Breaking Yield Barriers

PIONEER agronomy

SOUTHEASTERN FIELD **AGRONOMY**

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Theoretical Yields

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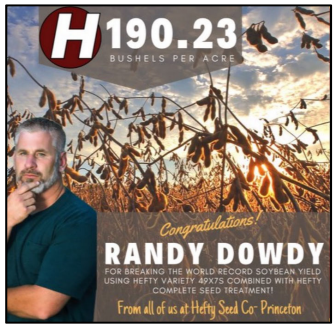
SOUTHEASTERN FIELD **AGRONOMY**

• Soybean

- ***335 bu (de Wit 1967)***

- ~~Max to date: 161 bu in 2010~~
  - ~~Pioneer 94M80~~
- ~~Max to date: 171 bu in 2016~~
  - ~~USG 74A74RS~~
- **Max to date: 190 bu in 2019**
  - **Hefty 49X7S**

- 57% of *attainable*
  (43% to go)



• Corn

- ***907 bu (Tollenaar 1985)***

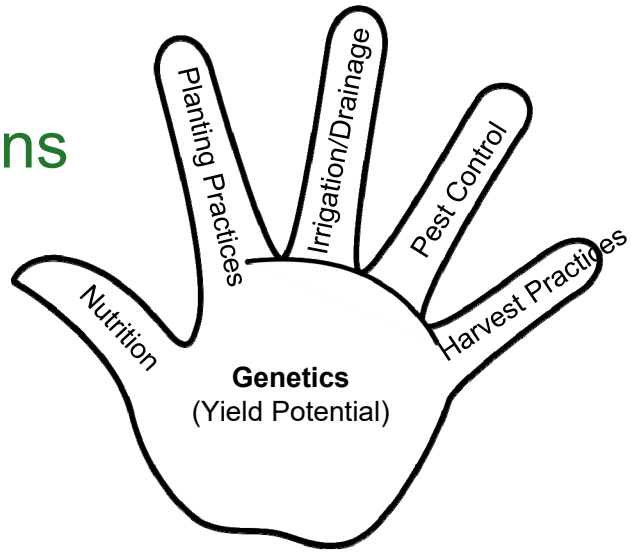
- ~~Max to date 455 bu in 2013~~
  - ~~Pioneer P2088YHR~~
- ~~Max to date 504 bu in 2014~~
  - ~~DeKalb DKC62-08~~
- ~~Max to date 532 bu in 2016~~
  - ~~Pioneer P1197YHR~~
- ~~Max to date 542 bu in 2017~~
  - ~~Pioneer P1197YHR~~
- **Max to date 616 bu in 2019**
  - **Pioneer P1197YHR**

- 68% of *attainable*
  (32% to go)


David Hula, of Charles City, Virginia, set his fourth world record with an irrigated corn yield of 616 bpa in the NCGA's 2019 National Corn Yield Contest. (DTN/Progressive Farmer file photo by Jim Patrico)

Realizing Yield Potential

- Management Focus Areas
  - *Genetics*
  - **Soil Fertility/Fertilizer**
  - Planting Practices/Conditions
  - Water Management
  - Pest Control
  - Harvest Practices



Current Process

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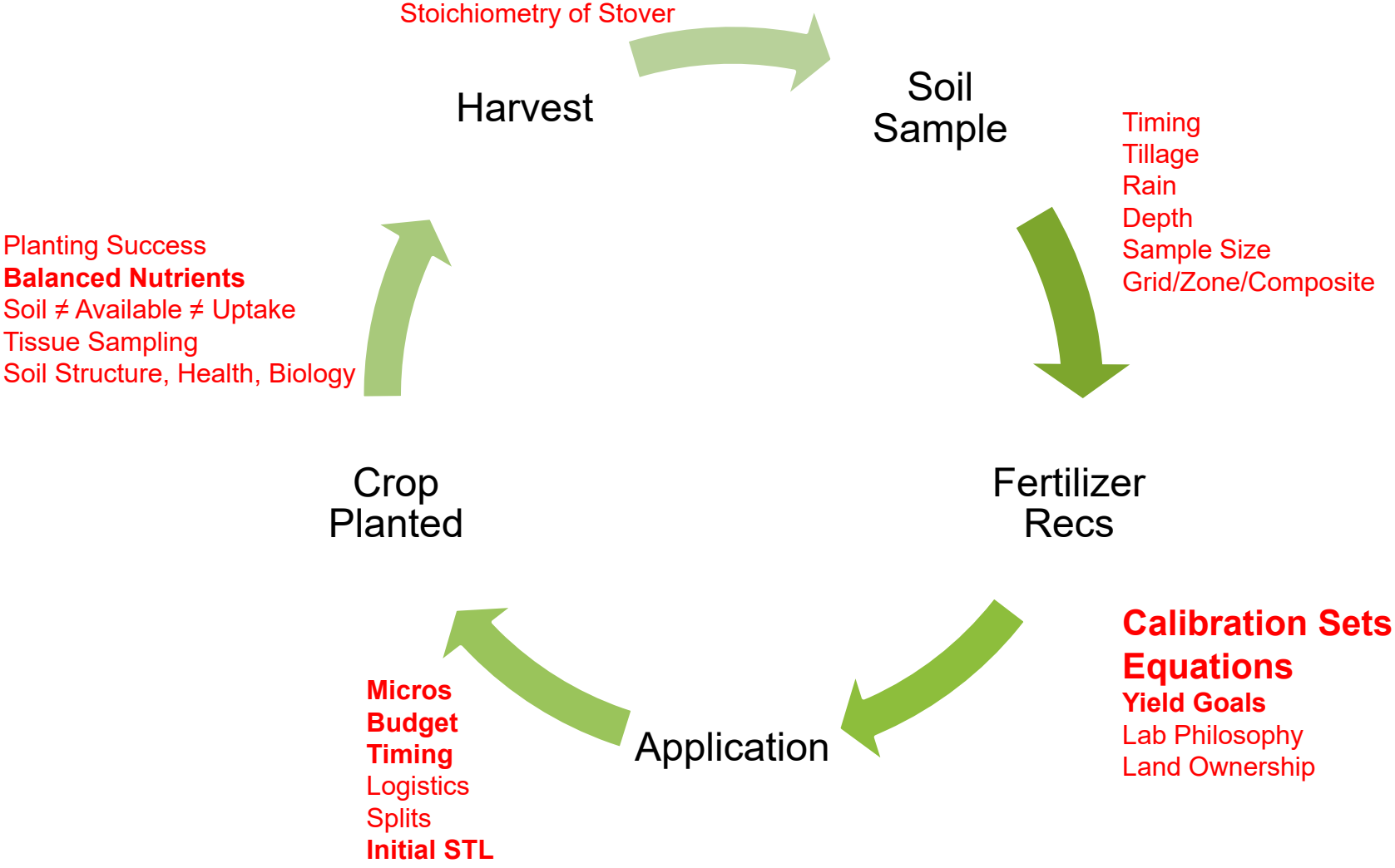
SOUTHEASTERN FIELD **AGRONOMY**



CALIBRATION PLOTS

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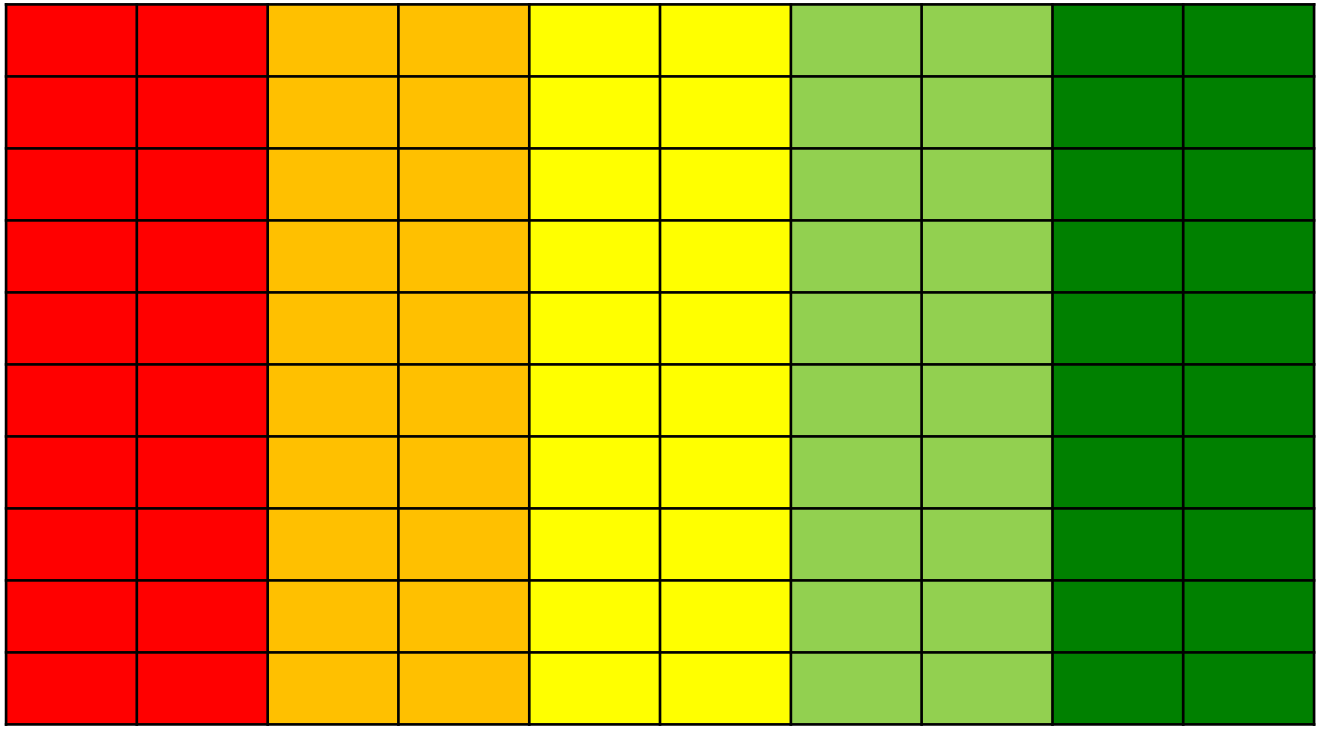
SOUTHEASTERN FIELD **AGRONOMY**



Field 1: Red=VL, Orange=L, Yellow=O, LtGrn=H, DkGrn=VH

CALIBRATION PLOTS

PIONEER agronomy

SOUTHEASTERN FIELD AGRONOMY

40	80	40	0	40	0	40	0	40	0
20	0	20	80	20	80	20	80	20	80
60	60	80	60	80	60	80	60	80	60
0	20	60	40	60	40	60	40	60	40
40	80	0	20	0	20	0	20	0	20
40	0	40	80	40	0	40	0	40	0
20	80	20	0	20	80	20	80	20	80
80	60	60	60	80	60	80	60	80	60
60	40	0	20	60	40	60	40	60	40
0	20	40	80	0	20	0	20	0	20

Field 1: Red=VL, Orange=L, Yellow=O, LtGrn=H, DkGrn=VH

Fertilizer applied in increments (0,20,40,60,80#)

CALIBRATION PLOTS

PIONEER agronomy

SOUTHEASTERN FIELD **AGRONOMY**

40	**80**	**40**	**0**	**40**	0	40	0	40	0
20	**0**	**20**	80	**20**	80	**20**	80	20	80
60	**60**	80	**60**	80	60	80	60	80	60
0	**20**	**60**	**40**	60	**40**	60	40	60	40
40	**80**	**0**	**20**	0	20	0	20	0	20
40	**0**	**40**	80	**40**	0	40	0	40	0
20	**80**	**20**	**0**	**20**	80	**20**	80	20	80
80	**60**	60	**60**	80	60	80	60	80	60
60	**40**	**0**	**20**	60	**40**	60	40	60	40
0	**20**	**40**	80	0	**20**	0	**20**	0	20

Field 1: Bold Values Now Indicates Yield Response

Frequency and *Magnitude* decrease at higher soil test levels.

CALIBRATION PLOTS

PIONEER agronomy

SOUTHEASTERN FIELD **AGRONOMY**

40	80	40					0		0
20		20		20		20			
60	60		60		60				
	20	60	40		40				
40	80		20	0		0		0	20
40	0	40		40			0		0
20	80	20	0	20		20			
80	60		60		60				
60	40	0	20		40				
	20	40		0	20	0	20	0	20

This is done over years and across geographies and yield levels.

Field 1: Remaining Font Indicates Economical Response

CALIBRATION PLOTS

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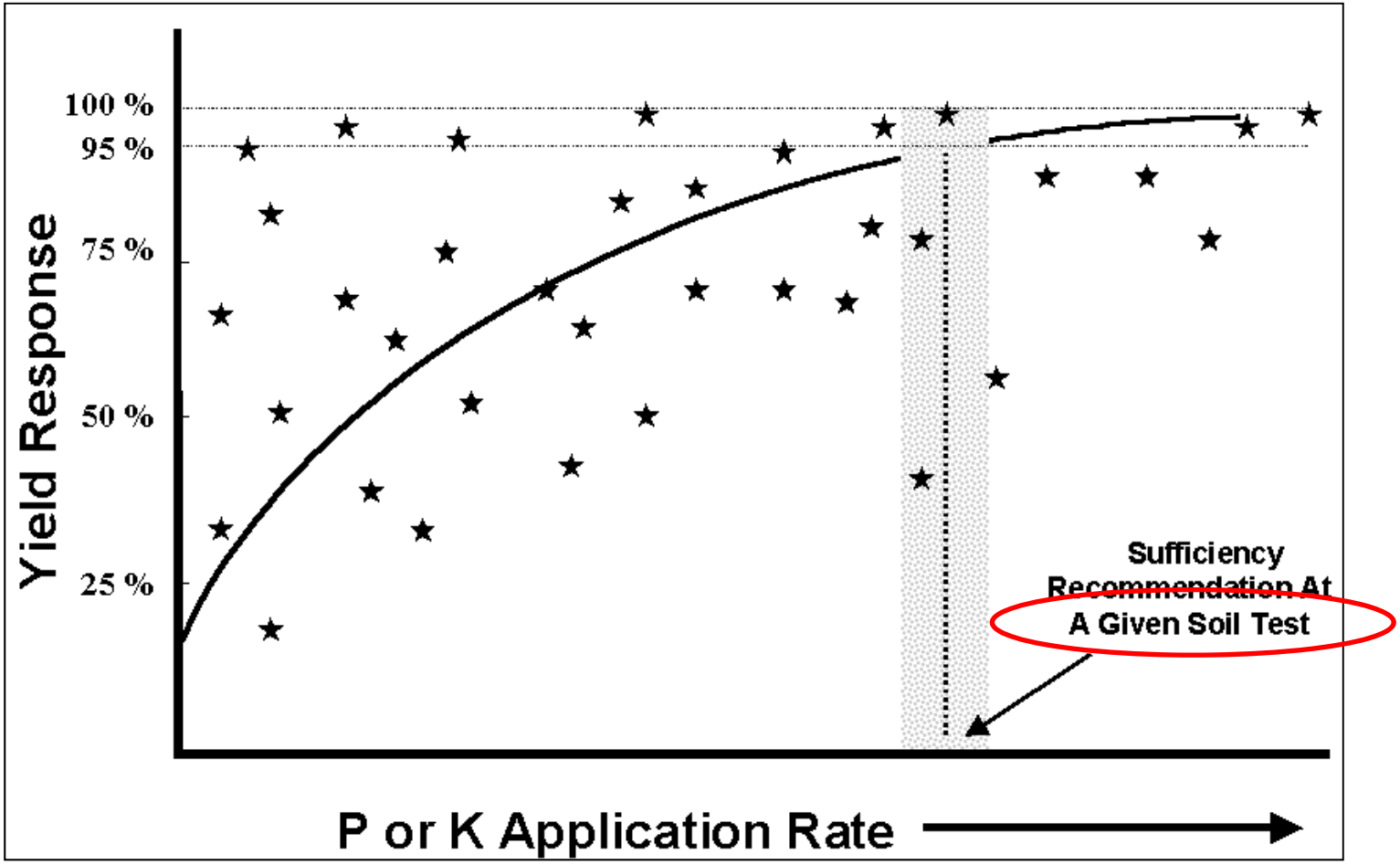
SOUTHEASTERN FIELD **AGRONOMY**



