Nitrogen fixation, nitrogen remobilization, and seed yield among soybean near isolines for maturity

Soybean Breeders Workshop
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UNIVERSITY of ARKANSAS 1871

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I. Review importance of N and N_2 fixation to soybean production

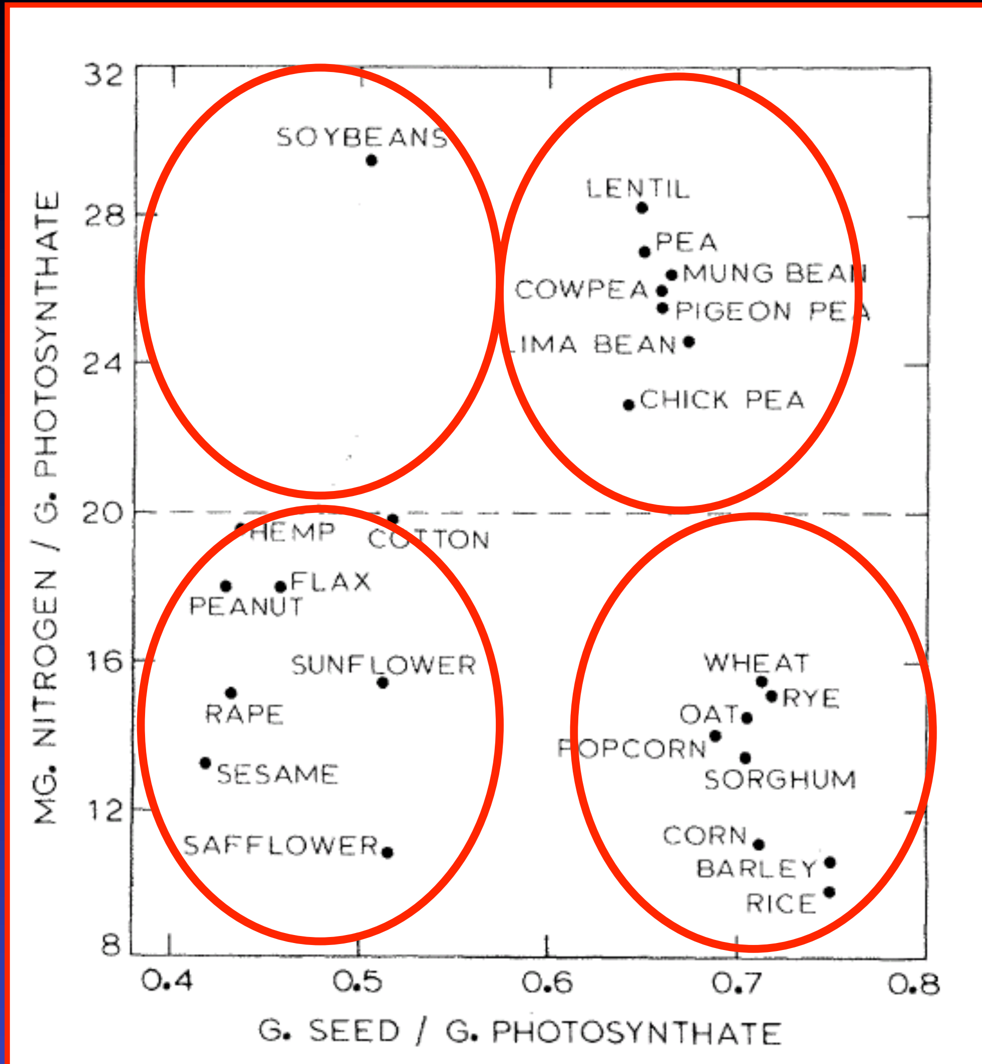
III. Evaluation of N_2 fixation, seed N, vegetative N

IV. Implications

- N_2 fixation reaches maximum during early- to mid-podfill and then rapidly declines (Harper and Hageman, 1974; Zapata et al., 1987).

Previous research has:

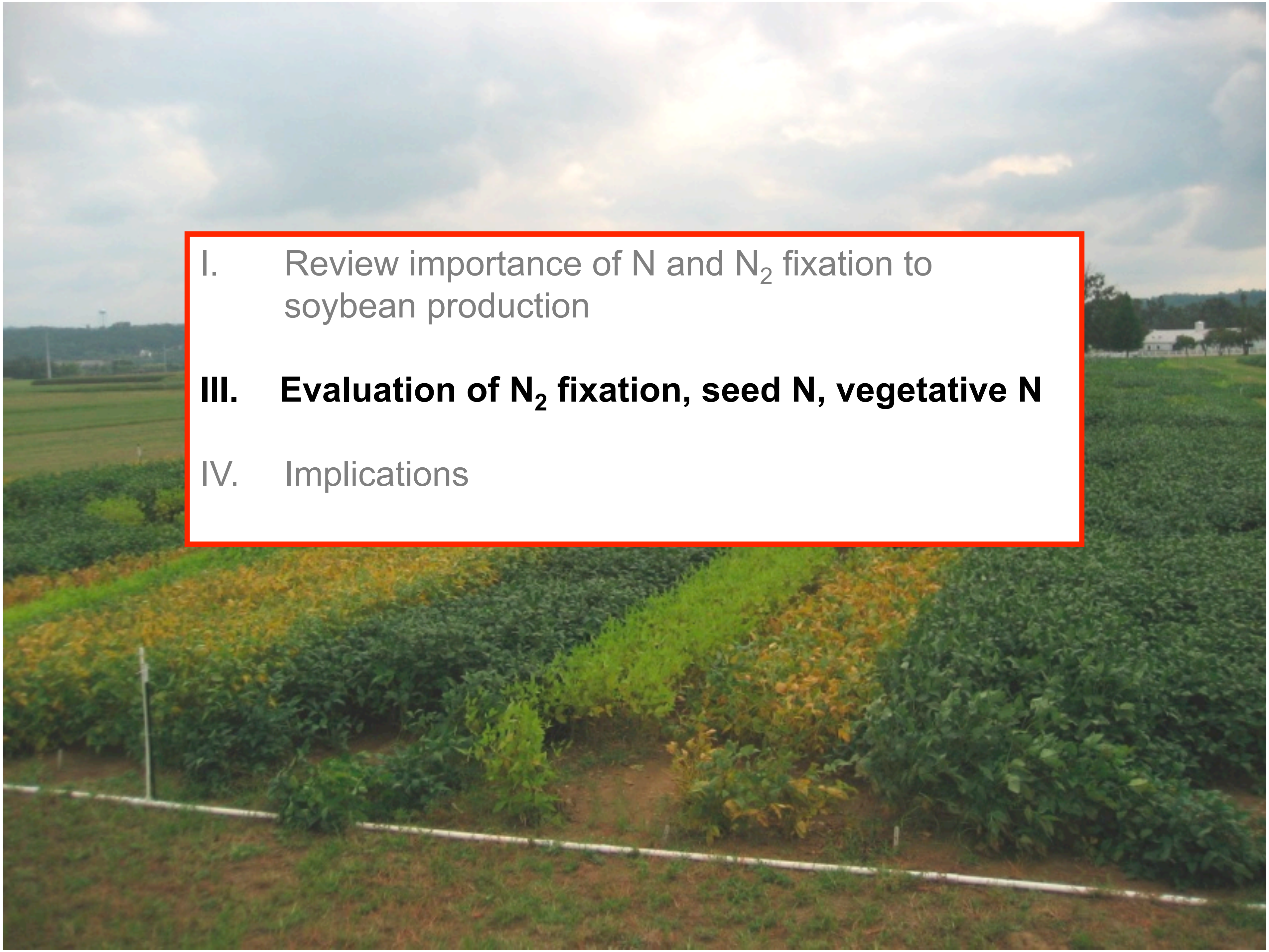
- relied heavily upon acetylene reduction assays,
- been conducted in soils with relatively high organic matter and high concentrations of mineral N,
- and/or been conducted in controlled environments.



