide CCC 33 plants	Late Fungicide CCC 33 plants	Dual Fungicide CCC 33 plants	Flag Fungicide 33 plants	Late Fungicide 33 plants	Dual Fungicide 33 plants
	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116

Yield Targets for:
Standard & Advanced Agronomic Management

	Magrath	High River	Killam	Bon Accord	Falher
Yield Target			bu/acre		
Feed Barley 1.0x (Standard)	110	80	100	86	81
Feed Barley 1.25x (Advanced)	138	100	125	107	101
Feed Barley 1.5x (Advanced)	165	120	150	128	121
Malt Barley 1.0x (Standard)	110	70	90	97	83

Fertilizer Applied at Seeding - Feed Barley

Location	N	P_2O_5	K_20	S	Cu
Magrath	110 lbs N/ac* 100 lbs N/ac applied in fall 2013 10 lbs N/ac applied at seeding	49 lbs P_2O_5/ac	n/a	n/a	n/a
High River	85 lbs N/ac	22 lbs P_2O_5/ac	n/a	n/a	n/a
Killam	116 lbs N/ac	20 lbs P_2O_5/ac	20 lbs K_2O/ac	5 lbs S/ac	n/a
Bon Accord	79 lbs N/ac	45 lbs P_2O_5/ac	20 lbs K_2O/ac	n/a	n/a
Falher	97 lbs N/ac	50 lbs P_2O_5/ac	20 lbs K_2O/ac	20 lbs S/ac	n/a

Barley Stacked Management – Yield Response

comparison of 64 different management practices

	Magrath	High River	Killam†	Bon Accord*	Falher
Average Yield	142 bu/ac	105 bu/ac	144 bu/ac	149 bu/ac	94 bu/ac
			ANOVA *F* test		
UAN	**<0.0001**	**<0.0001**	**0.0009**	**0.0155**	**0.0464**
Treatment‡	**<0.0001**	**<0.0001**	0.1803	0.4941	**0.0365**
UAN * Treatment‡	0.9967	0.8065	1.0000	1.0000	1.0000
			Contrast *F* test		
No UAN vs UAN	**<0.0001**	**<0.0001**	**0.0433**	**0.0338**	0.2926
22 vs 33 plants/sqft	0.4451	0.9754	0.2603	0.4572	**<0.0001**
No PGR vs PGR	**0.0126**	**<0.0001**	**0.0176**	0.4575	**0.0308**
No Fungicide vs Fungicide	**<0.0001**	**0.0001**	0.9932	0.2310	0.8509
CV %	5.1%	9.6%	16.0%	11.5%	14.3%

† Due to soil variability, data was run with a covariate of soil depth (P = 0.0166) for each individual plot

‡Treatment = the 16 Seeding Rate x PGR x Fungicide treatment combinations

* Note: Yield seems high given amount of precipitation, but field of *Meredith* malt barley surrounding research plots yielded 102 bu/acre with only 50 lbs N fertilizer per acre. Research plots at Bon Accord received a base N fertilizer rate of 79 lbs N fertilizer per acre.

Barley Stacked Management

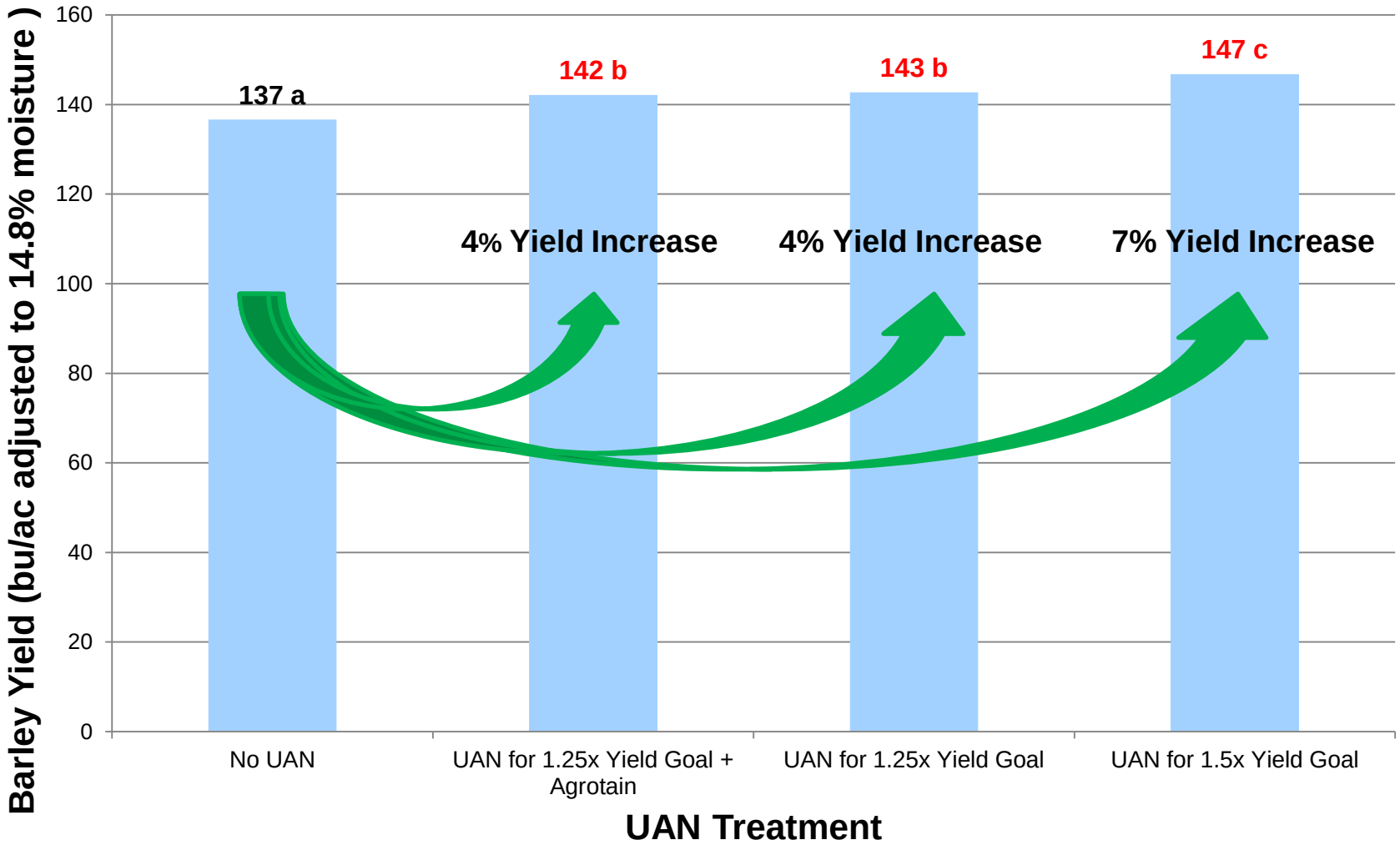
(comparing 64 management practices)

Yield Response to UAN

Positive Yield Response at 4 of 5 sites

(Magrath, High River, Bon Accord and Falher)

