What have raised beds, sub-surface water management, and N x S fertilization in common?

Hans Kandel,
NDSU Extension Agronomist

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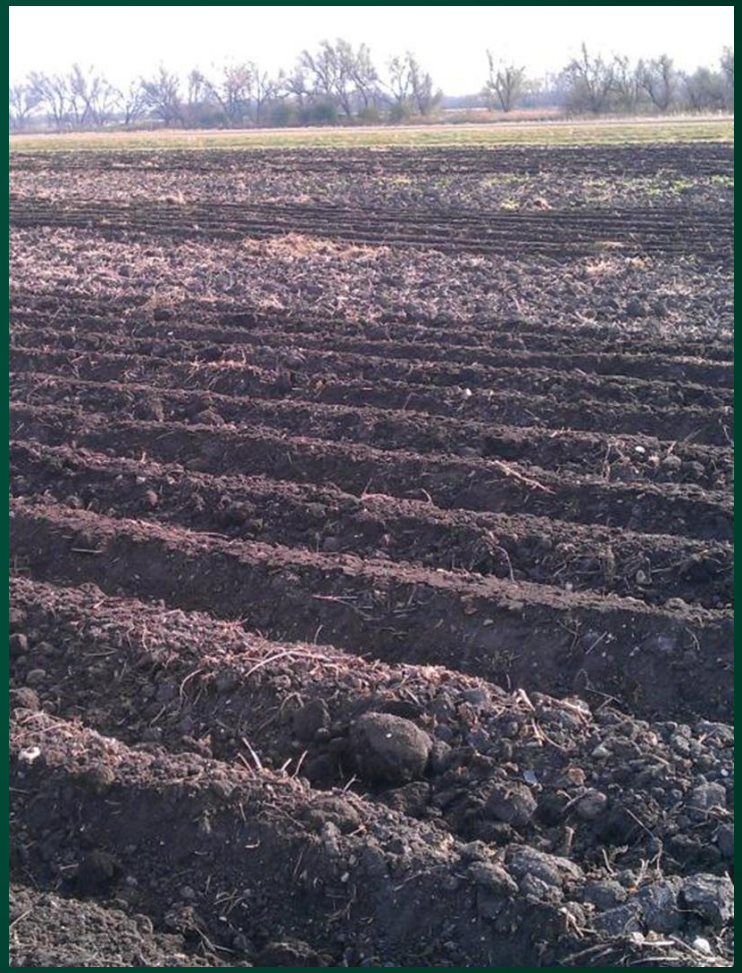
Soybean Productivity on Raised Seedbeds



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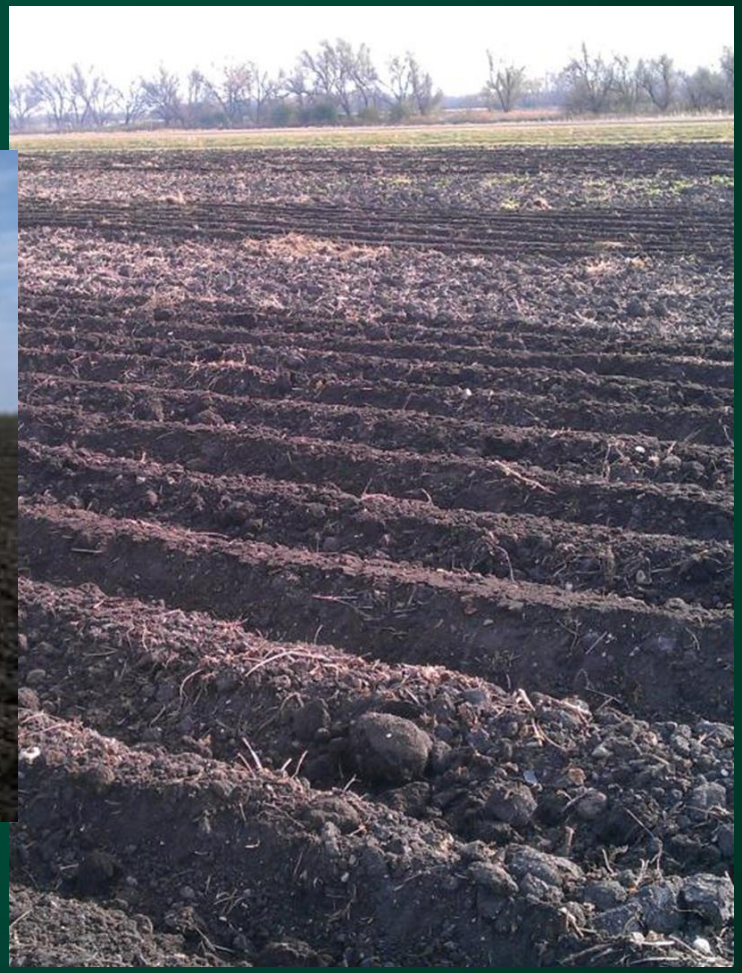
Soybean Productivity on Raised Seedbeds



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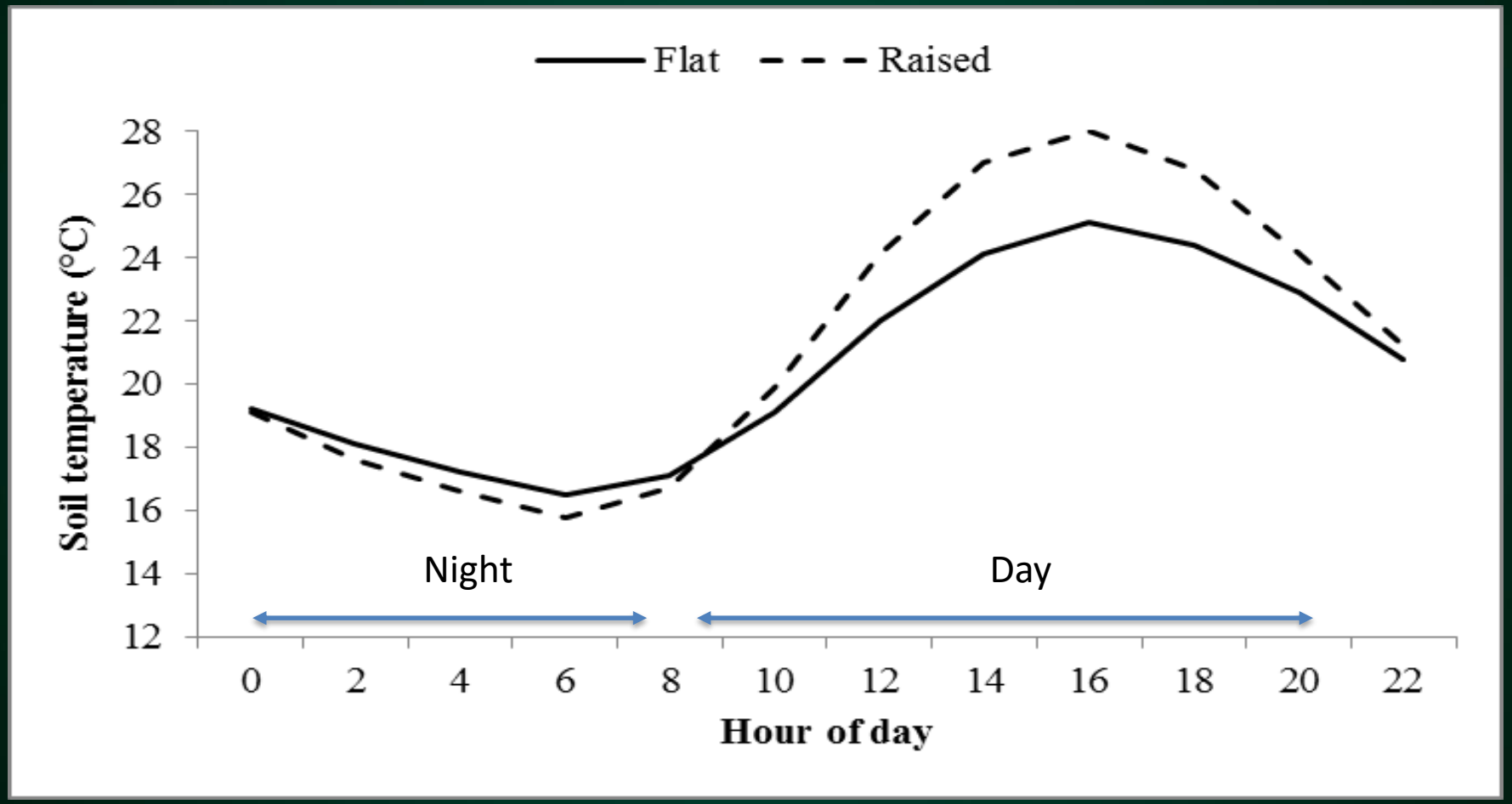
Soybean Productivity on Raised Seedbeds

- Evaluate soybean yield and response when grown on raised seedbeds compared with conventional tillage in flat land areas prone to soil water logging.

Hourly soil temperature for flat and raised seedbeds at Hitterdal, MN, in 2012.



Soybean Productivity on Raised Seedbeds

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Soybean Seed Yield

Tillage	Yield 2012[1]	Yield 2013[2]	Yield 2014[2]
	Bu/acre	Bu/acre	Bu/acre
Flat	44.6	30.3	49.7
Raised bed	44.4	33.4	51.7
LSD	NS	2.0	1.8

[1] Averaged across 5 locations.

[2] Averaged across 3 locations: tile and no tile in Fargo, and Casselton.

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Soybean Productivity on Raised Seedbeds

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Soybean Stand, Vigor and Yield 2013-2014

Tillage	Stand	Vigor	Yield 13-14
	Plant/acre	(1-9) [9= best]	Bu/acre
Flat	105,650b	4.4b	40.4b
Raised bed	134,050a	5.9a	43.0a

[1] Averaged across 6 environments: tile and no tile in Fargo, and Casselton 2013-2014.

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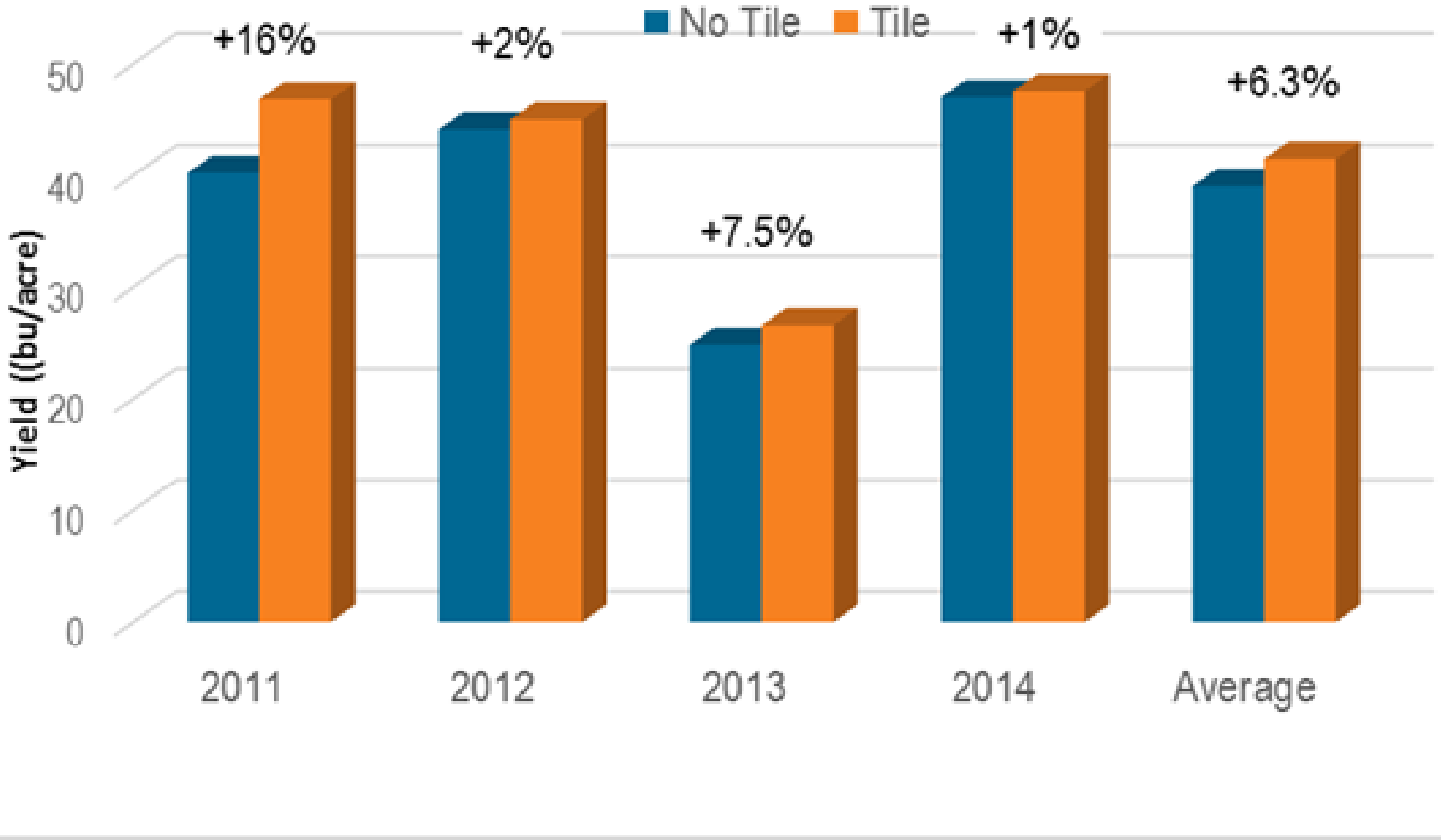
Soybean Seed Yield Raised Bed Study, No Tile and Tiled



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Summary Study

→Tile 6.3 % higher than no tile, including two dry years.

Summary Study

→Tile 6.3 % higher than no tile, including two dry years.

→ Raised Beds: Higher plant density, higher vigor score, taller plants, resulting in 6.4 % yield advantage.

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Penetrometer Readings

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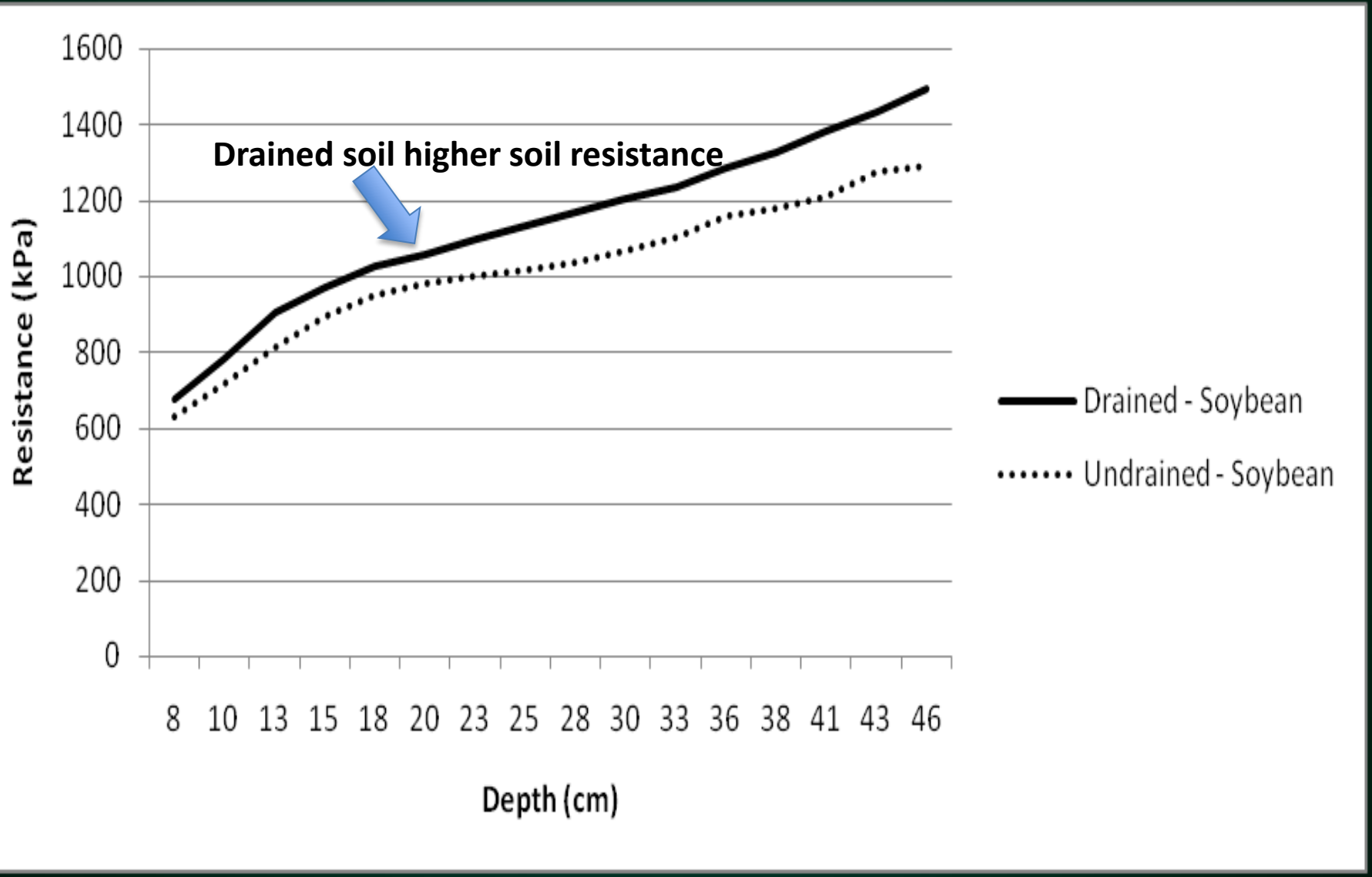
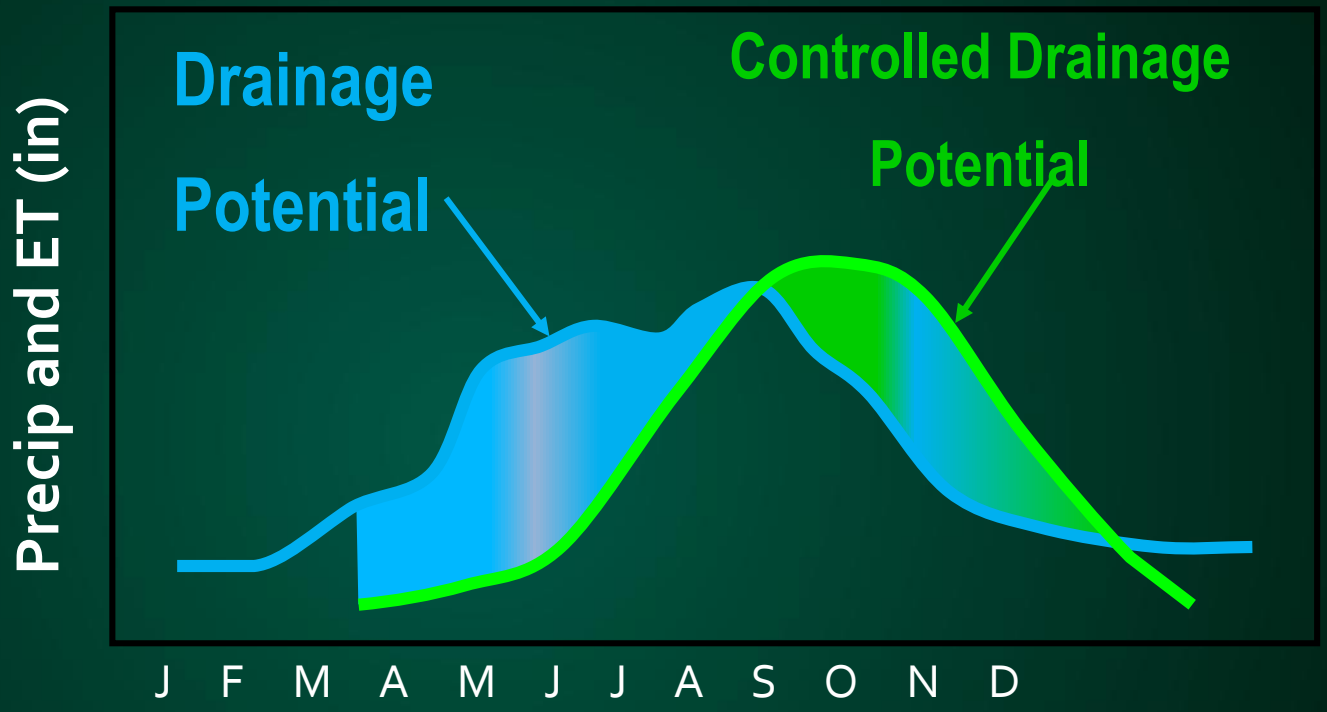
Resistance values for depths 8-46 cm on drained and undrained ground seeded into soybean.



Water Management Potential



- Old School: Managing excess water meant simply removing it
- New School: What if we had more control over the seasonal water balance?

