Soil Sampling Considerations for Site-Specific Nutrient Management in Row Crops

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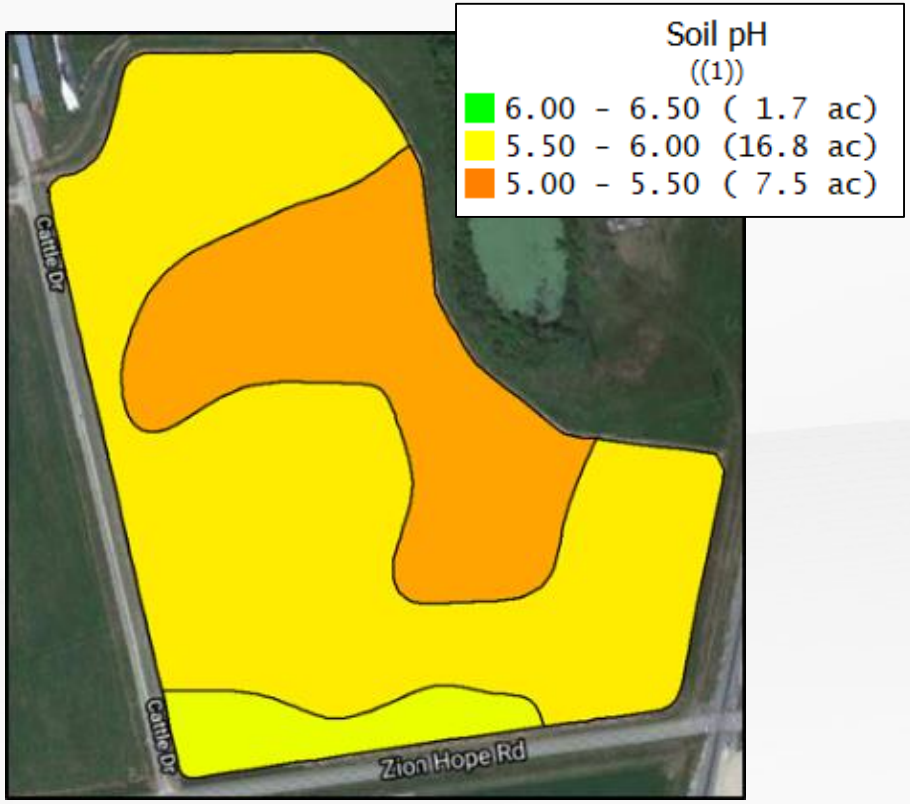
Row-Crop Fertilization

General Recommendations:

- Soil pH: 6.0 – 6.3
- P and K: upper to medium range
- N (Rate and Timing)

Precision soil sampling to guide Variable-rate fertilizer applications

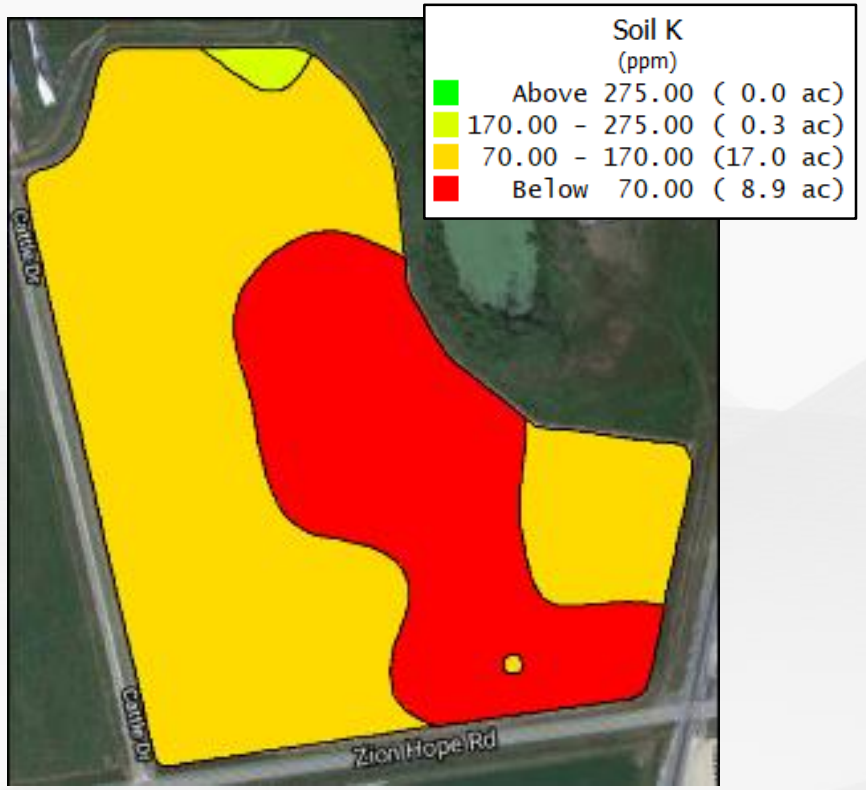
Uniform vs Variable-Rate Application



Lime

Uniform Application – 26 ton - $1,300
Variable-Rate Application – 14 ton - $700

$23/acre



N-P-K (30-0-110 lbs)

Uniform Application – 2,860 lbs - $3,224
Variable-Rate Application – 2,180 lbs - $2,566

$25/acre

Precision Soil Sampling Strategies

Traditional Soil Sampling

(1-2 composite sample)

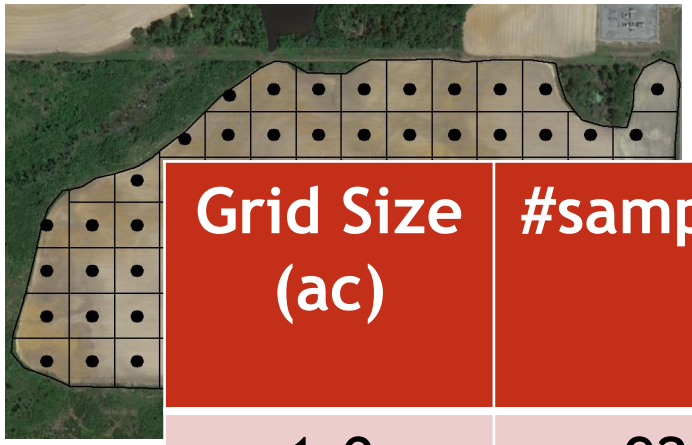
Grid Soil Sampling

(uniform sized grids)

Zone Soil Sampling

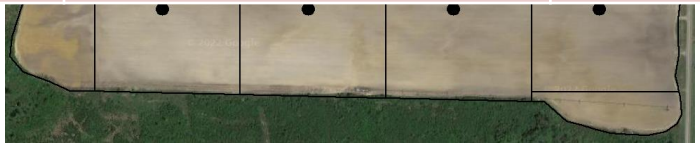
(zones based on certain soil/crop properties)

Is there an optimal grid size for precision soil sampling?



Grid Size (ac)	#samples	Soil Sampling/ Labor Costs ($)	Sample Analysis Costs ($)	Total Cost ($)
1.0	92	460	552	1012
2.5	35	414	210	624
5.0	17	368	102	470
7.5	13	368	78	446
10.0	8	368	48	416

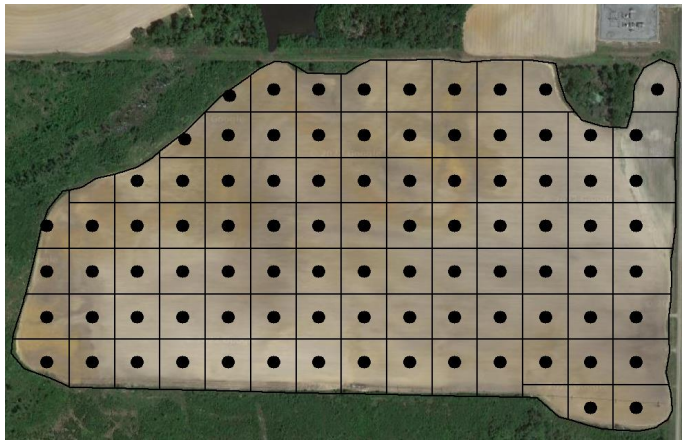
7.5 ac



10.0 ac

Accuracy and Economics of Different Grid Sizes

(2022 & 2023 – multiple fields across Georgia)



