Development of improved switchgrass selections in a northern environment

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REAP-Canada
Resource Efficient Agricultural Production

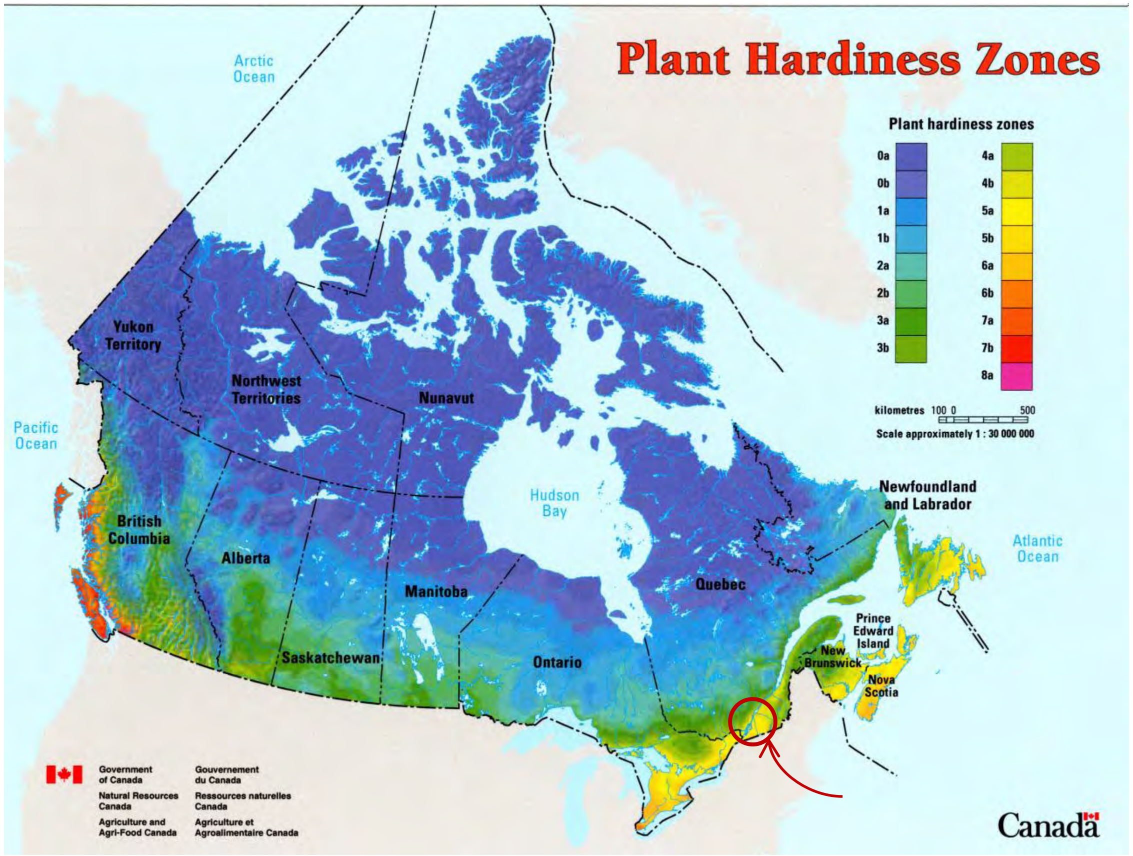
McGill

CDAQ
CONSEIL POUR LE DÉVELOPPEMENT DE L'AGRICULTURE DU QUÉBEC

Agriculture, Pêcheries et Alimentation
Québec

Introduction

- Southern upland cultivars are often slow to emerge and cold sensitive in northern zones.
- A breeding program was initiated by REAP-Canada in Southern Quebec, Canada (45 N) to improve yield and morphological traits in upland switchgrass in an northern environment
- From 2010-2012 McGill University evaluated a series of selections completed by REAP in 2009.



REAP-Canada Breeding Objectives

To reduce

- Seed dormancy
- Tiller number and mortality
- Lodging
- Length and cost of breeding cycles

To increase

- Seed size
- Seedling vigor
- Height
- % Reproductive tillers
- Weight per tiller

Approach

- Make incremental gains using a modest breeding investment and reduced cycle time, while still achieving considerable yield and morphological gains

- Evaluation of agronomic performance and features of several new selections made at two sites in southern Quebec

- Hypothesis:
  The selections made in Quebec have better features than the original cultivars

Breeding Method

A modified **RRPS** (Recurrent Restricted Phenotypic Selection)

- Advantages
  - Easy breeding system to use
  - Requires minimum time intervals per cycle
  - Utilizes all the additive genetic variation because of the large number of plants that are inter-mated
  - Inbreeding depression is minimized
- Disadvantages
  - the actual rate of inbreeding is unknown
  - Some families may contribute more members to the plants in the polycross nursery than others

On-farm cooperator Normand Caron and Erik Delaquis in a breeding plot

Breeding Methods - Steps

- Seed harvested from 30-50 superior plants chosen from older (10 year+) switchgrass fields
- Seed collected and largest seed derived through air-column separation of parent seed (Boe and Johnson, 1987)

Breeding Methods - Steps

- ~15 seeds planted in each pot of a 38-pot tray with 1000 plants per population
- Thinned to the single fastest to emerge seedling after 5-10 days to reduce dormancy
- After 8 weeks, population undergoes single tiller selection to reduce tiller number in mature plants (Smart et al,2003, Zarrough et al, 1983)

Breeding Methods - Steps

- Single-Tiller Selection:
  - Less tillers overall
  - Aim for less tiller mortality and greater % reproductive tillers
- At 8-9 weeks:
  - transplanted into larger pots and allowed to further mature in greenhouse to reduce field transplant shock
- Both greenhouse and field selection enables fewer field plants to manage

Spaced-Plant Nurseries for RRPS

- 200 plants of each population are then planted in isolated nurseries
- Experimenting with recycling the best ~5% of plants from each generation to the next cycle
- Aim to collect seed in first year to repeat cycle rapidly if desired
- Planting at 40 cm spacing in row and 55 cm between rows to enhance competition

1st year transplant of 5th cycle selection of sunburst in Sept 2013

Refining a 2-3 year breeding cycle that incorporates several selection strategies

- To date we have completed several cycles of selection on populations derived from High Tide, Sunburst, Summer and Cave-in-Rock
- Assessing gains in biomass yield, plant height and tiller number in partnership with McGill University and MAPAQ

Selections made in a 3rd year nursery of cave in rock lineage, approximately 100 of 200 plants are discarded prior to pollination

Tiller mortality and the carbon economy

- Carbon loss from the bottom of the canopy is lost solar energy
- Especially a problem with vegetative tillers
- Selecting for single-tiller in the seedling stage may reduce tiller mortality and improve carbon balance
- In upland switchgrass Yield/tiller may be more important than number of tillers for yield