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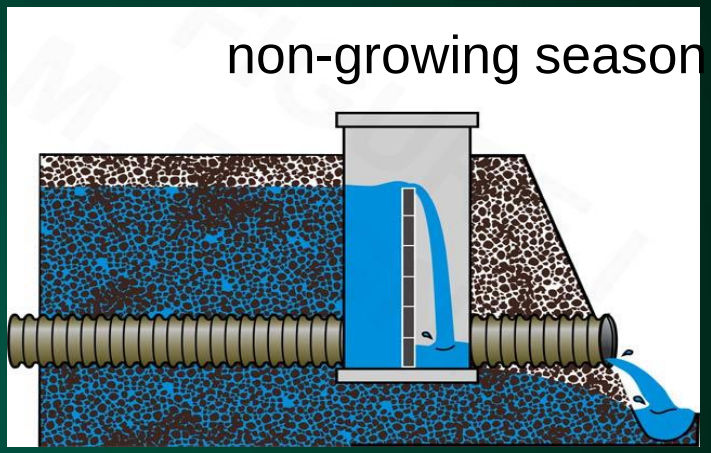
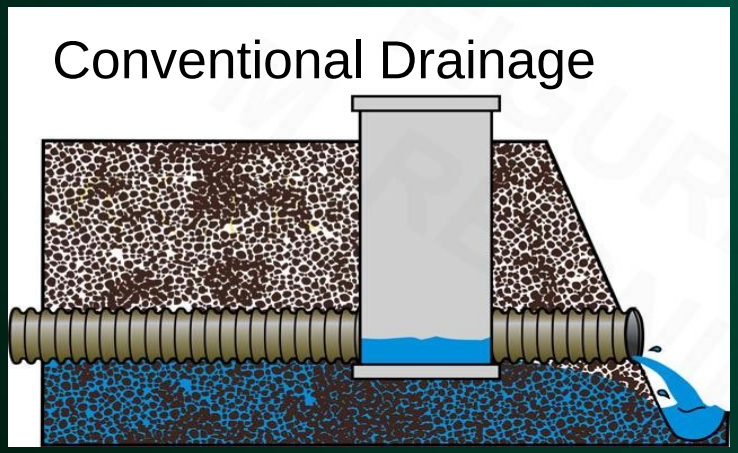
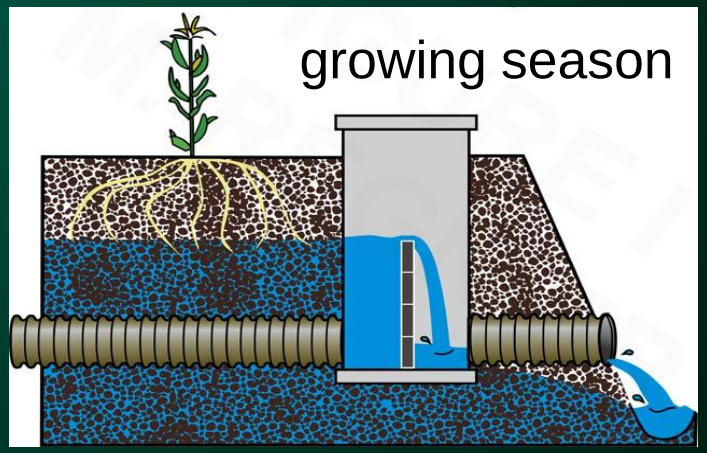
Source Gary Sands

Types of drainage water management

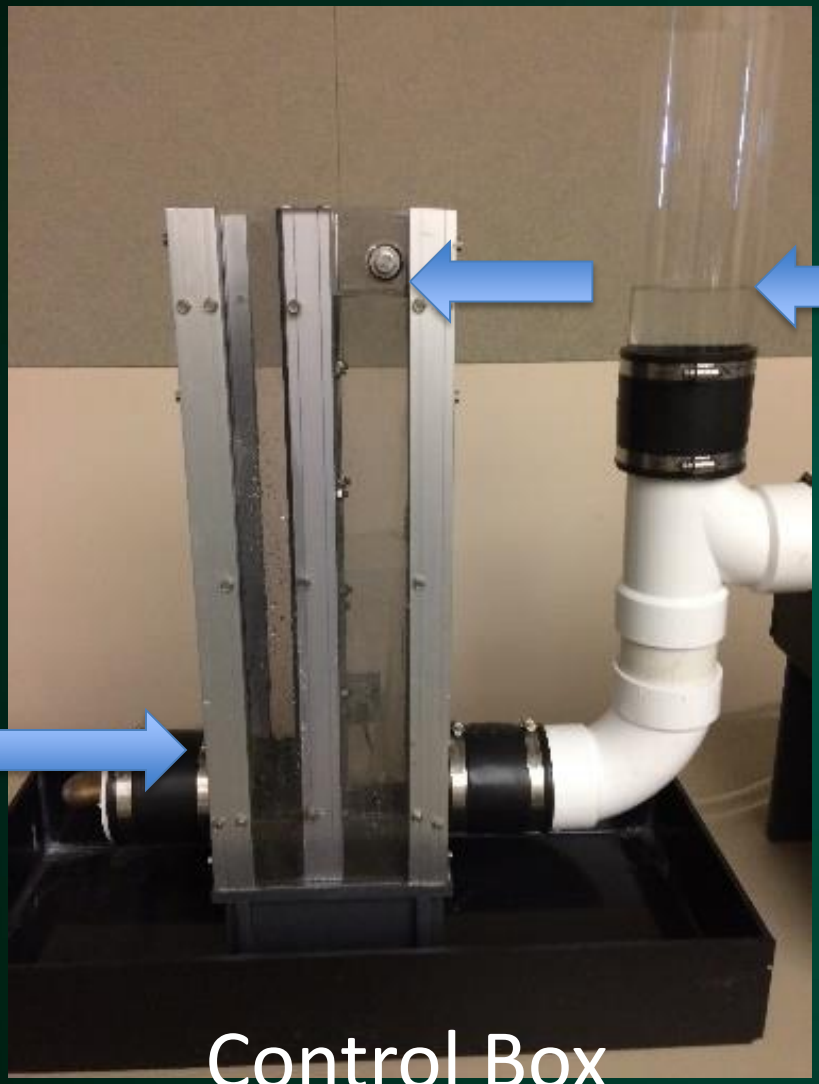
- Subsurface drainage
  - Conventional
  - Controlled
  - Subirrigation



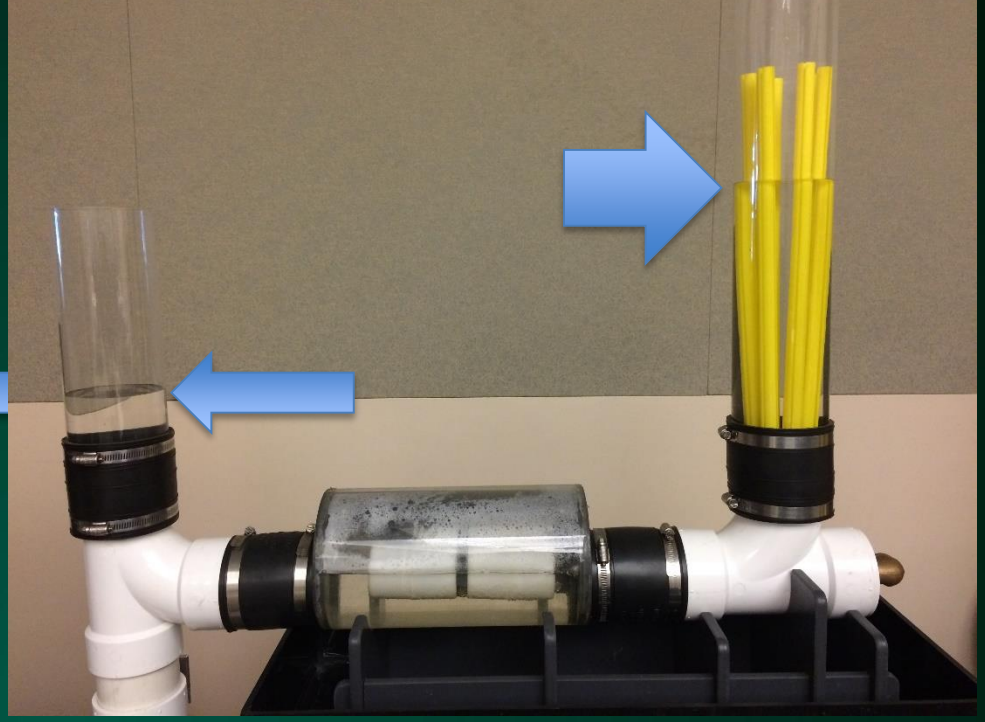




Controlled Drainage



Control Box



Sub-surface control device

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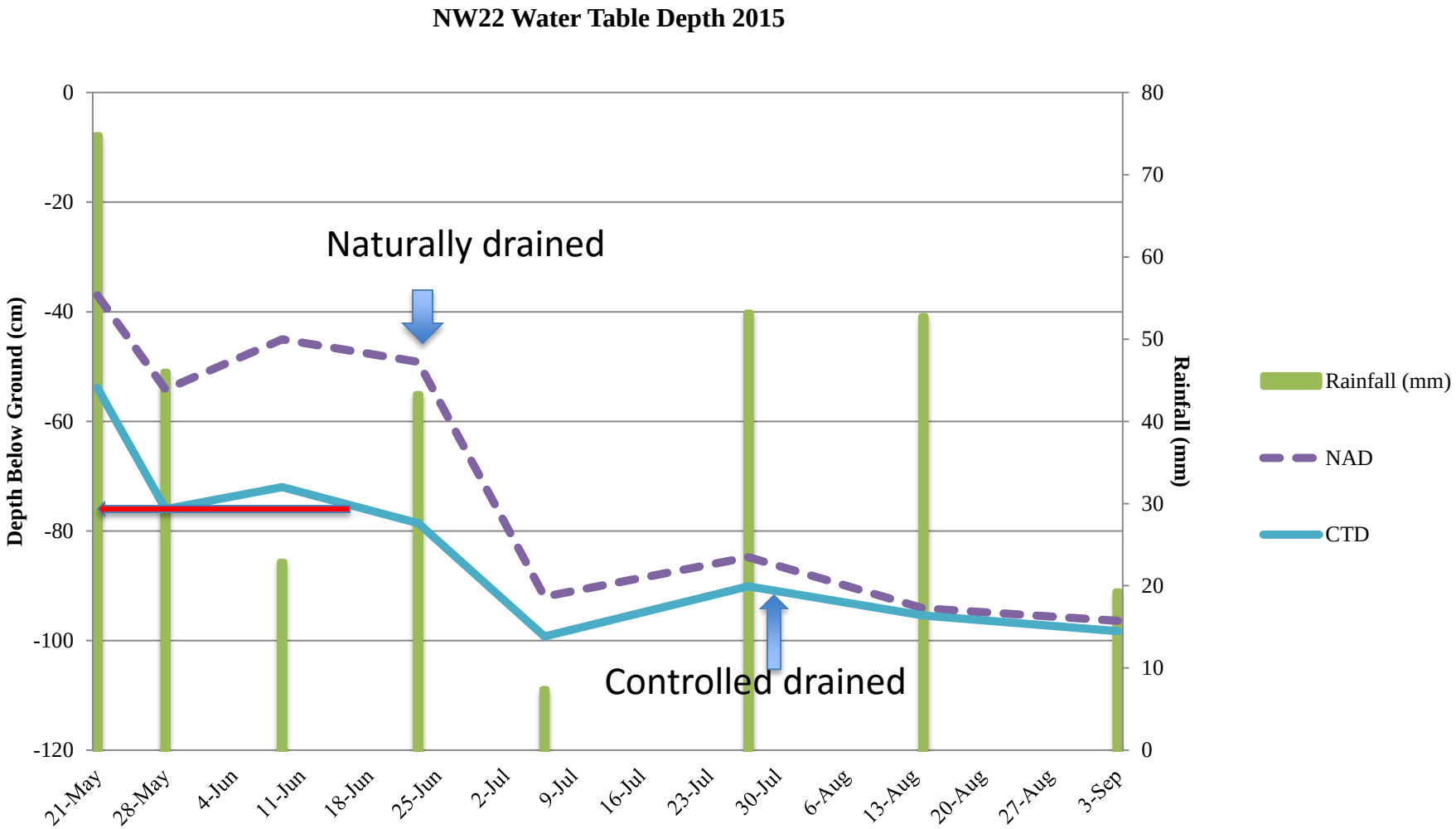
Water table



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Wheat Study 2009-2011

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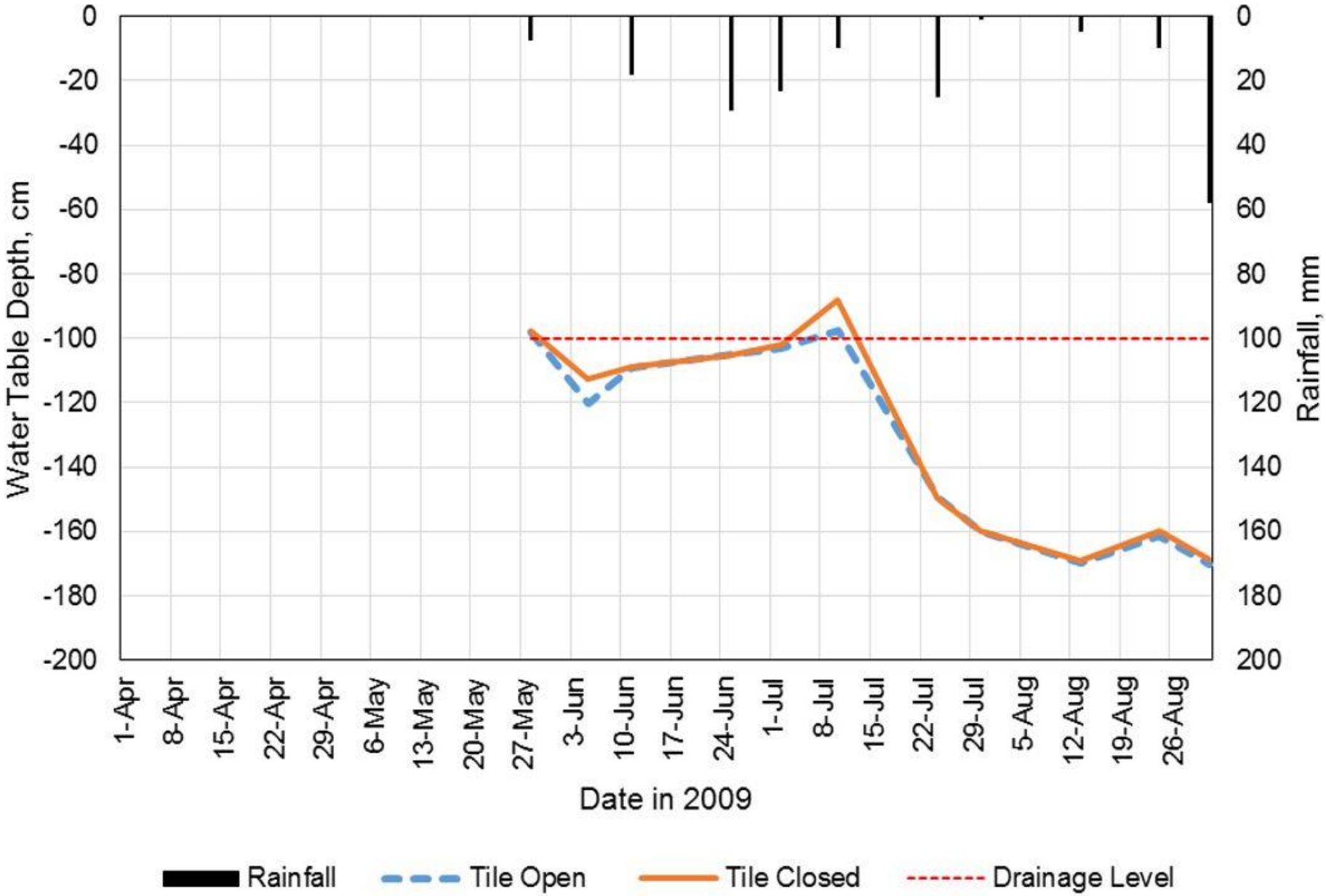
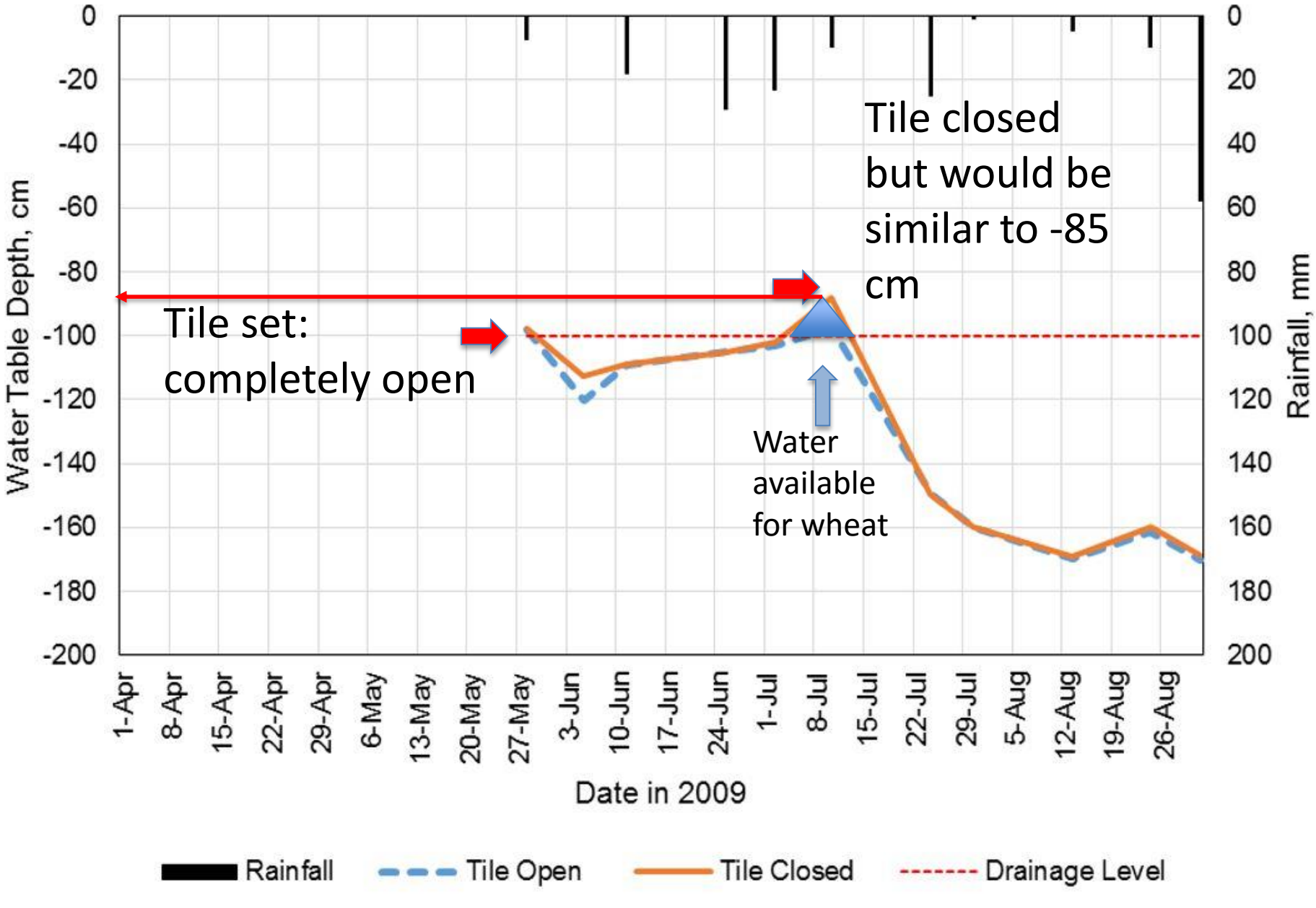
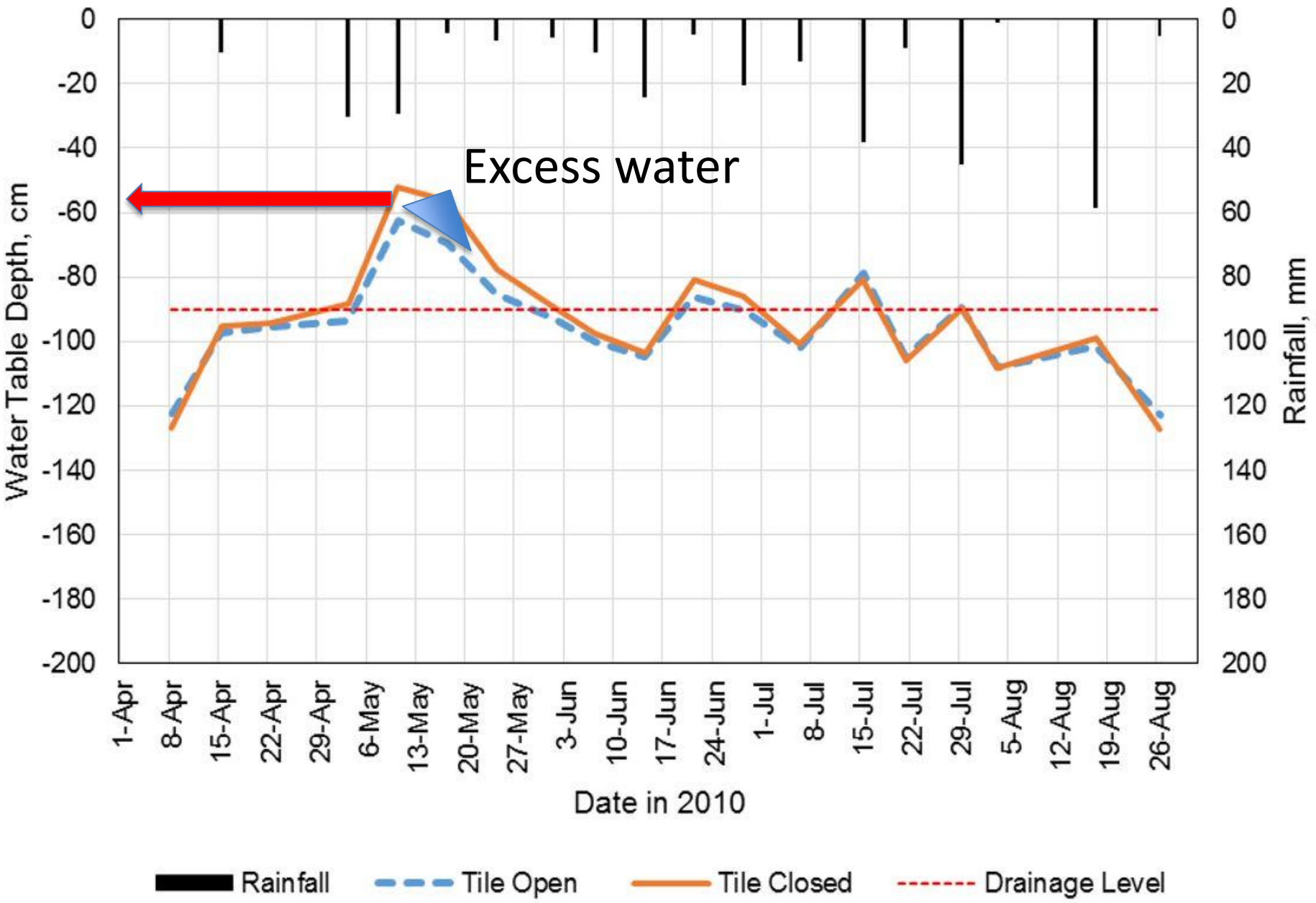
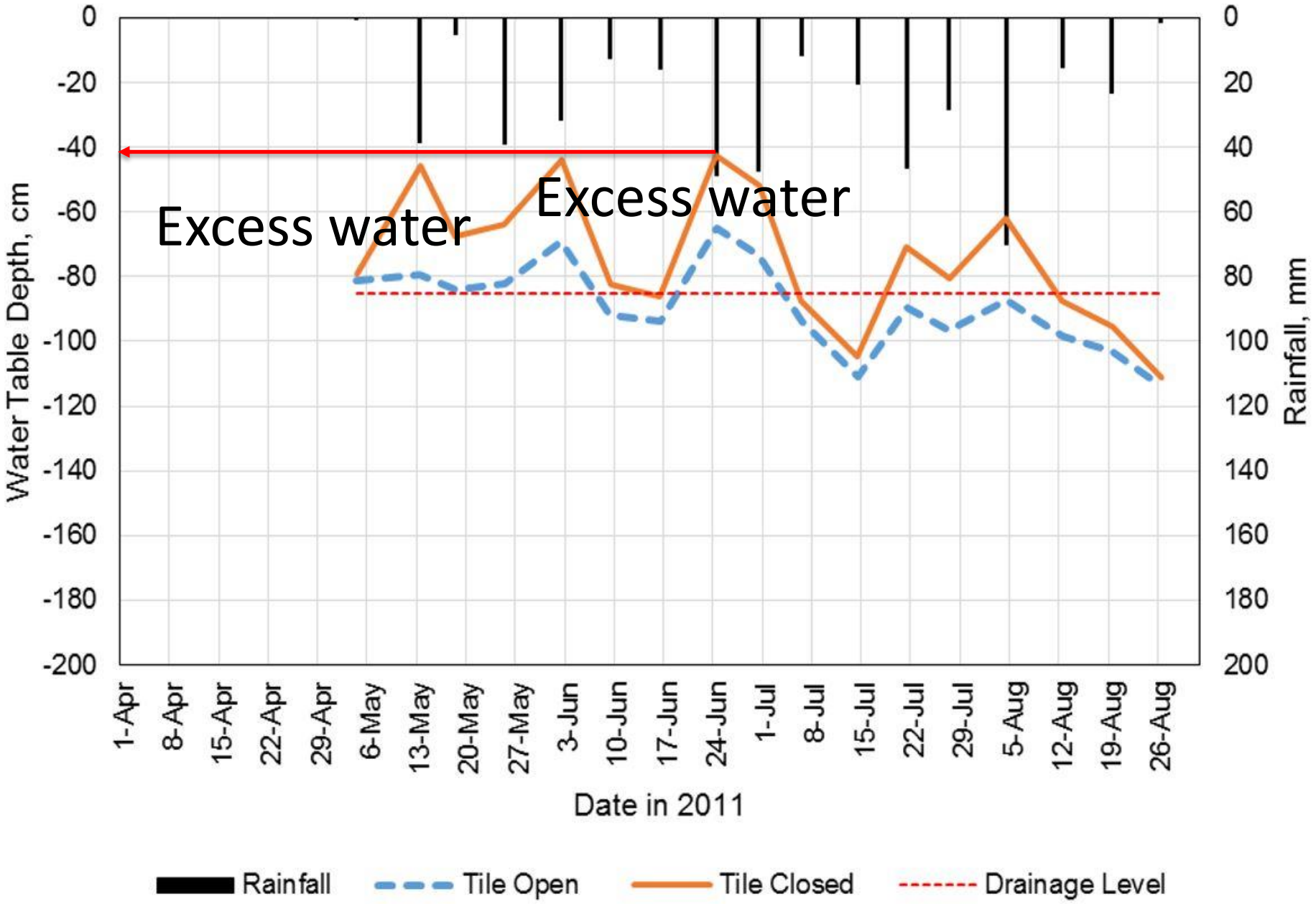

