Developing a yield loss prediction tool for Asian Soybean rust

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Embrapa

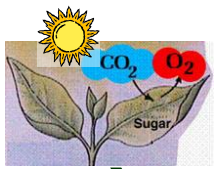
Challenge

- Develop a yield loss prediction tool for ASR
  - **Phase I:** How ASR reduces soybean yield? (Brazil)
  - **Phase II:** Develop a yield loss prediction Model for ASR (KY and LA)
  - **Phase III:** Model validation study (FL)
  - **Phase IV:** Software development

Yield

$$Y_g = Y_b \times HI$$

$$Y_b = \int_t (Q \times I_a \times \varepsilon)\, dt$$



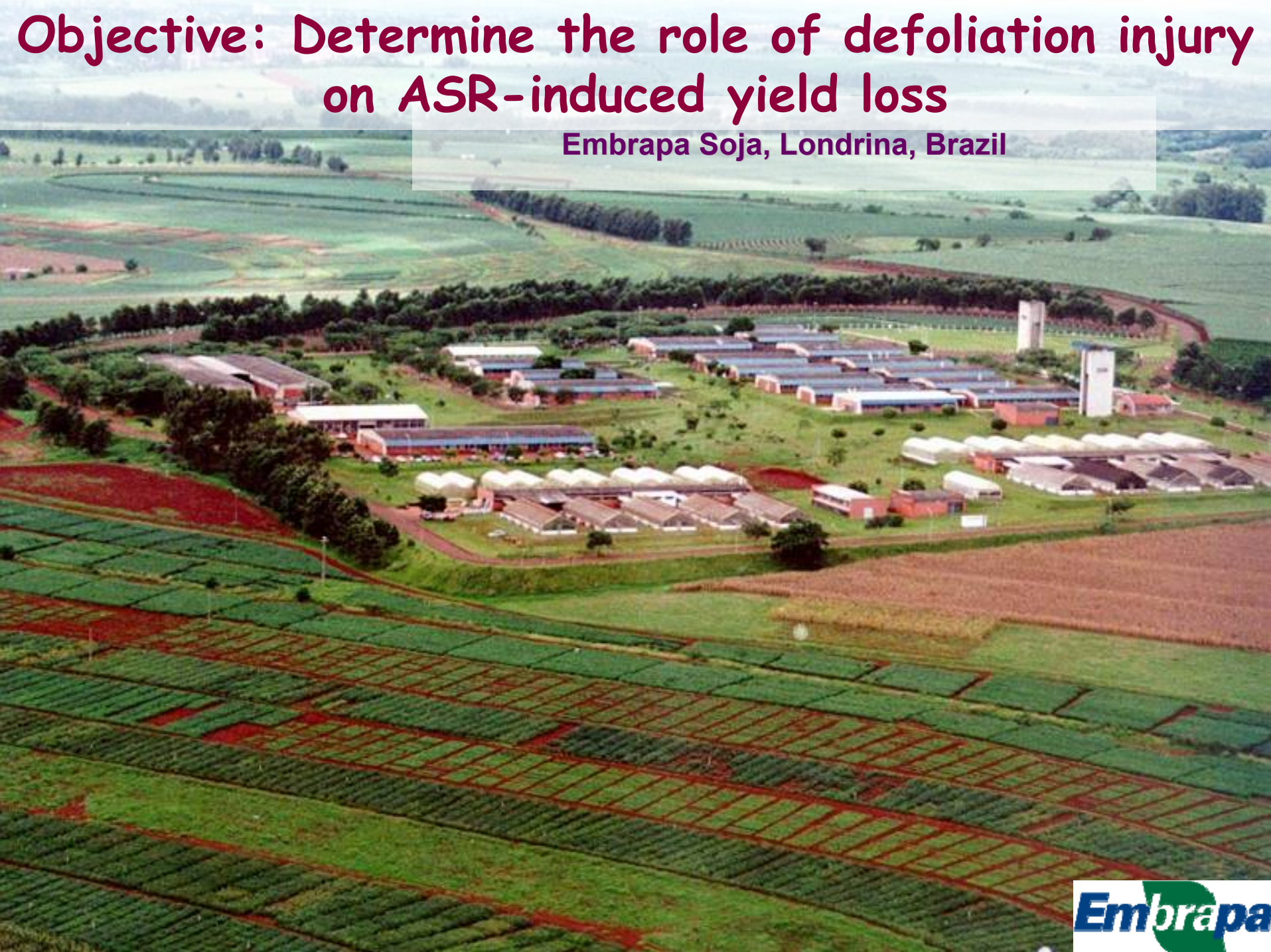
Phase I
Objective

Determine how ASR reduces soybean yield: Is ASR-induced yield loss due to defoliation injury?

$$Y_b = \int_t (Q \times I_a \times \varepsilon)\, dt$$

Objective: Determine the role of defoliation injury on ASR-induced yield loss

Embrapa Soja, Londrina, Brazil



Phase I. Determine how ASR reduces soybean yield? Londrina, Brazil

Cultivar BRS 154 (MG VII)
Rows 45 cm (~18 inches)

Materials and Methods

- RCBD design, 6 replications
- Five treatments
  1. ASR - R1

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- RCBD design, 6 replications
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  1. ASR - R1
  2. Mimic “ASR” at R1

Materials and Methods

- RCBD design, 6 replications
- Five treatments
  1. ASR - R1
  2. Mimic “ASR” at R1
  3. ASR - R5

Materials and Methods

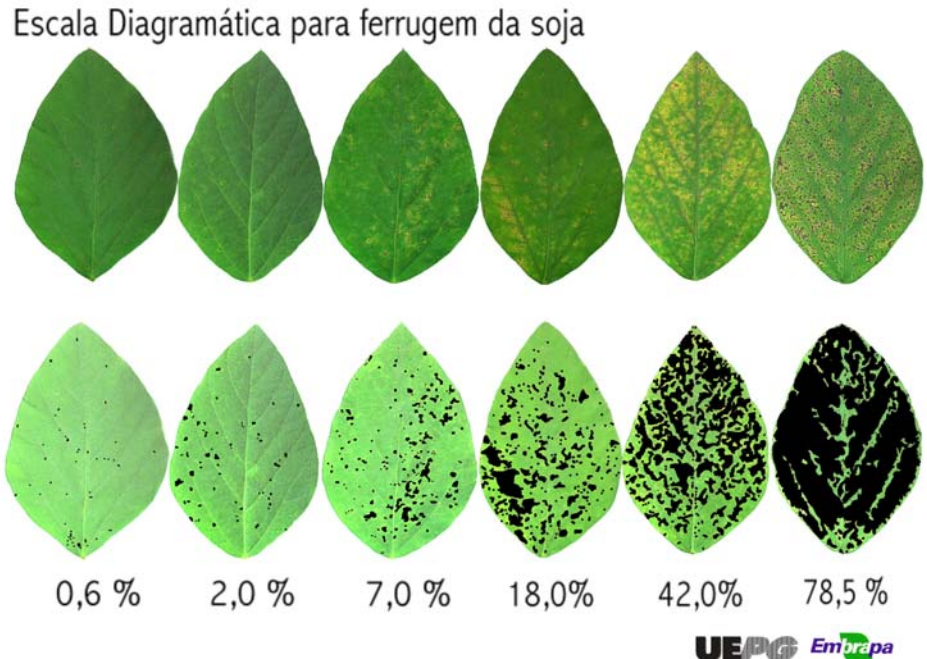
- RCBD design, 6 reps
- Five treatments
  1. ASR - R1
  2. Mimic - R1
  3. ASR - R5
  4. Mimic - R5

Materials and Methods

- RCBD design, 6 reps
- Five treatments
  1. ASR - R1
  2. Mimic - R1
  3. ASR - R5
  4. Mimic - R5
  5. Control

