Production Response of Sugar Beet Breeding Lines to Deficit Irrigation

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Albuquerque, New Mexico

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“Crop Production Down Due to Drought”

“Severe winter drought threatens crop production in China”

“U.S. farmers hit hard by drought”

“Russian drought devours world wheat supplies”

“World Running Short on Water”

“North Platte NRD Seeking Input on Proposed Changes to Allocations”

“The pending scramble for water”

“Idaho fighting another Snake River water war”

Headlines: Crop Production, Drought, Irrigation Water Demands

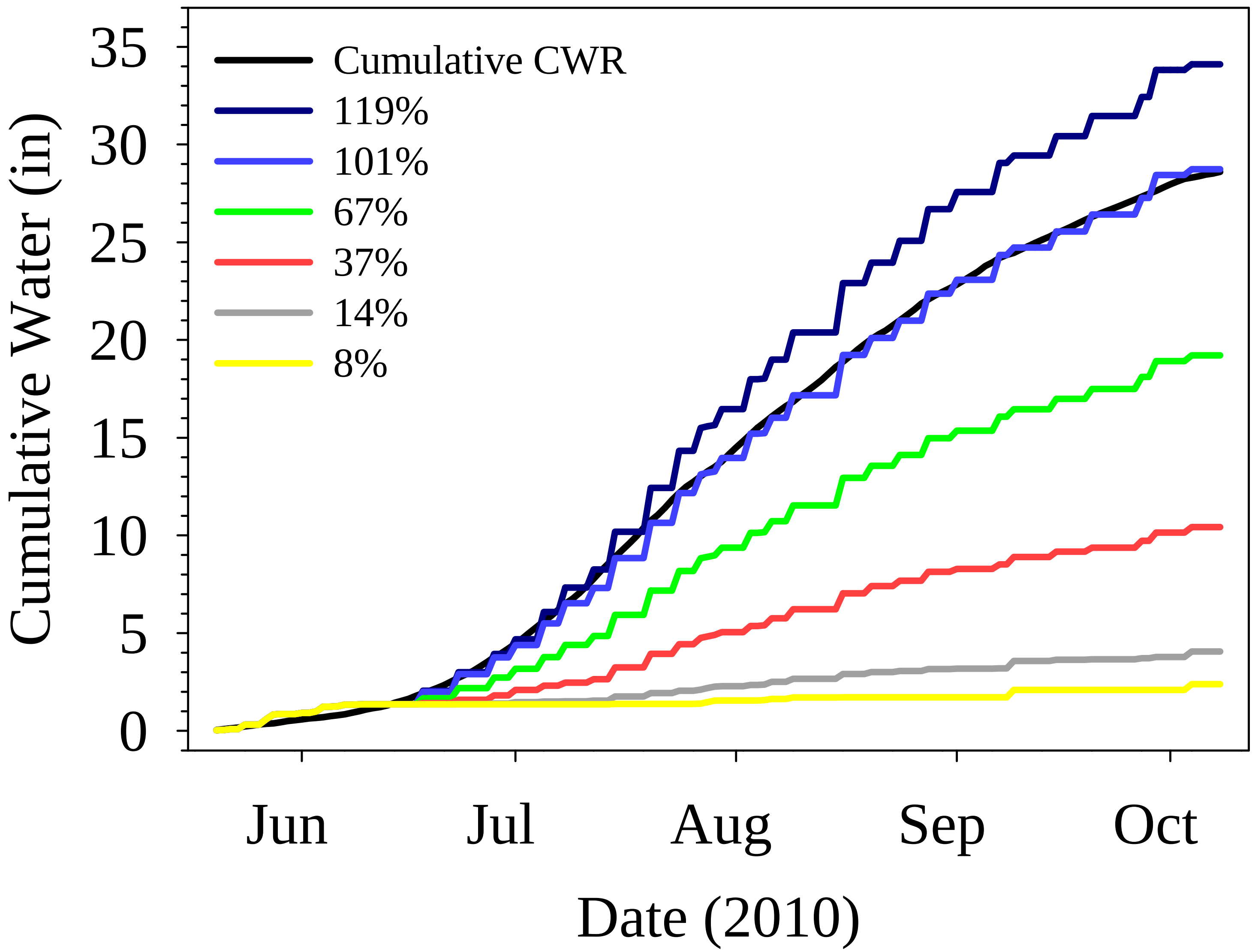
- There are limited breeding efforts to improve drought tolerance.
- Research shows significant sugar beet genotype diversity for tolerance to drought.
  - Ober, E.S. and A. Rajabi. 2011. Abiotic stress in sugar beet. Sugar Tech. Online: DOI 10.1007/s12355-010-0035-3.
  - Pidgeon, J.D., E.S. Ober, A. Qi, C.J.A. Clark, A. Royal, K.W. Jaggard. 2006. Using multi-environment sugar beet variety trials to screen for drought tolerance. Field Crop Research. 95:268-279.
  - Ober, E.S., C.J.A. Clark, M. Le Bloa, A. Royal, K.W. Jaggard, and J.D. Pidgeon. 2004. Assessing the genetic resources to improve drought tolerance in sugar beet: agronomic traits of diverse genotypes under droughted and irrigated conditions. Field Crop Research. 90:213-234.

Sugar Beet Drought Research Background

- Objective: Screen KWS Breeding Lines and a Commercial Line for Drought Tolerance Using a Line Source Sprinkler System
- Conducted a 3-year study (2008, 2009, 2010)

- 6 KWS breeding lines, 1 commercial cultivar line.
  - Selected and provided by KWS
- 6 irrigation levels.
  - Based on a percent of predicted crop seasonal ET (based on the Kimberly-Penman Reference Evapotranspiration Model)
  - Approximately 125%, 100%, 75%, 50%, 25% of ET, and rain-fed.
    - Varied year to year based on variability of sprinkler application pattern and wind.
    - Crop ET summed daily and replaced with irrigation based on treatment irrigation percentages 2 to 3 times a week.