Photos from Sept 11, 2013
Ste Anne de Bellevue Quebec

Sunburst

Blue Jacket II
(Sunburst 3 cycles later)

- *A 4th cycle of selection of the upland cultivar cave in rock approximately 9'tall in September 2013. It may be possible to achieve the biomass productivity of lowland ecotypes without the establishment and hardiness issues of lowland ecotypes.*

Results of Selection Lineages tested in 2010-2012 by Mcgill

Sunburst →	Bluejacket I →	Bluejacket II
	→	Bluejacket Early
Summer →	Tecumesh I →	Tecumseh II
Cave-In-Rock →		Cave-In-Rock II
→		Cave-In-Rock Early

Switchgrass parental cultivars + selections = 10 total

3 selections of big bluestem (*Andropogon gerardii*), another promising native grass were also evaluated

Results: Maturity

Sunburst (42 N)

Summer (40 N)

Cave-in-Rock (37 N)

Experimental Design

		A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C		
Rep 4	BORDER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	BORDER	20m
		401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416		
Rep 3		11	3	6	14	5	8	1	9	2	13	7	16	4	15	10	12		
		301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316		
Rep 2		11	2	5	7	4	14	13	1	6	15	10	8	9	16	12	3		
		201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216		
Rep 1		8	16	3	2	9	15	6	10	5	11	14	7	13	1	12	4		
		101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116		

65.1m

4.06m

1	CIR I	**9**	Tecumseh II
2	Summer	**10**	Tecumseh III early
3	Sunburst	**11**	CIR II
4	Prairie View	**12**	CIR Early
5	Bluejacket I	**13**	Prairie View II
6	Bluejacket II	**14**	Prairie View Early
7	Bluejacket Early	**15**	Sand Lover
8	Tecumseh I	**16**	High Tide II

- 2 sites: Ste. Anne-de-Bellevue and Cookshire-Eaton
- RCBD with 4 replications
- Planted in 2010, sampling sites during 2011 and 2012

Site 1: Ste Anne de Bellevue Quebec

(McGill –Lods agronomy research farm)

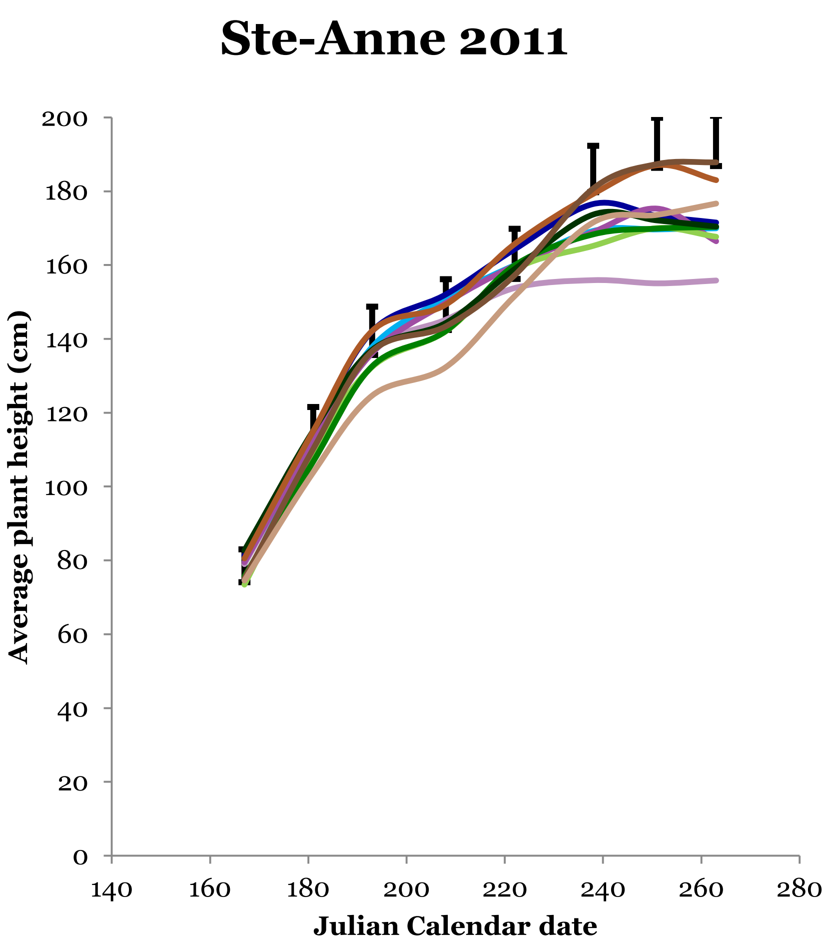
Site 2. Cookshire-Eaton: Ferme Madeleo

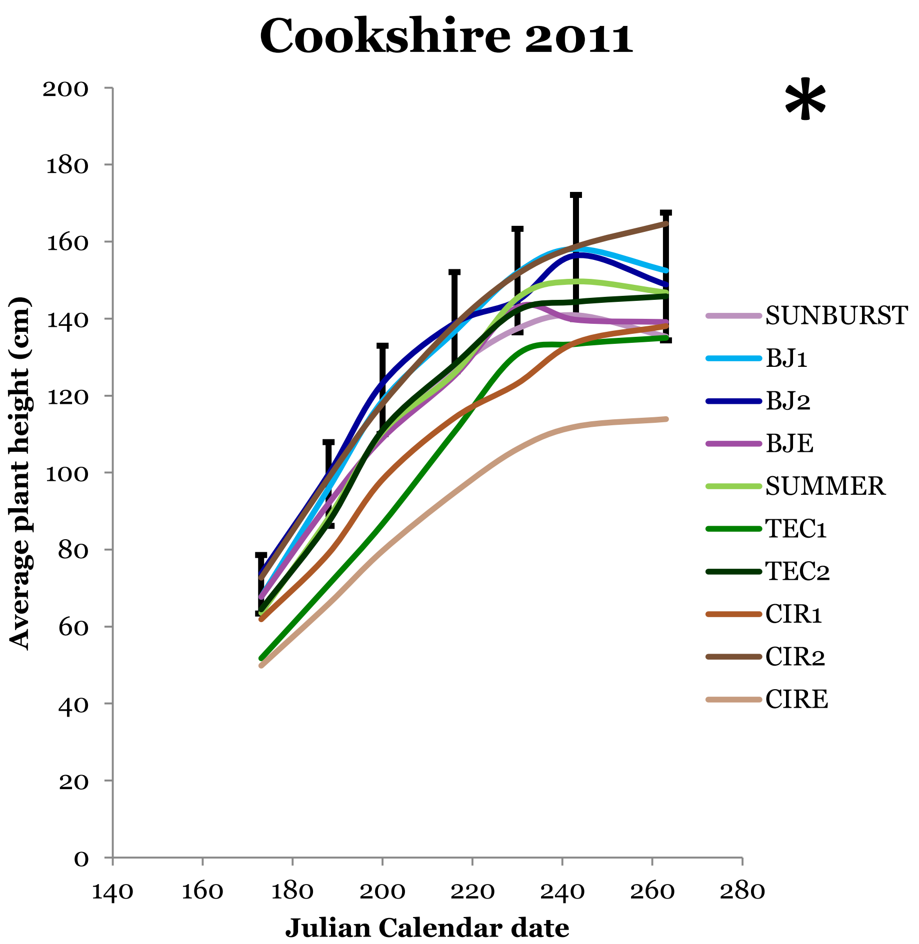
Data Collection

- Variables examined during the season:
  - Height biweekly
  - Tiller density biweekly
  - Phenological Stages