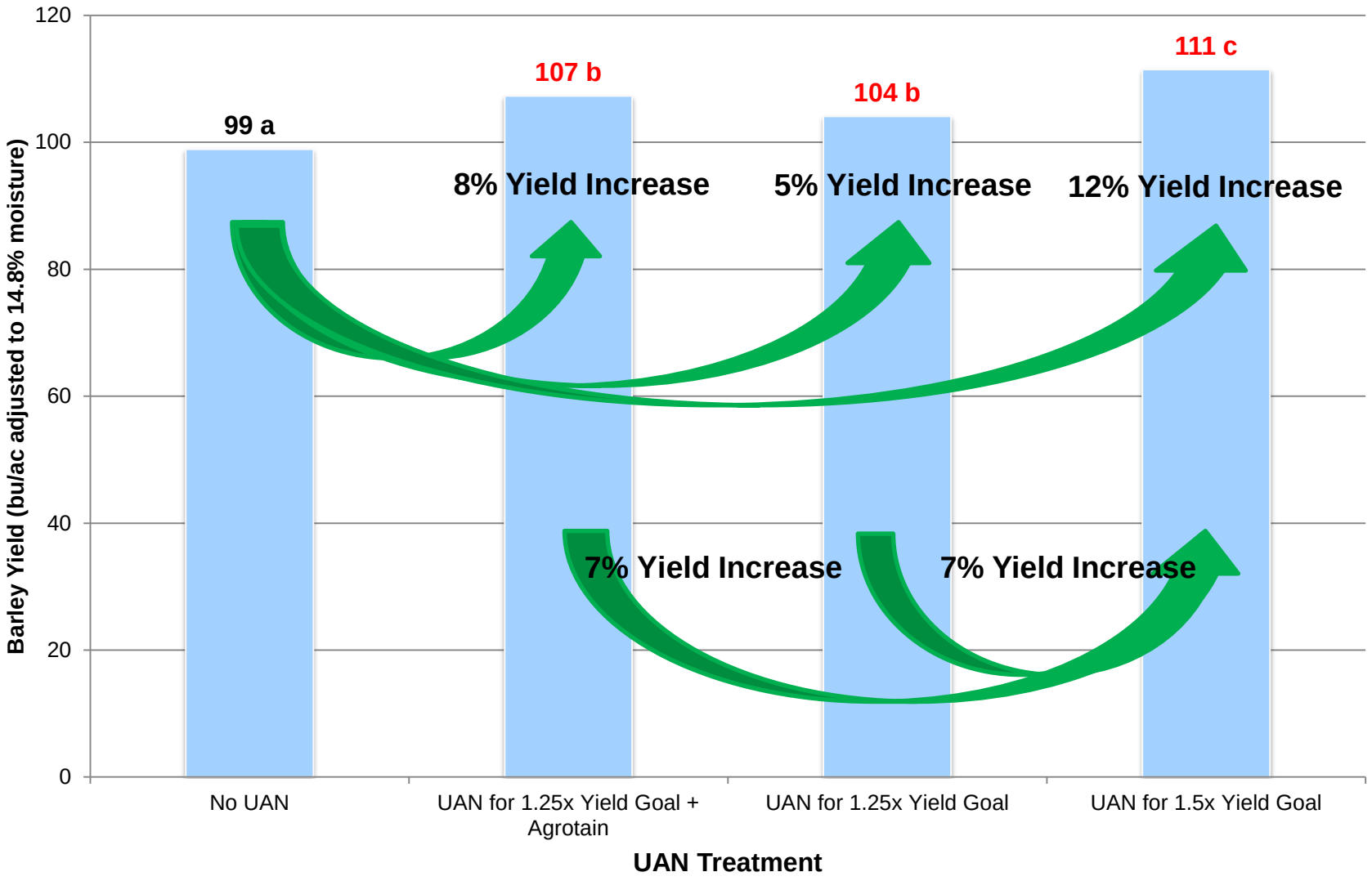
Magrath Barley Stacked – 2014 UAN Treatment Effect on Yield



Preliminary Results - Trends must be supported with additional years of data

Alberta

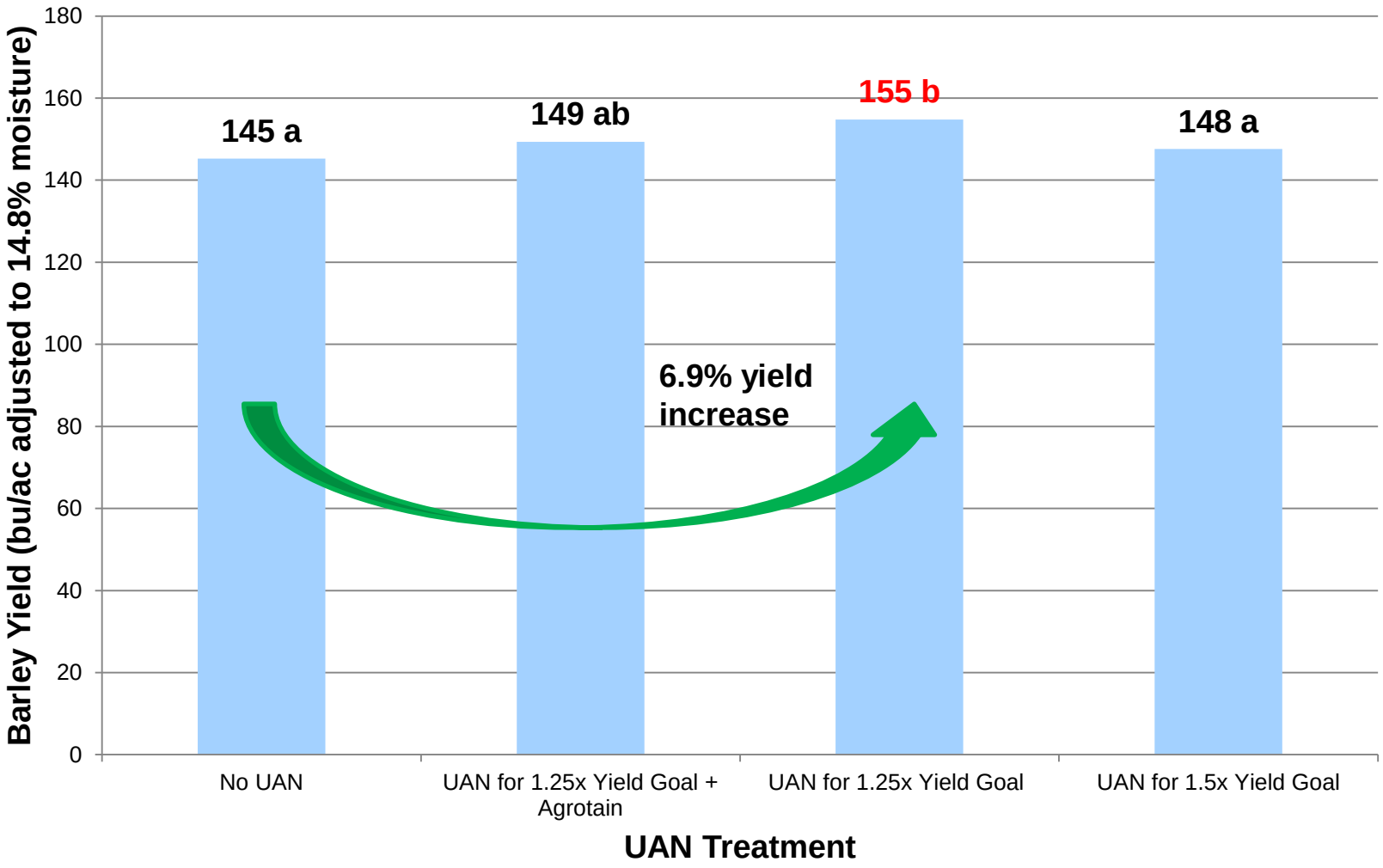
High River Barley Stacked - 2014 UAN Treatment Effect on Yield