Treatments



2010 Cumulative Irrigation and Precipitation

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- Design
  - Line source system used.
  - Irrigation treatments set relative to line source.
  - Breeding line treatments were randomized within irrigation treatments.
  - 4 Replications.
  - Each Plot is 4 rows wide by 36 ft long

	I - 6	7	2	6	3	5	1	4
	I - 5	4	7	1	3	6	5	2
	I - 4	2	3	5	7	4	1	6
Rep I	I - 3	6	5	4	2	7	3	1
	I - 2	6	4	7	1	2	5	3
	I - 1	2	4	5	7	1	3	6
	I - 1	5	4	2	6	7	3	1
	I - 2	7	2	3	5	1	4	6
Rep II	I - 3	2	5	7	4	3	6	1
	I - 4	3	5	4	6	7	1	2
	I - 5	2	7	3	1	5	4	6
	I - 6	4	3	7	6	1	2	5

Experimental Design and Protocol

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- Planted in late April in 2008, 2009, 2010.
- Entire study emergence irrigation:
  - 2008 – 2.4 inches
  - 2009 – 2.2 inches
  - 2010 – 2.8 inches
- Daily crop water use logged (based on the Kimberly-Penman Reference Evapotranspiration Model) and line source irrigations started after estimated 100% emergence.
- Stand hand thinned to an in-row plant spacing of 4 inches at about the 2-leaf stage.

- Beets harvested in October.
  - 2 center rows – 30ft (60 ft of row).
  - Yield (tons/acre)
  - Sugar analysis
    - 2 – eight beet samples for sugar and impurity analysis

Experimental Design and Protocol

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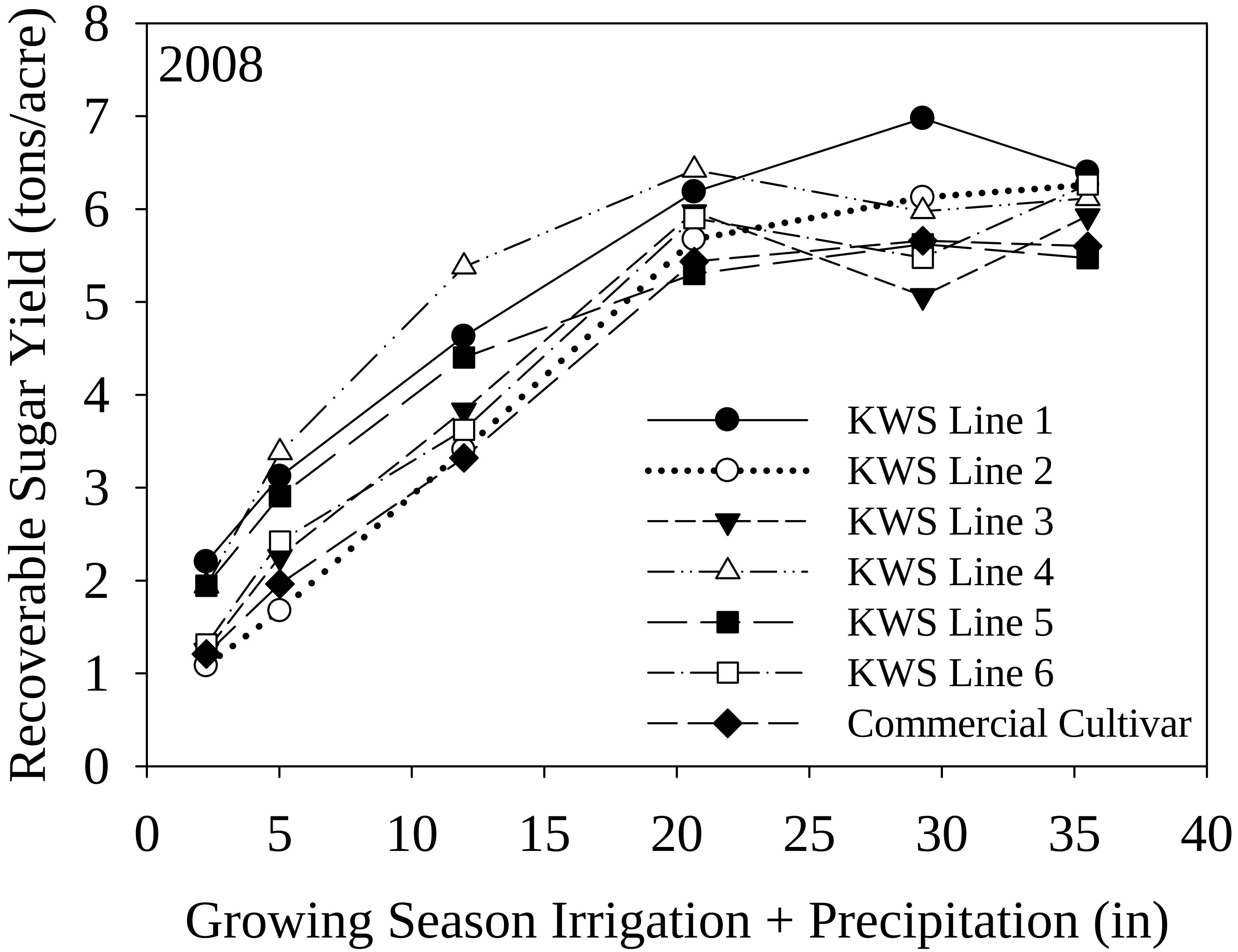
on-Irrigate



