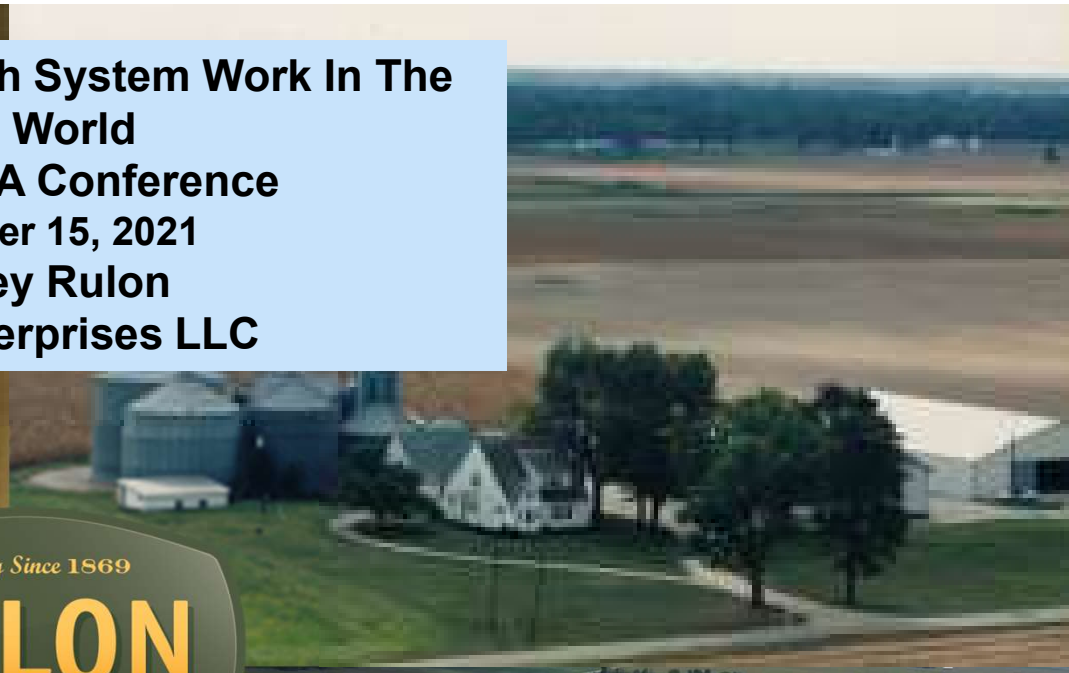
Making A Soil Health System Work In The Real World

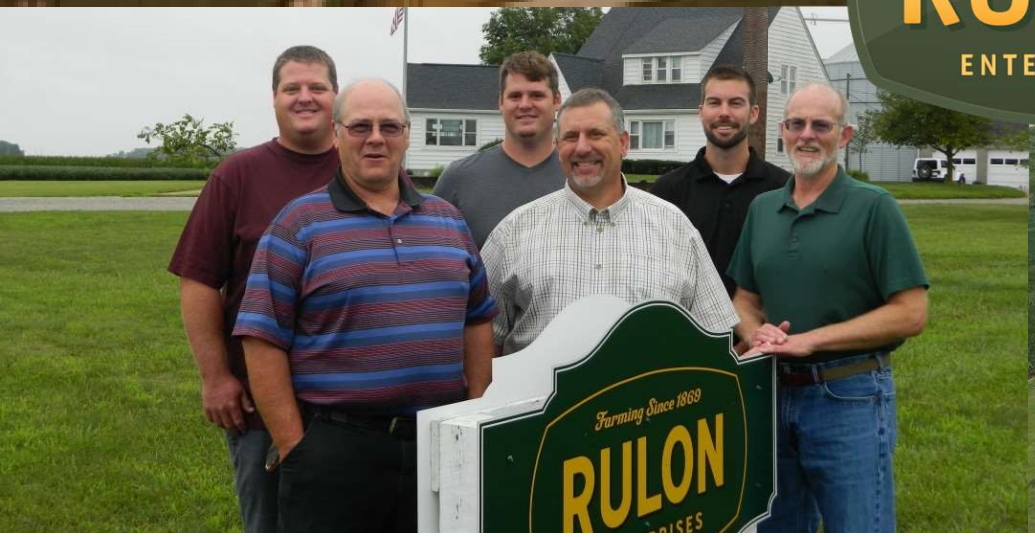
Indiana CCA Conference

December 15, 2021

Rodney Rulon
Rulon Enterprises LLC



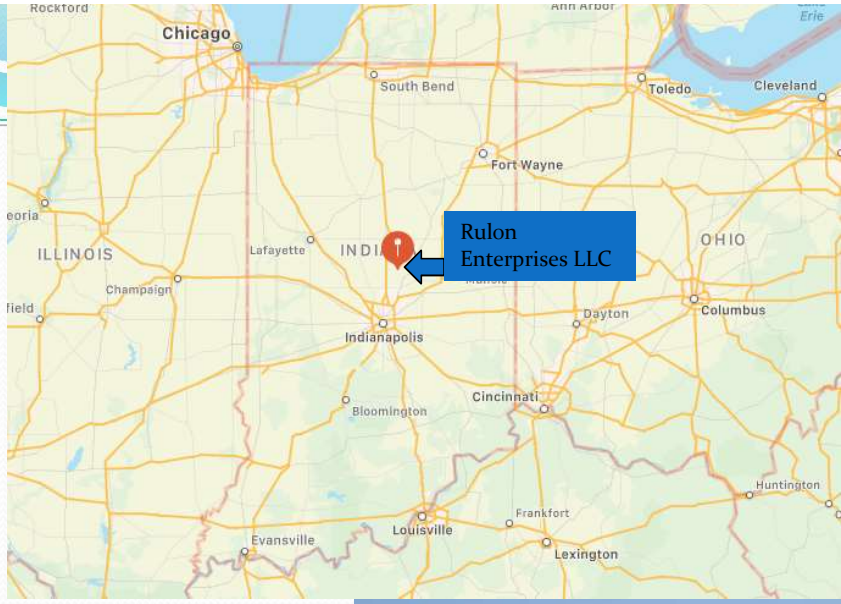
Farming Since 1869
RULON
ENTERPRISES



Our Cropping System:

PRODUCTIVE & SUSTAINABLE

-5th Generation family farm
-North Central Indiana
-Continuous No-Till since 1989
-7200 acres Corn/Soybean Rotation
-20 years cover crops
-1 acre grid management w/ full VRT



Conservation is the best economic model
We are accountable for what leaves our farm

We are a Legacy Farm

Healthy Soil is a System

- No-Till (infiltration/OM/cover/biology)
- Cover Crops (rooting/temp/OM/feed biology)
- Soil Carbon/Soil Health
- Drainage (Managing Air/Water)
- Soil Balance (Proper Chemistry-Structure)
- VRT N, P, K , Seed etc.
- VRT Lime/Gypsum/amendments/Litter/Manure
- Variety Selection (Plant health and Yield)
- Integrated Pest Management (IPM)
- On Farm Testing - Economic Tracking

Steps To Manage Soil Quality:

- **#1 Continuous No-Till – not rotational**
  - Eliminate catastrophic tillage events
  - Allow soil to build structure and biology
  - NO Erosion, NO Bare Soil, STOP leaching of nutrients, Manage Infiltration
- **Stop Soil Degredation/Increase Soil Carbon**

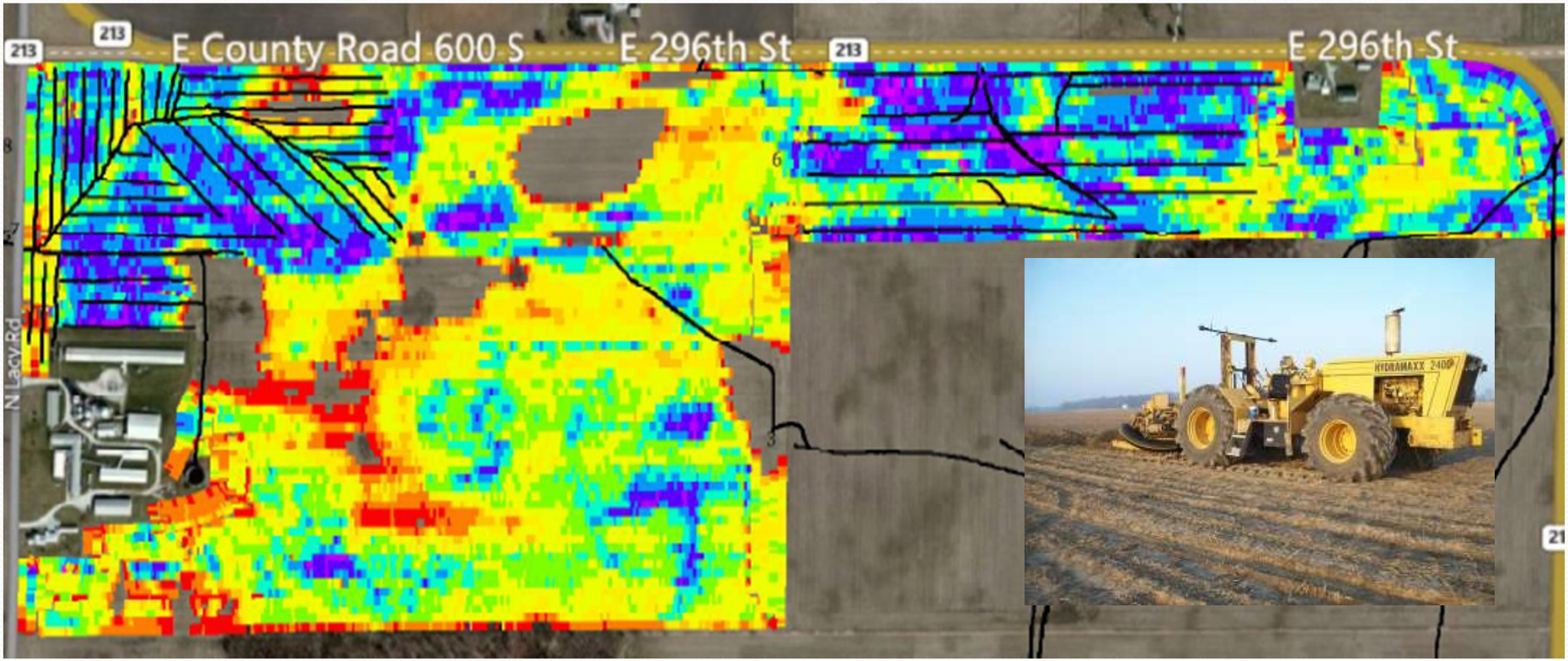
  <u>Build a SOIL HEALTH SYSTEM</u>





Step #2 Drainage

- **Drainage is Foundational to No-till and Soil Health**



Step #3 Manage Fertility:

- 1 Acre grid Fertility
- Hi-Cal Lime/Gypsum (Where Mg Lime has been over used)
- <u>Balanced Soil is More Stable</u>

Step #4 Cover Crops

- **Manage for long term Soil Health/Build OM - FAST**

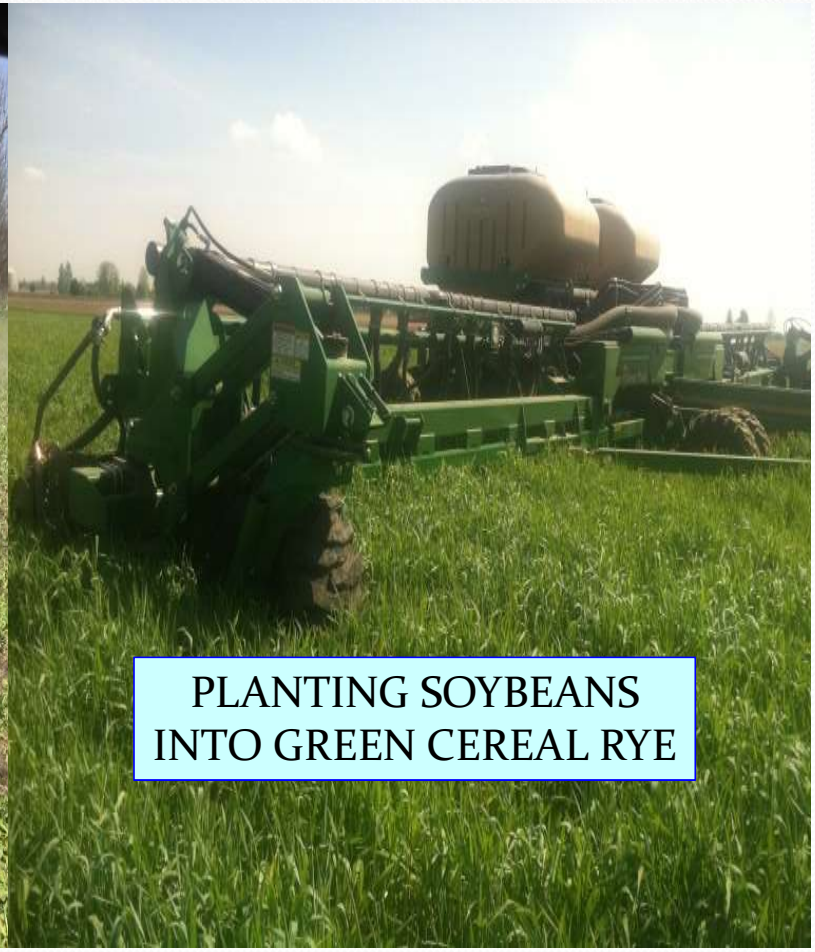
BUILDING SOIL HEALTH

REQUIRES

CARBON CAPTURE

CAN WE INCREASE SOIL CARBON?

PLANTING CORN
INTO GREEN RAPESEED+CLOVER



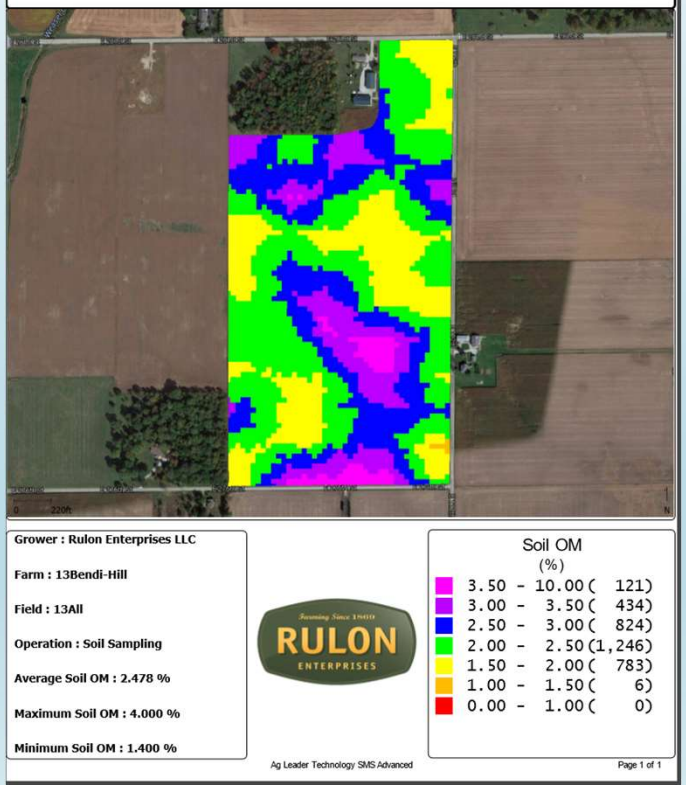
PLANTING SOYBEANS
INTO GREEN CEREAL RYE

PROVEN CARBON CAPTURE

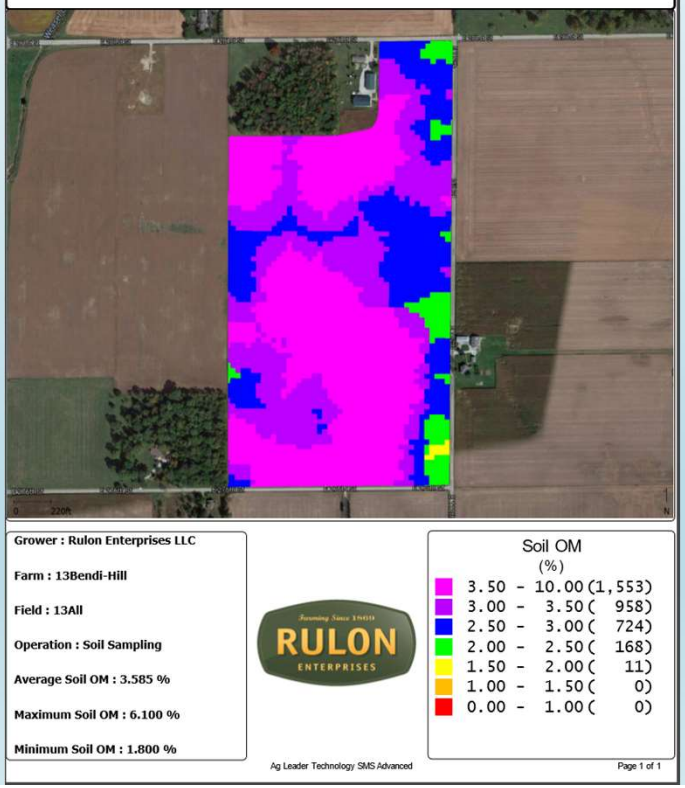
Organic Matter Average + 1.1% (0.1%/yr)