Preliminary Results - Trends must be supported with additional years of data

Alberta

Bon Accord Barley Stacked Yield - 2014 UAN Treatment Effect on Yield



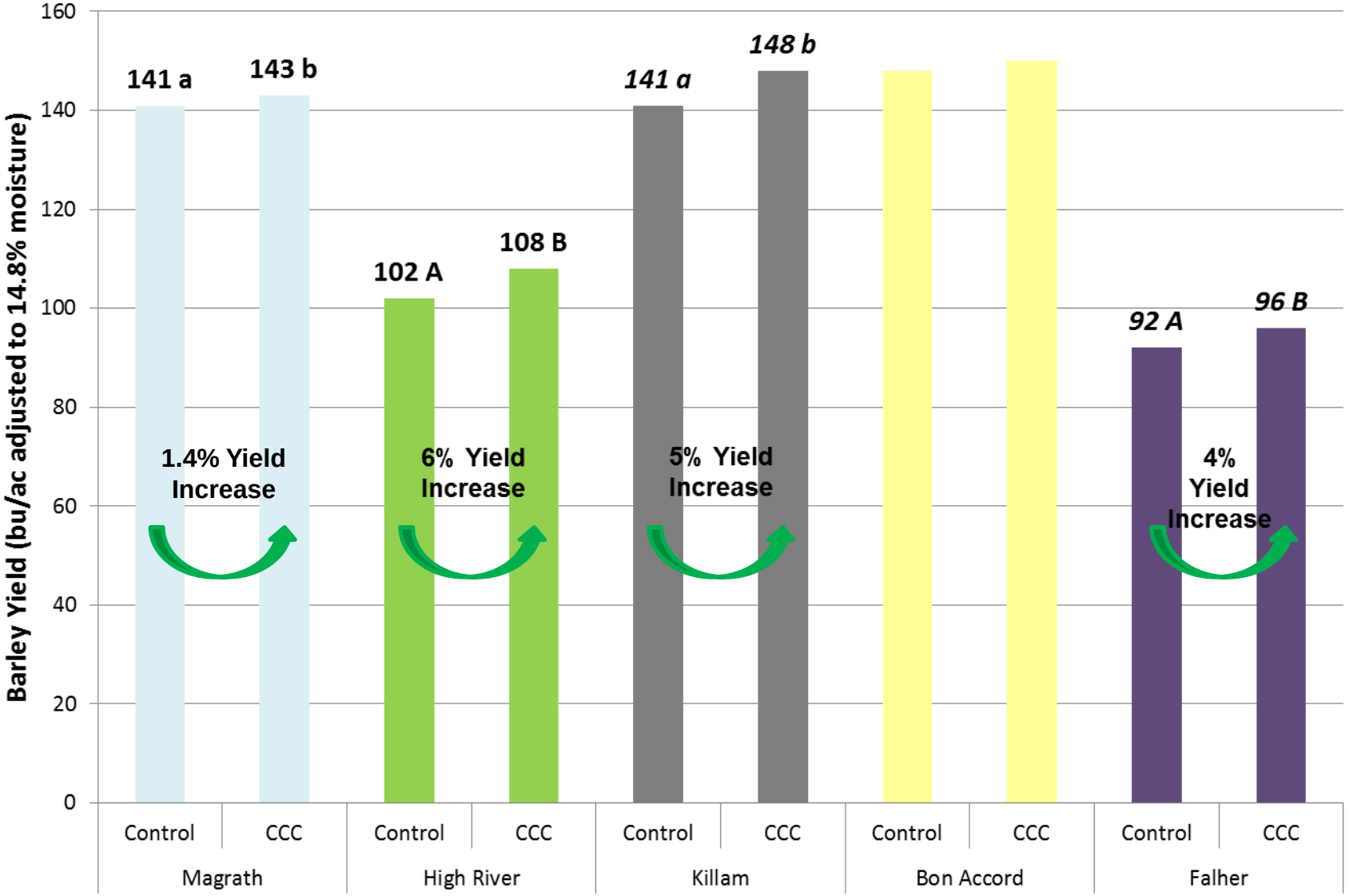
Preliminary Results - Trends must be supported with additional years of data

Barley Stacked Management

Yield Response to PGR

Positive Yield Response at 4 of 5 sites
Magrath, High River, Killam and Falher

Barley Stacked 2014 - Yield Response to PGR



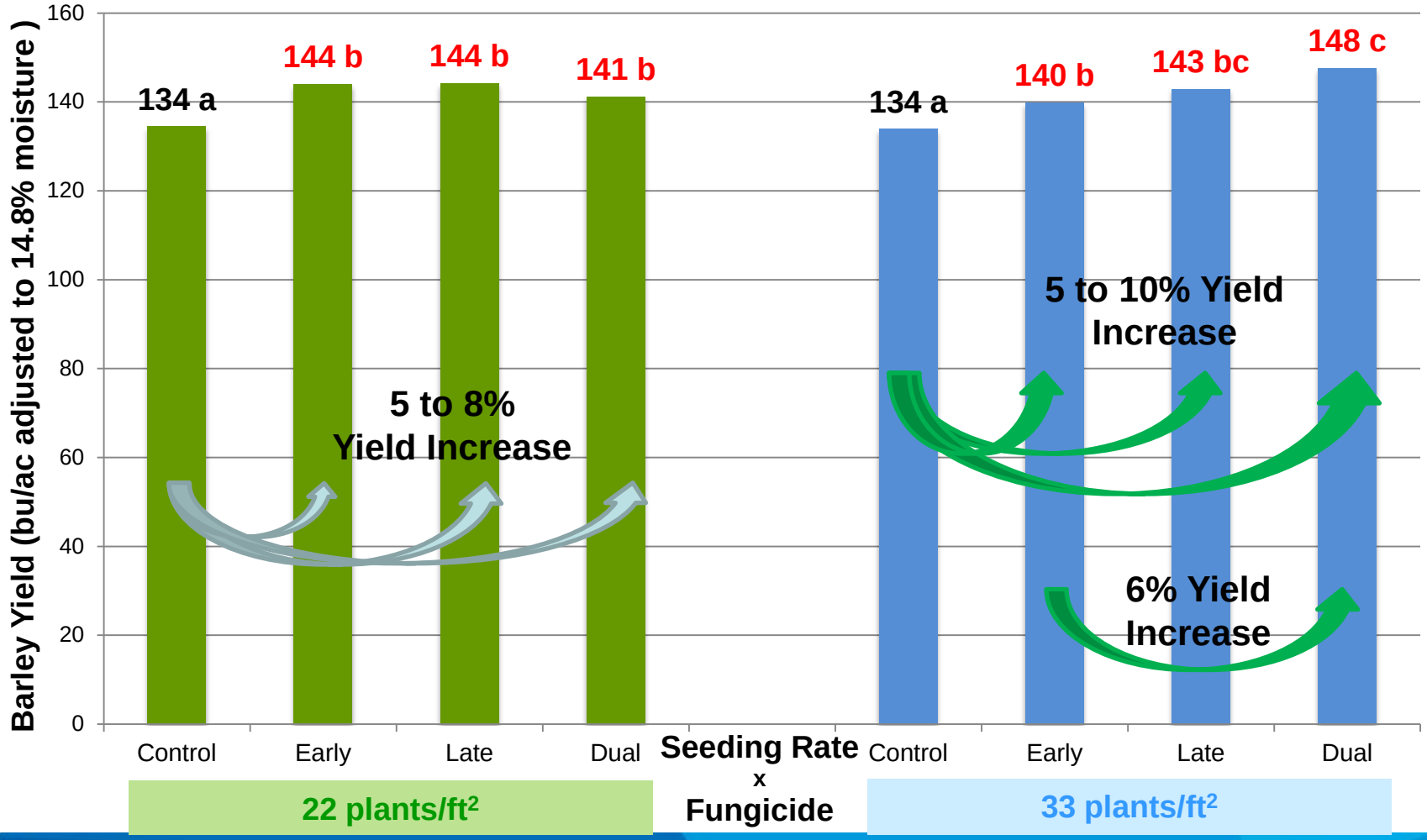
Preliminary Results - Trends must be supported with additional years of data

Barley Stacked Management

Yield Response to Seeding Rate x Fungicide Treatments

Positive Yield Response to Fungicide:
Magrath and High River

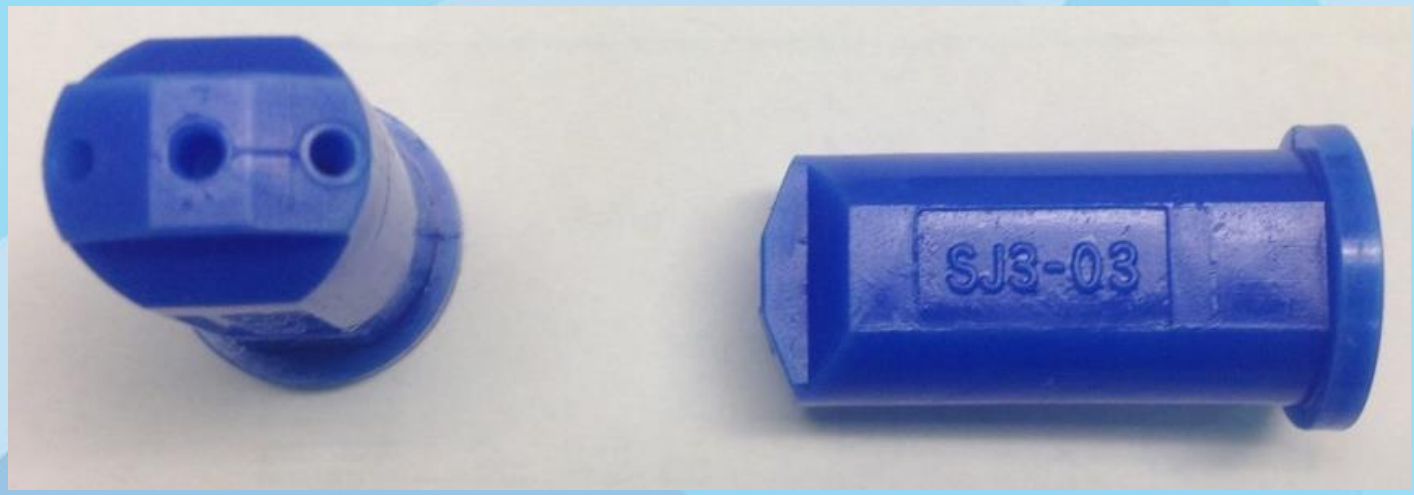
Magrath- 2014
Seeding Rate x Fungicide Effect on Yield