Soil Test Interpretation Categories

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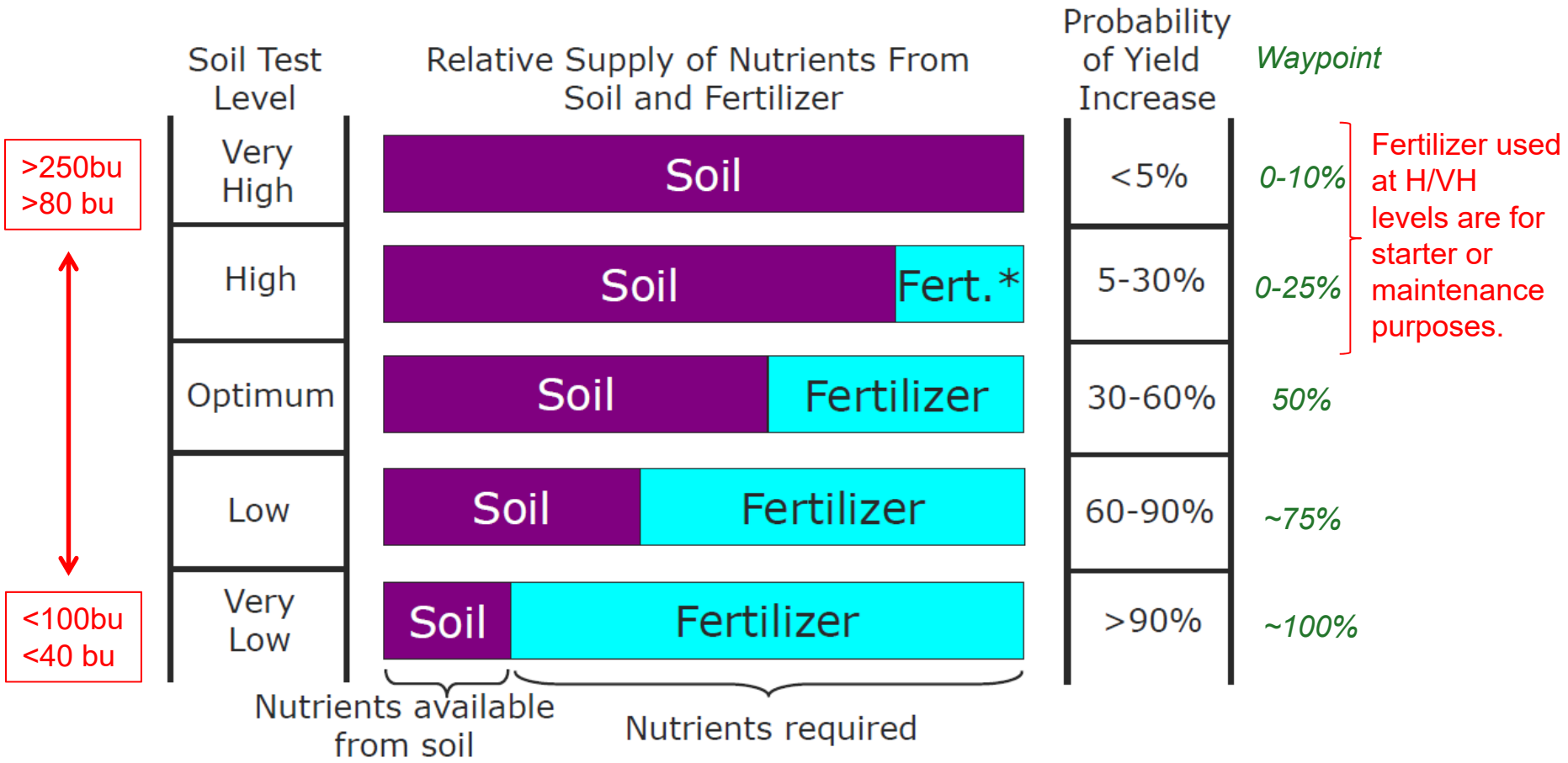
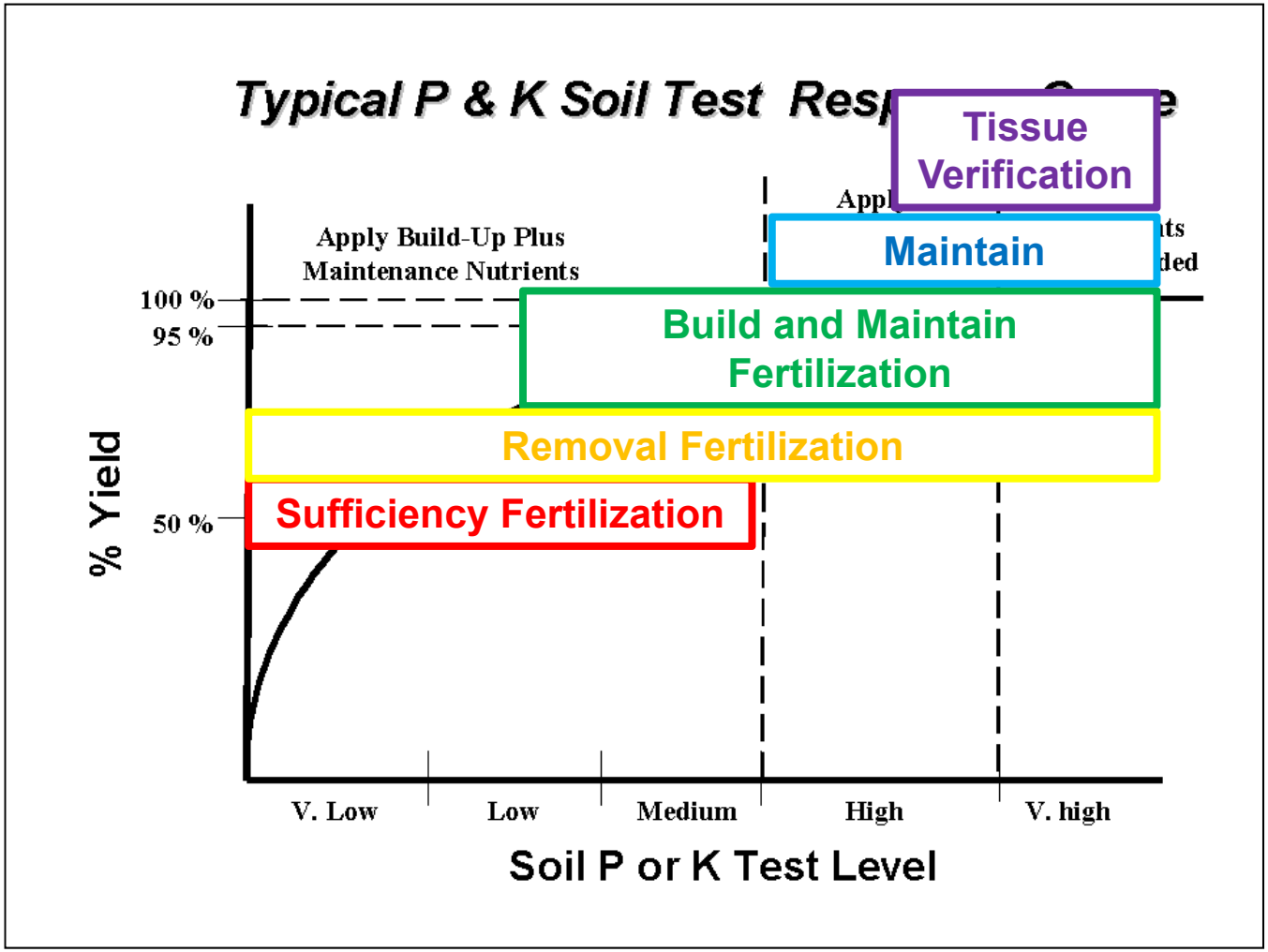
SOUTHEASTERN FIELD AGRONOMY



Courtesy of C. Laboski, UW

Fertilizer Philosophies

SOUTHEASTERN FIELD **AGRONOMY**



<100bu
<40 bu

>250bu
>80 bu

A few issues

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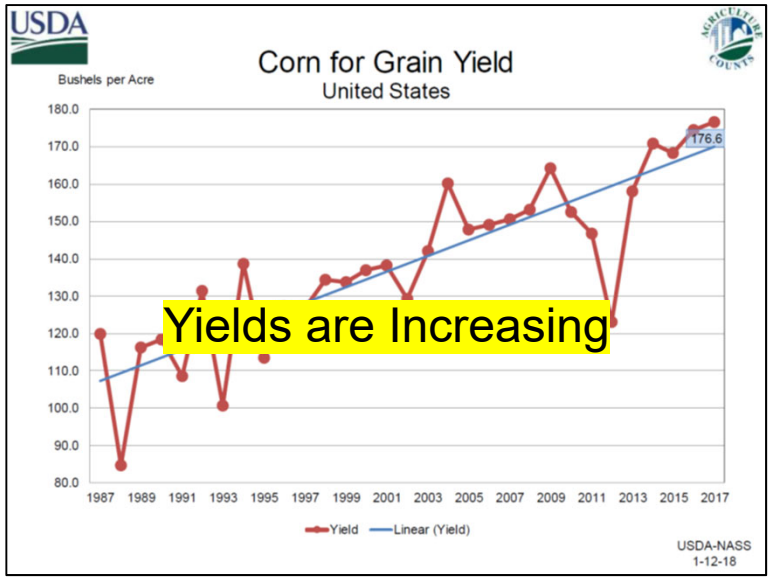
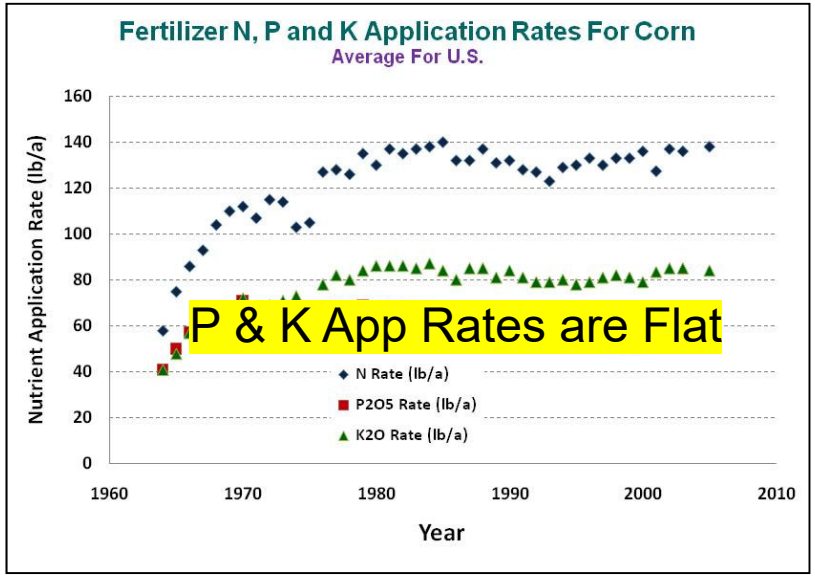
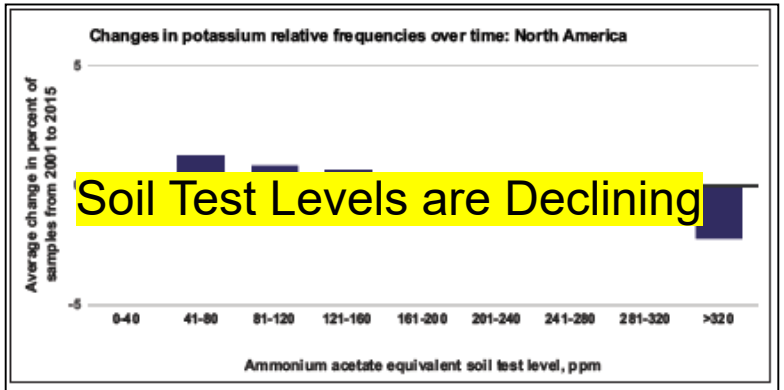
SOUTHEASTERN FIELD **AGRONOMY**



Yields are Increasing

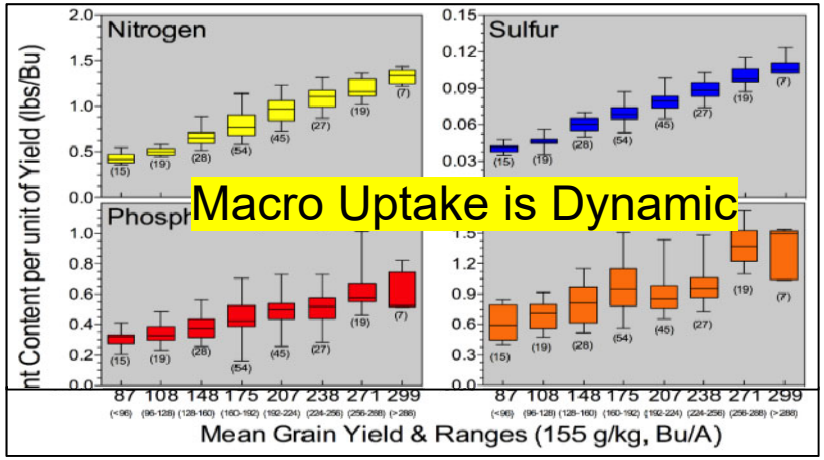


P & K App Rates are Flat



Soil Test Levels are Declining

Figure 15. Average change in ammonium acetate equivalent K soil test levels for North America from 2001-2015.



Macro Uptake is Dynamic

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From Point A to Point B

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SOUTHEASTERN FIELD **AGRONOMY**

'Modern' waypoints on the path from

*200 to **300 bushel** corn*

or

*60 to **100 bushel** soybeans*

High Yield Characterization: AI and Soil Test Values

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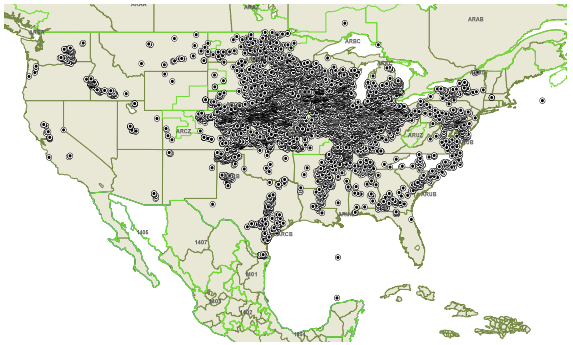
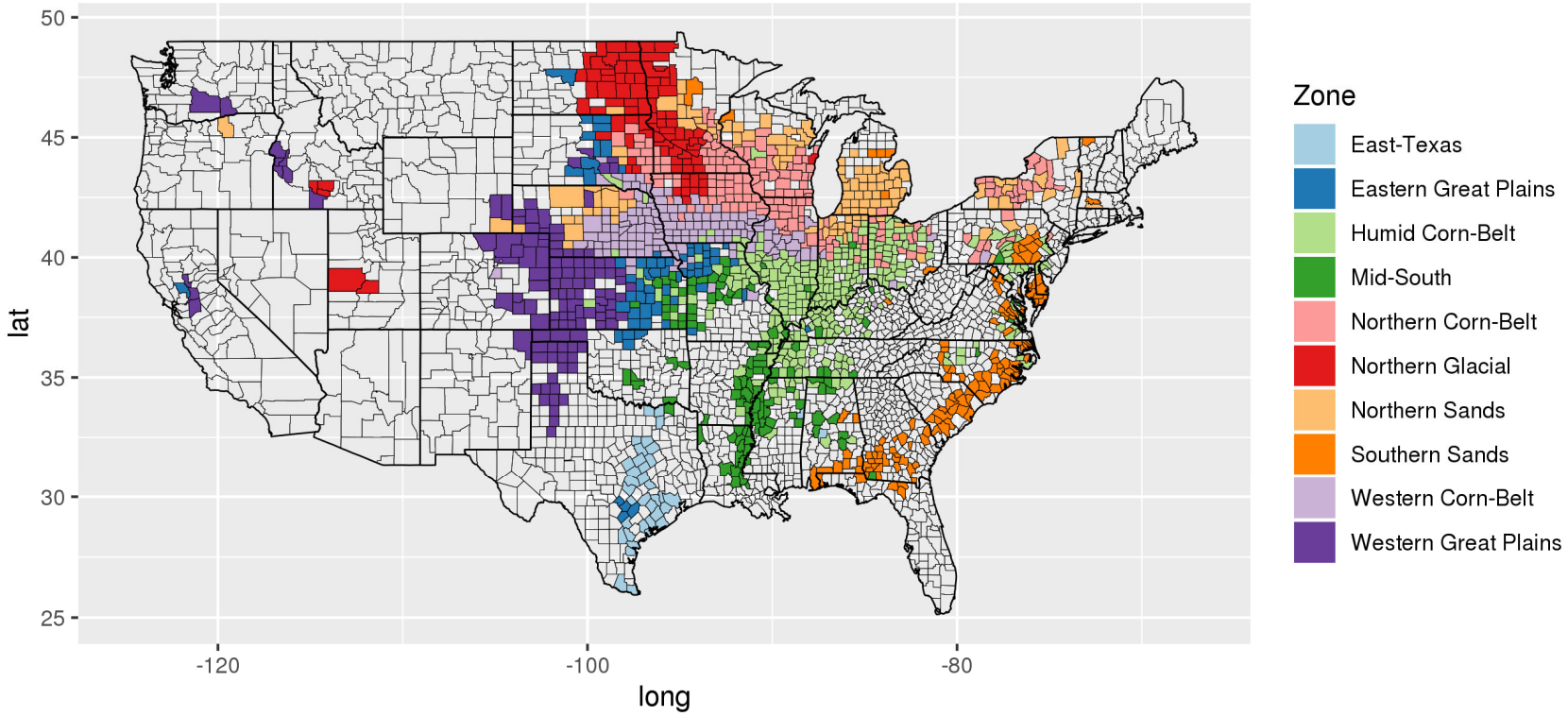