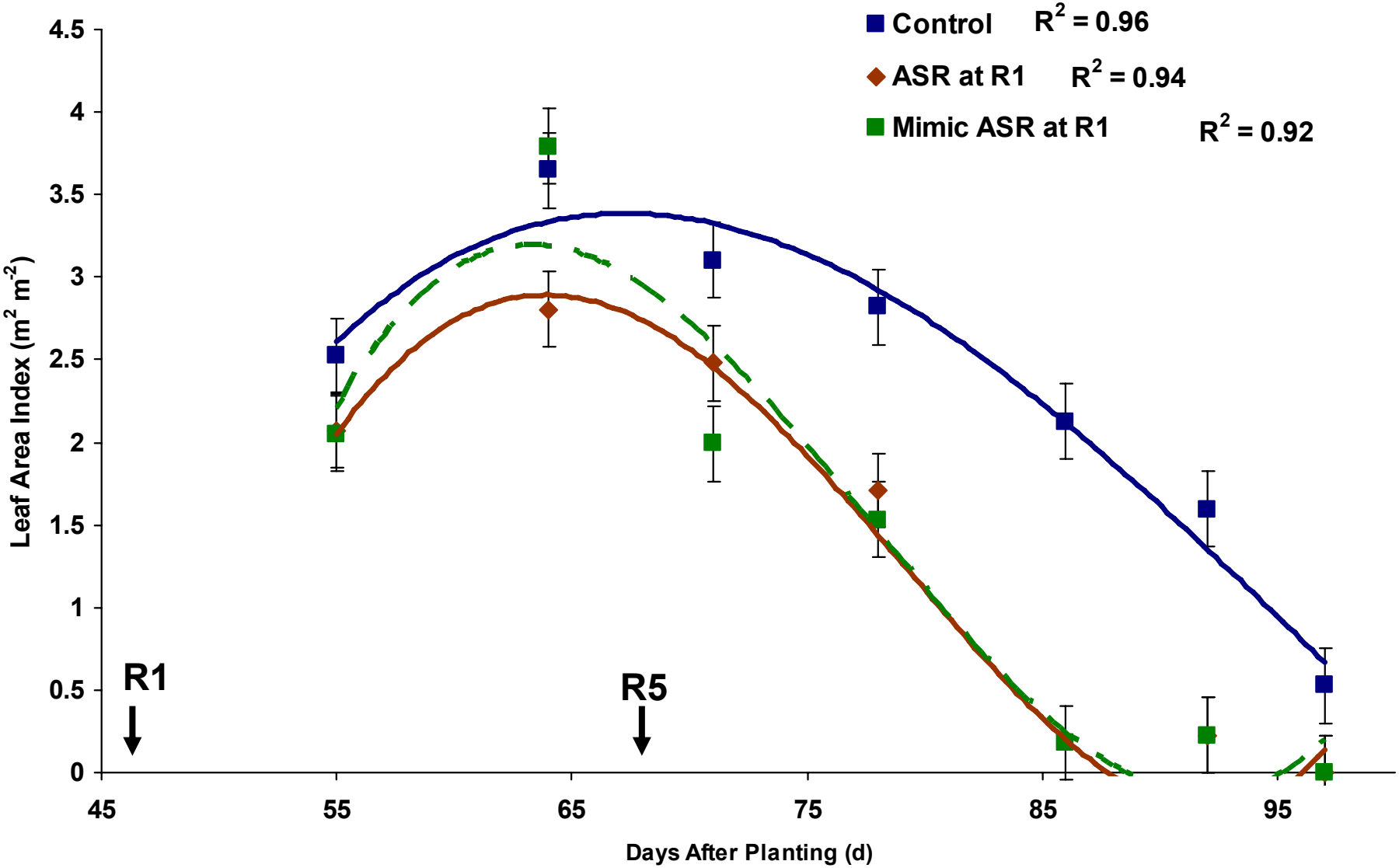
Materials and Methods

- Measured Leaf Area Index
- Disease severity
- Yield

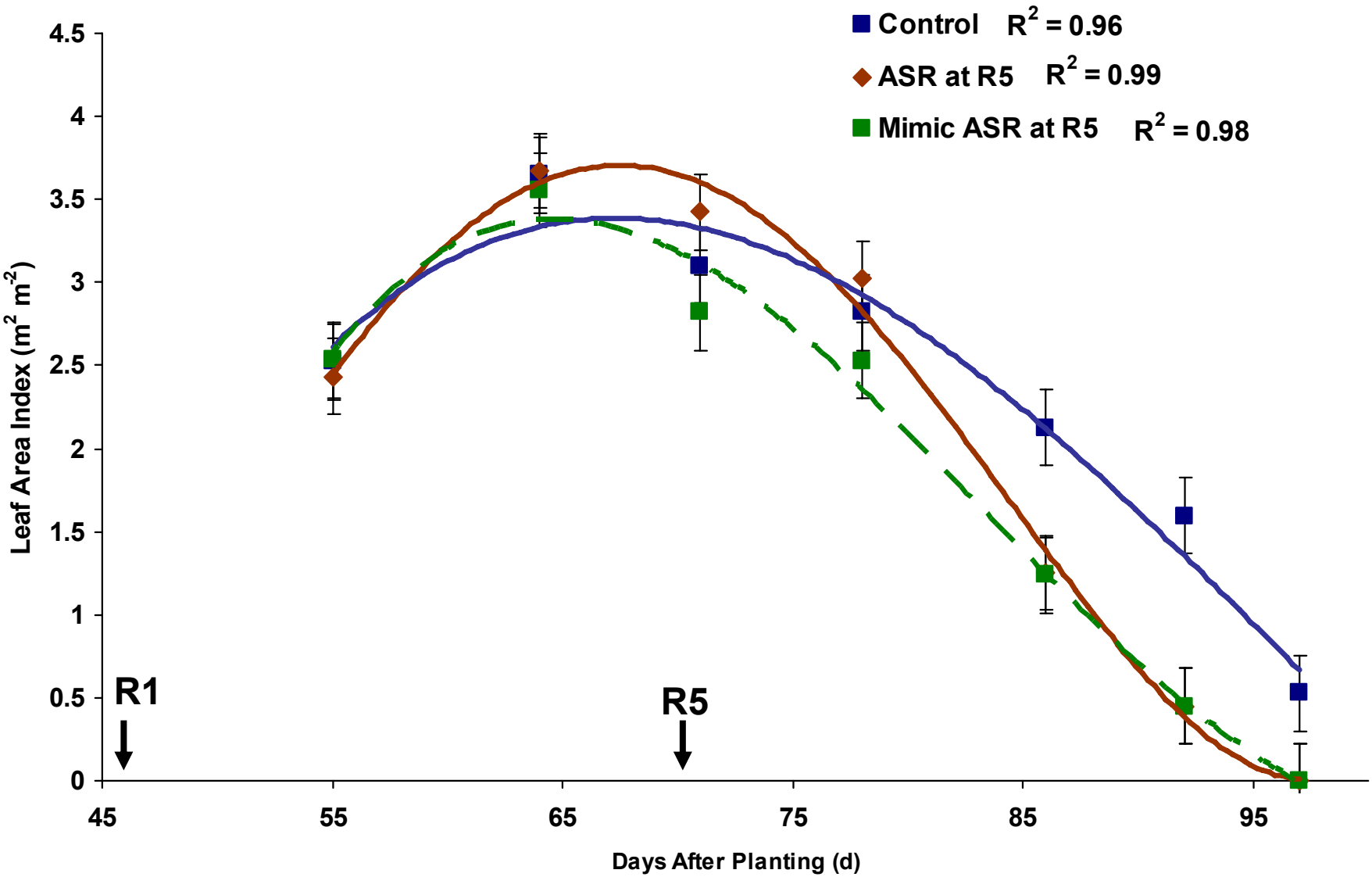


Results and Discussion

Plants infected at R1, leaf area over time – 2005/2006



Plants infected at R5, leaf area over time – 2005/2006



Role of defoliation injury in yield loss?

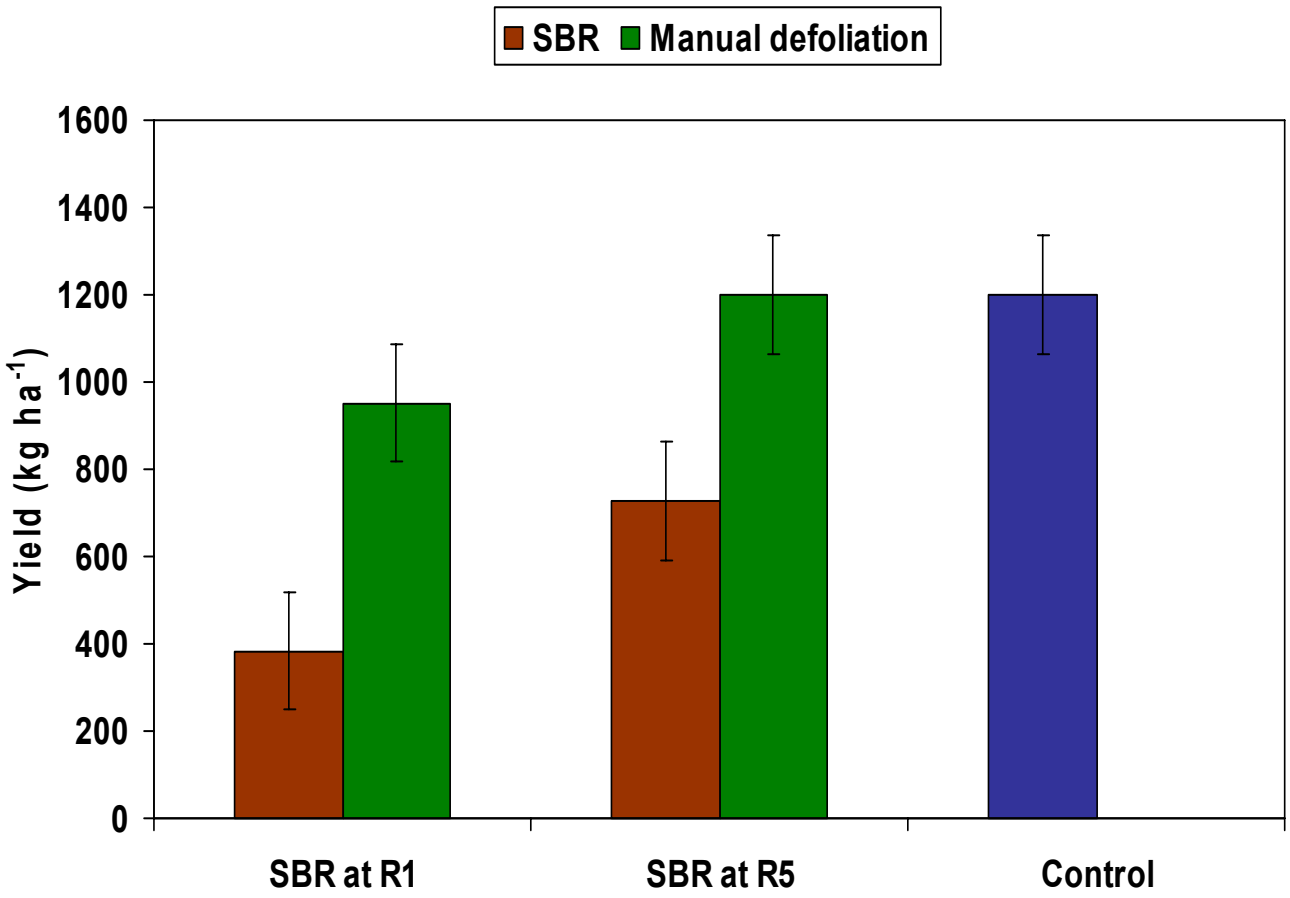
VS.