Preliminary Results - Trends must be supported with additional years of data

Barley Stacked Management Trends

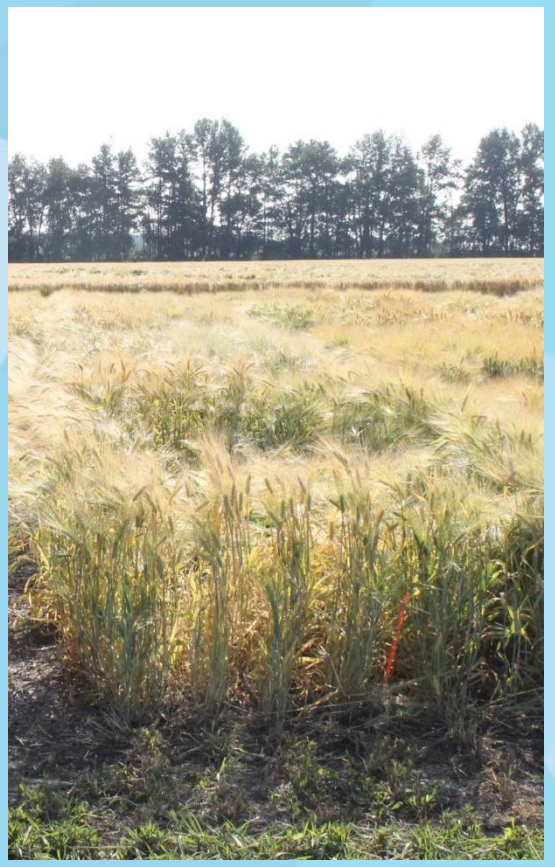
- **UAN**
  - 4-7% yield increase with 30 lbs N/ac @ 3 sites
  - 7-12% yield increase with 60 lbs N/ac @ 2 sites



Preliminary Results - Trends must be supported with additional years of data

Barley Stacked Management Trends

- **PGR**
  - 1.4 – 6% yield increase with CCC
  - Generally small yield increases, no yield decreases
  - Maybe cultivar specific



Preliminary Results - Trends must be supported with additional years of data

Barley Stacked Management Trends

- **Fungicide**
  - Significant response at only 2 of 5 sites
  - Single fungicide application increased yields by 5 - 10%
  - Smaller yield responses on barley (vs. wheat) maybe cultivar dependent

Preliminary Results - Trends must be supported with additional years of data

Barley Genetics x Management

Yield Response

Standard verses Advanced Management

Standard Agronomic Management		
Product	Rate	Timing
Supplemental UAN	n/a	Only N applied at seeding for area average yield goals
PGR	n/a	n/a
Foliar Fungicide	n/a	n/a

Advanced Agronomic Management		
Product	**Rate**	**Timing**
Supplemental UAN	30 lbs N/ac	Just prior to GS 30 (just before elongation). June 13th in Bon Accord
PGR - Manipulator	0.92 L/ac	GS 30-31. June 18th in Bon Accord
1st Foliar Fungicide Twinline	202 mL/ac	GS 39 Flag leaf fully unrolled. July 2nd, Bon Accord
2nd Foliar Fungicide Prosaro	320 mL/ac	2 weeks later . July 15th, Bon Accord

10 Barley Cultivars Tested

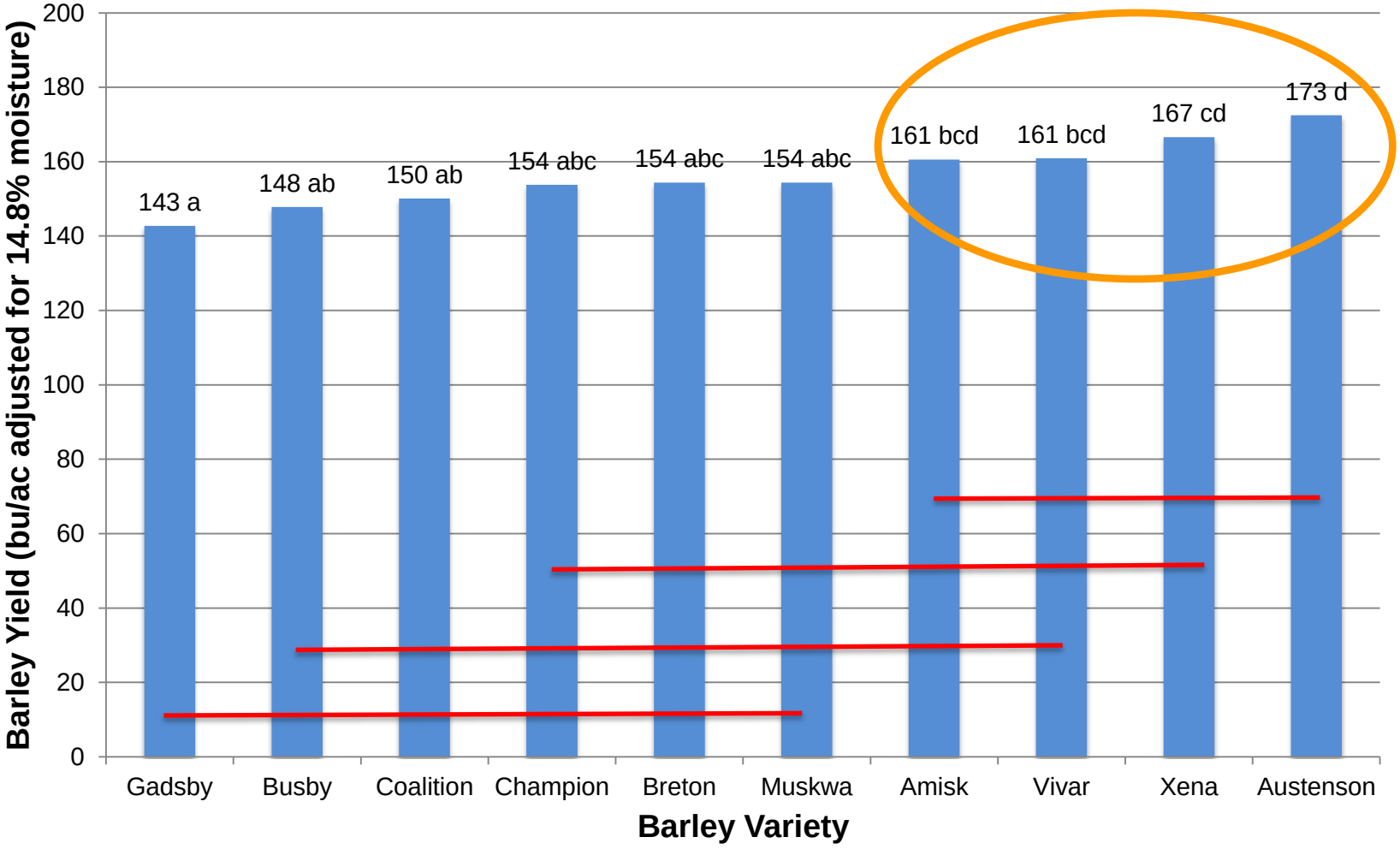
	Cultivar	Class	2013 Acres	% of acres	Height	Lodging	% Yield of Check	Distributor
1	Amisk	Feed - 6 row	new	new	74 cm	VG	similar to Vivar	SeCan
2	Vivar	Feed - 6 row	9182	0.4%	74 cm	VG	110%	SeCan
3	Gadsby	Feed - 2 row	4881	0%	83 cm	F	112%	SeCan
4	CDC Austenson	Feed - 2 row	229211	10%	78 cm	G	112%	SeCan
5	Xena	Feed - 2 row	461104	20%	78 cm	G	112%	CPS Canada
6	Champion	Feed - 2 row	317403	14%	77 cm	G	113%	CPS Canada
7	CDC Coalition	Feed - 2 row	88942	4%	74 cm	G	110%	Canterrra
8	Breton	Feed - 6 row	new	new	81 cm	F	106%	Canterra
9	Muskwa	Feed - 6 row	new	new	73 cm	G	105%	FCDC
10	Busby	Feed - 2 row	23393	1%	78 cm	G	104%	Mastin Seeds