Factors used to determine zone

- Yield
- Population
- Weather by growth stage (VE – V7, R1, etc.)
- Soil Texture
- Nutrients



Zone Means

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SOUTHEASTERN FIELD AGRONOMY

Zone	Yield	Population	Planting Date	Precip	Temp	Solar Rad	Soil Type	Drainage
East-Texas	130	24582	3/09	15.9	73.4	2317	Cl	MWD
Eastern Great Plains	142	26990	4/20	15.8	72.5	2690	SiClLo	WD
Humid Corn-Belt	***212***	***31559***	***5/11***	***22.1***	***73.5***	***2420***	***SiLo***	***WD***
Mid-South	***206***	***30651***	***4/13***	***27.1***	***71.0***	***2572***	***SiLo***	***SPD***
Northern Corn-Belt	233	33954	5/11	28.0	67.5	2746	SiLo	WD
Northern Glacial	203	33905	5/11	19.9	64.7	2855	Lo	WD
Northern Sands	217	32753	5/11	23.0	66.9	2753	SaLo	WD
Southern Sands	208	31698	4/27	22.9	72.8	2362	SaLo	WD
Western Corn-Belt	238	32171	5/4	21.4	69.5	2812	SiLo	WD
Western Great Plains	211	28163	5/11	13.0	72.3	2786	SiLo	WD
Average	217	31806	5/4	22.4	69.7	2691	SiLo	WD

Zone Differences - Irrigated

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SOUTHEASTERN FIELD AGRONOMY

Zone	Yield Level	Yield	CEC	OM	pH	P	K	Zn	Mn	Fe
Eastern Great Plains	High	238.8	16.9	2.7	6.4	55.5	264.3	3.6	107.8	178
East-Texas	High	200.5	59.1	4.6	7	63	235	4.8	77.7	276.7
	Med	147	37	2.1	8.2	59	570	1.3	105	22
Humid Corn-Belt	High	258.4	13.2	2.8	6.1	38.9	217.2	3.4	84.3	146.9
	Med	225.5	11.8	2.5	6.2	40.8	157.4	3.5	115.3	182.2
	Low	196	7.3	1.8	5.9	40.2	116.4	2.3	103.8	174.8
Mid-South	**High**	**246.2**	**9.6**	**2.3**	**6.3**	**40.2**	**183.1**	**3.5**	**100.6**	**156.9**
	Med	**213.9**	**12.8**	**2.3**	**6.2**	**45.2**	**153.7**	**3.1**	**98.7**	**200.6**
	Low	159.9	13.5	2.2	7.4	38.5	139.5	2.9	97	163.5
Northern Corn-Belt	High	251.3	14.5	4.1	6.4	56.7	297.5	5.3	116	125.2
	Med	239.8	17.3	3.6	6.8	40.1	268.5	4.9	79.1	92.4
	Low	186.9	15	6.1	6.3	61	205	3.8	74	120
Northern Glacial	High	266.1	36.7	2.9	7.8	101	277.5	7.1	134	30
	Med	200.5	24.7	4.1	7.5	54.7	259	4.1	135	51
	Low	175.6	35.3	3	7.9	114.5	354.5	7.9	162	36
Northern Sands	High	252.4	10.3	2	6.2	48.6	254.4	4.8	56.7	76
	Med	221.1	8.8	2.1	6.2	68.1	216	5.2	74.4	138.1
	Low	186.6	8.9	2.2	6.2	61	298.5	4.2	59.5	84
Southern Sands	High	250.5	8.3	1.9	6.2	134.3	220.2	7.1	79.7	146.8
	Med	218	6.2	1.5	6.3	142.3	139	8.2	65	144.2
	Low	189.8	4.2	1.1	6.1	130.9	118.6	6.1	34.8	132.3
Western Corn-Belt	High	272.4	15	3.1	6.5	42.6	348.6	4.5	72.8	86.2
	Med	240.6	16.2	3.4	6.5	44.7	313.8	3.7	91.7	86.5
	Low	211.2	15.8	3.6	6.5	44	304.4	3.8	99.9	117.5
Western Great Plains	High	265.8	17.5	2.7	7.1	60.5	424.3	5.4	107.5	63.3
	Med	229.7	21.7	2.8	7.3	75.2	475.7	6.2	109.3	77.7
	Low	156.8	18.7	2.8	7.2	60.8	530.2	4.9	154.8	71.3

Yield Limiting Factors

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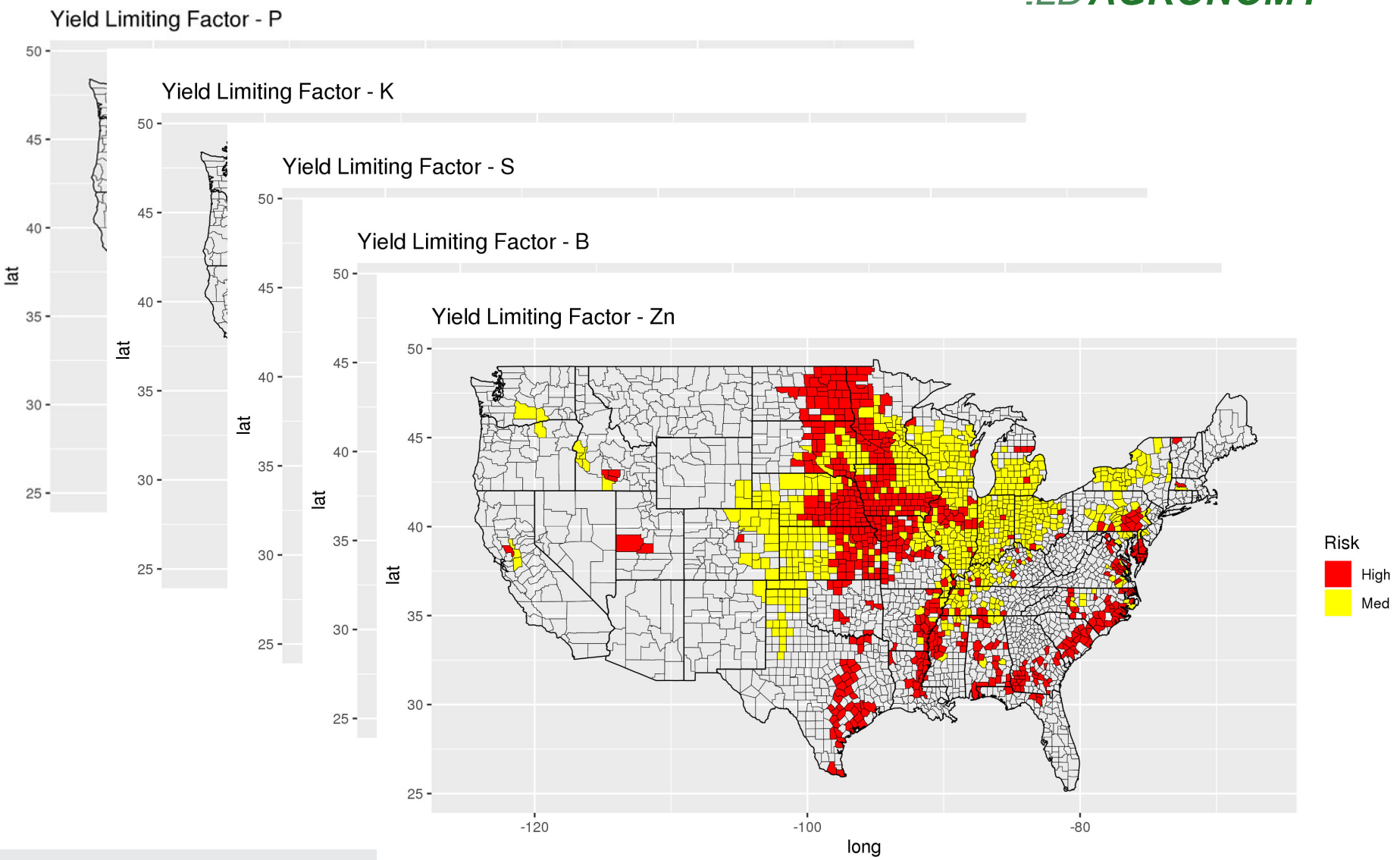
ELD AGRONOMY



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Recap of AI and Soil Fertility

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SOUTHEASTERN FIELD **AGRONOMY**

- *Big data set, broken by yield level, zones for large but like geography.. Snapshot of soil nutrient status*

  WHEN CROP IS ESTABLISHED

- *Likely gives a bigger footprint than calibration sets*

- *May assist in refining Soil Test Levels*
  - *Operational Range for High Yields aren't well defined*
  - *Most are operating higher and applying crop removal*

High Yield Characterization: Tissue Sampling

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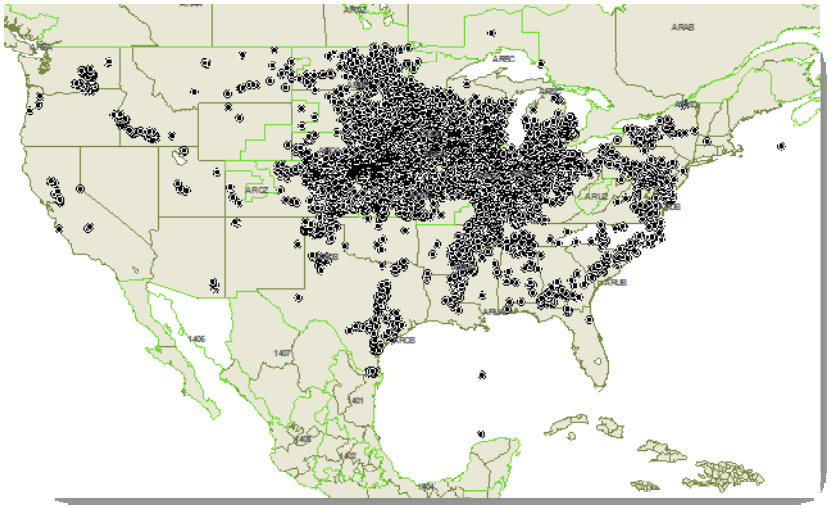
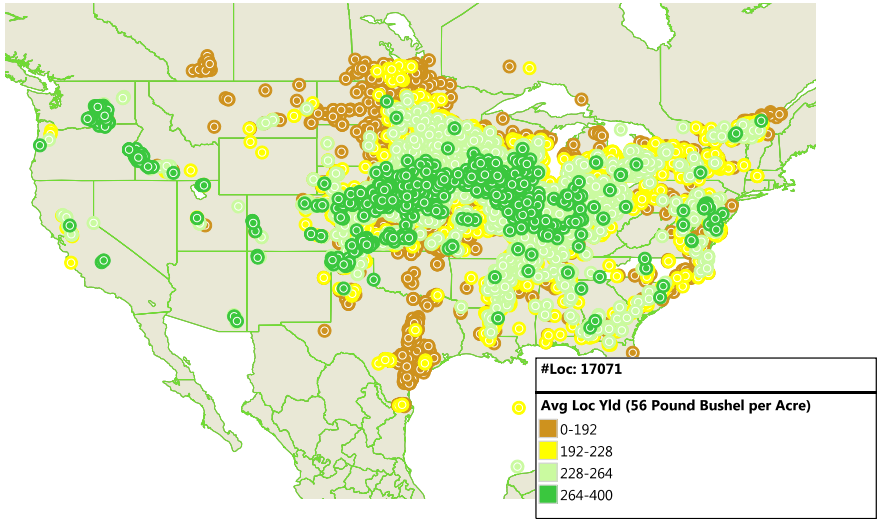
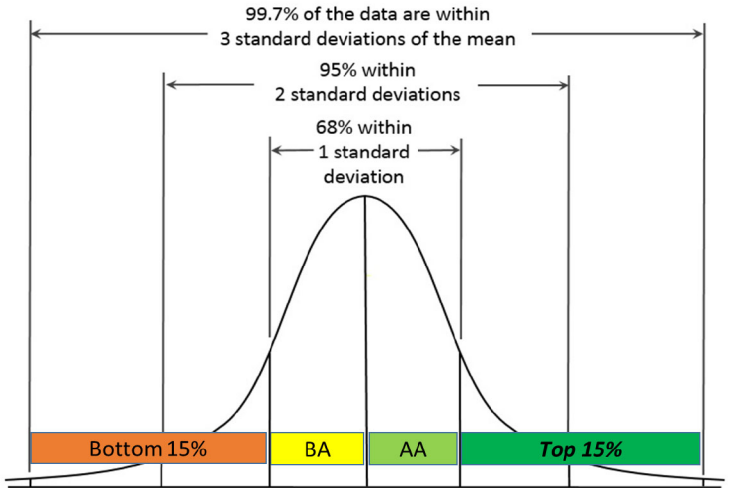
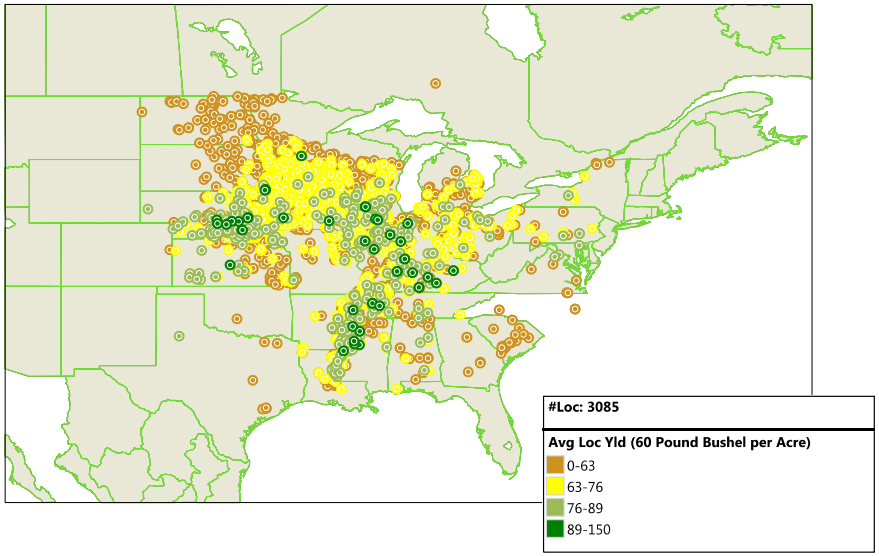
SOUTHEASTERN FIELD AGRONOMY









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Waypoints to 300 bushels

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SOUTHEASTERN FIELD **AGRONOMY**

V6-V8

Push N > 4%

Push K > 3%

Push S > 0.3%

Push B > 10ppm

Push Cu > 12ppm

Zn ~ 30-40 ppm

(w/o > 75 ppm)

Mg ~ 0.2-0.3%

(w/o > 0. 4%)