ASR-infected plot (ASR at R1)

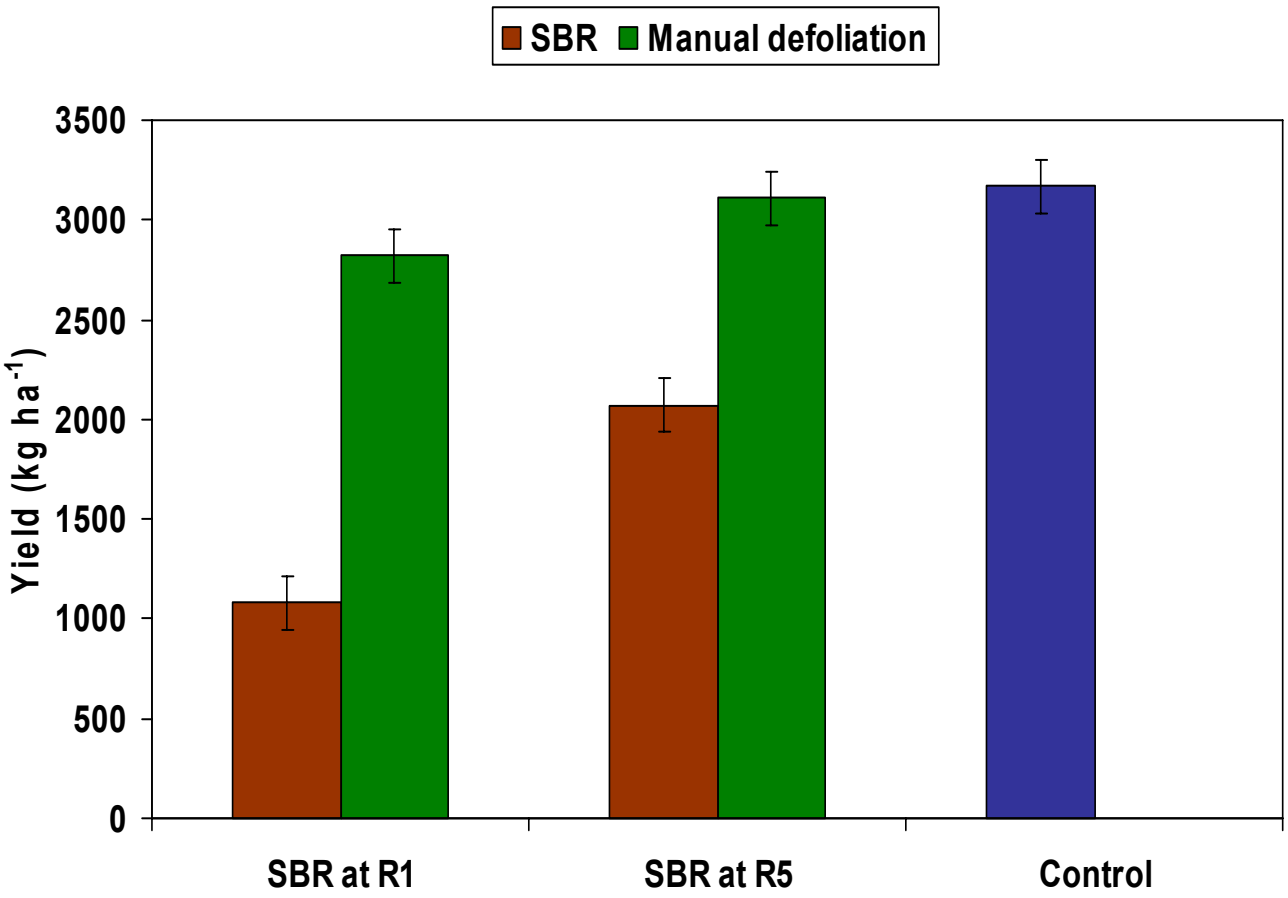
Mimic ASR at R1
Fungicide treated, and manually defoliated to mimic ASR- plots

Plants around R6

Impact of ASR on yield - 2005/2006



Impact of ASR on yield – 2006/2007



$$Y_b = \int_t (Q \times I_a \times \varepsilon)\, dt$$

$$\text{Absorbed PAR} = \sum[\text{PAR} \times (1 - e^{-k} \times \text{LAI})]$$

(by LAI)

Table of Absorbed radiation from R1 to R7 in 2005/2006 and 2006/2007

Treatment	Absorbed PAR (MJ m^{-2})	Yield
	LAI	
	----------2005/2006----------	
ASR-R1	238 b	
DF-R1	243 b	
Control	318 a	
	----------2006/2007----------	
ASR-R1	278 b	
DF-R1	278 b	
Control	309 a	

Table of Absorbed radiation from R1 to R7, and yield in 2005/2006 and 2006/2007

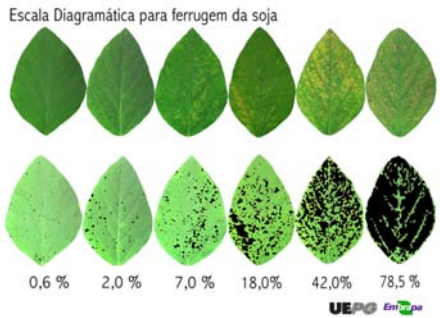
Treatment	Absorbed PAR (MJ m^{-2}) LAI	Yield
	----------2005/2006----------	
ASR-R1	238 b	384 c
DF-R1	243 b	952 b
Control	318 a	1200 a
	----------2006/2007----------	
ASR-R1	278 b	1080 b
DF-R1	278 b	2820 a
Control	309 a	3170 a

Close look at ASR-infected plot

Non-abscised ASR-infected leaf

Green leaf area index (GLAI)

GLAI = LAI x (1- disease severity)



$$Y_b = \int_t (Q \times I_a \times \varepsilon)\, dt$$

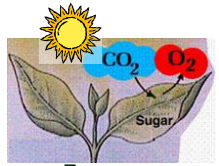
$$\text{Absorbed PAR} = \sum[PAR \times (1 - e^{-k \times GLAI})]$$

(by GLAI)

Table of radiation absorbed by leaf area, and green leaf area from R1 to R7 in 2005/2006 and 2006/2007

Treatment	Absorbed PAR (MJ m^{-2})		Yield
	LAI	GLAI	
	----------2005/2006----------		
ASR-R1	238 b	**193 c**	**384 c**
DF-R1	243 b	**232 b**	**952 b**
Control	318 a	**311 a**	**1200 a**
	----------2006/2007----------		
ASR-R1	278 b	**238 c**	**1080 b**
DF-R1	278 b	**276 b**	**2820 a**
Control	309 a	**305 a**	**3170 a**

Biological Yield



$$Y_b = \int_t (Q \times I_a \times \varepsilon)\, dt$$

What is the impact of ASR on radiation use efficiency (RUE)?

Objective: What is the impact of ASR on RUE?