1.0 ac

2.5 ac

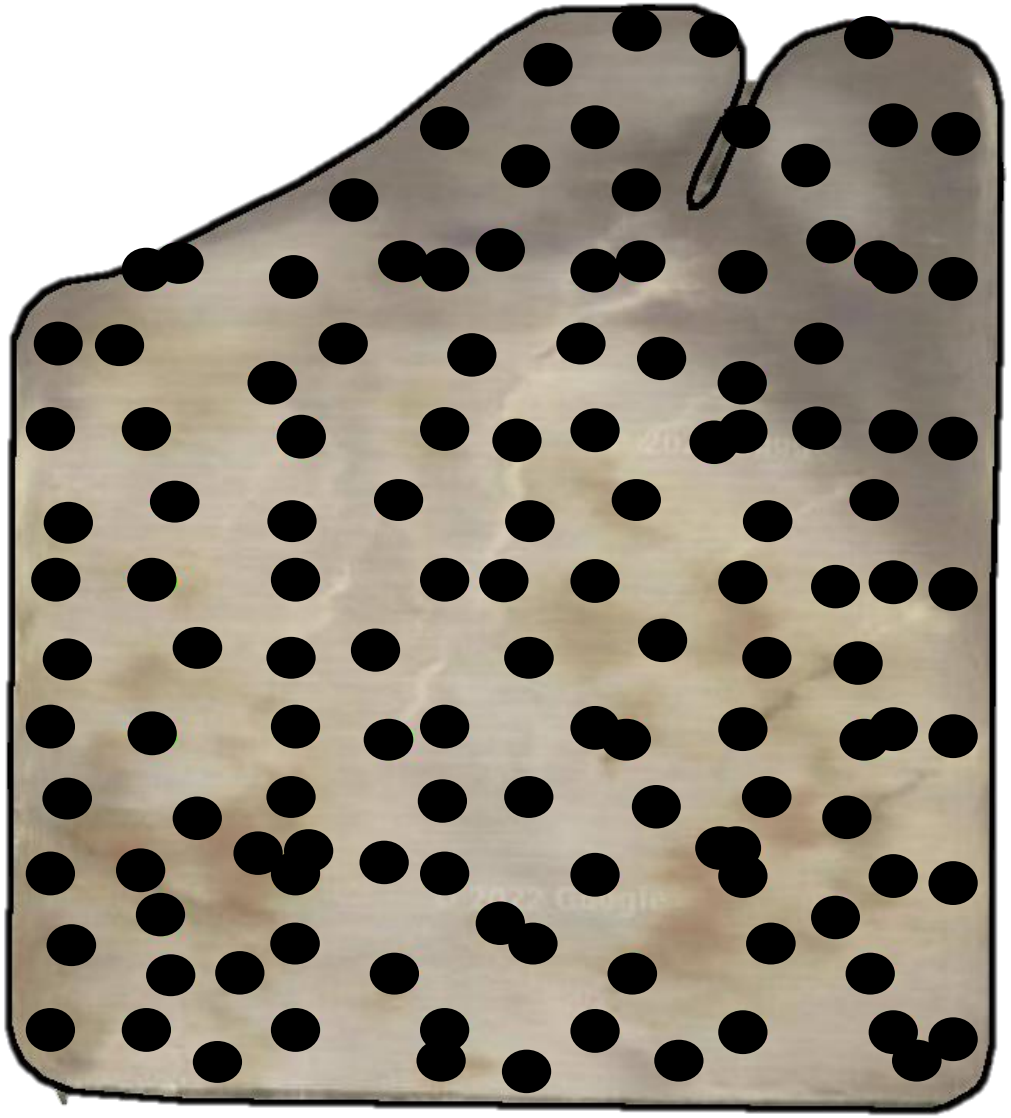
5.0 ac

7.5 ac

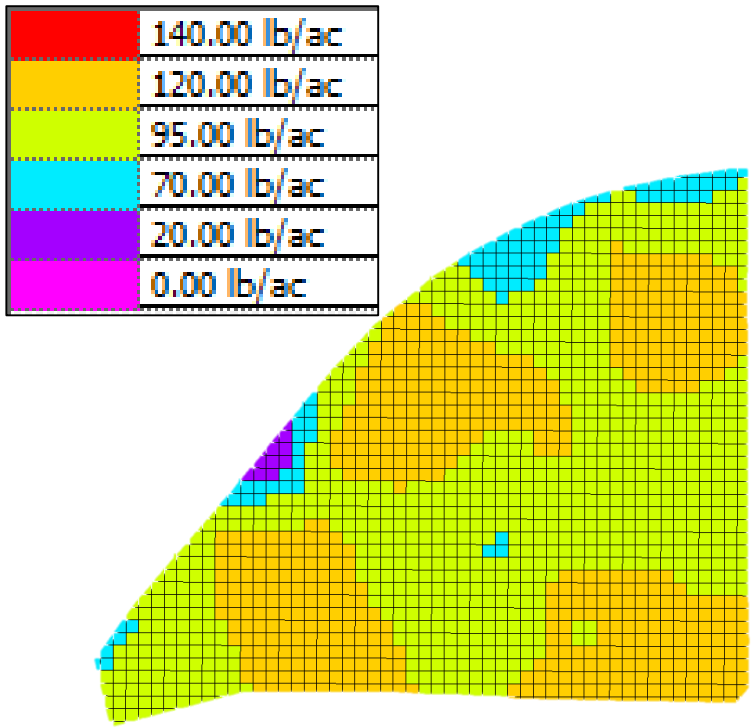
10.0 ac

Reference - (Assumed) Actual Nutrient Variability

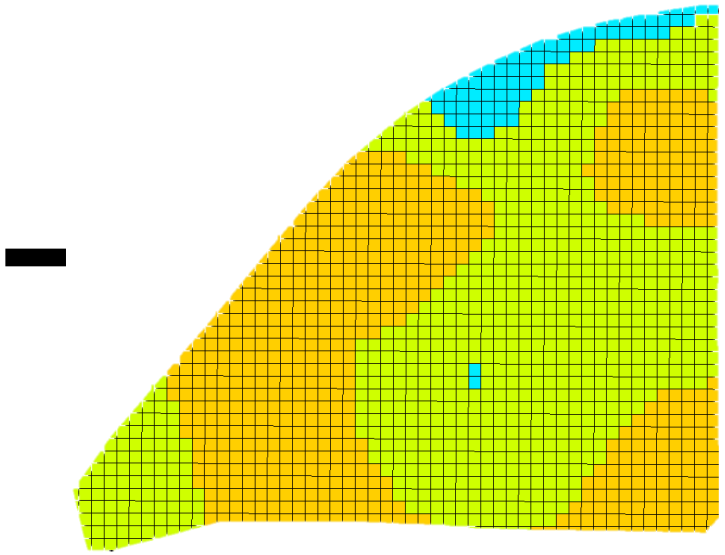
This high-density sampling map (2-4 samples/ac) was assumed to represent actual nutrient variability.



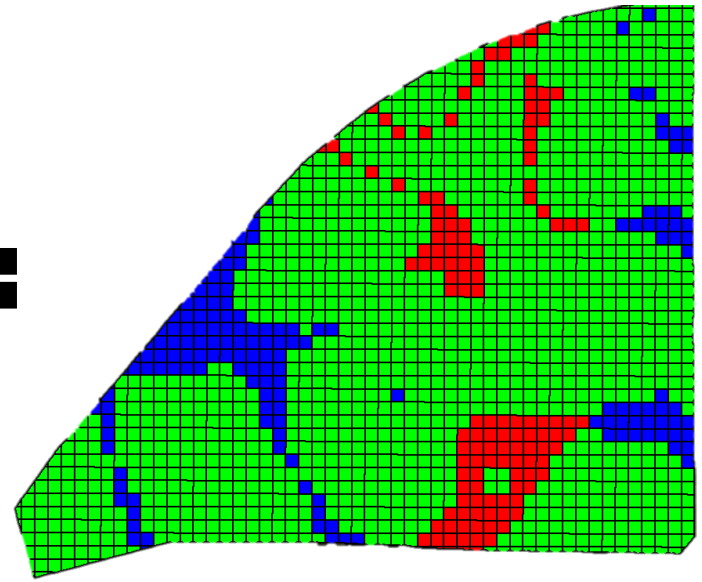
Spatial Application Accuracy



K Prescription Map
(All points representing actual nutrient variability)



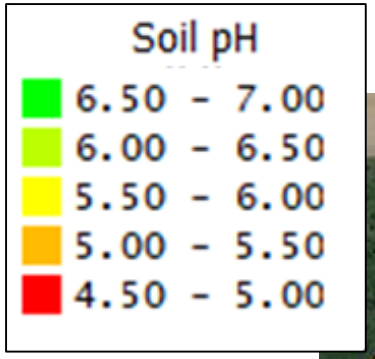
K Prescription Map
(2.5 ac grid sampling)



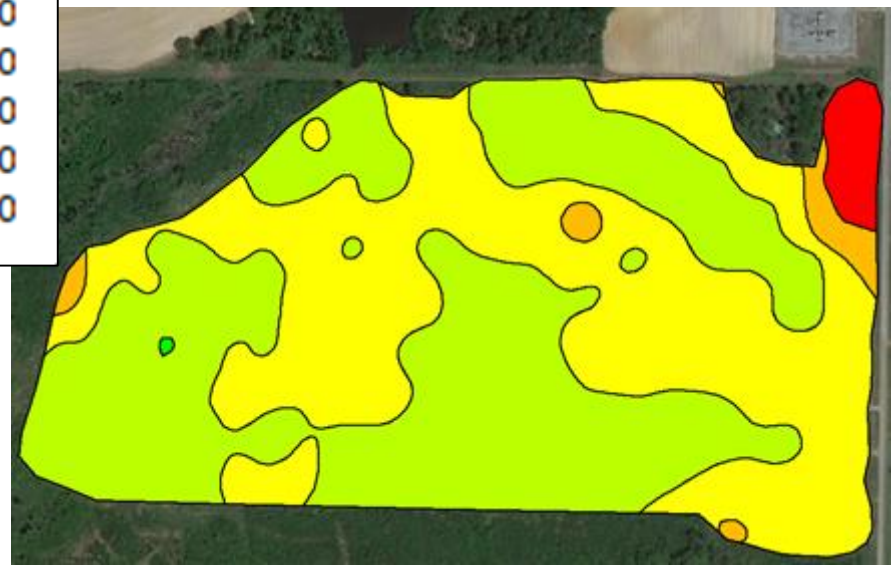
Map showing on-target, under- and over-application areas

Under Applied

Over Applied



Actual Soil pH Variability (163 Samples)



1 ac
(92 samples)

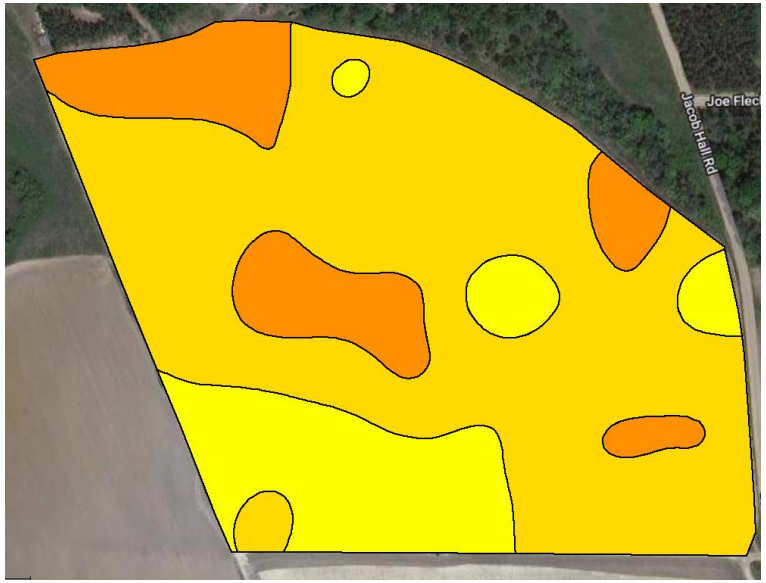
2.5 ac
(35 samples)

5 ac
(17 samples)

Soil K
(lb/ac)

135.00	170.00
100.00	135.00
70.00	100.00
35.00	70.00
0.00	35.00

Actual Soil K Variability (100 samples)



1 ac
(53 samples)

2.5 ac
(23 samples)

5 ac
(10 samples)

Economic Analysis

Consultant/Soil Lab Fees:

Soil sampling/Labor = $4-6/ac
Sample analysis = $6/sample

Variable-Rate Prescription Maps:

Cotton Lint Yield Goal = 1200 lb/ac

2023 UGA Cotton Enterprise Budget:

Lime = $50/ton
Phosphorus = $0.67/lb
Potassium = $0.68/lb

Grid Size (ha)	Samples (#)	Sampling Cost ($/ac)	Analysis Cost ($/ac)	Fertilizer Cost ($/ac)	Total Cost ($/ac)
1.0	90	6	6	33	45
2.5	35	5	2	29	36
5.0	17	4	1	26	31
7.5	13	4	1	28	33
10.0	8	4	1	37	41

Total Cost ($/ac)

=

Soil Sampling Cost ($/ac)

+

Soil Analysis Cost ($/ac)

+

Fertilizer Cost ($/ac)

Grid Size – Effectiveness vs Cost

Lime, Potassium and Phosphorus

Application Accuracy (%)

Grid Size	F1	F2	F3	F4	F5	F6	F7	F8	F9
1.0	87	89	95	90	95	75	91	90	91
2.5	66	85	92	78	93	82	41	70	13
5.0	51	75	75	81	87	80	68	65	77
7.5	46	66	94	11	92	75	41	70	81
10.0	45	34	65	54	30	75	41	48	76

Application Costs ($/ac)

Grid Size	F1	F2	F3	F4	F5	F6	F7	F8	F9
1.0	43	20	34	33	34	43	40	38	56
2.5	35	14	28	27	30	41	31	33	64
5.0	31	15	23	26	32	41	35	36	55
7.5	33	20	30	5	30	42	30	31	51
10.0	41	17	22	18	39	42	30	22	55

Grid Size – Application Accuracy vs Cost

Field 1

Grid Size	Accuracy (%)	Cost ($/ac)
1.0	89	20
2.5	85	14
5.0	75	15
7.5	66	20
10.0	34	17

Field 2

Grid Size	Accuracy (%)	Cost ($/ac)
1.0	87	43
2.5	66	35
5.0	51	31
7.5	46	33
10.0	45	41

Field 3

Grid Size	Accuracy (%)	Cost ($/ac)
1.0	95	34
2.5	93	30
5.0	87	32
7.5	62	30
10.0	30	39

Does a fixed grid size adequate for all fields?

