Crop Growth Models with Fewer Cultivar-Specific Inputs to Enhance Use in Research and Decision Support

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Outline

- Genotype-Specific Coefficients (GSCs)
- Evaluation
- Applications

This presentation is available online at:
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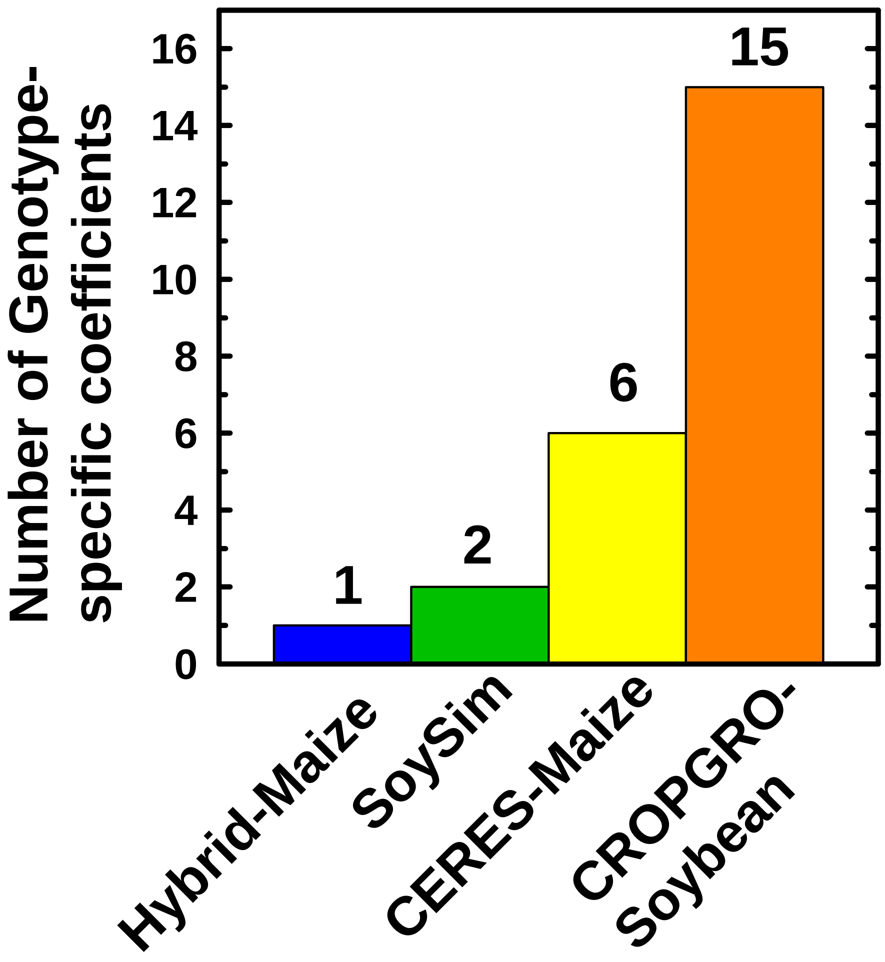
Genotype-specific inputs (minimum req.)

Hybrid-Maize
Thermal time
(EM to R6)

SoySim
Maturity group
Stem termination type

Ceres-Maize



- Hybrid-Maize
  Yang *et al*., (2004)
- SoySim
  Setiyono *et al*., (2010)
- CERES-Maize*
  Jones & Kiniry (1986)
- CROPGRO-Soybean*
  Boote *et al*., (1998)

* in DSSAT 4.0.2.0
Jones *et al*., (2003)

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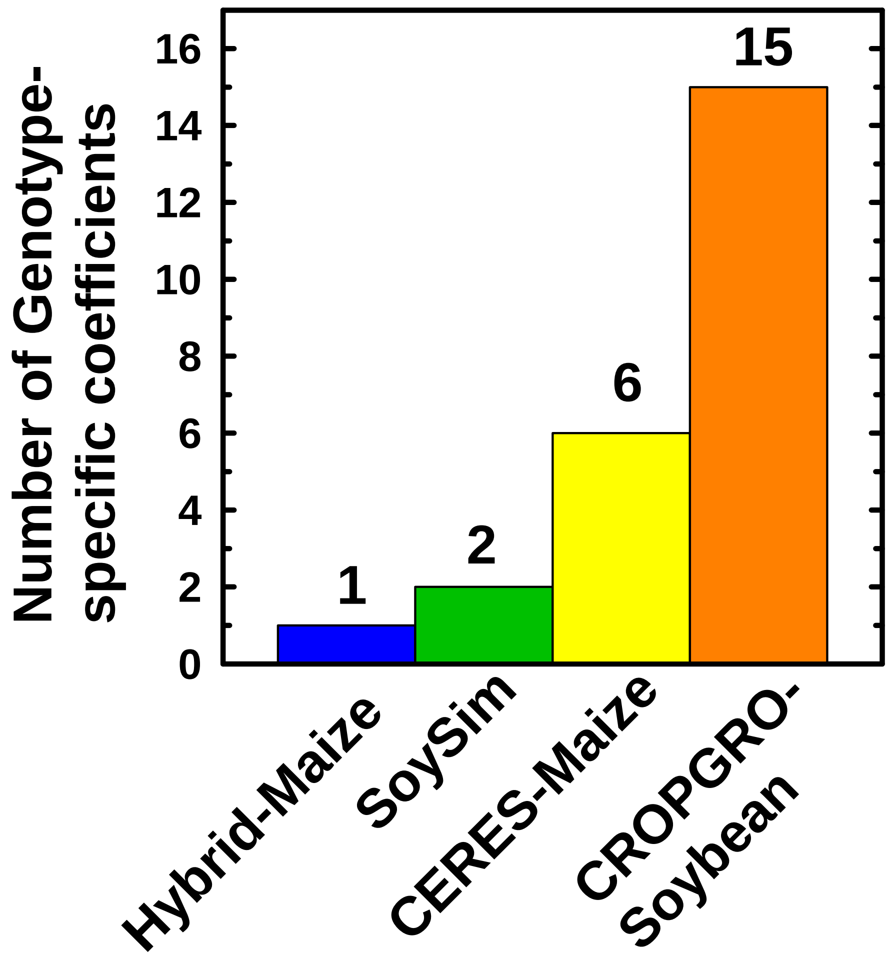