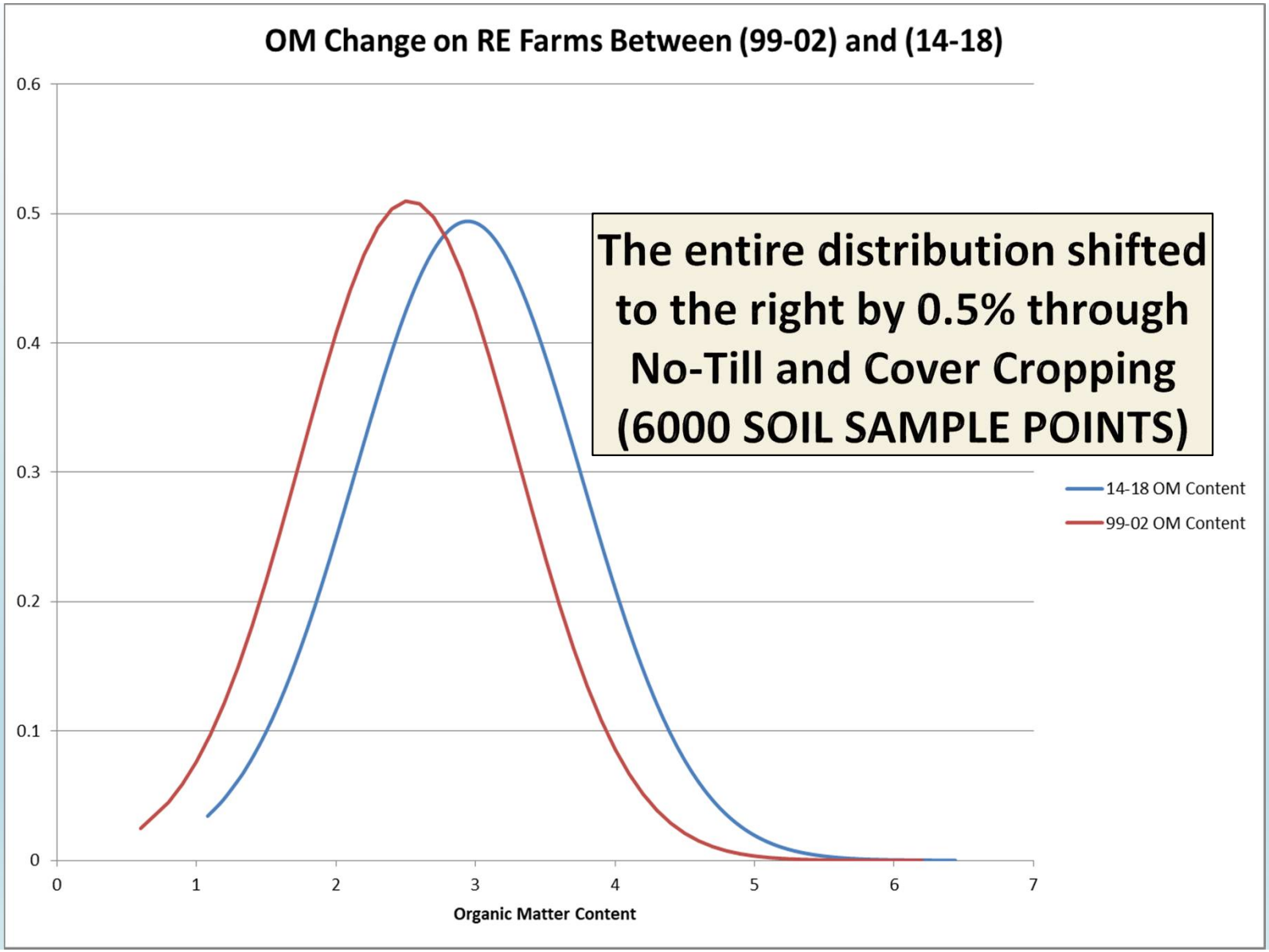
2.47 (1.4 to 4.0) **3.58** (1.8 to 6.1)

SOIL OM% YEAR 1



SOIL OM% YEAR 10




OM Change on RE Farms Between (99-02) and (14-18)
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
6
7
Organic Matter Content
The entire distribution shifted to the right by 0.5% through No-Till and Cover Cropping (6000 SOIL SAMPLE POINTS)
14-18 OM Content
99-02 OM Content

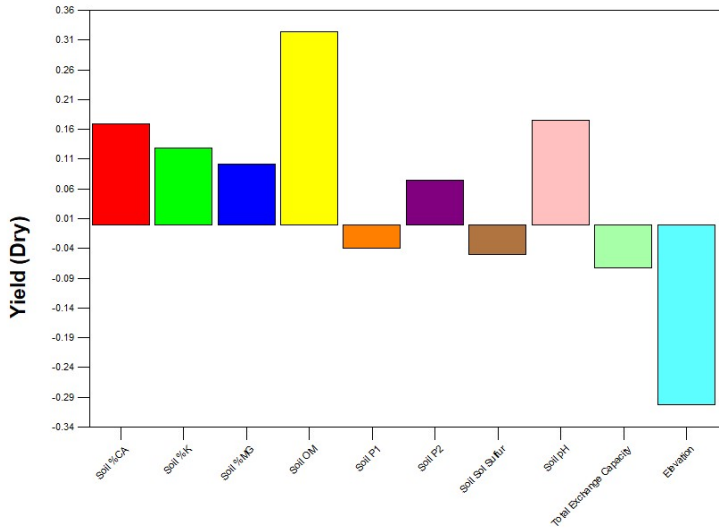
What's The Connection?

Analysis Description
Generates a correlation table for selected attribu
Rulon Enterprises | 02HartleyPlace | 02Hartley | Analysis Results | Corn | CORN | NO Pest | Inst Multi-Year Averages Analysis
Analysis Results

Correlation Analysis:

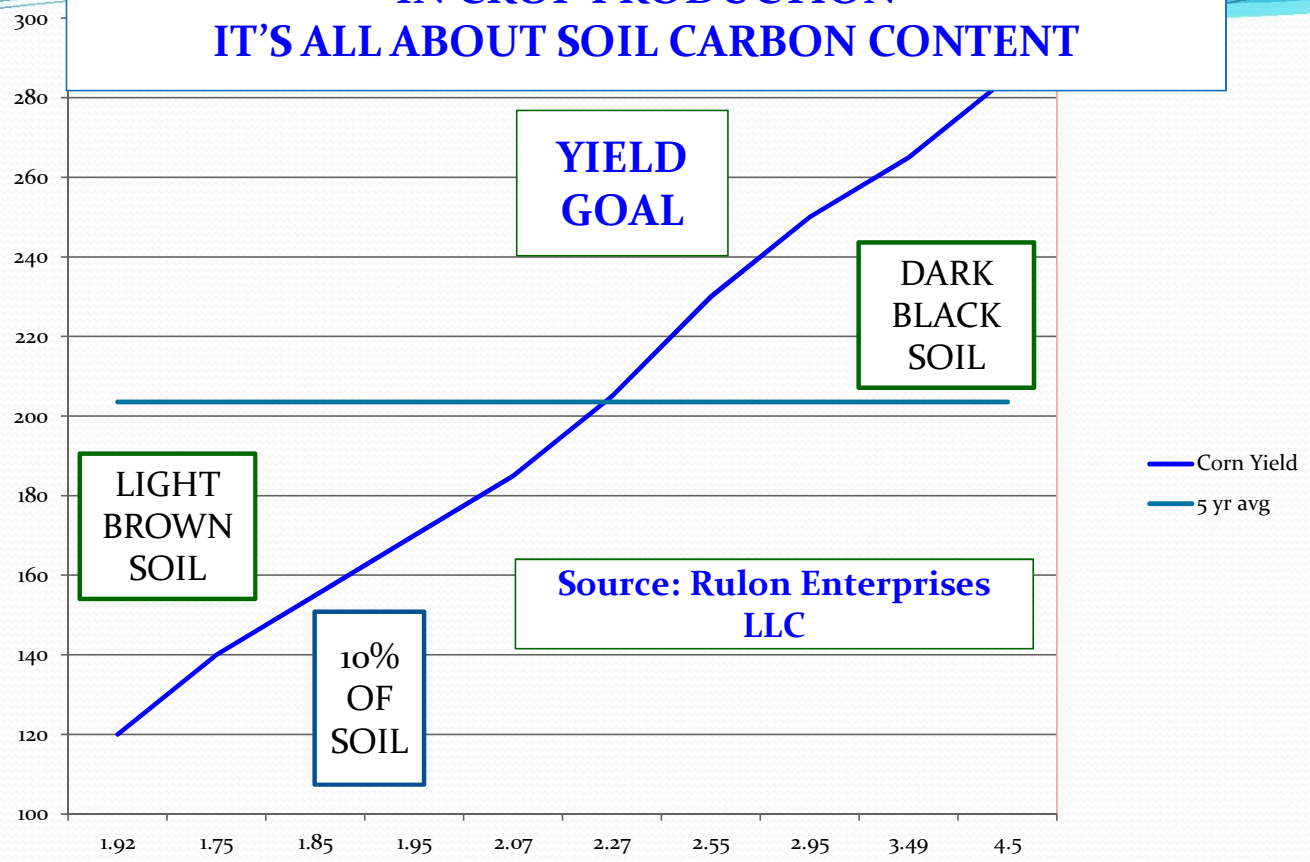
- MG has a fairly strong negative correlation
- OM and TEC both have strong positive correlation

- What does that mean?
  - %MG decrease = yield increases
  - OM or TEC increase = yield increases



ATTRIBUTE	Soil %CA (1)	Soil %K (1)	Soil %MG (1)	Soil OM (1)	Soil P1 (1)	Soil P2 (1)	Soil Sol Sulfur (1)	Soil pH (1)	Total Exchange Capacity (1)	Elevation (1)	Estimated Volume (Dry) (1)	Moisture (1)
Soil %CA	1.000	0.618	0.597	-0.018	0.182	0.192	-0.294	0.936	-0.605	-0.120	-0.272	-0.120
Soil %K	0.618	1.000	0.311	0.105	0.363	0.356	-0.577	0.600	-0.592	-0.298	-0.072	-0.139
Soil %MG	0.597	0.311	1.000	-0.102	0.100	0.132	-0.308	0.778	-0.407	-0.160	-0.384	-0.125
Soil OM	-0.018	0.105	-0.102	1.000	0.140	0.226	-0.051	-0.091	0.487	-0.534	0.449	-0.354
Soil P1	0.182	0.363	0.100	0.140	1.000	0.987	0.011	0.291	0.123	-0.124	0.244	-0.338
Soil P2	0.192	0.356	0.132	0.226	0.987	1.000	0.010	0.297	0.183	-0.166	0.281	-0.397
Soil Sol Sulfur	-0.294	-0.577	-0.308	-0.051	0.011	0.010	1.000	-0.291	0.595	0.059	0.111	0.054
Soil pH	0.936	0.600	0.778	-0.091	0.291	0.297	-0.291	1.000	-0.576	-0.147	-0.317	-0.147
Total Exchange Capacity	-0.605	-0.592	-0.407	0.487	0.123	0.183	0.595	-0.576	1.000	-0.099	0.503	-0.230
Elevation	-0.120	-0.298	-0.160	-0.534	-0.124	-0.166	0.059	-0.147	-0.099	1.000	-0.092	0.123
Estimated Volume (Dry)	-0.272	-0.072	-0.384	0.449	0.244	0.281	0.111	-0.317	0.503	-0.092	1.000	-0.274
Moisture	-0.120	-0.139	-0.125	-0.354	-0.338	-0.397	0.054	-0.147	-0.230	0.123	-0.274	1.000

IN CROP PRODUCTION
IT'S ALL ABOUT SOIL CARBON CONTENT



SOIL %OM CONTENT ON OUR INDIANA FARM BY PERCENTILE

1 Acre Grid Soil Samples

Whole farm spatial fertility Record Since 1996

1 Acre Grids = 80% reliable

Invest the Money and do it right.