Field 1

Lime

Grid Size	Accuracy (%)	Cost ($/ac)
1.0	89	20
2.5	85	14
5.0	75	15
7.5	66	20
10.0	34	17

P

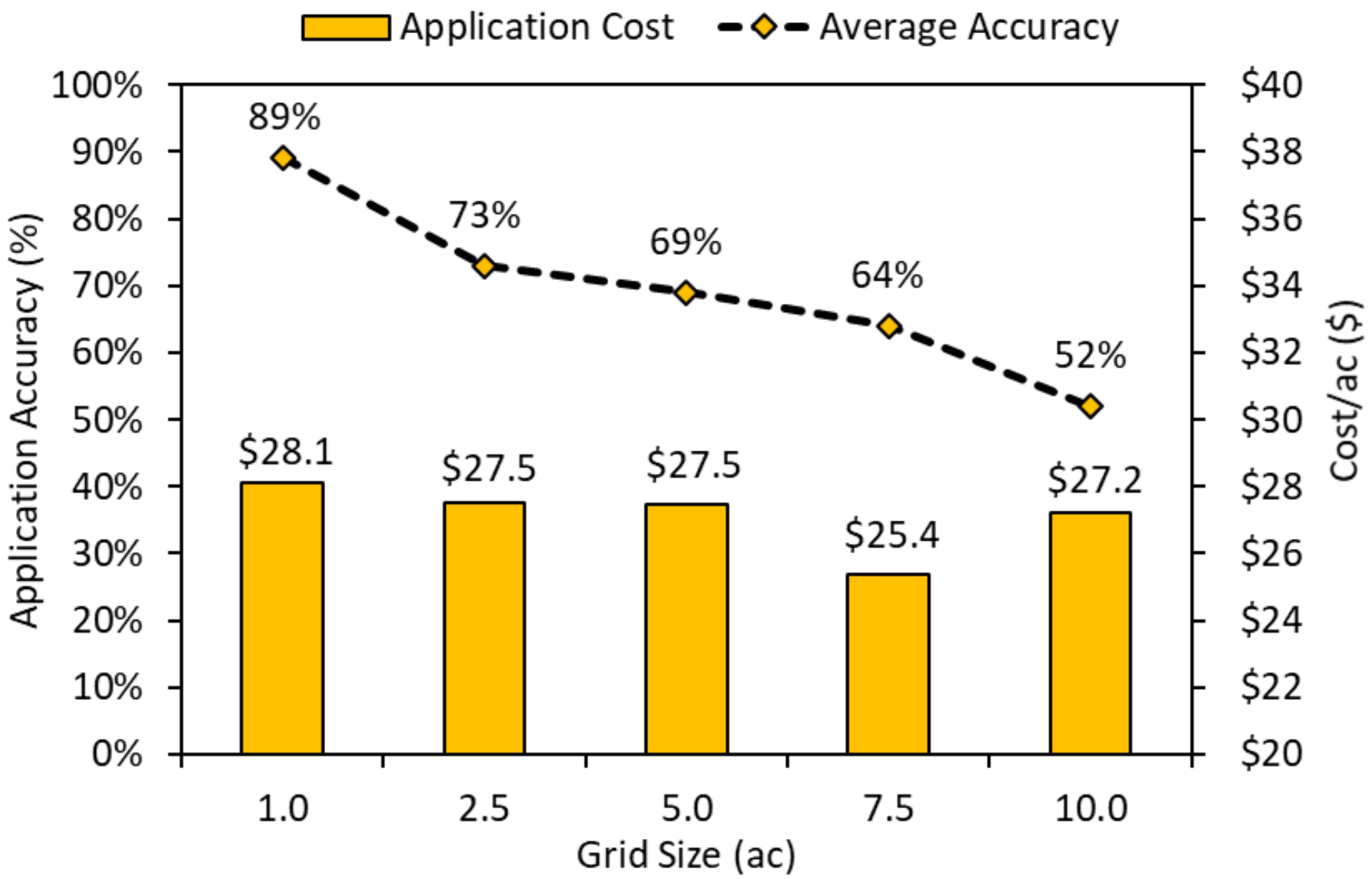
Grid Size	Accuracy (%)	Cost ($/ac)
1.0	92	16
2.5	82	15
5.0	70	13
7.5	74	14
10.0	77	10

K

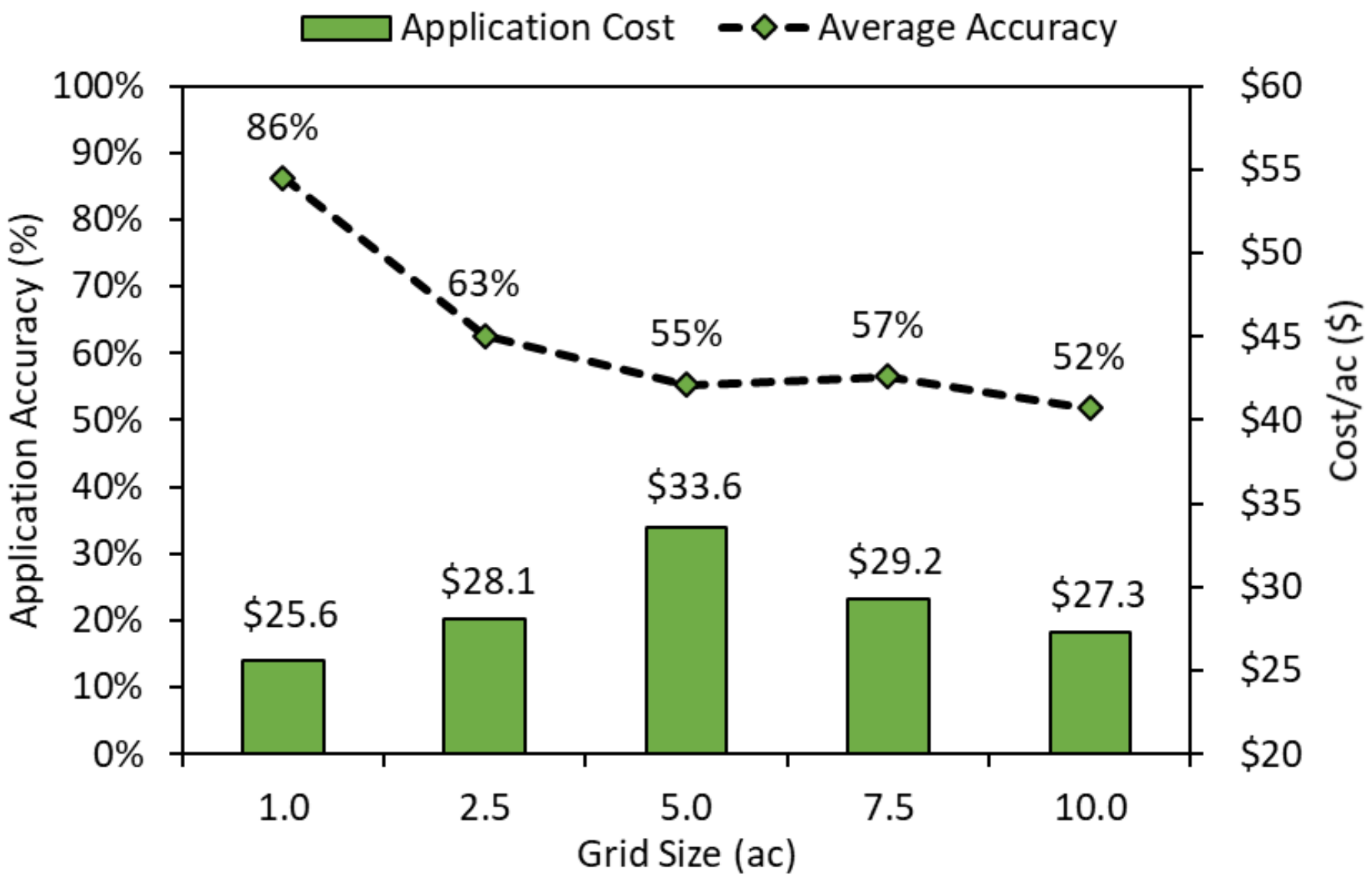
Grid Size	Accuracy (%)	Cost ($/ac)
1.0	88	89
2.5	72	85
5.0	66	82
7.5	49	86
10.0	44	86

How do we make a grid size decision here?