Water Input vs. Recoverable Sugar

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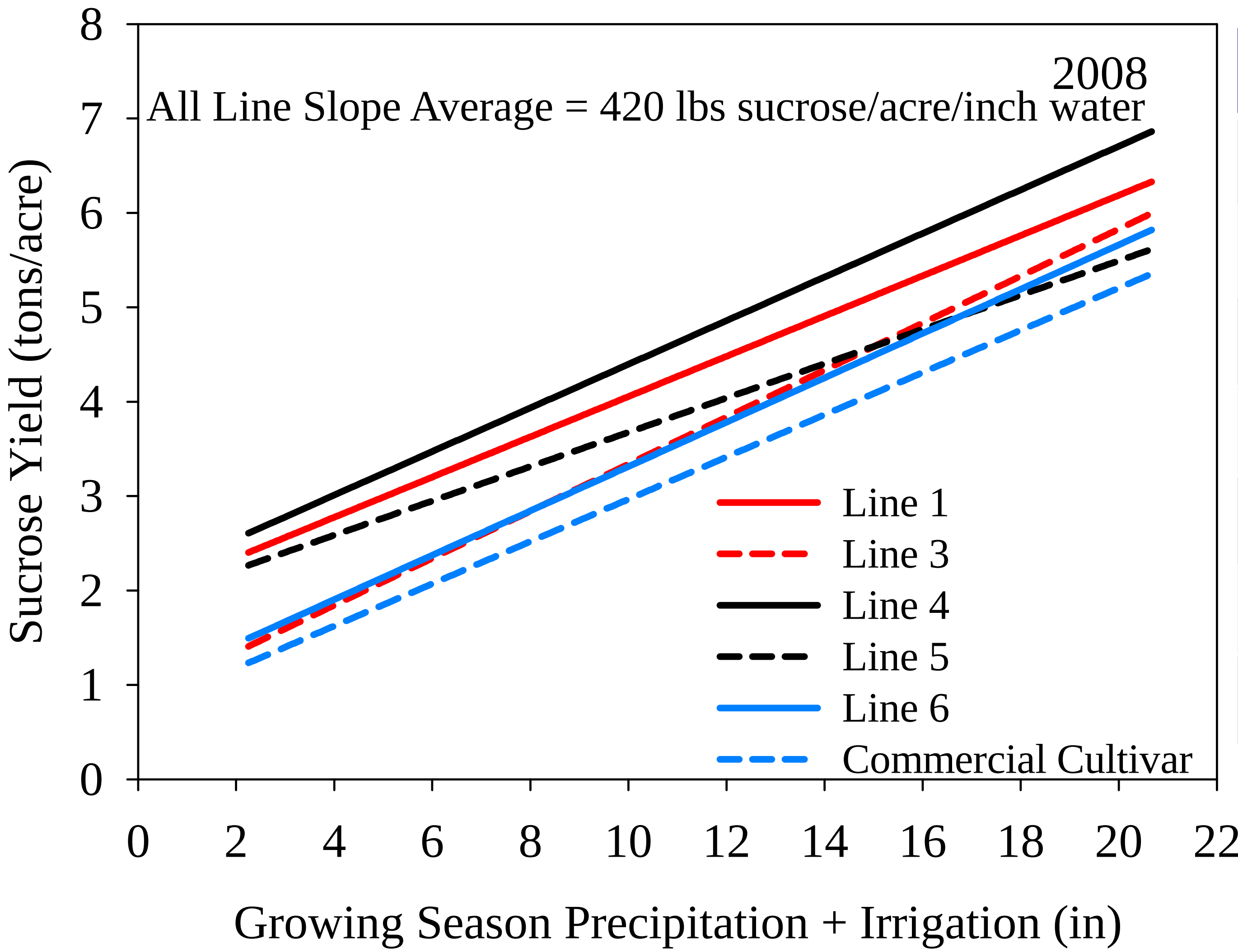
- Linear regression analysis for deficit irrigation treatments.
  - rain-fed – ≈75% ET.
  - Intercept and slope comparisons.
- Non-Linear regression used to compare maximum yields.
  - Spherical Model.
  - All irrigation levels.

		2008	2009	2010
Sucrose Yield (lbs/acre)	Rain-Fed	1,430 – 5,450	3,480-10,090	980-4,450
	≈100% ET	6,520-14,460	8,479 – 13,300	9,100-15,440
Root Yield (tons/acre)	Rain-Fed	6.4-26.7	12.4-34.6	5.1-16.3
	≈100% ET	24.3-44.1	29.5-45.6	32.5-48.4

Root Yield and Recoverable Sugar Ranges



Line	Int.	Slope
1	ab	a
2		
3	c	a
4	a	a
5	ab	a
6	bc	a
Com.	c	a

Water Input vs. Recoverable Sugar

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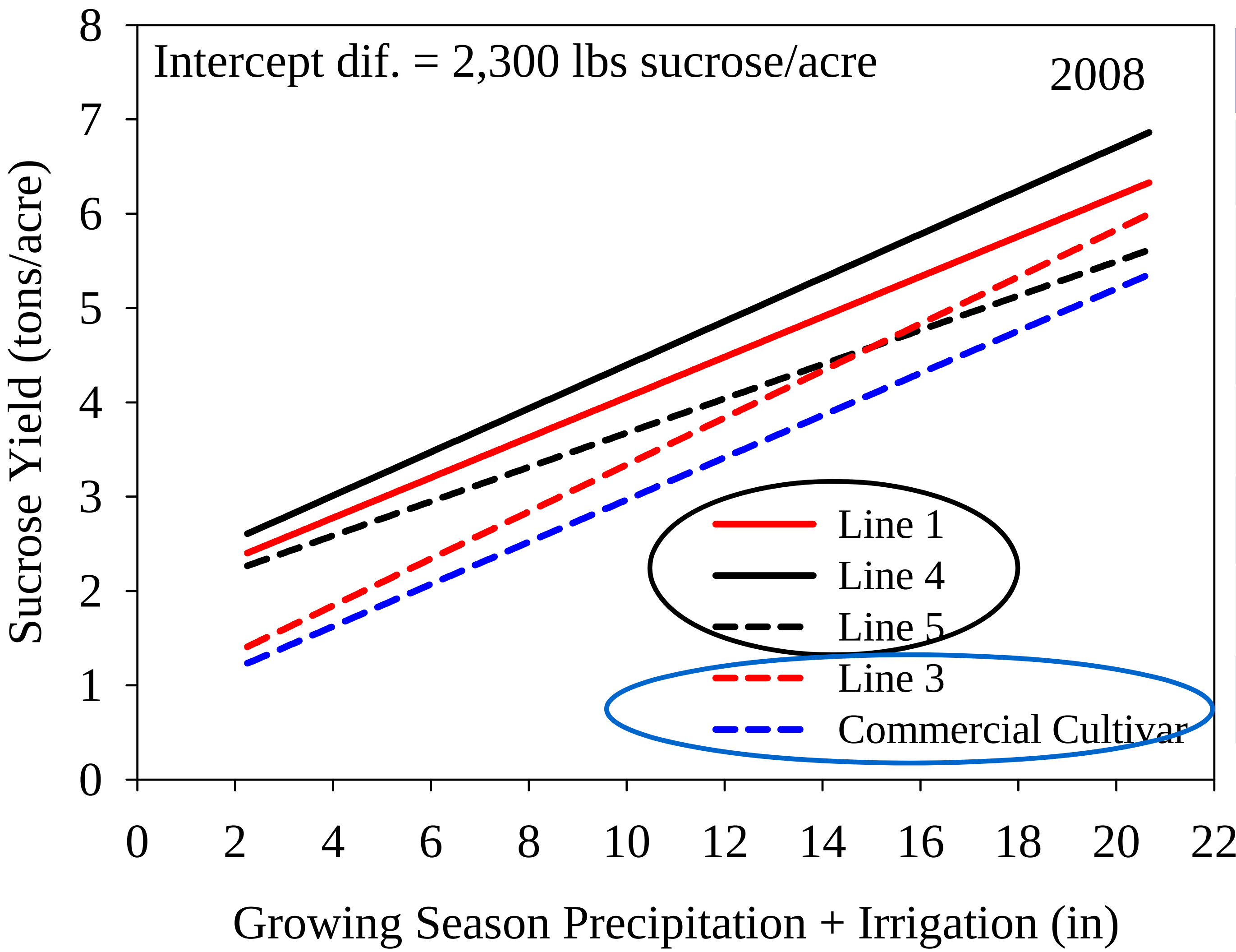