Resolution = Value

Input Management and Planning

More than P, K, Lime , Seed, Gypsum, N -
can't do well with less than 1/acre

Yield Correlations and Tracking

= Farm Specific Recs

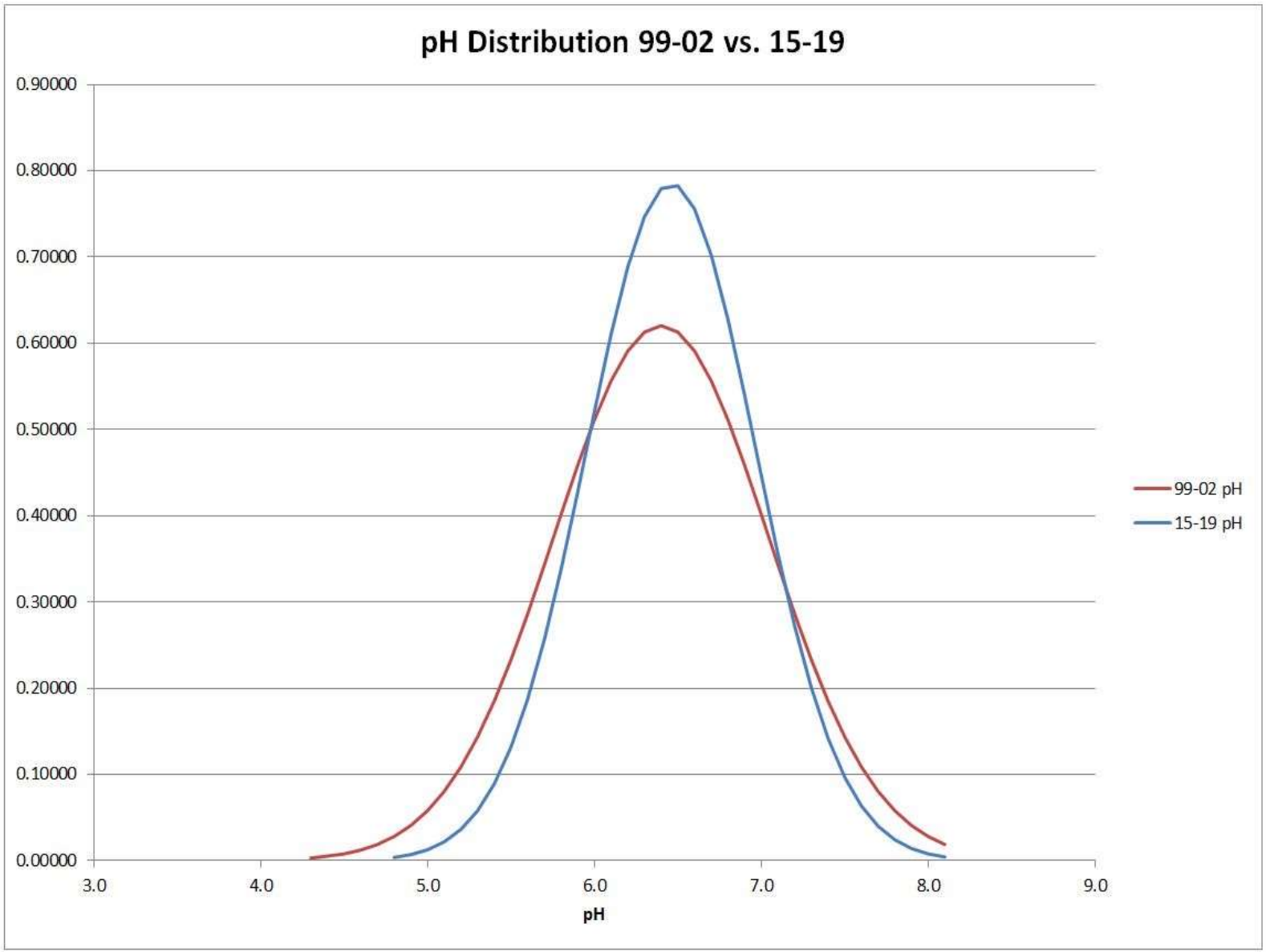
Prediction and Validation

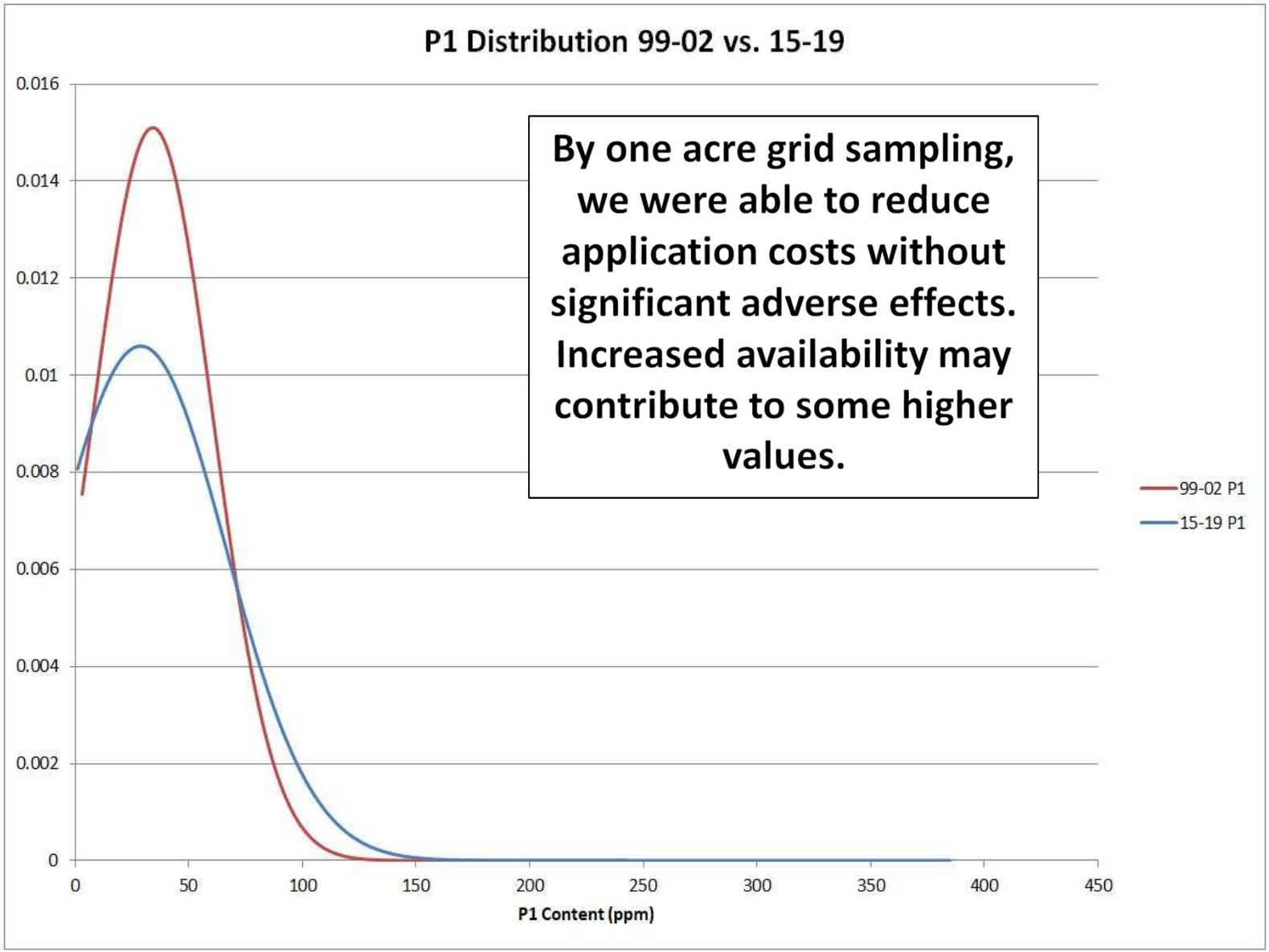
<u>Manage Productivity, Health and Balance of Soil</u>

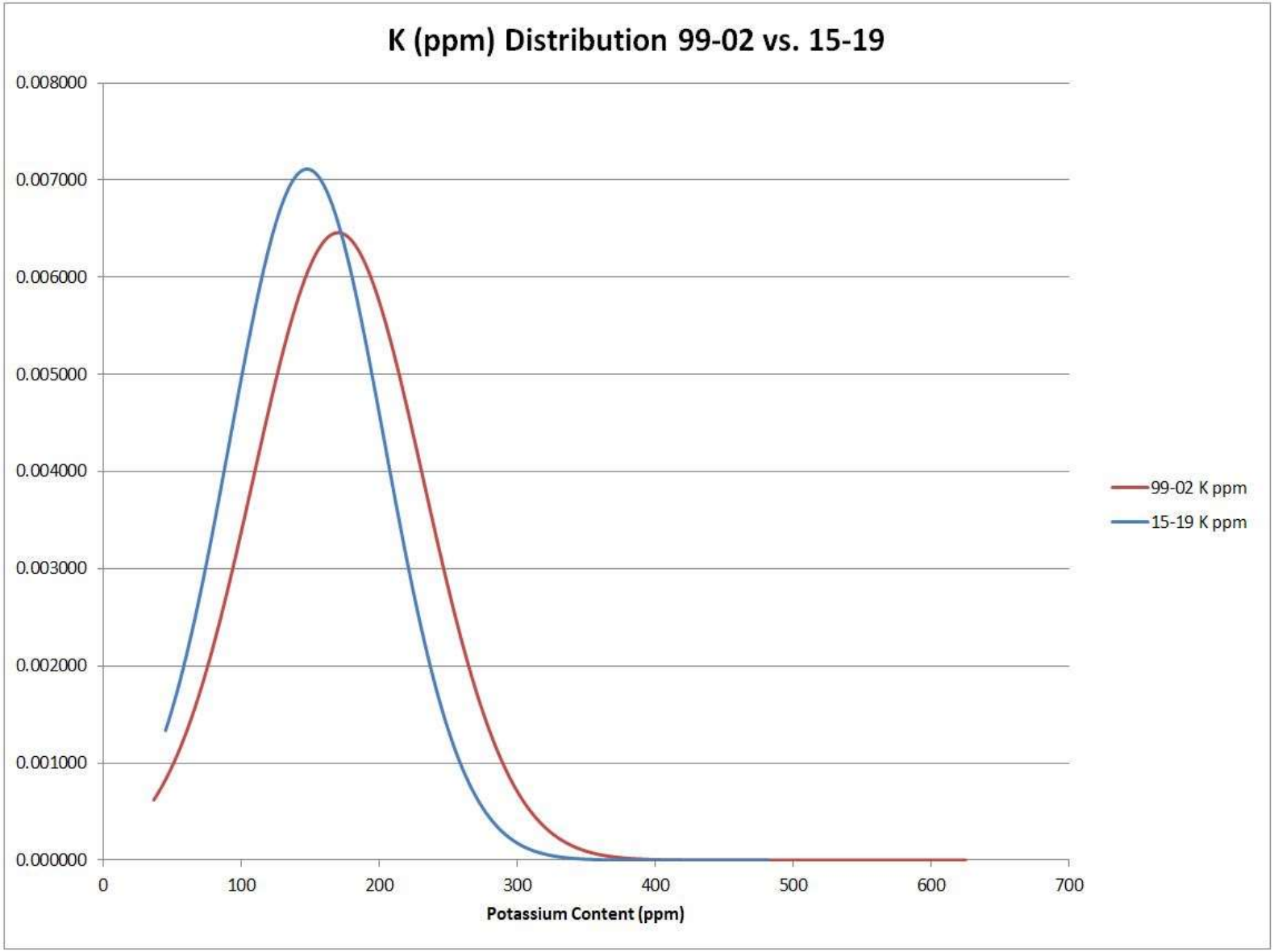
Soil Sample Percentile Breakdown
6000 Samples 2015-2019

%	TEC	pH	OM	N lb/ac	S ppm	Easy P P2O5	P1 ppm	Easy P ppm	k ppm	ca %	mg %	K %	na %	Other %	H %
5%	10.36	5.6	1.92	58	7	46	4	10	77	54.68	7.6	1.3	0.32	4.1	0
10%	11.23	5.8	2.07	61	8	60	6	13	86	59.95	8.37	1.47	0.38	4.3	0
15%	11.95	5.9	2.19	64	8	64	14	7	93	62.89	8.93	1.59	0.41	4.4	0
20%	12.54	6	2.28	66	9	73	9	16	100	64.81	9.44	1.68	0.45	4.5	1.5
25%	13.05	6.1	2.36	67	10	82	10	18	107	66.4	9.93	1.77	0.48	4.6	3
30%	13.62	6.2	2.45	69	10	87	12	19	112	67.45	10.4	1.86	0.51	4.7	4.5
35%	14.15	6.3	2.54	71	10	96	13	21	118	68.46	10.84	1.93	0.53	4.7	4.5
40%	14.67	6.3	2.64	73	11	105	15	23	124	69.38	11.31	2.02	0.56	4.8	6
45%	15.22	6.4	2.75	75	11	115	17	25	132	70.26	11.75	2.11	0.59	4.9	7.5
50%	15.79	6.5	2.85	77	12	128	19	28	138	71.01	12.2	2.19	0.61	4.9	7.5
55%	16.35	6.5	2.96	79	13	142	22	31	145	71.92	12.64	2.29	0.64	5	9
60%	17.07	6.6	3.07	81	13	156	25	34	152	72.61	13.12	2.39	0.67	5.1	10.5
65%	17.81	6.7	3.19	82	14	174	29	38	160	73.49	13.69	2.49	0.71	5.1	10.5
70%	18.6	6.7	3.31	83	16	192	34	42	169	74.29	14.27	2.6	0.75	5.2	12
75%	19.58	6.8	3.47	85	19	224	41	49	178	75.09	14.89	2.74	0.79	5.2	13.5
80%	20.64	6.9	3.64	86	30	252	50	55	190	76.02	15.57	2.87	0.85	5.4	15
85%	21.91	7	3.84	88	80	293	65	64	204	77.16	16.51	3.05	0.91	5.6	18
90%	23.6	7.1	4.09	91	149	357	94	78	222	78.5	17.66	3.31	0.98	5.8	21
95%	26.44	7.3	4.48	95	236	467	0	102	250	80.51	19.75	3.75	1.1	6.2	27
100%	74.7	8.1	16.36	128	5978	3412	0	745	482	90.15	30.18	7.42	6.45	7.8	49

This chart shows the nutrient values over all of our farms ranked in 5% intervals. We use this chart to help in writing our formulas for seeding rate, N rate, etc.


pH Distribution 99-02 vs. 15-19
0.90000
0.80000
0.70000
0.60000
0.50000
0.40000
0.30000
0.20000
0.10000
0.00000
3.0
4.0
5.0
6.0
7.0
8.0
9.0
pH
99-02 pH
15-19 pH


P1 Distribution 99-02 vs. 15-19
By one acre grid sampling, we were able to reduce application costs without significant adverse effects. Increased availability may contribute to some higher values.
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
0
50
100
150
200
250
300
350
400
450
P1 Content (ppm)
99-02 P1
15-19 P1


K (ppm) Distribution 99-02 vs. 15-19
0.008000
0.007000
0.006000
0.005000
0.004000
0.003000
0.002000
0.001000
0.000000
0
100
200
300
400
500
600
700
Potassium Content (ppm)
99-02 K ppm
15-19 K ppm

P & K

Long term continuous no-till will improve nutrient use efficiency

Adequate P & K levels and soil balance are critical to low risk, high yielding production.

This should be accomplished with a well thought out nutrient management plan and applications should be made based on good quality soil tests and sound economic recommendations. Over application to avoid ever having P or K as a limiting factor is no longer practical.