- Harvest in late autumn:
  - Yield, dry matter content
  - Weight per tiller
  - % Vegetative and reproductive tillers

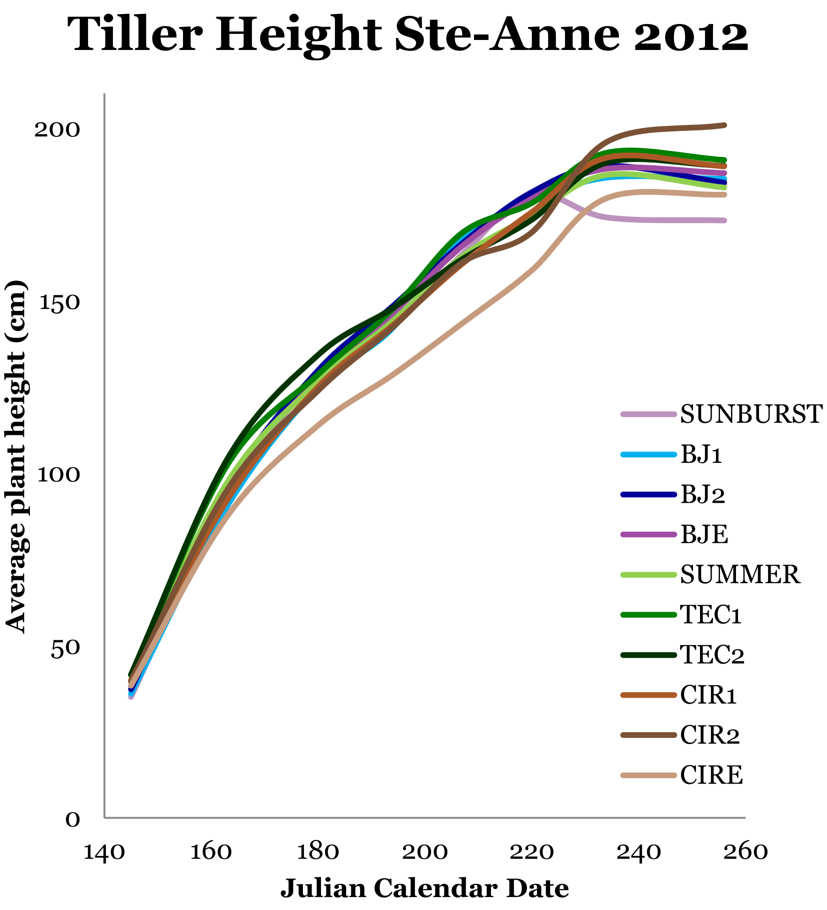
Results: Height

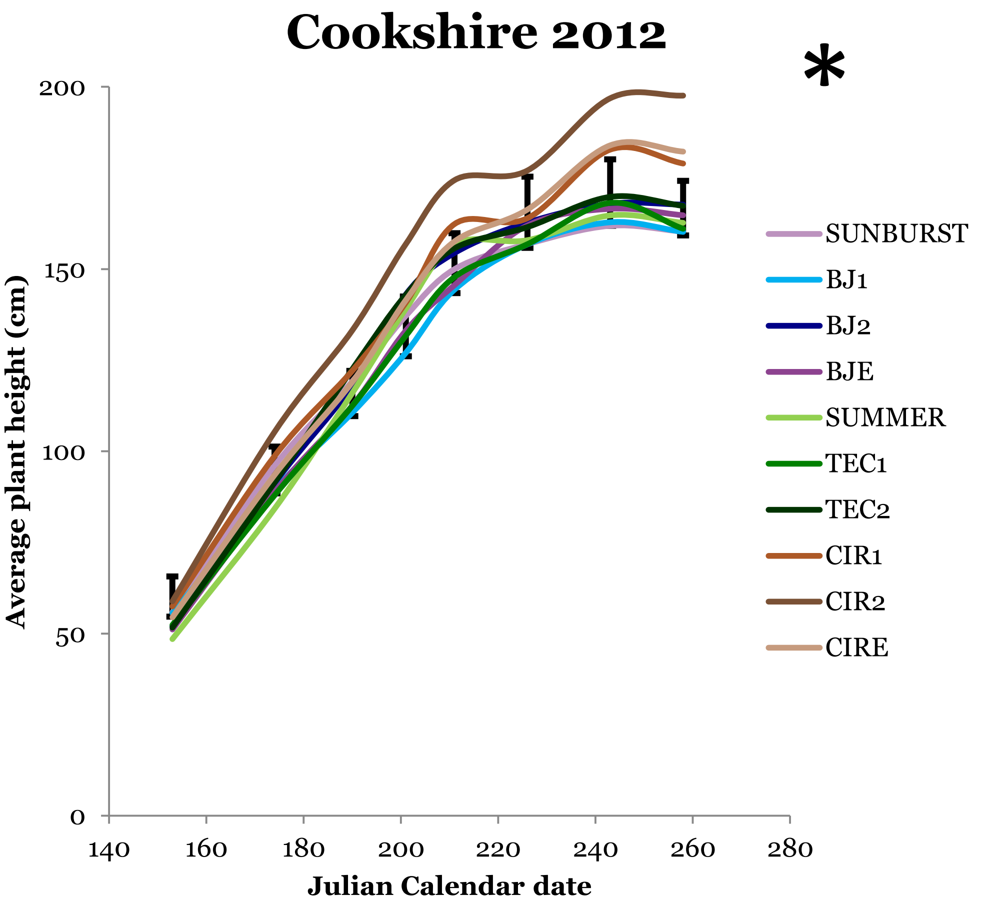