Yield Response to Cultivar

- CDC Coalition was the top yielding variety at 2 of 4 locations
- Vivar was the among the top yielding varieties at 3 of 4 locations

- Busby was the lowest yielding variety at 3 of 5 locations
- Gadsby was the lowest yielding variety at 2 of 5 locations

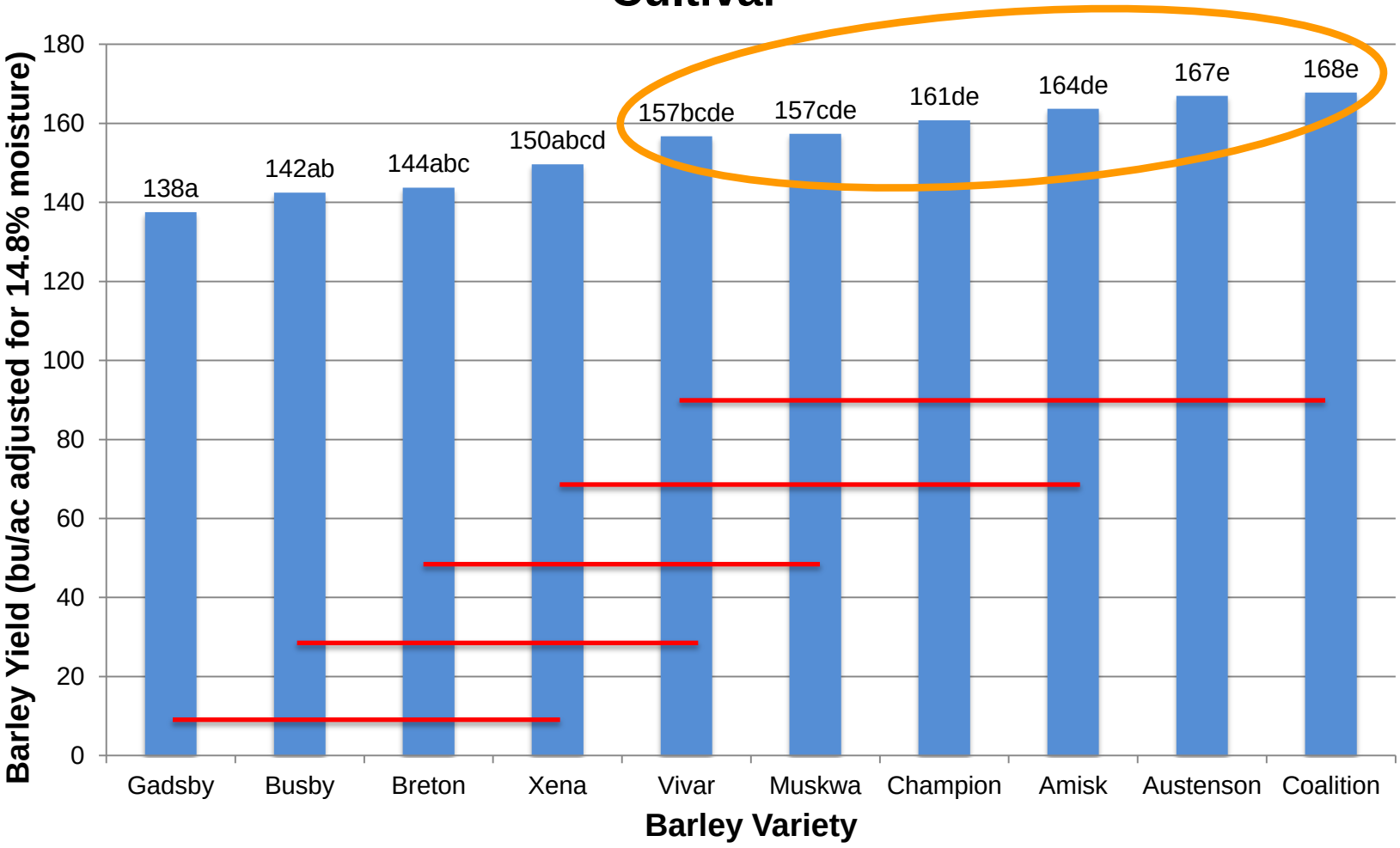
Killam Barley GxM 2014- Yield Response to Cultivar



Preliminary Results - Trends must be supported with additional years of data

Alberta

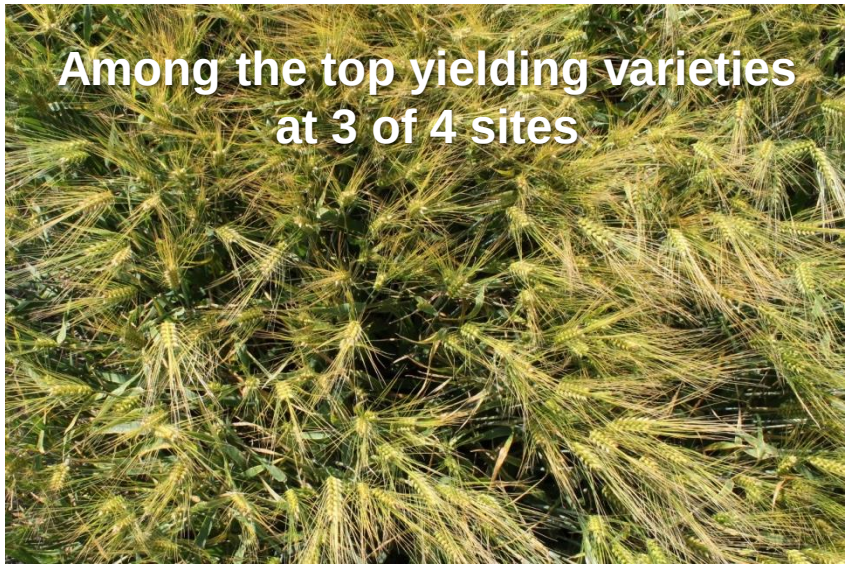
Bon Accord Barley GxM 2014- Yield Response to Cultivar



Preliminary Results - Trends must be supported with additional years of data

Alberta

CDC Coalition – August 12th



Vivar – August 12th

Busby – August 12th

Gadsby – August 12th

Yield Response to Cultivar x Management

- Breton
- Xena
- CDC Coalition
- CDC Austenson

most often showed a yield response to advanced agronomic management

% Yield Increase with Advanced Management

Cultivar	Magrath	High River	Killam	Bon Accord	Falher	# of positive site responses
Breton	**12.8†**	**11.9**	**10.2**	**10.7**	-2.3	4
Xena	**31.4**	**16.3**	**12.6**	5.2	2.8	3
CDC Coalition	**27.6**	**14.3**	8.5	**12.0**	-2.2	3
CDC Austenson	5.6	**21.5**	**13.0**	**13.1**	-1.1	3
Amisk	**15.5**	**26.1**	**-10.2**	1.1	0.0	2
Busby	**16.3**	**20.5**	3.4	9.4	1.5	2
Gadsby	**10.4**	**12.4**	-3.8	3.4	0.7	2
Muskwa	**10.2**	**11.5**	0.4	3.3	3.2	2
Champion	0.3	**12.6**	7.2	**10.0**	-2.0	2
Vivar	7.1	**15.2**	5.4	5.4	7.5	1
Average	**13.7**	**16.2**	**4.7**	**7.4**	0.8	

† Values highlighted in red indicate a significant yield difference between standard & advanced management