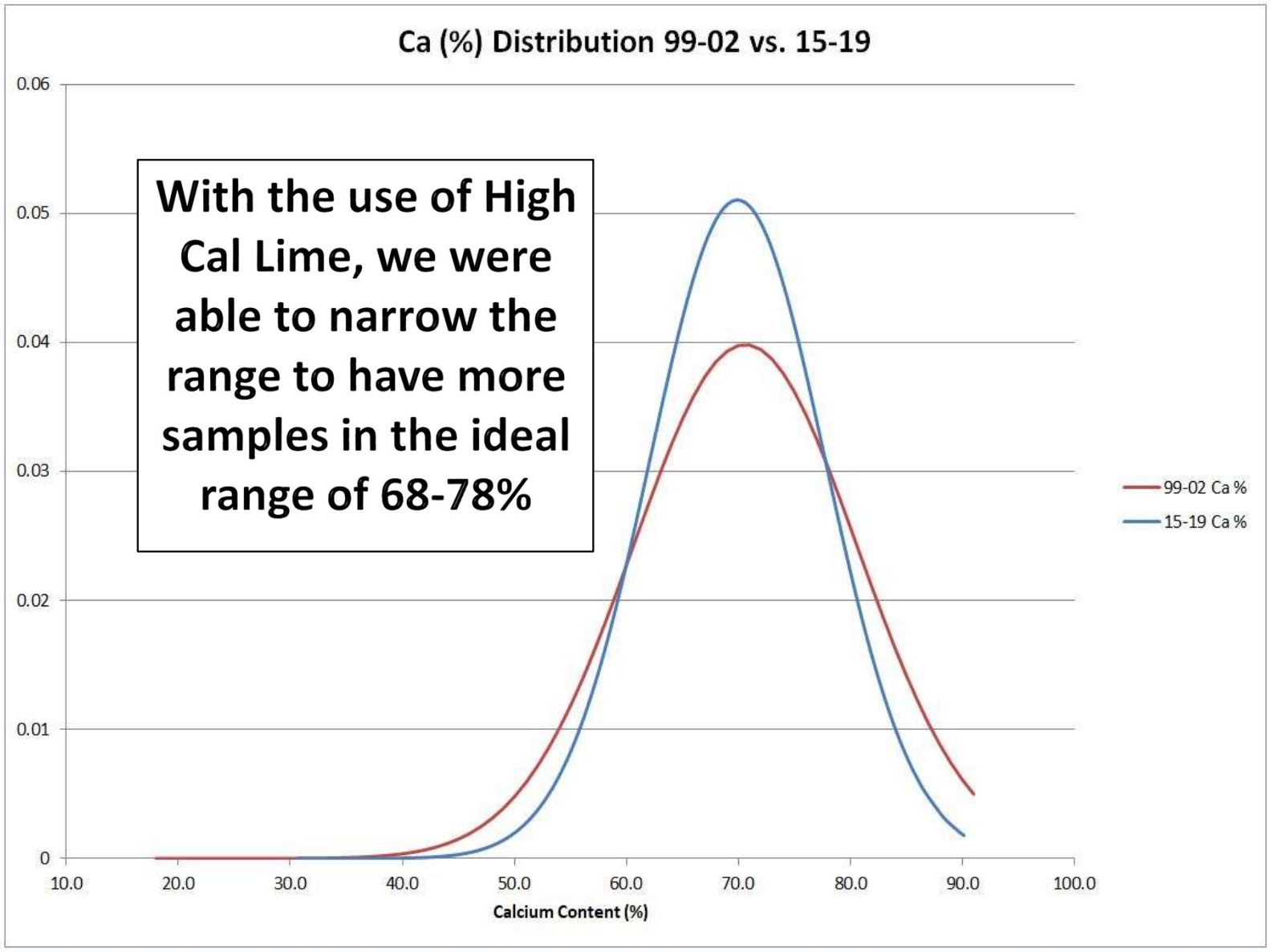
Lime & Gypsum/Amendments

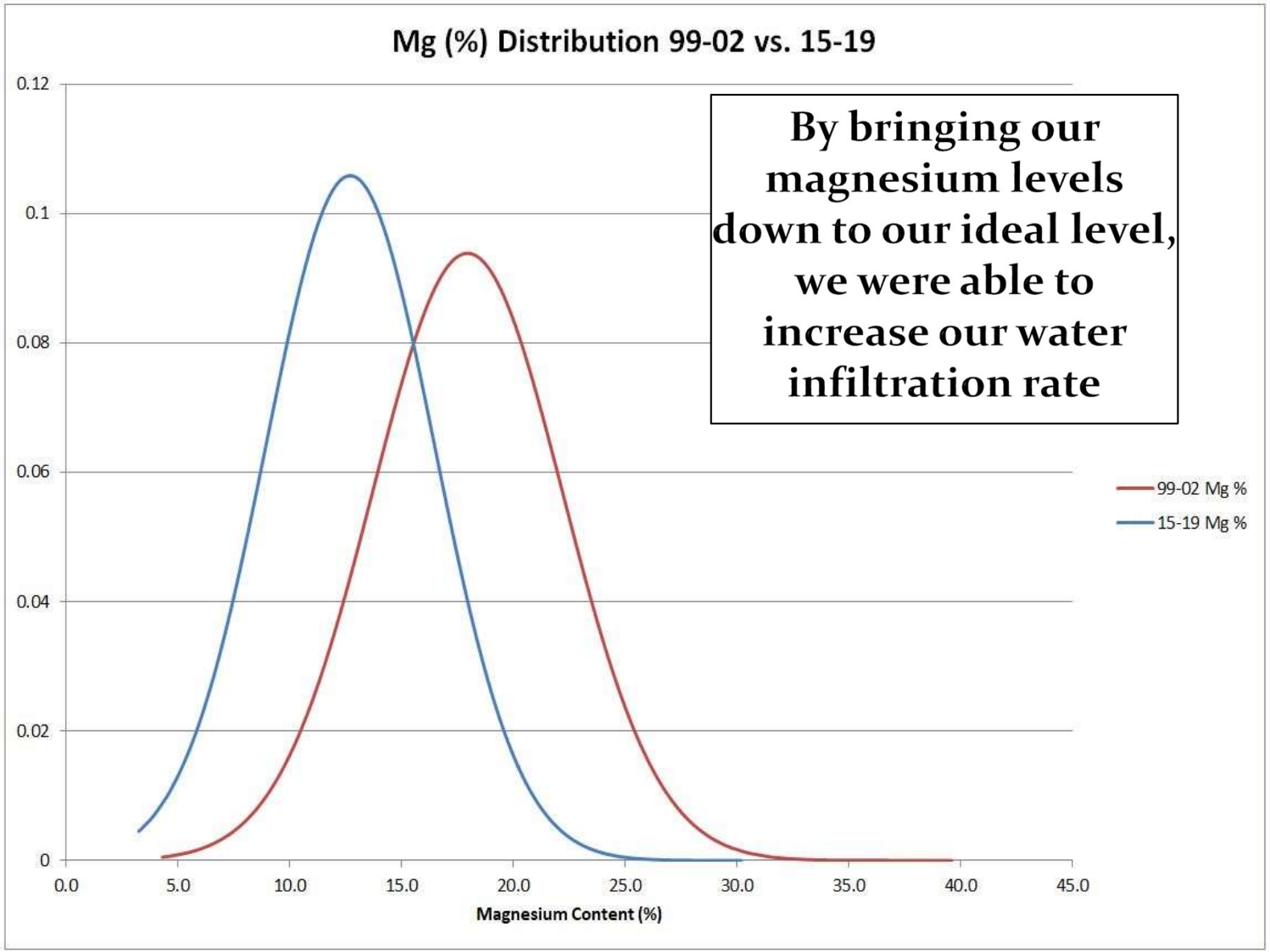
Ca is Critical to build soil structure and healthy no-till soils.

Excellent use of quality VRT maps – over application can be as bad as under application

25 years of VRT Hi-Cal lime

Result: Current average need less than 0.8 t/a/4 years


Ca (%) Distribution 99-02 vs. 15-19
With the use of High Cal Lime, we were able to narrow the range to have more samples in the ideal range of 68-78%
0.06
0.05
0.04
0.03
0.02
0.01
0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Calcium Content (%)
99-02 Ca %
15-19 Ca %


Mg (%) Distribution 99-02 vs. 15-19
0.12
0.1
0.08
0.06
0.04
0.02
0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
Magnesium Content (%)
99-02 Mg %
15-19 Mg %
By bringing our magnesium levels down to our ideal level, we were able to increase our water infiltration rate

The Best Indicator for us?

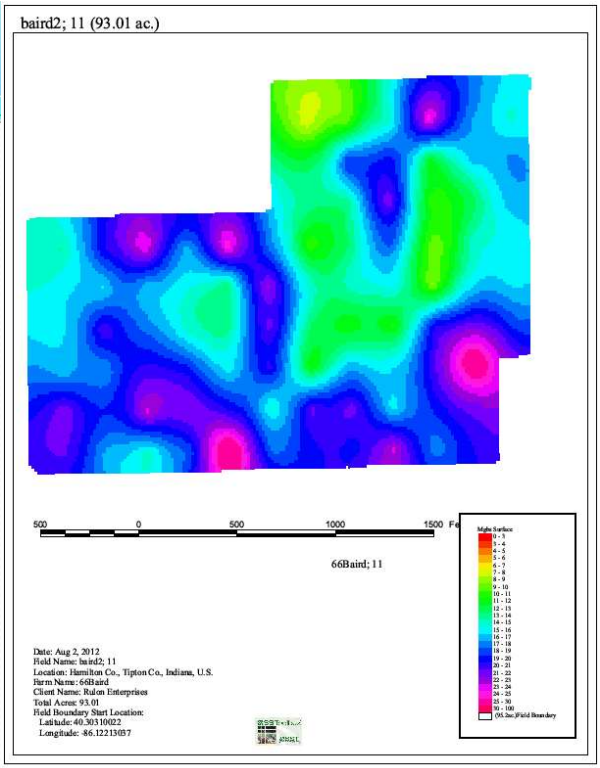
Organic Matter.

Beats:

Soil type, yield, conductivity, soil test levels

Similar to:

Topo, yield potential, CEC



Organic Matter Based Equations

NH3 2016

If ([Soil OM(%)] > 0.00 AND [Soil OM(%)] <= 1.7) Then RESULT= (95.00)

Else If ([Soil OM(%)] > 1.7 AND [Soil OM(%)] <= 1.8) Then RESULT= (100.00)

Else If ([Soil OM(%)] > 1.8 AND [Soil OM(%)] <= 1.9) Then RESULT= (110.00)

Else If ([Soil OM(%)] > 1.9 AND [Soil OM(%)] <= 2.0) Then RESULT= (115.00)

Else If ([Soil OM(%)] > 2.0 AND [Soil OM(%)] <= 2.15) Then RESULT= (120.00)

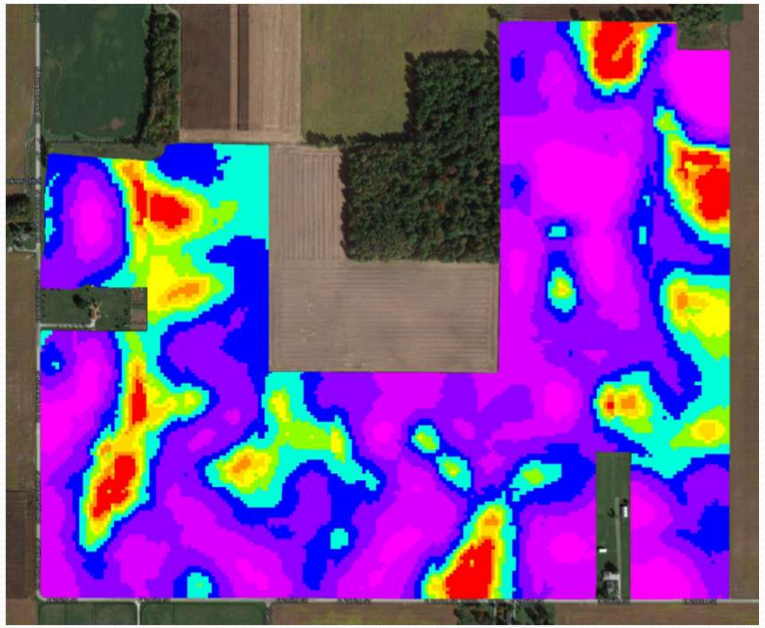
Else If ([Soil OM(%)] > 2.15 AND [Soil OM(%)] <= 2.4) Then RESULT= (125.00)

Else If ([Soil OM(%)] > 2.4 AND [Soil OM(%)] <= 2.7) Then RESULT= (135.00)

Else If ([Soil OM(%)] > 2.7 AND [Soil OM(%)] <= 3.2) Then RESULT= (140.00)

Else If ([Soil OM(%)] > 3.2 AND [Soil OM(%)] <= 3.8) Then RESULT= (155.00)

Else If ([Soil OM(%)] > 3.8 AND [Soil OM(%)] <= 100) Then RESULT= (165.00)



OM LOW	OM HIGH	Yield	lbs/bu	Total N	Planter	Cover Crop	Bean Credit	om/100	Soil Carbon Total	% of Carbon as N	Mineralized N %	Sidedress N	%loss	Net	REC
1.6	1.7	90	1.4	126	25	1	30	0.016	1000000	0.05	0.03	46	0.4	64.4	65
1.7	1.8	100	1.35	135	25	1	30	0.017	1000000	0.05	0.03	53.5	0.4	74.9	75
1.8	1.9	120	1.3	156	25	1	30	0.018	1000000	0.05	0.04	64	0.4	89.6	90
1.9	2	140	1.25	175	25	1	30	0.019	1000000	0.05	0.04	81	0.4	113.4	115
2	2.14	160	1.2	192	25	1	30	0.02	1000000	0.05	0.04	96	0.3	124.8	120
2.14	2.4	170	1.2	204	25	1	30	0.0214	1000000	0.05	0.05	94.5	0.3	122.9	125
2.4	2.7	190	1.15	218.5	25	1	30	0.024	1000000	0.05	0.05	102.5	0.3	133.3	135
2.7	3.2	210	1.1	231	25	1	30	0.027	1000000	0.05	0.05	107.5	0.3	139.8	140
3.2	3.8	230	1.1	253	25	1	30	0.032	1000000	0.05	0.05	117	0.3	152.1	155
3.8	4	260	1.05	273	25	1	30	0.038	1000000	0.05	0.05	122	0.3	158.6	165

VRT/OM Based Equations

Soybeans

Corn

P, K, Lime

Gypsum

Nitrogen

Cover Crops and Litter

Soybeans and OM

Soybeans-That was Easy!!

150K Beans

(([Org] < 1.6)) : (198000)

(([Org] >= 1.6) and ([Org] < 1.8)) : (186000)

(([Org] >= 1.8) and ([Org] < 1.9)) : (174000)

(([Org] >= 1.9) and ([Org] < 2.1)) : (162000)

(([Org] >= 2.1) and ([Org] < 2.3)) : (150000)

(([Org] >= 2.3) and ([Org] < 2.5)) : (138000)

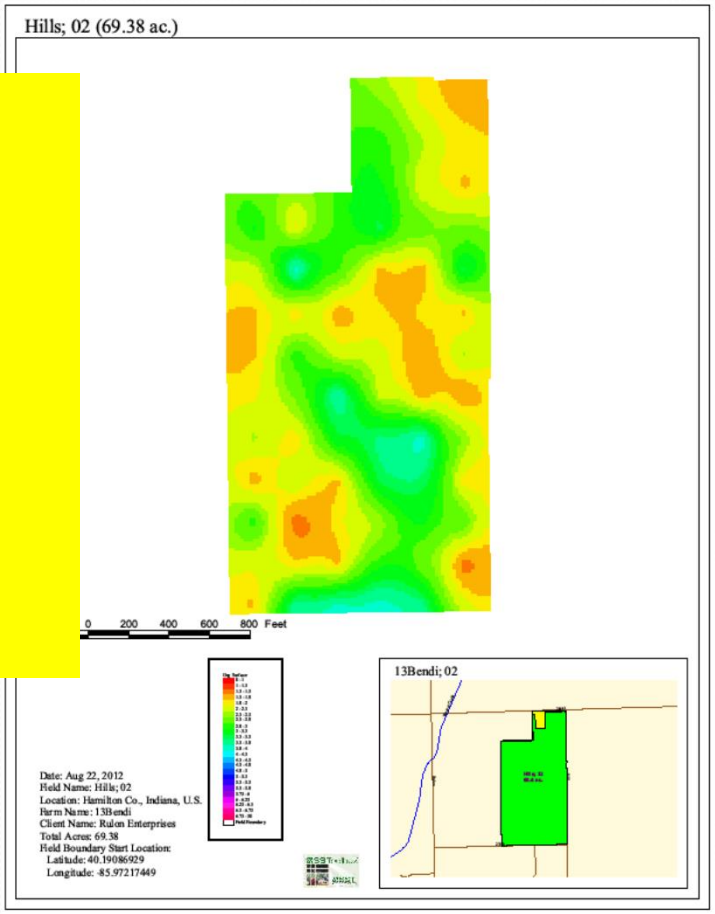
(([Org] >= 2.5) and ([Org] < 2.8)) : (126000)

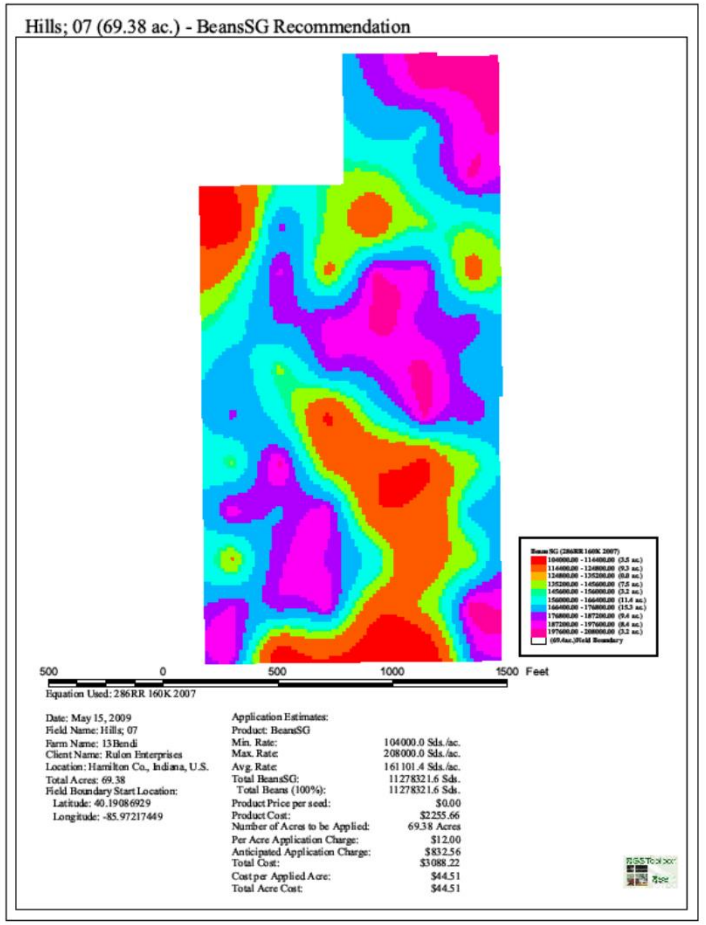
(([Org] >= 2.8) and ([Org] < 3.1)) : (114000)

(([Org] >= 3.1) and ([Org] < 3.5)) : (106000)

(([Org] >= 3.5) and ([Org] < 50)) : (94000)

GENERAL VALUES FOR REFERENCE ONLY





Corn and OM

Corn

(([Org] < 1.7)) : (24000)

(([Org] >= 1.7) and ([Org] < 1.8)) : (25000)

(([Org] >= 1.8) and ([Org] < 1.9)) : (26000)

(([Org] >= 1.9) and ([Org] < 2.0)) : (28000)

(([Org] >= 2.0) and ([Org] < 2.15)) : (30000)

(([Org] >= 2.15) and ([Org] < 2.4)) : (32000)