Sinclair and deWit (1975) Science 189:565

Implications of Self Destruct Hypothesis

- Increasing the amount of vegetative N at the beginning of seed fill will provide a greater pool of N that can be remobilized to seed.
- Later-maturing isolines would expectantly have larger amounts of N to remobilize and increased yields.



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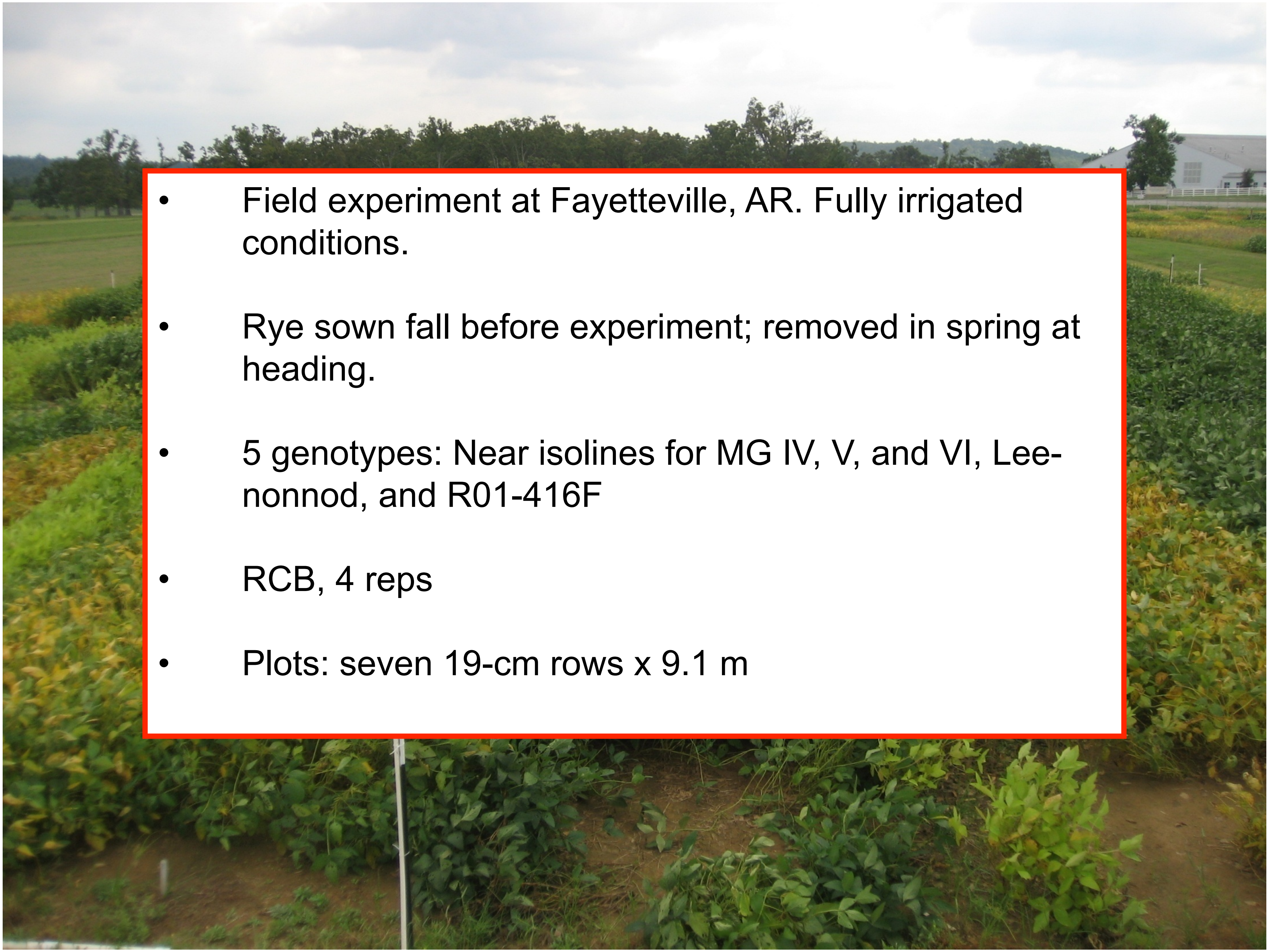
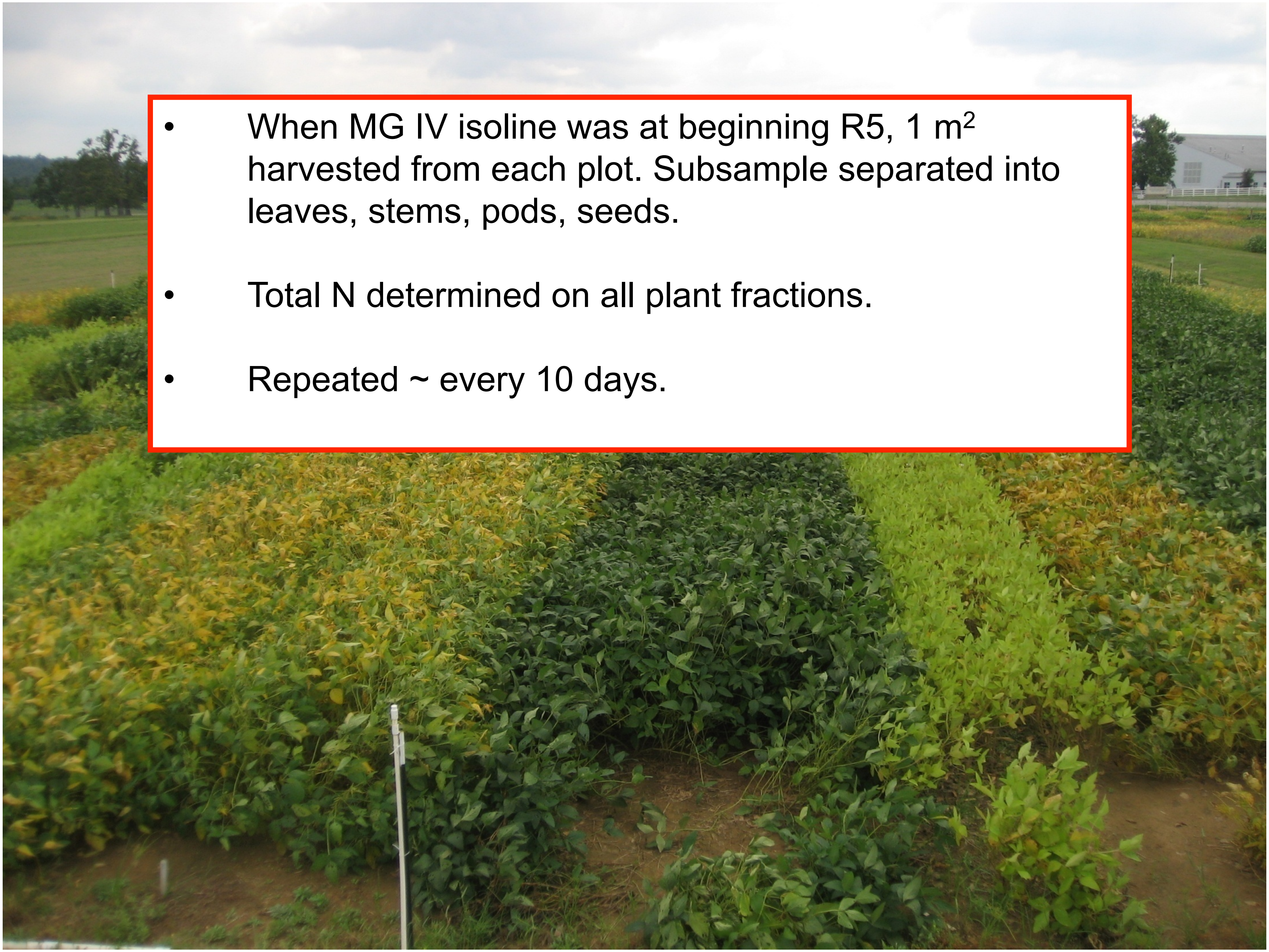
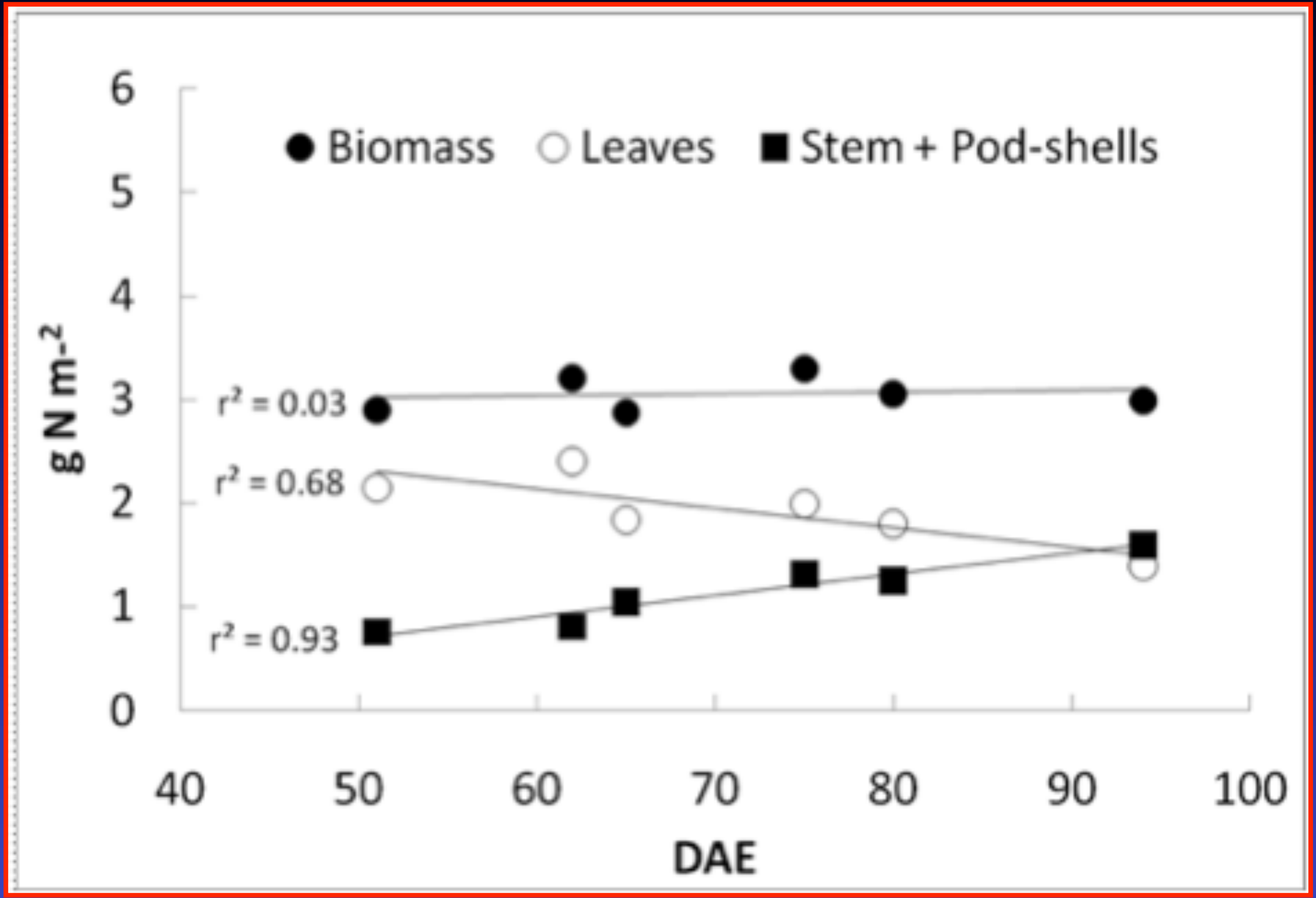