0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
Water Table Depth, cm
0
20
40
60
80
100
120
140
160
180
200
Rainfall, mm
1-Apr
8-Apr
15-Apr
22-Apr
29-Apr
6-May
13-May
20-May
27-May
3-Jun
10-Jun
17-Jun
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug
Date in 2009
Rainfall
Tile Open
Tile Closed
Drainage Level

Management	2009	2010	2011	2009-2011
	----------Bushel acre^{-1} -------			
Closed tile	69.9a			
Open tile	67.0a			

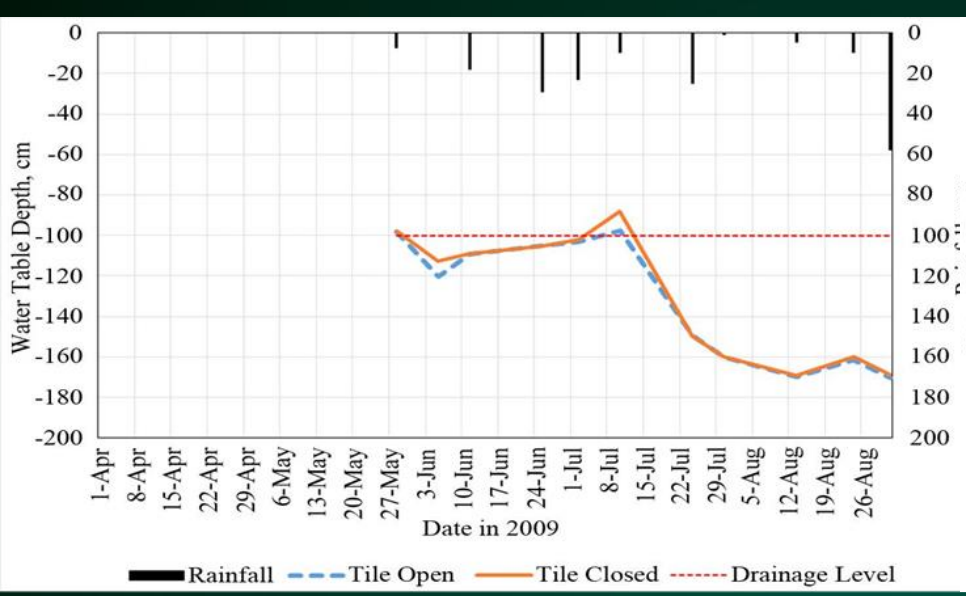

Tile closed but would be similar to -85 cm
Tile set: completely open
Water available for wheat
Water Table Depth, cm
Rainfall, mm
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
0
20
40
60
80
100
120
140
160
180
200
1-Apr
8-Apr
15-Apr
22-Apr
29-Apr
6-May
13-May
20-May
27-May
3-Jun
10-Jun
17-Jun
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug
Date in 2009
Rainfall
Tile Open
Tile Closed
Drainage Level

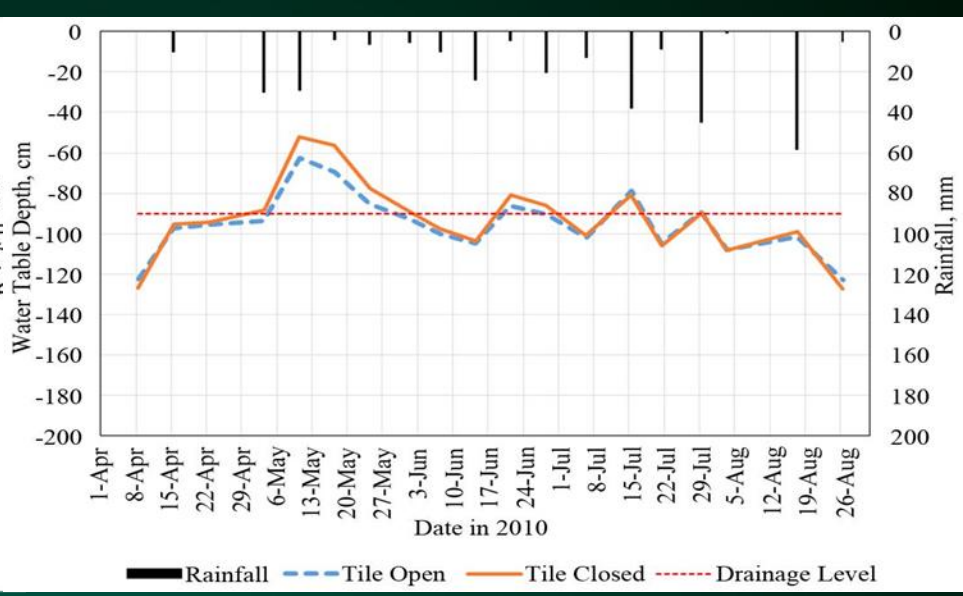

Excess water
Water Table Depth, cm
Rainfall, mm
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
20
40
60
80
100
120
140
160
180
200
1-Apr
8-Apr
15-Apr
22-Apr
29-Apr
6-May
13-May
20-May
27-May
3-Jun
10-Jun
17-Jun
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug
Date in 2010
Rainfall
Tile Open
Tile Closed
Drainage Level

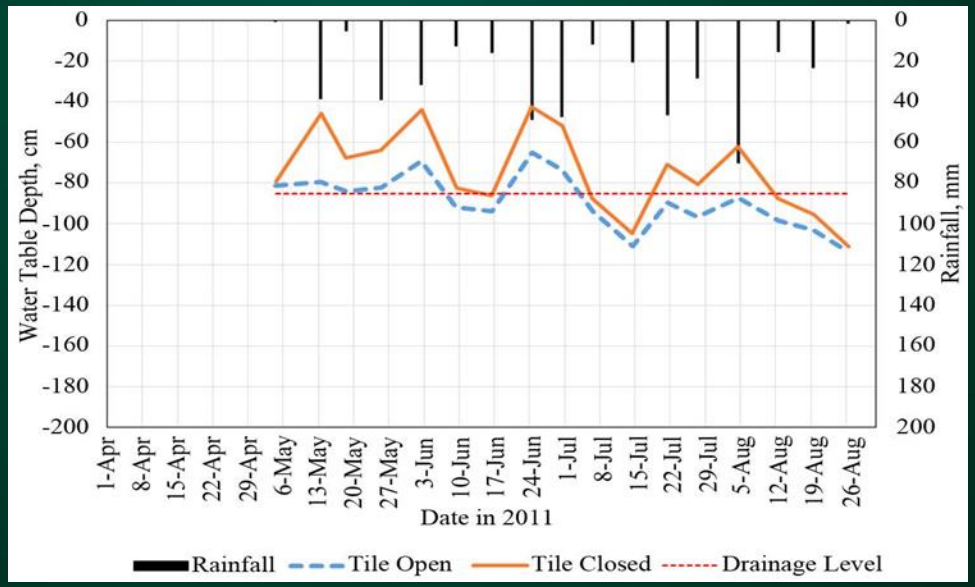
Management	2009	2010	2011	2009-2011
	----------Bushel acre^{-1} -------			
Closed tile	69.9a	61.8a		
Open tile	67.0a	62.7a		


Excess water
Excess water
Water Table Depth, cm
Rainfall, mm
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
0
20
40
60
80
100
120
140
160
180
200
1-Apr
8-Apr
15-Apr
22-Apr
29-Apr
6-May
13-May
20-May
27-May
3-Jun
10-Jun
17-Jun
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug
Date in 2011
Rainfall
Tile Open
Tile Closed
Drainage Level

Management	2009	2010	2011	2009-2011
	----------Bushel acre^{-1} -------			
Closed tile	69.9a	61.8a	35.4a	55.7a
Open tile	67.0a	62.7a	37.6a	55.8a







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Mgt Level 1	2009-2011	Mgt Level 2	2009-2011
	Bu/A		Bu/A
Closed tile	55.7a	Limited Mgt	54.8b
Open tile	55.8a	Best Mgt	56.7a

Level 2 is best management approach, i.e. tile closed in 2009 in response to dry conditions and tile open in 2010 and 2011 in response to wetter conditions. Numbers with the same column with the same letter are not significantly different at $p \leq 0.10$.

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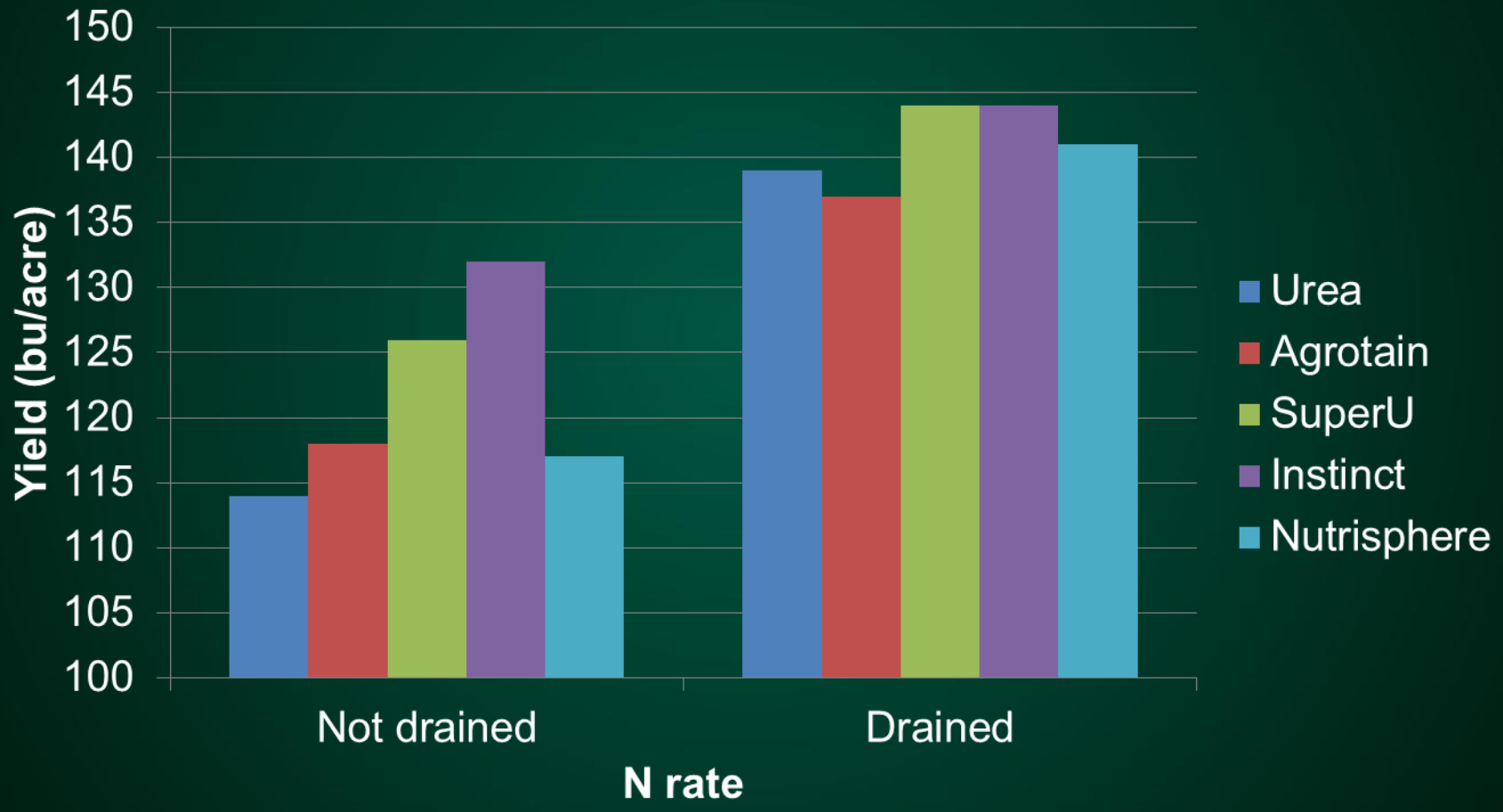
Effect of tile drainage and additive at the 112 N rate on yield of corn, NW22, 2011.



Iron Deficiency Chlorosis (IDC)

- Fe is a micronutrient
- Fe is essential in the formation of chlorophyll
- IDC often associated with high pH, stressed plant, lack of soil aeration
- Normally not a lack of Fe in the soil
- Caused by the inability of the plant to take up Fe or utilize it

Symptoms occur usually in the newest leaves formed. The leaf looks yellow and the veins in the leaf stay green.

SOYBEAN IRON CHLOROSIS

1. High pH (7.8 - 8.5).
2. High amounts of bi carbonates.
3. High levels of soluble salts (>0.7 ppm).
4. Very dry or wet soils (higher moisture more IDC).
5. Low Soil Temperature.
6. High Soil Nitrate Concentration.