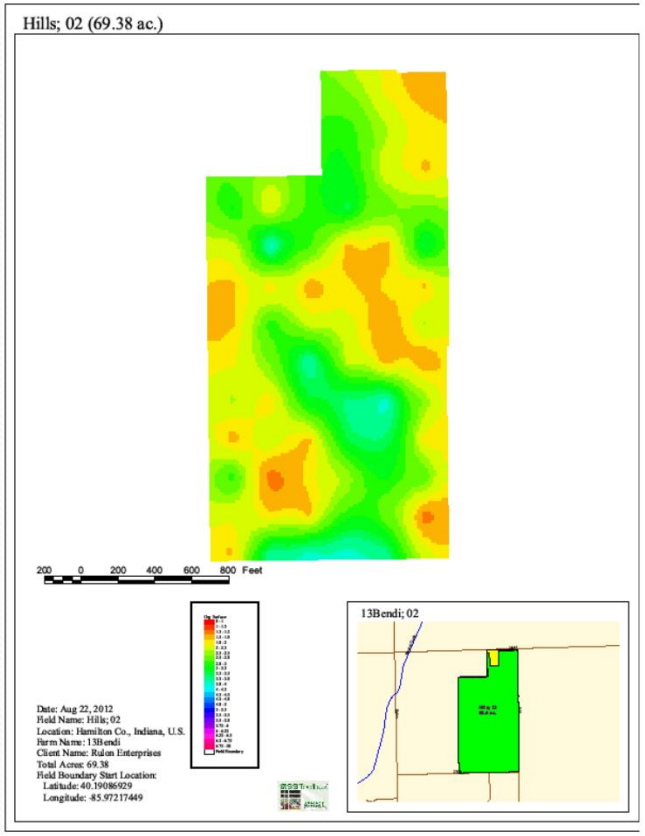
(([Org] >= 2.4) and ([Org] < 2.7)) : (34000)

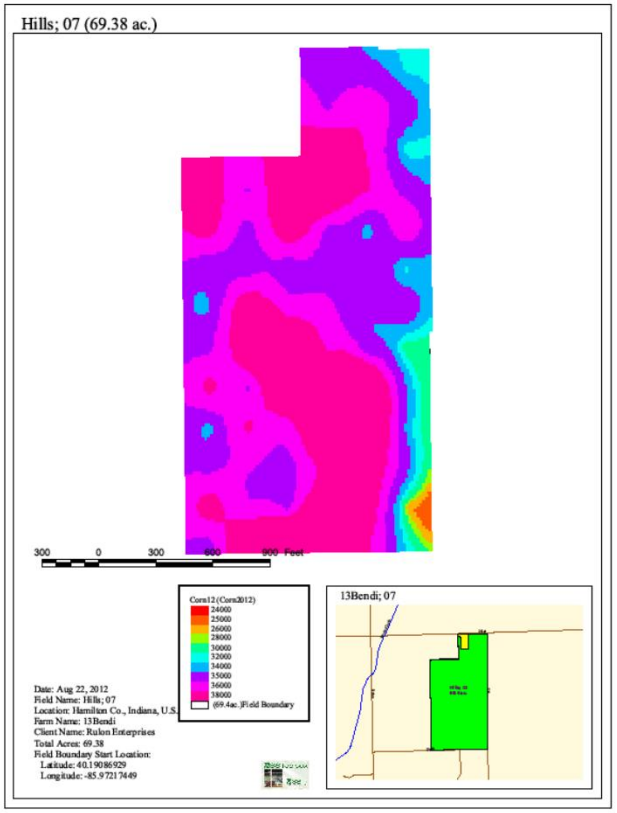
(([Org] >= 2.7) and ([Org] < 3.2)) : (35000)

(([Org] >= 3.2) and ([Org] < 3.8)) : (36000)

(([Org] >= 3.8) and ([Org] < 50)) : (38000)

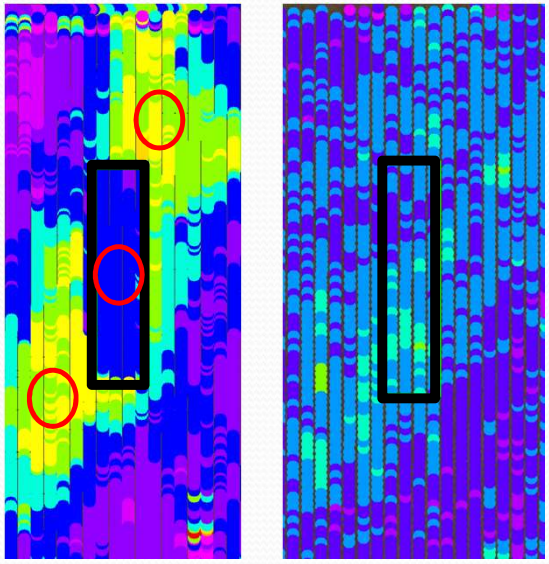
GENERAL VALUES FOR REFERENCE ONLY





Were We Able To Get Results?

Test #1B	36Reynolds	Average Rate (33k) planted in a low population area					
Population	Additional Seeds	Yield (bu/ac)	Cost of Seed	Cost of Extra Seeds	Additional Yield	Benefit of $4/bu	NET
32,929	5,012	172.38	$ 103.81	$ 15.80	-9.72	$ (38.88)	$ (54.68)
27,917	-	182.1	$ 88.01	-	-	-	-



This test block was located in a Low Organic Matter area. In this situation we *increased* the seeding rate, and did not see a yield gain. This tells us that the soil was not able to support more plants.

The test block was less profitable than VRT REC due to increased seed cost/reduced yield.

pH and Lime

Lime (Hi-Cal)

([CEC] >=24) and ([pH] <=6.4) and ([pH] >1): ((6.4-[pH])*7)

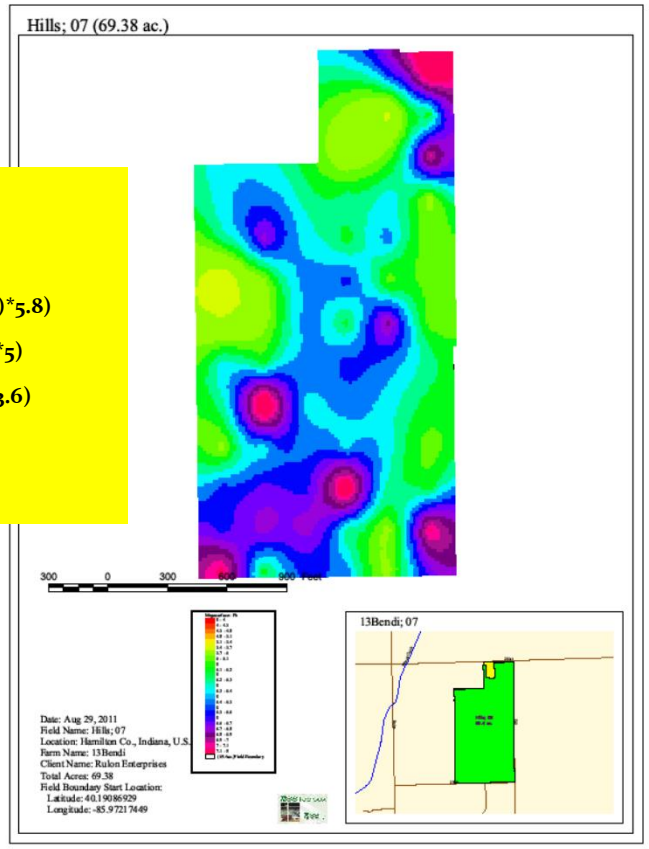
([CEC]<24) and ([CEC] >=15) and ([pH] <=6.4) and ([pH] >1): ((6.4-[pH])*5.8)

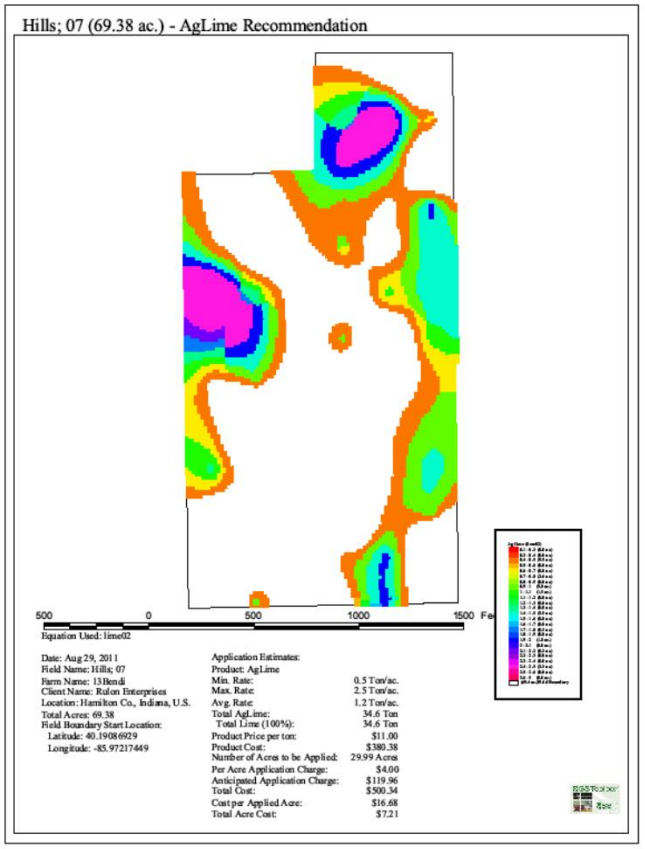
([CEC]<15) and ([CEC] >=8) and ([pH] <=6.4) and ([pH] >1): ((6.4-[pH])*5)

([CEC]<8) and ([CEC] >=1) and ([pH] <=6.4) and ([pH] >1): ((6.4-[pH])*3.6)

([CEC] >1) and ([PH] >6.4) : (0)

GENERAL VALUES FOR REFERENCE ONLY





MGBS and Gypsum

Gypsum

([Mag] >=25) : (1.4)

([Mag] <25) and ([Mag] >=23) : (1.3)

([Mag] <23) and ([Mag] >=21) : (1.15)

([Mag] <21) and ([Mag] >=19) : (1.0)

([Mag] <19) and ([Mag] >=17) : (0.9)

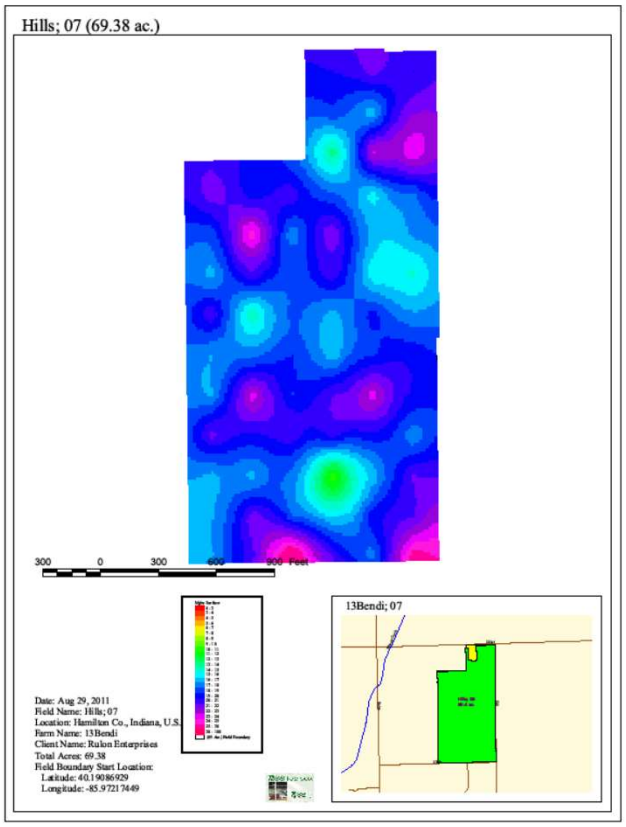
([Mag] <17) and ([Mag] >=15) : (0.8)

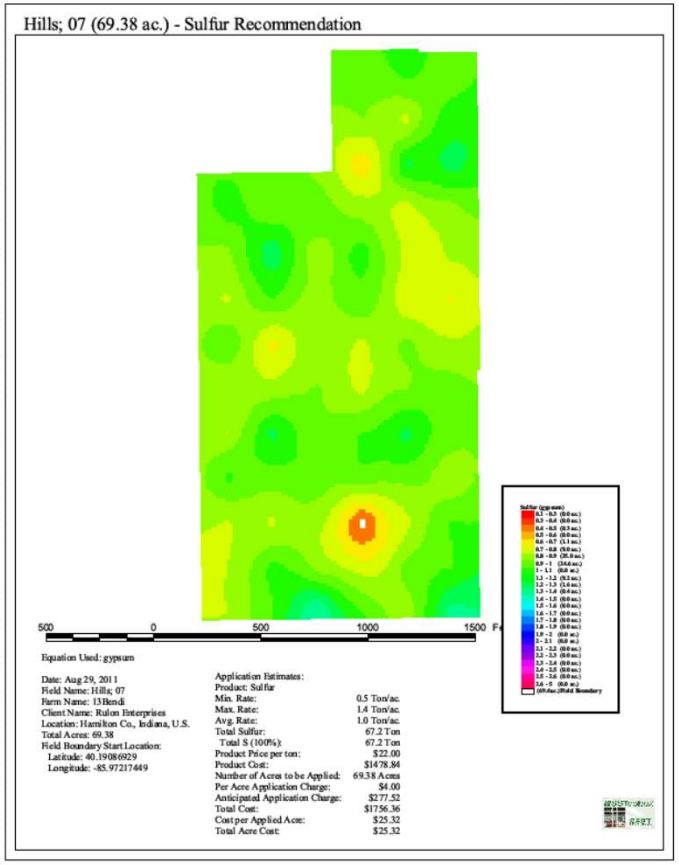
([Mag] <15) and ([Mag] >=13) : (0.7)

([Mag] <13) and ([Mag] >=11) : (0.5)

([Mag] <11) and ([Mag] >=0) : (0)

GENERAL VALUES FOR REFERENCE ONLY





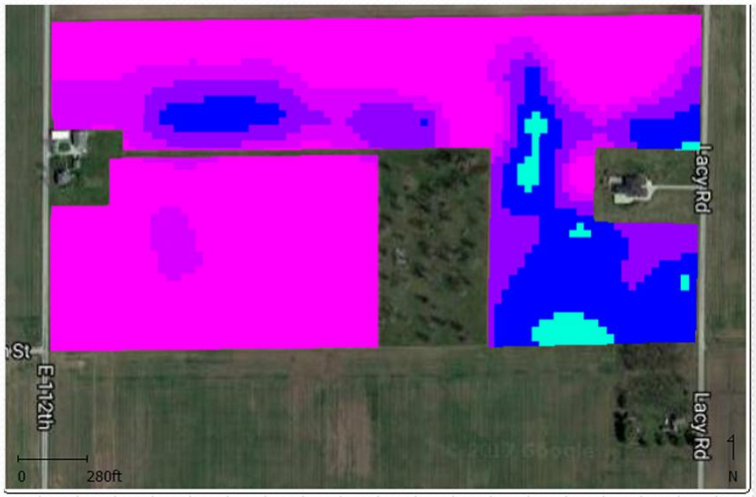
Why We Use Gypsum

- **Water management**
- **Transition from tillage to no-till**
- **Build soil structure with calcium**
- **Soil repair (remove magnesium)**
- **High Quality Sulfur Source**
- **Nutrient availability and cycling (Balance)**
- **Promote soil biology and build organic matter**

DECREASE SOIL MG CONTENT : AVG = -0.5%/year

%MG Change over 15 years = - 7%

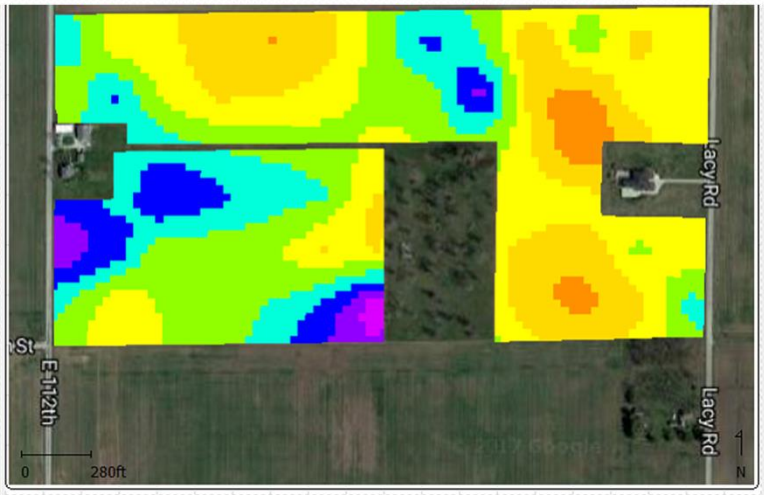
19.03 (13.1 to 25.9) **12.04** (7.58 to 19.08)