- Field experiment at Fayetteville, AR. Fully irrigated conditions.
- Rye sown fall before experiment; removed in spring at heading.
- 5 genotypes: Near isolines for MG IV, V, and VI, Lee-nonnod, and R01-416F
- RCB, 4 reps
- Plots: seven 19-cm rows x 9.1 m

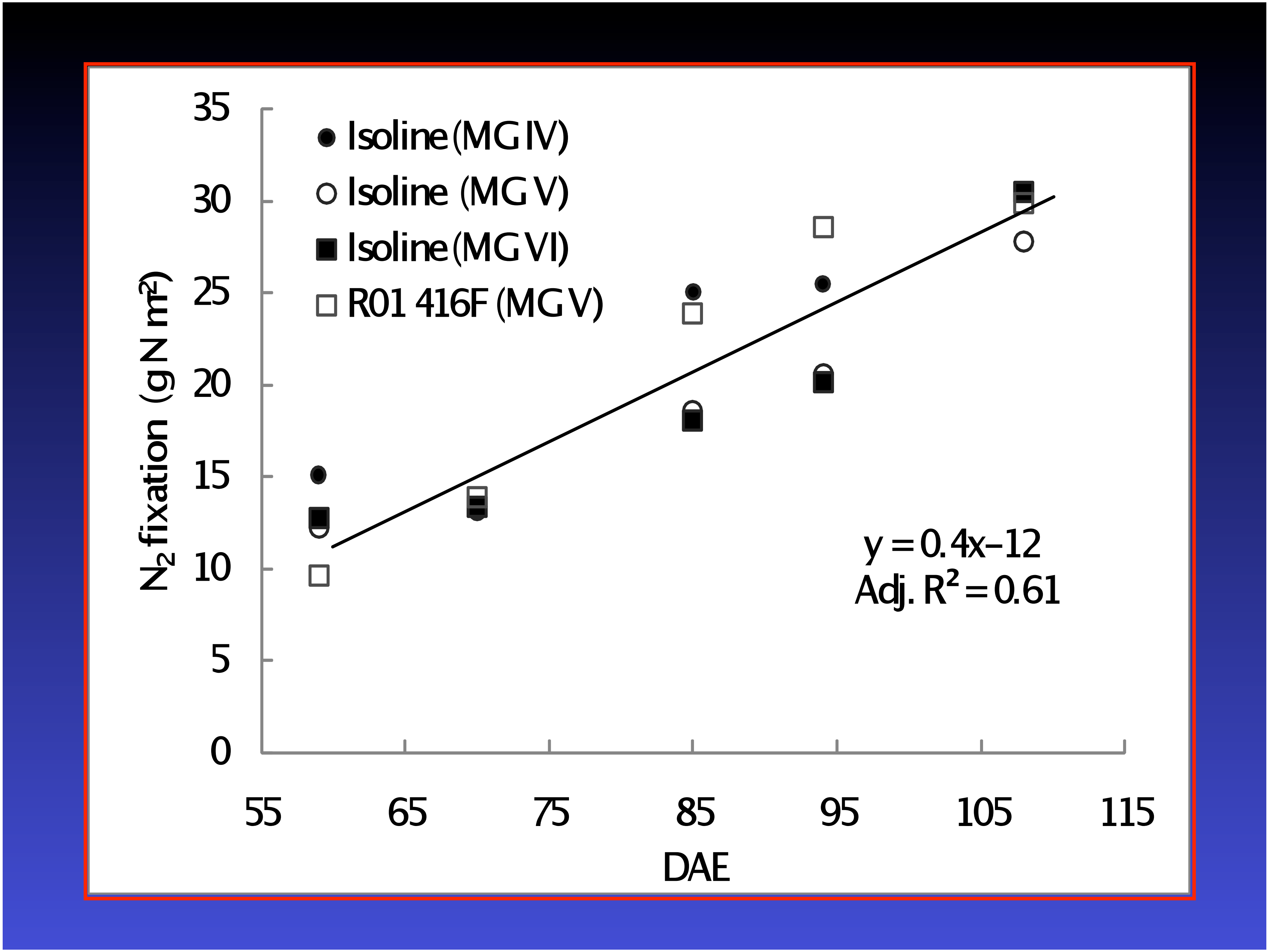
- When MG IV isoline was at beginning R5, 1 m^2 harvested from each plot. Subsample separated into leaves, stems, pods, seeds.
- Total N determined on all plant fractions.
- Repeated ~ every 10 days.