Iron Deficiency Chlorosis Score

Numerical Score		Description
1-5 scale	1-9 scale	Rating
1 to 2	1 to 2.5	Tolerant
2.1 to 3	2.6 to 5	Moderately Tolerant
3.1-4	5.1 to 7.5	Moderately Susceptible
4.1 to 5	7.5 to 9	Susceptible

Iron Chlorosis score 4

Iron Chlorosis score 5

Source: Dr. Jay Goos

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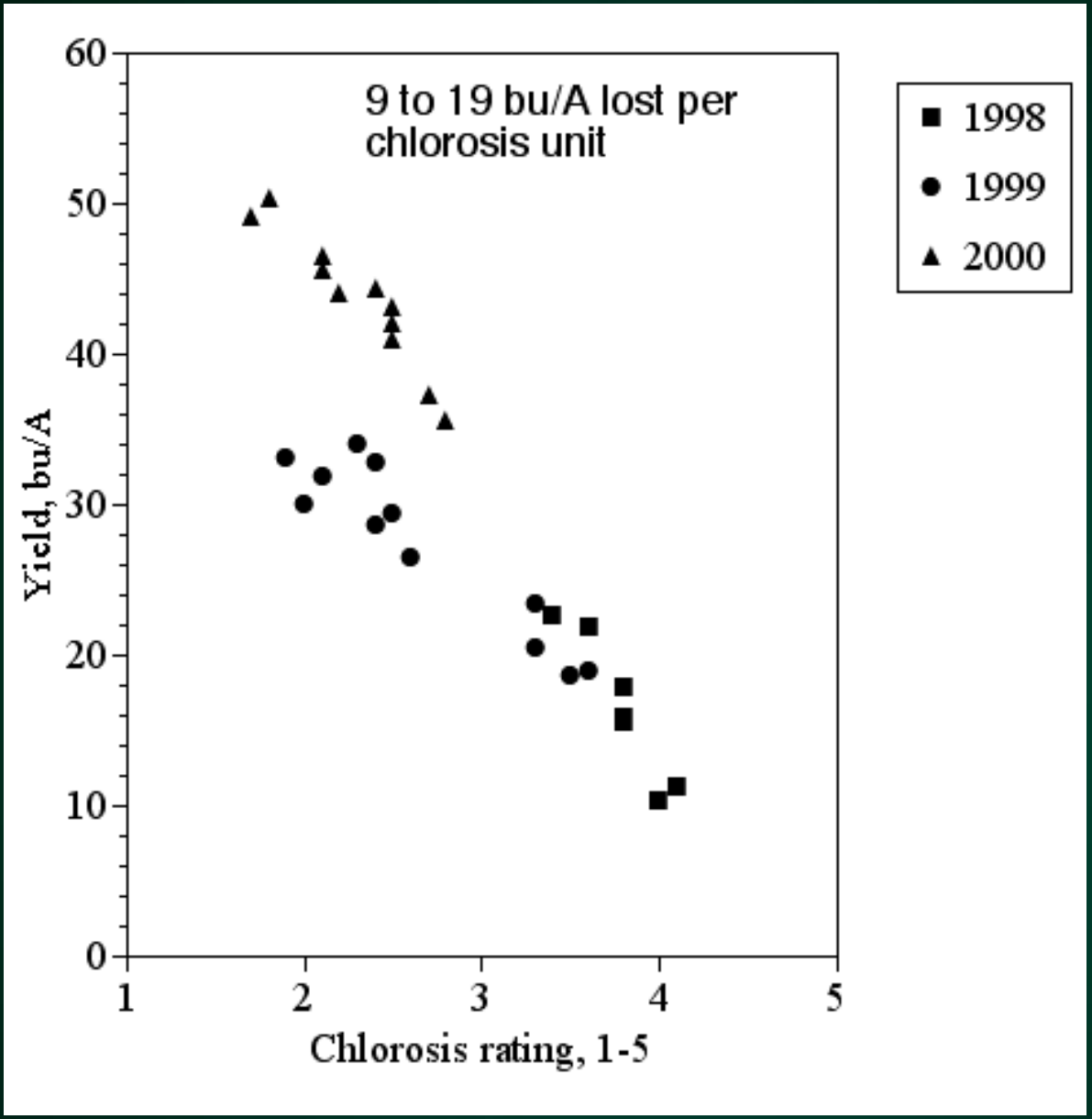

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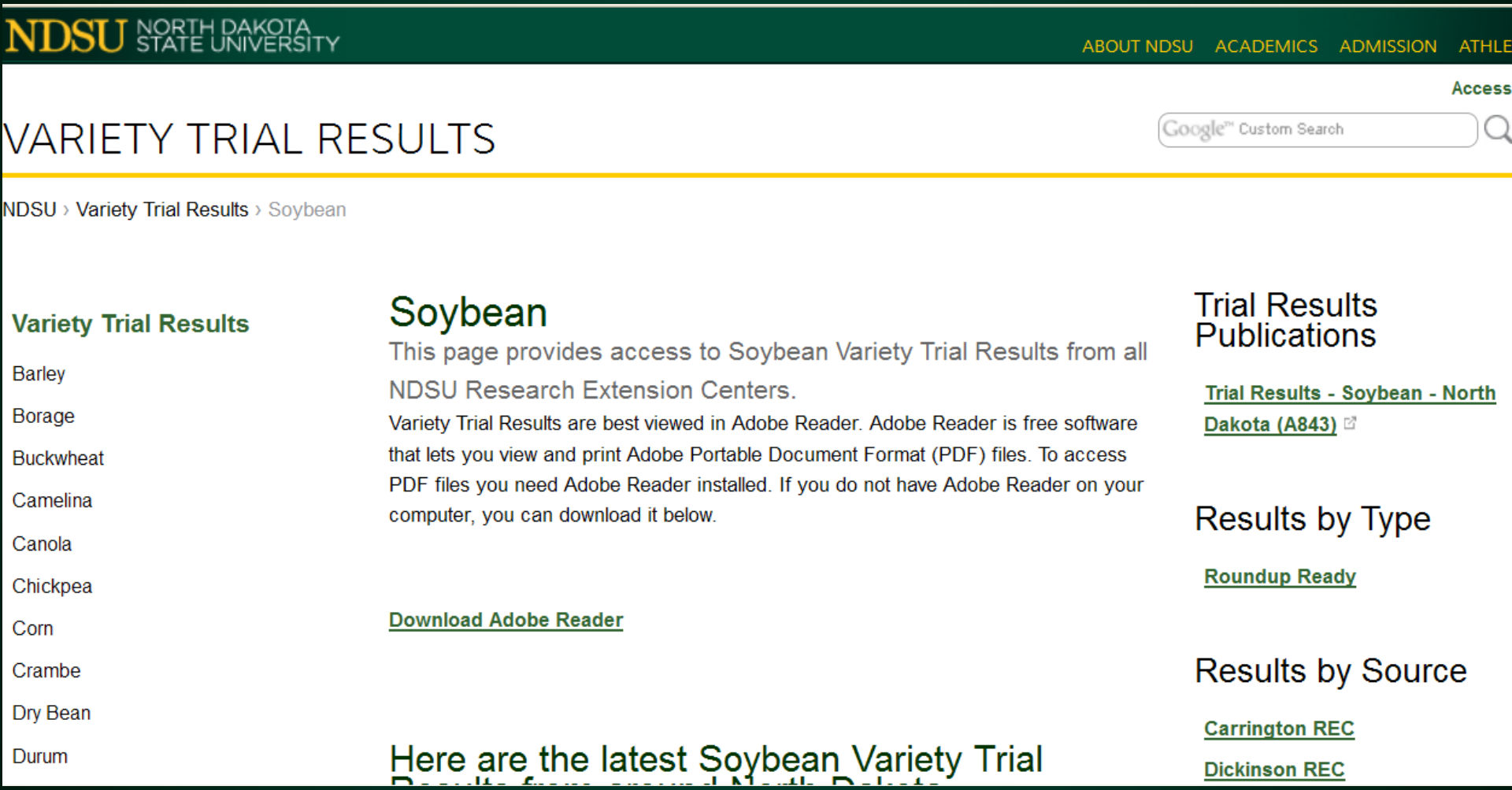
Source: J. Goos

http://www.ag.ndsu.edu/varietytrials



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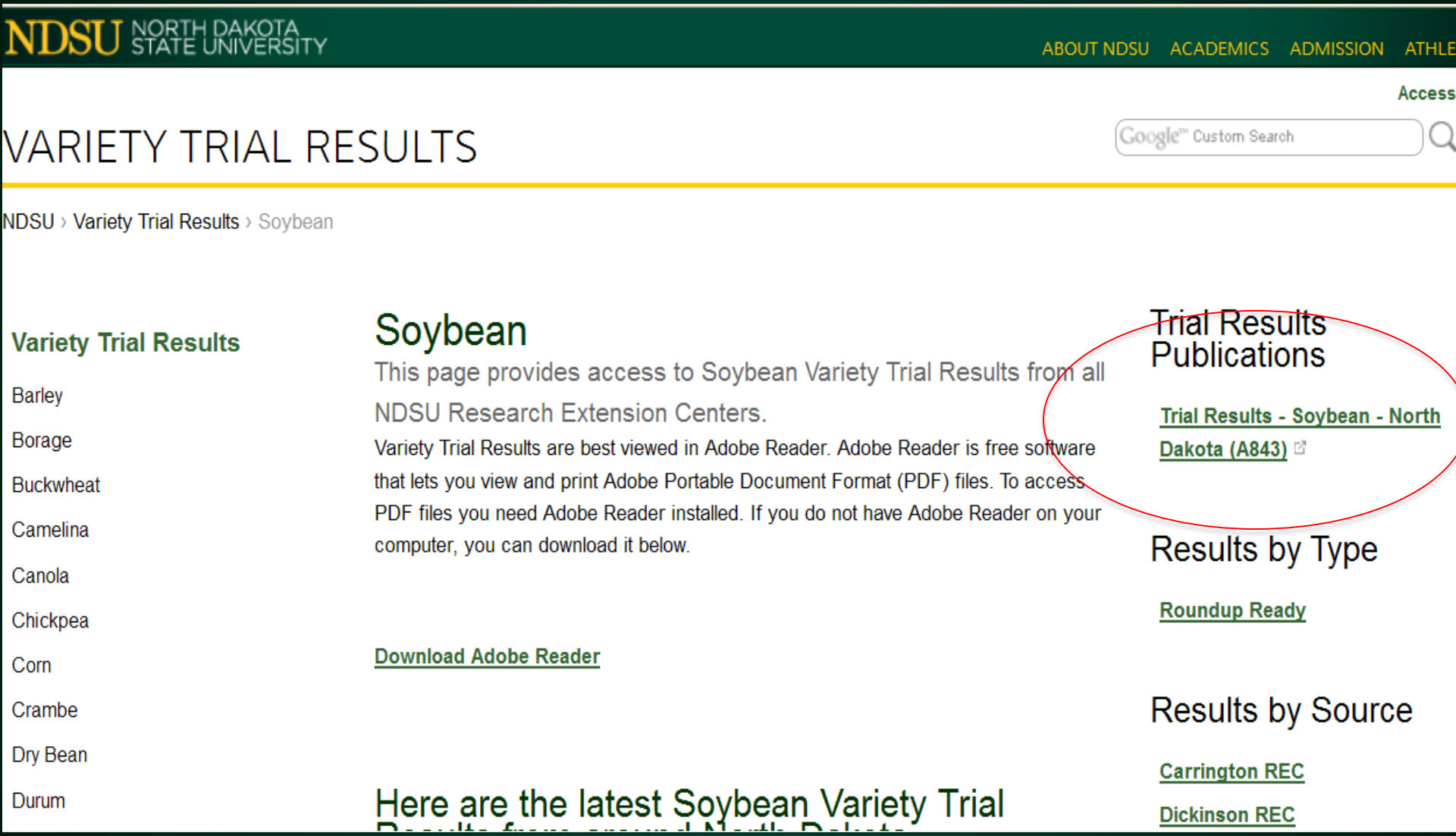

https://www.ag.ndsu.edu/pubs/plantsci/rowcrops/a843_16.pdf
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North Dakota Soybean Variety Trial Results for 2016 and Selection Guide

Hans Kandel, Ted Helms and Sam Markell (NDSU Main Station); Mike Ostlie, Blaine Schatz, Greg Endres, Ezra Aberle, Tim Indergaard, Steve Zwinger, Jesper Nielsen and Steve Schaubert (Carrington Research Extension Center); Kelly Cooper, Leonard Besemann, and Heidi Eslinger (Oakes Irrigation Site); John Rickertsen and Rick Olson (Hettinger Research Extension Center); Eric Eriksmoen, James Tarasenko and Joe Effertz (North Central Research Extension Center, Minot); Bryan Hanson, Travis Hakanson and Lawrence Henry (Langdon Research Extension Center); Jerry Bergman, Gautam Pradhan, Emma Link, Austin Link, Tyler Tjelde and Justin Jacobs (Williston Research Extension Center)

We thank all producer cooperators for contributing their time, labor, land and other material to the 2016 soybean yield trial program in the central and southern Red River Valley and other off-station sites.

Table 3. 2016 NDSU Roundup Ready Soybean Iron-deficiency Chlorosis Trial - Author, T. Helms (Page 1 of 2).

Company	Variety	4-site Mean IDC[1]	Company	Variety	4-site Mean IDC[1]	Company	Variety	4-site Mean IDC[1]
Asgrow	AG 00932 (check)	1.4	Peterson	17X04N	1.8	Proseed	50-60N	2.0
Pioneer	P01T06R	1.4	Integra	20468	1.8	Proseed	XT603	2.0
Pioneer	P005T13R	1.4	Integra	20600	1.8	Wensman	W30085NR2	2.0
Pioneer	P008T22R2	1.5	Legend	11R760N	1.8	Asgrow	AG 0732 (check)	2.0
Channel	0205R2	1.5	Syngenta	NKS08-M2	1.8	Channel	0507R2	2.0
Hefty	H009R5	1.5	Prairie	PB-1257R2	1.8	Dairyland	DSR-0305/R2Y	2.0
Legacy	LS-0334RR2	1.5	Peterson	16R01	1.8	Dyna-Gro	S04XT77	2.0
REA	R0815	1.5	Peterson	16X07N	1.8	Hefty	H03X7	2.0
Hefty	H008R3	1.5	REA	R00727	1.8	Dyna-Gro	SX16006R	2.0
REA	R0216	1.5	Wensman	W1037RX	1.8	Hefty	H02X7	2.0
Wensman	W1016RX	1.6	Wensman	W30048R2	1.8	Prairie	PB-0987R2	2.0
REA	64G94	1.6	Wensman	W3031NR2	1.8	Thunder	SB8707N	2.0

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Hefty	H009R5	1.5	Prairie	PB-1257R2	1.8	Dairyland	DSR-0305/R2Y	2.0
Legacy	LS-0334RR2	1.5	Peterson	16R01	1.8	Dyna-Gro	S04XT77	2.0
Hefty	H006R7	1.8	Legacy	LS-0837N	2.0	Syngenta	NKS02-R2	2.1
Hefty	H03R5	1.8	NuTech	6097R2	2.0	Proseed	XT610	2.1
Mean		2.0	Mean		2.0	Mean		2.0
LSD 0.05		0.30	LSD 0.05		0.30	LSD 0.05		0.30
LSD 0.10		0.21	LSD 0.10		0.21	LSD 0.10		0.21

Table 3. 2016 NDSU Roundup Ready Soybean Iron-deficiency Chlorosis Trial - Author, T. Helms (Page 1 of 2).

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Legacy	LS-0334RR2	1.5	Peterson	16R01	1.8	Dyna-Gro	S04XT77	2.0
Hefty	H006R7	1.8	Legacy	LS-0837N	2.0	Syngenta	NKS02-R2	2.1
Hefty	H03R5	1.8	NuTech	6097R2	2.0	Proseed	XT610	2.1
Mean		2.0	Mean		2.0	Mean		2.0
LSD 0.05		0.30	LSD 0.05		0.30	LSD 0.05		0.30
LSD 0.10		0.21	LSD 0.10		0.21	LSD 0.10		0.21

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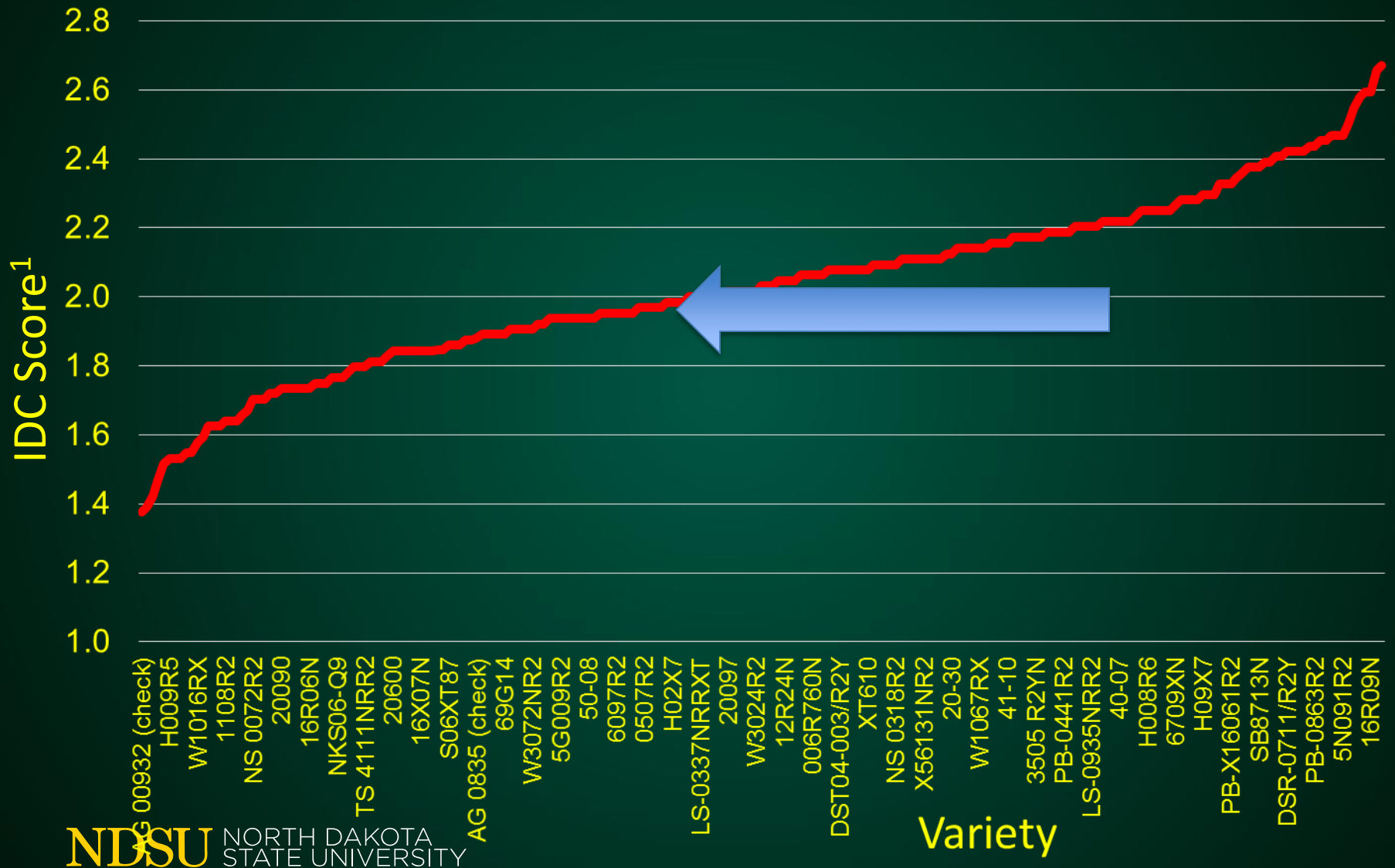
Table 3. 2016 NDSU Roundup Ready Soybean Iron-deficiency Chlorosis Trial - Author, T. Helms (Page 2 of 2).

Company	Variety	4-site Mean IDC[1]	Company	Variety	4-site Mean IDC[1]	Company	Variety	4-site Mean IDC[1]
Thunder	3606 R2YN	2.1	Mycogen	5N078R2	2.2	Hefty	H08X7	2.5
Thunder	3614 R2YN	2.1	Channel	0807R2	2.2	Integra	20215	2.5
Asgrow	AG 0333 (check)	2.1	Dairyland	DSR-0404/R2Y	2.2	Mycogen	5N091R2	2.5
Dairyland	DSR-0807/R2Y	2.1	Legend	04R560	2.2	Legend	09R606N	2.5
Dyna-Gro	S009RY56	2.1	Proseed	40-07	2.2	Syngenta	NKS006-W5	2.5
Legend	10R551N	2.1	Thunder	3408 R2YN	2.2	Peterson	16R10	2.6
Northstar	NS 0318R2	2.1	Wensman	W3018R2	2.2	Hefty	H009R3	2.6
Channel	00806R2	2.1	Thunder	SB8704	2.2	Peterson	16R09N	2.6
Dyna-Gro	S09RY64	2.1	Dairyland	DSR-0225/R2Y	2.3	Dairyland	DSR-1120/R2Y	2.7
Hefty	H01R4	2.1	Hefty	H008R6	2.3	Stine[2]	0480 (check)	2.7
Mycogen	5B082R2	2.1	Hefty	H02R3	2.3	Stine[2]	0480 (check2)	2.7

223 RR Varieties IDC Score 2016



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[1]IDC score was 1-5 scale with 1-green, 5-dead.

Table 4. 2016 NDSU Conventional and Liberty Link Soybean Iron-deficiency Chlorosis Trial - Author, T. Helms.