Alberta

Preliminary Results - Trends must be supported with additional years of data

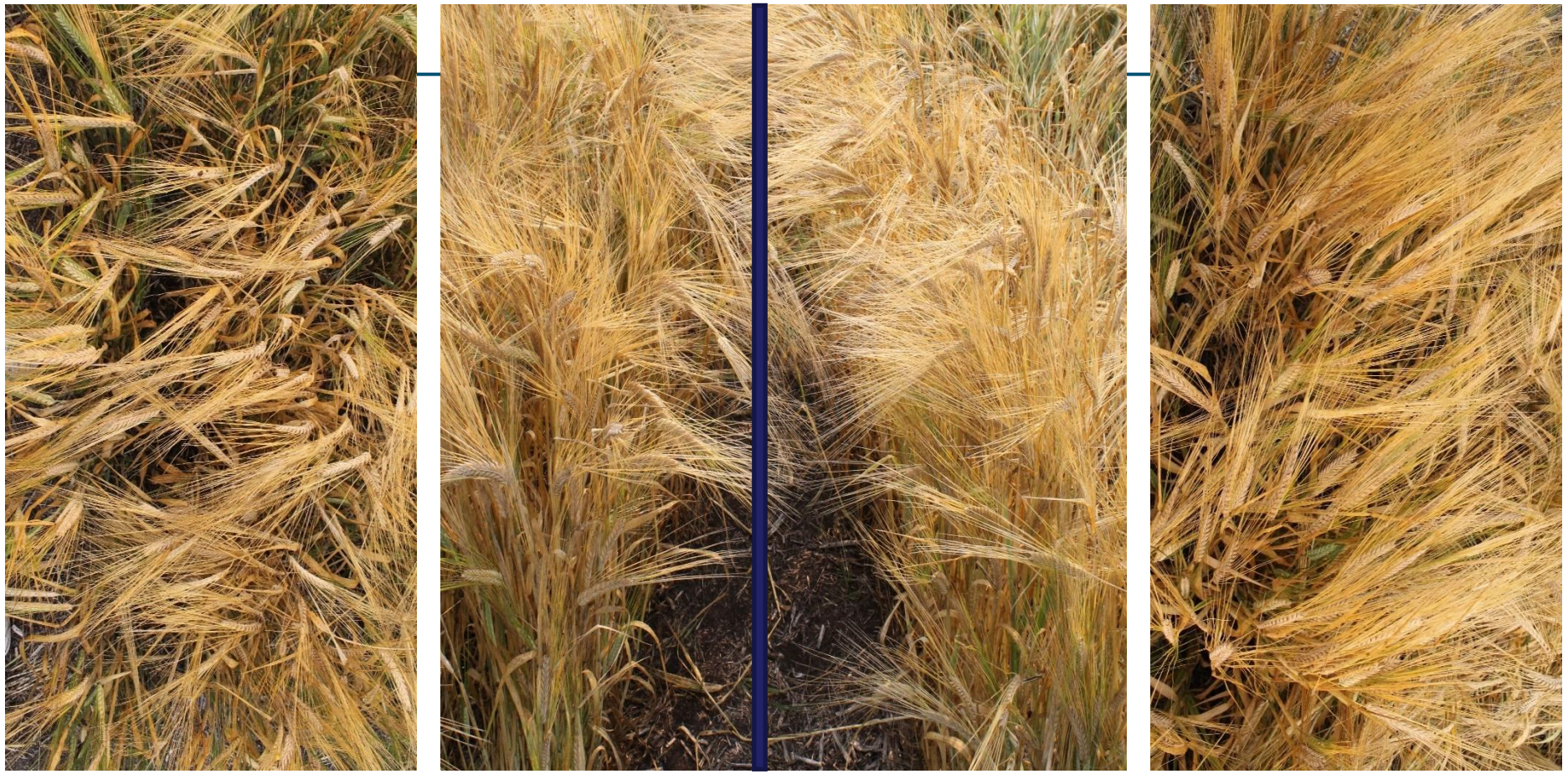
CDC Austenson @ Bon Accord – August 12, 2014

	Standard Agronomy		Advanced Agronomy	
Yield (bu/acre)	157 bu/ac	A	177 bu/ac	B
Height (cm)	77 cm		78 cm	
Lodging	37		38	
NDVI	0.68		0.71	
Head Length	7.6 cm		8.5 cm	

Preliminary Results - Trends must be supported with additional years of data

Alberta

CDC Austenson



Standard Agronomy

Advanced Agronomy

Barley Genetics x Management Trends

- **Summary**
  - CDC Coalition and Vivar were among the top yielding varieties
  - Busby and Gadsby were among the lowest yielding varieties
  - Advanced management significantly increased yields at 4 of 5 sites
  - Advanced management increased yields from 5-16%

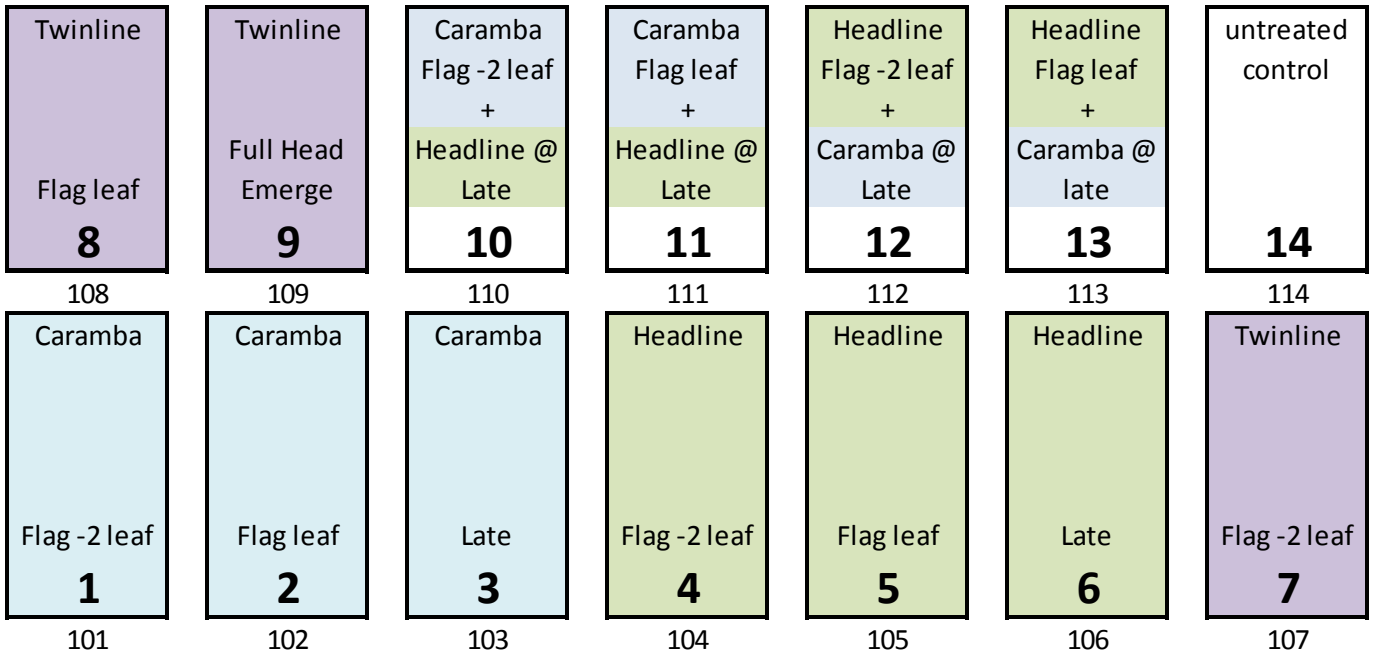
Preliminary Results - Trends must be supported with additional years of data

Malt Barley Fungicide Trial

Yield Response

14 Treatments:

- 3 fungicides (Caramba, Headline, Twinline)
- 3 spray timings (Flag -2, Flag, Late)
- Dual applications
- Untreated control