Ca ~ 0.5%

(w/o > 0.75%)

Fe ~140-210 ppm

(w/o > 250 ppm)

VT-R1

K ~ 2.3-2.7%

(w/o > 3%)

P ~ 0.3-0.4%

(w/o > 0.4%)

Push S > 0.2%

R2-R5

K ~ 1.5-2.0 %

X > 2.0 %

Mn < 80ppm

Waypoints to 100 bushels

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SOUTHEASTERN FIELD **AGRONOMY**

R1

Mg ~ 0.5%
- Dolomitic Lime, KMag

P ~ 0.6-0.7%
- Litter, STP, Enzymes

K ~ 2.5-2.8%
- STK, Solum Labs
- Spring, Split, PolyOn

N ~ 5.3-5.8%

S ~ 0.3%
- AMS, ATS

B ~ 42-50 ppm

Zn ~ 50-55 ppm

Cu ~ 11.5-13 ppm

R3

P ~ 0.6-0.7%
- STP

K ~ 2.25-3.0%
- Split, KTS, Kmag

Mg ~ 0.45-0.5%

N ~ 5.3-5.8%
- Inoculant, AMS/Urea

Zn ~ 51-57ppm

Cu ~ 10 ppm

Mn ~ 80-100 ppm

R5

Mg ~ 0.4-0.45 %

S ~ 0.3-0.33 %

P ~ 0.4-0.46 %

N ~ 5.3-5.6 %

B ~ 60-70 ppm

Zn ~ 60-70

Cu ~ 8-10 ppm

Mn ~ 130-160 ppm

Corn Waypoints '20

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SOUTHEASTERN FIELD **AGRONOMY**

V6-V8

Push

N > 4%
K > 3%
S > 0.3%
B > 10ppm
Cu > 12ppm

Target

Fe < 250 ppm
Zn ~ 30-40 ppm
Na ~0.03%
Ca ~ 0.5%
Mg ~ 0.25%

VT-R1

Push

S > 0.2%
Na > 0.02%

Target

K ~ 3%
P ~ *0.35%*

R2-R5

Target

K ~ 1.75 %
Mn < 80ppm

Soybean Waypoints '20

PIONEER agronomy

SOUTHEASTERN FIELD **AGRONOMY**

R1

Push

P > 0.5%
Mg > 0.5%
K > 2.5%
Zn > 45ppm
N > 5%
S > 0.3%

Target

Cu ~11ppm
B ~50ppm
Na < 0.015%
Fe <250ppm

R3

Push

P > 0.6%
K > 2.1%
Zn > 50ppm
Mg > 0.4%
S > 0.27%

Target

Fe < 200ppm
Mn ~125ppm
B ~ 50ppm
Ca < 1.5%
Cu ~ 10ppm
Na <0.02%

R5

Push

Zn >60ppm
B > 50ppm
N > 5%
K > 1.5%

Target

Cu < 15ppm
Mn ~ 175ppm
Mg ~ 0.4%
S ~ 0.33%
Ca ~ 2%
P ~ 0.4%
Na < 0.025%

Tissue Sampling

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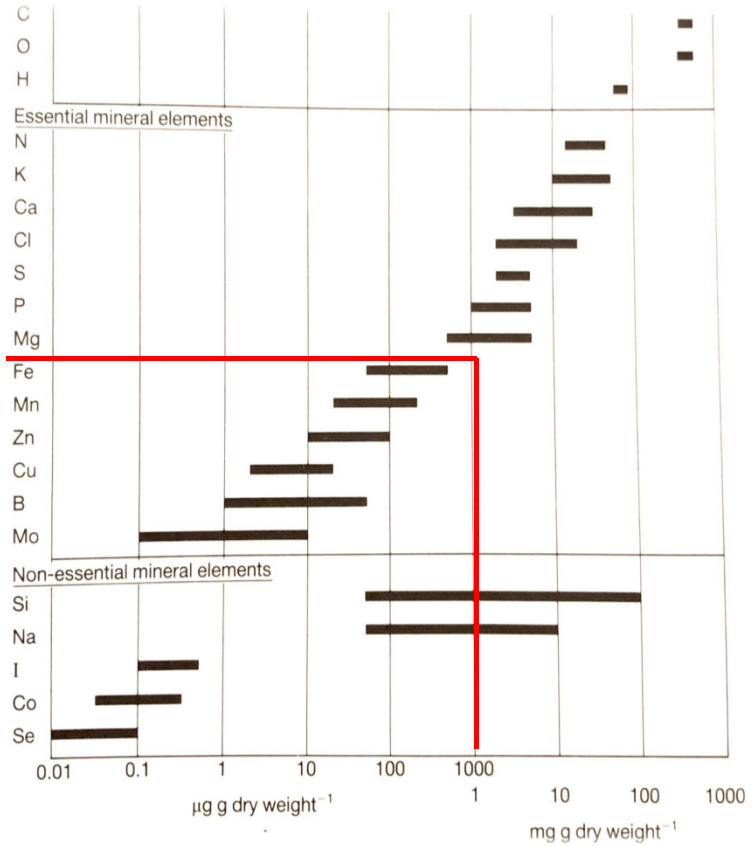
SOUTHEASTERN FIELD **AGRONOMY**

- Portion of dry weight of plants is minerals, generally ~6%
  - Varies
    - **Yield***
    - **Time**
    - **Tissue**
- Some nutrients in %
  - **N**, **P**, S, **K**, Mg, Ca, Na
- Some nutrients in ppm
  - Fe, Mn, Zn, Cu, B, Mo, Al



From: Plants in Agriculture. Forbes and Watson, 1992.

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Tissue Sampling- Over Yield

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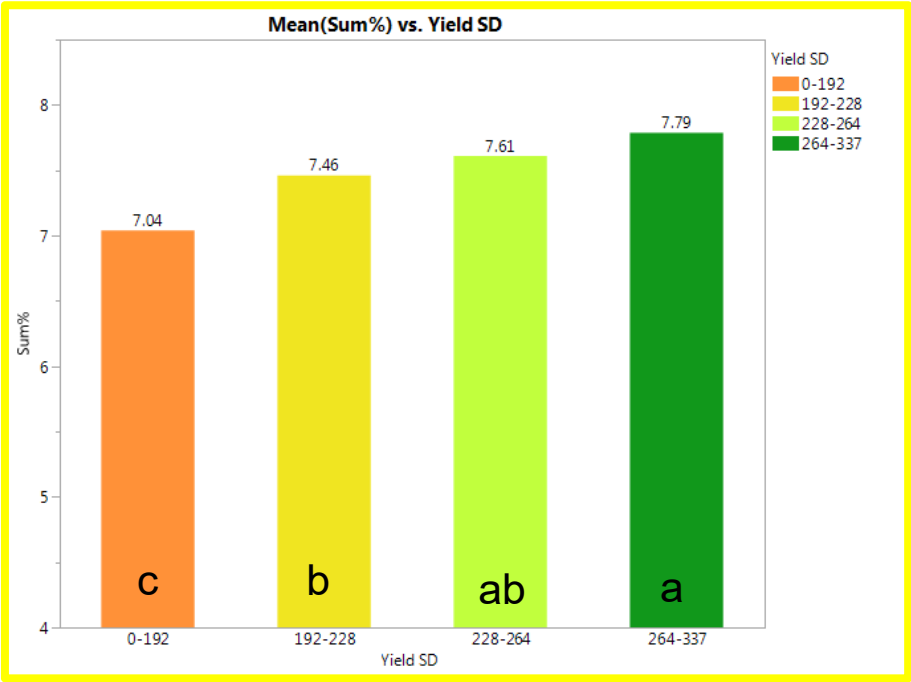
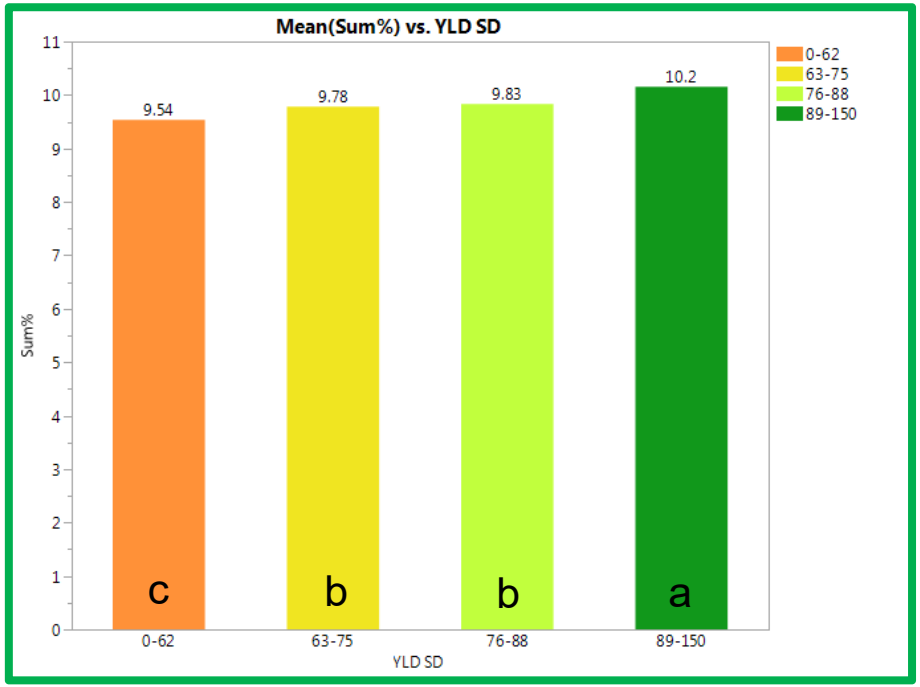
SOUTHEASTERN FIELD **AGRONOMY**





Sum% = % N+P+S+K+Mg+Ca+Na + *Fe+Mn+Zn+Cu+B+Mo+Al*

What about Dry Matter?

What about Dry Matter

- Dry Matter
  - 1000lb DM increase for 10k Seeding rate increase
  - **6000lb DM increase for 100 bu yield increase**

Table 1. Grain yield (15.5% moisture) from combine harvest (bu/A), total plant biomass (lbs/A), and total plant nutrient concentration (%, g nutrient per 100 g dry matter [DM]) at maturity across two maize hybrids grown at three plant densities (PD) and N rate (Nr) levels across two locations (at Pinney-Purdue Agricultural Center and Purdue University Agronomy Center for Research and Education) and two growing seasons (2010 and 2011).

N rates	Yield	Biomass	Plant nutrient concentration					
			N	P_2O_5	K_2O	S	Zn	Mg
	bu/A	lbs/A	%					
Low PD (22,000 pl/A)								
22N	123	13,712	0.89	0.55	1.13	0.08	0.22	0.22
100N	175	17,039	1.03	0.55	1.06	0.09	0.18	0.18
200N	197	18,898	1.20	0.60	1.08	0.10	0.17	0.17
Medium PD (32,000 pl/A)								
22N	109	14,380	0.87	0.57	1.22	0.08	0.22	0.22
100N	168	17,889	0.97	0.57	1.13	0.08	0.16	0.16
200N	210	20,536	1.13	0.55	1.05	0.09	0.15	0.15
High PD (42,000 pl/A)								
22N	97	14,962	0.87	0.53	1.19	0.08	0.21	0.21
100N	164	19,094	0.94	0.50	1.16	0.08	0.16	0.16
200N	199	20,728	1.12	0.53	1.12	0.09	0.15	0.15
ANOVA								
PD	***	*	*	ns	ns	ns	ns	ns
N rate	***	***	***	ns	ns	**	**	**
PD × N rate	***	ns†	ns	ns	ns	ns	ns	ns

*Significant at the 0.05 probability level.

**Significant at the 0.001 probability level.

***Significant at the 0.0001 probability level.

†ns = not significant ($P > 0.05$).

Bender et al, 2013.

7.46% of 21000 lb/ac DM = **1567 lb/ac sum nutrient**

7.79% of 27000 lb/ac DM = **2103 lb/ac sum nutrient**

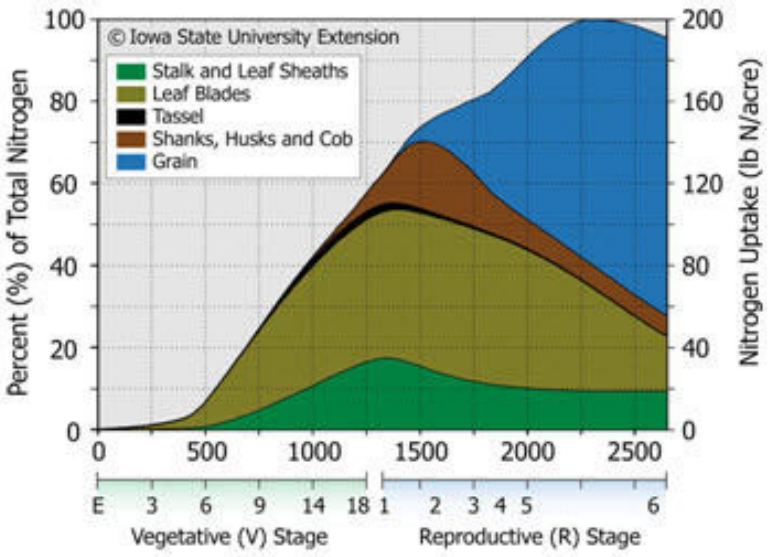
Tissue Sampling – Over Time

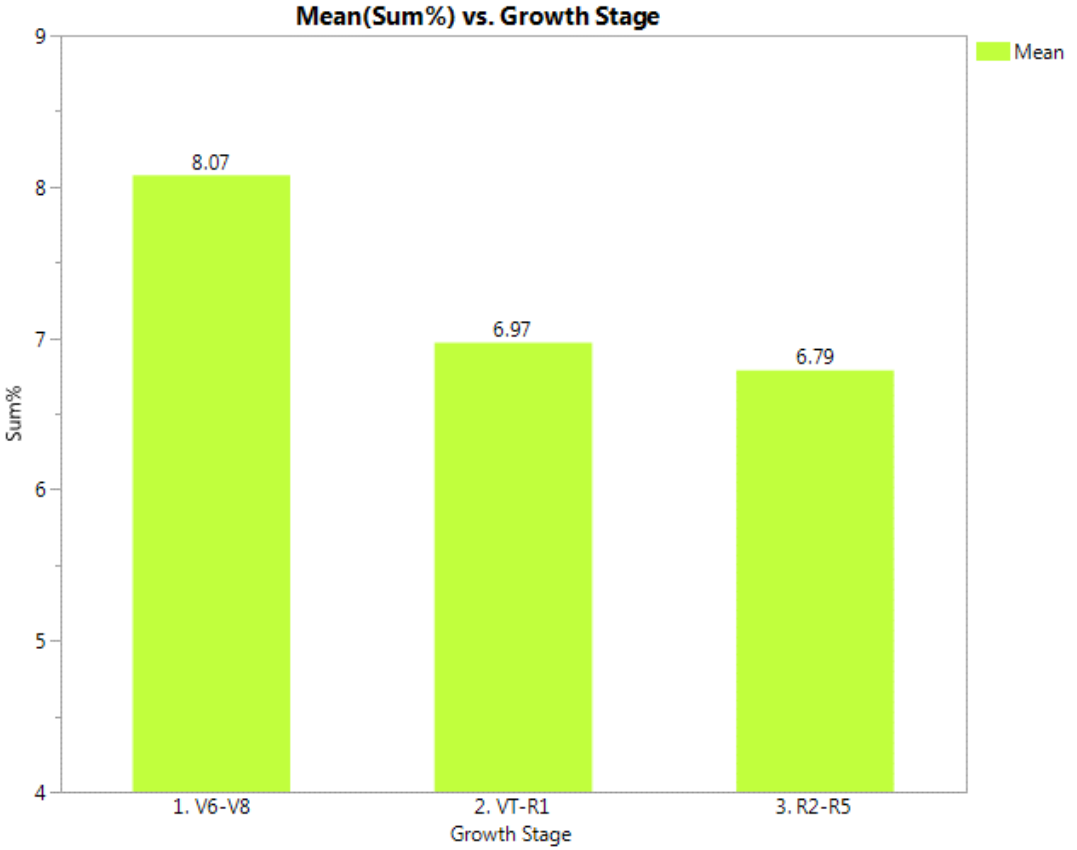
PIONEER agronomy

Expected Nutrient Level Declines
Field Corn

Plant Age	Total Nitrogen	Total Phosphorus	Total Potassium
30 days	4.6%	.30%	3.4%
60 days	3.9%	.26%	2.4%
80 days	3.4%	.24%	1.9%
110 days	3.0%	.20%	1.8%

From: Interpreting Plant Analysis Reports. Agvise Labs.