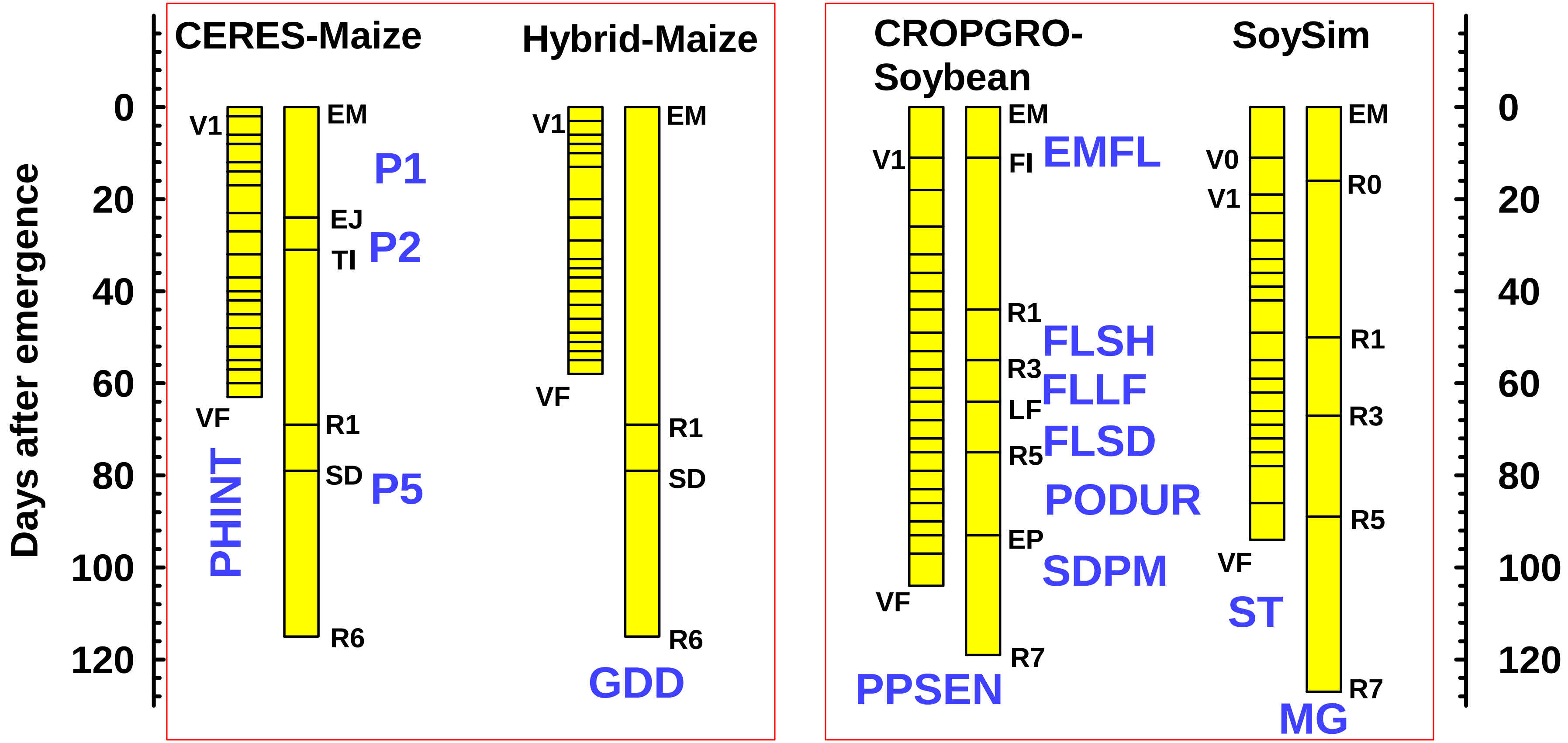
Ceres-Maize

Thermal time coeffs (• EM to end of juvenile, • R1 to R6, • phyllochron)
- Photoperiod sensitivity for silking
- Maximum kernels per plant (G2)
- Potential grain filling rate (G5)

CROPGRO-Soybean

Photo-thermal coeffs (•EM to R1, • R1 to R3, • R1 to R5, • R5 to R7, • R1 to end of leaf exp., • seed filing duration, • pod filling duration)
- Critical short daylength
- Photoperiod sensitivity
- Specific leaf area ($cm^2\ g^{-1}$)
- Max. leaf Ps (mg CO_2 $m^{-2}\ s^{-1}$)
- Max. leaf size (cm^2)
- Max. seed weight,
- Average seed per pod

Phenology & Genotype-Specific Coeffs.



EM = Seedling emergence, V1 = First leaf, VF = Final V-Stage

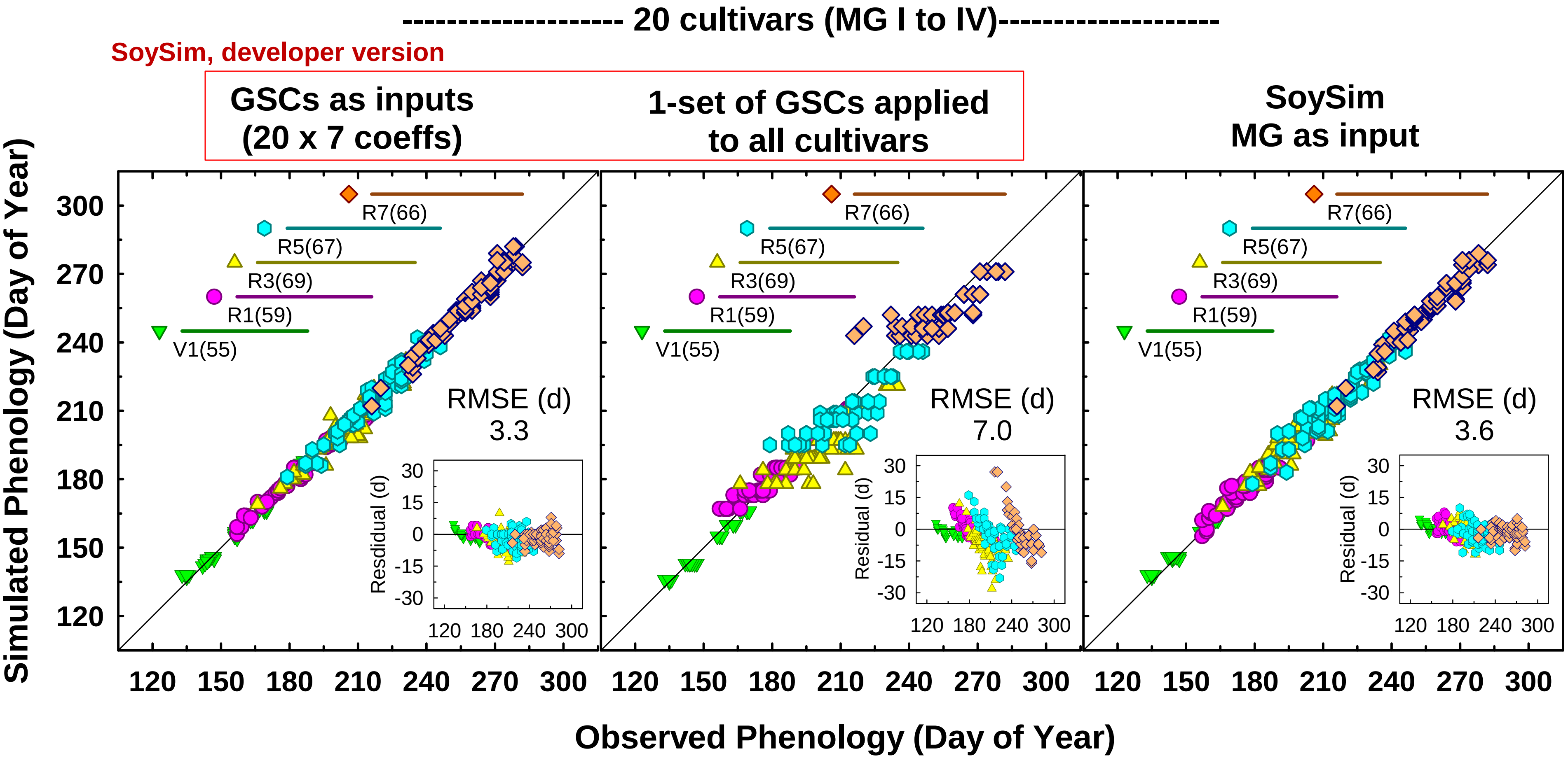
Maize
EJ = End of juvenile
TI = Tassel initiation
R1 = Silking
SD = Begining grain filling
R6 = Physiological maturity