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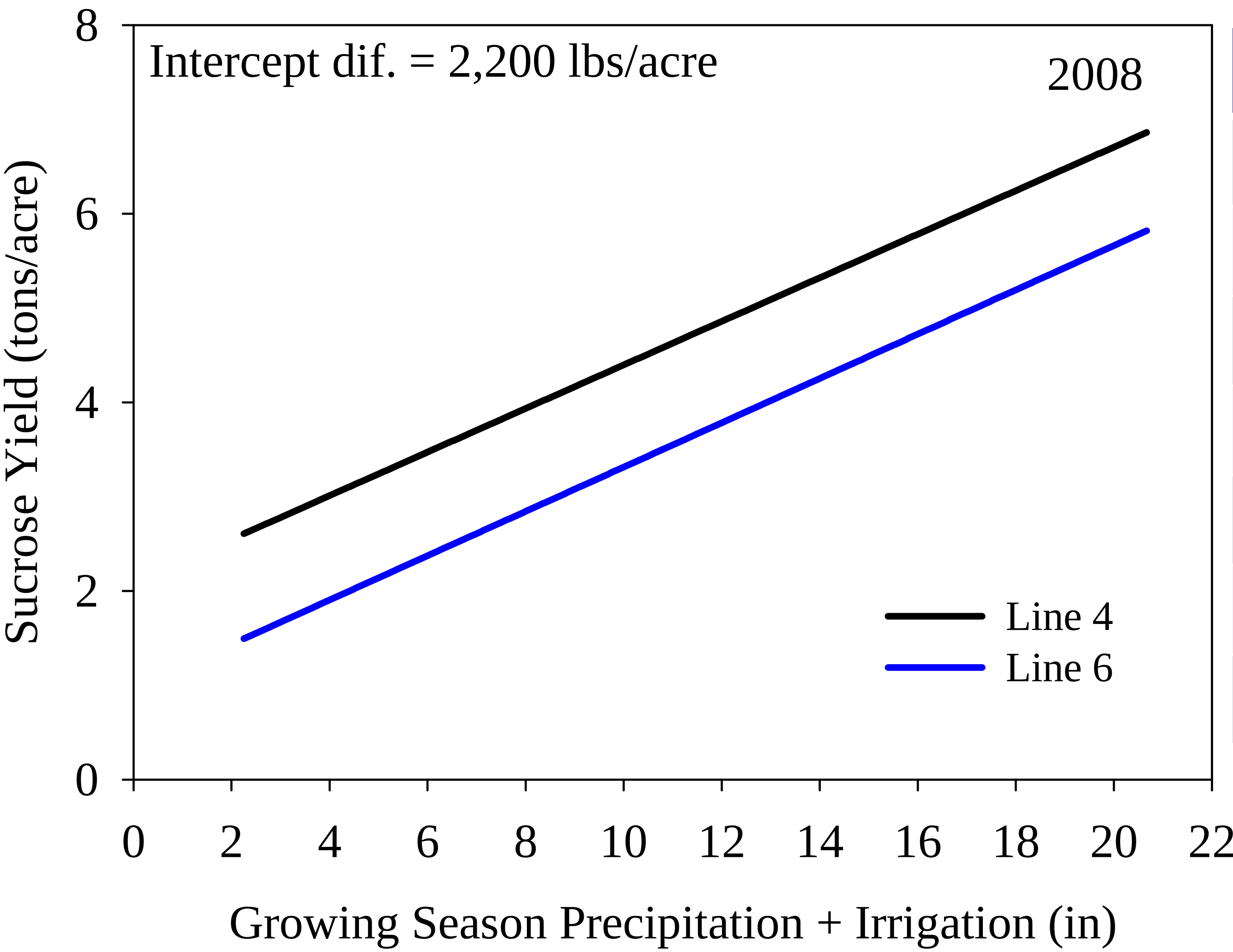

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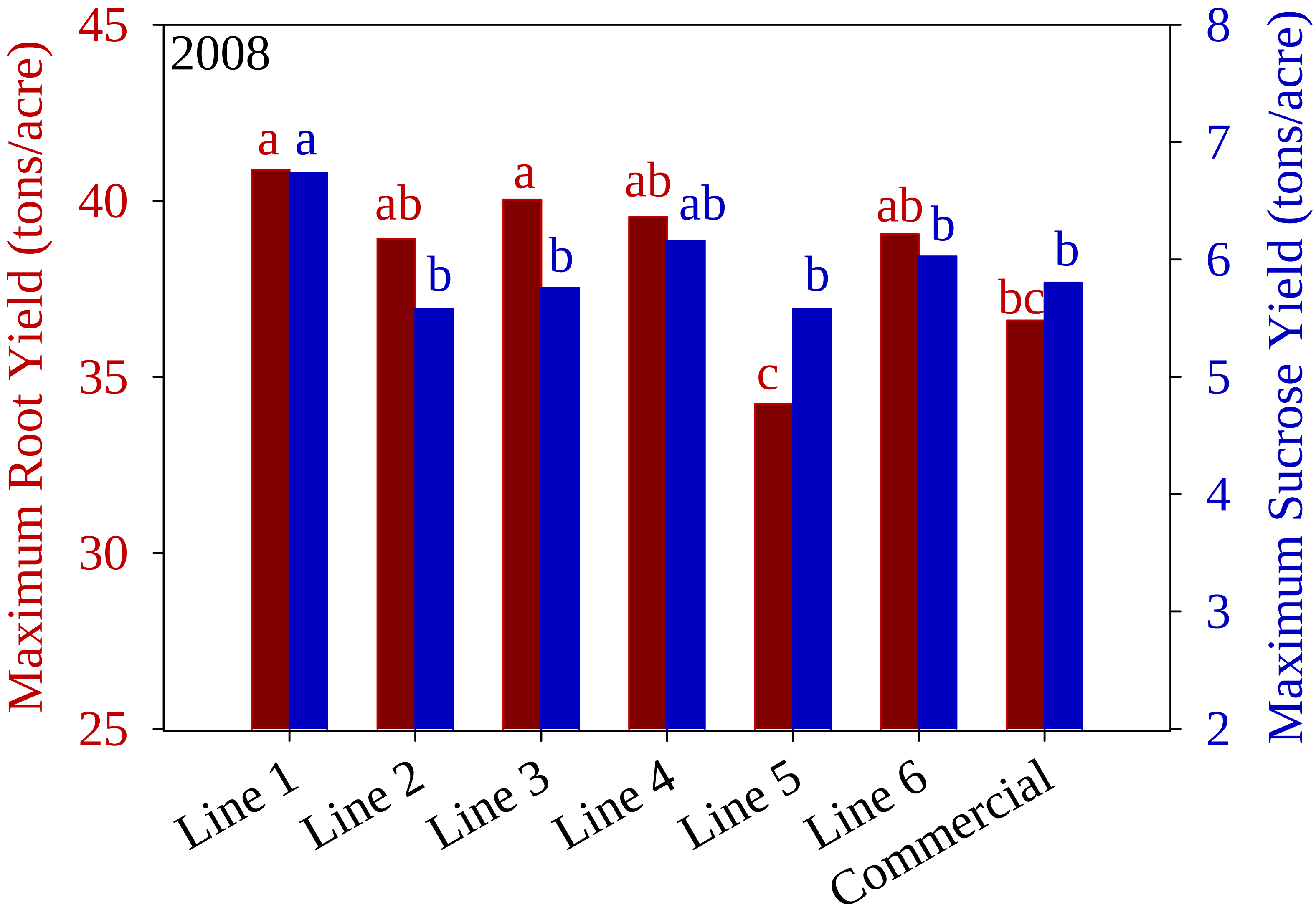