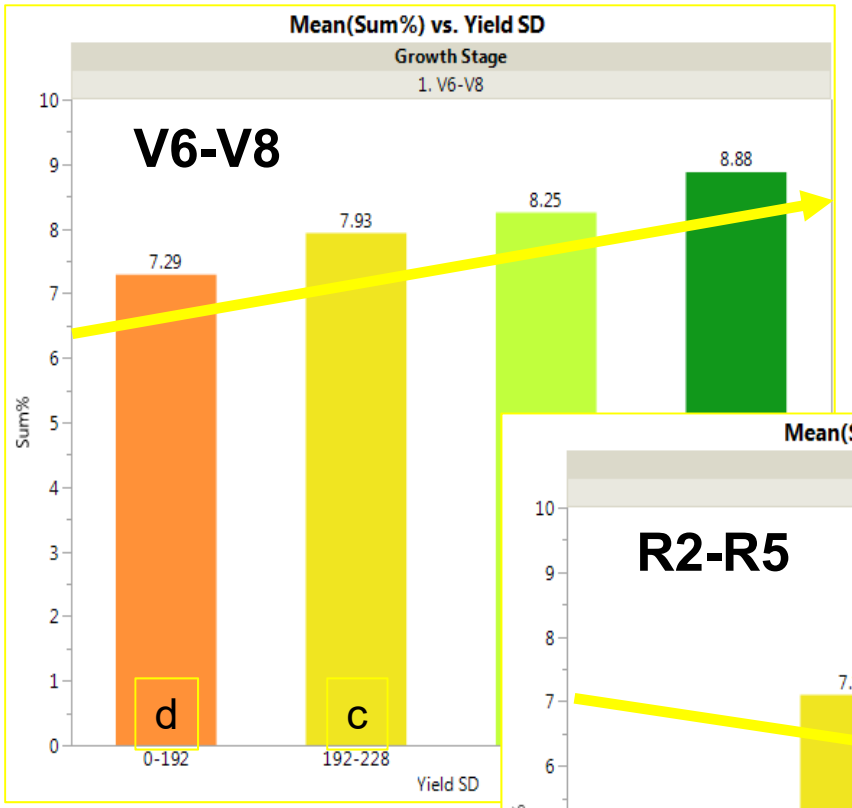


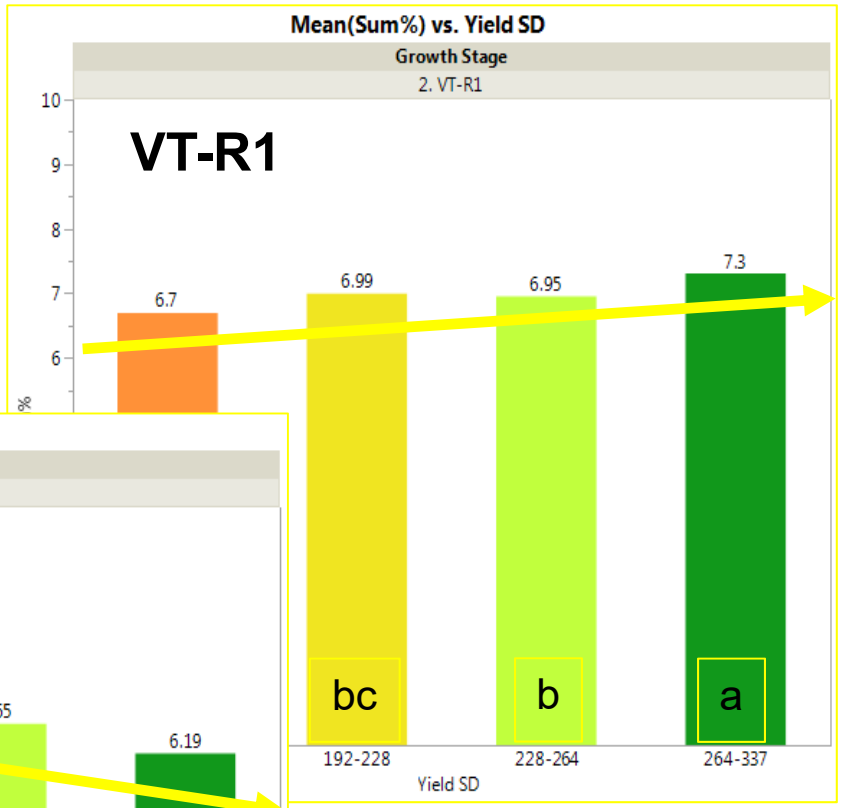


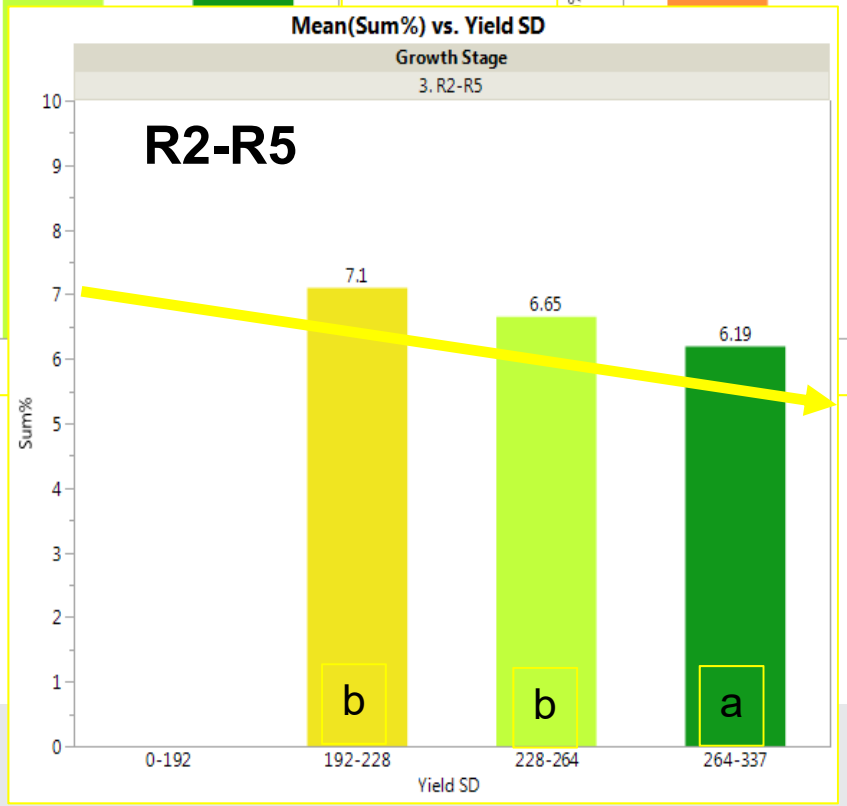
Corn Growth Stage and Yield

PIONEER agronomy

SOUTHEASTERN FIELD AGRONOMY





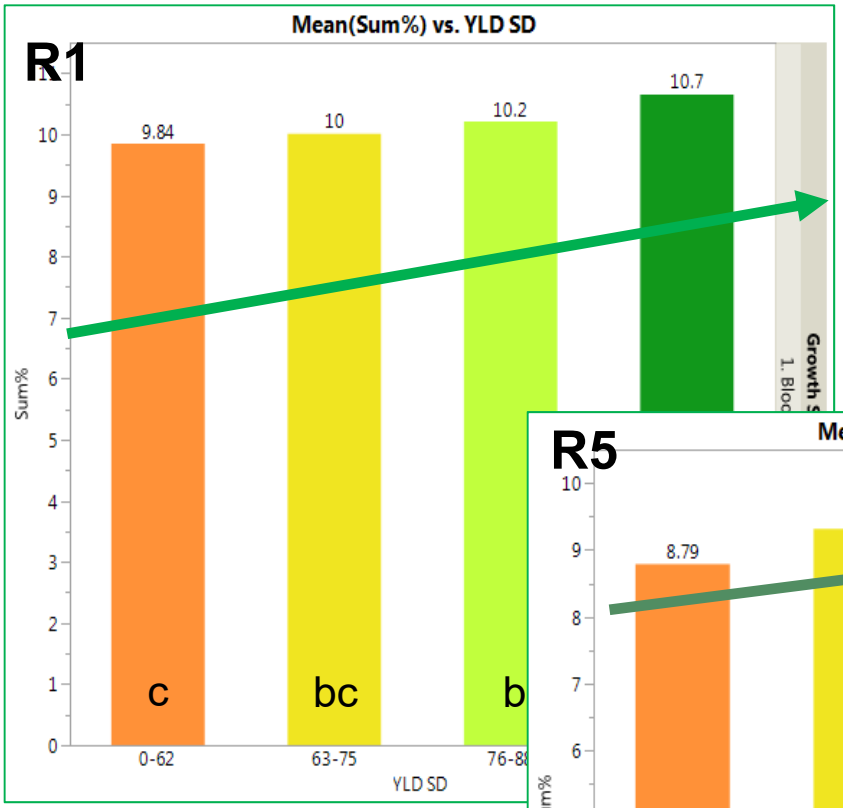


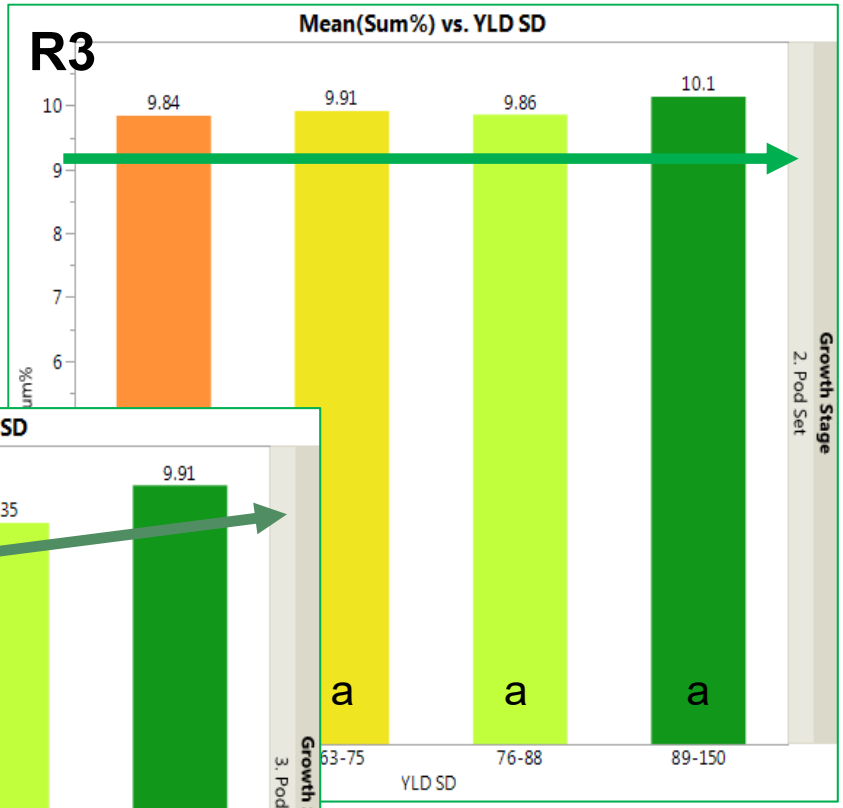
CORTEVA agriscience

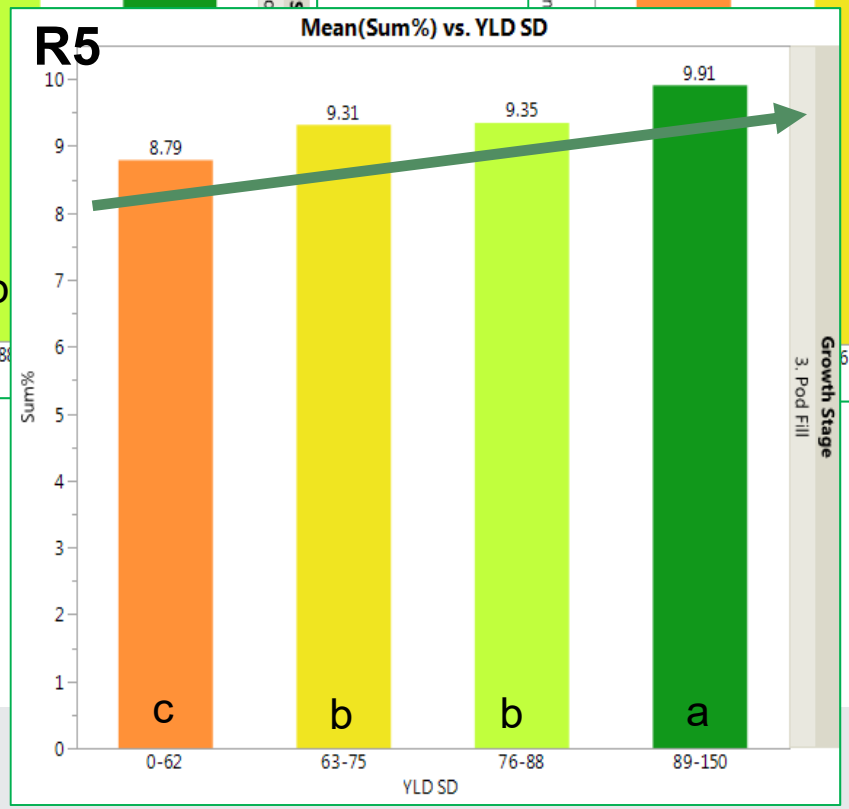
Soy Growth Stage and Yield

PIONEER agronomy

SOUTHEASTERN FIELD AGRONOMY

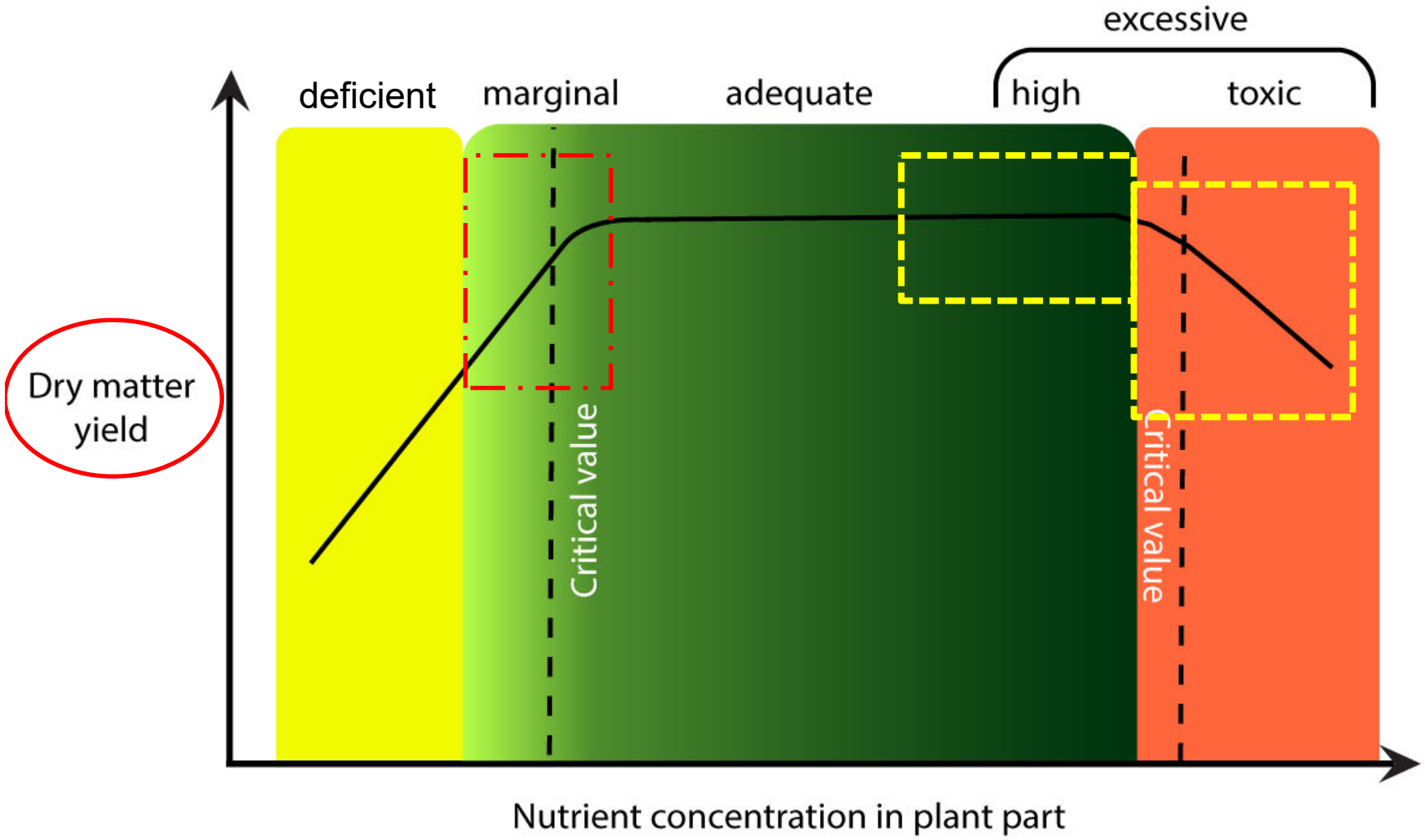






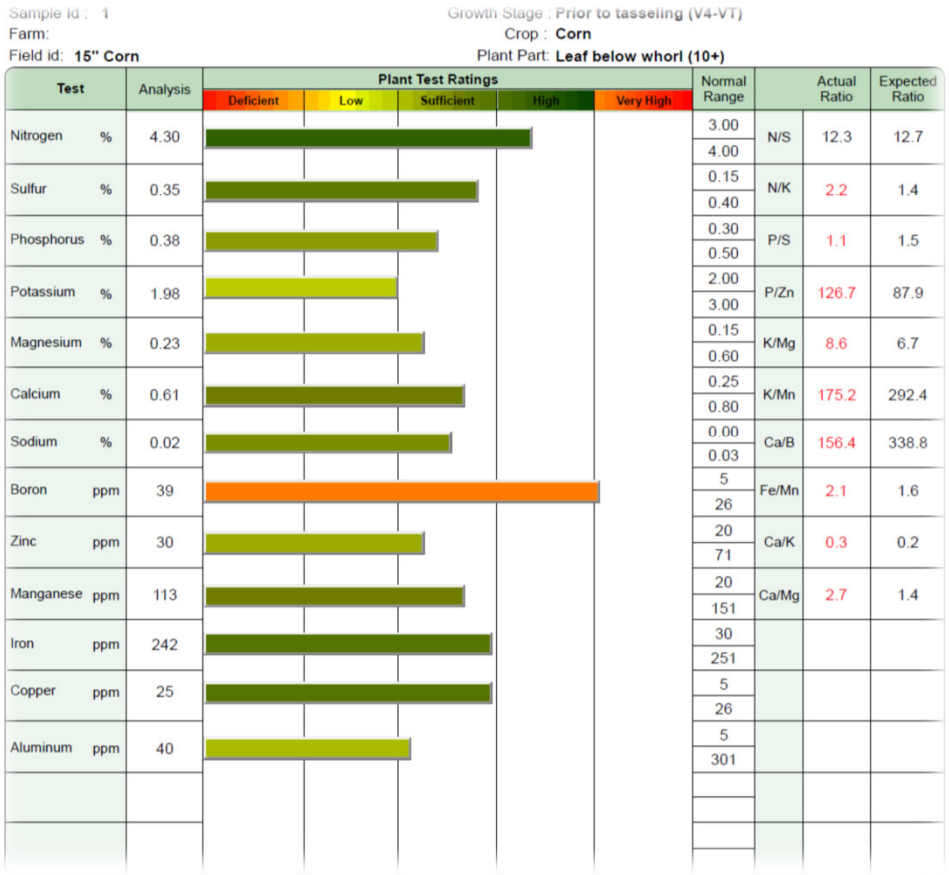
CORTEVA agriscience

Tissue Sampling



From: Government of Western Australia, PIRC.

Preliminary Processing



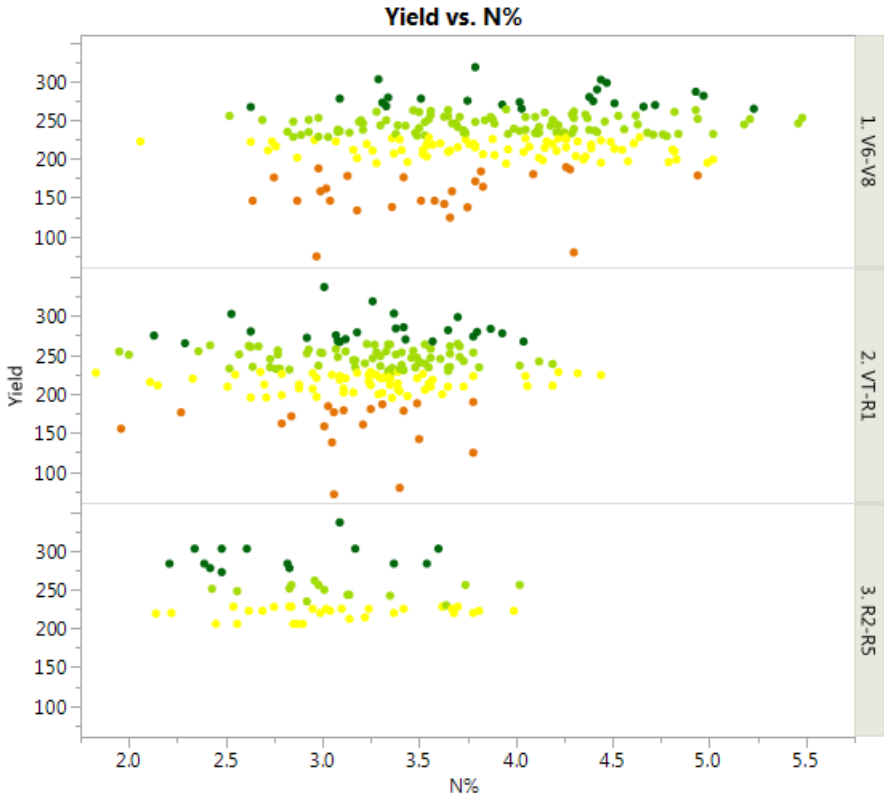
Sample Id : 1
Farm:
Field id: **15" Corn**

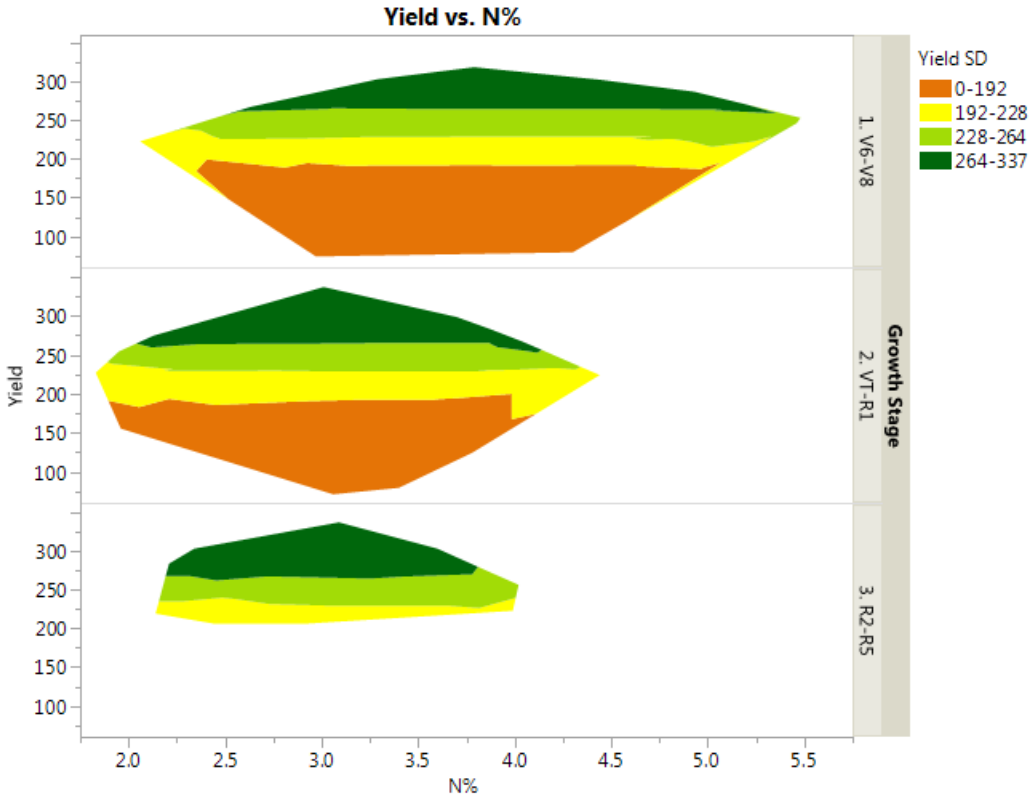
Growth Stage : **Prior to tasseling (V4-VT)**
Crop : **Corn**
Plant Part: **Leaf below whorl (10+)**

Test		Analysis	Plant Test Ratings: Deficient / Low / Sufficient / High / Very High	Normal Range		Actual Ratio	Expected Ratio
Nitrogen	%	4.30		3.00 – 4.00	N/S	12.3	12.7