Company	Variety	4-site Mean IDC[1]	Company	Variety	4-site Mean IDC[1]
Dyna-Gro	S04LL37	1.3	NuTech	3066L	2.1
Asgrow check[2]	AG 00932	1.4	Richland	MK0249	2.1
Check variety	A11 (early)	1.5	Richland	MK0508	2.1
Dyna-Gro	S06LL26	1.6	NuTech	3115L	2.1
NDSU	ND1100S	1.6	NDSU	Traill	2.1
Peterson	L07-16N	1.7	Proseed	40-51N	2.2
Dyna-Gro	SX16206L	1.8	Asgrow check[2]	AG 0333	2.2
Terning	TS2010	1.9	Peterson	L02-16N	2.2

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NDSU	ND1100S	1.6	NDSU	Traill	2.1
Peterson	L07-16N	1.7	Proseed	40-51N	2.2
Dyna-Gro	SX16206L	1.8	Asgrow check[2]	AG 0333	2.2
Terning	TS2010	1.9	Peterson	L02-16N	2.2
NDSU	Ashtabula	2.1	Richland	MK42	2.5
Bayer	CZ 0121 LL	2.1	NDSU	ND1406HP	2.6
Hefty	H007X7	2.1	Check variety[3]	Sargent	2.6
NuTech	2086L	2.1	Check variety[3]	Sargent (2)	2.7
Mean		2.1	Mean		2.1
LSD 0.05		0.22	LSD 0.05		0.22
LSD 0.10		0.20	LSD 0.10		0.20

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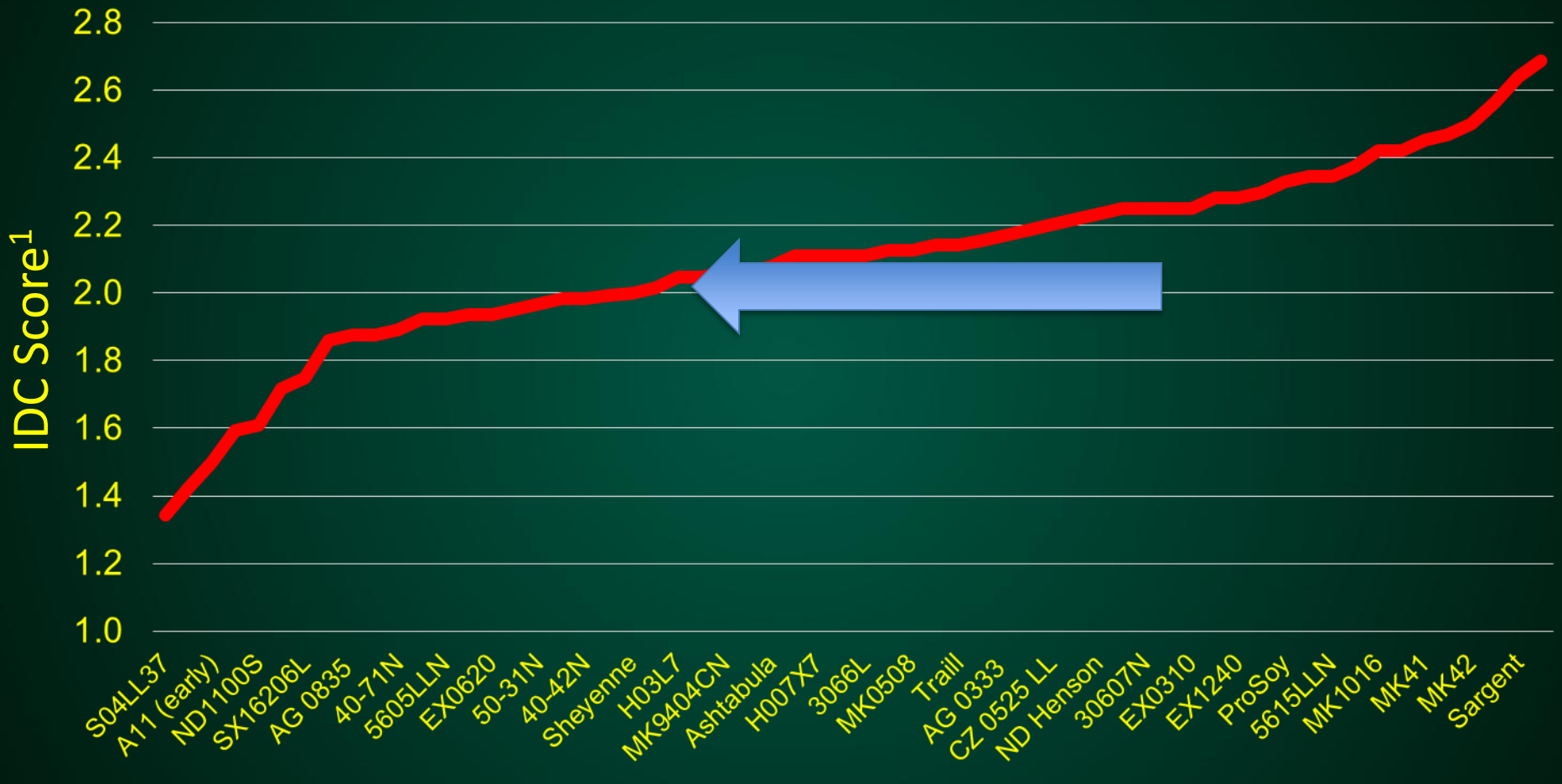
60 non RR Varieties IDC Score 2016



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[1]IDC score was 1-5 scale with 1-green, 5-dead.

2016 NDSU Conv. IDC Trial

Company	Cultivar	IDC visual* score
Dyna-Gro	S04LL37	1.3
Peterson	L07-16N	1.7
NDSU	Sheyenne	2.0
NDSU	ND Bison	2.0
NDSU	Ashtabula	2.1
Thunder	5615LLN	2.3
Susceptible check	Sargent	2.7
LSD (0.05)		0.22

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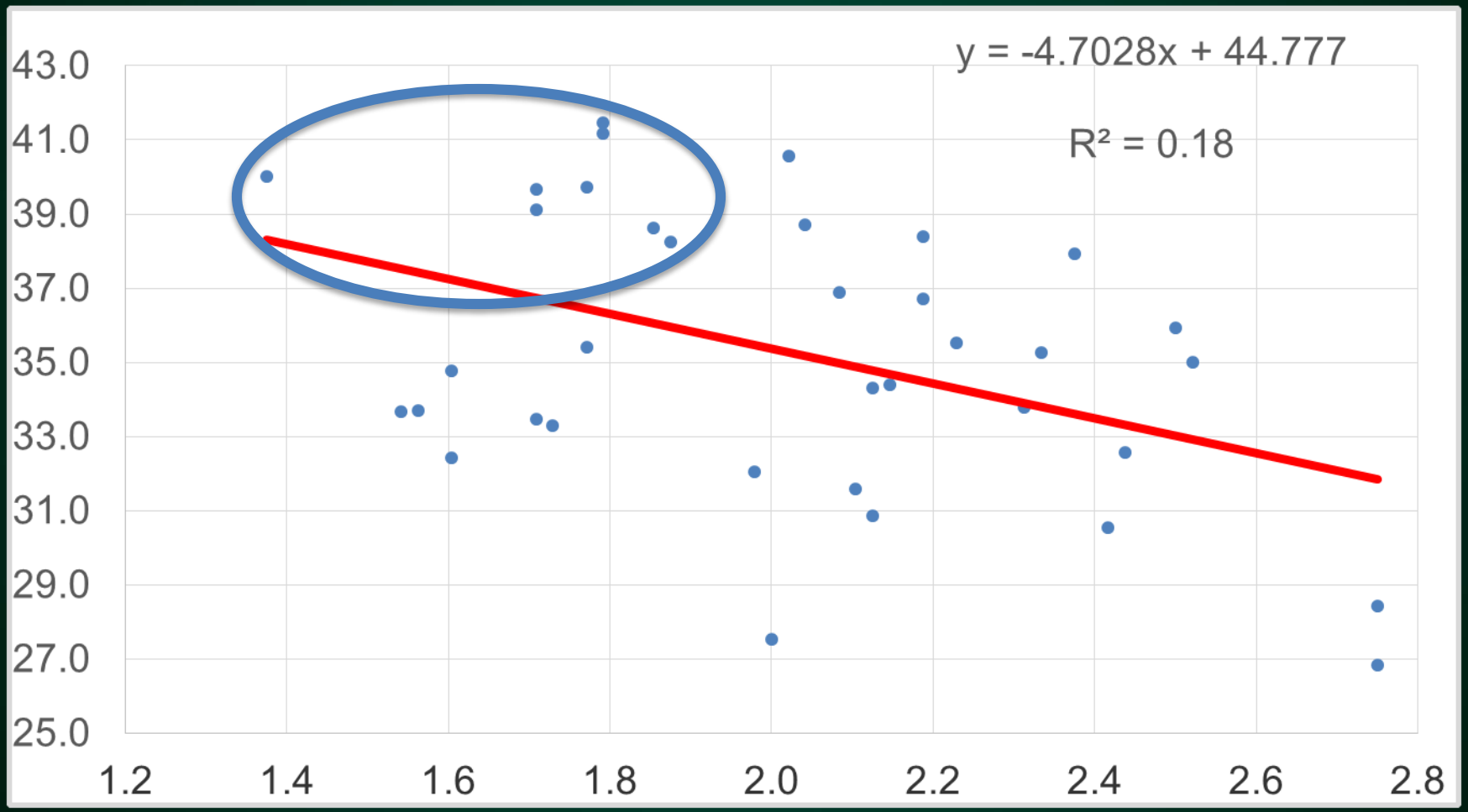
[1]IDC score was 1-5 scale with 1-green, 5-dead.

2016 IDC Yield

Table 5. 2016 NDSU Roundup Ready Soybean Iron-deficiency Chlorosis Yield Trial - Auth

Company/E	Variety	Maturity[1]	IDC Score[2]	2016 Seed Yield			
				Leonard	Colfax	Erie	3-site Avg.
		(date)	(1-5)	(bu/a)			
REA	R0815	9/21	1.7	61.0	85.3	67.8	71.4
Integra	20915N	9/23	1.9	52.4	90.4	69.1	70.6
Syng NK	NKS12-R3	9/24	1.5	55.0	90.3	64.8	70.0
Syng NK	NKS08-M2	9/19	1.7	65.5	84.5	59.3	69.7
Peterson	15R07N	9/19	1.7	56.0	85.1	63.5	68.2
Legend	11R760N	9/24	2.2	53.7	86.6	61.3	67.2
Integra	20775N	9/21	1.9	55.0	88.4	55.9	66.4
Legacy	0334	9/17	1.7	56.1	86.8	56.1	66.3

NDSU Previous year RR Soybean yield and IDC



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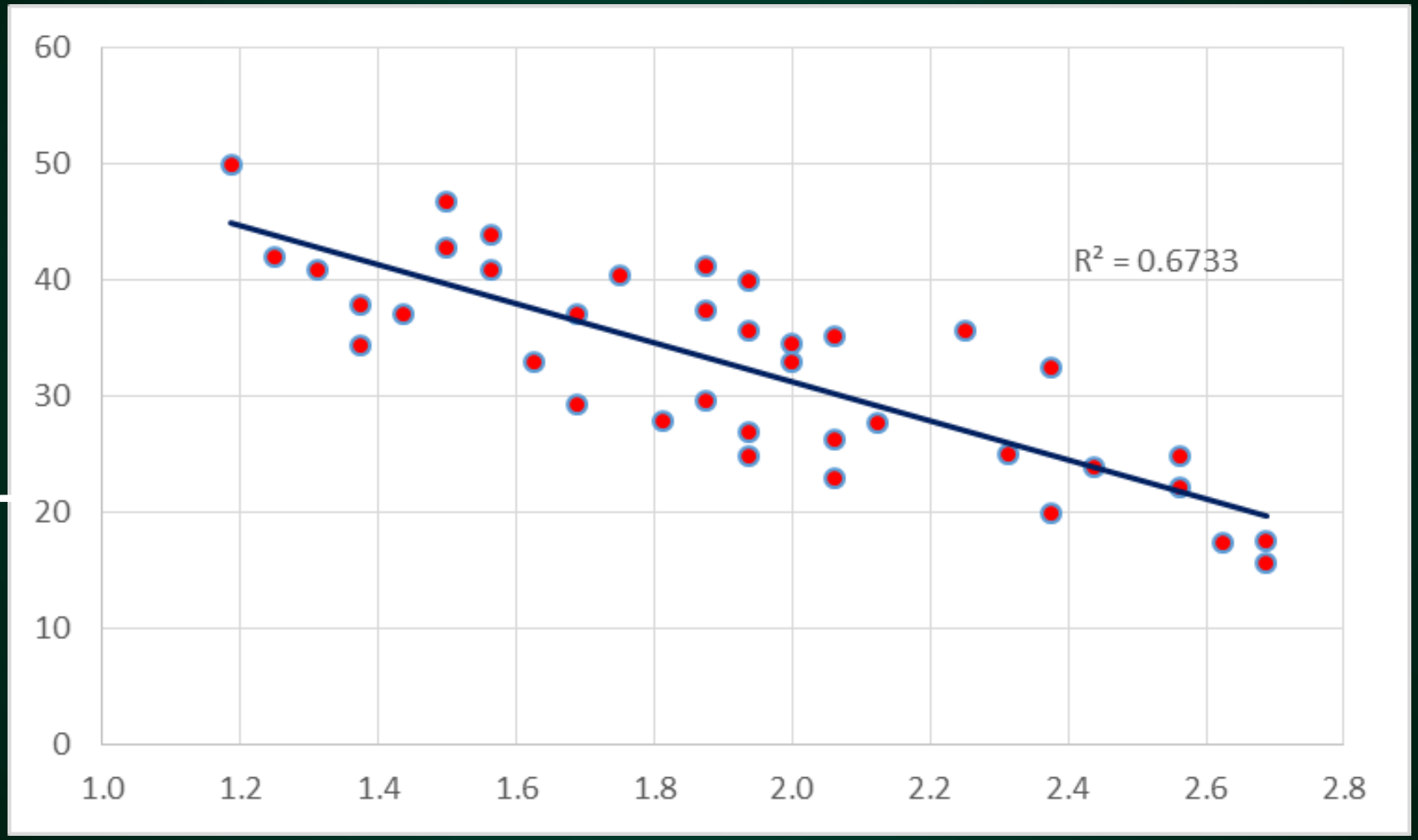
IDC and Yield NDSU Trial 2015



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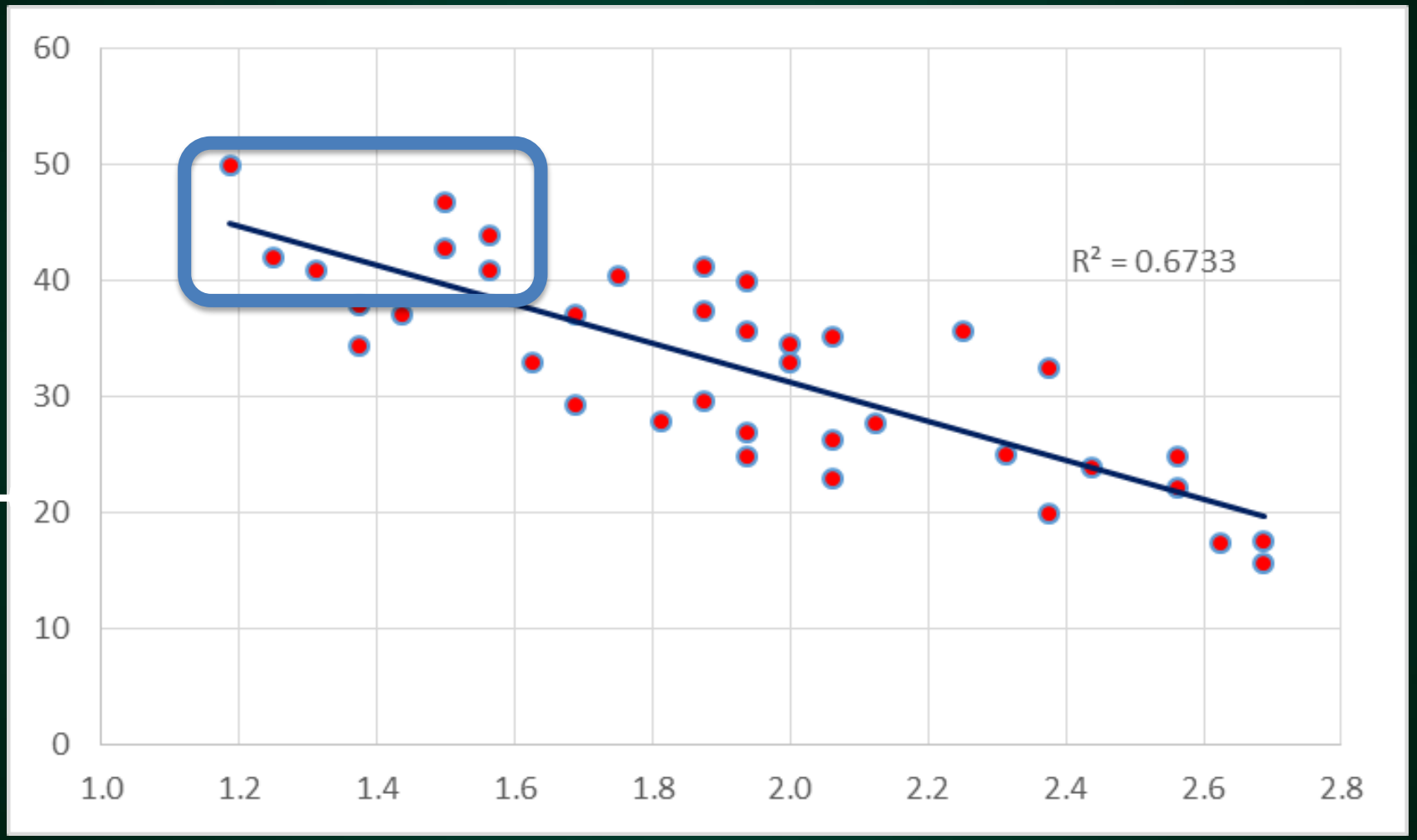
IDC: 1 green, 5 dead tissue

IDC and Yield NDSU Trial 2015



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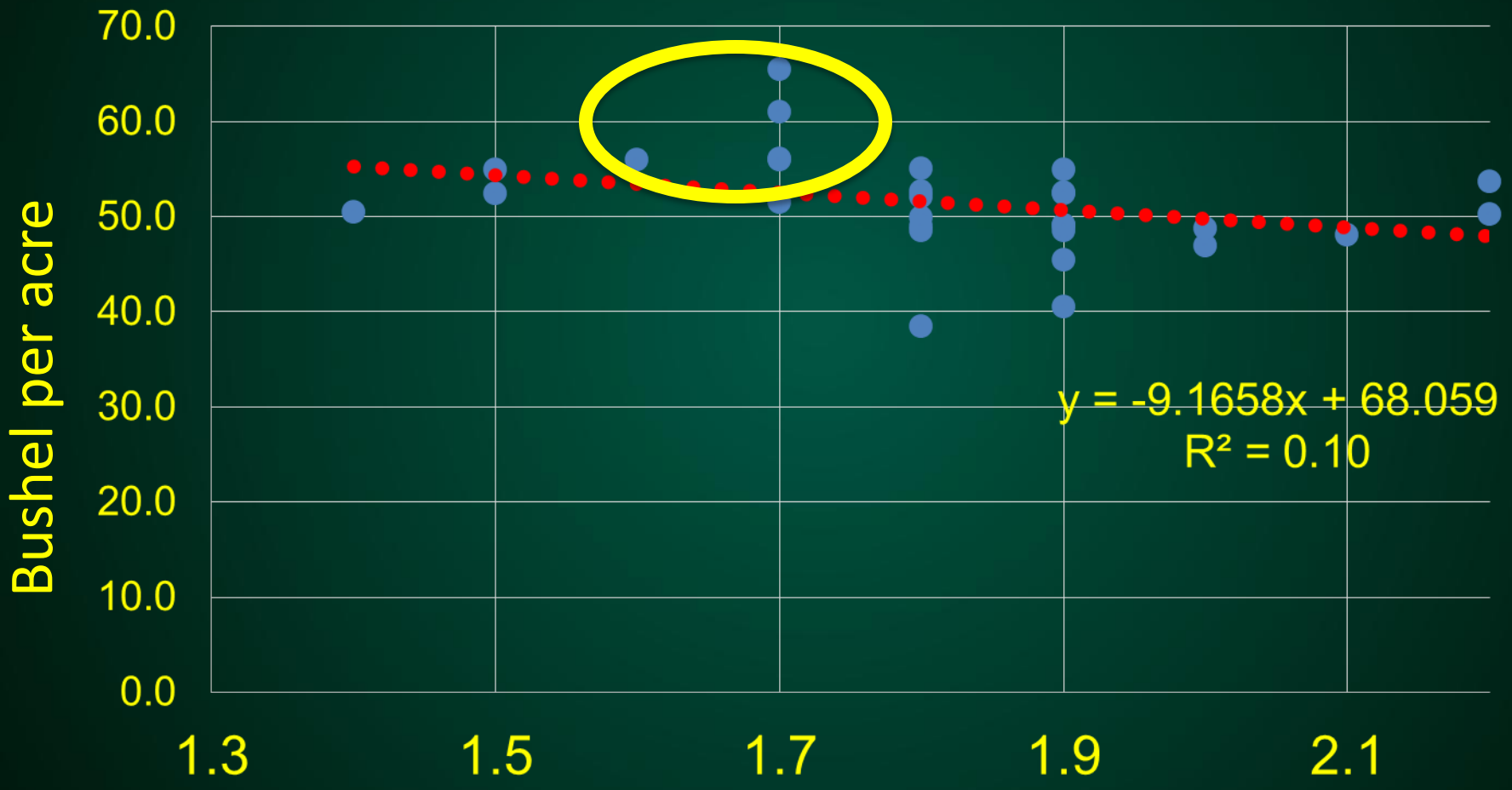
IDC: 1 green, 5 dead tissue