AC Metcalfe

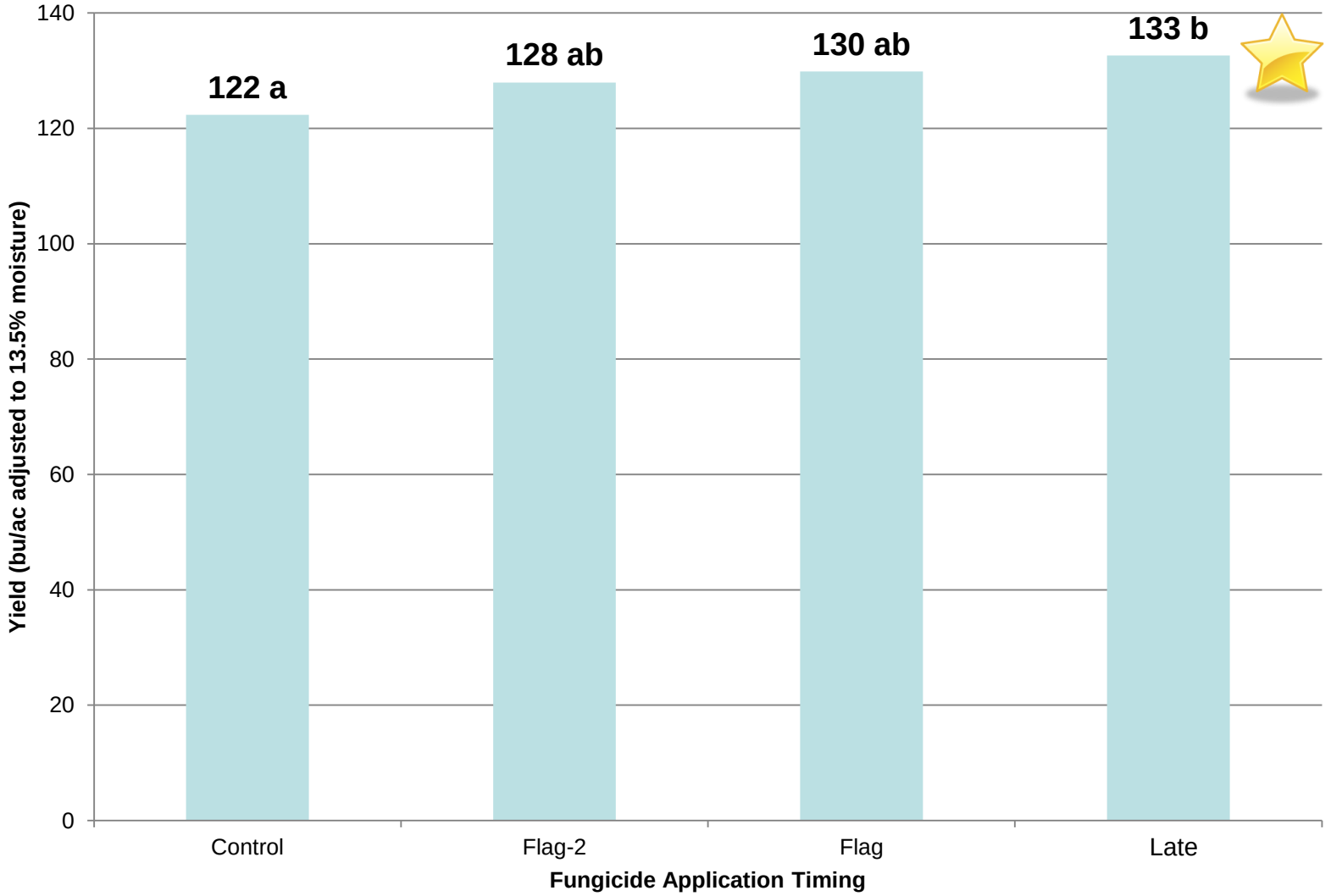
Disease	AC Metcalfe Disease Resistance Ratings
Common Root Rot Resistance	Fair
False and Covered Smut Resistance	Fair
Fusarium Head Blight Tolerance	Fair
Loose Smut Resistance	Very Good
Net Blotch (Net Form) Resistance	Very Poor
Net Blotch (Spot Form) Resistance	Fair
Scald Resistance	Very Poor

Yield Response to Fungicide & Application Timing

Positive Yield Response to Fungicide at 4 of 5 sites

Timing of Fungicide mattered at 1 of 5 locations

Bon Accord 2014 - Malt Barley Fungicide Yield



Preliminary Results - Trends must be supported with additional years of data

Yield Response to Different Fungicide Groups

Yields Differed Depending on Type of Fungicide at 3 of 5 sites

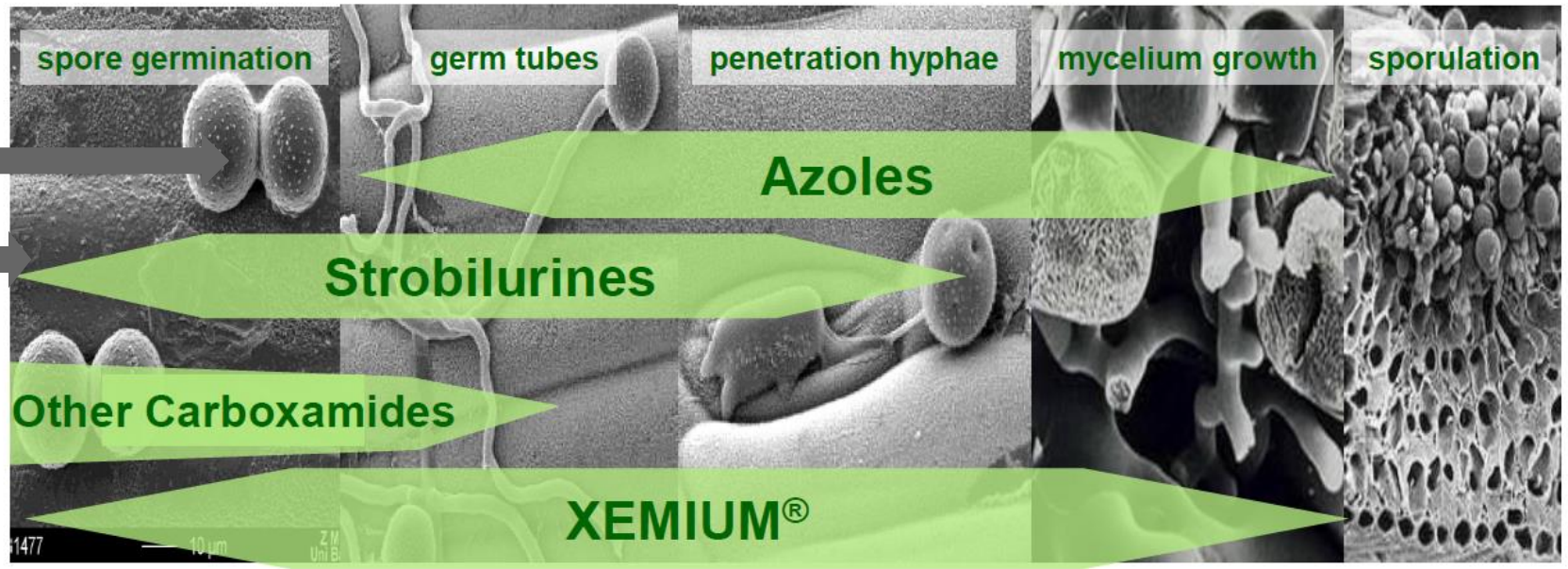
Fungicide Groups Tested in Study

Fungicide	Group	Active	Rate
Caramba	Group 3	Metconazole 90 g/L	283 mL/acre 699 mL/ha
Headline	Group 11	Pyraclostrobin 250g/L	240 mL/acre 593 mL/ha
Twinline	Group 3+11	Metconazole 90 g/L + Pyraclostrobin 130 g/L Note: the reduced concentration of pyraclostrobin vs Headline	202 mL/ac 499 mL/ha