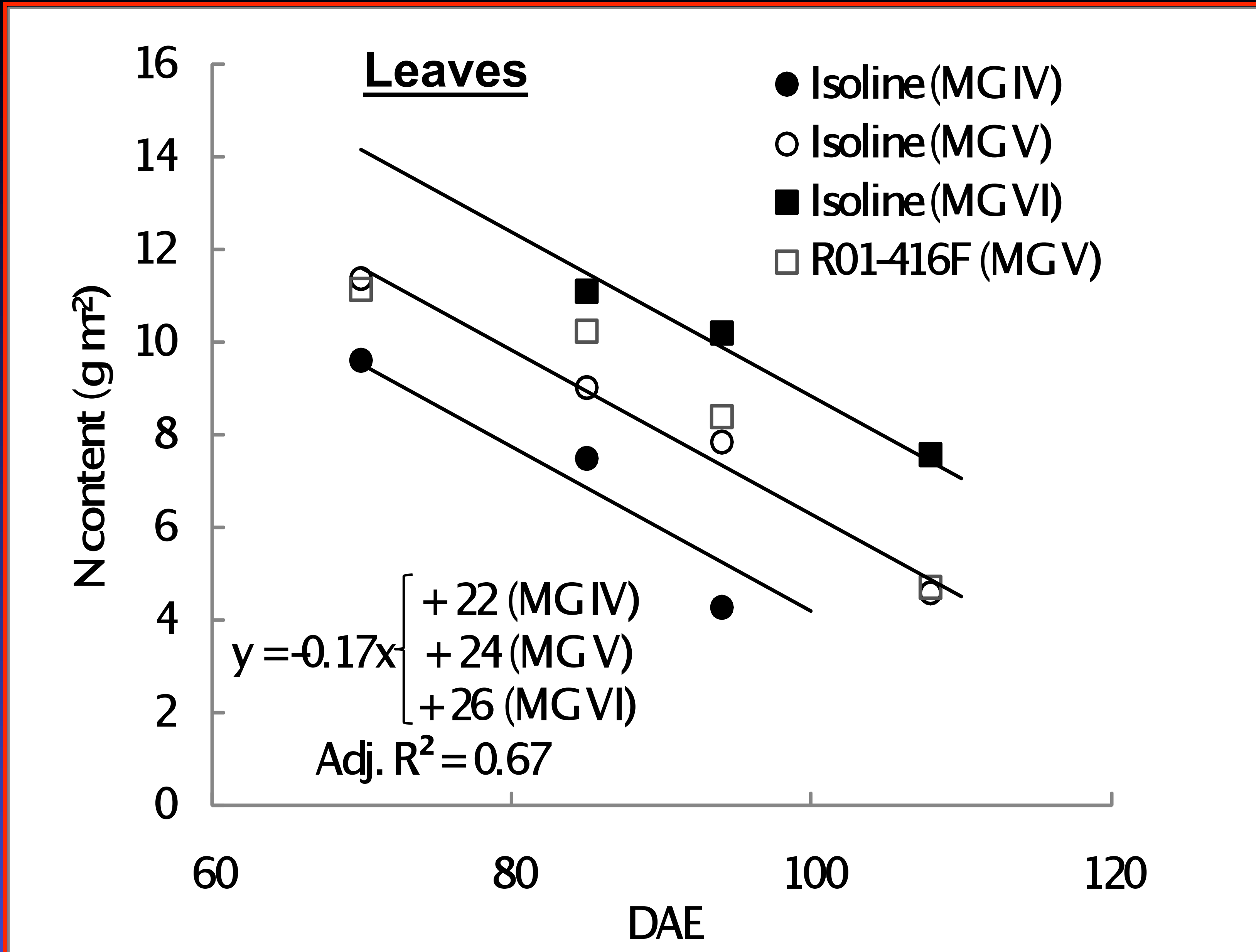
Genotype	MG	Pedigree
Lee Nonnod (D68-0099)	VI	Lee(6) x T201
D49-2491	VI	S100 x CNS (same F2 as Lee)
D66-5566	IV	D49-2491(4) x Hawkeye
D61-1513	V	D49-2491(5) x Hawkeye
R01-416F	V	Jackson x KS4895