Sulfur	%	0.35		0.15 – 0.40	N/K	2.2	1.4
Phosphorus	%	0.38		0.30 – 0.50	P/S	1.1	1.5
Potassium	%	1.98		2.00 – 3.00	P/Zn	126.7	87.9
Magnesium	%	0.23		0.15 – 0.60	K/Mg	8.6	6.7
Calcium	%	0.61		0.25 – 0.80	K/Mn	175.2	292.4
Sodium	%	0.02		0.00 – 0.03	Ca/B	156.4	338.8
Boron	ppm	39		5 – 26	Fe/Mn	2.1	1.6
Zinc	ppm	30		20 – 71	Ca/K	0.3	0.2
Manganese	ppm	113		20 – 151	Ca/Mg	2.7	1.4
Iron	ppm	242		30 – 251			
Copper	ppm	25		5 – 26			
Aluminum	ppm	40		5 – 301			

- Each Nutrient
  - Watch for Trend
  - Evaluate Relationship
  - Rank by effect
  - Create Ranges
    - By Nutrient
    - By Growth Stage
    - By Yield Level
- In time, build a ratio database

1. Scatter to Contour plots





2. Looking for Trends

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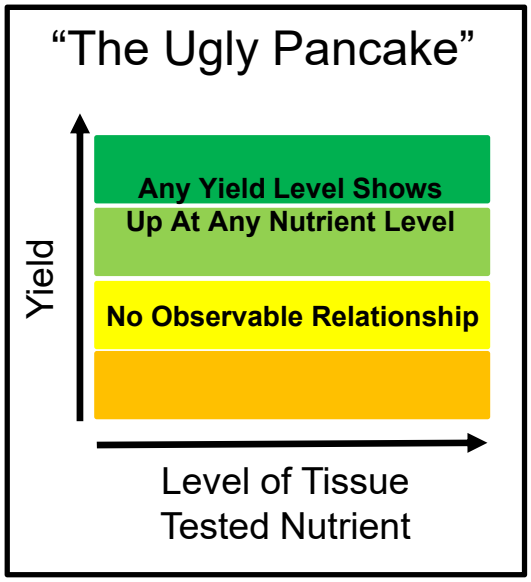
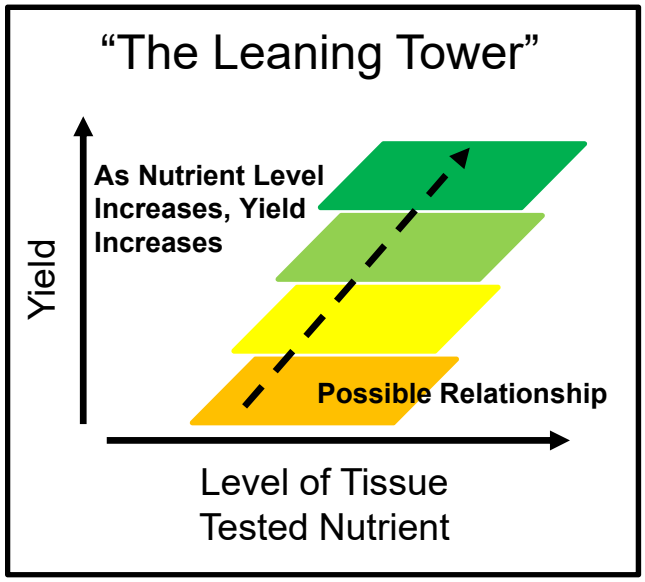
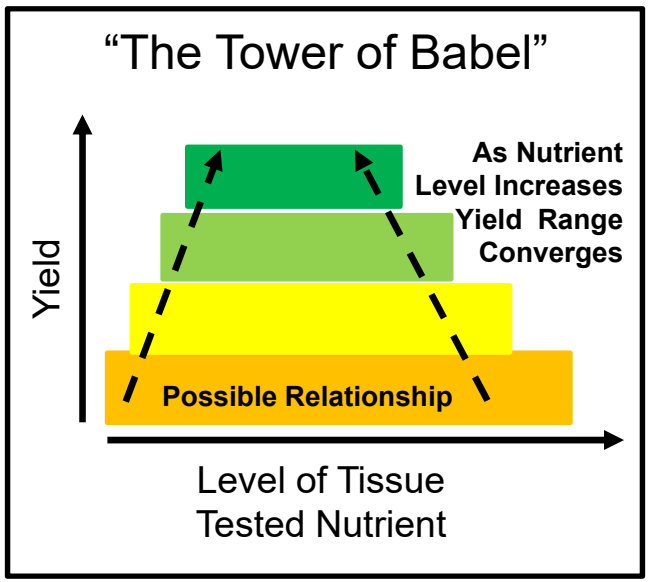
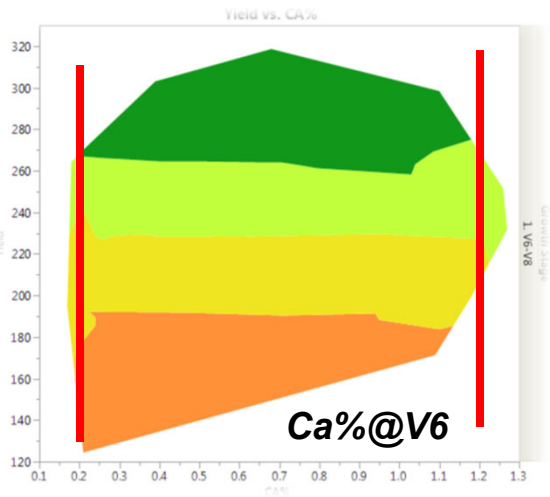
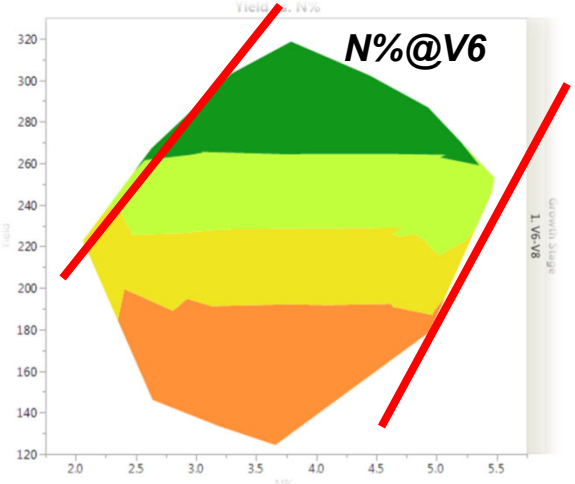
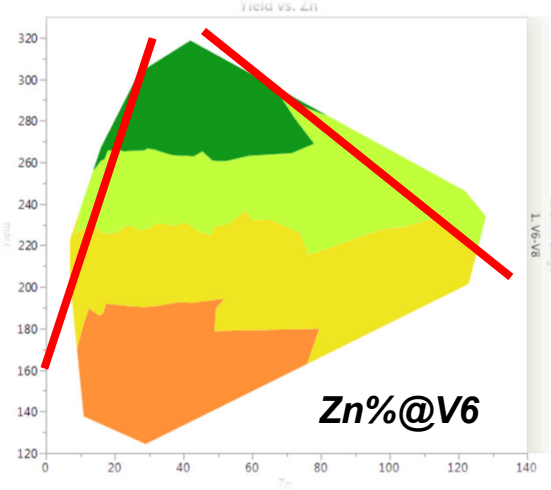