1st year of production

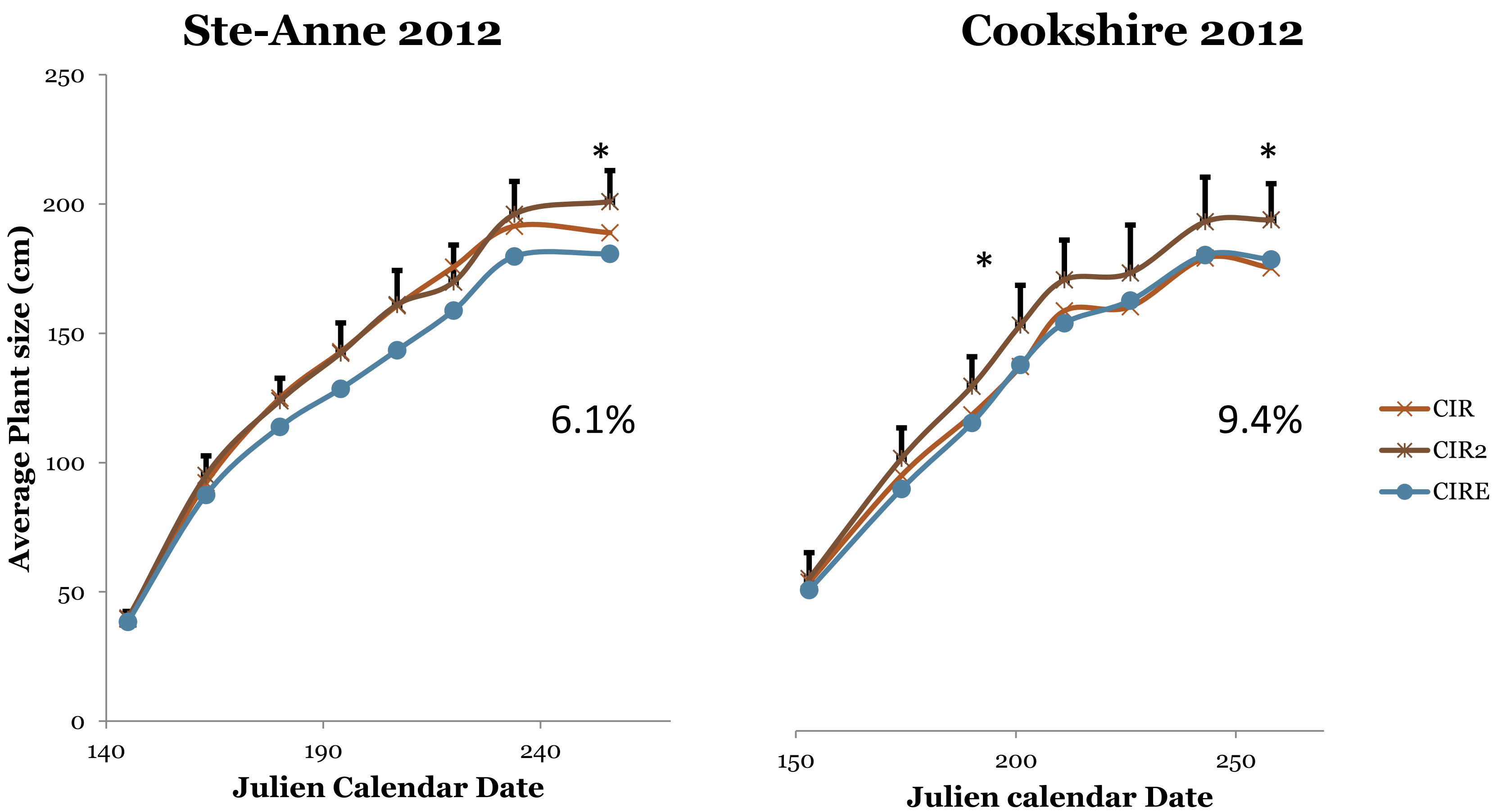
Results: Height





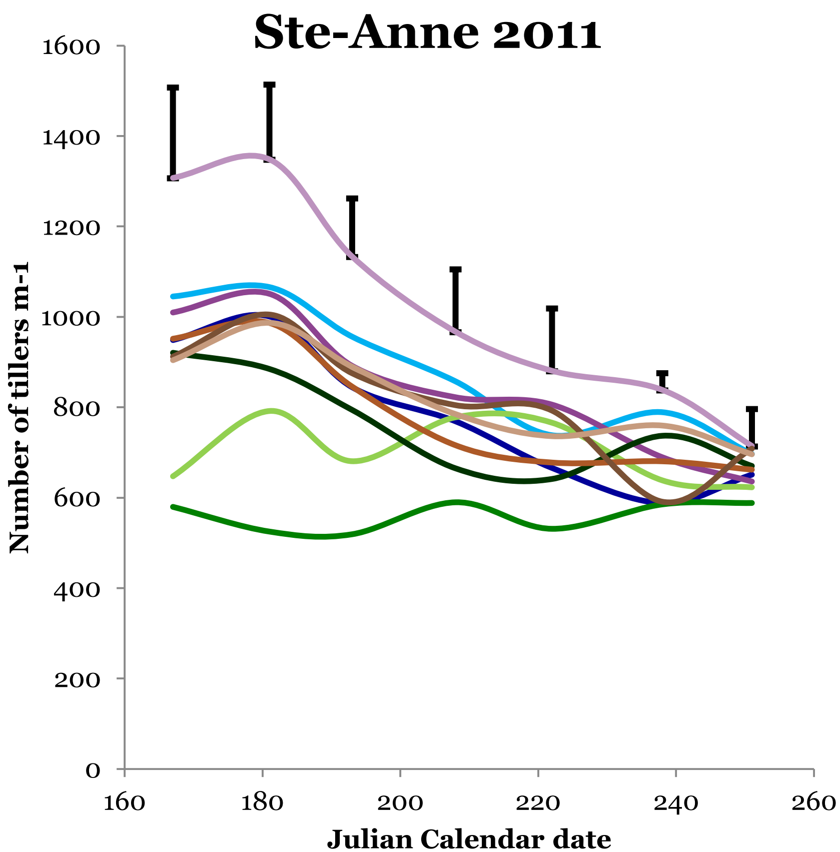
2nd year of production

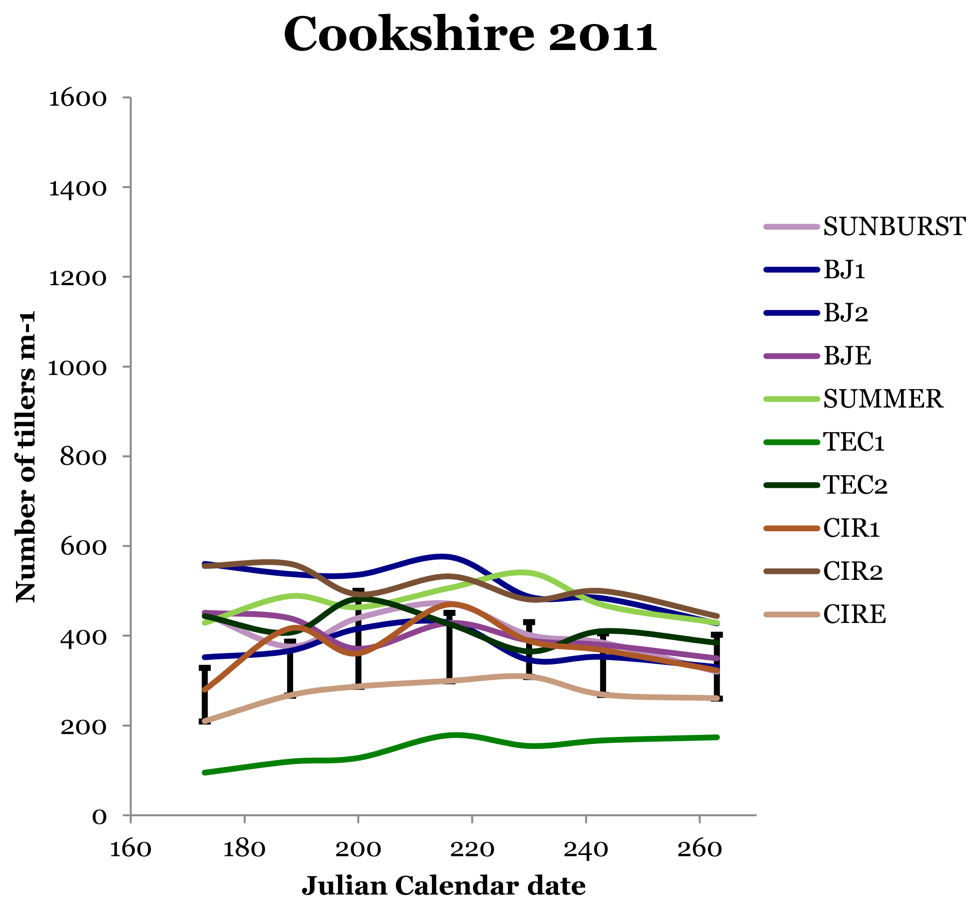
Results: Height increase in cave in rock selection