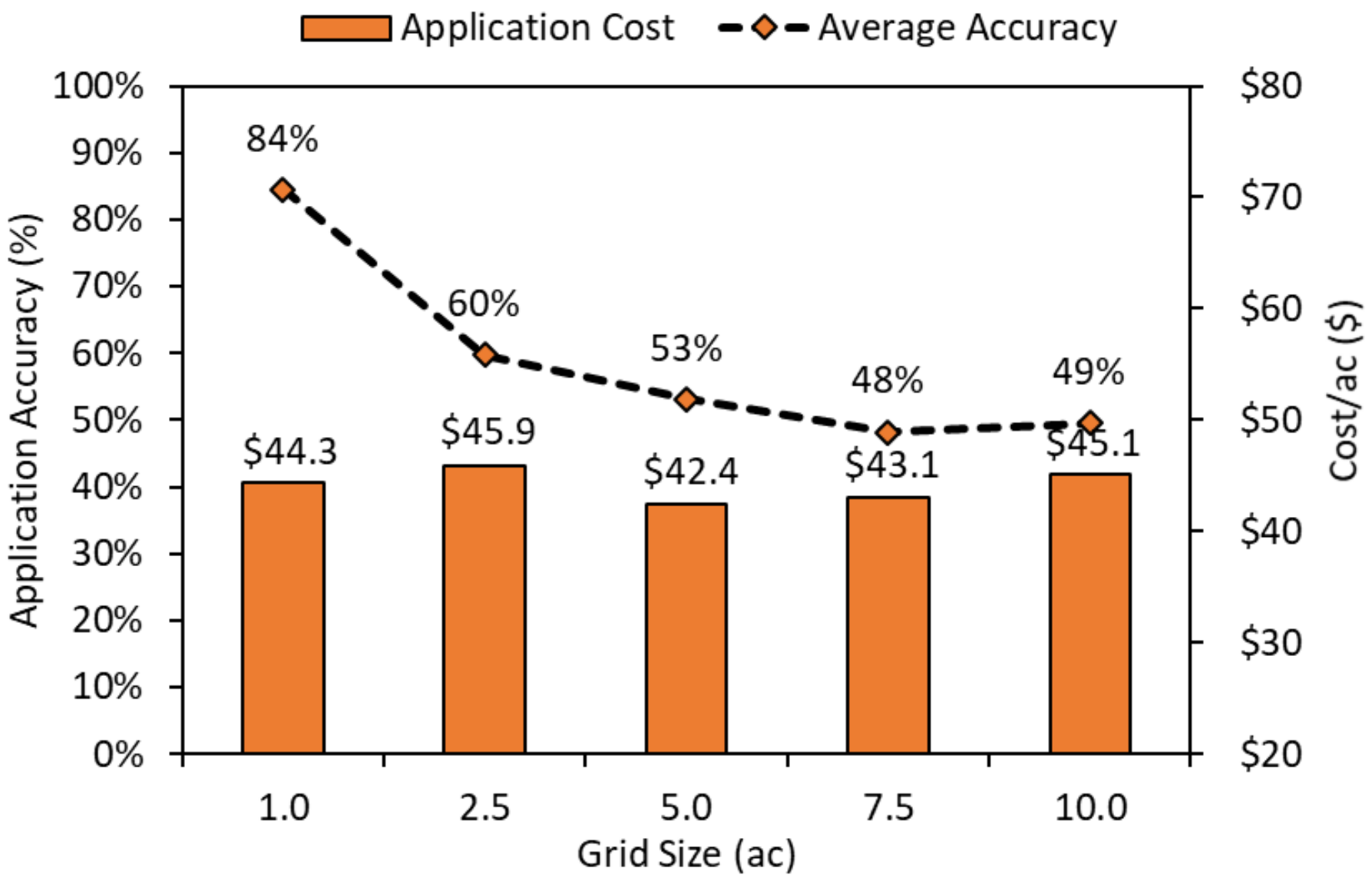
Lime


Application Cost
Average Accuracy
Application Accuracy (%)
Cost/ac ($)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
$40
$38
$36
$34
$32
$30
$28
$26
$24
$22
$20
89%
73%
69%
64%
52%
$28.1
$27.5
$27.5
$25.4
$27.2
1.0
2.5
5.0
7.5
10.0
Grid Size (ac)

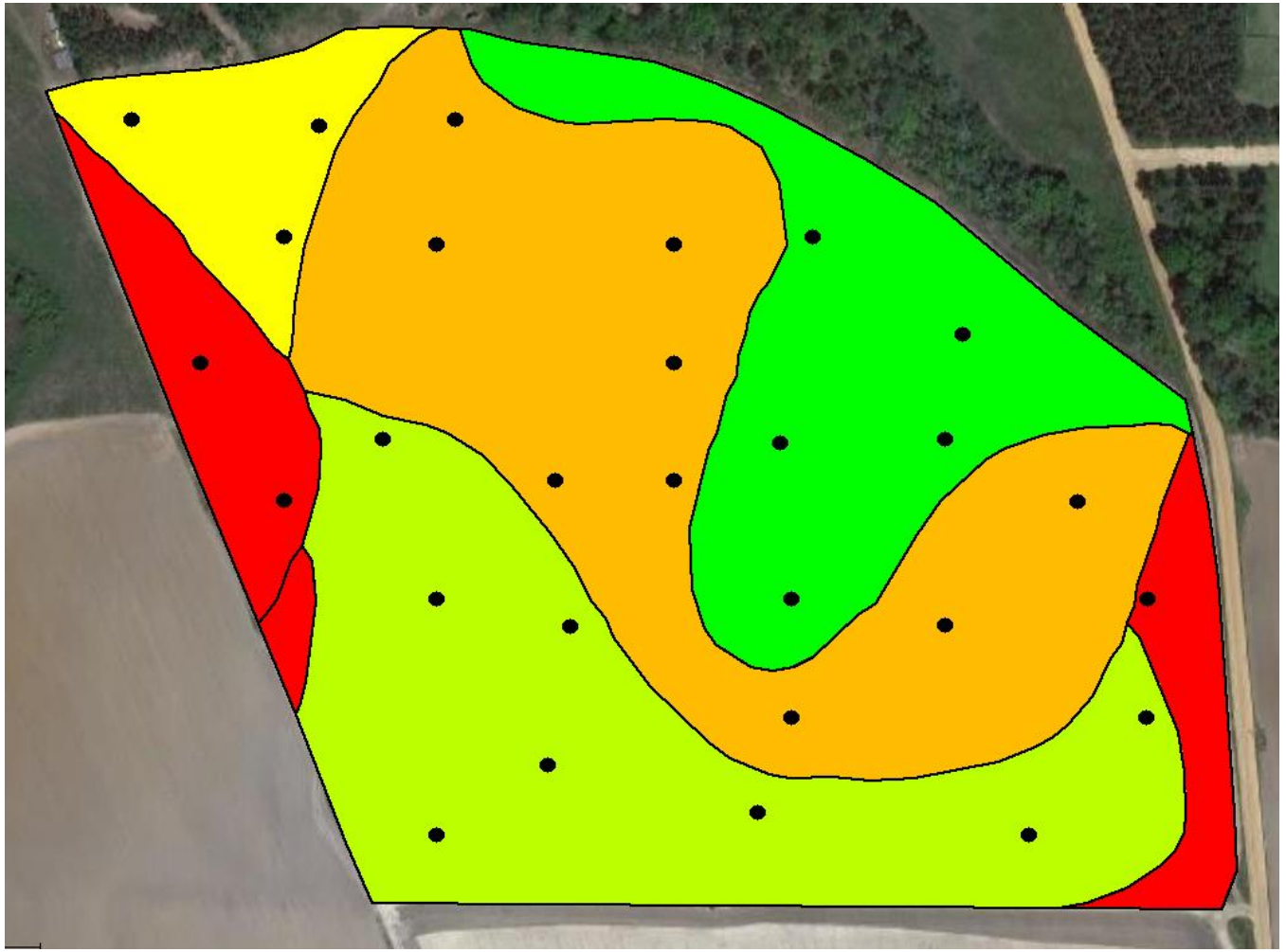
Phosphorus


Application Cost
Average Accuracy
Application Accuracy (%)
Cost/ac ($)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
$60
$55
$50
$45
$40
$35
$30
$25
$20
86%
63%
55%
57%
52%
$25.6
$28.1
$33.6
$29.2
$27.3
1.0
2.5
5.0
7.5
10.0
Grid Size (ac)

Potassium


Application Cost
Average Accuracy
Application Accuracy (%)
Cost/ac ($)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
$80
$70
$60
$50
$40
$30
$20
84%
60%
53%
48%
49%
$44.3
$45.9
$42.4
$43.1
$45.1
1.0
2.5
5.0
7.5
10.0
Grid Size (ac)

Zone-Based Soil Sampling

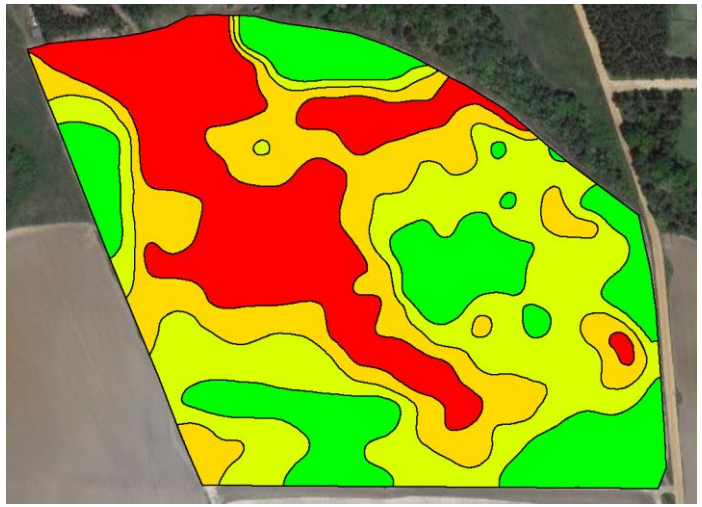


5 Zones = 5 Soil Samples *(composite for each zone)*

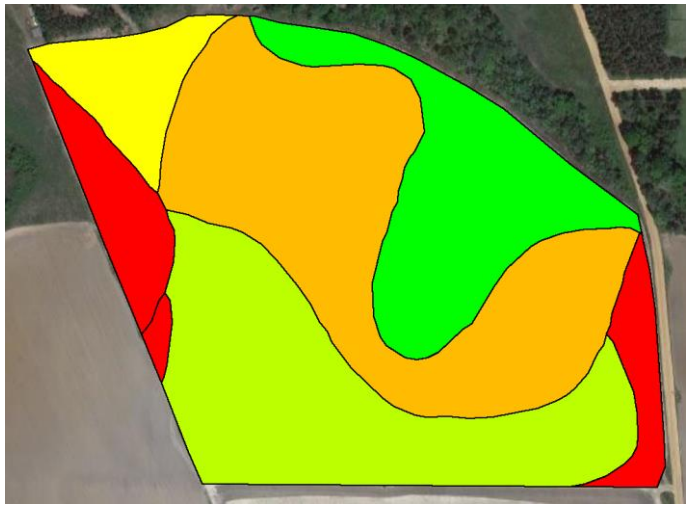
Each zone = 3 – 10 soil cores mixed together to make a composite sample

Soil Sampling/labor costs - $8-10/ac *(expertise to create zones)*

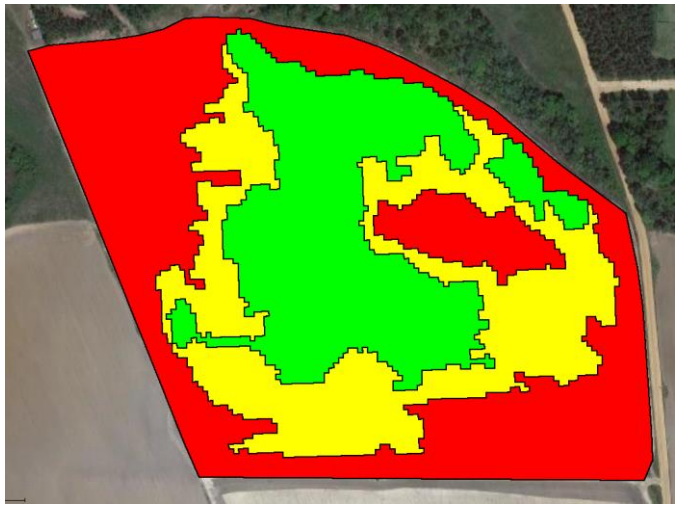
Zone Soil Sampling – Single Spatial Layers