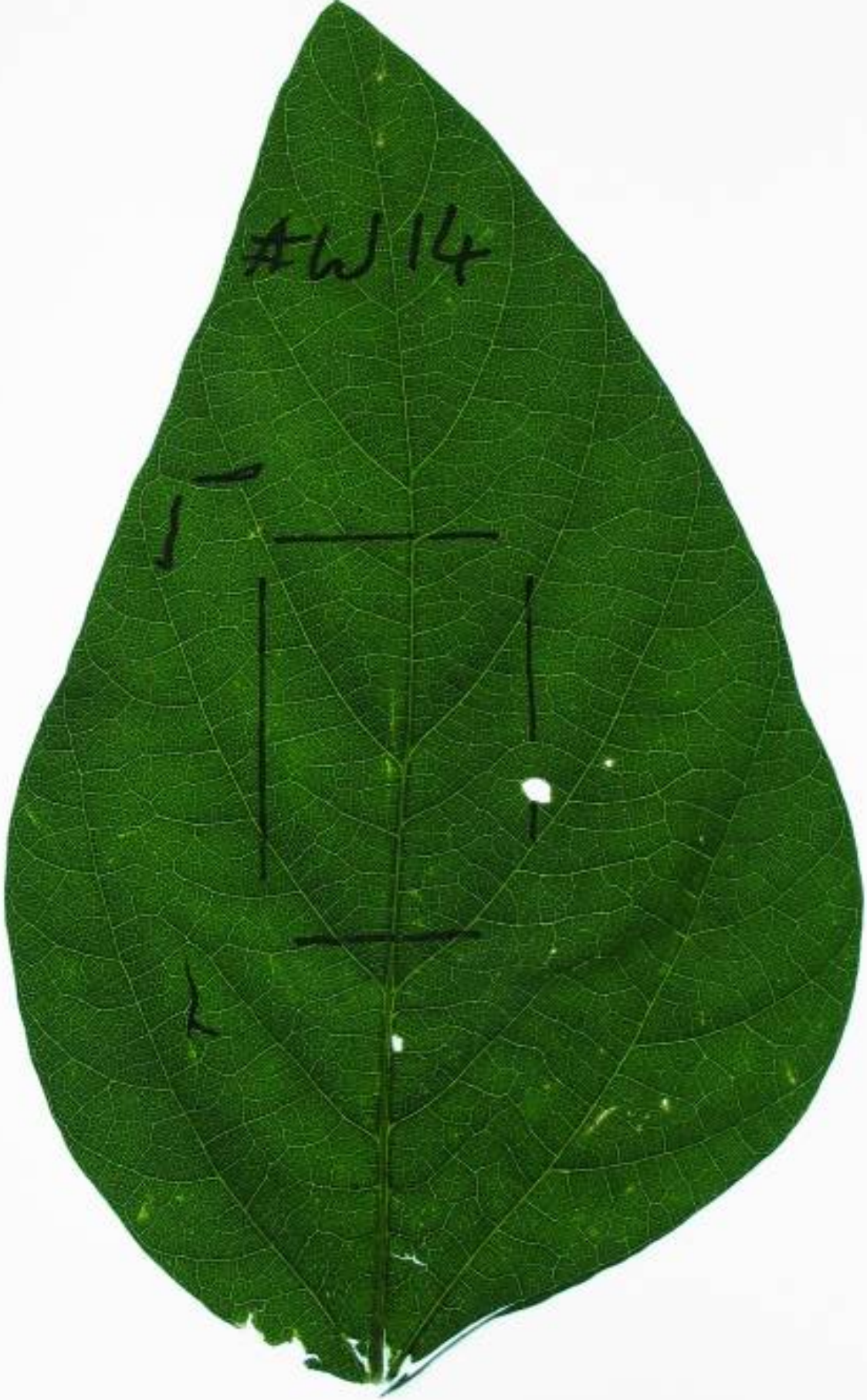
- **Study in Quincy, FL**
  - North Florida Research and Education Center
  - Cultivar DP 72200-RR
  - Row widths 36”
  - Fungicide: Headline ASR

Controlled Environment Study - KY

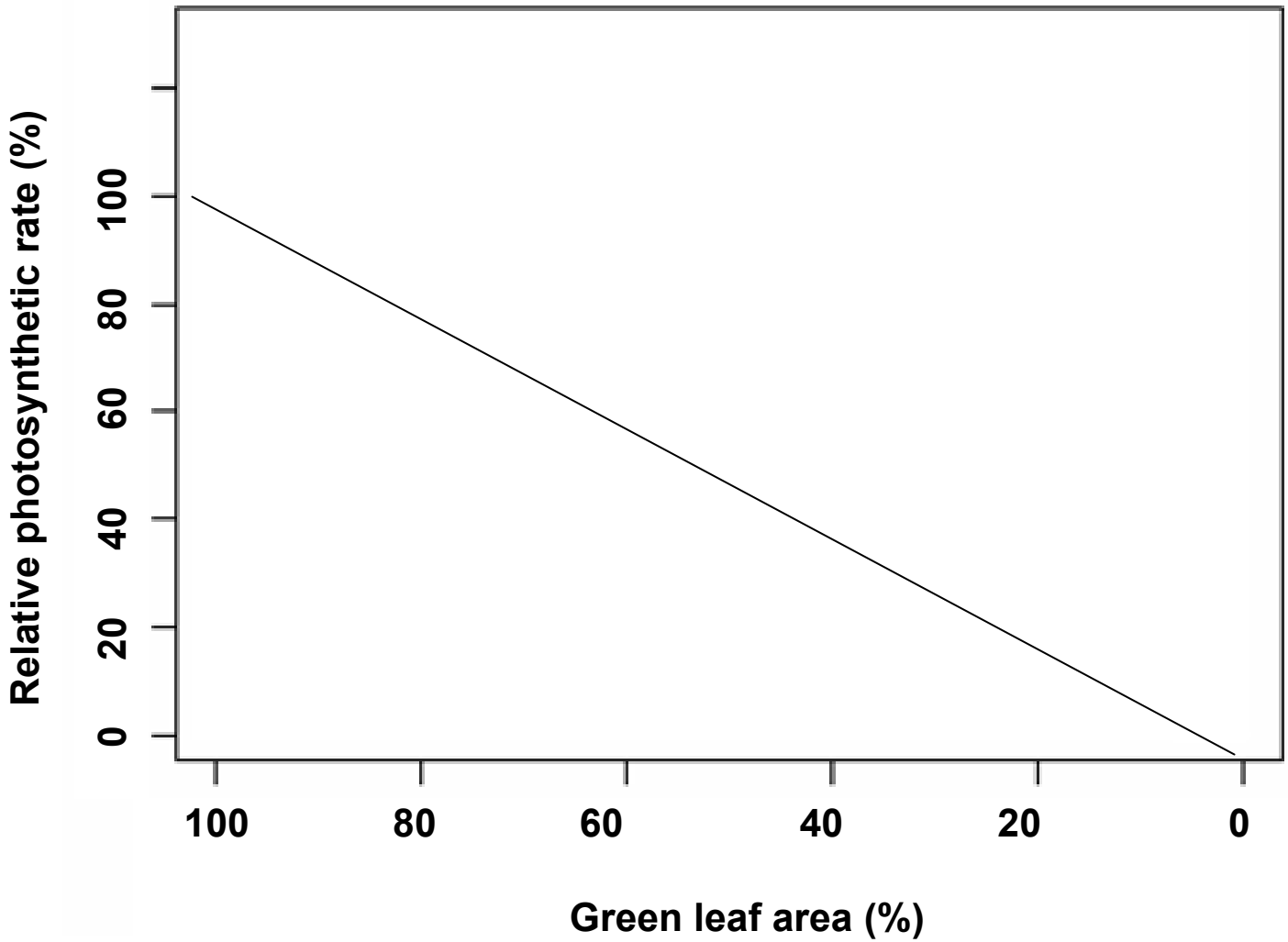
Main plot: High, zero disease severity
Split plot: Resistant versus Susceptible RILs
Split-split plot: pre-sporulating versus post sporulating

Measurements

- Selected sun-lit, upper canopy leaves with variation in disease severity
- Net photosynthetic rate
- Disease severity