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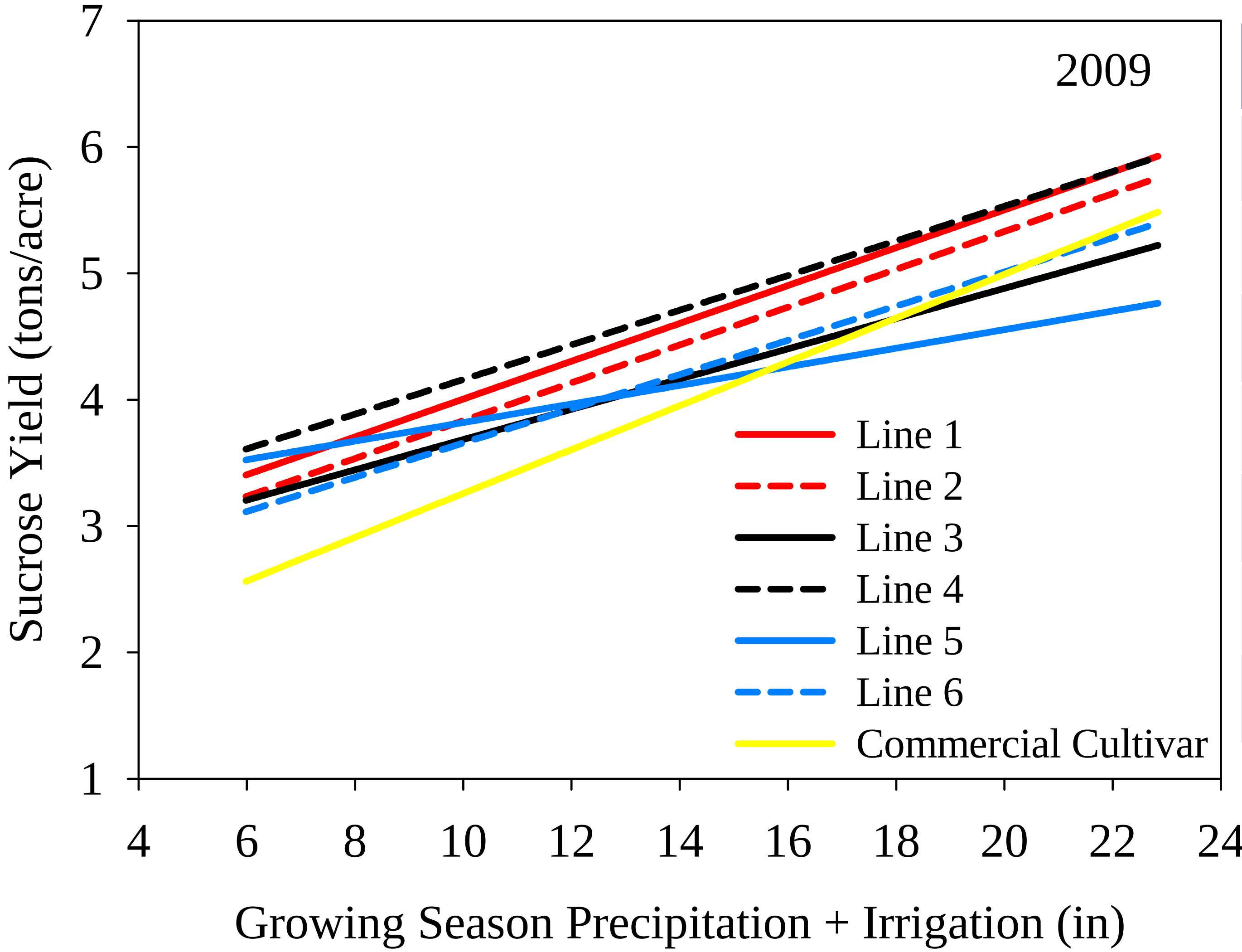