Soybean
R0 = Fully induced
R1 = First flower
R3 = First pod
R5 = Begining seed
R7 = Physiological maturity

V0 = Cotyledon stage
FI = Floral induction
LF = End of leaf expansion
EP = End of pod

Simulated phenology is for P33P67 (1517°Cdays) and P93M11 (MG 3.1) in Lincoln, NE (2001) May-5 emergence

Avoiding GSCs: SoySim Example



from Setiyono *et al*., (2007)
Field Crop Res. 100, 257-271

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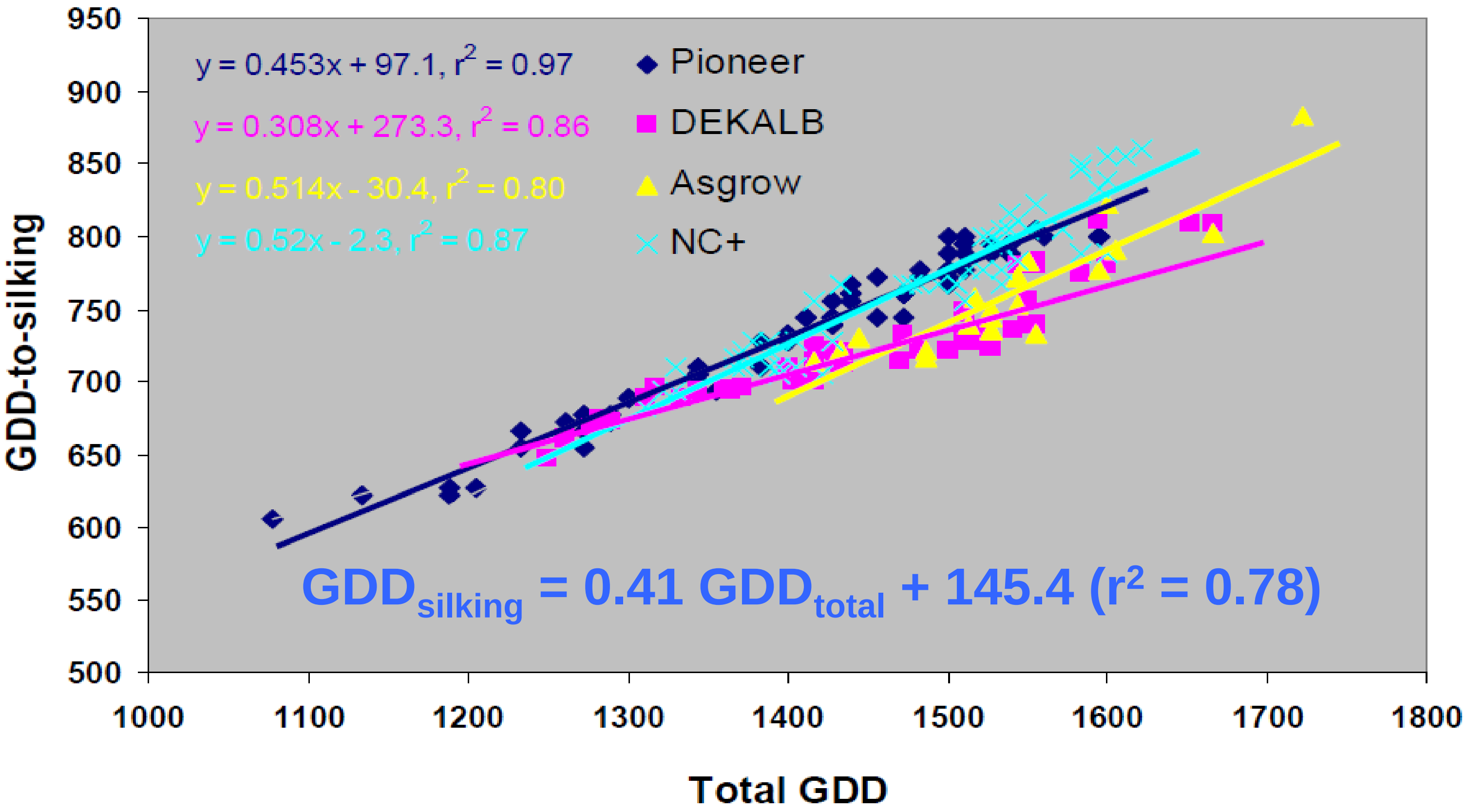
Avoiding GSCs: Hybrid-Maize Example