AW14

Impact of ASR lesions on photosynthesis – Growth chamber data from Lexington, KY



Impact of ASR lesions on photosynthesis – Field data from Quincy, FL

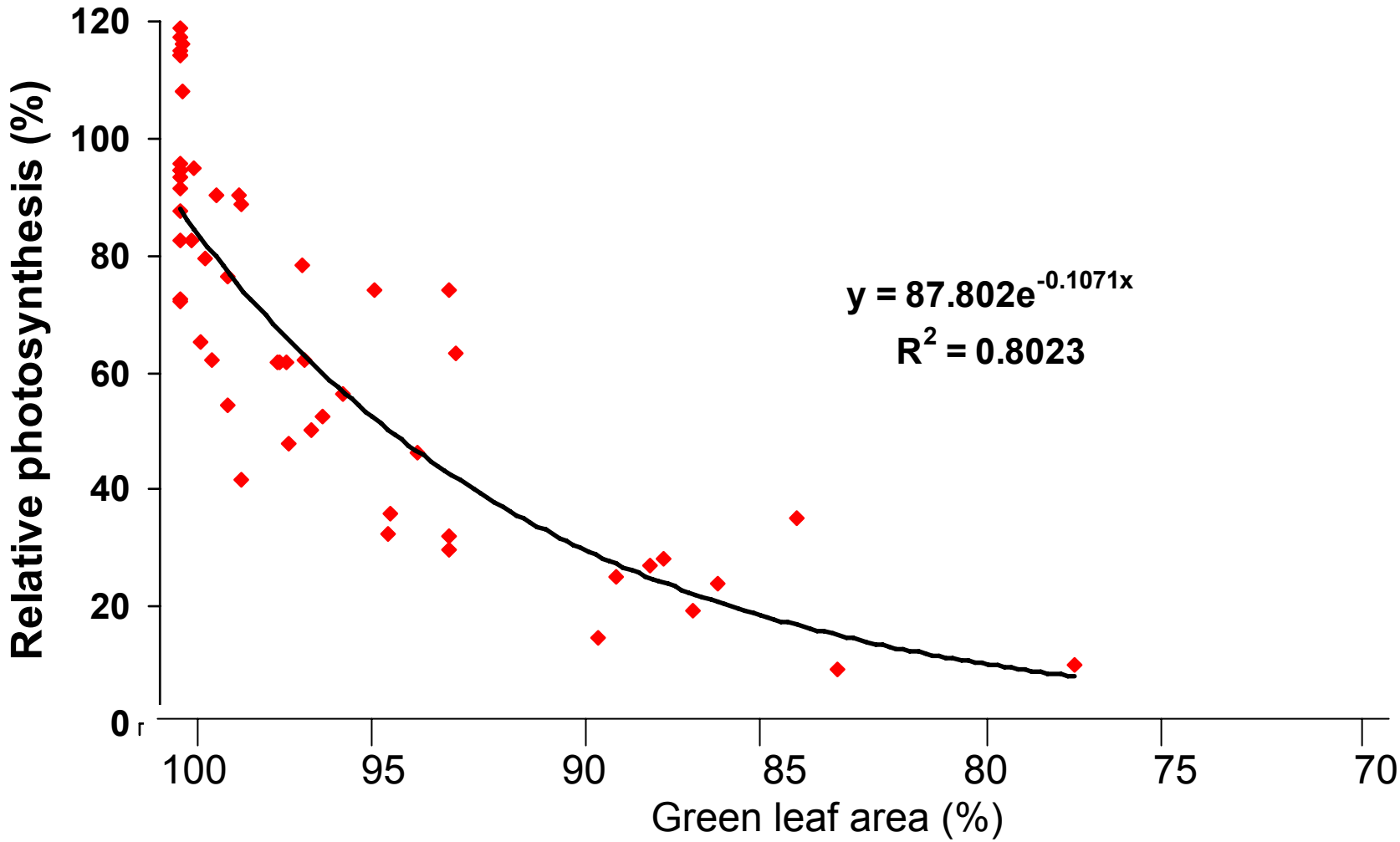
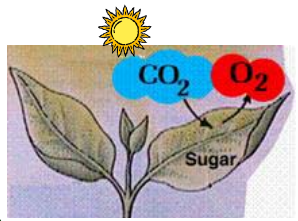


Table of RUE from R1 to R7, and yield in 2005/2006 and 2006/2007

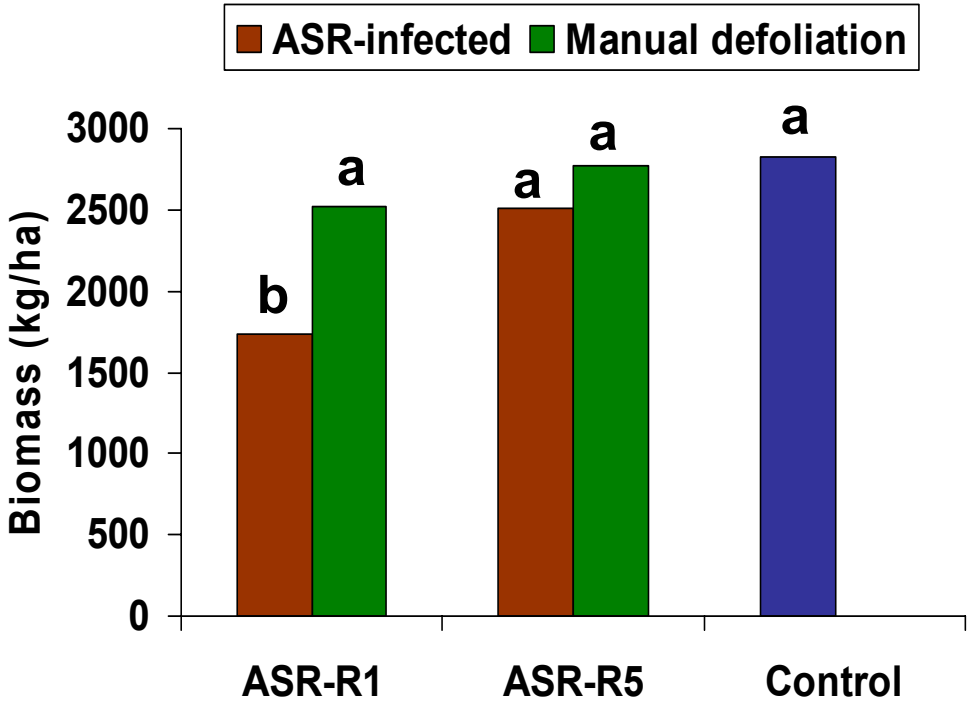
Treatment	RUE (g MJ^{-1})	Yield
	----------2005/2006----------	
ASR-R1	0.85 b	384 c
DF-R1	1.21 a	952 b
Control	0.89 ab	1200 a
	----------2006/2007----------	
ASR-R1	1.00 b	1080 b
DF-R1	1.88 a	2820 a
Control	1.63 a	3170 a