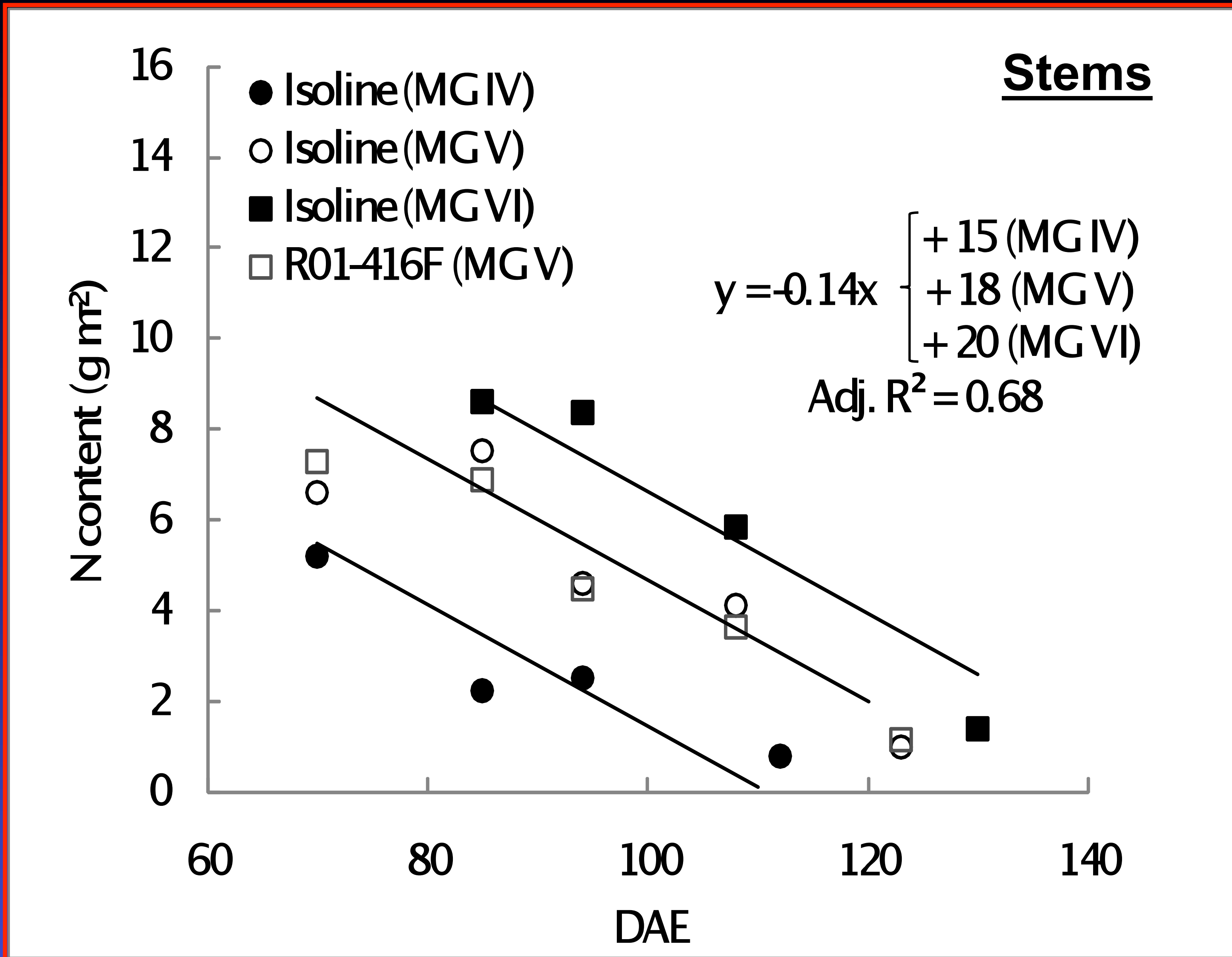
Biomass
Leaves
Stem + Pod-shells
r² = 0.03
r² = 0.68
r² = 0.93
g N m-2
DAE
0
1
2
3
4
5
6
40
50
60
70
80
90
100



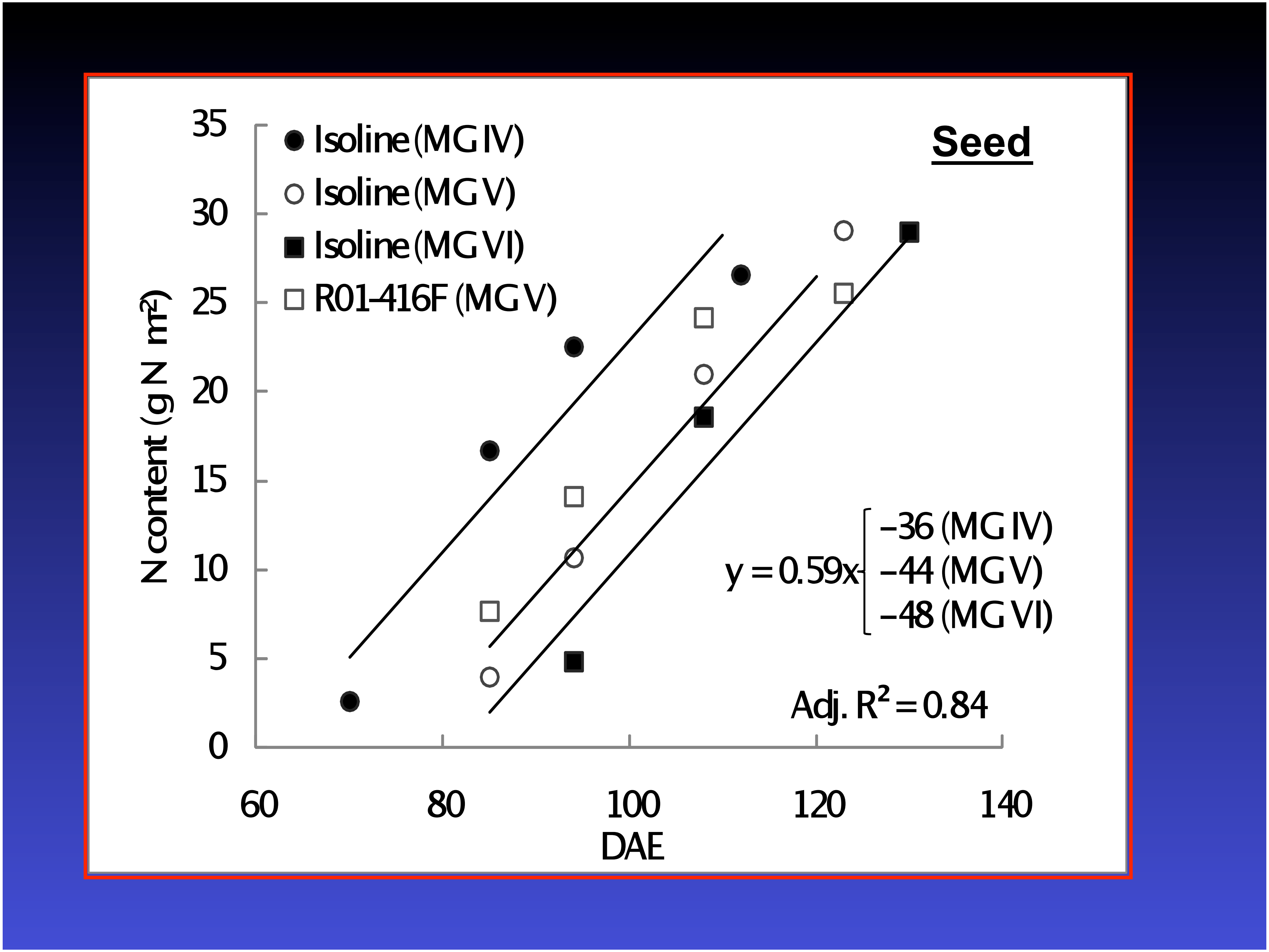
Isoline (MG IV)
Isoline (MG V)
Isoline (MG VI)
R01 416F (MG V)
35
30
25
20
15
10
5
0
N2 fixation (g N m-2)
55
65
75
85
95
105
115
DAE
y = 0.4x–12
Adj. R2 = 0.61



Leaves
Isoline (MG IV)
Isoline (MG V)
Isoline (MG VI)
R01-416F (MG V)
N content (g m-2)
16
14
12
10
8
6
4
2
0
60
80
100
120
DAE
y = -0.17x
+ 22 (MG IV)
+ 24 (MG V)
+ 26 (MG VI)
Adj. R2 = 0.67