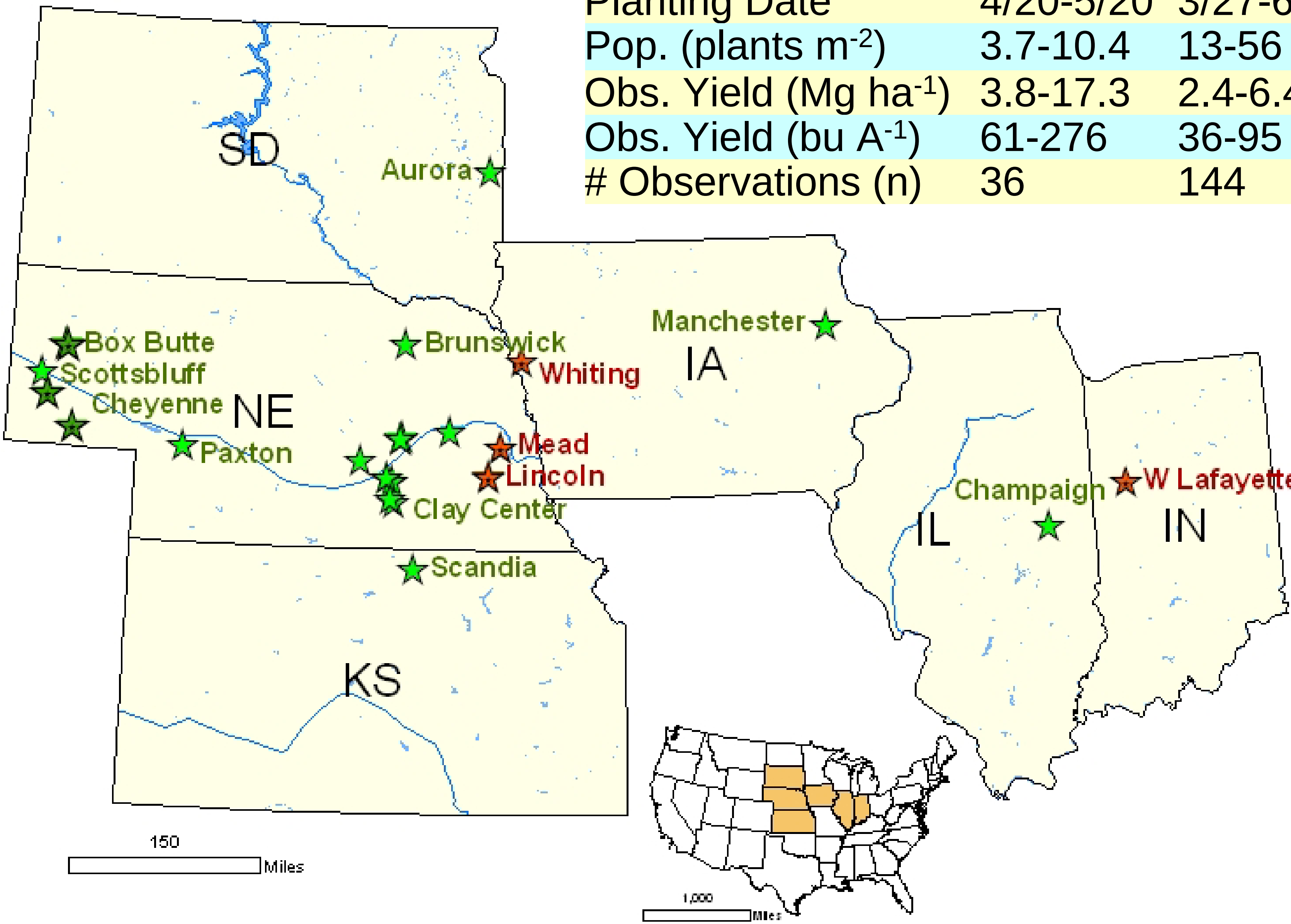


$$\mathbf{GDD_{tassel\ to\ silking} = 0.46\ GDD_{silking} + 155.83}$$

from Yang *et al*., (2004)
Field Crop Res. 87, 131-154

Resp. coeffs are not cultivar-specific (Katsura *et al*. 2009, Field Crop Res. 87, 131-154)

Aspects	Maize	Soybean
Planting Date	4/20-5/20	3/27-6/14
Pop. (plants m^{-2})	3.7-10.4	13-56
Obs. Yield (Mg ha^{-1})	3.8-17.3	2.4-6.4
Obs. Yield (bu A^{-1})	61-276	36-95
# Observations (n)	36	144