Biological Yield

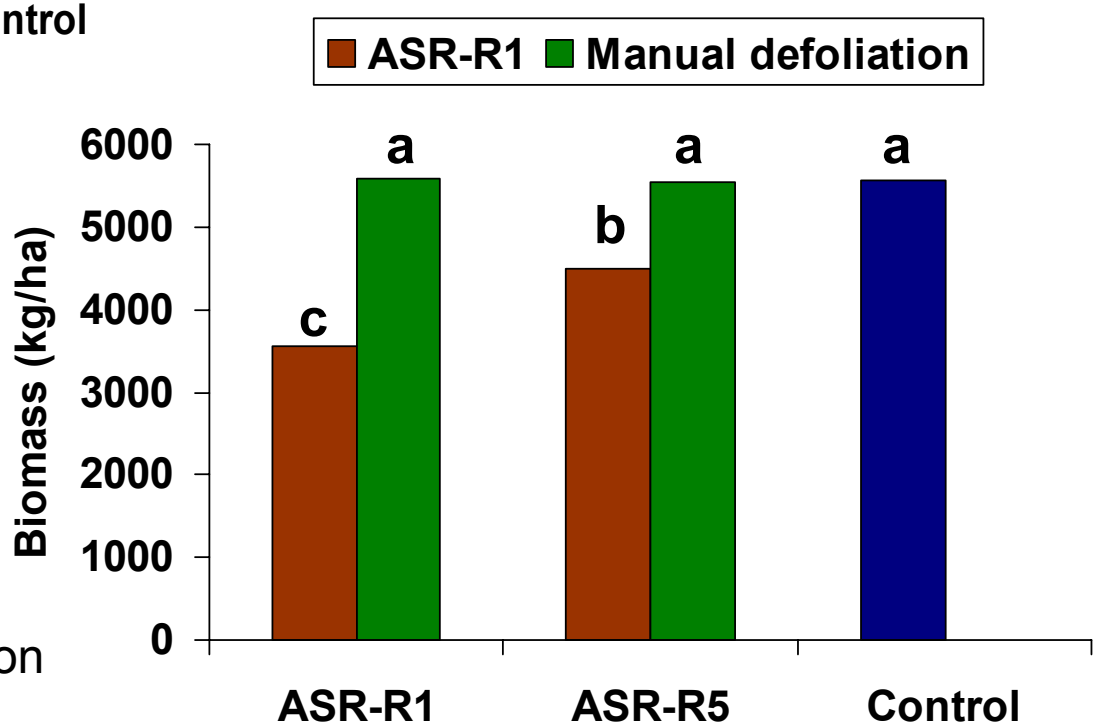


$$Y_b = \int_t (Q \times I_a \times \varepsilon)\, dt$$

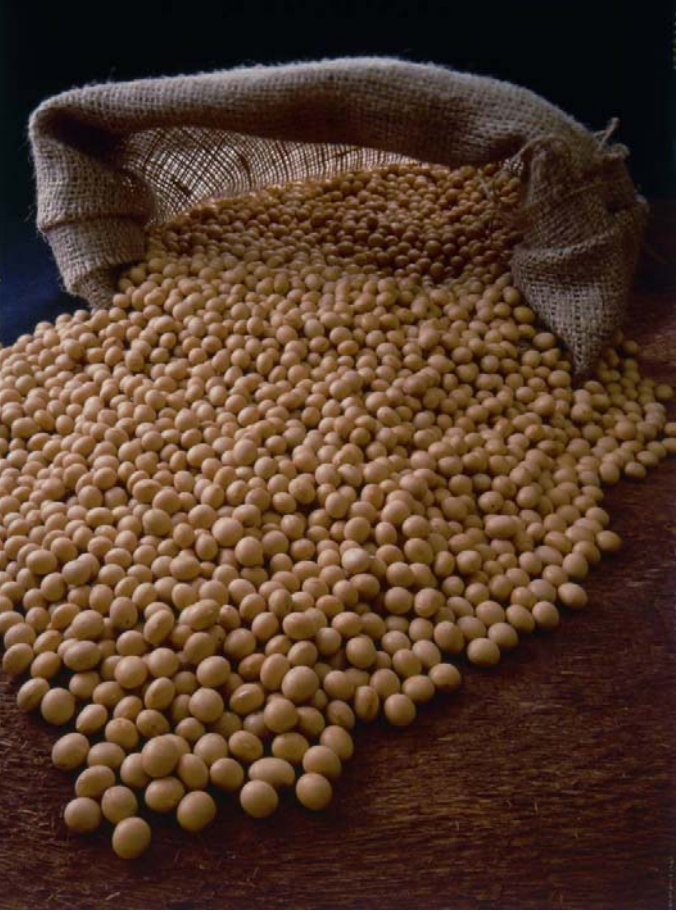
Effects of ASR and manual defoliation starting on biomass at maturity