Grower : Rulon Enterprises LLC
Farm : 53Hancock
Field : 53Hancock
Operation : Soil Sampling
Average Soil %MG : 19.03 %
Maximum Soil %MG : 25.90 %
Minimum Soil %MG : 13.10 %

Soil %MG (%)

19.35 - 50.00	(1,899)
17.87 - 19.35	(440)
16.39 - 17.87	(437)
14.91 - 16.39	(518)
13.43 - 14.91	(78)
11.95 - 13.43	(0)
10.47 - 11.95	(0)
8.99 - 10.47	(0)
7.51 - 8.99	(0)
0.00 - 7.51	(0)



Grower : Rulon Enterprises LLC
Farm : 53Hancock
Field : 53Hancock
Operation : Soil Sampling
Average Soil %MG : 12.04 %
Maximum Soil %MG : 19.08 %
Minimum Soil %MG : 7.580 %

Soil %MG (%)

19.35 - 50.00	(0)
17.87 - 19.35	(15)
16.39 - 17.87	(59)
14.91 - 16.39	(202)
13.43 - 14.91	(532)
11.95 - 13.43	(850)
10.47 - 11.95	(1,022)
8.99 - 10.47	(600)
7.51 - 8.99	(92)
0.00 - 7.51	(0)

Nitrogen and OM

Nitrogen

Side dress N

([Org] < 1.7)) : (65)

(([Org] >= 1.7) and ([Org] < 1.8)) : (75)

(([Org] >= 1.8) and ([Org] < 1.9)) : (90)

(([Org] >= 1.9) and ([Org] < 2.0)) : (115)

(([Org] >= 2.0) and ([Org] < 2.15)) : (120)

(([Org] >= 2.15) and ([Org] < 2.4)) : (125)

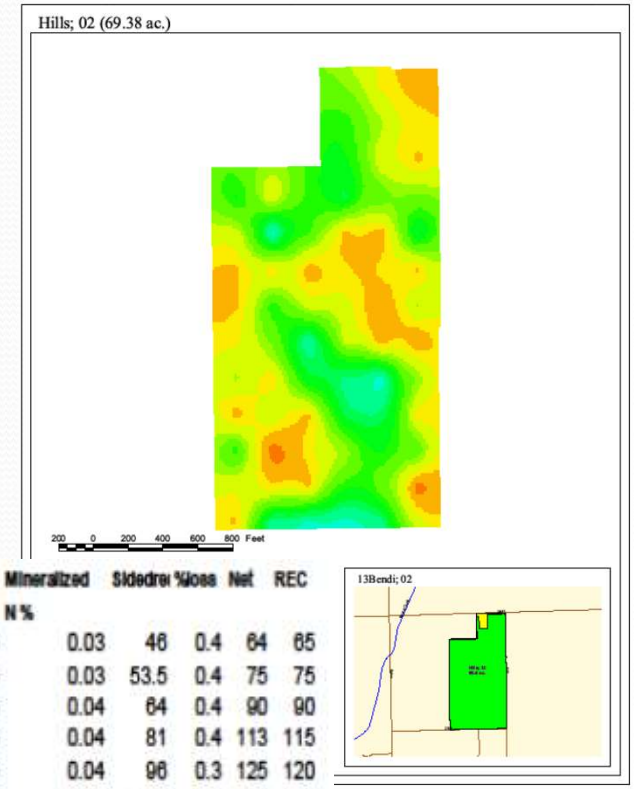
(([Org] >= 2.4) and ([Org] < 2.7)) : (135)

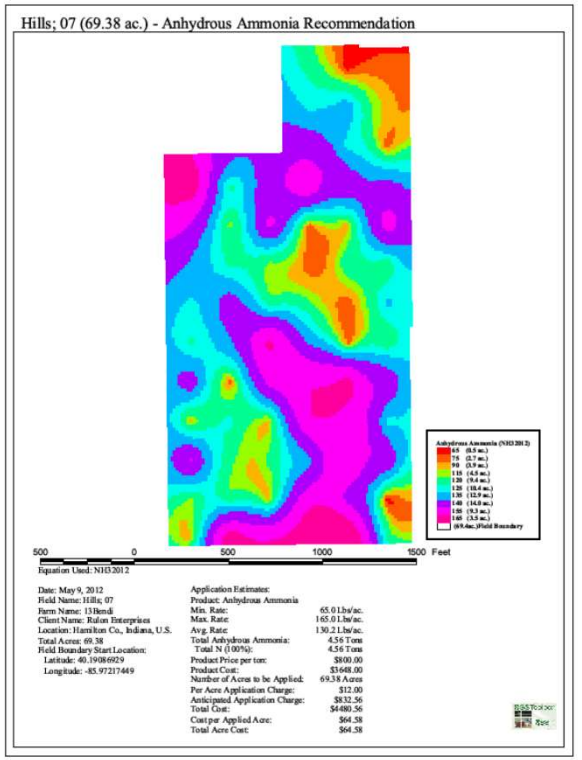
(([Org] >= 2.7) and ([Org] < 3.2)) : (140)

(([Org] >= 3.2) and ([Org] < 3.8)) : (155)

(([Org] >= 3.8) and ([Org] < 50)) : (165)

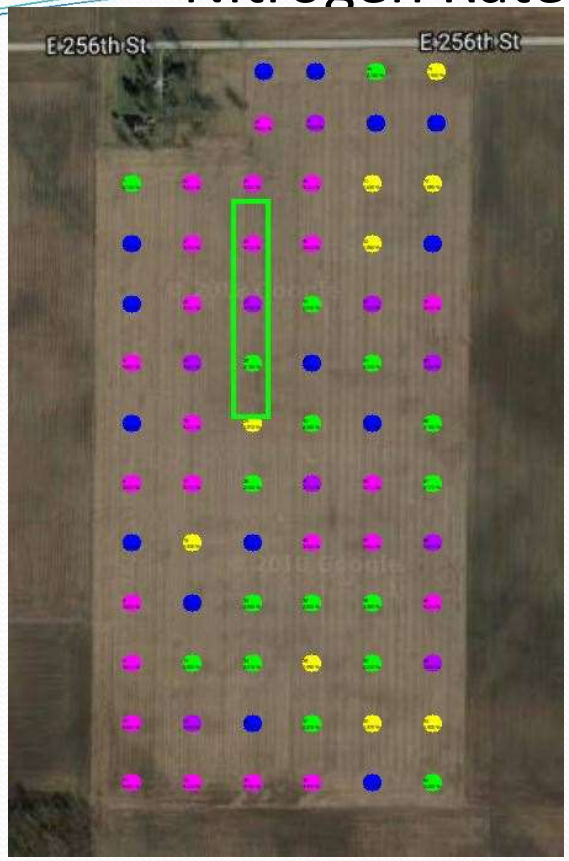
GENERAL VALUES FOR REFERENCE ONLY





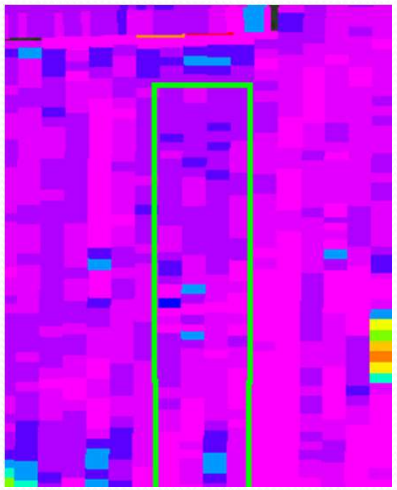
OM LOW	OM HIGH	Yield	lbs/bu	Total N	Plant	Cover Crop	Bean Credit	om/100	Soil Carbon Total	% of C as N	Mineralized N %		Sidedres	%loss	Net	REC
1.6	1.7	90	1.4	126	25	1	30	0.016	1000000	0.05		0.03	46	0.4	64	65
1.7	1.8	100	1.35	135	25	1	30	0.017	1000000	0.05		0.03	53.5	0.4	75	75
1.8	1.9	120	1.3	156	25	1	30	0.018	1000000	0.05		0.04	64	0.4	90	90
1.9	2	140	1.25	175	25	1	30	0.019	1000000	0.05		0.04	81	0.4	113	115
2	2.1	160	1.2	192	25	1	30	0.02	1000000	0.05		0.04	96	0.3	125	120
2.1	2.4	170	1.2	204	25	1	30	0.021	1000000	0.05		0.05	94.5	0.3	123	125
2.4	2.7	190	1.15	218.5	25	1	30	0.024	1000000	0.05		0.05	102.5	0.3	133	135
2.7	3.2	210	1.1	231	25	1	30	0.027	1000000	0.05		0.05	107.5	0.3	140	140
3.2	3.8	230	1.1	253	25	1	30	0.032	1000000	0.05		0.05	117	0.3	152	155
3.8	4	260	1.05	273	25	1	30	0.038	1000000	0.05		0.05	122	0.3	159	165

Nitrogen Rate Blocks



OM Grid with Test Block Layout

Rate Applied (Units)
135 units/ac



Yield Map

	Test #2	09CMAX	Average Rate (135#) across through a high N rate/OM area					
OM Level	# of N	Additional N	Yield (bu/ac)	Cost of N	Cost of Extra N	Additional Yield	Benefit of $4/bu	NET
High	135.23	-	223.82	$ 40.40	-	-	-	
	164.82	29.59	238.7	$ 49.25	$ 8.84	14.88	$ 59.52	$ 50.68

- **Test blocks were applied to strategic locations to test our VRT Equation across different soil types, OM changes, elevations, and other variables.**
- **The goal is to overlay this block on the harvest map and see if there are any differences where we may want to tweak our equation.**
- **Also these test blocks are "built in" to the prescription, so no action was needed from the operator during application.**

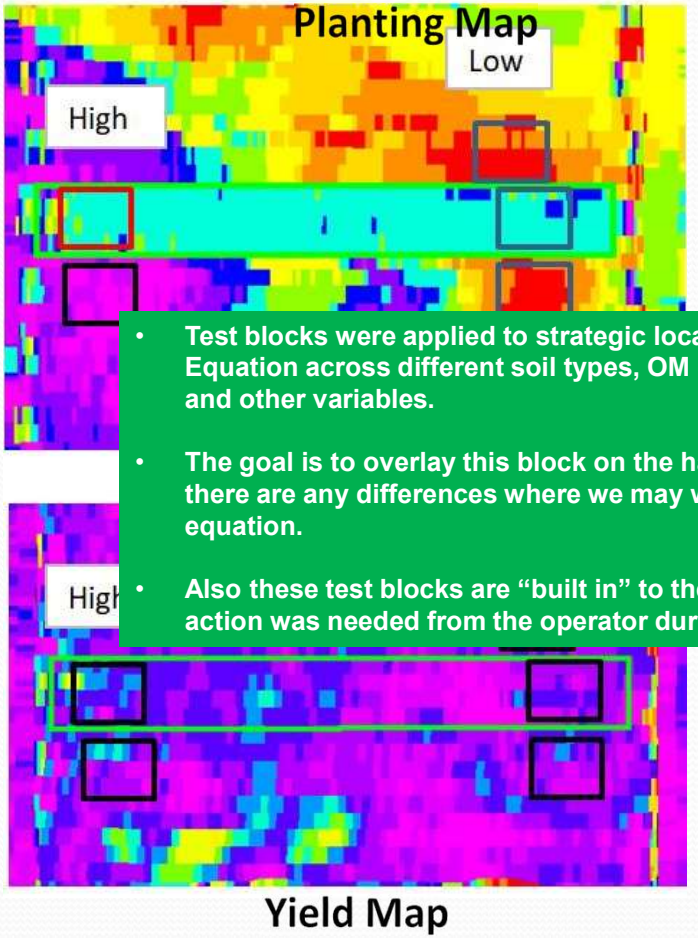
Were We Able To Get Results?

	Test #3A	10Lee-South	Average Rate (32k) planted in a high population/OM area					
	5829A4							
	Population	Additional Seeds	Yield (bu/ac)	Cost of Seed	Cost of Extra Seeds	Additional Yield	Benefit At $4/bu	NET
FLAT	31,980	-	195.08	$ 87.91	-	-	-	-
VRT	35,760	3,780	207.58	$ 98.30	$ 10.39	12.5	$ 50.00	$ 39.61

	Test #3B	10Lee-South	Average Rate (32k) planted in a low population/OM area					
	Population	Additional Seeds	Yield (bu/ac)	Cost of Seed	Cost of Extra Seeds	Additional Yield	Benefit of $4/bu	NET
FLAT	31,960	-	216.79	$ 87.85	-	-	-	-
VRT	24,710	-7,250	213.41	$ 67.92	$ (19.93)	-3.38	$ (13.52)	$ 6.41

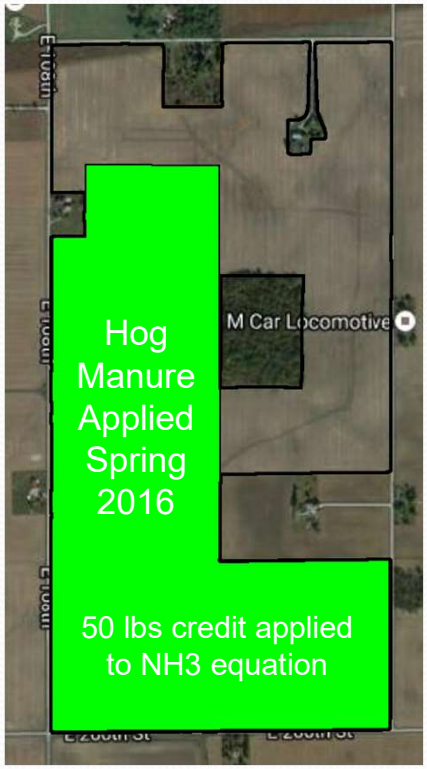
- This test block shows a test of our Corn VR Prescription through both low and high OM areas.
- Below is the projected profit from using VRT and our formula over all of our corn acres.

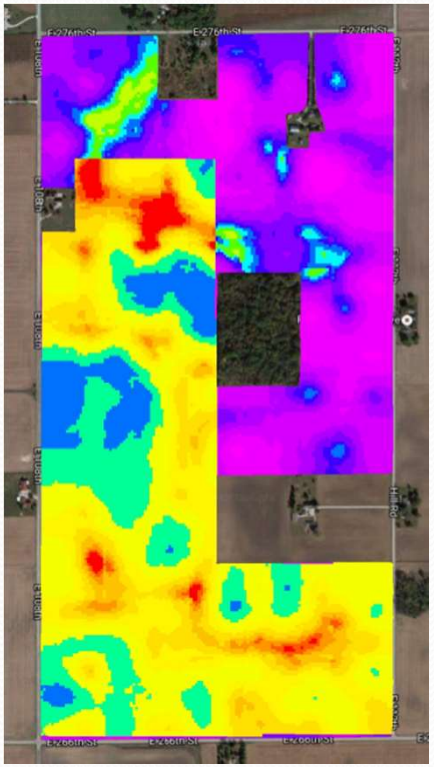
Average Gain for VRT across all tests:	$ 24.60
	x 3000 acres
	$ 73,800.34

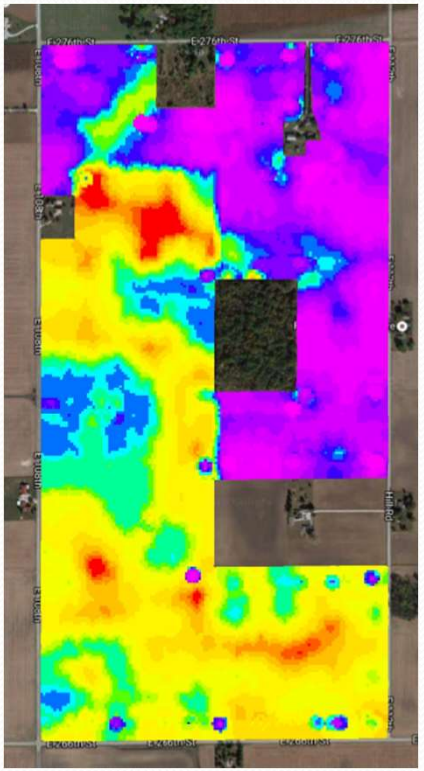


- Test blocks were applied to strategic locations to test our VRT Equation across different soil types, OM changes, elevations, and other variables.
- The goal is to overlay this block on the harvest map and see if there are any differences where we may want to tweak our equation.
- Also these test blocks are “built in” to the prescription, so no action was needed from the operator during application.