2nd year of production

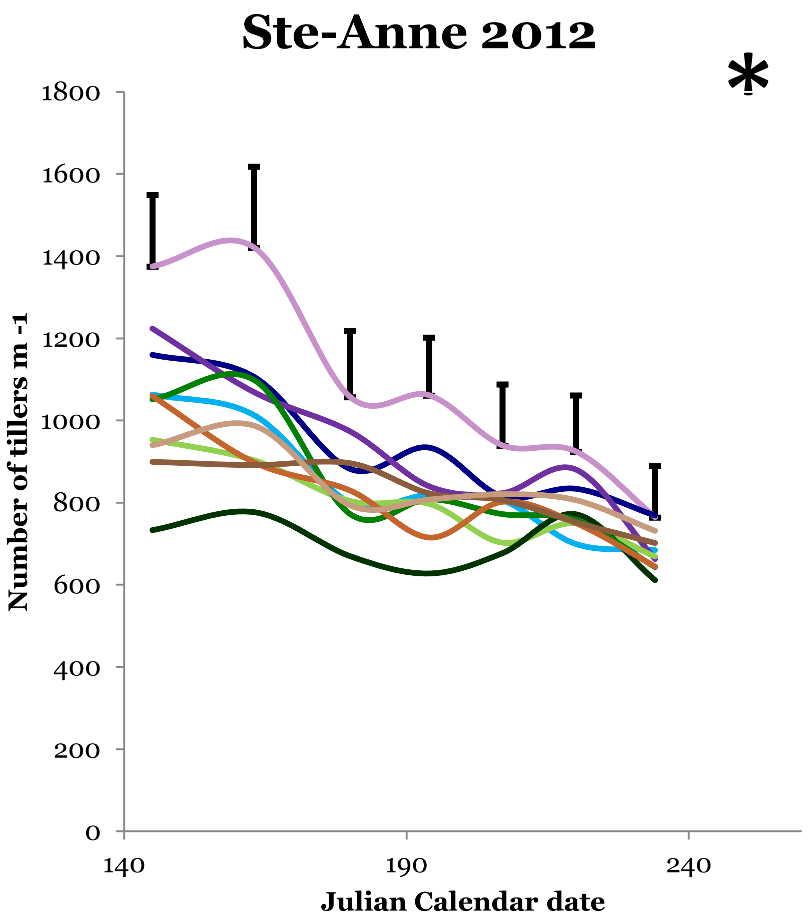
Results: Number of Tillers

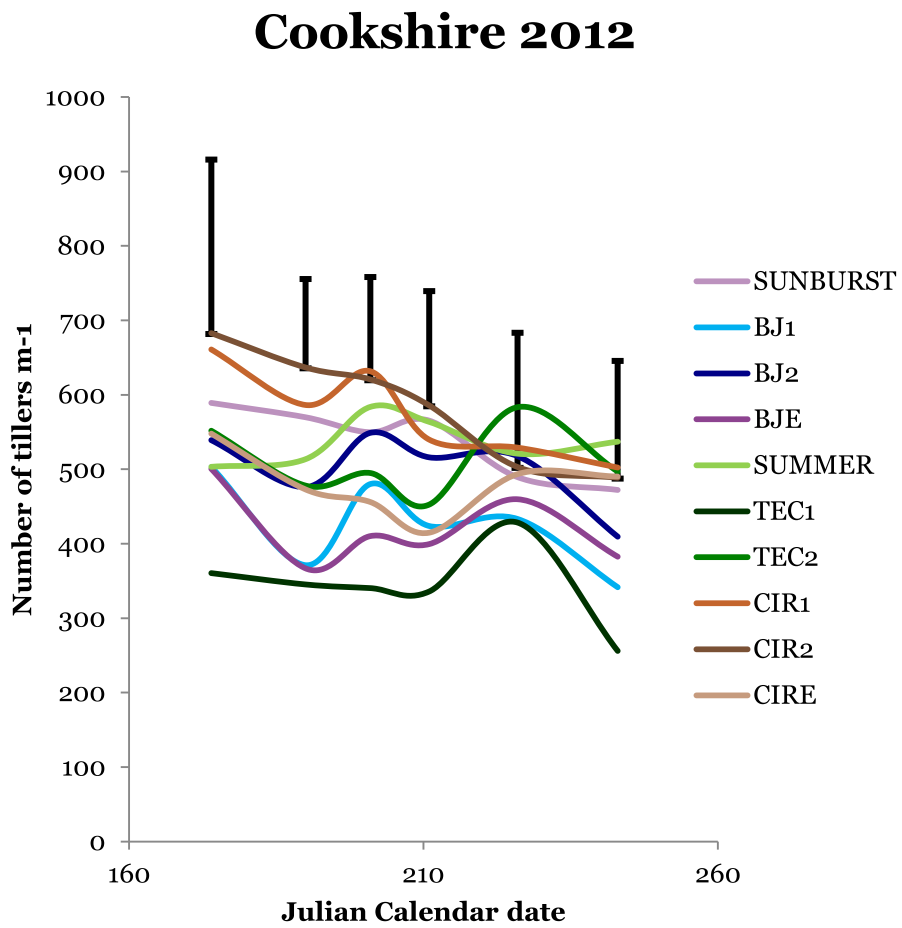




1st year of production

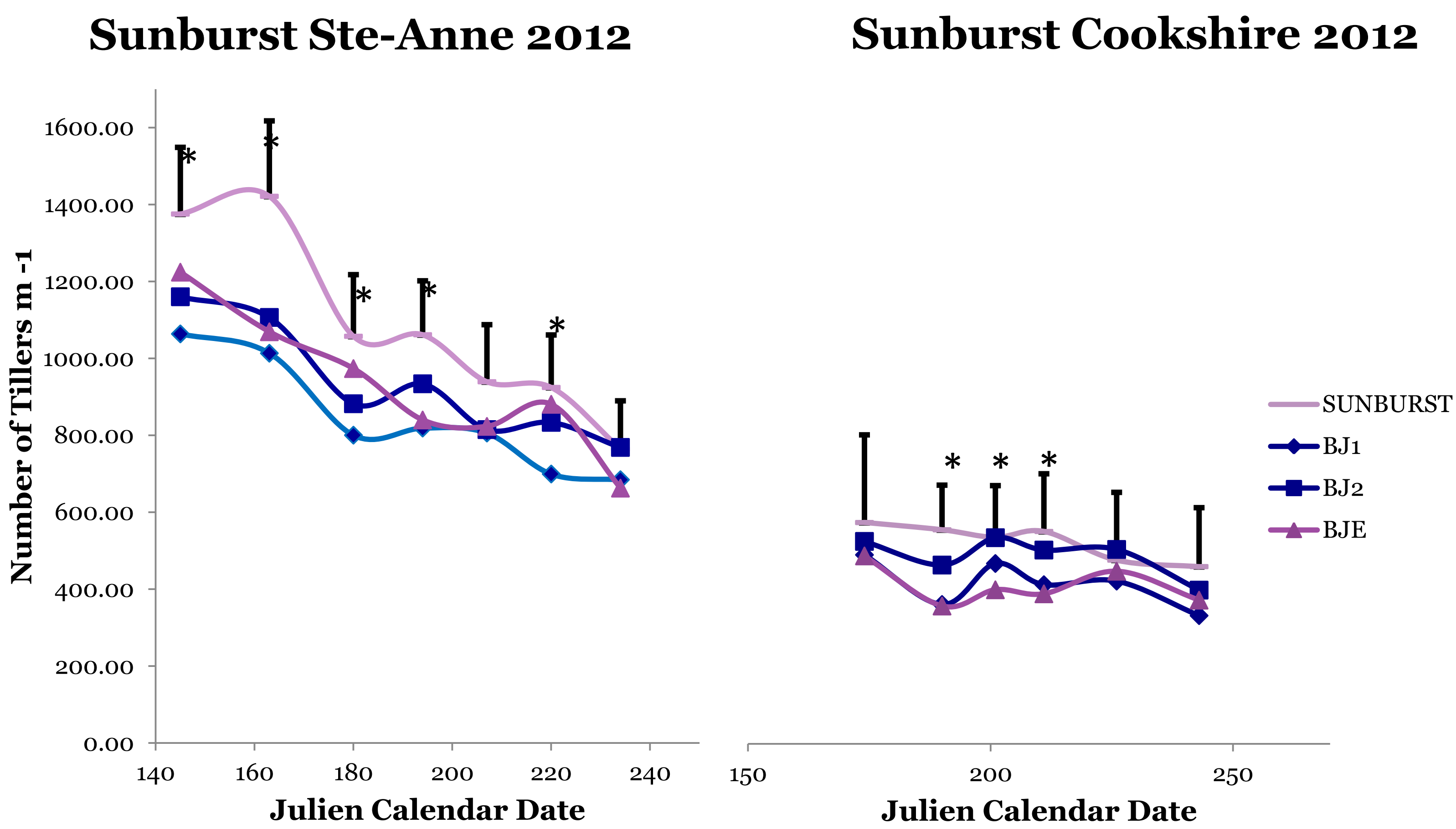
Results: Number of Tillers





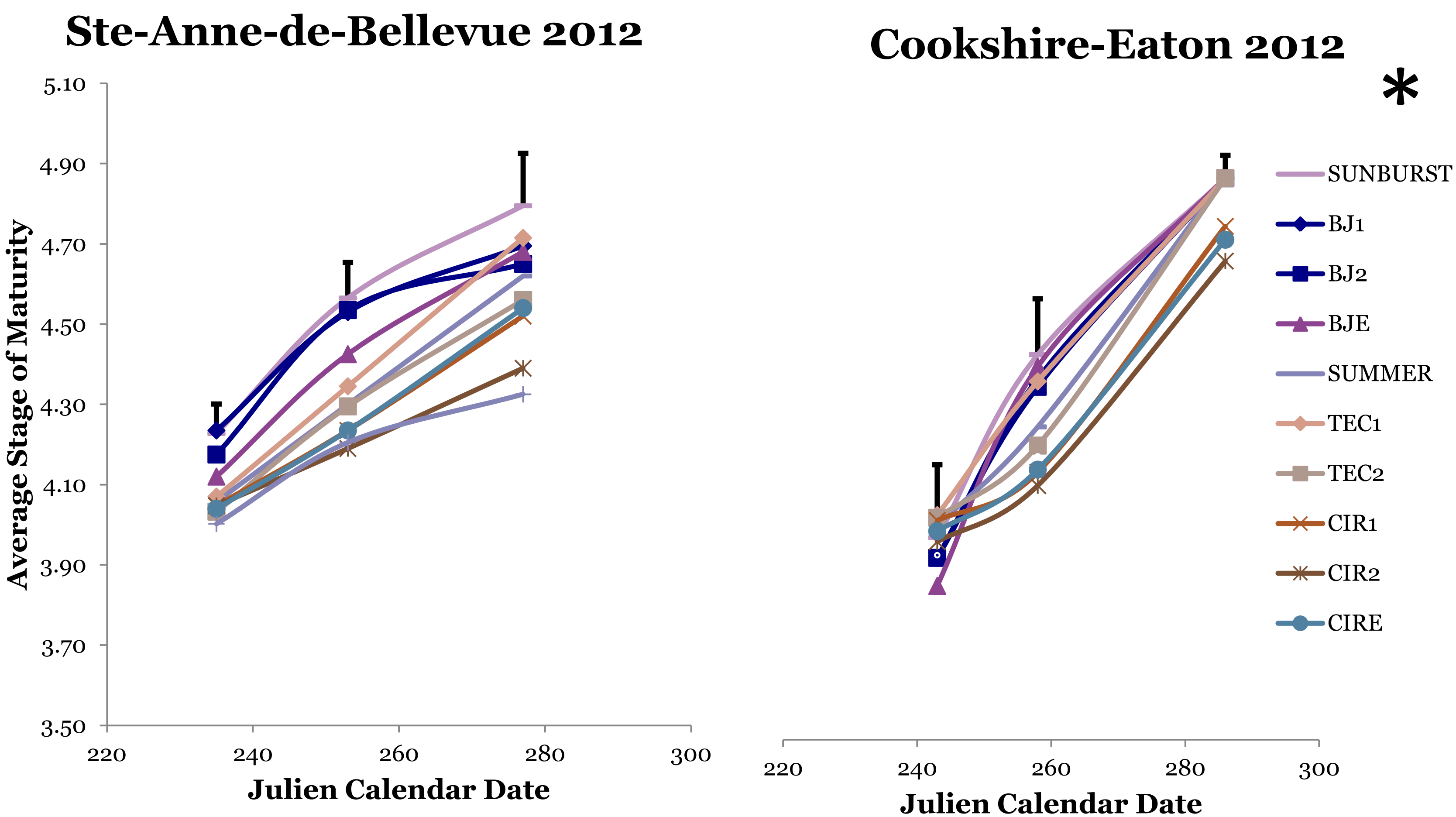
2nd year of production

Results: Number of tillers in Blue Jacket selection



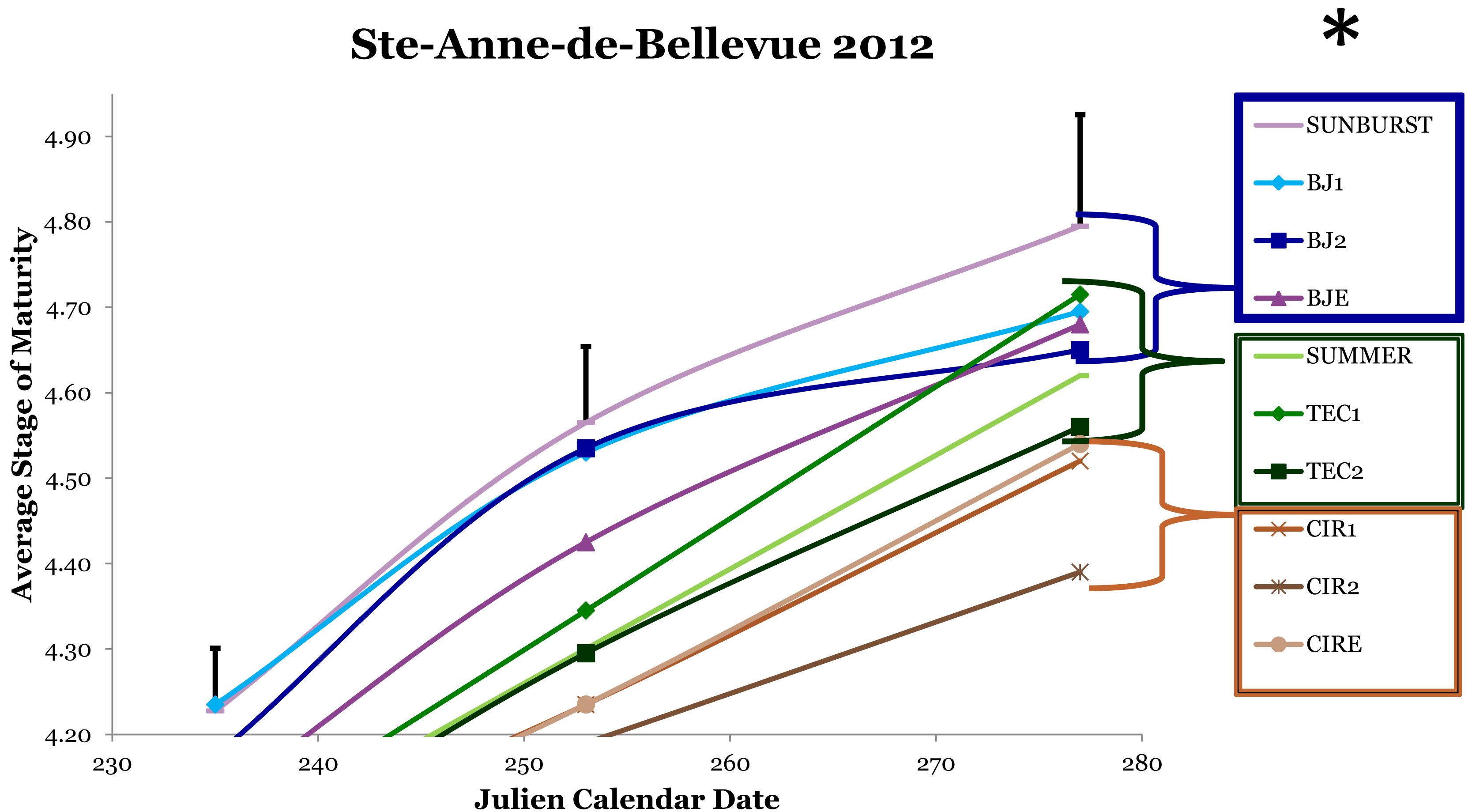