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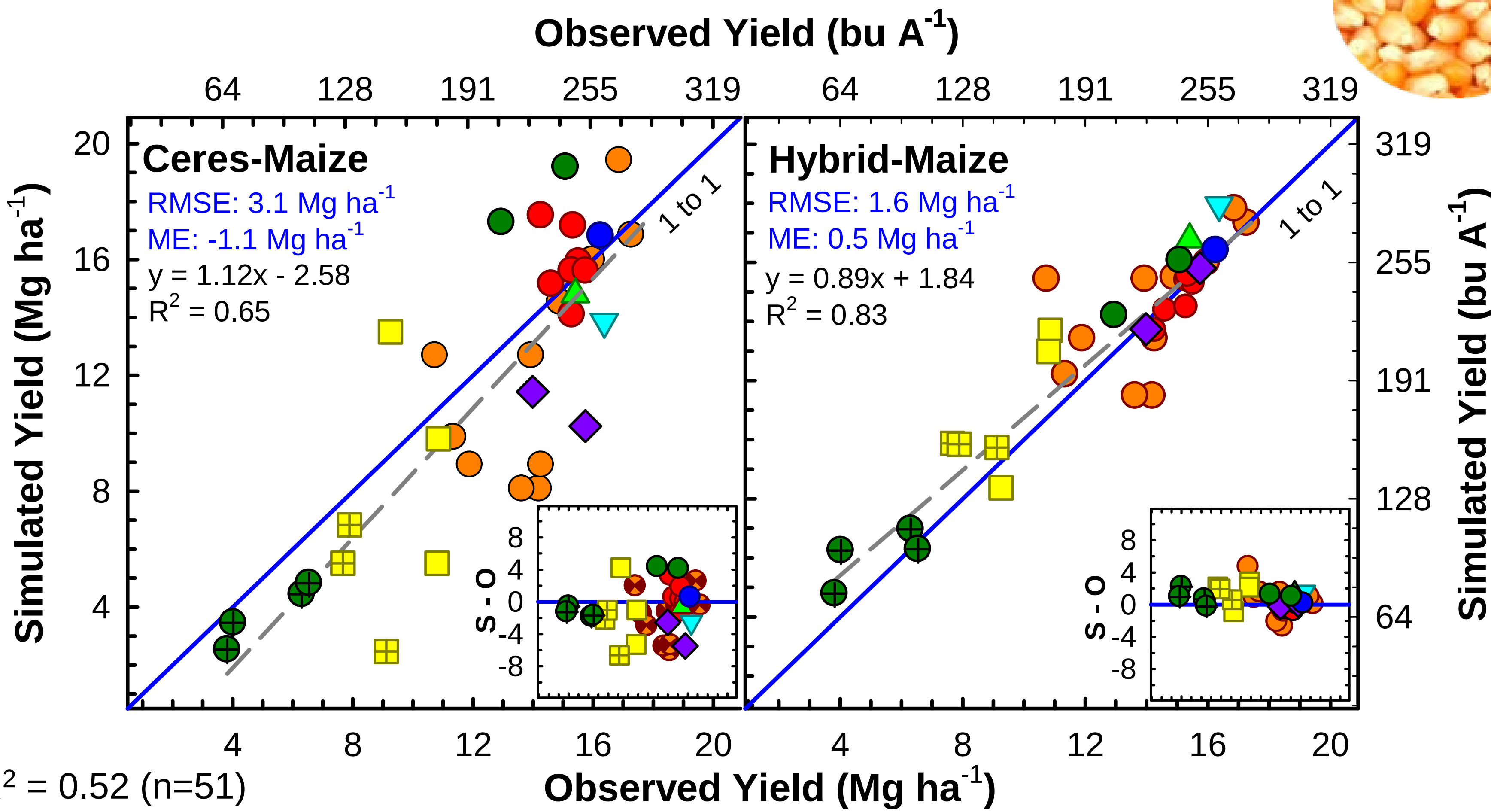
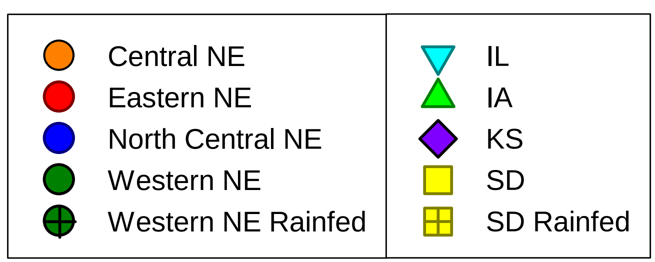
Evaluation: Maize





$R^2 = 0.52$ (n=51)
in Jones & Kiniri (1986)
CERES-Maize:
A Simulation Model for
Maize Growth and Dev.

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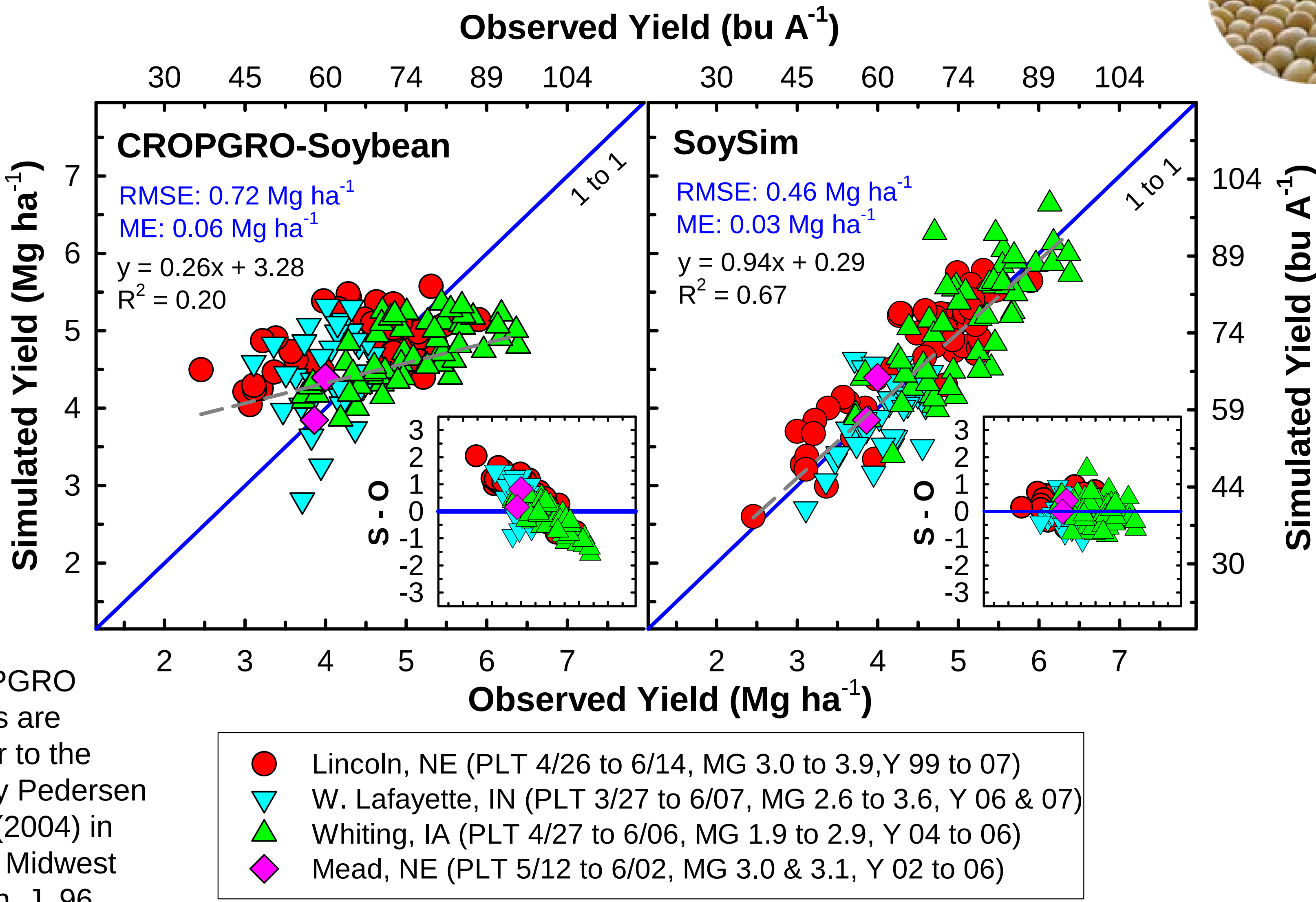
Evaluation: Soybean