Line	Int.	Slope
1	ab	ab
2	ab	ab
3	ab	ab
4	ab	ab
5	a	a
6	ab	ab
Com.	b	b

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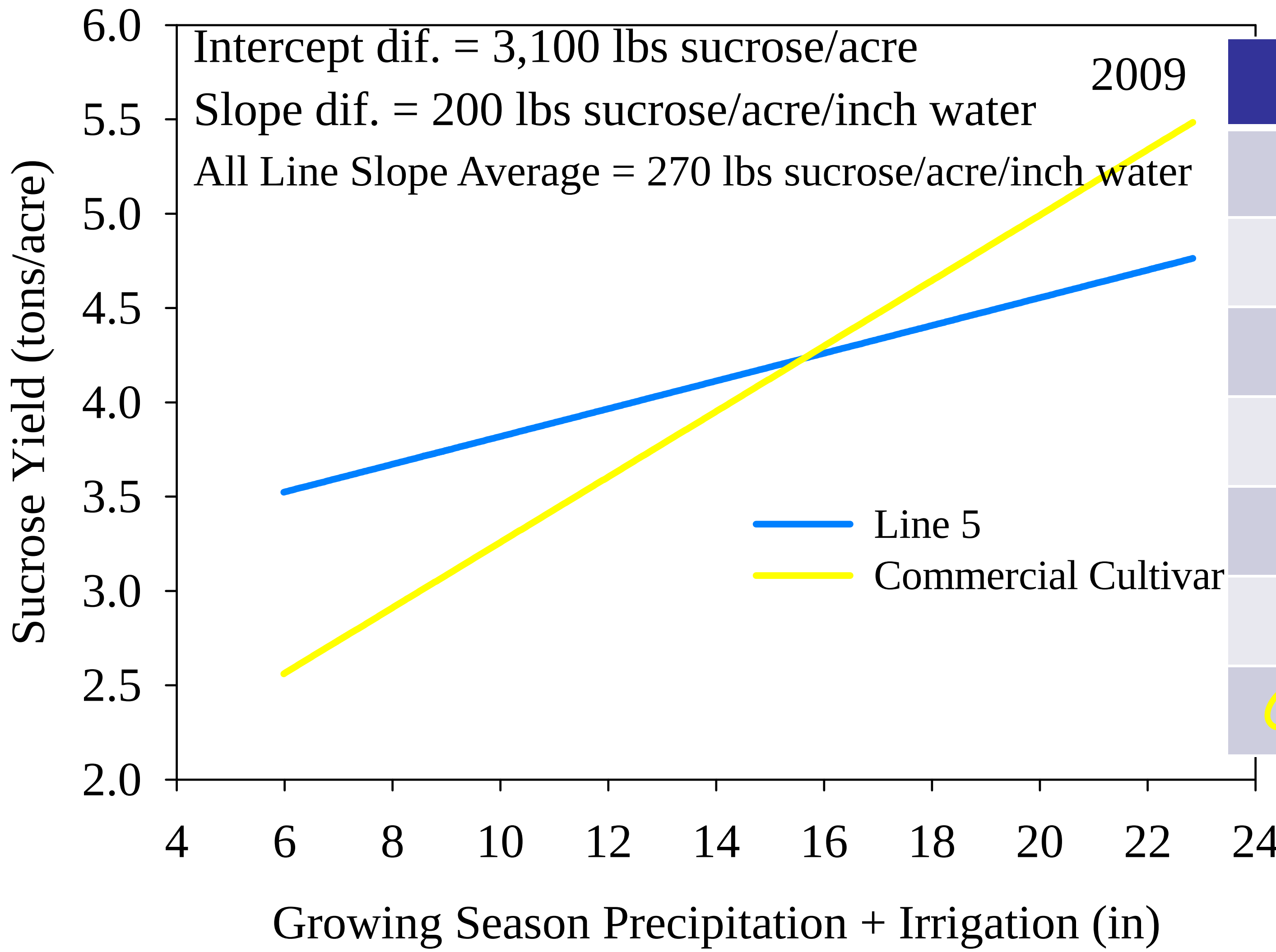

Line	Int.	Slope
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3	ab	ab
4	ab	ab
5	a	a
6	ab	ab
Com.	b	b

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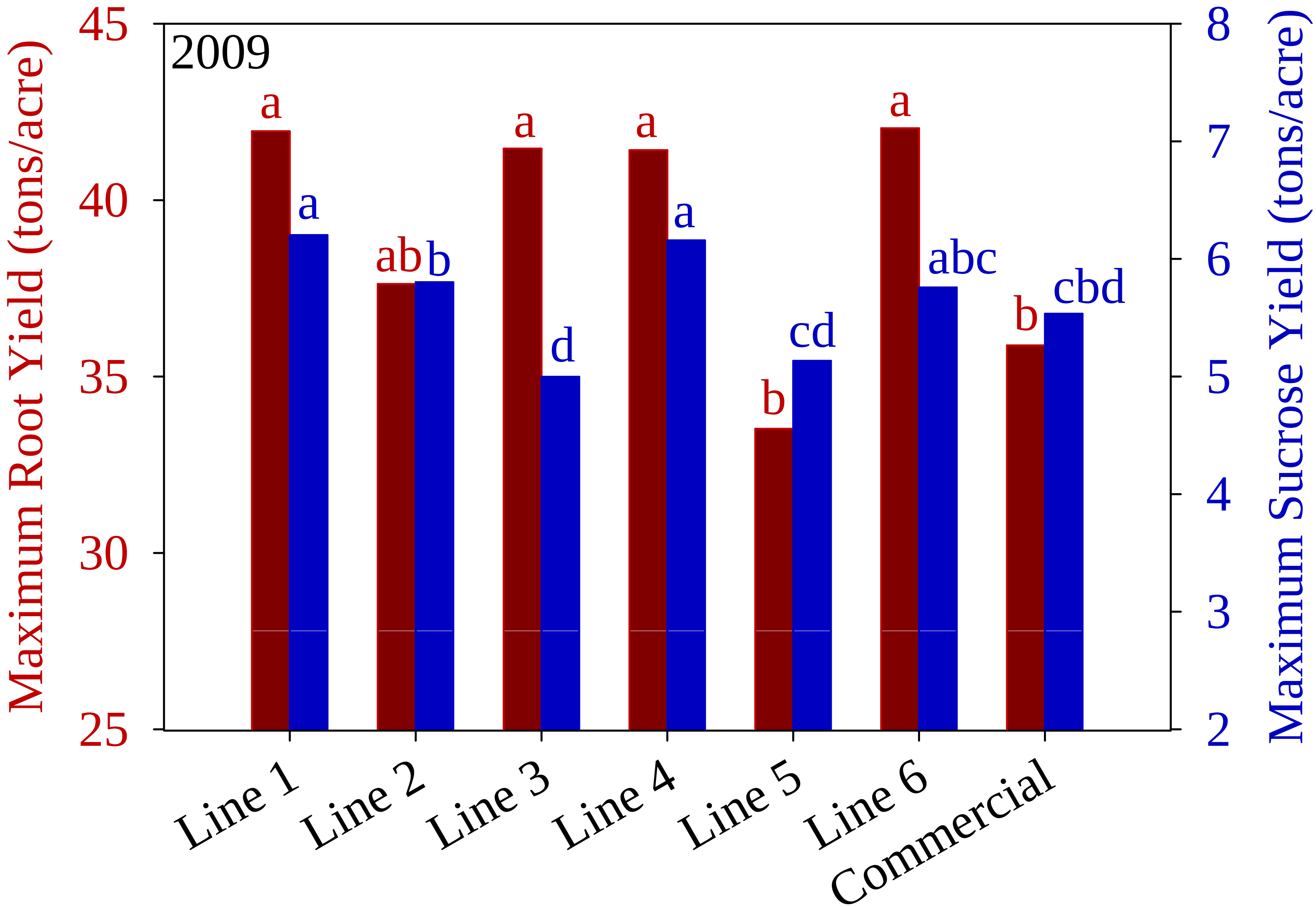