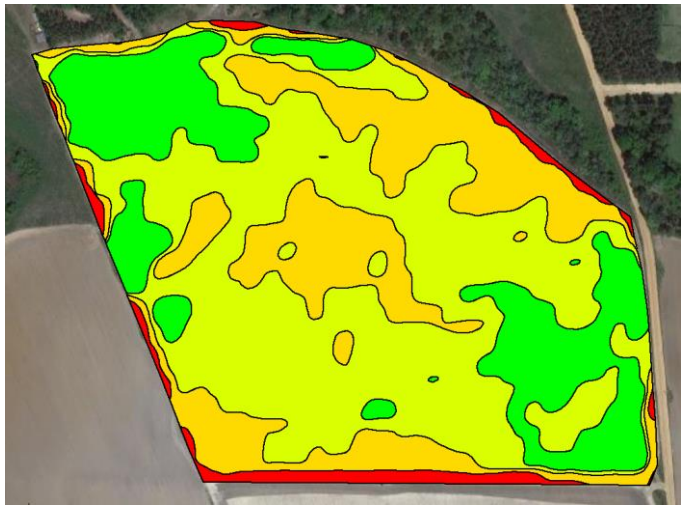
Soil EC (4 zones)



Soil Type (5 zones)

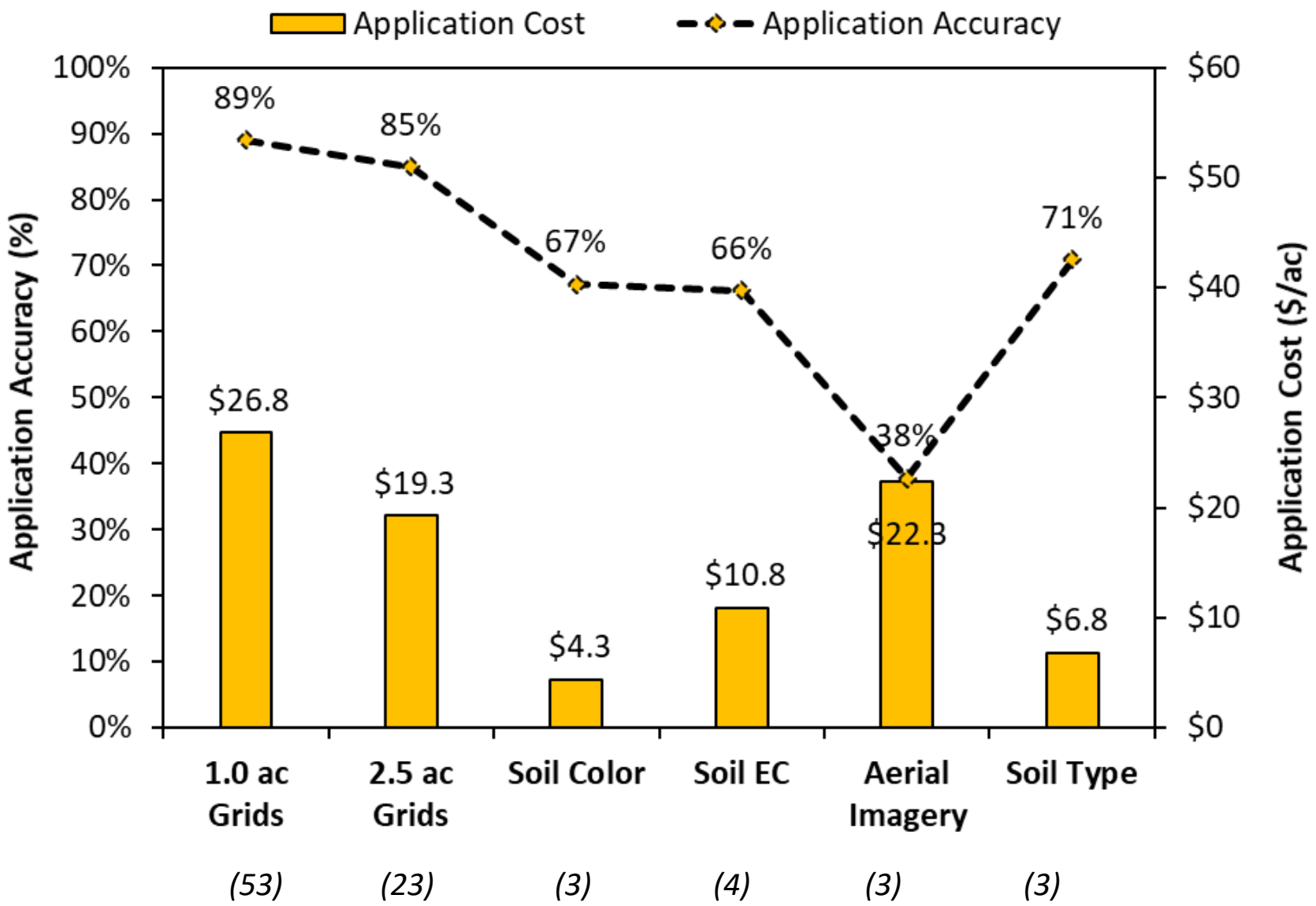


In-Season Crop Imagery (3 zones)

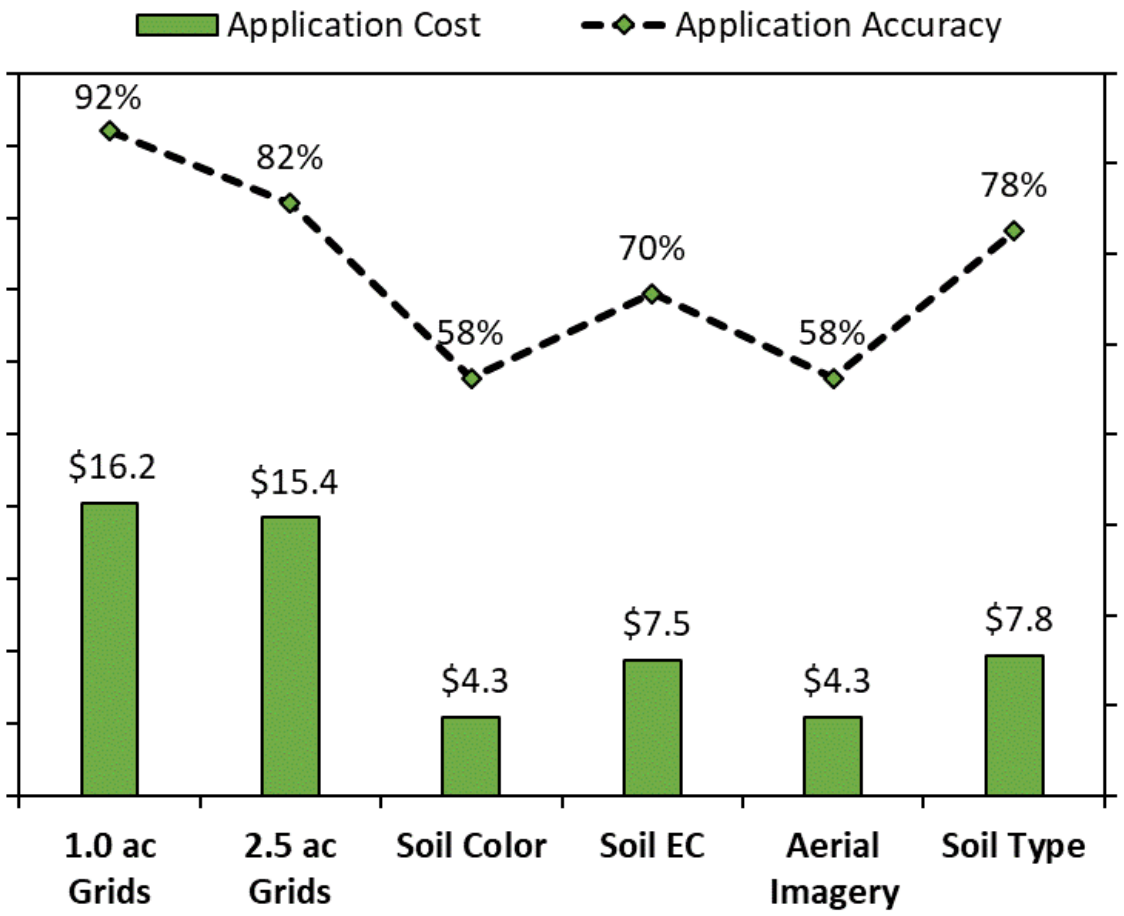


Soil Color/Brightness (3 zones)