IDC rating and Yield Leonard 2016



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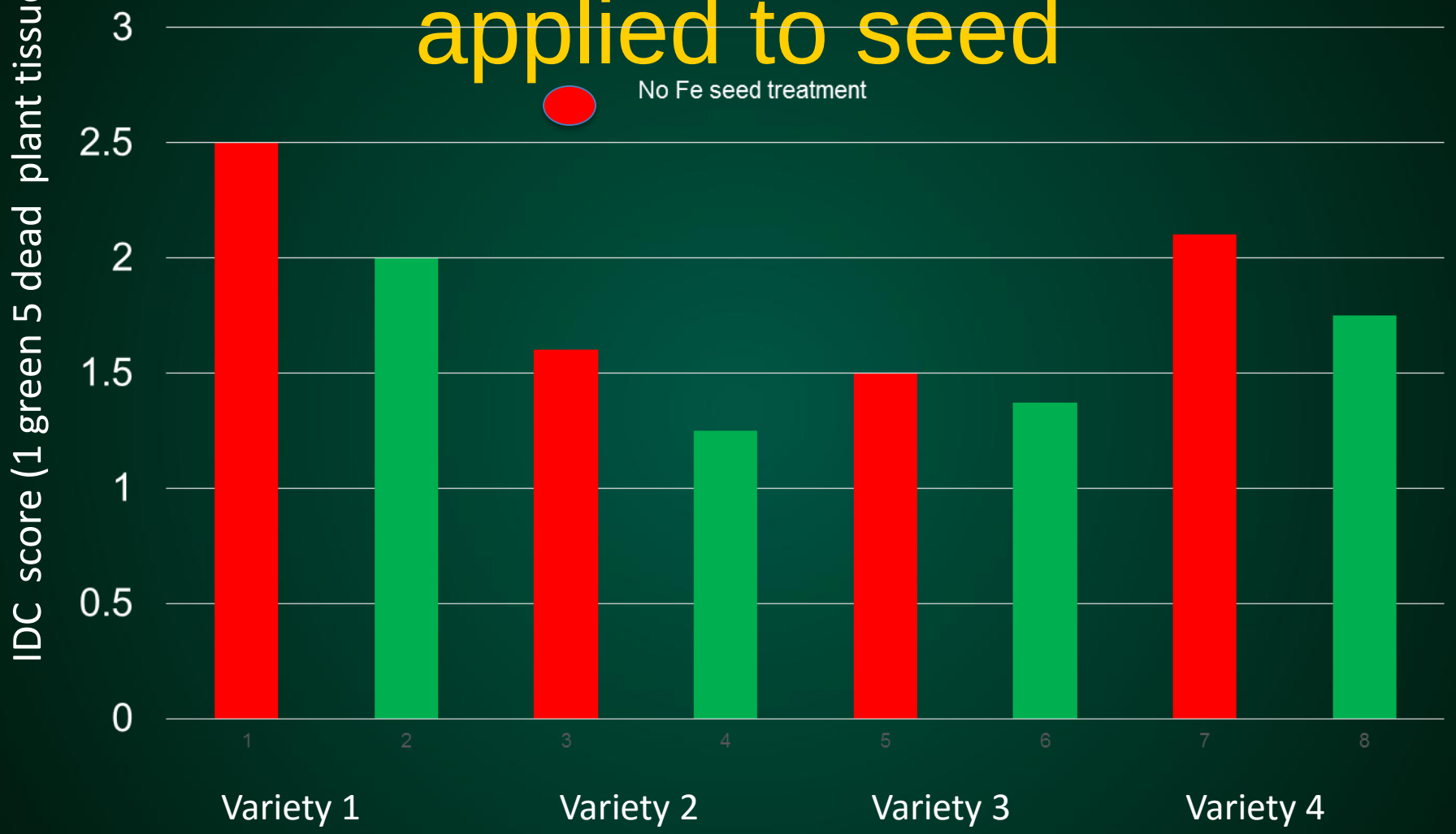
IDC 1 Green 5 dead tissue

Guidelines for Iron Chlorosis

- Select Varieties with high tolerance when:
  - pH above 8
  - Salts above 1 mmhos
  - Carbonates above 6-8%
    - Still a lot to learn about carbonates
  - Need to handle saturated soils
  - Disease resistance package

IDC score Fe chelate at 3 lb/a applied to seed



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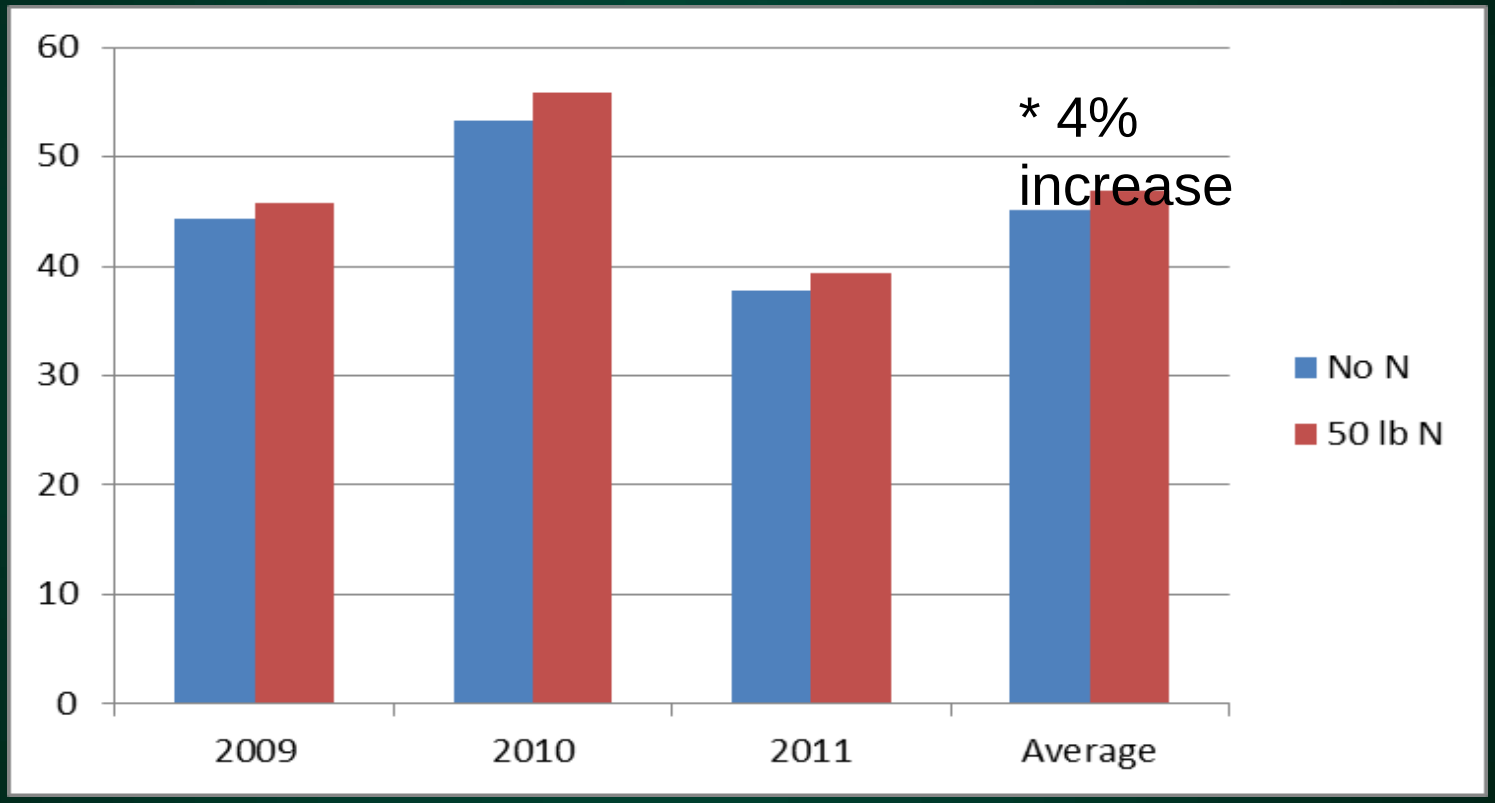
Data: Holmes , Arthur ND

Soybean and Nitrogen

- Nitrate may aggravate iron chlorosis
- Soybeans can fix their own Nitrogen
- If carryover of NO 3 -N from previous crops is high, the soybean uses the NO 3 -N from the soil. The partnership with the *Rhizobia* bacteria becomes less efficient.

Soybean Response to Nitrogen Inputs under Tile Drained Conditions

Soybean Yield With and Without N, 2009-2011



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Sources of N for a Soybean Crop

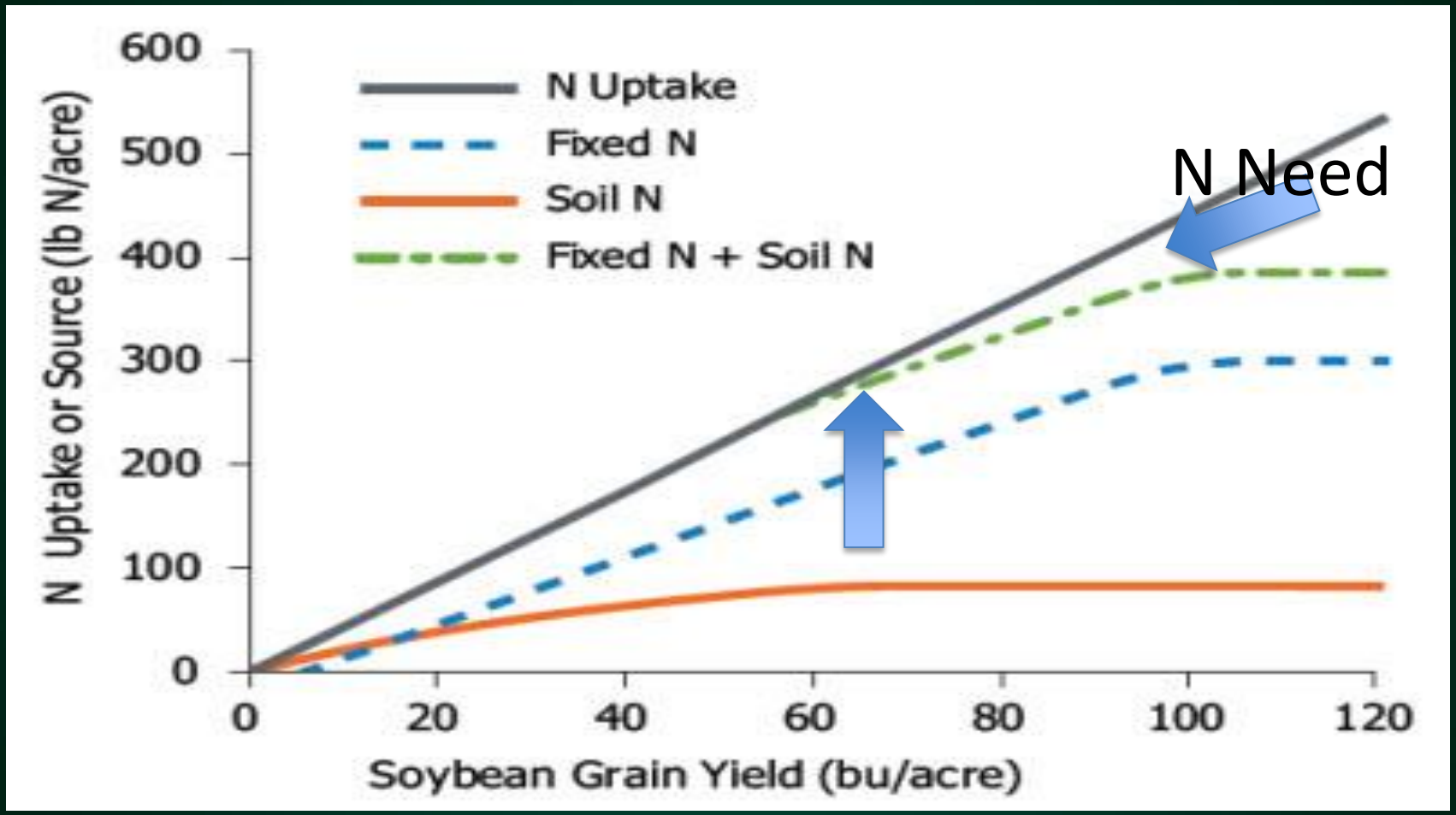

Figure 1. A generalized N budget for soybean. Adapted from Salvagiotti et al., 2008.

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Measurements taken

- Stand count
- Early and late vigor score
- IDC score
- Visual greenness score
- Plant height
- Yield

Soybean IDC 2013-2014 across varieties

N applied	IDC
Lbs/acre	(1-5) [1= green 5 = dead tissue]
0 (control)	2.1d
25-25(as urea) split	2.6b
50 (as urea)	2.8a
50 (as ESN)	2.3c
50 (as urea) at R2	2.1d
75 (as urea)	2.9a

Soybean IDC 2013-2014 across varieties

N applied	IDC
Lbs/acre	(1-5) [1= green 5 = dead tissue]
0 (control)	2.1d
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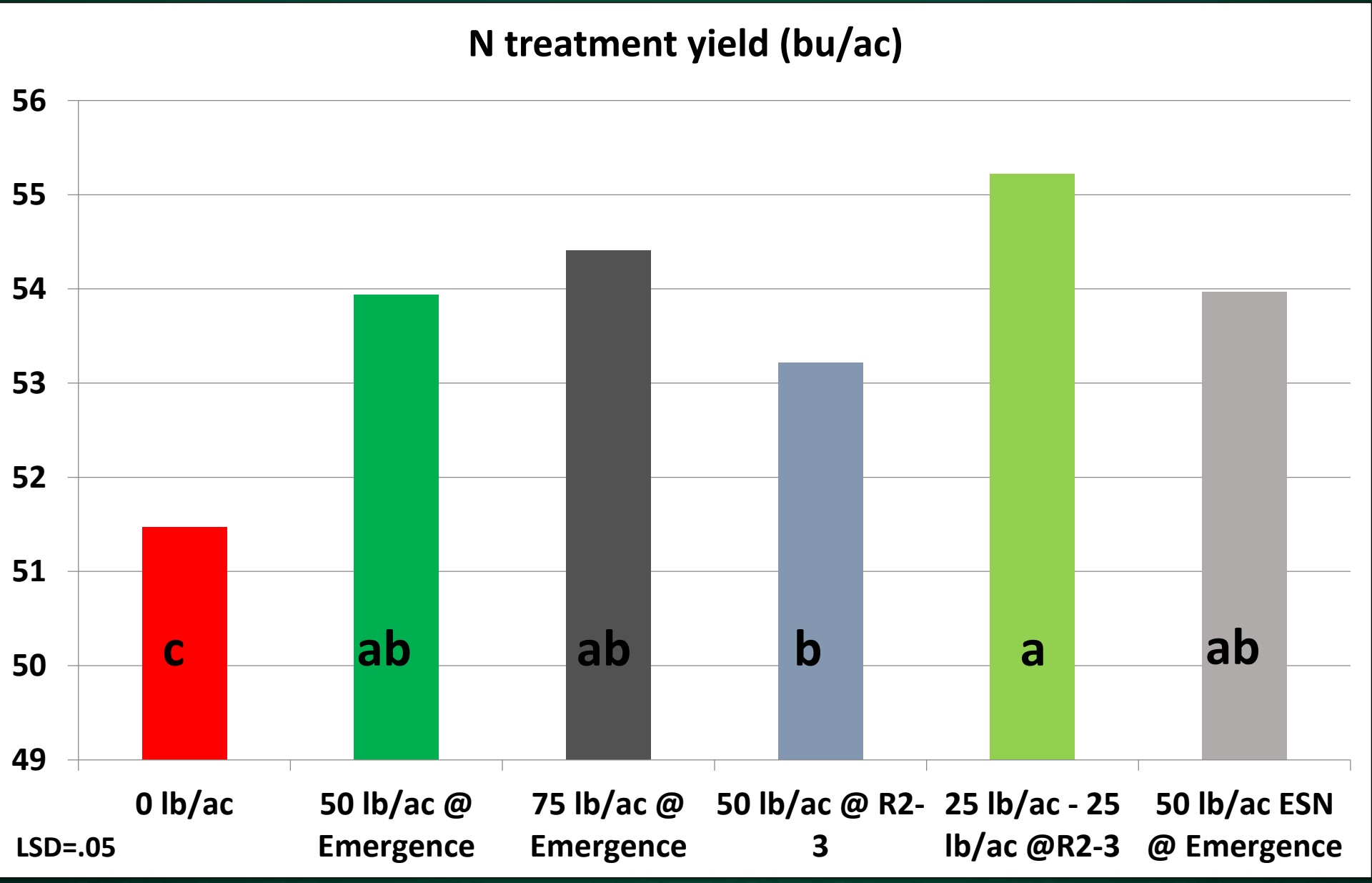
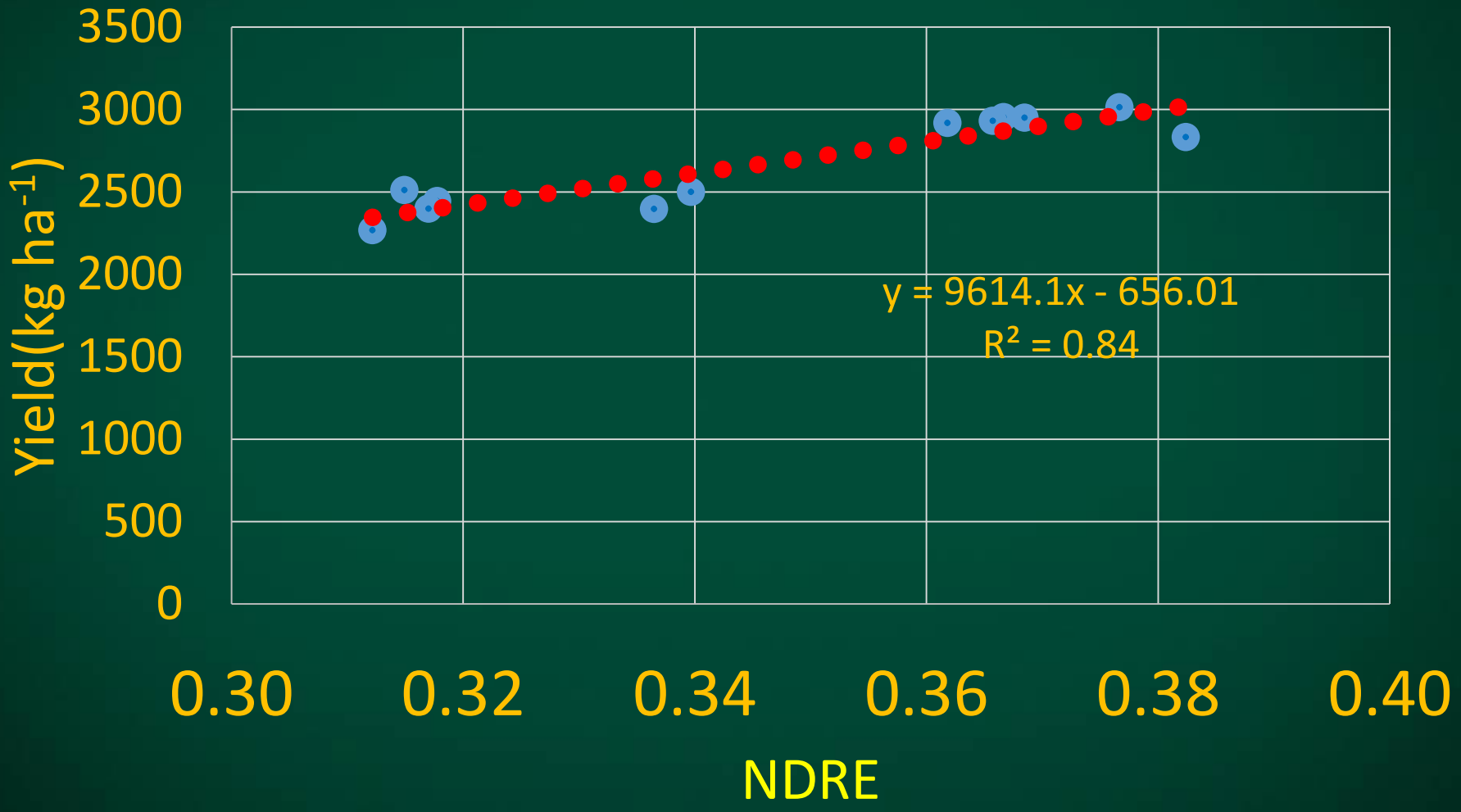
2014 NW22 soybean



OptRx active optical sensor

- This sensor operates similar to the greenseeker sensor but has three channels.
- The sensor emits light at three wavelengths: 670 and 730 nm in the visible band, and 780 nm in the near infra-red (NIR) band.
- Sensor has the ability to provide NDRE (Normalized Difference Vegetation Index Red Edge) values calculated as (NIR – Red edge)/ (NIR + Red edge).