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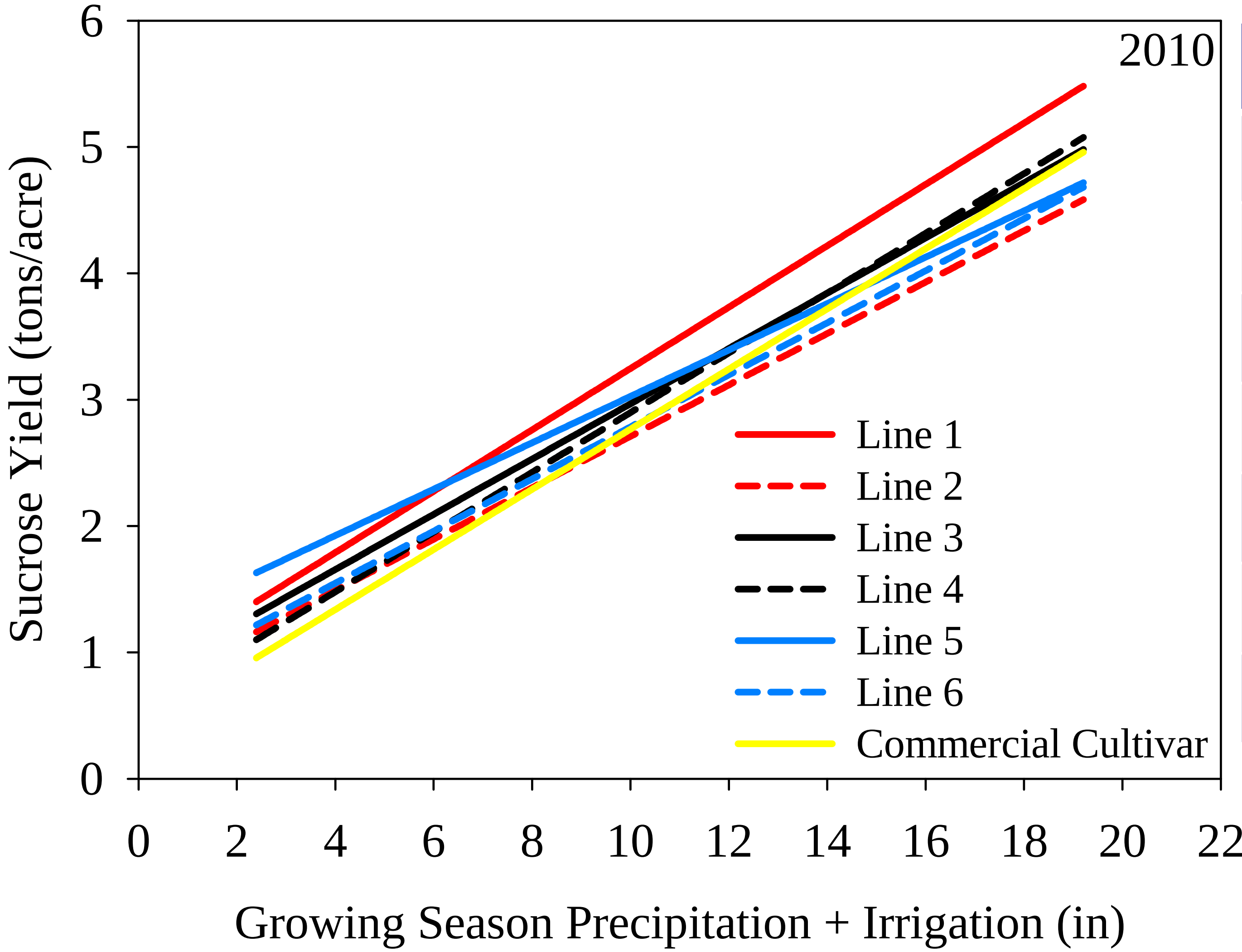