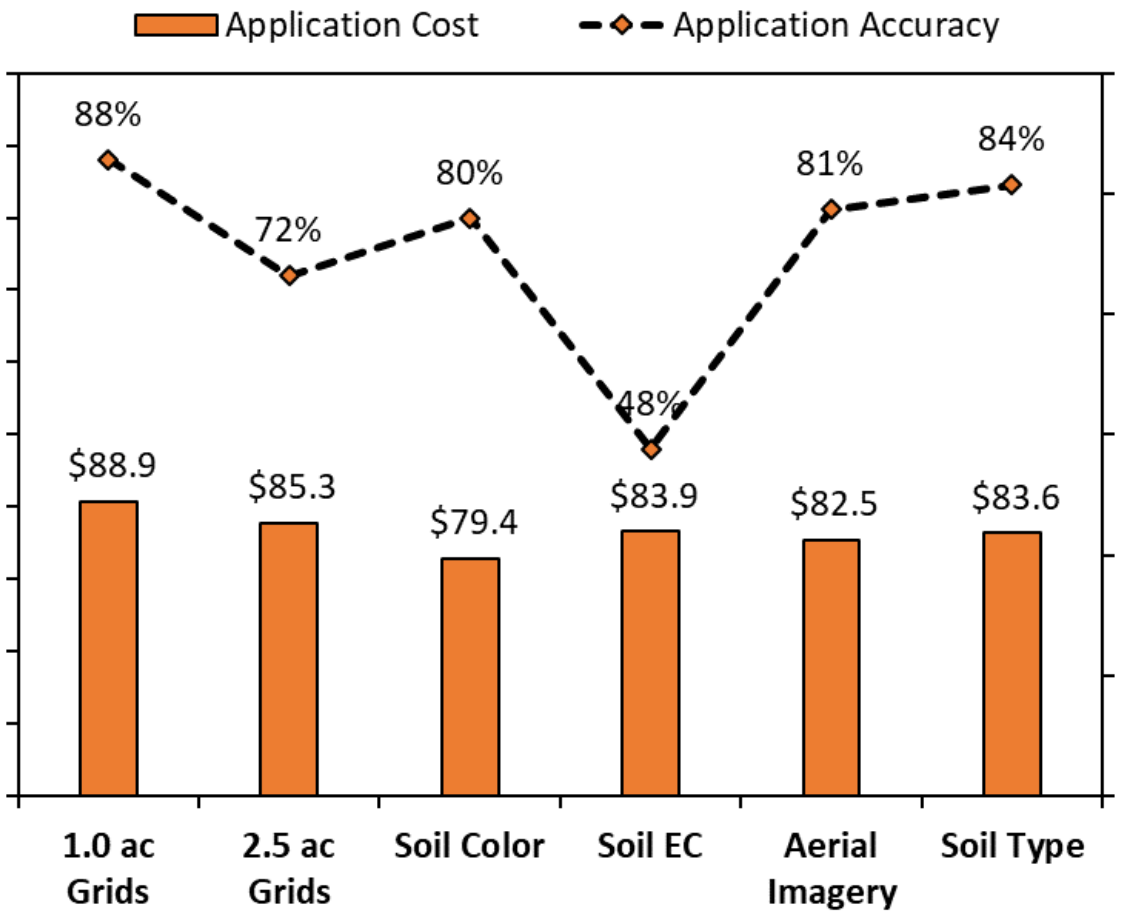
Lime


Application Cost
Application Accuracy
Application Accuracy (%)
Application Cost ($/ac)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
$60
$50
$40
$30
$20
$10
$0
89%
85%
67%
66%
38%
71%
$26.8
$19.3
$4.3
$10.8
$22.3
$6.8
1.0 ac Grids
2.5 ac Grids
Soil Color
Soil EC
Aerial Imagery
Soil Type
(53)
(23)
(3)
(4)
(3)
(3)

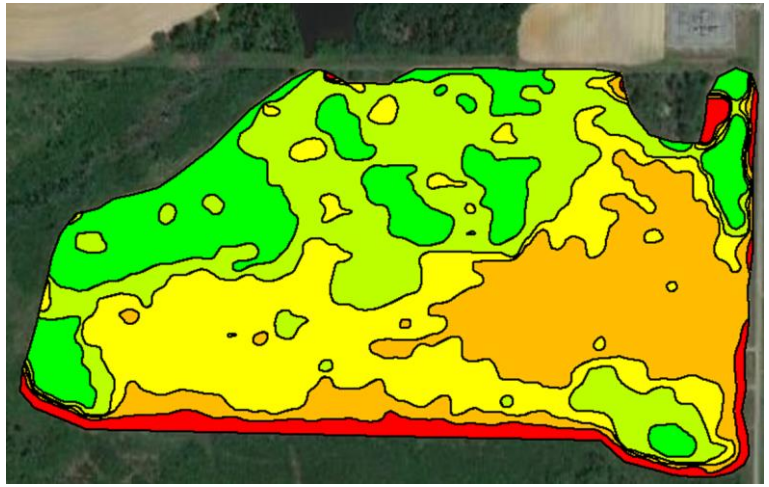
Phosphorus (P)



Potassium (K)

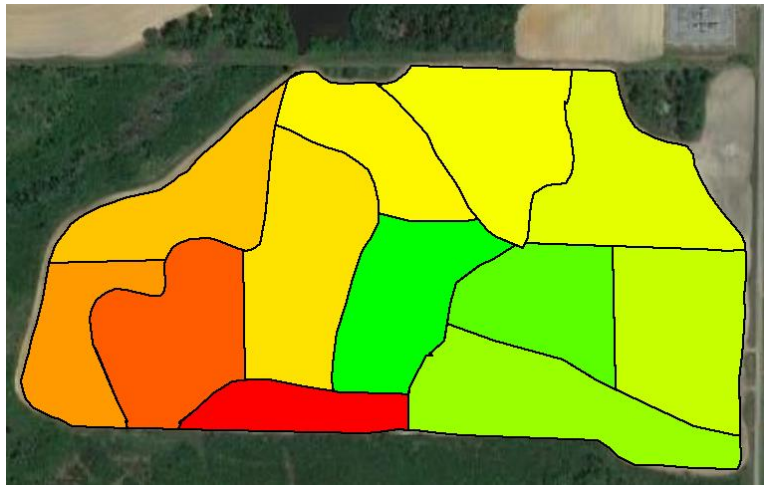


Zone Sampling – Combining Two or More Layers

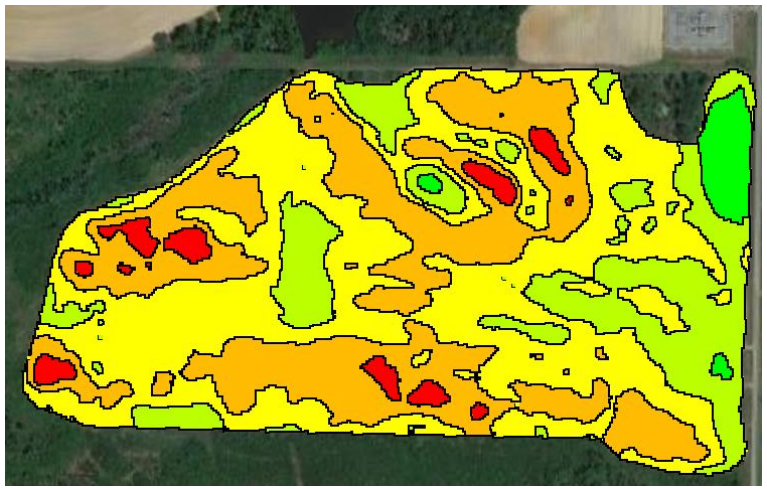


Soil Color/Brightness (5 samples)

Soil EC (4 samples)

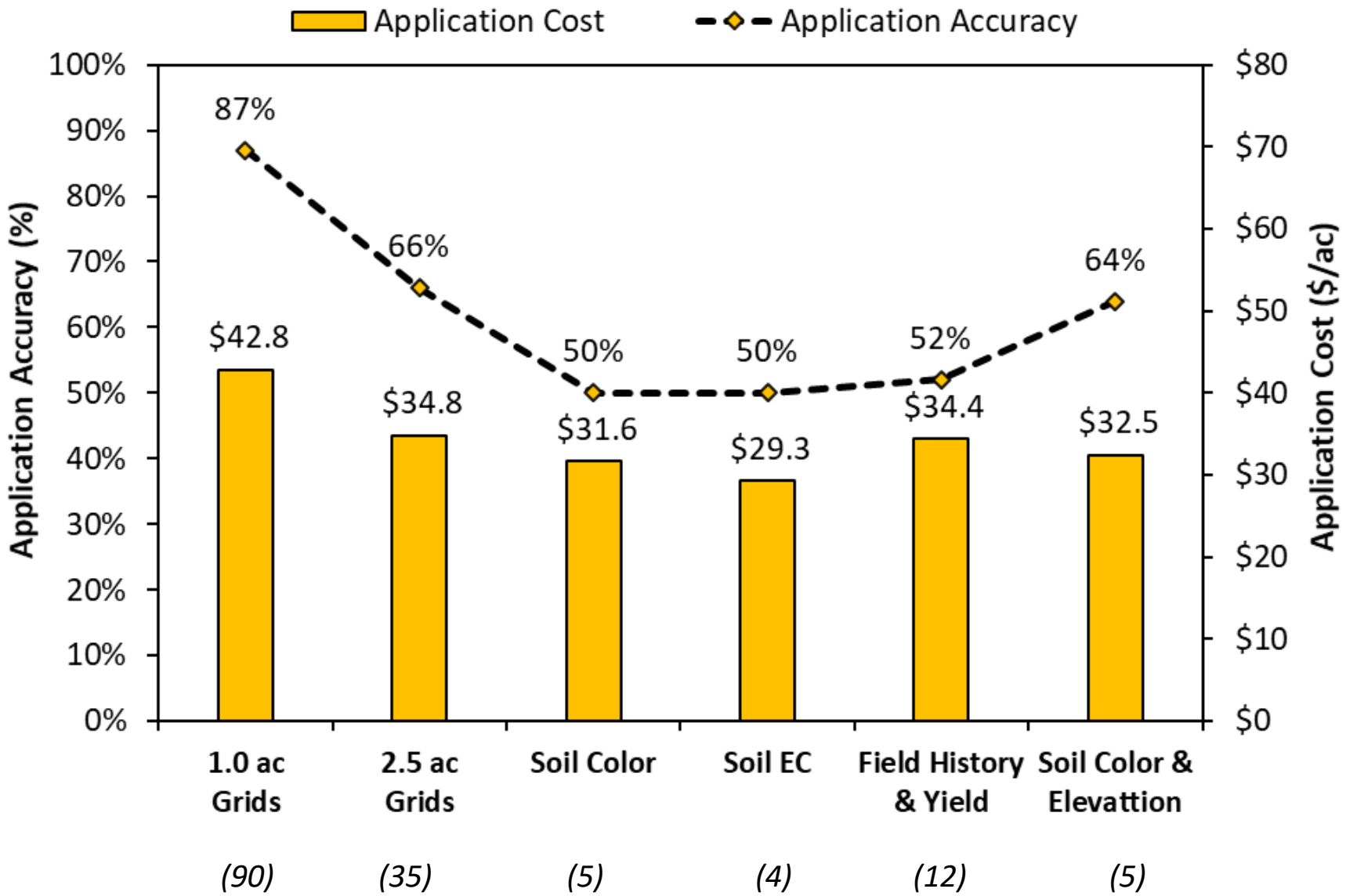


Field Knowledge and Yield (12 samples)