Soybean greenness and yield across N treatments and varieties



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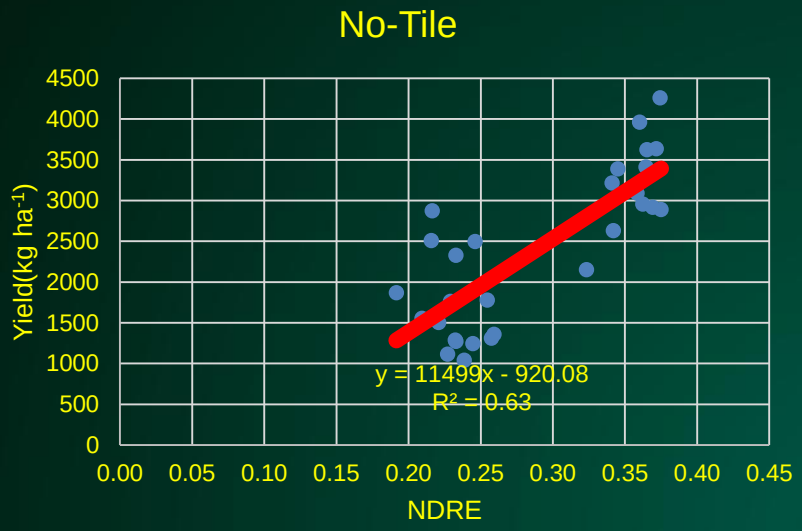
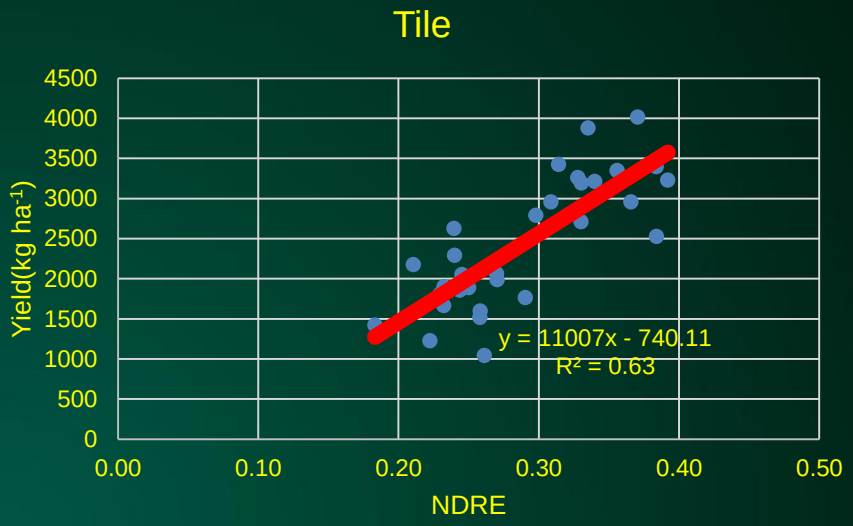
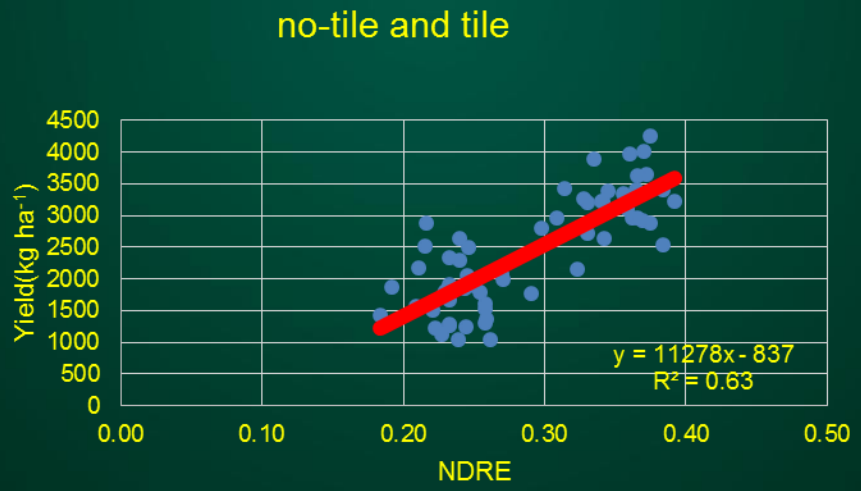
Variety-4







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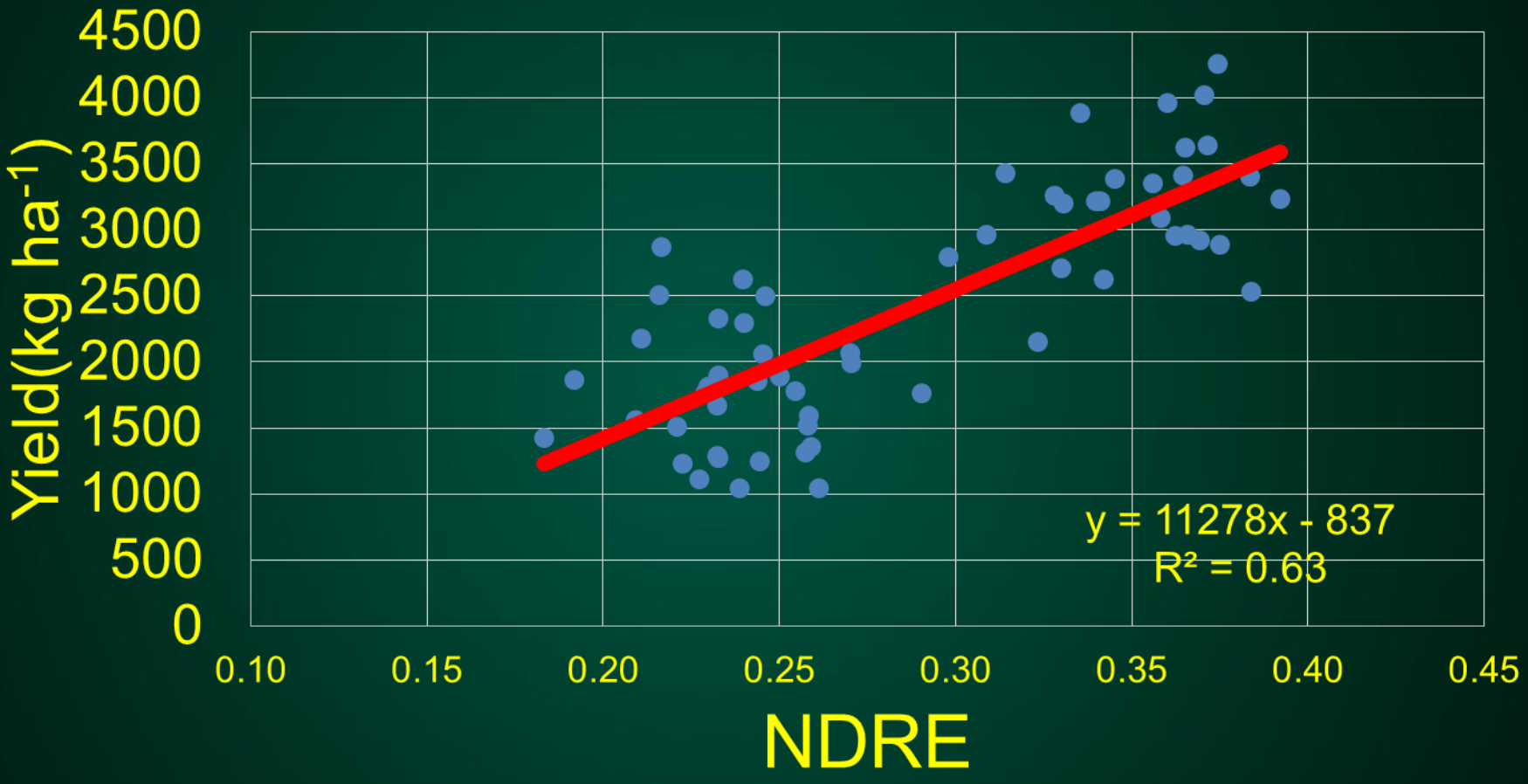
Variety-4 all data points



Soybean Yield 2013-2014 across varieties

N applied	Yield
Lbs/acre	Bu/acre
0 (control)	42.8b
25-25(as urea) split	45.3a
50 (as urea)	45.0a
50 (as ESN)	44.3a
50 (as urea) at R2	44.2a
75 (as urea)	45.2a

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Means in column with different letter are significantly different at P≤0.10.

Soybean Yield 2013-2014 across varieties

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Lbs/acre	Bu/acre
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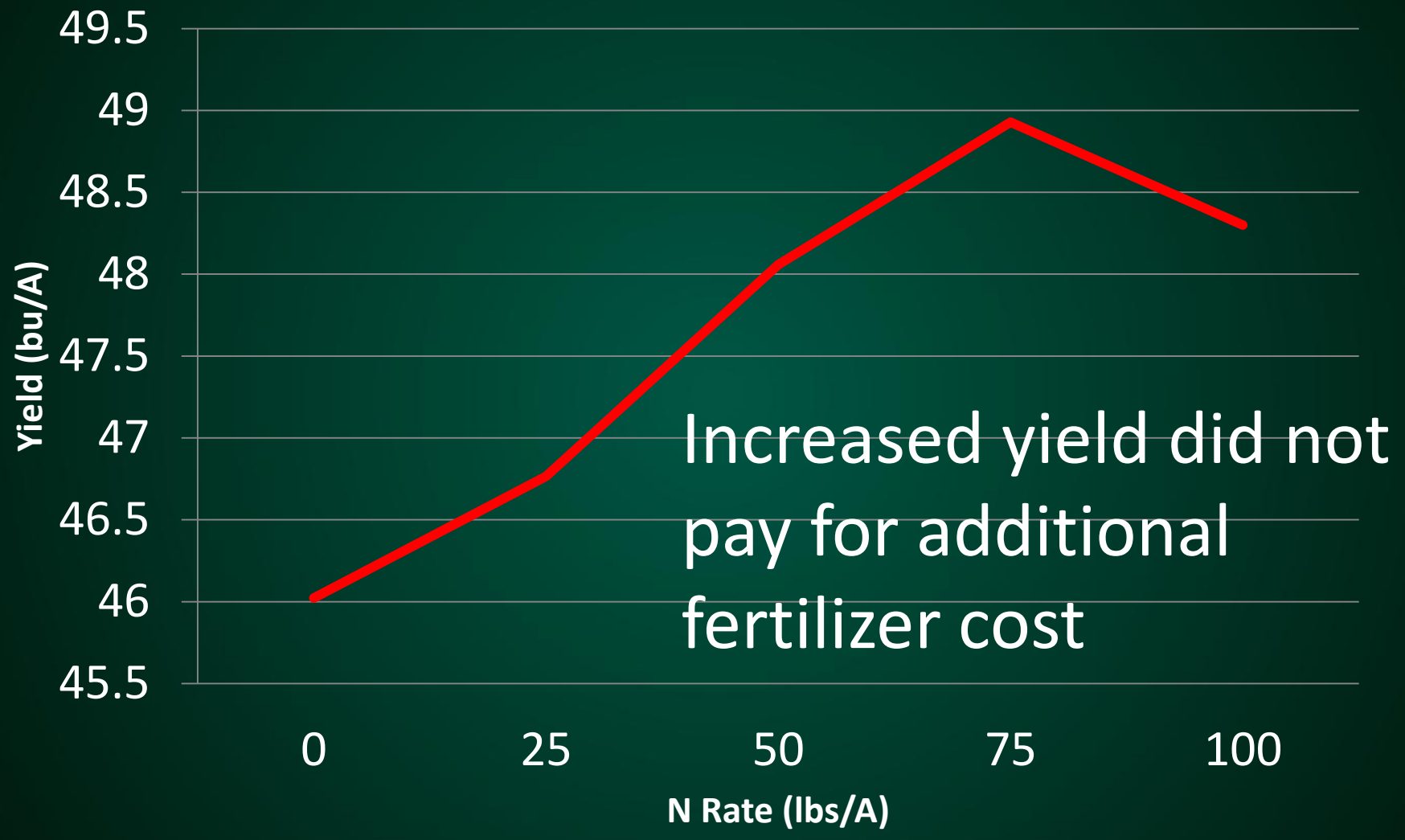
Means in column with different letter are significantly different at P≤0.10.

Soybean Yield over 5 N Rates, 2015



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N application and Nodulation, 2015

N (as Urea) In lb/acre	Nodules	Percent large nodules
0	41	45

N application and Nodulation, 2015

N (as Urea) In lb/acre	Nodules per root	Percent large nodules
0	41	45
25	30	15

N application and Nodulation, 2015

N (as Urea) In lb/acre	Nodules per root	Percent large nodules
0	41	45
25	30	15
50	26	8

N application and Nodulation, 2015

N (as Urea) In lb/acre	Nodules per root	Percent large nodules
0	41a	45a
25	30b	15b
50	26b	8b

N application and Nodulation, 2015

N (as Urea) In lb/acre	Nodules per root	Percent large nodules
0	41	45
25	30	15
50	26	8

N application and Nodulation, 2015

N (as Urea) In lb/acre	Nodules per root	Percent large nodules
0	41a	45a
25	30b	15b
50	26b	8b

Conclusions N application

- Fertilizer N application increased IDC.
- N application decreased nodulation

Conclusions N application

- Yields increased modestly 4% (2009-11) 5% (2013-2014) and 6% {with 75 lb N} in 2015.
- No N treatments provided a positive net return compared with the control.

Soybean Response to Nitrogen and Sulfur Fertilization

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Main N and S treatments

Table 4. Fertilizer treatments used in the factorial study.

Fertilizer	kg N ha^{-1}	kg S ha^{-1}
Check	0	0
Urea	28	0
Urea	56	0
Urea+gypsum	28	11.2
Urea+gypsum	28	22.4
Urea+gypsum	56	11.2
Urea+gypsum	56	22.4
Gypsum	0	11.2
Gypsum	0	22.4

Visual greenness score

- 1-5 scale
  - 1 = green

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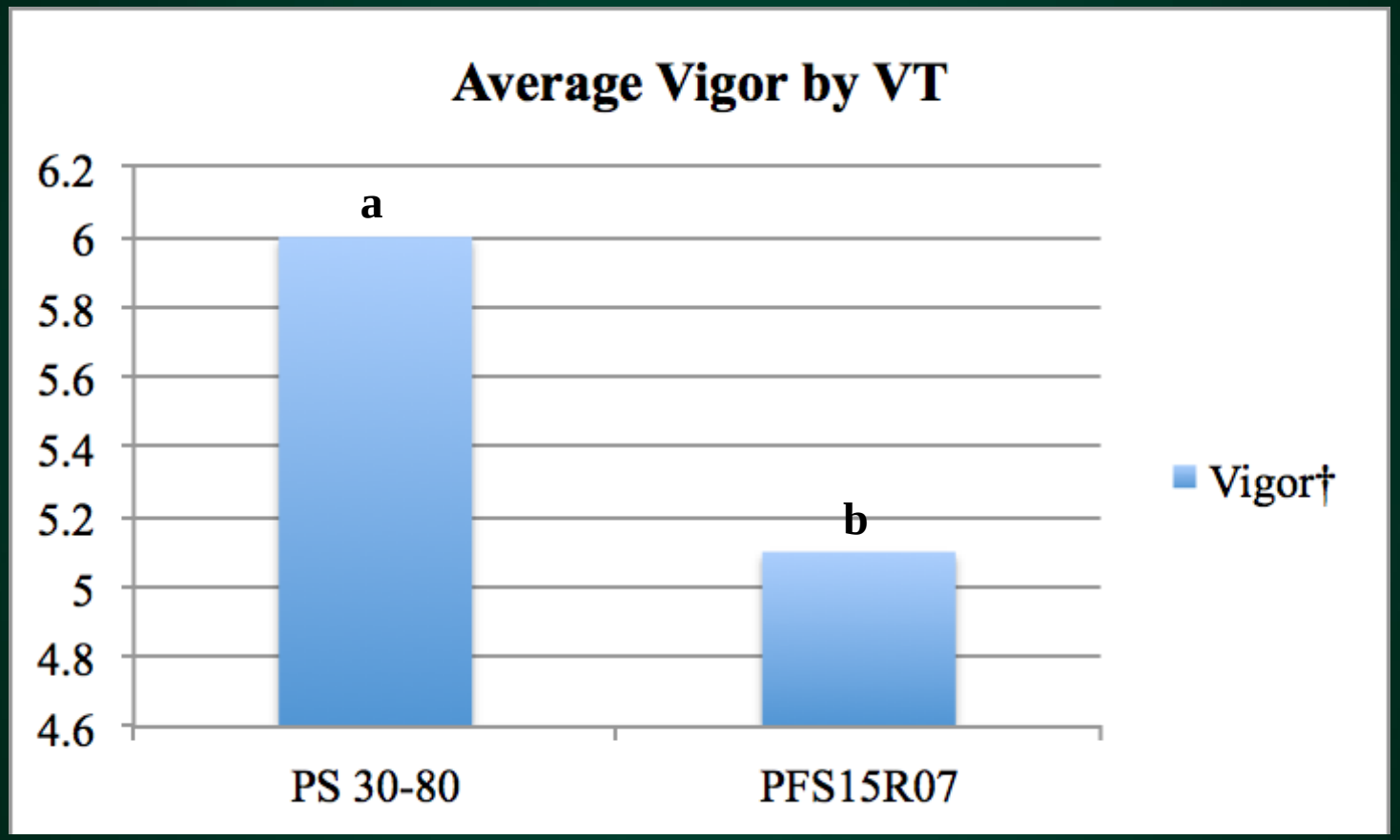
Vigor score between VTs



†Vigor was scored visually on a scale of 1-9 (9 = most vigorous)

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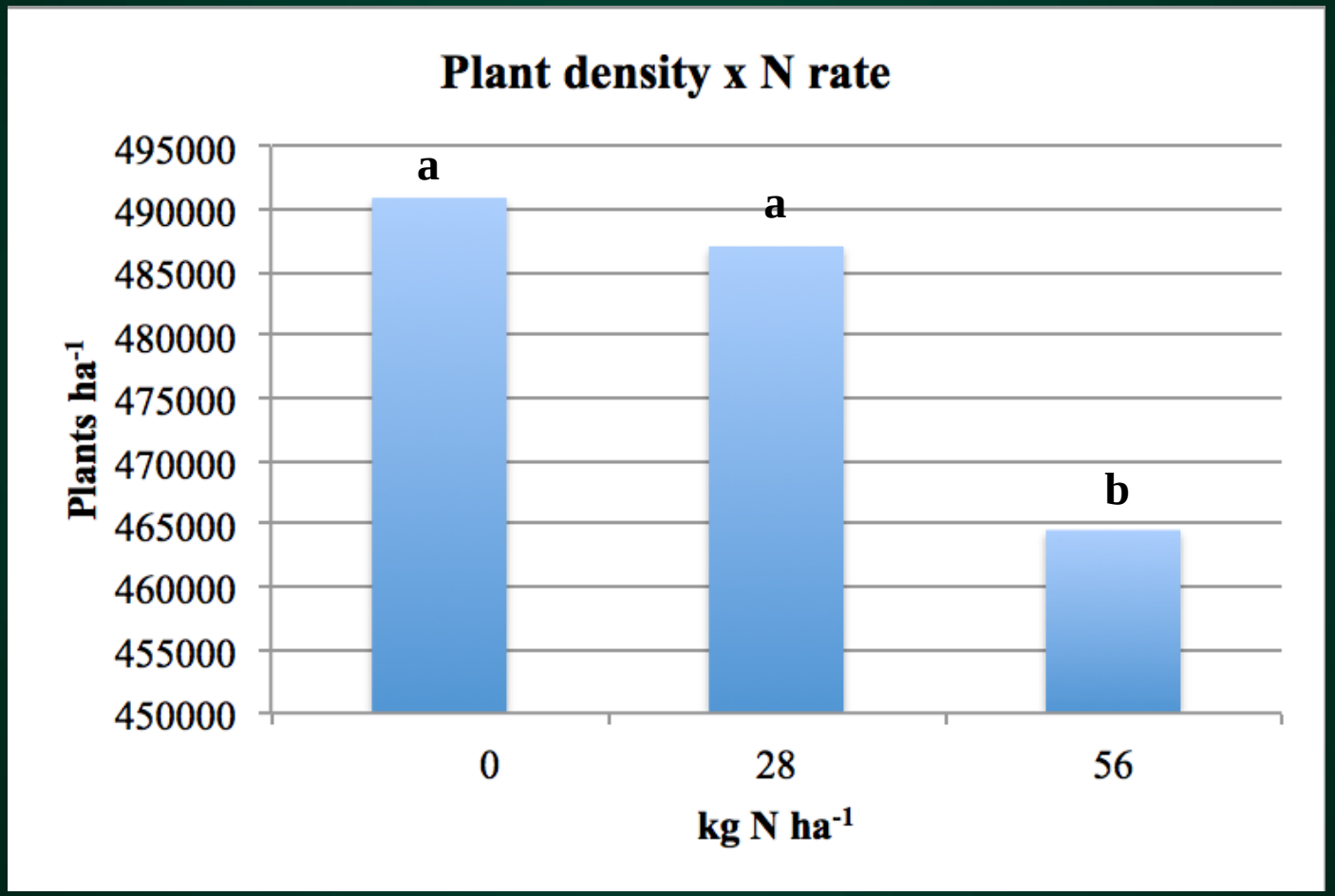
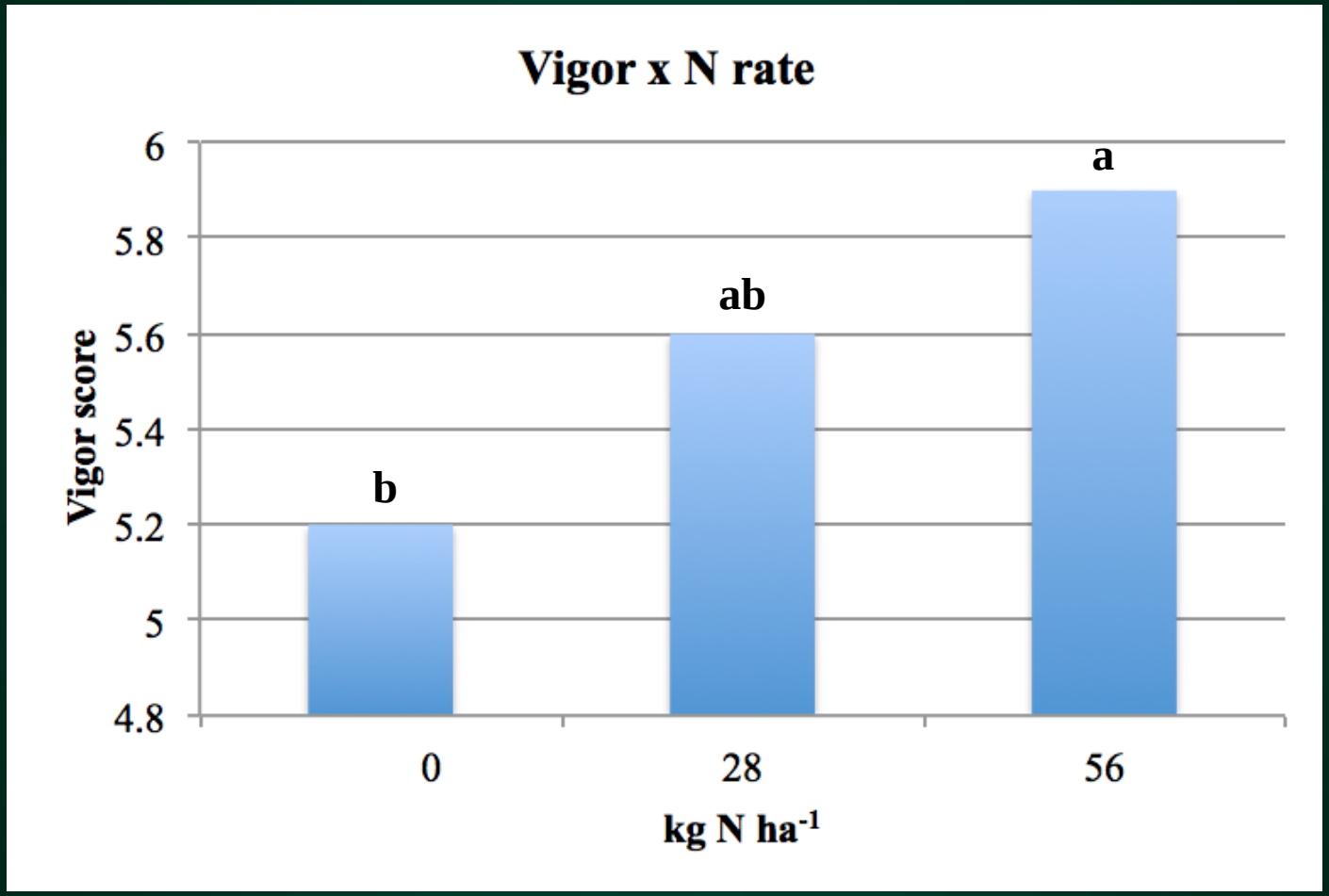
N effect on plant density