A. 2005/2006 growing season



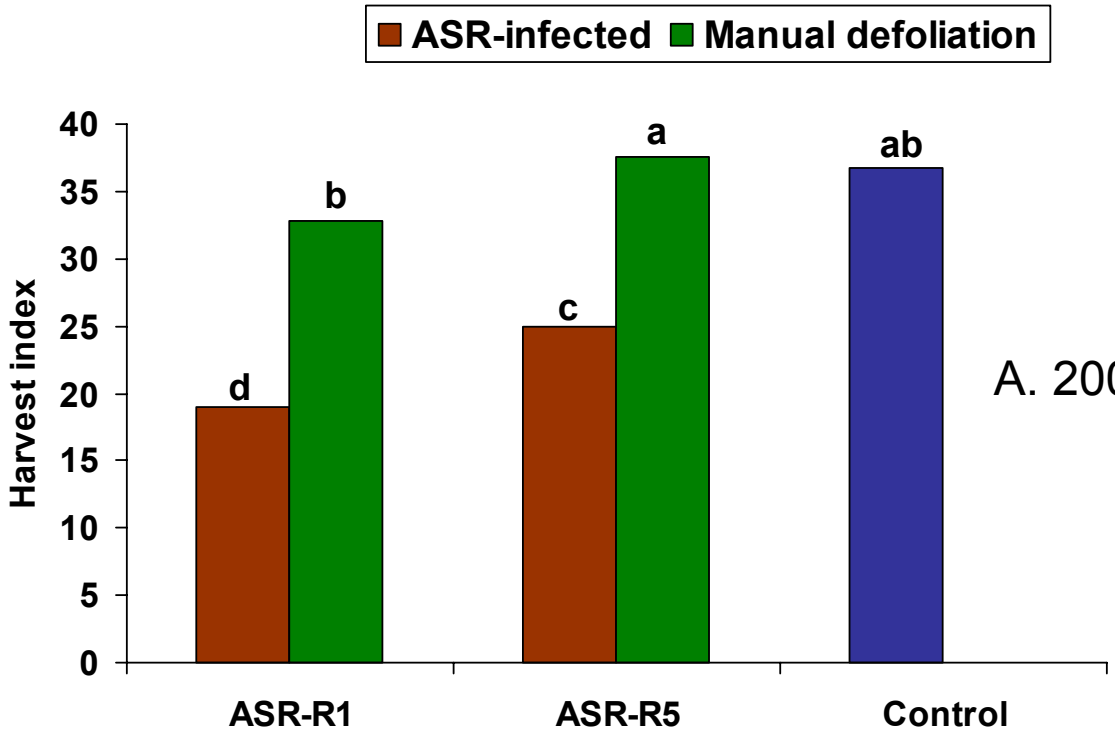
B. 2006/2007 growing season



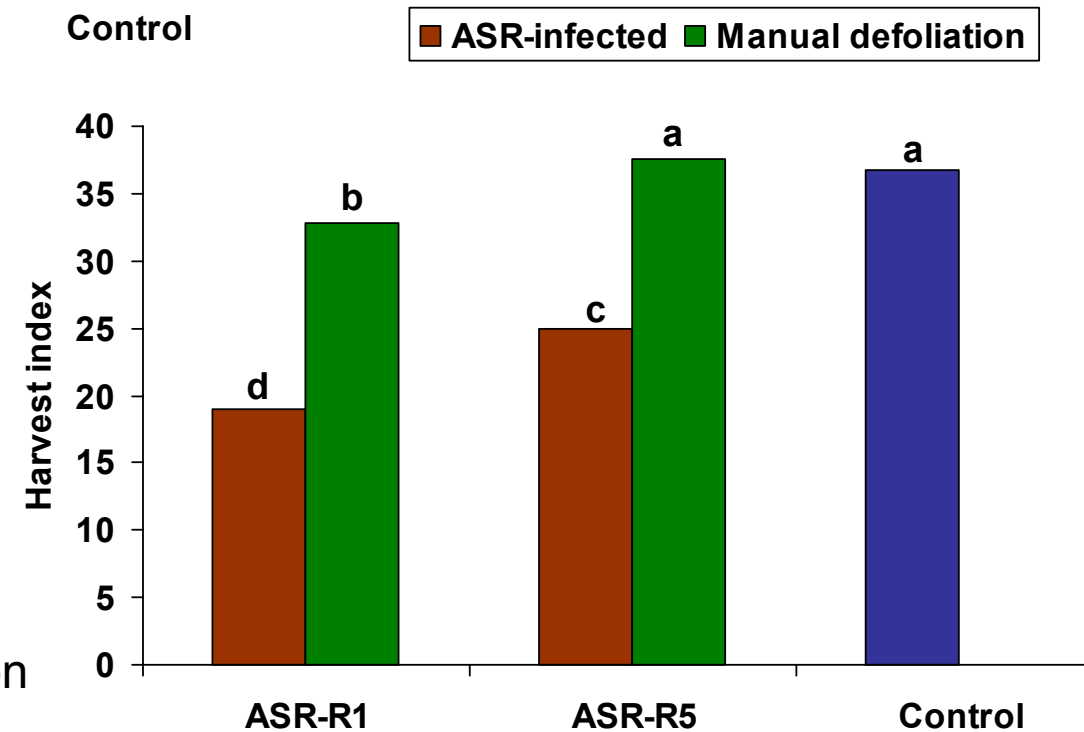
Grain Yield

$$Y_g = Y_b \text{ X HI}$$

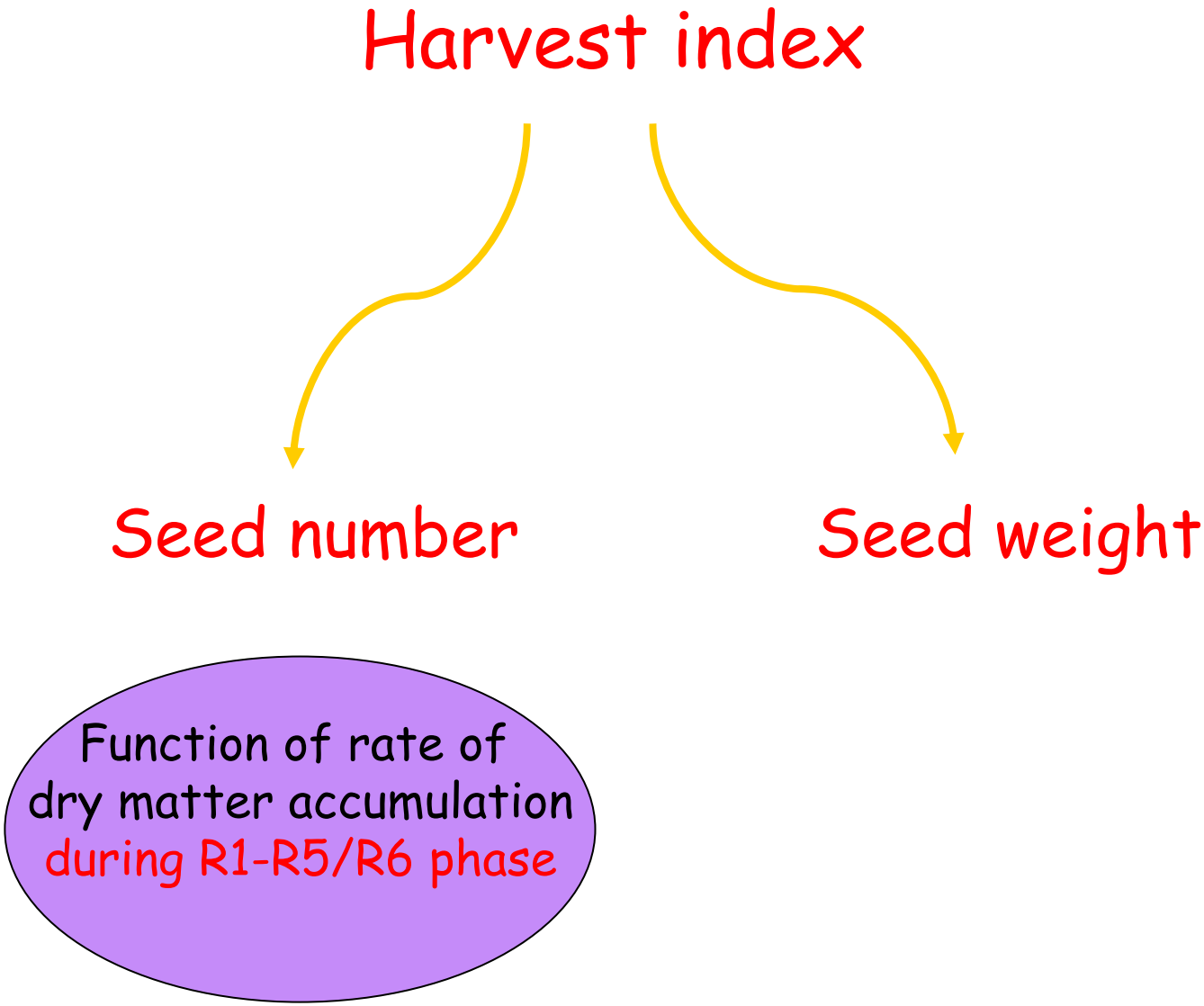
Effects of ASR and manual defoliation on harvest index



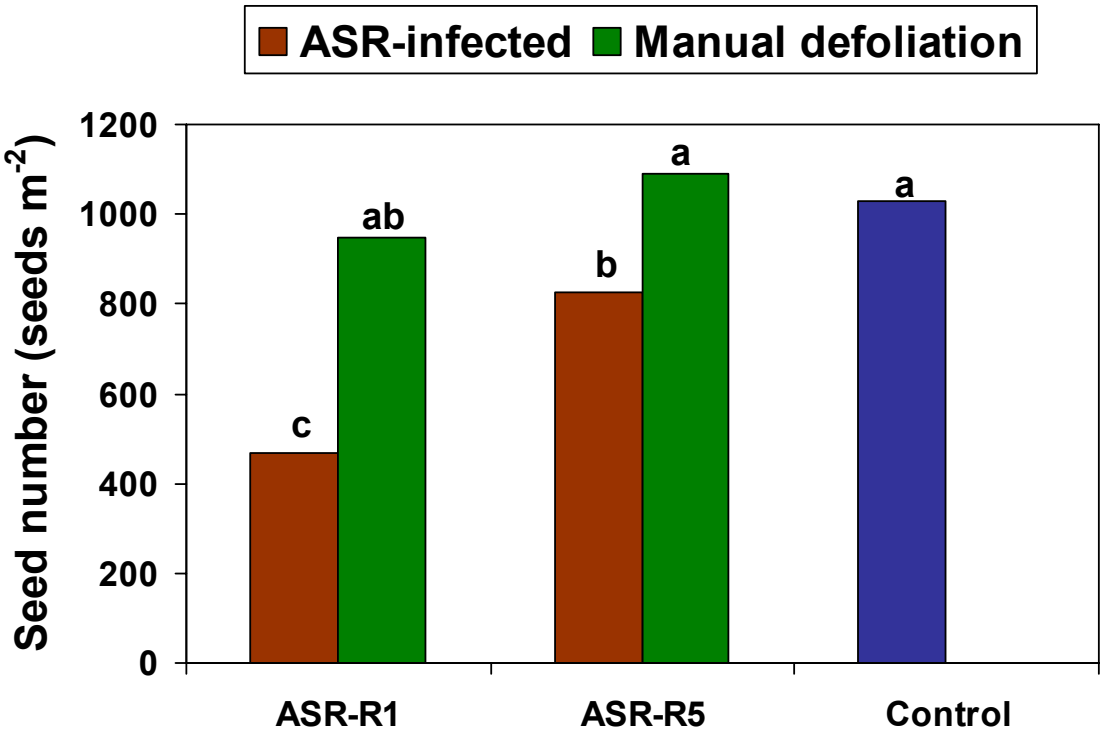
A. 2005/2006 growing season



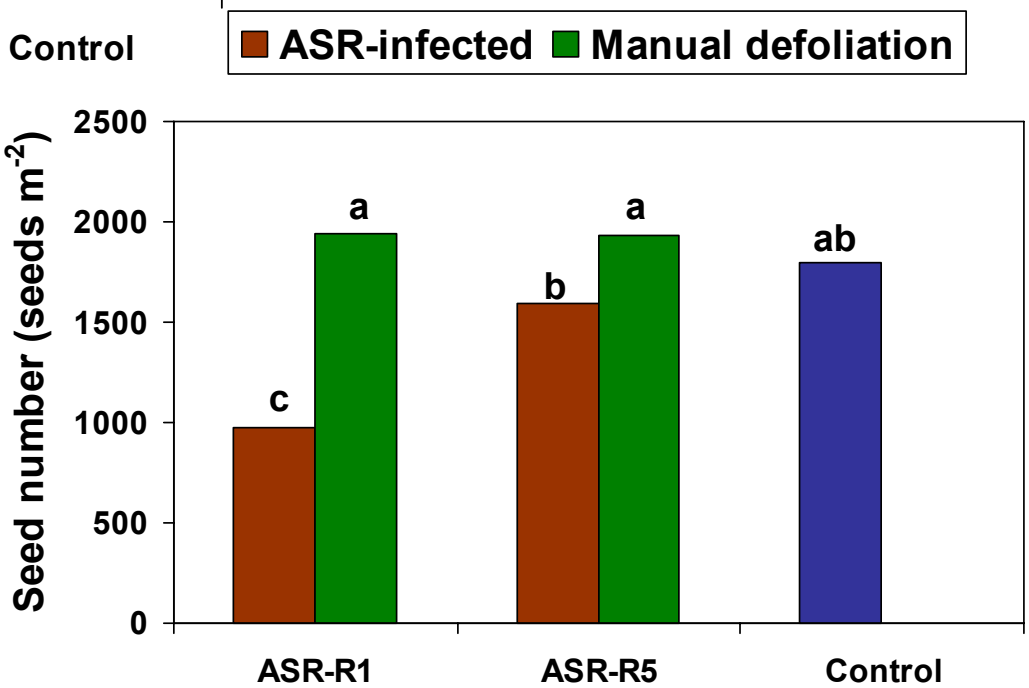
B. 2006/2007 growing season


Harvest index
Seed number
Seed weight
Function of rate of
dry matter accumulation
during R1-R5/R6 phase