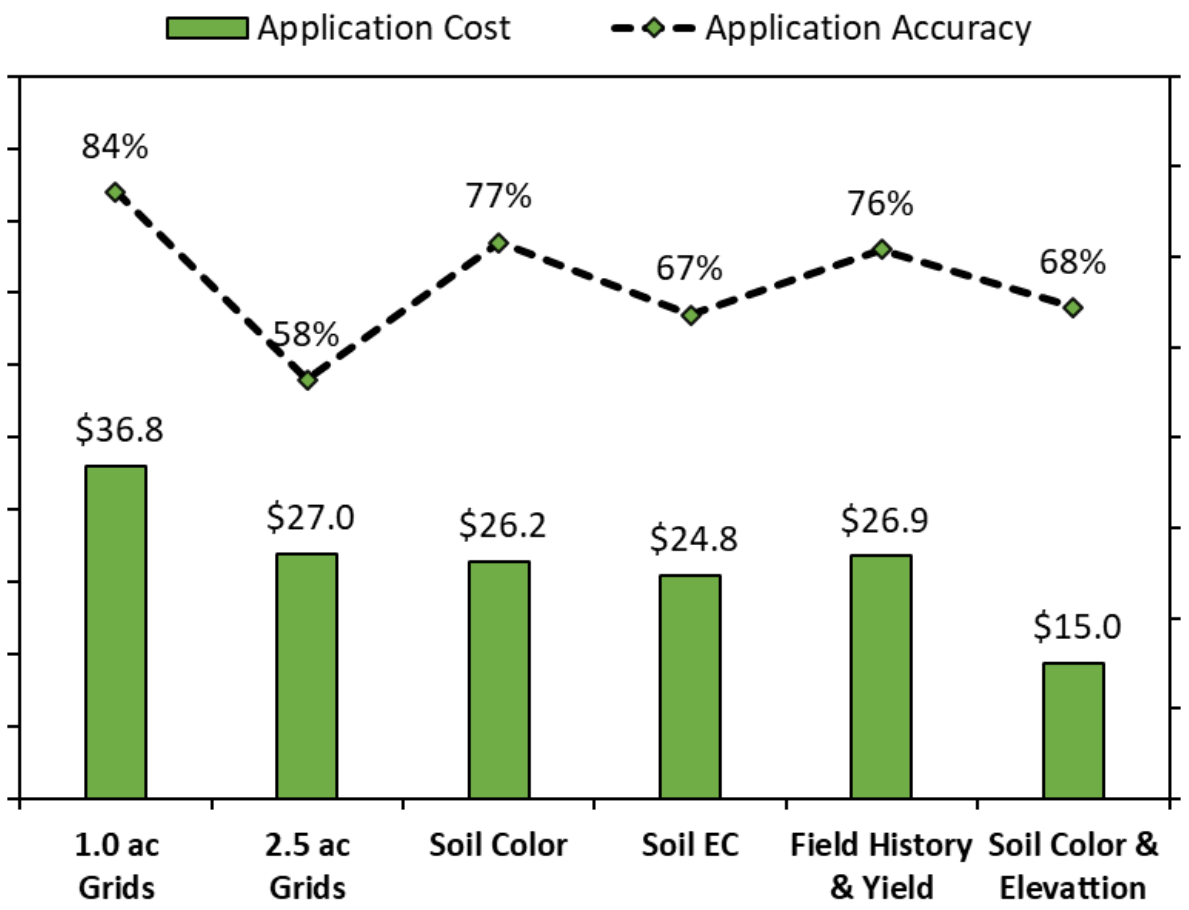


Soil Color and Elevation (5 samples)

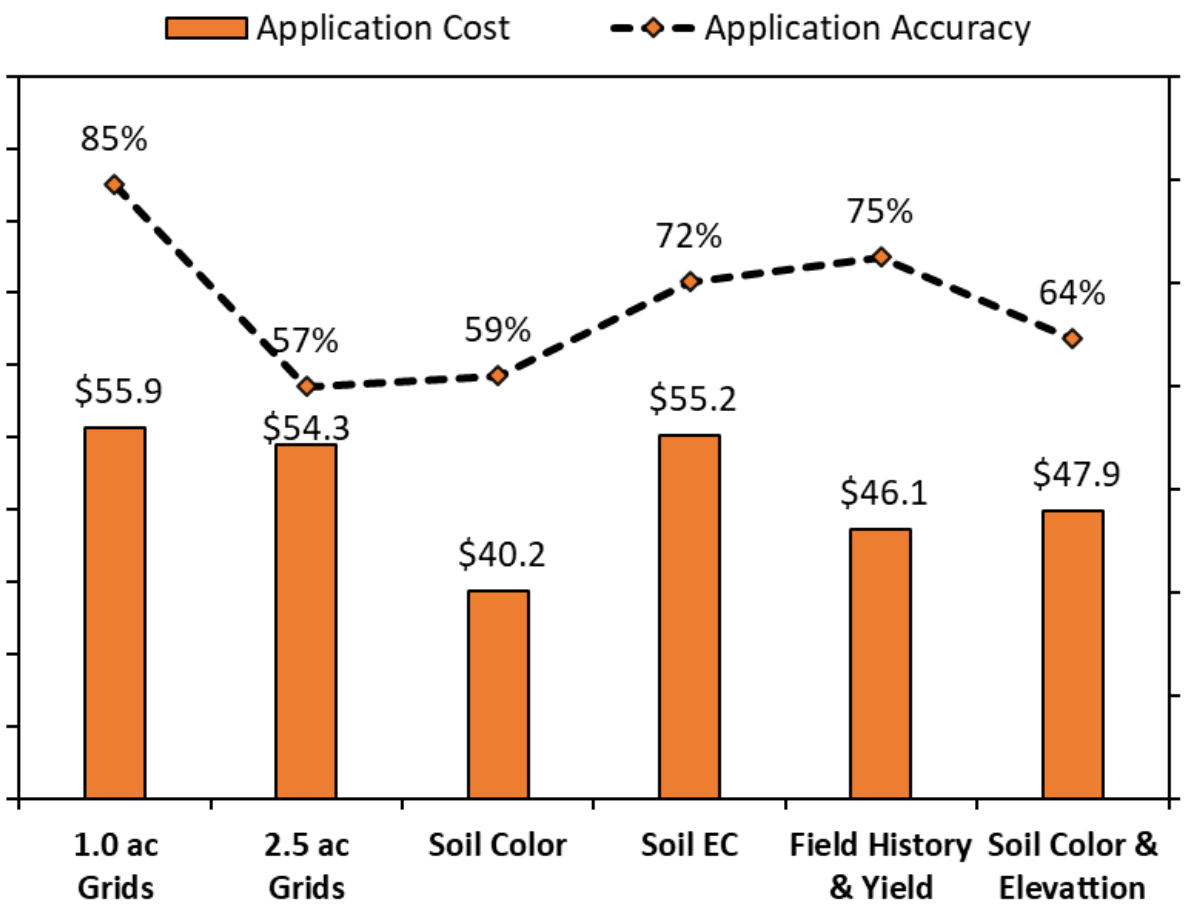
Lime


Application Cost
Application Accuracy
Application Accuracy (%)
Application Cost ($/ac)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
$80
$70
$60
$50
$40
$30
$20
$10
$0
87%
66%
50%
50%
52%
64%
$42.8
$34.8
$31.6
$29.3
$34.4
$32.5
1.0 ac Grids
2.5 ac Grids
Soil Color
Soil EC
Field History & Yield
Soil Color & Elevattion
(90)
(35)
(5)
(4)
(12)
(5)

Phosphorus (P)



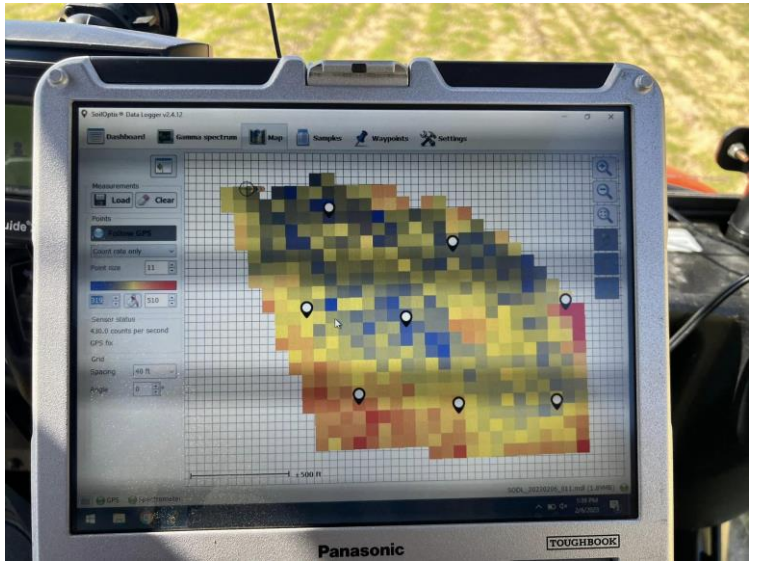
Potassium (K)

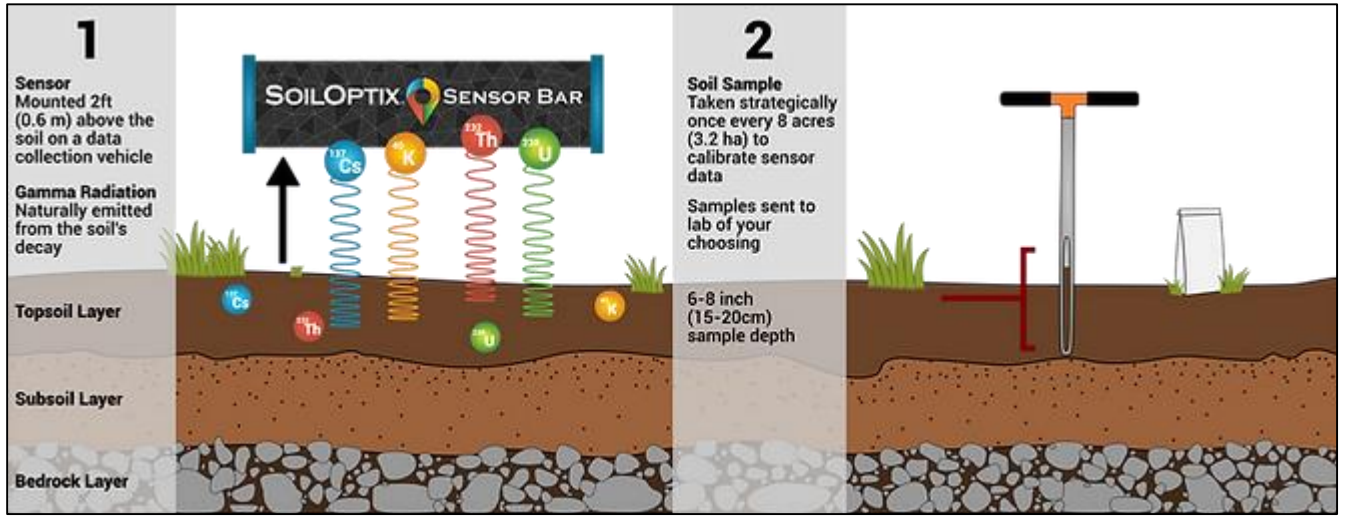


Zone Sampling – Commercial Provider’s/Software's

Soil Optix

- Gamma Radiation sensor
- 2 ft off the ground and 40 ft swaths
- Measures natural geological properties emitted from the soil’s decay
- Soil samples are taken in strategically placed locations (min. 4 samples per field)