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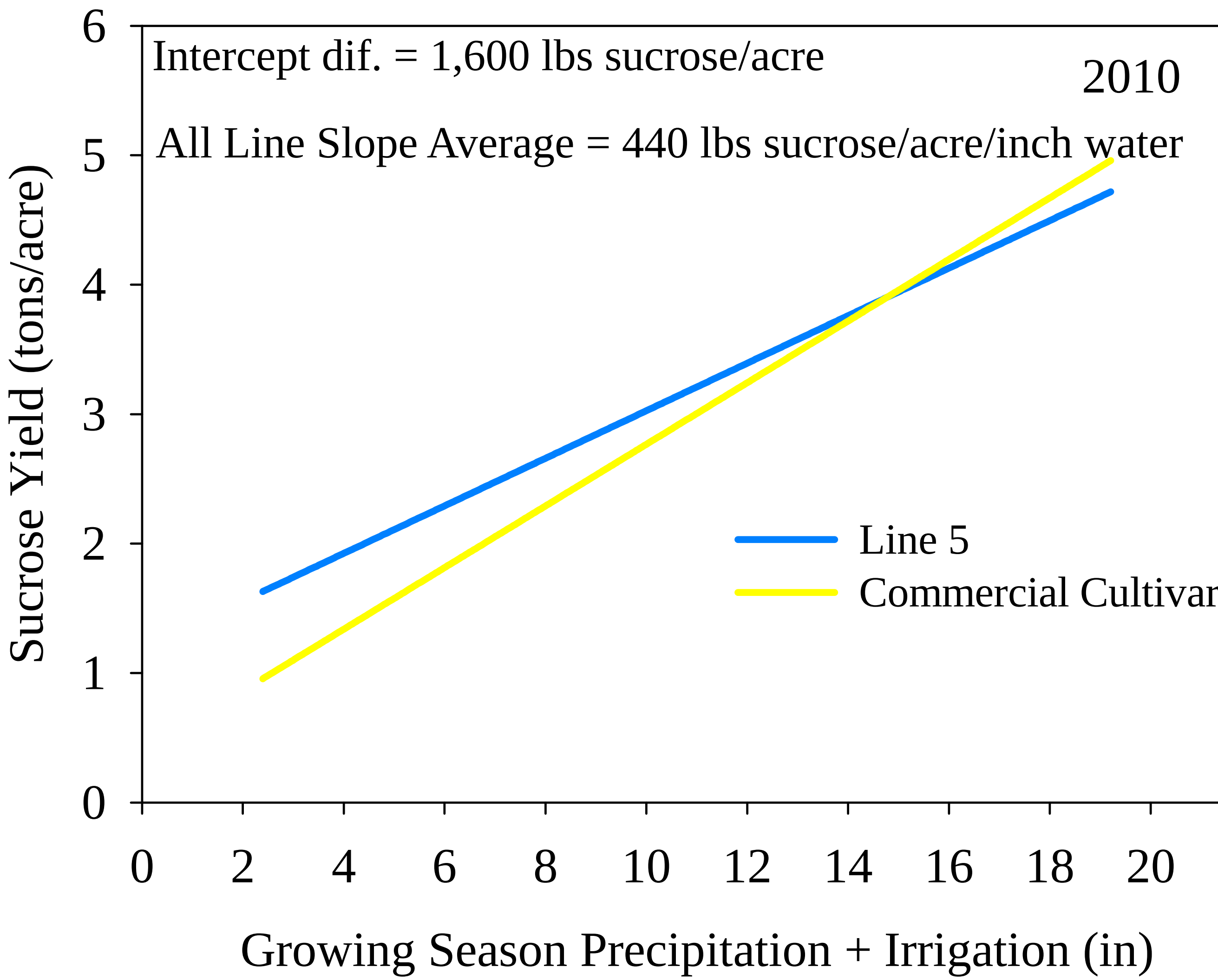

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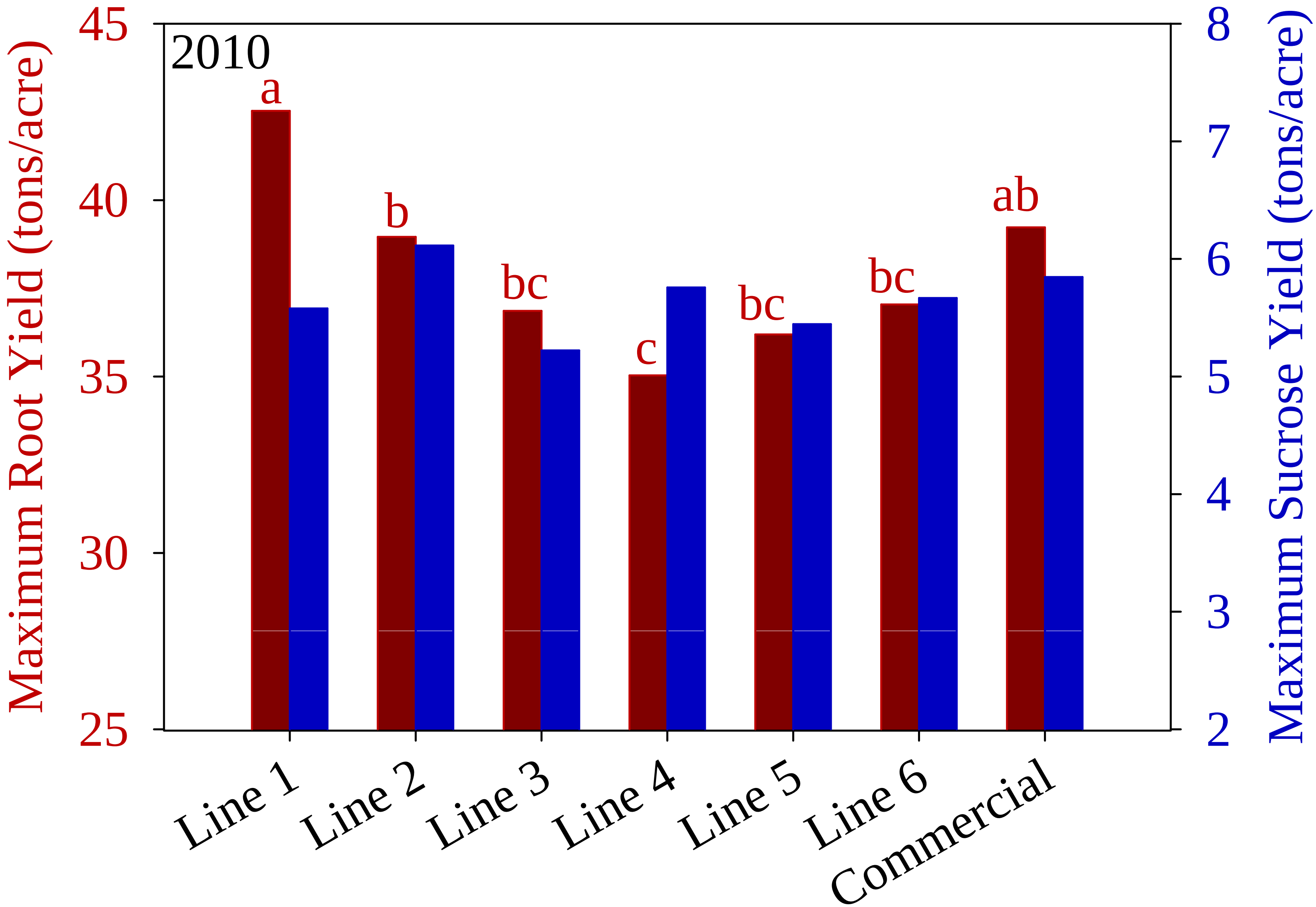

Water Input vs. Recoverable Sugar

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- Genetic differences in the production of lines under deficit water conditions.
- Response rate of lines to water inputs under deficit water conditions can differ.
  - E.g. Line 5. – High comparative sucrose and root yield under low water inputs; low comparative sucrose and root yield under higher and optimum water inputs.
- Yield potential differences exist between lines.

Summary

Questions?

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