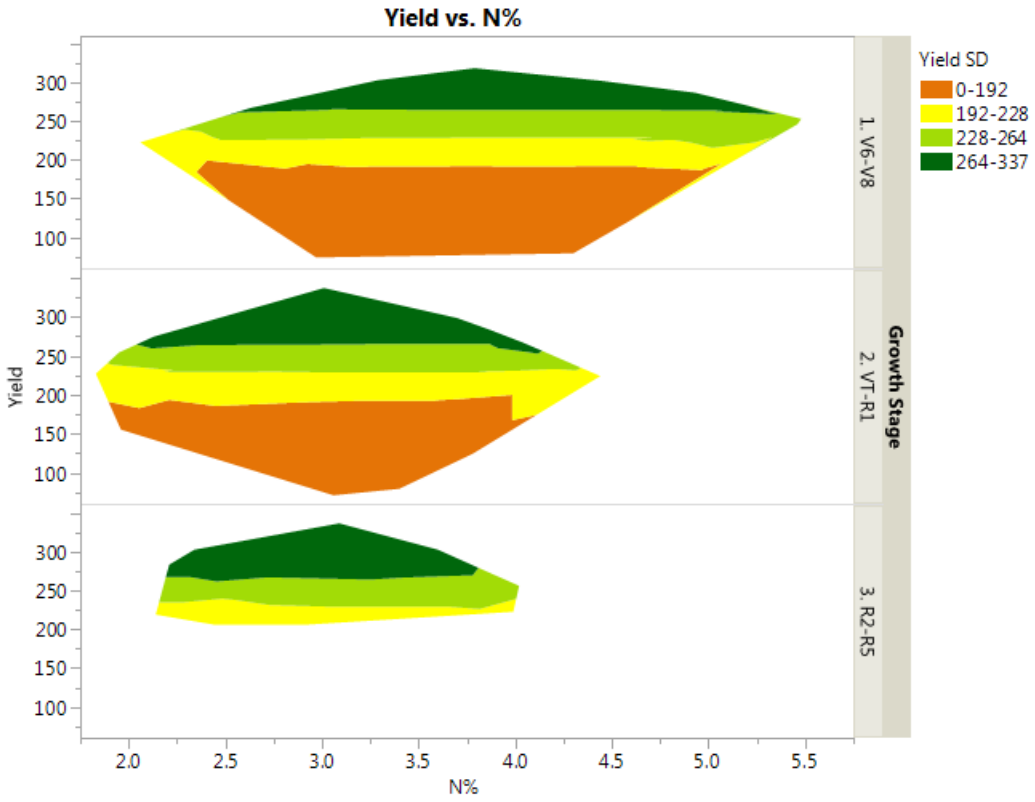




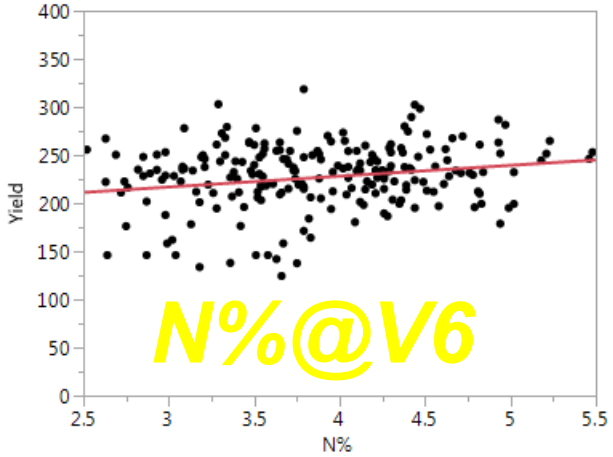


3. Range Evaluation

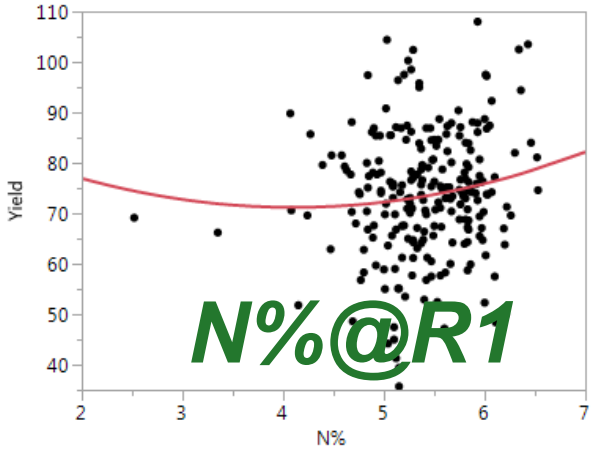
Growth Stage	Yield Range	N	Mean	95% Confidence Interval
V6-V8 *Vegetative*	>264	28	4.08*	3.83-4.34
	228-264	161	3.87	3.77-3.98
	192-228	114	3.81	3.69-3.92
(3.0-4.0)	<192	46	3.47	3.31-3.64
VT-R1 *Flowering*	>264	30	3.24	3.06-3.41
	228-264	128	3.23	3.15-3.31
	192-228	93	3.24	3.14-3.40
(2.8-4.0)	<192	33	3.14	2.99-3.29
R2-R5 *Grain Fill*	>264	14	*2.81	2.54-3.08
	228-264	21	3.16	2.95-3.36
	192-228	32	3.07	2.90-3.24
(2.5-3.5)	<192	-	-	-



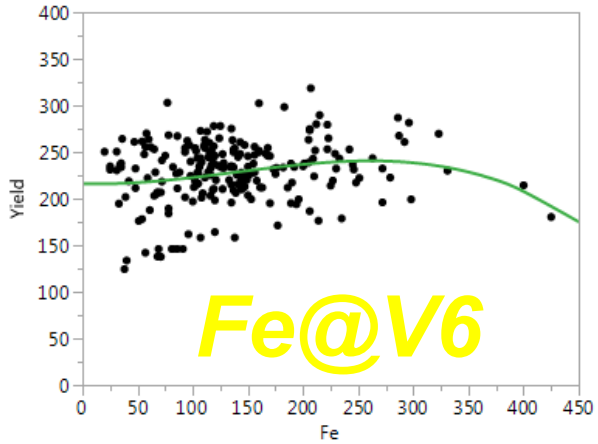
4. Relationship



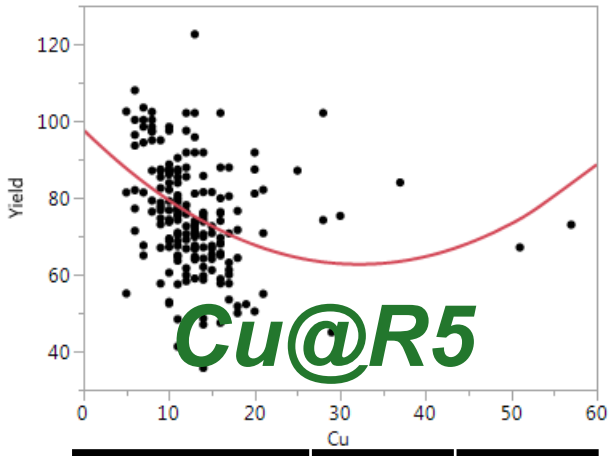
Relationship	Pr>F	Rsq
Linear	<.0001	0.0457



Relationship	Pr>F	Rsq
Quad	0.1425	0.0166



Relationship	Pr>F	Rsq
Cubic	0.0006	0.0502



Relationship	Pr>F	Rsq
Quad	<.0001	0.1207

Corn Significance '20

PIONEER

SOUTHEASTERN FIELD **AGRONOMY**

V6-V8

Stat	Fe	%N	Zn	%K	%S	%Na	%Ca	Al	%Mg	B	Cu
Rsq	0.050	0.047	0.047	0.042	0.039	0.039	0.037	0.029	0.027	0.018	0.011
Fxn	Cubic	Linear	Quad	Linear	Linear	Quad	Quad	Linear	Quad	Linear	Linear
Pr>F	0.0006	<.0001	0.0003	0.0001	0.0002	0.0010	0.0014	0.0013	0.0090	0.0003	0.0495
HY Range	***143-208***	***3.83-4.34***	***31.2-39.5***	***3.00-3.59***	***0.26-0.32***	***0.020-0.037***	***0.45-0.61***	***65-114***	***0.20-0.27***	***9.82-14.97***	***12.0-16.0***
Effect	Peak (**250**)	Positive	Peak (**75**)	Positive	Positive	Peak (**0.06**)	Peak (**0.75**)	Positive*	Peak (**0.4**)	Positive	Positive

VT-R1

Stat	%K	%P	%Na	%S
Rsq	0.040	0.035	0.023	0.013
Fxn	Quad	Quad	Linear	Linear
Pr>F	0.0034	0.0070	0.0120	0.0554
HY Range	***2.28-2.65***	***0.33-0.38***	***0.021-0.029***	***0.21-0.25***
Effect	Peak (**3.0**)	Peak (**0.35**)	Positive	Positive

R2-R5

Stat	%K	Mn
Rsq	0.169	0.125
Fxn	Cubic	Linear
Pr>F	0.0082	0.0032
HY Range	***1.52-2.07***	***36-80***
Effect	Peak (**1.75**)	Inverse

<u>Growth Stage is important.</u>

V6-V8 Proactive need with fertilizer or fertility (or report card).

VT-R1 Proactive possibility with fertilizer/foliar application.

R2-R5 Proactive harvest priority and report card.

Soybean Significance '20

PIONEER®

SOUTHEASTERN FIELD **AGRONOMY**

R1

Stat	Cu	%P	%Mg	%K	Zn	B	%Na	Fe	%S	%N
Rsq	0.121	0.110	0.081	0.079	0.068	0.032	0.024	0.014	0.013	0.016
Fxn	Cubic	Linear	Linear	Linear	Linear	Cubic	Linear	Quad	Linear	Quad
Pr>F	<.0001	<.0001	<.0001	<.0001	<.0001	0.0582	0.0171	0.110	0.0790	0.1425
HY Range	*11.5-14*	*0.50-0.63*	*0.49-0.51*	2.4-2.8	*46-60*	*39-51*	*0.014-0.022*	85-206	*0.28-0.32*	5.3-5.8
Effect	*Peak (11)*	Positive	Positive	Positive	Positive	Peak (50)	Inverse	Keep <250	Positive	Push >5

R3

Stat	%P	Fe	Mn	%K	B	Zn	%Mg	%Ca	Cu	%Na	%S	%N
Rsq	0.120	0.080	0.071	0.058	0.047	0.041	0.037	0.026	0.024	0.023	0.020	0.010
Fxn	Cubic	Quad	Quad	Linear	Cubic	Linear	Linear	Quad	Quad	Linear	Linear	Linear
Pr>F	<.0001	<.0001	<.0001	<.0001	0.0037	0.0005	0.0009	0.0234	0.0297	0.0189	0.0927	0.0695
HY Range	*0.50-0.62*	*71-110*	*87-123*	*2.1-2.4*	*43-57*	*50-58*	*0.40-0.46*	*0.98-1.11*	*11.2-12.9*	*0.015-0.022*	*0.27-0.30*	*5.2-5.7*
Effect	Positive (>0.6)	Keep <200	Peak (125)	Positive	Peak (55)	Positive	Positive	Keep <1.5	Peak (10)	Inverse	Positive	Inverse

R5

Stat	Zn	Cu	Mn	%Mg	B	S	%Ca	%P	Al	%N	%Na	%K
Rsq	0.186	0.161	0.123	0.100	0.052	0.076	0.052	0.050	0.041	0.037	0.024	0.008
Fxn	Linear	Quad	Quad	Cubic	Linear	Cubic	Cubic	Quad	Linear	Linear	Linear	Linear
Pr>F	<.0001	<.0001	<.0001	<.0001	0.0007	0.0008	0.0102	0.0041	0.0008	0.0043	0.0229	0.2033
HY Range	*57-72*	*9-12*	*145-207*	*0.39-0.44*	52-63	*0.29-0.32*	*1.67-2.04*	*0.35-0.41*	*21-29*	*5.0-5.5*	*0.020-0.025*	*1.5-1.75*
Effect	Positive	Trough (<15)	Peak (175)	Peak (0.475)	Positive	Peak (0.33)	Peak (2.75)	Peak (0.48)	Positive	Positive	Inverse	Linear

5. Output-Corn

PIONEER agronomy

PIONEER HIGH YIELD CORN NUTRIENT RANGES

V6-V8	Nutrient	N%	S%	P%	K%	*Mg%	*Ca%	*Na%
	PIO Range	3.83-4.34	0.26-0.32	0.35-0.40	3.00-3.59	0.20-0.27	0.45-0.61	0.020-0.037
	Nutrient	B	*Zn	Mn	Fe*	Cu	Al	
	PIO Range	9.82-14.97	31.2-39.5	59.0-87.1	143-208	12.0-16.0	65-114	

VT/R1	Nutrient	N%	S%	*P%	*K%	Mg%	Ca%	Na%
	PIO Range	3.06-3.41	0.21-0.25	0.33-0.38	2.28-2.64	0.19-0.27	0.54-0.87	0.021-0.029
	Nutrient	B	Zn	Mn	Fe	Cu	Al	
	PIO Range	9.03-14.03	23.7-35.8	52.1-71.9	105-129	10.2-12.5	35-98	

R3-R5	Nutrient	N%	S%	P%	*K%	Mg%	Ca%	Na%
	PIO Range	2.54-3.08	0.20-0.25	0.25-0.31	1.52-2.07	0.21-0.31	0.64-0.91	0.025-0.032
	Nutrient	B	Zn	*Mn	Fe	Cu	Al	
	PIO Range	7.45-18.55	26.1-38.9	36.0-80.0	87-111	10.9-15.0	24-38	

* Denotes that relationship exists where a peak is seen. If level is beyond range, consult Pioneer agronomist for specifics on nutrient. Asterisks on the left of appear more of luxury feeding, whereas asterisks on the right appear true watch outs.

Green shading indicates a significant increase from accepted nutrient sufficiency ranges.
Yellow shading indicates either slight increase or narrowing of nutrient sufficiency ranges.
Orange would indicate a significant decrease or narrowing of nutrient sufficiency range.

5. Output- Soybean

PIONEER agronomy

PIONEER HIGH YIELD SOYBEAN NUTRIENT RANGES

R1-R2	Nutrient	N%	S%	P%	K%	Mg%*	Ca%	Na%
	PIO Range	5.27-5.80	0.28-0.32	0.50-0.63	2.38-2.82	0.49-0.51	1.01-1.24	0.014-0.022
	Nutrient	*B	Zn	Mn	Fe*	*Cu	Al	
	PIO HY	39-51	46-60	60-80	85-206	11.5-14	16-92	

R2-R3	Nutrient	N%	S%	P%	K%	Mg%	*Ca%	Na%*
	PIO Range	5.18-5.68	0.27-0.30	0.50-0.62	2.14-2.38	0.40-0.46	0.98-1.11	0.015-0.022
	Nutrient	B	Zn	*Mn	Fe*	*Cu	Al	
	PIO Range	43-57	44-51	87-123	71-110	11.2-12.9	18-31	

R4-R5	Nutrient	N%	S%	P%	K%	*Mg%	*Ca%	Na%*
	PIO Range	5.04-5.48	0.29-0.32	0.35-0.41	1.50-1.75	0.39-0.44	1.67-2.04	0.020-0.025
	Nutrient	B	Zn	*Mn	Fe*	*Cu	Al	
	PIO Range	52-63	57-72	145-207	98-116	9-12	21-29	

* Denotes that relationship exists where a peak is seen. If level is beyond range, consult Pioneer agronomist for specifics on nutrient. Asterisks on the left of appear more of luxury feeding, whereas asterisks on the right appear true watch outs.

Green shading indicates a significant increase from accepted nutrient sufficiency ranges.
Yellow shading indicates either slight increase or narrowing of nutrient sufficiency ranges.
Orange would indicate a significant decrease or narrowing of nutrient sufficiency range.