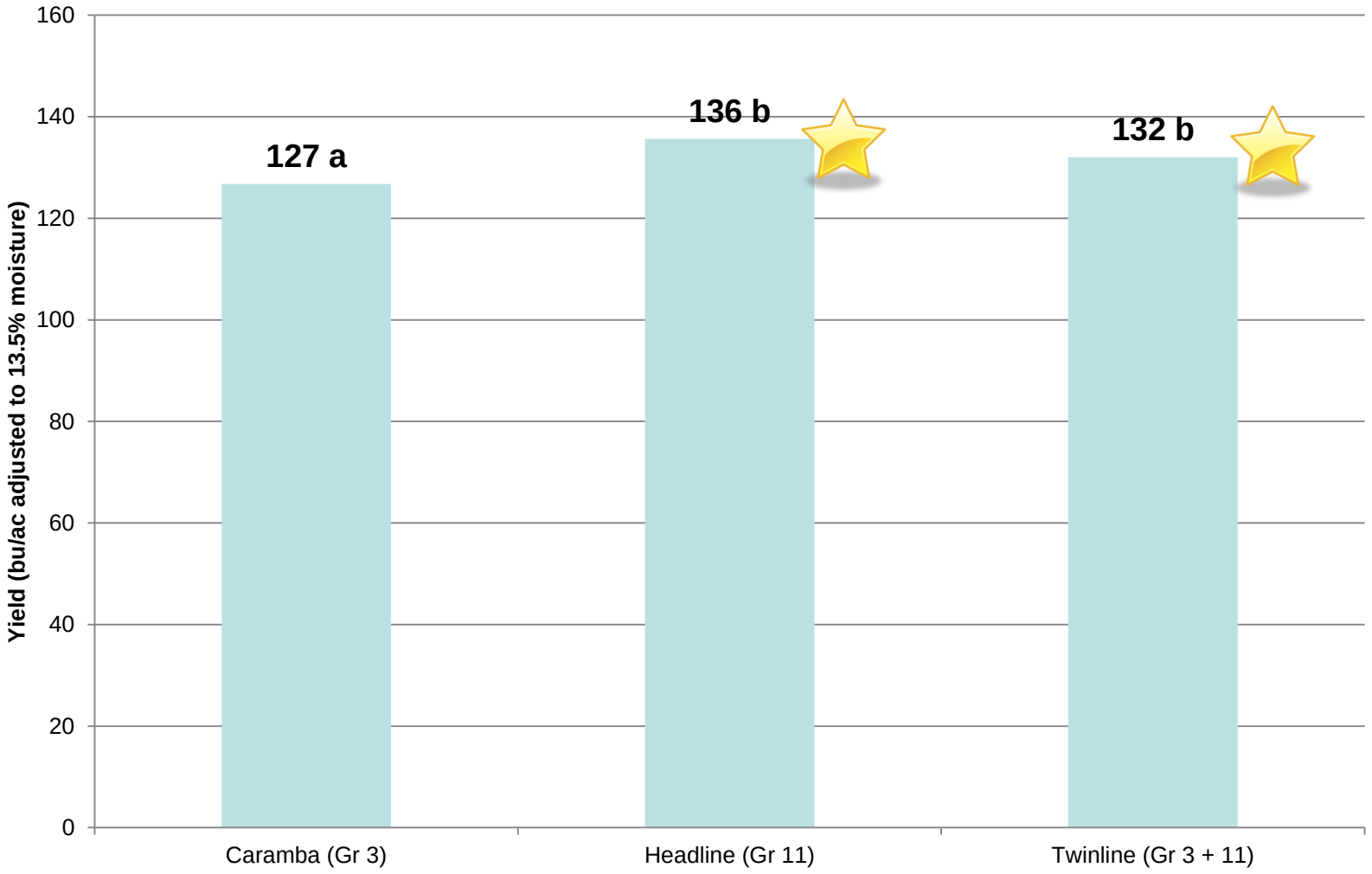
The Multiple Modes of Action

BASF
The Chemical Company

Activity on Multiple Stages of the Fungus

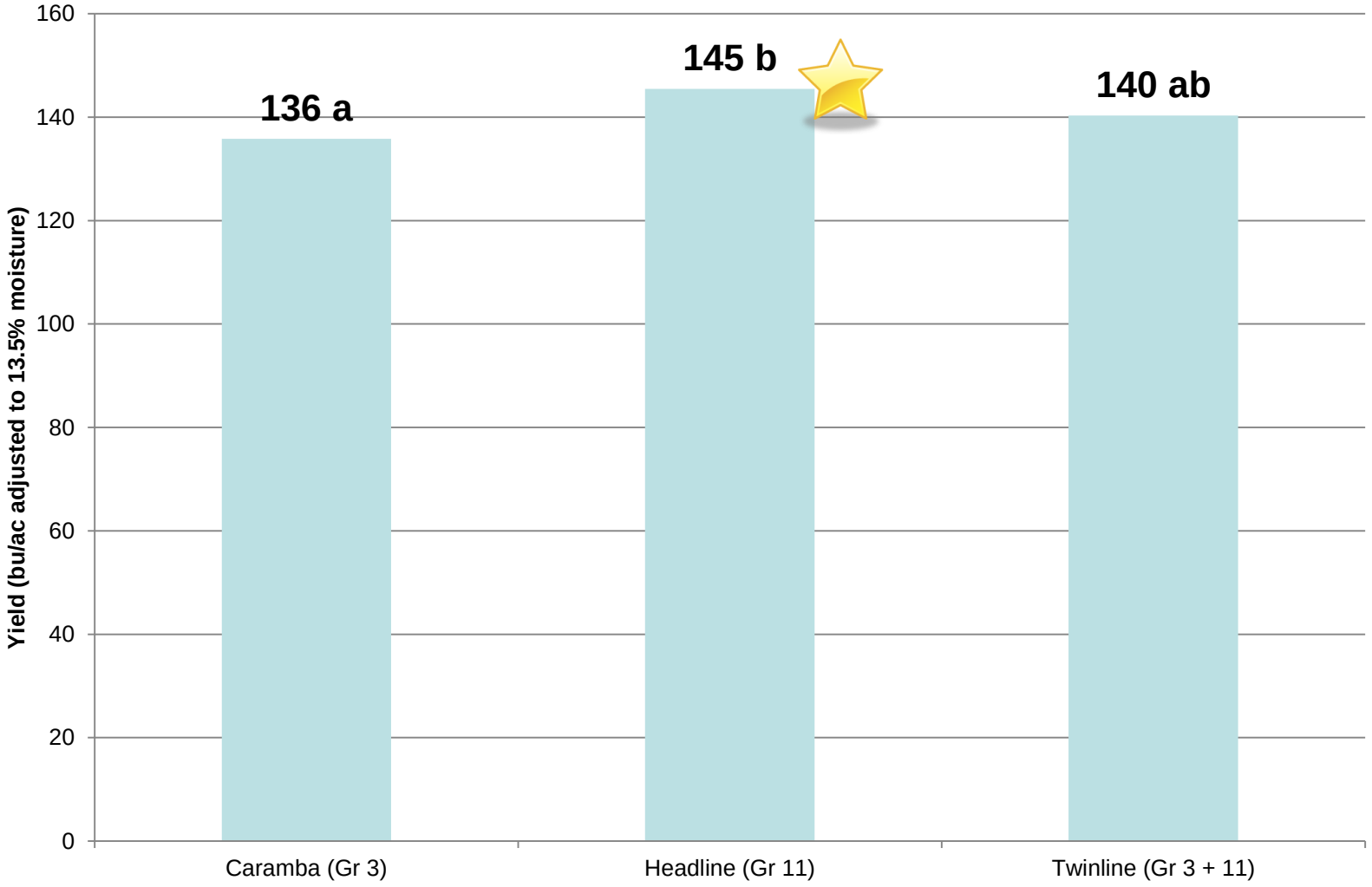


Magrath 2014 - Malt Barley Fungicide Yield



Preliminary Results - Trends must be supported with additional years of data

Killam 2014 - Malt Barley Fungicide Yield



Preliminary Results - Trends must be supported with additional years of data

Malt Barley Fungicide Trends

- **Summary**
  - Fungicide increased yields by 6-13% at 4 of 5 sites
  - Flag or late fungicide applications tended to be better
  - Group 11 (Headline) occasionally performed better than Group 3. However this product has a risk of developing resistance

Preliminary Results - Trends must be supported with additional years of data

- Data Analysis
  - Biomass
  - Lodging
  - Disease
  - NDVI
  - Heights
  - Maturity
- Economic Analysis

- Analyze samples for:
  - CGC Grade
  - TWK
  - NIR protein
  - Baking quality (HRS)
- Repeat experiments in 2015 and 2016

Wheat Stacked Management Trends

•Summary

- In high moisture environments:
  - **UAN resulted in small (4-11%) yield increases**
  - **PGR B resulted in small (4-8%) yield increases**
  - **Single and Dual fungicide resulted in large (28-48%) yield increases**

- In dry environments:
  - **A high rate of UAN reduced yields**
  - **The PGR CCC resulted in a 7-8% yield decrease**
  - **Fungicides increased yields by 6-15%**

Preliminary Results - Trends must be supported with additional years of data

Barley Stacked Management Trends

•Summary

- Based on this data set:
  - **UAN generally increased yield**
  - **PGR occasionally increased yield**
  - **Fungicide response was seen at 2 sites**
    - **Smaller yield responses on barley (vs. wheat) maybe cultivar dependent**
  - **An economic analysis needs to be conducted to determine profitability of these practices**

Preliminary Results - Trends must be supported with additional years of data

Malt Barley Fungicide Trends

- **Summary**
  - Fungicide increased yields by 6-13% at 4 of 5 sites
  - Flag or late fungicide applications tended to be better
  - Group 11 (Headline) occasionally performed better than Group 3. However this product has a risk of developing resistance

Preliminary Results - Trends must be supported with additional years of data

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Thank You for
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Questions?