Nitrogen/Hog Manure Application







What we do to manage soil Quality:

- Low Disturbance N-Applicator/Manure

Target Your Cover Crop Choice

- **Choose the right cover for your goal**
  - **Compaction removal**
  - **Ease of management**
  - **Disease control**
  - **Nutrient cycling**
  - **Erosion control**
  - **Enhance Rotations**
  - **BUILD SOIL HEALTH**

Fall 2021 Mixes

CORN 22

25# Oats
2# Radish
2# Rape
3# Balansa
Clover

Late Harvest

15# Cereal Rye
15# Oats
3# Rape

SOYBEANS 22

25# Oats
2# Radish
3# Rape

Late Harvest

35# Cereal Rye

FLOODING/EROSION

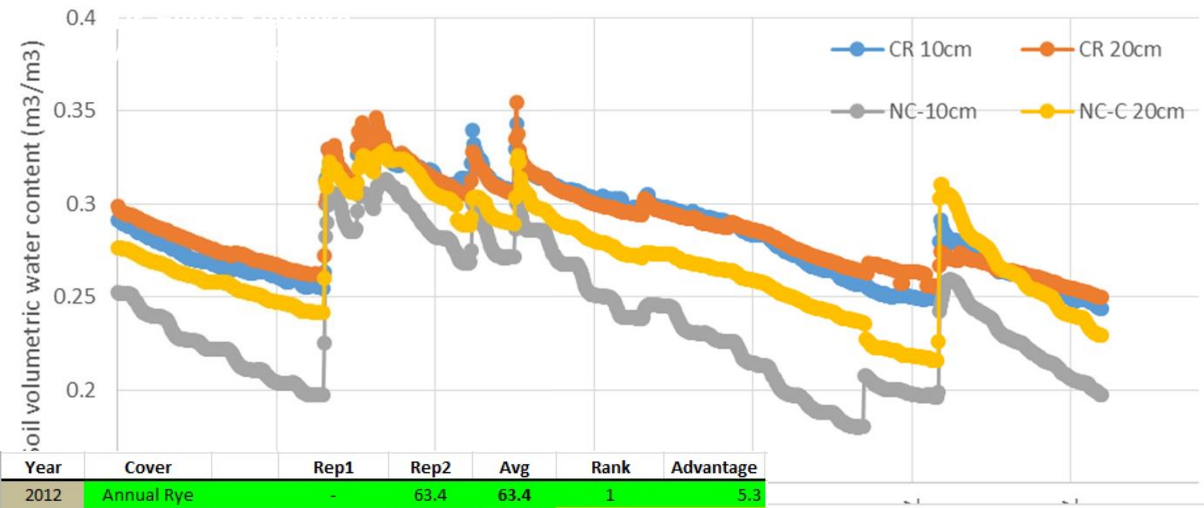
WIND EROSION


HEALTHY SOIL

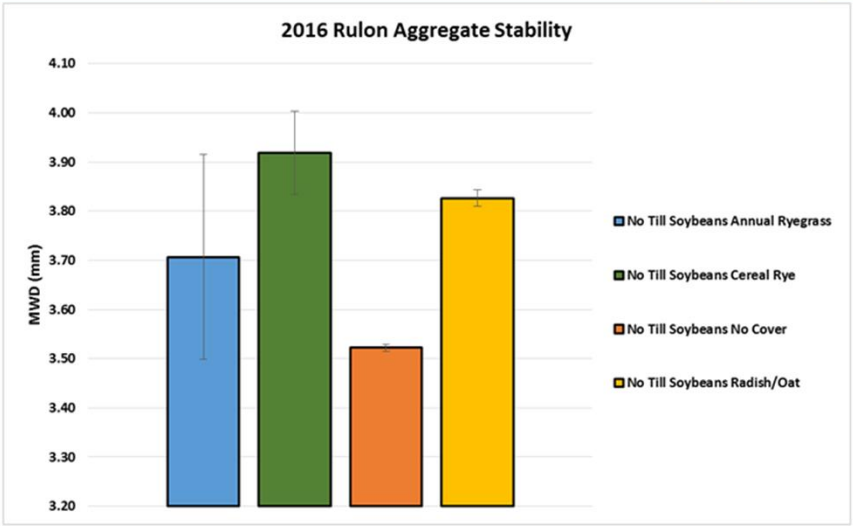

Weasel Creek
Oat/Radish
Cereal Rye
Annual Rye
No Cover
Oat/Radish
Cereal Rye
Annual Rye
No Cover

PURDUE UNIVERSITY

Rulon July Soil Moisture

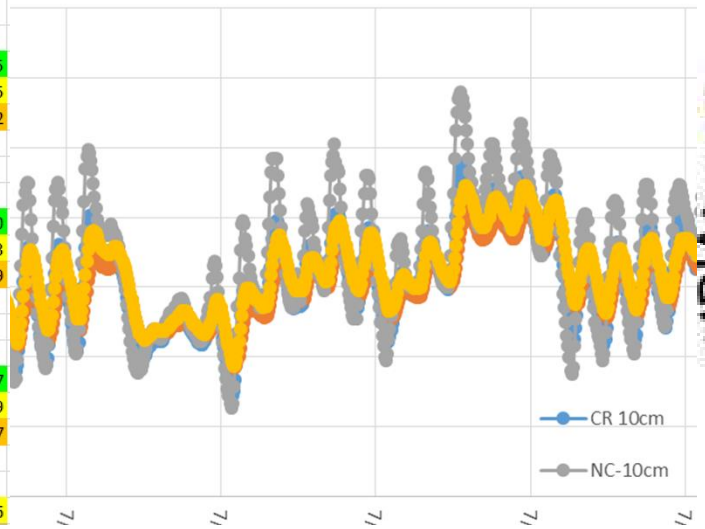


2016 Rulon Aggregate Stability



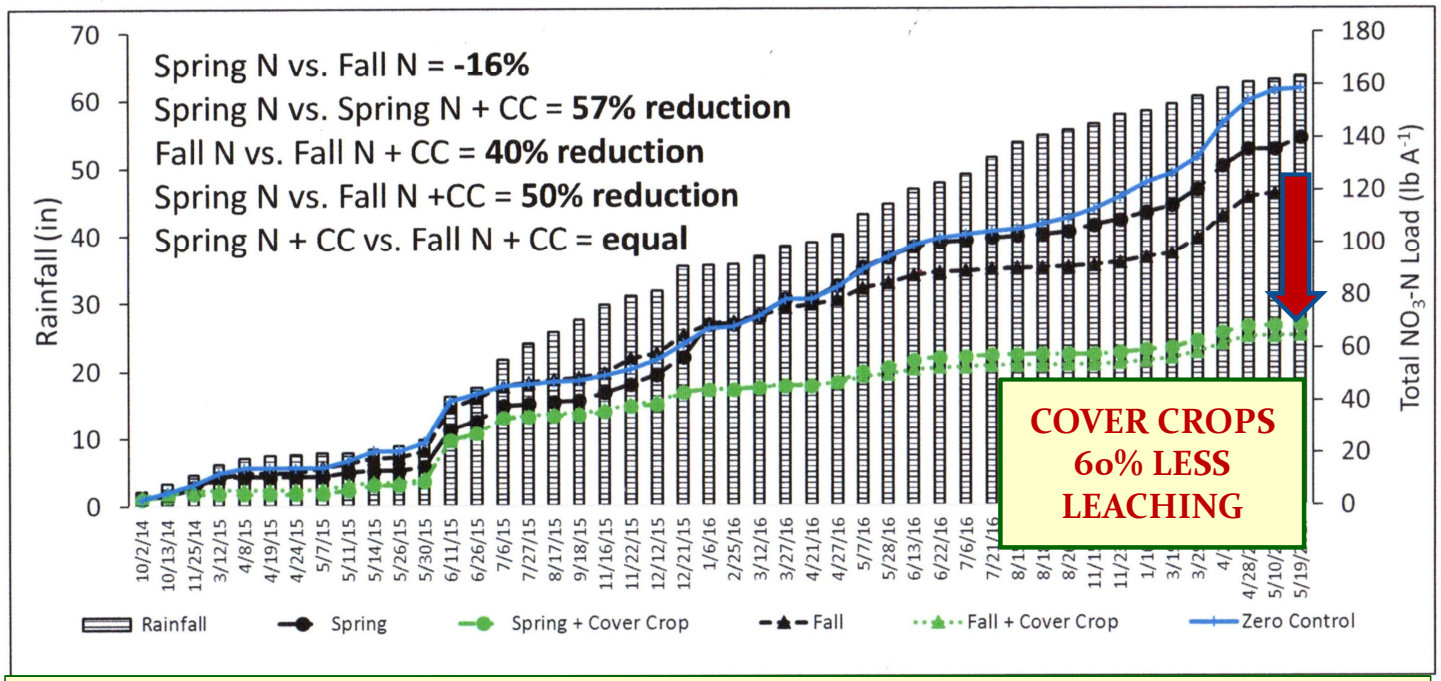
Year	Cover	Rep1	Rep2	Avg	Rank	Advantage
2012	Annual Rye	-	63.4	**63.4**	1	5.3
	Cereal Rye	-	59.8	59.8	2	1.7
	Oats/Radish	-	59.5	59.5	3	1.4
	No Cover	-	58.1	58.1	4	
2014	Oats/Radish	76.3	72.7	**74.5**	1	2.95
	Cereal Rye	72.8	75.4	74.1	2	2.55
	Annual Rye	72.3	74.8	73.55	3	2
	No Cover	73.5	69.6	71.55	4	
2016	Oats/Radish	68.4	67.8	**68.1**	1	8.0
	Cereal Rye	66	62.9	64.5	2	4.3
	Annual Rye	64.7	61.3	63.0	3	2.9
	No Cover	64.3	56	60.2	4	
2018	Oats/Radish	67.6	72.5	**70.1**	1	3.7
	Cereal Rye	66	72.4	69.2	2	2.9
	Annual Rye	67.9	70.2	69.1	3	2.7
	No Cover	67.4	65.22	66.3	4	
					Average	3.36

Rulon July Soil Temperature



INDIANA CONSERVATION PARTNERSHIP

HOW DO WE STOP NUTRIENT LEACHING?



BARE SOIL (control) w/ NO FERTILIZER LEACHED THE MOST!

Source: Purdue University
Dr. Shalamar Armstrong

2011-2021 CCSI Cover Crop Test
Harvest Data

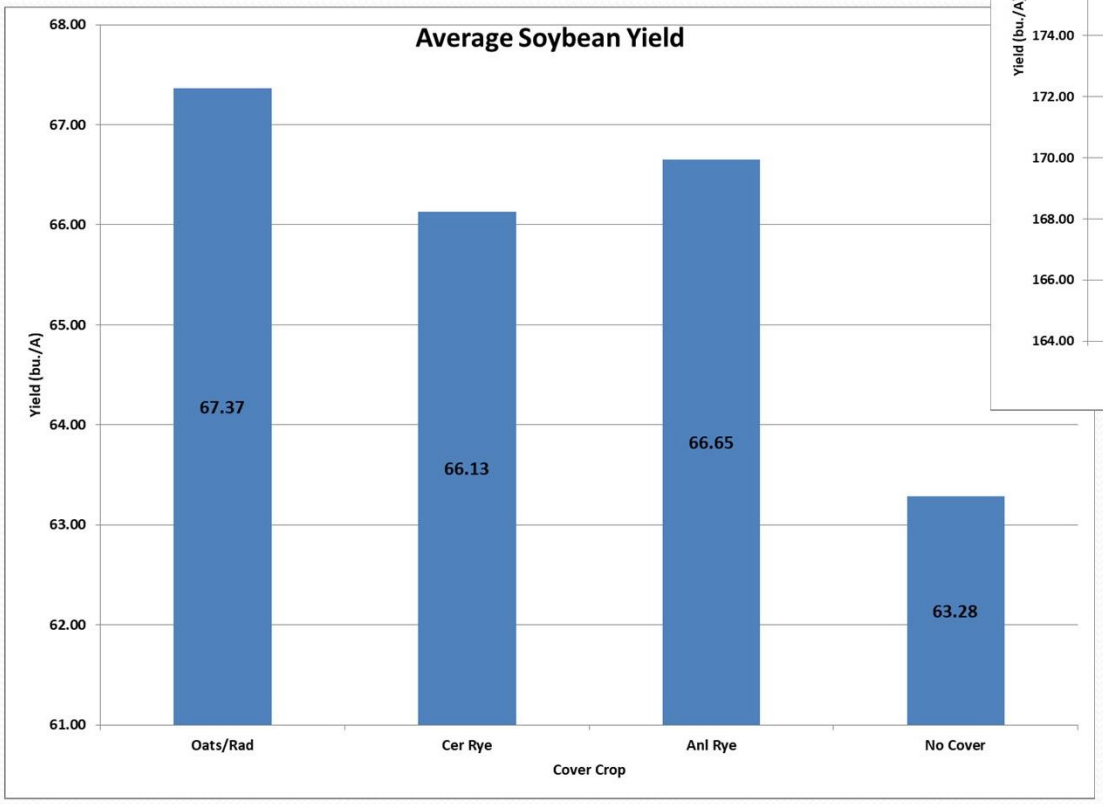
COVER CROP	CASH CROP	2011 AVG YIELD	2013 AVG YIELD	2015 AVG YIELD	2017 AVG YIELD	2019 AVG YIELD	2021 AVG YIELD	ALL YEARS AVG YIELD	ALL YEARS ADVANTAGE
Oat Radish	CORN	148.11	189.50	177.15	218.97	193.98	230.53	193.04	10.75
Cereal Rye	CORN	140.55	176.78	176.82	203.77	188.99	227.20	185.69	3.39
Annual Rye	CORN	146.60	178.31	166.44	205.64	188.35	226.55	185.32	3.02
No Cover	CORN	146.70	173.59	160.54	209.65	185.91	217.38	182.30	0.00

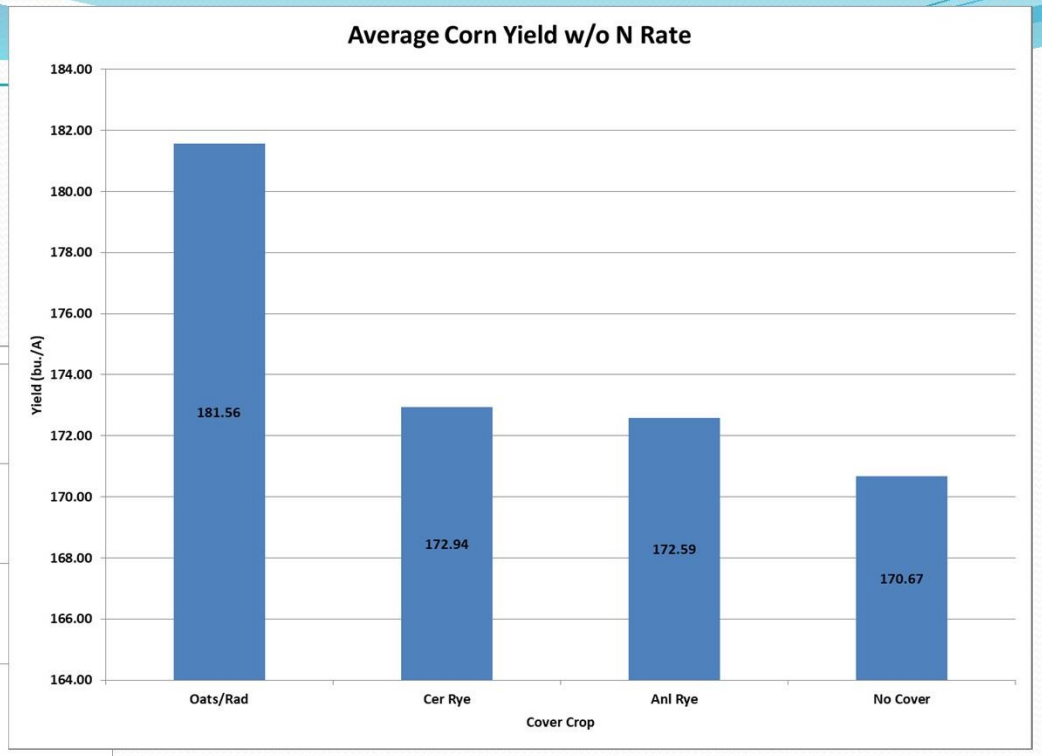
COVER CROP	CASH CROP	2012 AVG YIELD	2014 AVG YIELD	2016 AVG YIELD	2018 AVG YIELD	2020 AVG YIELD	2022 AVG YIELD	ALL YEARS AVG YIELD	ALL YEARS ADVANTAGE
Oat Radish	SOYBEANS	59.5	74.5	68.1	70.1	70.6		68.56	4.11
Cereal Rye	SOYBEANS	59.8	74.1	64.5	69.2	70.4		67.60	3.15
Annual Rye	SOYBEANS	63.4	73.55	63	69.1	69.6		67.73	3.28
No Cover	SOYBEANS	58.1	71.55	60	66.3	66.3		64.45	0.00