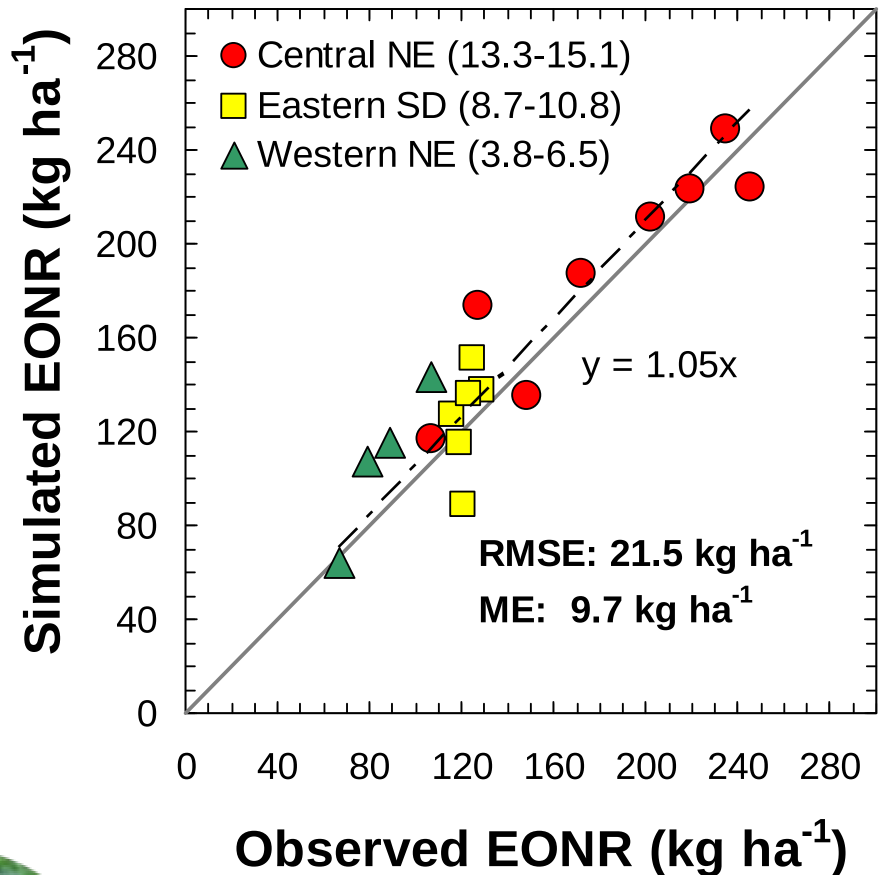


CROPGRO results are similar to the exp.by Pedersen *et al*. (2004) in upper Midwest (Agron. J. 96, 556-564)

from Setiyono *et al*., (2010) Field Crop Res. 119, 161-174

Applications: Decision Supports

- Hybrid-Maize:
  - Estimating maize N fertilizer requirements (Maize-N)
  - Evaluating maize productivity and water use in western corn-belt (Grassini *et al*., 2009, Agric. Forrest. Meteorol. 149, 1254-1265)



- SoySim:
  - Soybean Irrigation Scheduling for Nebraska

EONR = Economically optimum N rate
RMSE = Root Mean Square Error
ME = Mean Error

Yield response to climate change (CO_2), simulation study using SoySim

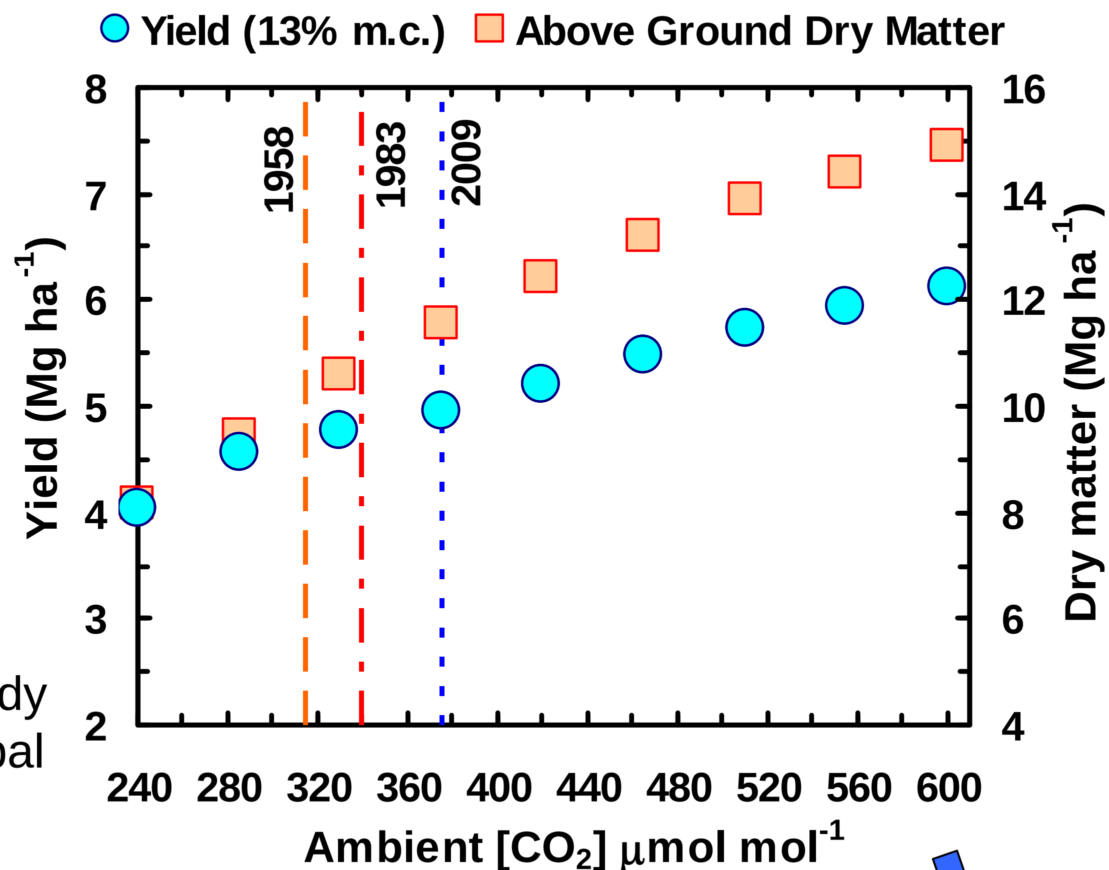
Hist. yield increase from CO_2

6 kg year^{-1} (Simulated)
5 kg year^{-1} (Specht *et al*., 1999)