Apply the new corn ranges…

PIONEER agronomy

DM Accumulation lb/ac			
GS	187bu DM	*% Total DM*	*300 bu DM*
V6	641	*3%*	827
V10	2563	*12%*	3306
V14	6281	*30%*	8102
R2	9481	*46%*	12229
R4	15277	*74%*	19705
R6	20697	*100%*	26697
Grain	10488	*51%*	13529

Adapted from Source: Bender, Haegele, Ruffo, and Below, 2013. Nutrient Uptake, Partitioning, and Remobilization in Modern, Transgenic Insect-Protected Maize Hybrids. Agron. J. 105, 1, p161-170.

Average was 187 bushel corn

PIONEER HIGH YIELD CORN NUTRIENT RANGES

V6-V8	Nutrient	N%	S%	P%	K%	*Mg%	*Ca%	*Na%
	PIO Range	3.83-4.34	0.26-0.32	0.35-0.40	3.00-3.59	0.20-0.27	0.45-0.61	0.020-0.037
	Nutrient	B	*Zn	Mn	Fe*	Cu	Al	
	PIO Range	9.82-14.97	31.2-39.5	59.0-87.1	143-208	12.0-16.0	65-114	

VT/R1	Nutrient	N%	S%	*P%	*K%	Mg%	Ca%	Na%
	PIO Range	3.06-3.41	0.21-0.25	0.33-0.38	2.28-2.64	0.19-0.27	0.54-0.87	0.021-0.029
	Nutrient	B	Zn	Mn	Fe	Cu	Al	
	PIO Range	9.03-14.03	23.7-35.8	52.1-71.9	105-129	10.2-12.5	35-98	

R3-R5	Nutrient	N%	S%	P%	*K%	Mg%	Ca%	Na%
	PIO Range	2.54-3.08	0.20-0.25	0.25-0.31	1.52-2.07	0.21-0.31	0.64-0.91	0.025-0.032
	Nutrient	B	Zn	*Mn	Fe	Cu	Al	
	PIO Range	7.45-18.55	26.1-38.9	36.0-80.0	87-111	10.9-15.0	24-38	

* Denotes that relationship exists where a peak is seen. If level is beyond range, consult Pioneer agronomist for specifics on nutrient. Asterisks on the left of appear more of luxury feeding, whereas asterisks on the right appear true watch outs.

Apply the new corn ranges…

PIONEER agronomy

DM DYNAMIC ACROSS YIELDS														
GS	N *lb/ac*	S *lb/ac*	P *lb/ac*	K *lb/ac*	Mg *lb/ac*	Ca *lb/ac*	Na *lb/ac*	B *lb/ac*	Zn *lb/ac*	Mn *lb/ac*	Fe *lb/ac*	Cu *lb/ac*	Al *lb/ac*	*Nutrient Sum*
>264 BU (26697 lb/ac DM)														
V6-V8	33.7	2.4	3.1	27.3	2.0	4.4	0.2	0.1	0.3	0.6	1.4	0.1	0.7	***76.3***
VT-R1	396.2	28.1	42.8	302.1	28.1	85.6	3.1	1.4	3.6	7.6	14.3	1.4	8.2	***922.5***
R2-R5	553.7	43.4	55.2	352.7	53.2	151.7	5.7	2.6	6.4	11.4	19.5	2.5	6.1	***1264.1***
192-228 BU (20697 lb/ac DM)														
V6-V8	24.4	1.6	2.2	17.3	1.6	3.4	0.1	0.1	0.2	0.5	0.9	0.1	0.4	***52.9***
VT-R1	307.2	20.9	33.2	226.6	20.9	51.2	1.8	0.9	2.7	7.8	10.7	1.1	4.7	***689.7***
R2-R5	469.0	36.7	48.9	365.1	38.2	113.0	4.9	1.8	5.6	20.2	20.9	1.8	7.9	***1134.1***
	DIFFERENCE													
V6-V8	**9.3**	**0.8**	**0.9**	**10.0**	**0.4**	**1.0**	**0.1**	**0.0**	**0.1**	**0.1**	**0.5**	**0.0**	**0.3**	***23.4***
VT-R1	**89.0**	**7.2**	**9.6**	**75.5**	**7.2**	**34.4**	**1.3**	**0.5**	**0.9**	**(0.2)**	**3.6**	**0.3**	**3.5**	***233.0***
R2-R5	**84.7**	**6.7**	**6.3**	**(12.4)**	**15.0**	**38.7**	**0.8**	**0.8**	**0.8**	**(8.8)**	**(1.4)**	**0.7**	**(1.8)**	***154.5***

Apply the new soy ranges…

PIONEER agronomy

GS	DM (lb/ac)		
	54bu	66bu	82bu
R1	912	994	1064
R3	3292	3917	4742
R5	5407	6178	7030
R8	6614	7829	9246

Adapted from: Gaspar et al, 2017. *Dry Matter and Nitrogen Uptake, Partitioning, and Removal across a Wide Range of Soybean Seed Yield Levels. Crop Science: 57. 2170-2182.*

PIONEER HIGH YIELD SOYBEAN NUTRIENT RANGES

R1-R2	Nutrient	N%	S%	P%	K%	Mg%*	Ca%	Na%
	PIO Range	5.27-5.80	0.28-0.32	0.50-0.63	2.38-2.82	0.49-0.51	1.01-1.24	0.014-0.022
	Nutrient	*B	Zn	Mn	Fe*	*Cu	Al	
	PIO HY	39-51	46-60	60-80	85-206	11.5-14	16-92	

R2-R3	Nutrient	N%	S%	P%	K%	Mg%	*Ca%	Na%*
	PIO Range	5.18-5.68	0.27-0.30	0.50-0.62	2.14-2.38	0.40-0.46	0.98-1.11	0.015-0.022
	Nutrient	B	Zn	*Mn	Fe*	*Cu	Al	
	PIO Range	43-57	44-51	87-123	71-110	11.2-12.9	18-31	

R4-R5	Nutrient	N%	S%	P%	K%	*Mg%	*Ca%	Na%*
	PIO Range	5.04-5.48	0.29-0.32	0.35-0.41	1.50-1.75	0.39-0.44	1.67-2.04	0.020-0.025
	Nutrient	B	Zn	*Mn	Fe*	*Cu	Al	
	PIO Range	52-63	57-72	145-207	98-116	9-12	21-29	

* Denotes that relationship exists where a peak is seen. If level is beyond range, consult Pioneer agronomist for specifics on nutrient. Asterisks on the left of appear more of luxury feeding, whereas asterisks on the right appear true watch outs.

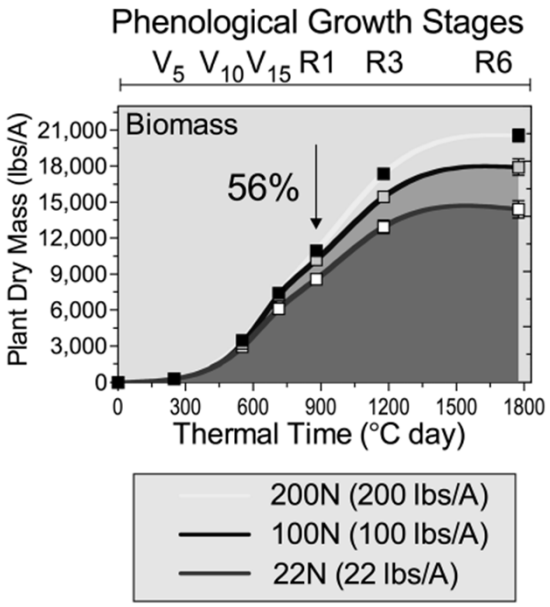
Green shading indicates a significant increase from accepted nutrient sufficiency ranges.
Yellow shading indicates either slight increase or narrowing of nutrient sufficiency ranges.
Orange would indicate a significant decrease or narrowing of nutrient sufficiency range.

Apply the new soy ranges…

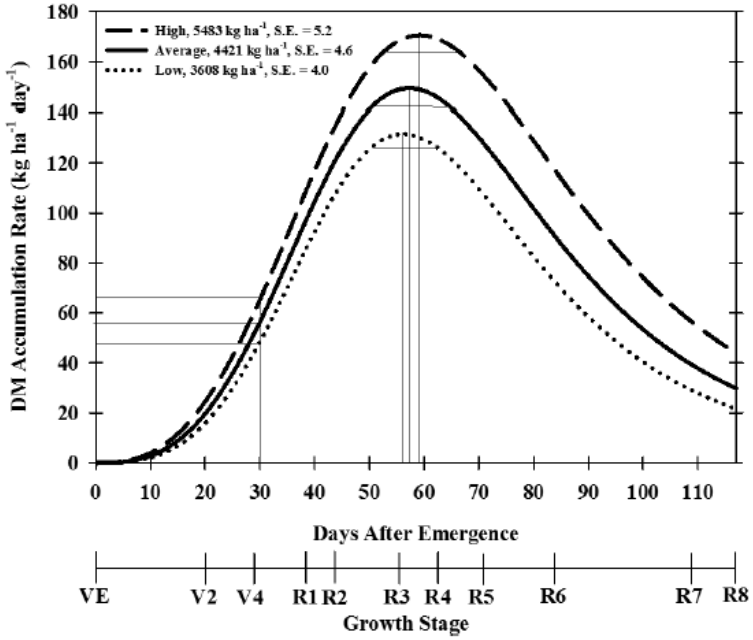
PIONEER agronomy

DM DYNAMIC ACROSS YIELDS														
GS	N *lb/ac*	S *lb/ac*	P *lb/ac*	K *lb/ac*	Mg *lb/ac*	Ca *lb/ac*	Na *lb/ac*	B *lb/ac*	Zn *lb/ac*	Mn *lb/ac*	Fe *lb/ac*	Cu *lb/ac*	Al *lb/ac*	***Nutrient Sum***
>88 BU (8880 lb/ac DM)														
R1 (680)	58.9	3.2	6.1	27.7	5.0	12.0	0.2	0.5	0.6	0.7	1.5	0.1	0.6	
R3 (4280)	257.5	13.8	26.6	107.2	20.4	52.6	0.9	2.4	2.6	5.1	4.3	0.6	1.2	
R5 (7930)	369.8	21.1	26.7	113.9	28.8	130.1	1.5	4.1	4.5	12.4	7.5	0.7	1.8	
66 BU (7630) lb/ac DM)														
R1 (580)	53.7	2.9	4.8	22.1	4.4	11.0	0.2	0.4	0.5	0.7	1.5	0.1	0.5	
R3 (3880)	222.1	11.4	18.0	77.2	15.3	43.1	0.9	1.8	1.9	2.7	4.4	0.5	1.1	
R5 (6880)	317.5	16.7	23.5	100.1	19.8	93.9	1.7	2.6	2.8	5.9	8.8	0.9	2.0	
	DIFFERENCE													
R1	**5.3**	**0.3**	**1.3**	**5.6**	**0.6**	**1.0**	**(0.0)**	**0.0**	**0.1**	**0.0**	**0.1**	**(0.0)**	**0.1**	**14.5**
R3	**35.4**	**2.4**	**8.5**	**30.0**	**5.1**	**9.5**	**(0.1)**	**0.5**	**0.6**	**2.3**	**(0.1)**	**0.1**	**0.0**	**94.6**
R5	**52.2**	**4.4**	**3.2**	**13.8**	**9.1**	**36.1**	**(0.1)**	**1.5**	**1.7**	**6.4**	**(1.3)**	**(0.2)**	**(0.3)**	**128.5**

Quick Math



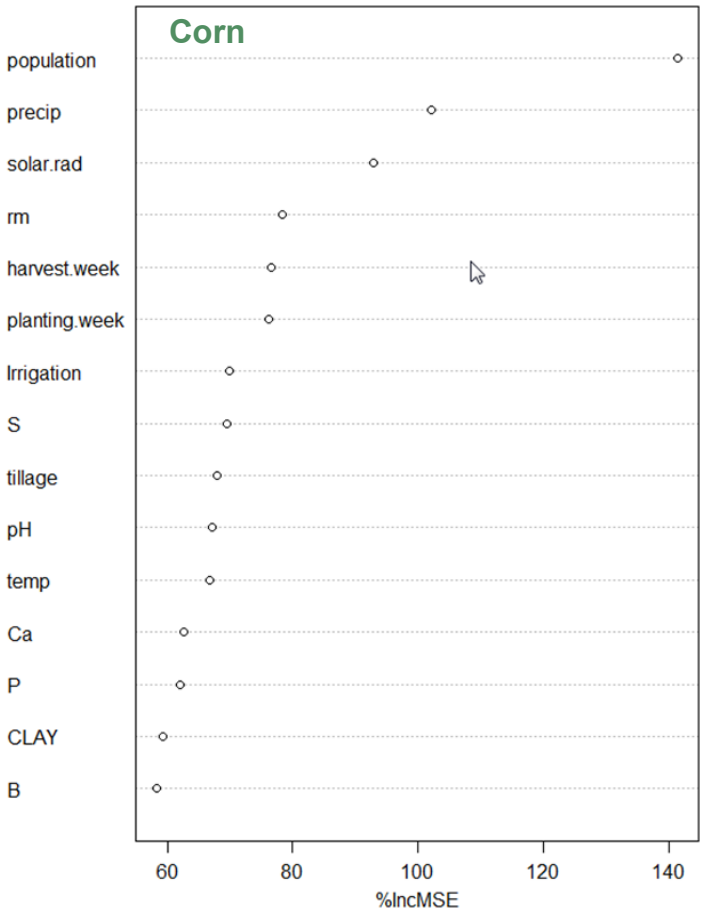
VT P diff in DM = 10 lb
P → P2O5 = 30# P2O5
P2O5 to TSP → **49# TSP**

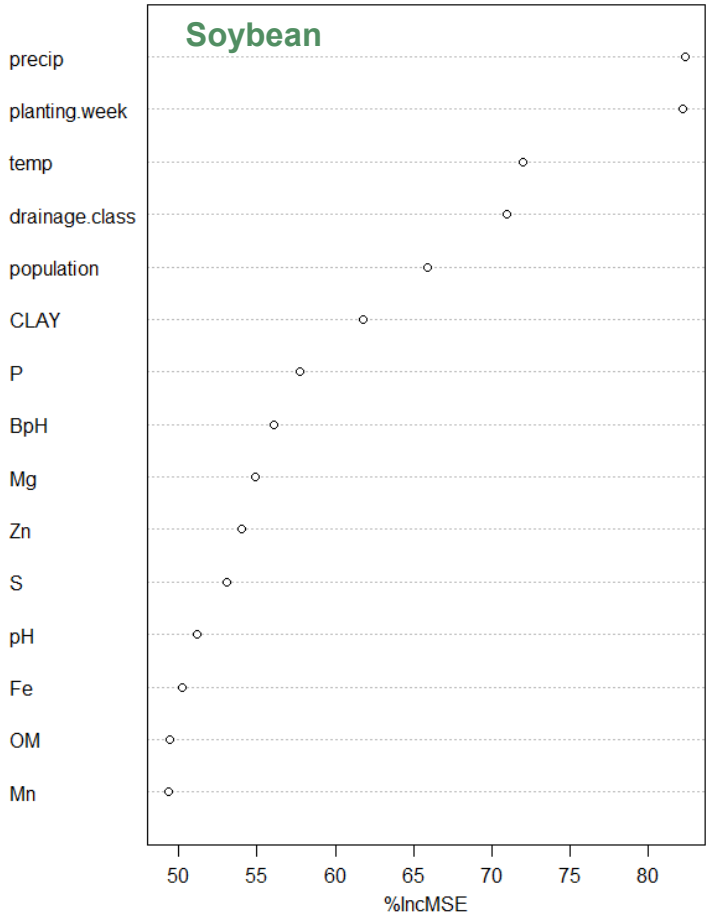


R3 K diff in DM = 30 lb
K → K2O = 36# K2O
K2O to MOP → **60# MOP**

AI and Plot Characterization

Rank impact of variables





Takeaways

- Critical nutrient values in tissue, in general, do appear to be different at higher yield levels vs lower yield levels.
- Tissue sampling coupled with refined nutrient ranges may offer waypoints for a management plan to boost yield levels.
- New values may allow better focus on nutrient balance and maximizing ROI.
- Reach out to your local Pioneer Representative for more information or participation in this project. This is an ongoing project; the more quality data points, the better the outcome.