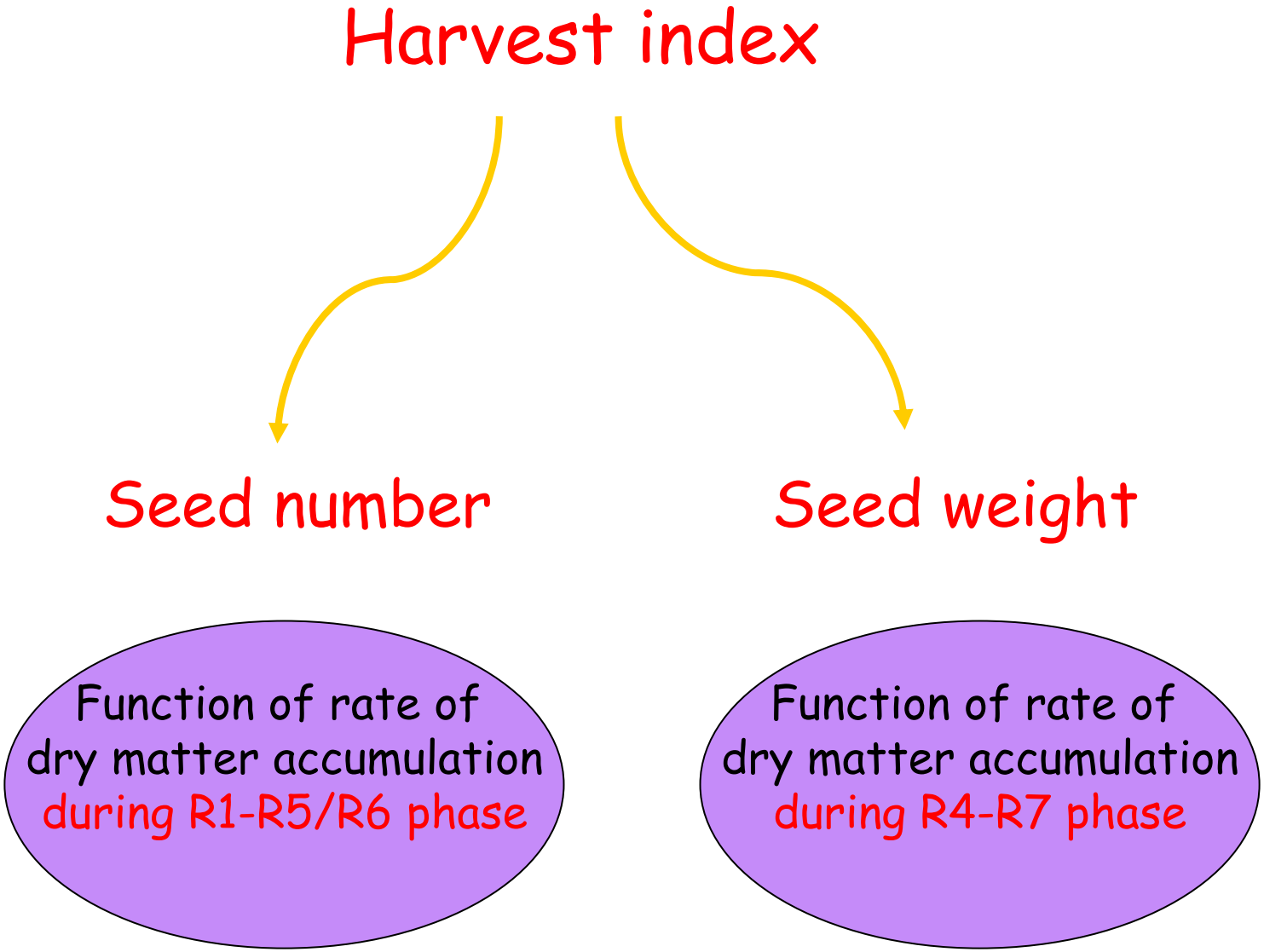
Effects of ASR and manual defoliation on seed number



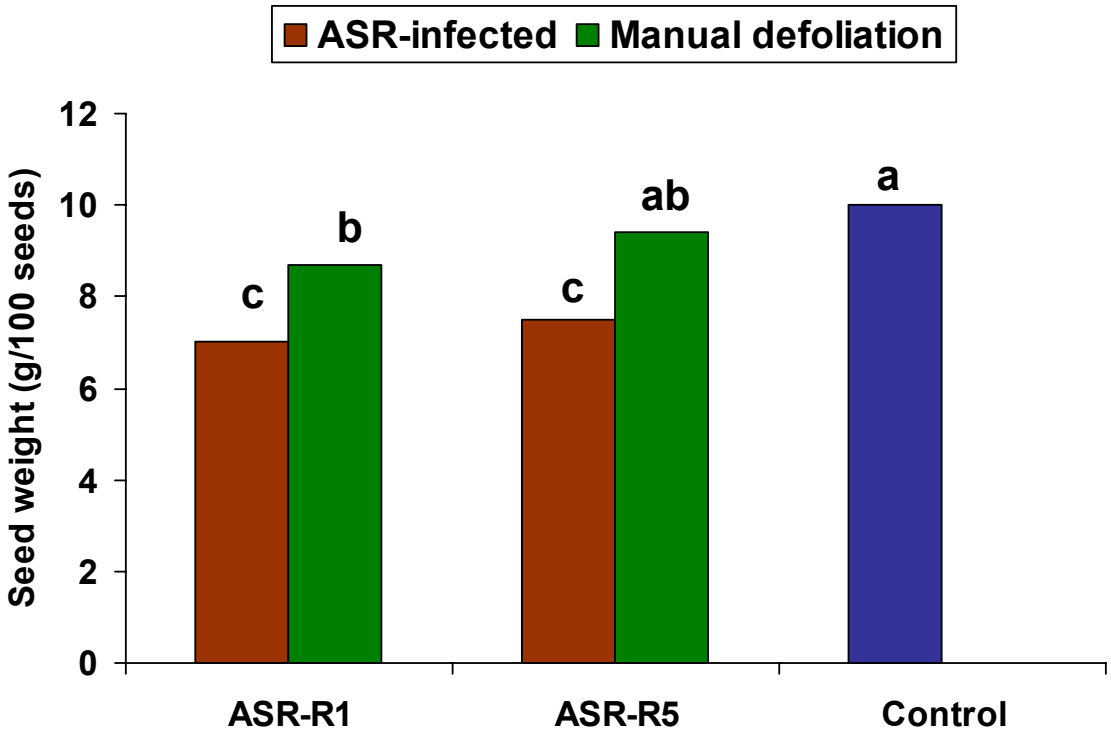
A. 2005/2006 growing season

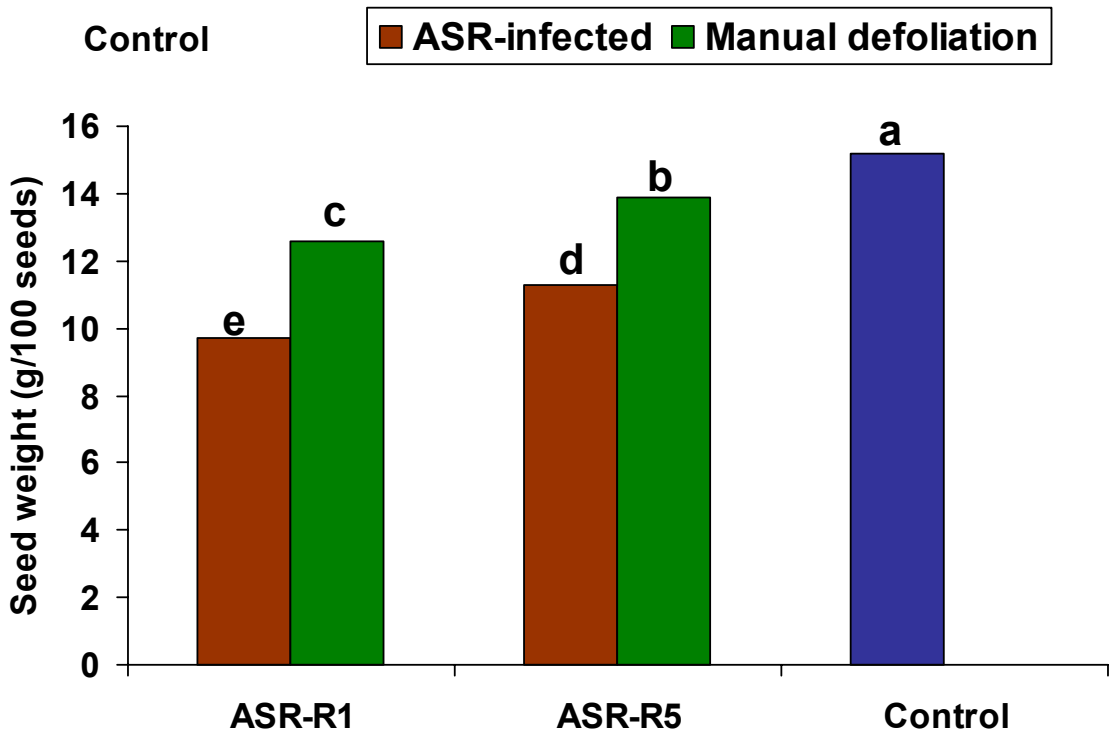


B. 2006/2007 growing season


Harvest index
Seed number
Seed weight
Function of rate of dry matter accumulation during R1-R5/R6 phase
Function of rate of dry matter accumulation during R4-R7 phase

Effects of ASR and manual defoliation on seed weight





Summary

ASR-induced yield loss was a function of:

i. Leaf loss, resulting in a reduction in light absorption.

reduction in
reen leaf

non-

lesion green

iv. Reduction in
both crop bi
harvest index

Summary

ASR-induced yield loss was a function of:

i. Leaf loss, resulting in a reduction in light absorption.

ii. Disease lesions, resulting in a reduction in light absorption by reducing green leaf area.

iii. Reduction in photosynthesis of the non-lesion green leaf area.

iv. Reduction in seed yield due to reduction in **both** crop biomass accumulation and harvest index.

What's next ?

- Validate the model under ASR-infected conditions in the USA (Phase III)

Acknowledgments

- Project website:
  - http://www.uky.edu/Ag/Agronomy/Department/sbr/index.htm

Funding

- USDA, Risk Mangement Agency
- Southern Soybean Research Program
- KY soybean board