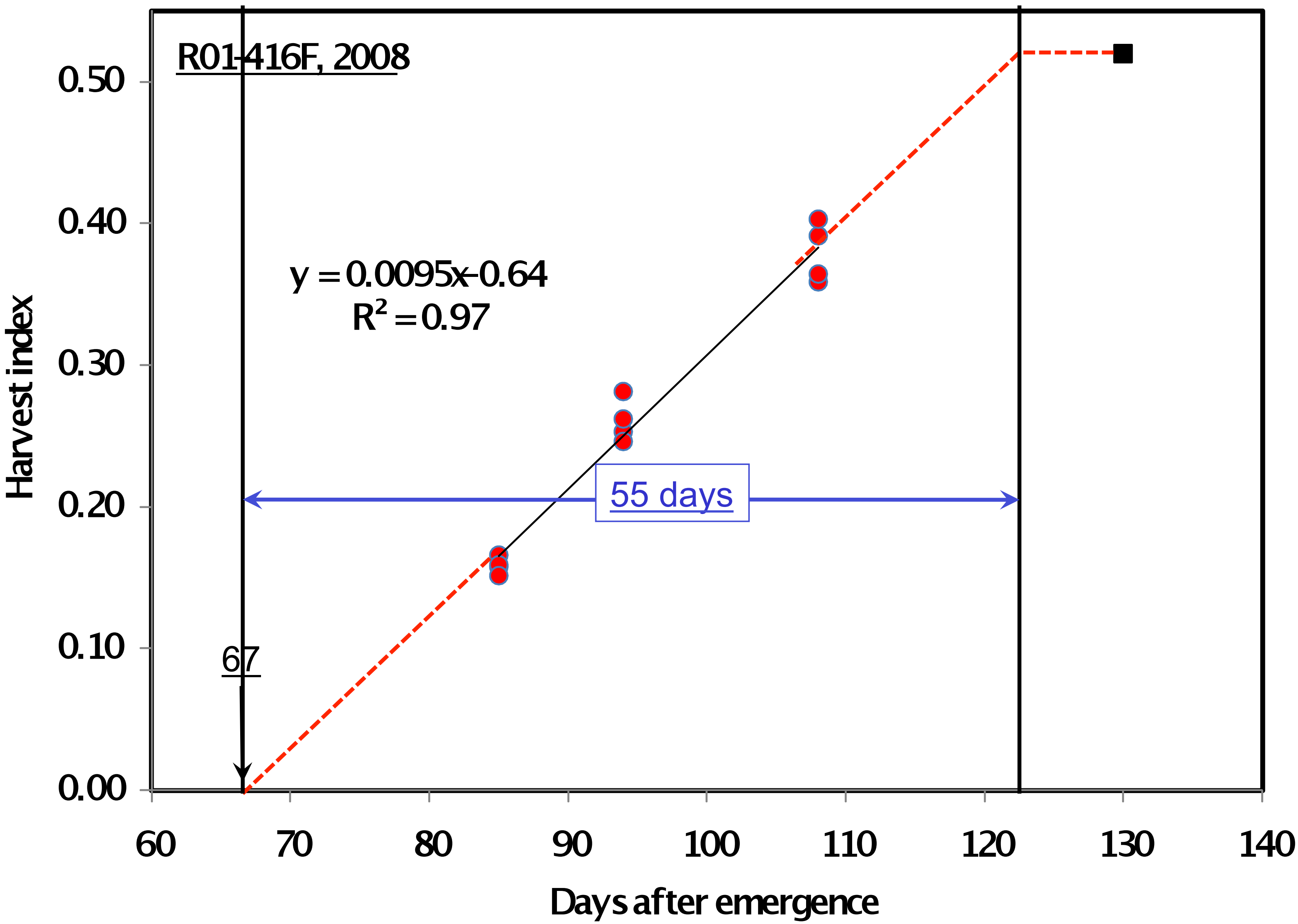


Stems
Isoline (MG IV)
Isoline (MG V)
Isoline (MG VI)
R01-416F (MG V)
y = -0.14x
+ 15 (MG IV)
+ 18 (MG V)
+ 20 (MG VI)
Adj. R2 = 0.68
N content (g m-2)
DAE
0
2
4
6
8
10
12
14
16
60
80
100
120
140

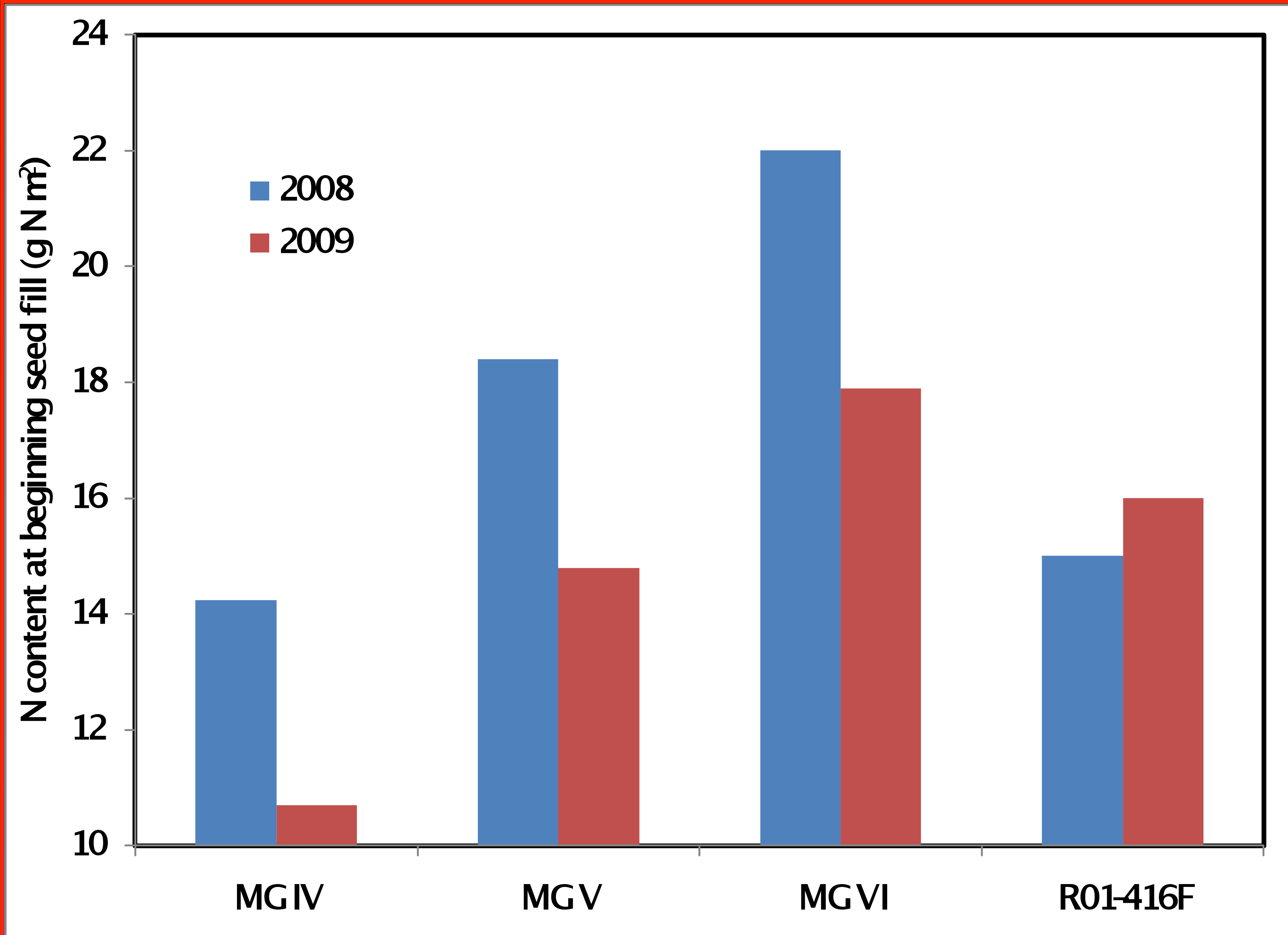

Seed
Isoline (MG IV)
Isoline (MG V)
Isoline (MG VI)
R01-416F (MG V)
N content (g N m-2)
DAE
y = 0.59x −36 (MG IV)
−44 (MG V)
−48 (MG VI)
Adj. R2 = 0.84
0
5
10
15
20
25
30
35
60
80
100
120
140