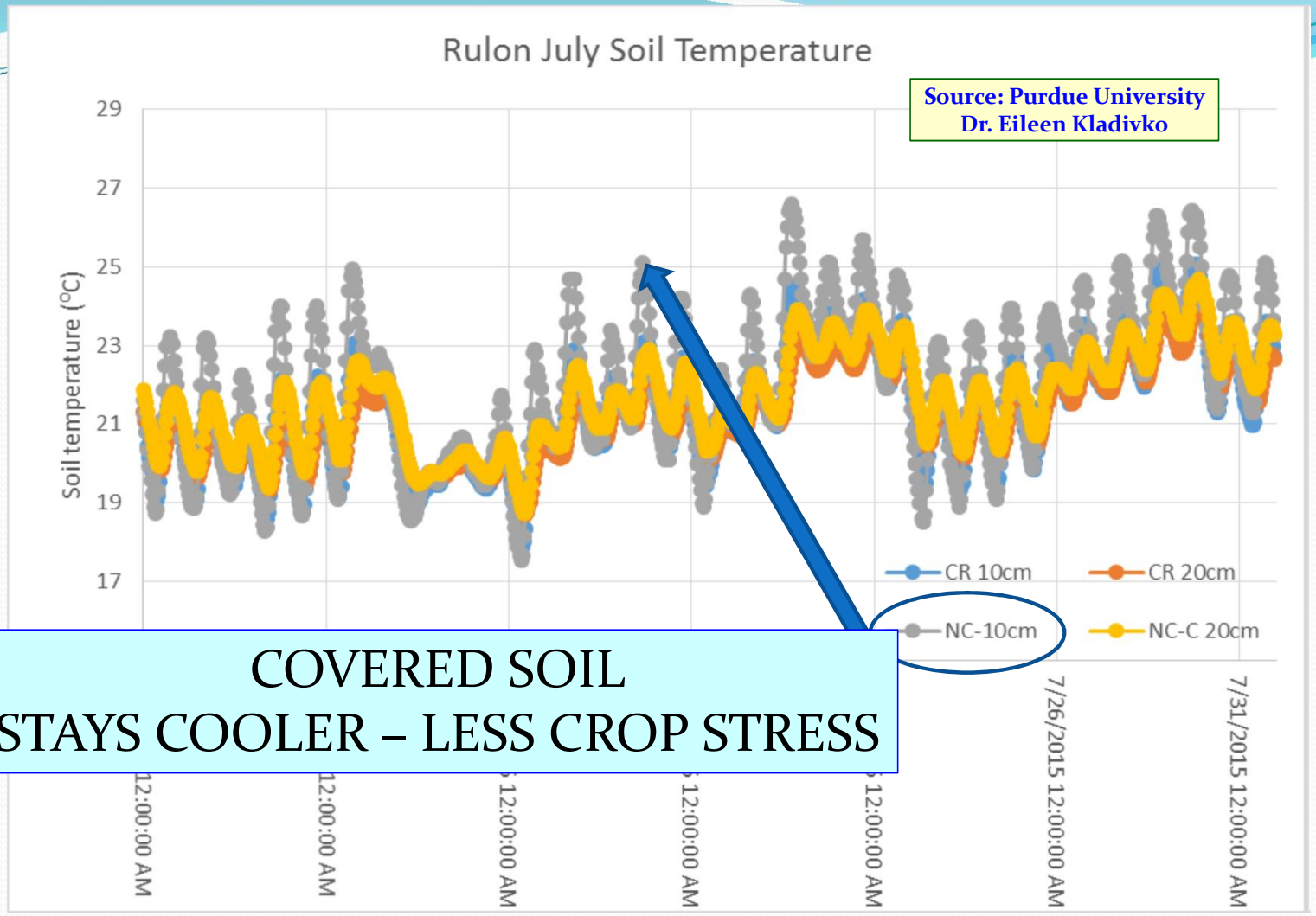
1. When planting into a Grass (ie cereal rye/annual rye) stand establishment and nitrogen management become critical. (2011 and 2017)
2. This plot does not allow for varying N management or planter setup so the grass covers are not optimized but do still show an advantage (3bu) over no cover.
3. All covers show similar benefits for soybeans (+3.1-4.1bu) with a potential advantage to the nematicide effect of radish in the Oat/radish mix

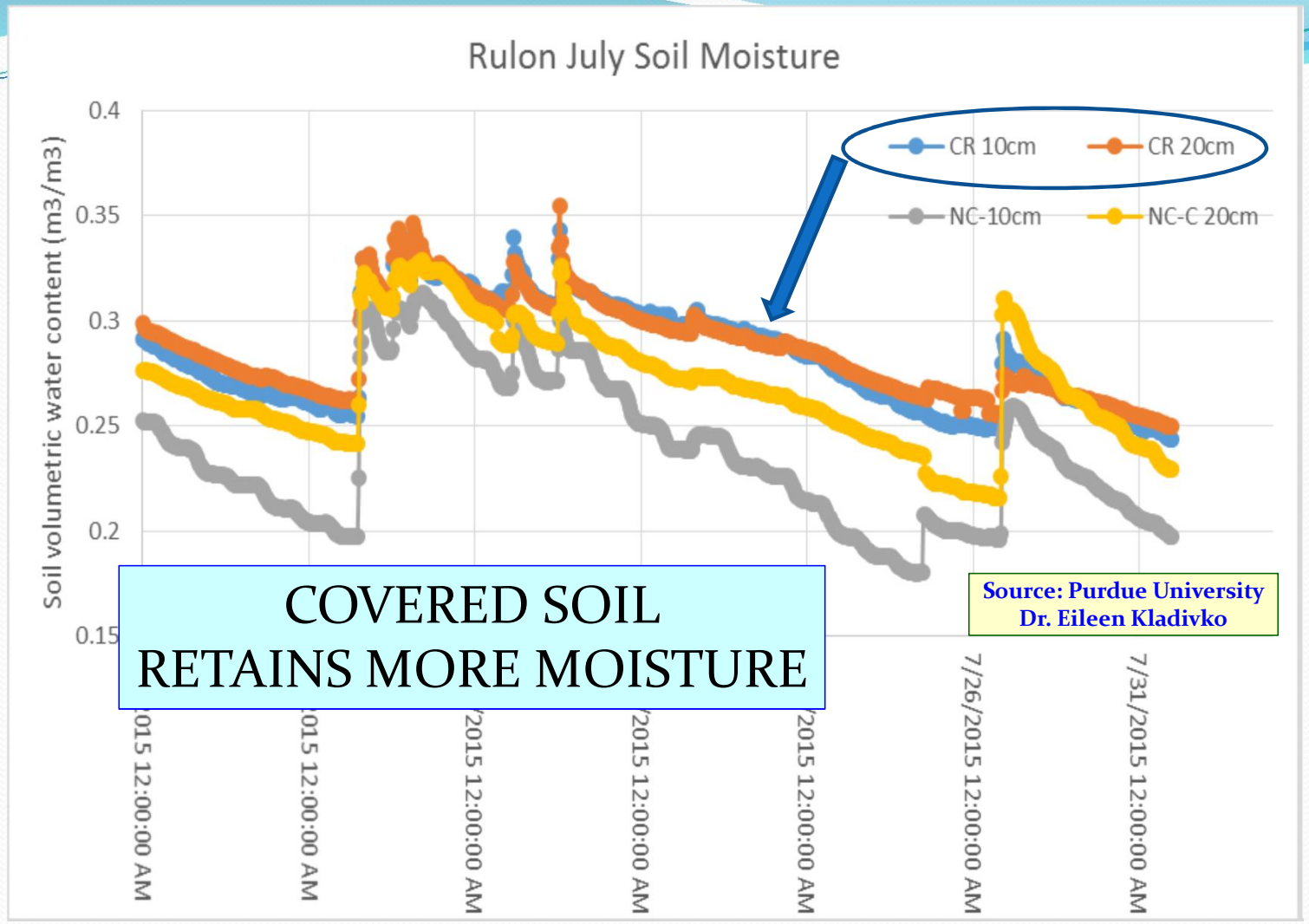
Cover Crop +10.75 bu/ac Corn
Cover Crop +4.11 bu/ac Soybeans

COVER CROPS INCREASE YIELD






Rulon July Soil Temperature
Source: Purdue University
Dr. Eileen Kladivko
Soil temperature (°C)
29
27
25
23
21
19
17
CR 10cm
CR 20cm
NC-10cm
NC-C 20cm
12:00:00 AM
7/26/2015 12:00:00 AM
7/31/2015 12:00:00 AM
COVERED SOIL
STAYS COOLER – LESS CROP STRESS


Rulon July Soil Moisture
Soil volumetric water content (m3/m3)
0.4
0.35
0.3
0.25
0.2
0.15
CR 10cm
CR 20cm
NC-10cm
NC-C 20cm
7/26/2015 12:00:00 AM
7/31/2015 12:00:00 AM
COVERED SOIL
RETAINS MORE MOISTURE
Source: Purdue University
Dr. Eileen Kladivko

Last Planting Date (Central Indiana)

Summer (Aug 10)	**Lots of Choices**
September 15	**Austrian Peas/expensive legumes**
October 1-7	**Oats/Radish/Clover**
October 21	**Rape/Annual Rye Grass**
November 10	**Cereal Rye**

Check out Midwest Cover Crop Council

Cover Crop Selection Tool

http://www.midwestcovercrops.org

Planting Methods

- **Aerial/Surface**
- **Air Cart/harrow**
- **No-Till Drill**
- **Precision Planter**
- **CONSIDER:**
  - **Seed size (Hopper size)**
  - **Planting date (Timing)**
  - **Moisture required to germinate**
  - **Fall growth needs**
  - **Seeding rates and cost**
  - **Mixes**
  - **Coatings**
  - **Inoculants**










Planting Methods
Drilled on Sept. 15 Photos Nov. 1

Planting Methods

Aerial App Sept. 15 Photos Nov. 1

Mixes

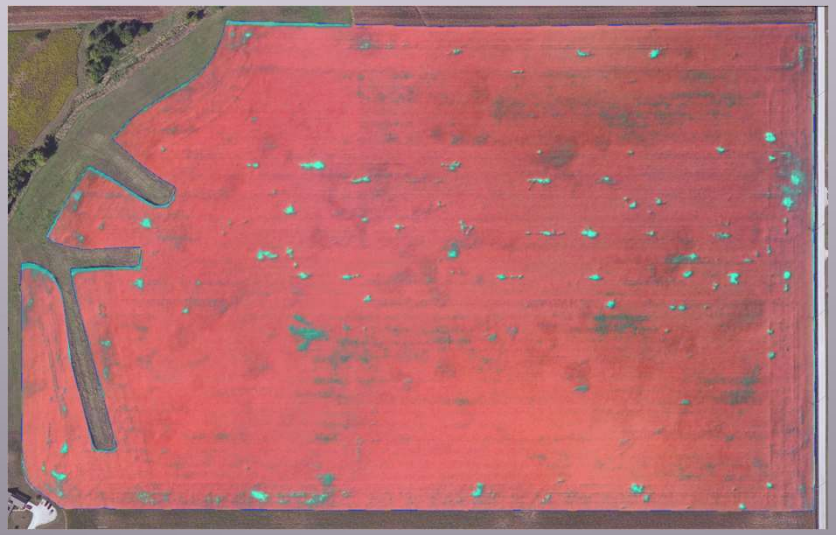
- **Root types**
- **Growth rate**
- **Planting date**
- **Feeder/Scavenger/Storage**
- **Legume/Grass/Brassica**
- **Build OM**
- **Boost cash crop**
- **Save on inputs**
- **Improve winter survival**
- **Termination method/timing**

Other things to worry about

- **Quality Seed Source/Supply**
- **Bulk blending/delivery**
- **Spring germination of fall seeding (Hard Seed)**
- **Mis-application (uneven/outside field)**
- **Seeding rates**
- **Chemical Programs**
  - **Residuals from cash crop**
  - **Termination of cover crop+Timing**
- **Test Strips**
- **Tile lines (Roots?)**
- **Voles**

Roots In Tile Lines?? Can Be Good or Bad

Voles and Different Cover Crops



Crop Type	lbs Applied
Annual Ryegrass	(18#)
Cereal Ryegrass	(35#)
Oats/Radish Mix	(32# & 2.5#)

Considerably less vole holes in the Oats/Radish mix strips.

Rulon Enterprises LLC - Cover Crop Cost Analysis

SEED COSTS		Cost/Acre	Acres	Seed Cost	
Mix #1- Early After Soybeans		$20.79	1,300	$27,027	
Mix #2- Late After Soybeans (Oct 10th)		$15.12	1,300	$19,656	
Mix #3- Early After Corn		$14.85	1,300	$19,305	
Mix #4- Late After Corn (Oct 15th)		$7.25	1,300	$9,425	
	5,200		Seed Cost =	$75,413	
				Seed Cost/Acre =	$14.50
Planting Costs for Season		**Quantity**	**Rate**	**Total Cost**	
Tractor Hours		338	$59.00	$19,942	
Labor (40 acres/hr@70%=28 acres/hr)		185.7	$17.50	$3,250	
Fuel		1267.5	$3.05	$3,866	
Planter Repairs/Wear		5,200	$3.00	$15,600	
Total Other Costs	**Acres =**	**5,200**		$42,658	
				Planting Cost/Acre =	$8.20
			Total Cover Crop Cost =	$118,071	

Total Cost/Acre Planted = $22.71

Rulon Enterprises LLC Cover Crop Benefits

	Per acre	Acres	Total Benefit
Fertilizer Saved-P&K (20#P@$.38 + 30#K@$.225)	$14.35	5,200	$74,620
Fertilizer Saved-N (35#/Acre: 200 versus 165)	$7.35	2,600	$19,110
Corn Yield (4yearsx64strips:Plot Data: 7.1bu@$4)	$28.40	2,600	$73,840
Soybean Yield Increase (1.95bu@$10)	$19.50	2,600	$50,700
TOTAL ANNUAL BENEFIT=	**$41.98**		**$218,270**
Drought Tolerence (2004-17: 30 bu every 5th=6 Bu@$4)	$24.00	2,600	$62,400
Carbon Content (5.35bu/.1 of OM x 50% = 2.7bu@$4)	$10.80	5,200	$56,160
Erosion Reduction (2 ton/acre @ $4)	$8.00	5,200	$41,600
CSP Program Payment ($40,000)	$7.69	5,200	$40,000
TOTAL LONG-TERM BENEFIT=	**$50.49**		**$200,160**

Total Cover Crop Benefit = $418,430

Net Economic Return = $300,359

ROI = 254%

Net Profit/Acre Planted = $57.76

In Conclusion…….
Soil Health and Fertility Pay Big

You can Manage HEALTH and FERTILITY in your Soil!!

A Soil Health System can increase yield (10 bu Corn/ 4 bu Soybeans)

$$$ Spent to increase Soil Health is a good investment (254% ROI)

Land Owners should be asking to see Soil Health Reports, not just fertilizer tests

THANK YOU!!


Farming Since 1869
RULON
ENTERPRISES
Rodney Rulon
rodney@rulonenterprises.com
www.rulonenterprises.com