2nd year of production

Results: Maturity



2nd year of production

Results: Maturity

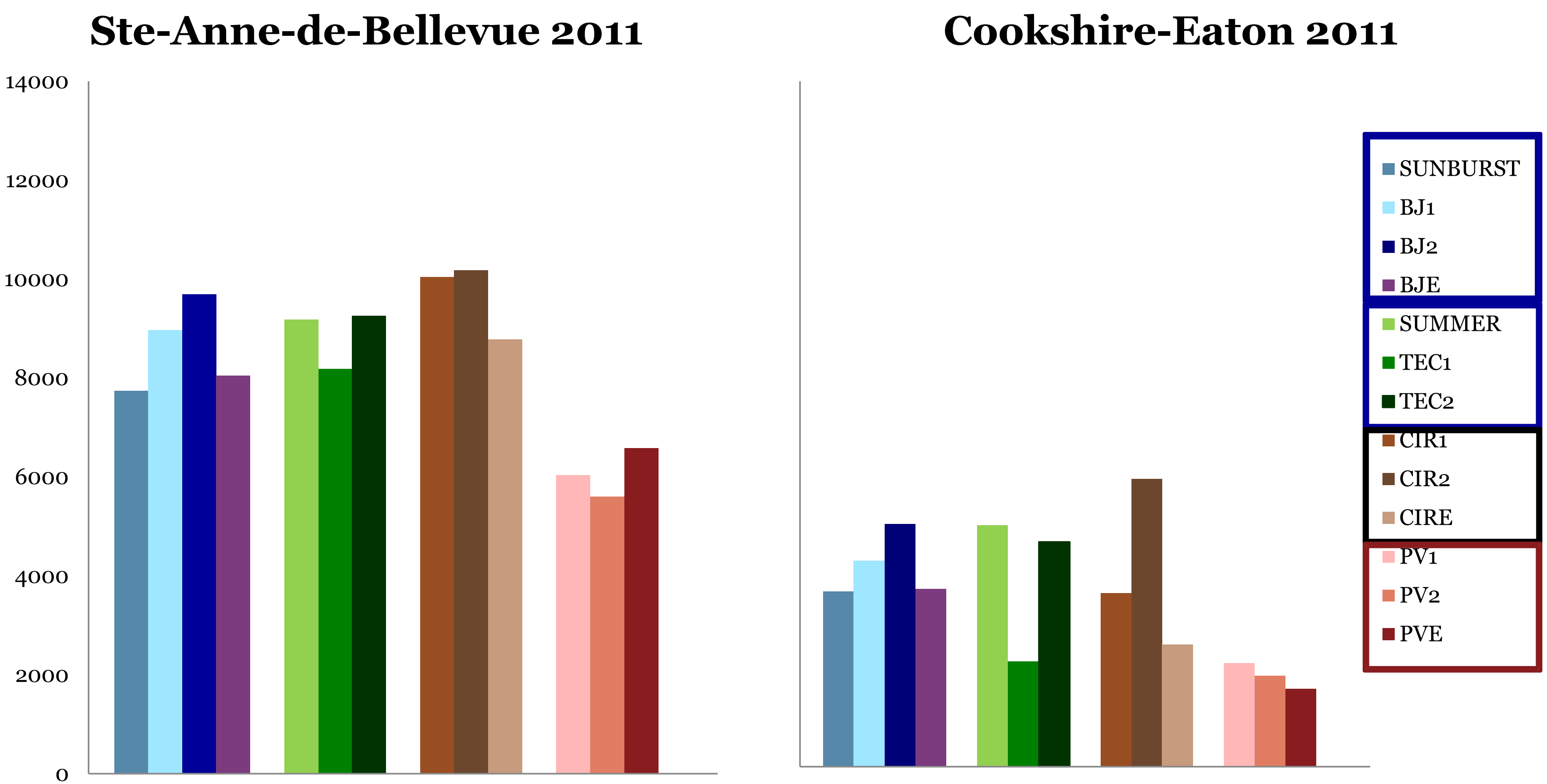


2^{nd} year of production

Results: Fall Yield

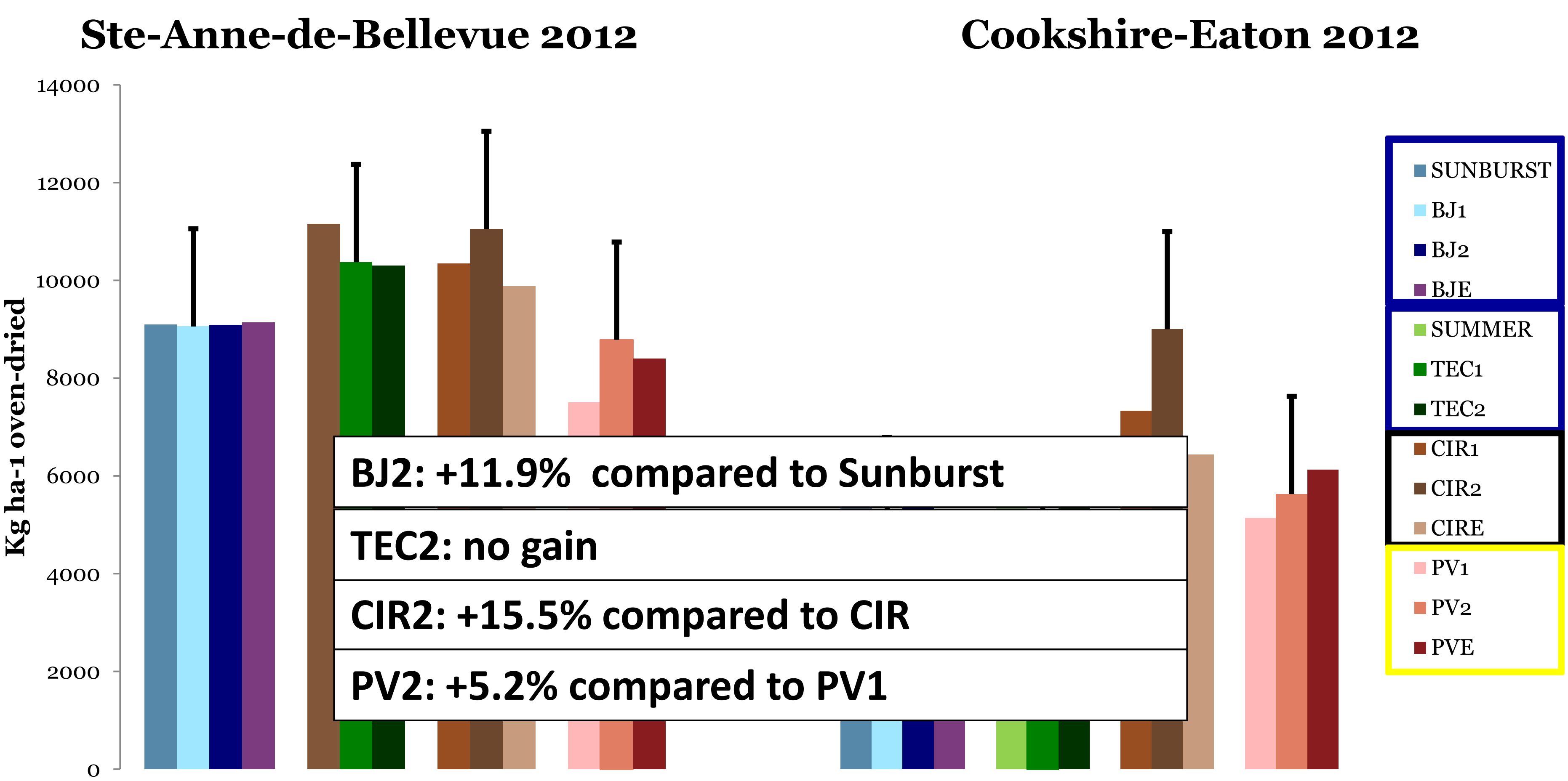
- Harvest pass (width: 60cm) in fall, spring

Results: Fall Yield



1st production year

Results: Fall Yield



2nd year of production

Conclusions

- Breeding progress can be made with a simplified RRPS system in a humid northern environment
- Differences were observed between selections for all variables studied. Best improvements to date were on Cave-in-rock and Sunburst. Summer had a relatively low tiller number at the outset and relatively high yield for its maturity class (It was pretty good already).
- Switchgrass cultivars tended to reach a similar tiller equilibrium in both years which appeared linked to site productivity. Some selections appeared to undergo appreciable tiller mortality.
- Intensified efforts are required to understand the morphological traits of switchgrass and identify effective low cost breeding strategies to advance the domestication of the species for northern environments.
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