2008	N_2 fix	Seed N	Leaf N	Stem N
	----------------- g N m^{-2} d^{-1} ------------------			
MG IV	0.40	0.59	-0.17	-0.14
MG V	0.40	0.59	-0.17	-0.14
MG VI	0.40	0.59	-0.17	-0.14
R01-416F	0.40	0.59	-0.17	-0.14

2009	N_2 fix	Seed N	Leaf N	Stem N
	---------------- g N m^{-2} d^{-1} -----------------			
MG IV Iso	0.46 a	0.59	-0.15	-0.09
MG V Iso	0.33 b	0.59	-0.15	-0.09
MG VI Iso	0.33 b	0.59	-0.15	-0.09
R01-416F	0.46 a	0.59	-0.15	-0.09



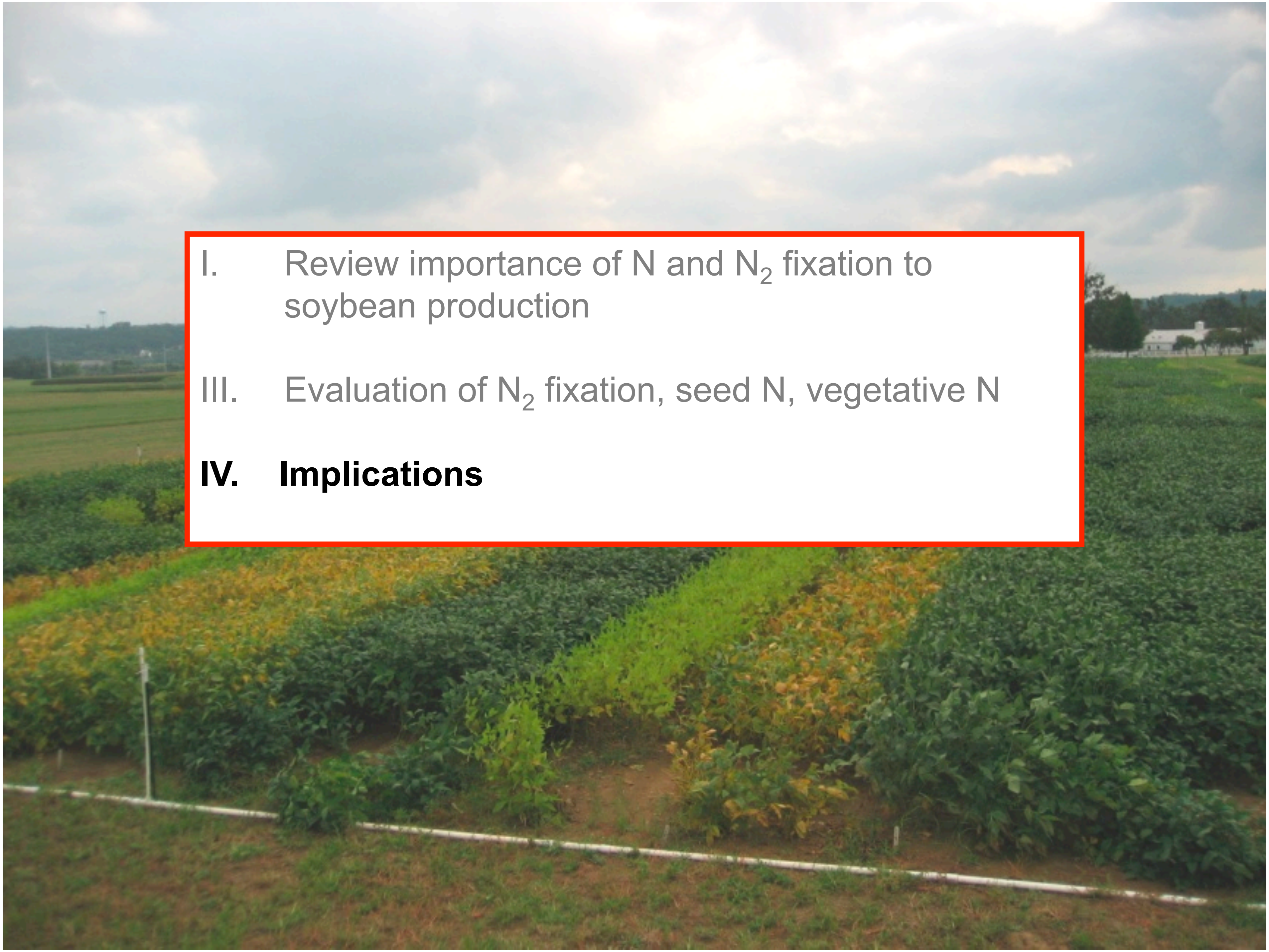
R01-416F, 2008
y = 0.0095x-0.64
R² = 0.97
55 days
67
Harvest index
0.00
0.10
0.20
0.30
0.40
0.50
60
70
80
90
100
110
120
130
140
Days after emergence


N content at beginning seed fill (g N m-2)
24
22
20
18
16
14
12
10
2008
2009
MG IV
MG V
MG VI
R01-416F

Genotype	Yield	NHI	Stem N	Seed N	Total N
	$g\ m^{-2}$		-------------- $g\ N\ m^{-2}$ --------------		
MG IV Iso	412 a	0.90 a	0.8 c	24.9 a	27.7 b
MG V Iso	445 a	0.88 a	1.3 b	27.6 a	31.4 a
MG V Iso	440 a	0.89 a	1.4 ab	27.2 a	30.6 a
R01-416F	438 a	0.86 b	1.7 a	24.7 a	28.7 b

Lee NonNod	**49**	**0.39**	**1.3**	**3.2**	**4.9**

Genotype	Yield	NHI	Stem N	Seed N	Senesced Leaf N
	g m^{-2}		---- g N m^{-2} ----		g N $100g^{-1}$
MG IV Iso	351 b	0.89 a	2.5 c	21.3 b	1.5 c
MG V Iso	374 b	0.85 b	3.7 b	21.8 b	1.7 b
MG V Iso	336 b	0.78 c	5.8 a	20.2 b	2.1 a
R01-416F	460 a	0.86 b	4.2 b	25.3 a	1.9 a
Lee NonNod	**81**	**0.59**	**1.7**	**1.9**	**---**