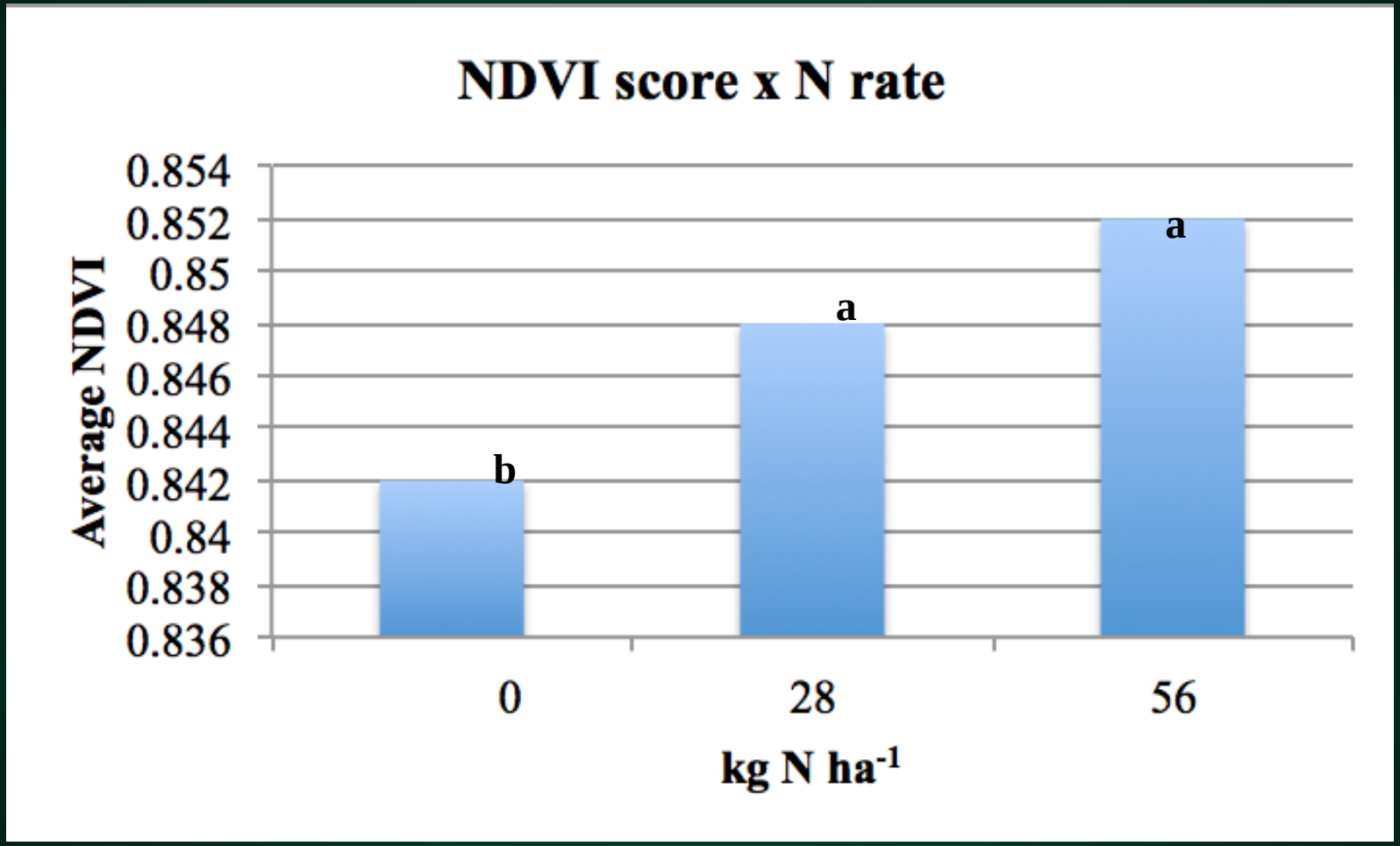


N effect on vigor score



†Vigor was scored visually on a scale of 1-9 (9 = most vigorous)

N effect on NDVI score



†NDVI obtained from the handheld GreenSeeker on scale of 0 – 0.99 (0.99 = most vigorous)

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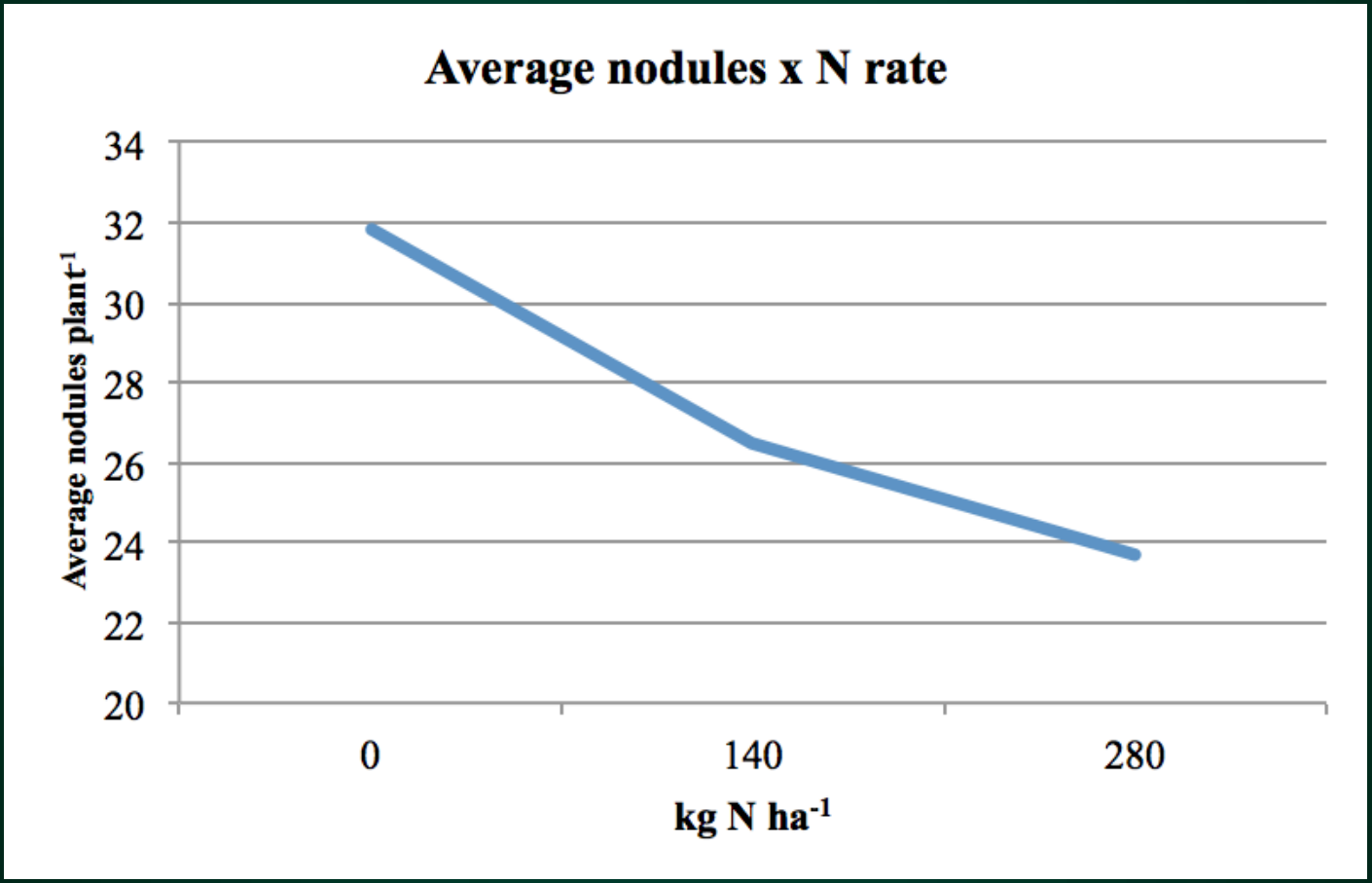
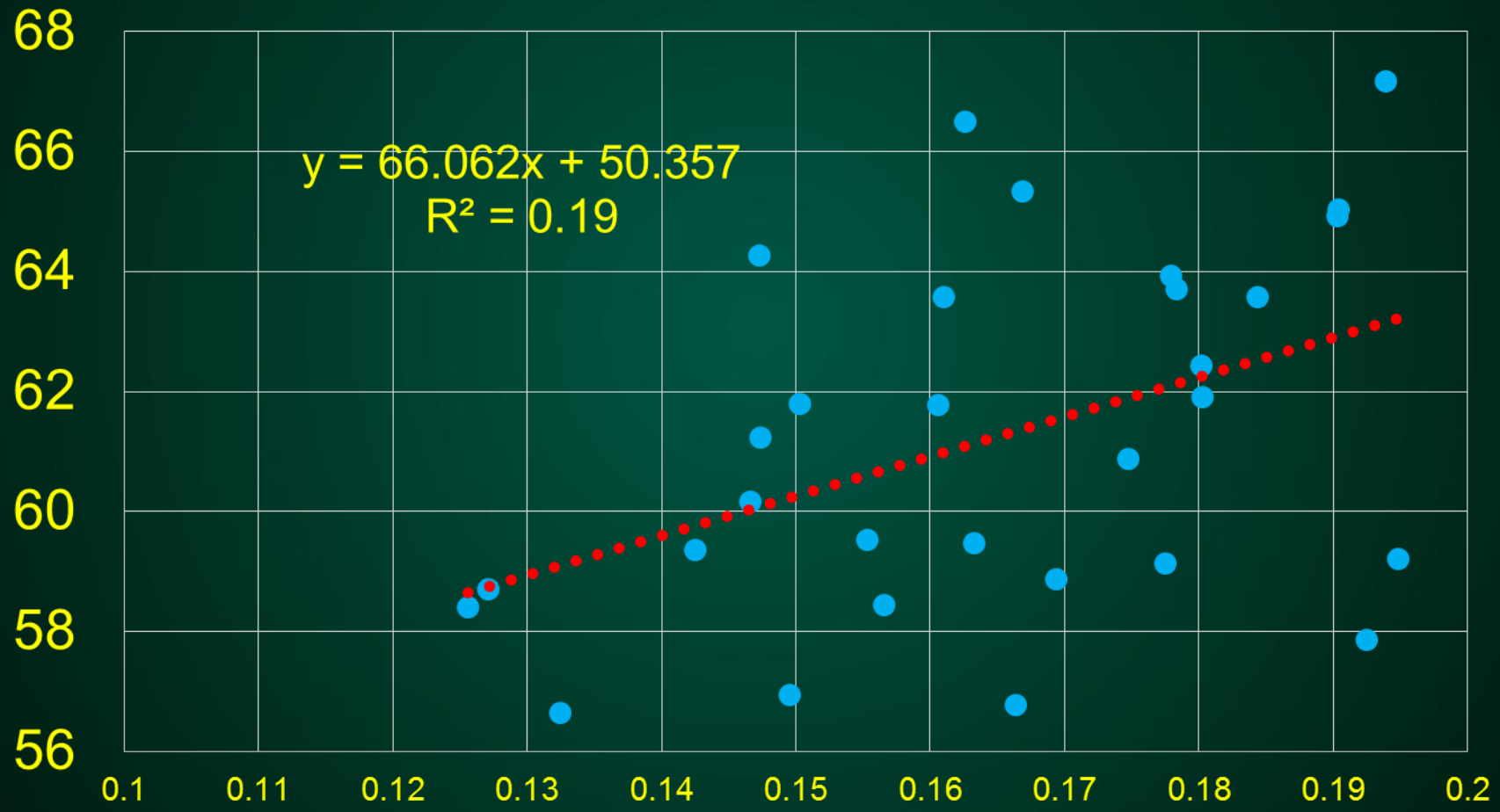
N effect on V4 average nodules



Summary

- Varieties
  - Differ in vigor
- Nitrogen
  - Decreased density
  - Increased vigor, G, NDVI, height, & yield
- N x S
  - Influenced visual greenness but not yield at ($p \leq 0.05$)

NDVI vs Yield Steele County Variety Trial



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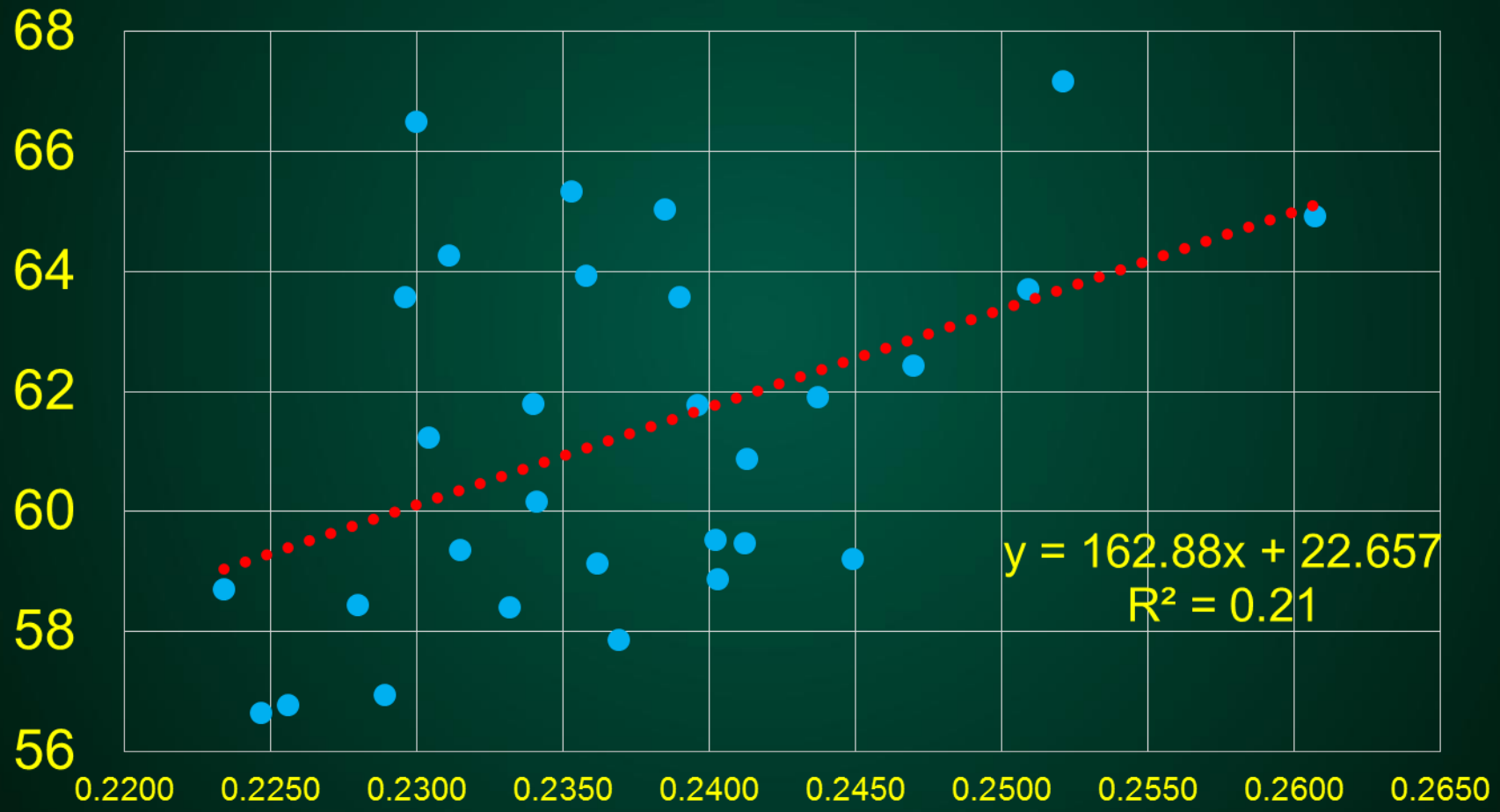
DGCI vs Yield Steele County Variety trial



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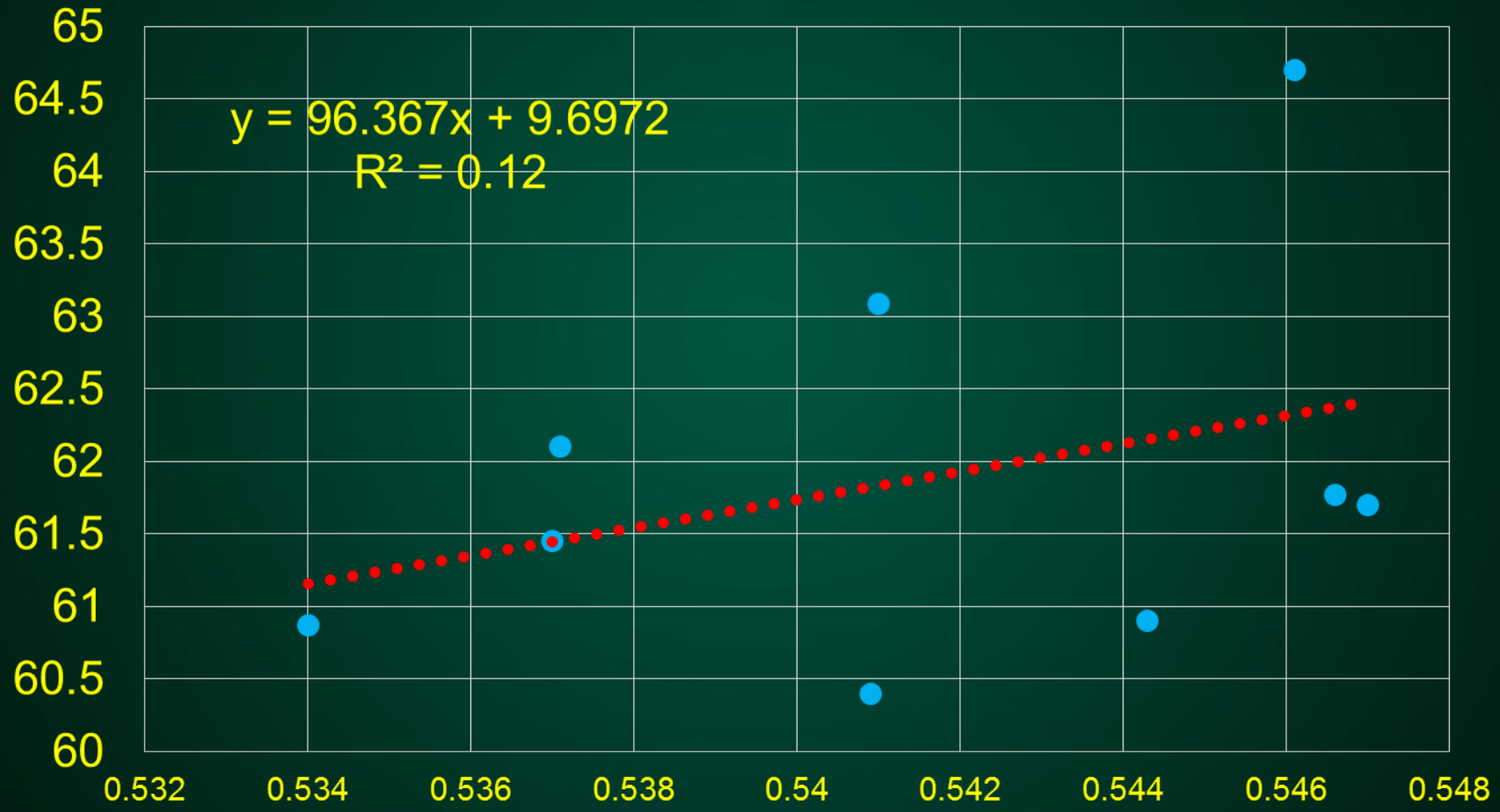
NDVI August and yield N x S across varieties



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