From 315 to 630 μmol mol^{-1} CO_2

30% increase in yield (SoySim)
24 % (Ainsworth *et al*., 2002, Global Change Biol., 8, 695-709)
35 % (Allen & Boote, 2000, *In* Reddy & Hodges, Climate Change & Global Climate Crop Productivity)

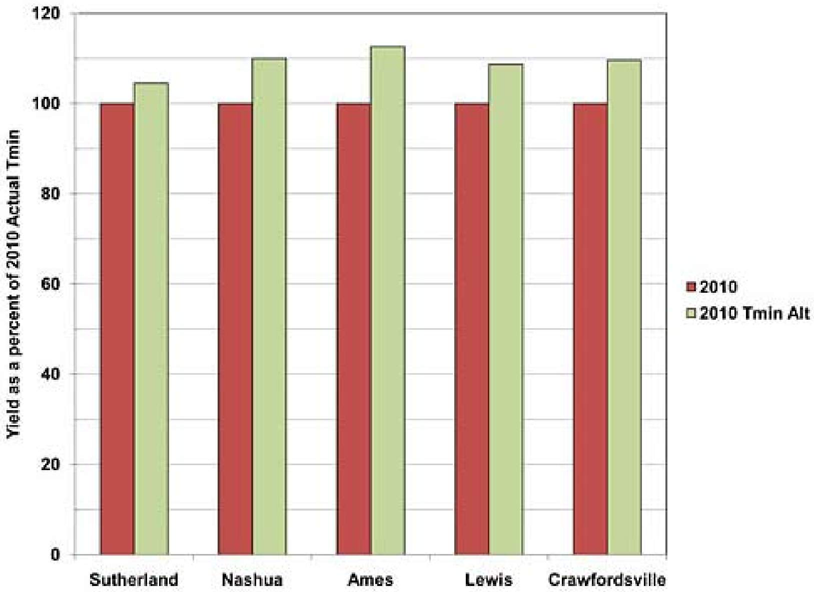
51% increase in ADM (SoySim)
Decrease in HI (Allen *et al*., 1991, Agron, J., 83,875-883)



24-year simulation for MG 3.1 in Lincoln, NE with 30 plants m^{-2}

Applications: Hybrid-Maize

Warm night temperature & the drop in Oct 2010 yield forecast for Iowa



October's corn yield forecast for Iowa dropped to 169 bushels per acre, a significant reduction from the August and September forecasts of 179 bushels per acre (see October USDA-NASS forecast). If realized, 2010 yields will rank 6th among the last seven years - higher only than the yields of 2006 (166 bushels per acre). Numerous yield reports substantiate lower than expected yields this year.

We've talked a lot this year about 2010 conditions and the possibility of reduced yields resulting from rapid crop development following silking. Statewide Growing Degree Day (GDD) accumulations were 116% of normal during most of the seed fill period - silk to dent - this year (see my September 10th and 15th postings).

Remember that cool night temperatures after silking in 2009 resulted in the highest average yield ever recorded in Iowa: 182 bushels per acre. In contrast, warm night temperatures after silking typically reduce yields.

Roger Elmore
ISU Extension

PARTNER
IOWA STATE UNIVERSITY
CORN AND SOYBEAN INITIATIVE

▶**Above:** Crop consultant Jerry Mulliken uses the *Hybrid-Maize* model to monitor corn-yield potential through the growing season.

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Summary

Genotype-Specific Inputs can be minimized in crop simulation models

- ➲ Reasonable phenology predictions
- ➲ Allow robust simulation of yield
- ➲ Enhance effective use for decision support and in research