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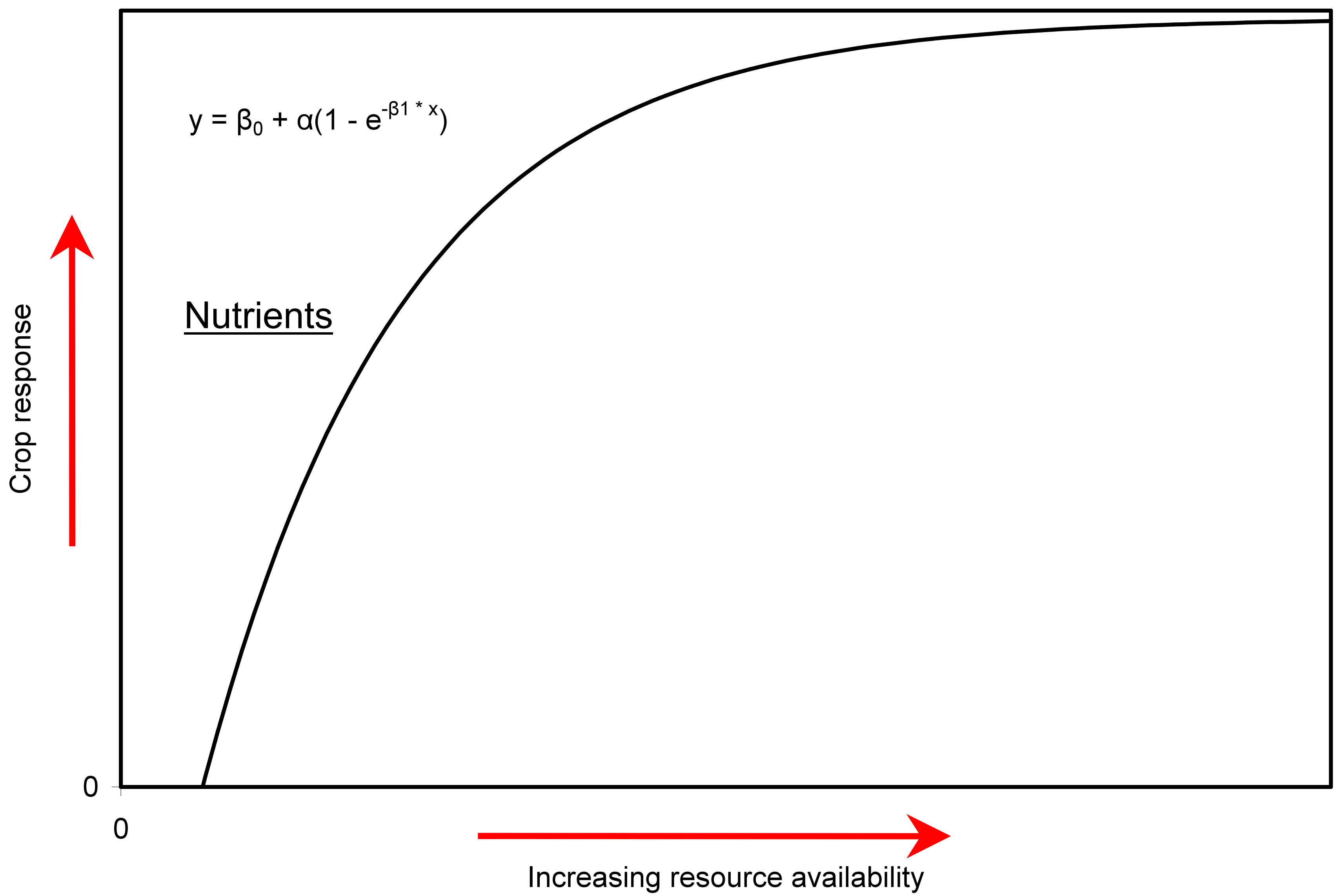
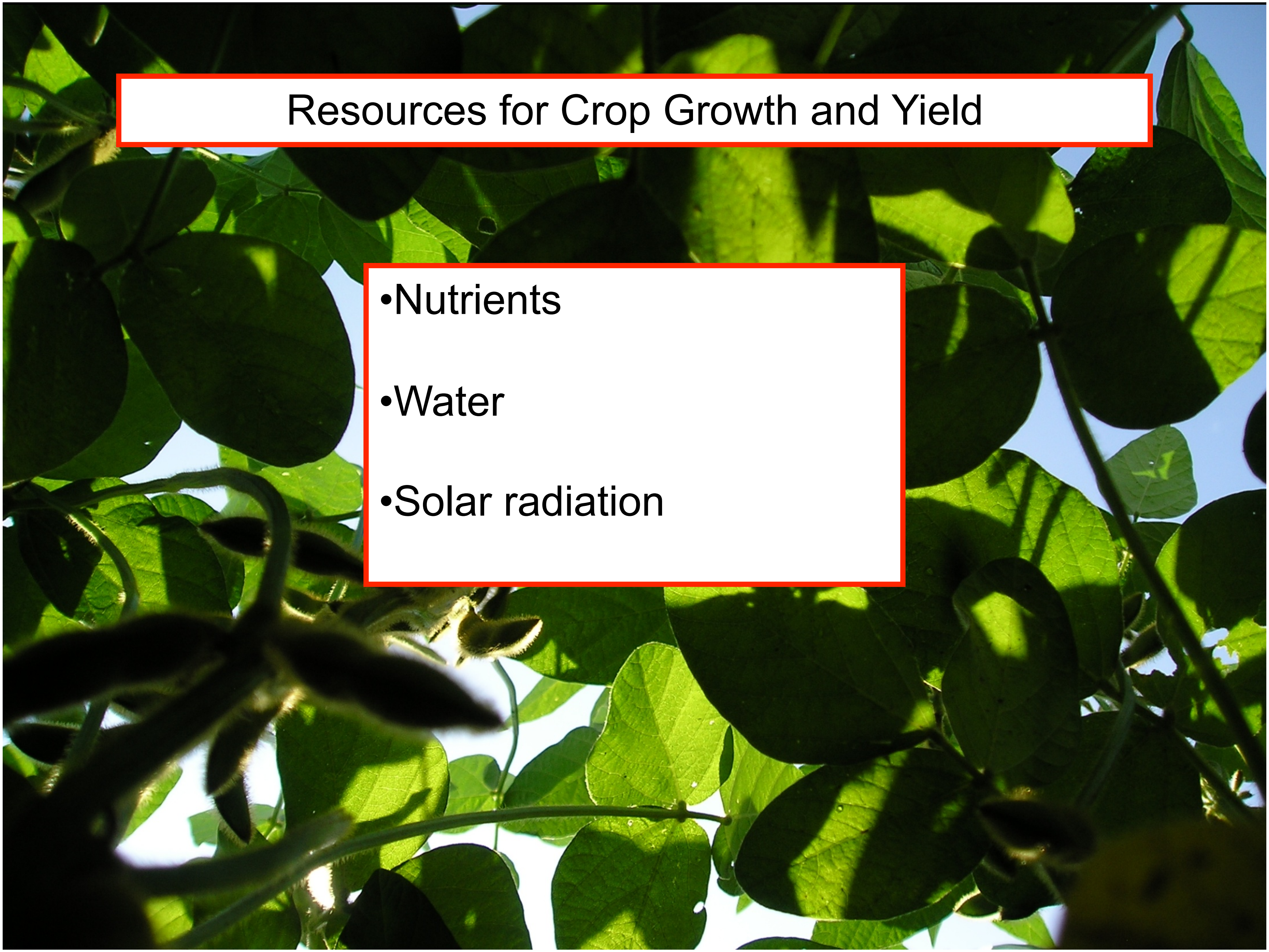


$y = \beta_0 + \alpha(1 - e^{-\beta1 * x})$
Nutrients
Crop response
0
0
Increasing resource availability


Resources for Crop Growth and Yield
•Nutrients
•Water
•Solar radiation

Final Thoughts

Approximately 90% of the N in seed was derived from N_2 fixation.

N_2 fixation continued at high rates almost until maturity.

Current N_2 fixation was inadequate for the seed N accumulation rate.

N was remobilized from both leaves and stems.

N accumulated prior to seed fill for MG VI > V > IV isolines.

N in vegetative tissues at maturity for MG VI > V > IV isolines.

N in seed and final yield was similar among MG isolines.

N does not appear to be a limitation to yield under these conditions.