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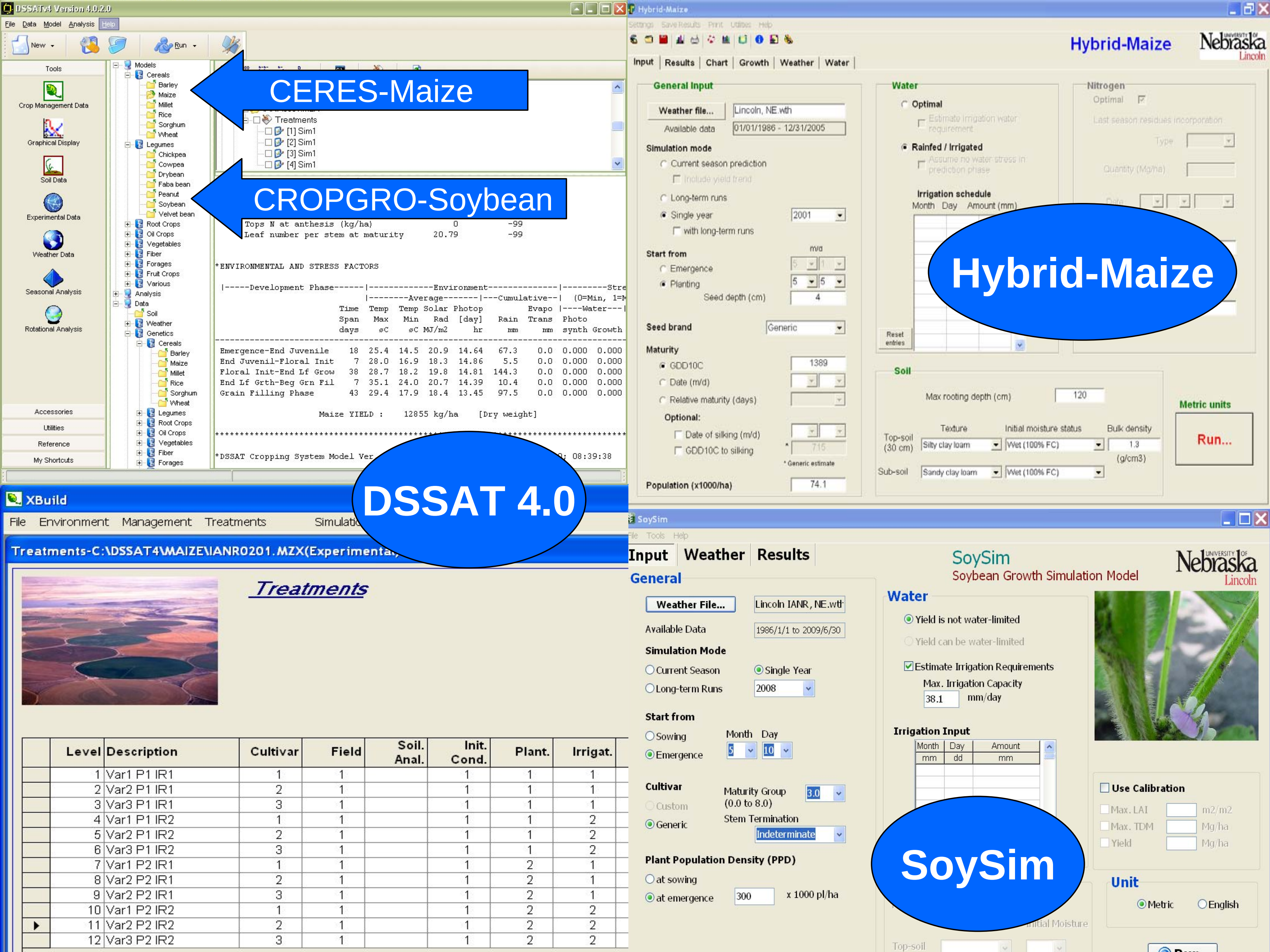
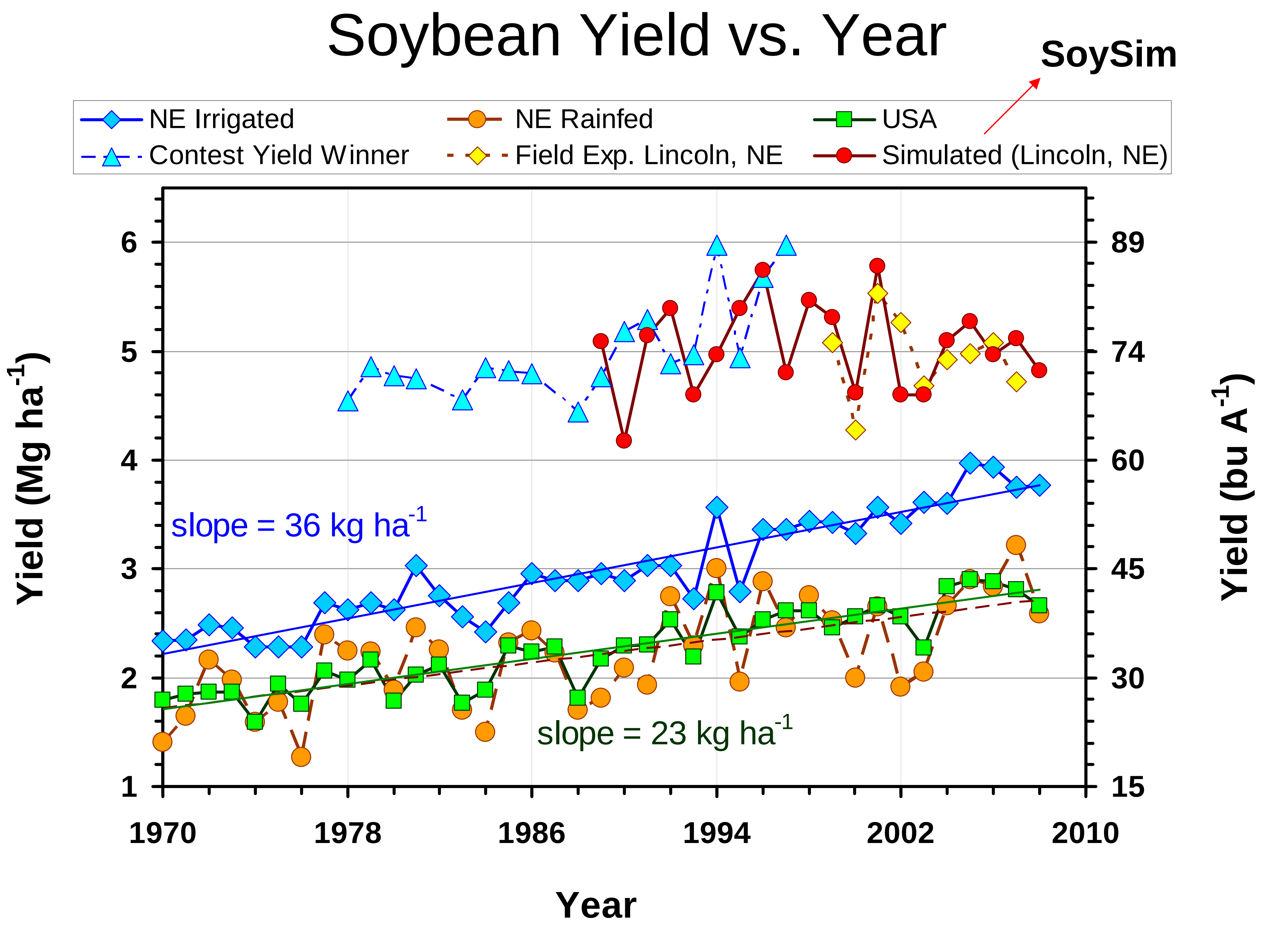

DSSATv4 Version 4.0.2.0
CERES-Maize
CROPGRO-Soybean
Hybrid-Maize
DSSAT 4.0
XBuild
Treatments-C:\DSSAT4\MAIZE\IANR0201.MZX(Experimental)
Treatments
SoySim
Soybean Growth Simulation Model
Nebraska Lincoln

Crop Models

Crop	Model	Version	Interface
Maize	CERES-Maize (Jones & Kiniry, 1986)	3.0 RUE	DSSAT 4.0.2.0 (Jones *et al*., 2003)
Soybean	CROPGRO-Soybean (Boote *et al.*, 1998)	2004 Phs, Resp	DSSAT 4.0.2.0 (Jones *et al*., 2003)
Maize	Hybrid-Maize (Yang *et al.*, 2004)	2006 Phs, Resp	Hybrid-Maize (Yang *et al*., 2006)
Soybean	SoySim (Setiyono *et al.*, 2010)	2009 Phs, Resp	SoySim (Setiyono *et al*., 2010)

Calibration Datasets:
Maize: Lincoln NE (2001)
Soybean: Lincoln NE (2004, 2005), Mead NE (2002)

CERES, Crop-Environment Resource Synthesis
DSSAT, Decision Support System for Agrotechnology Transfer
RUE, Radiation Use Efficiency; Phs, Photosynthesis; Resp, Respiration



Soybean Yield vs. Year
SoySim
NE Irrigated
NE Rainfed
USA
Contest Yield Winner
Field Exp. Lincoln, NE
Simulated (Lincoln, NE)
slope = 36 kg ha-1
slope = 23 kg ha-1
Yield (Mg ha-1)
Yield (bu A-1)
Year
1970
1978
1986
1994
2002
2010
1
2
3
4
5
6
15
30
45
60
74
89

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