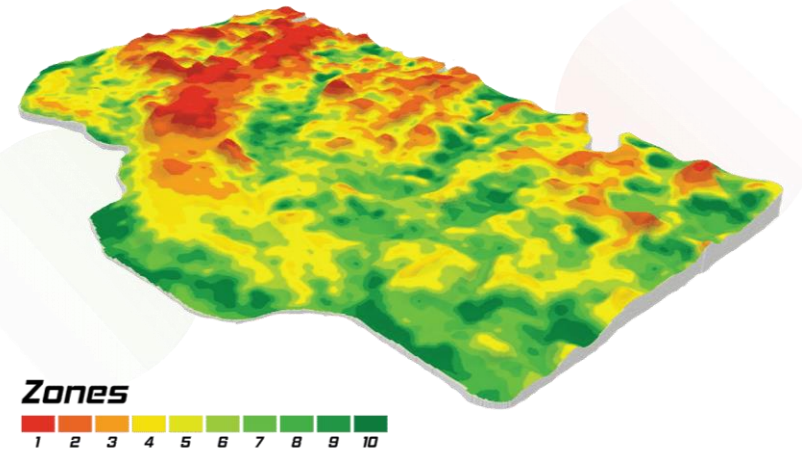


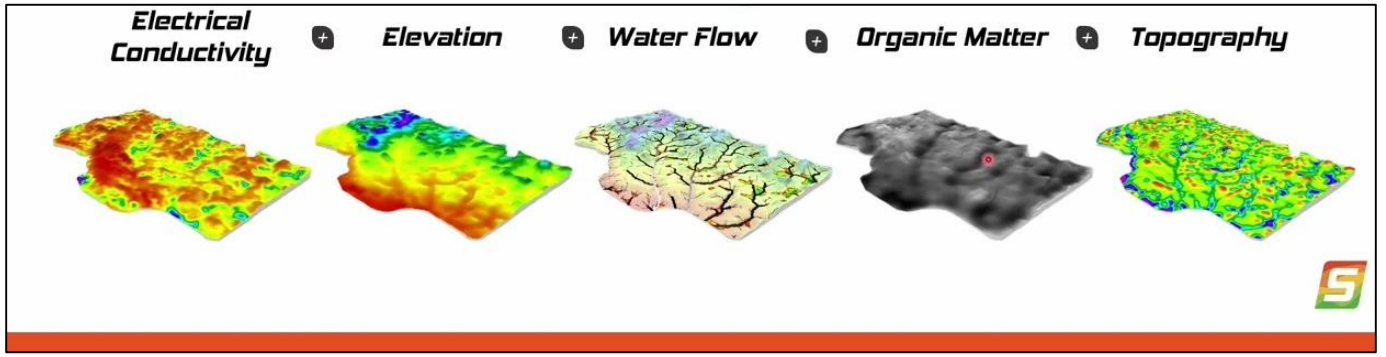


Zone Sampling – Commercial Provider’s/Software's

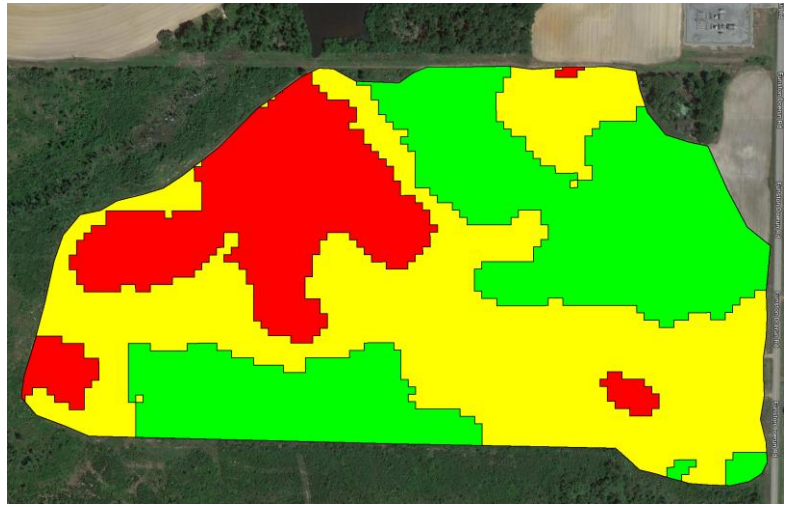
SWAT Maps

- Utilizes EC, Elevation, Water Flow, Organic Matter and Topography
- SWAT Box logs soil EC and elevation
- High-resolution maps with 10 different zones
- Soil samples are taken in 5 out of 10 zones (varies by field size)

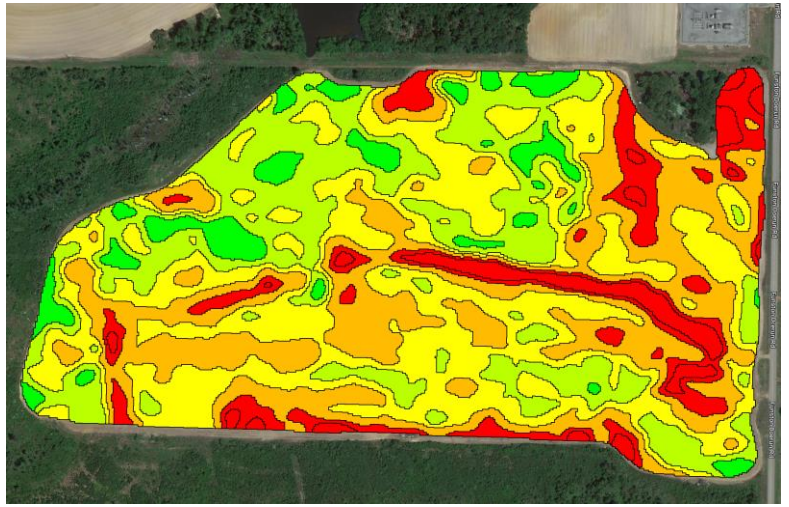




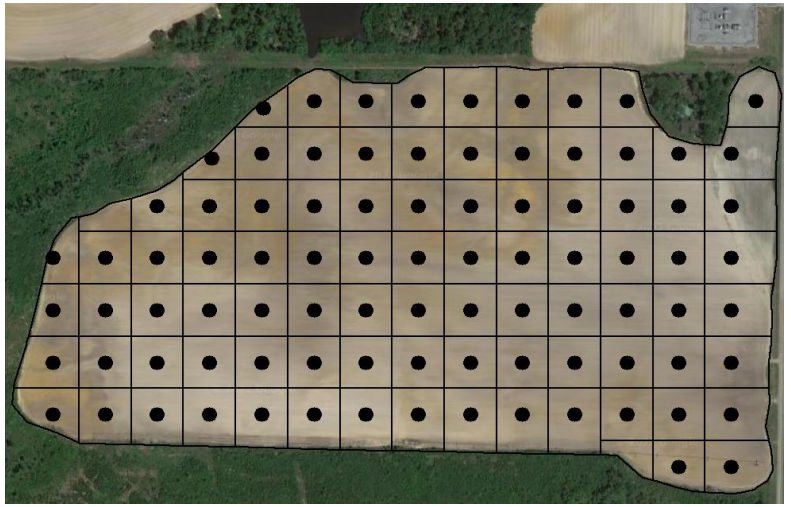
Zone Sampling - Commercial Provider's/Software's



Soil Optix (8 samples)



SWAT Maps (12 samples)



1-ac Grid Sampling (88 samples)

Field 1

Method	pH	P	K
1 ac Grid	93%	89%	83%
EC Zones	86%	73%	52%
SoilOptix	80%	78%	73%
SWAT Maps	82%	79%	71%

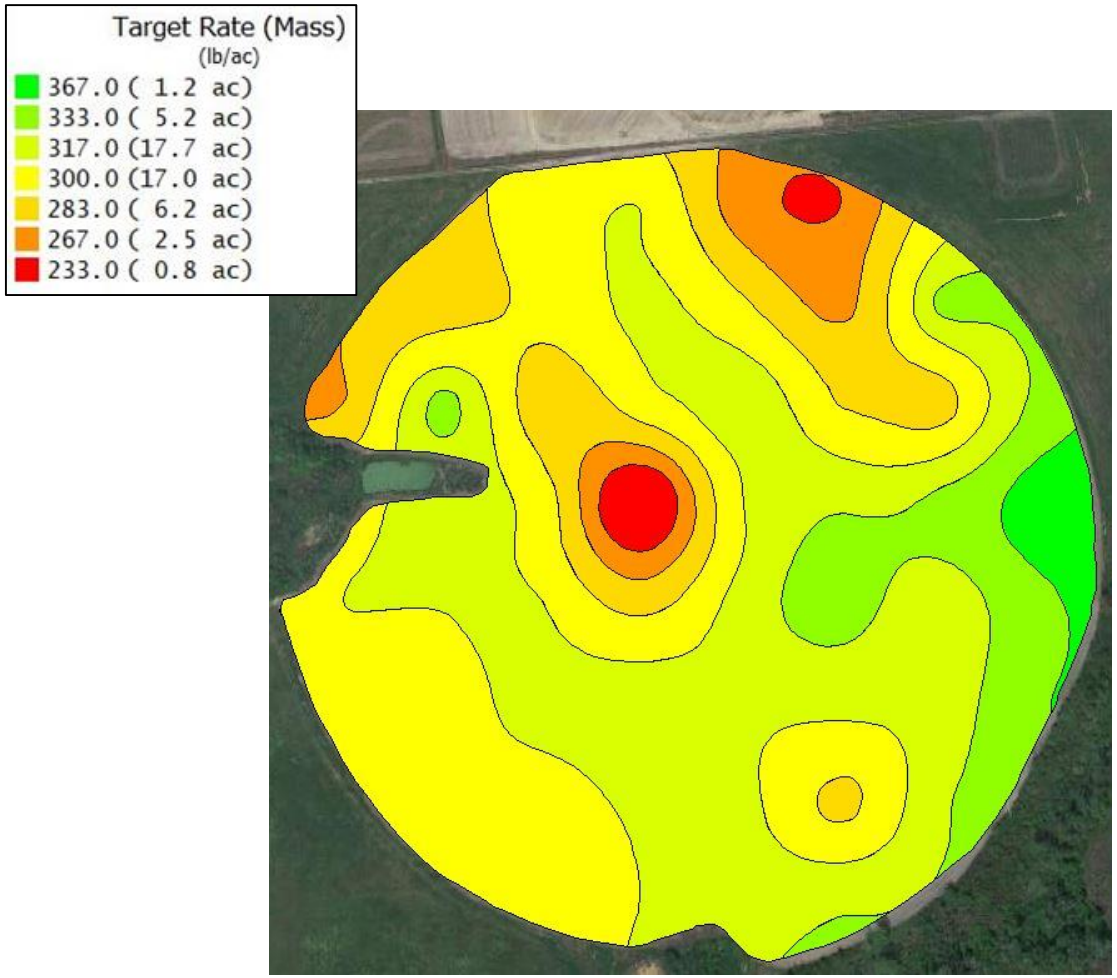
Field 2

Method	pH	P	K
1 ac Grid	84%	82%	84%
EC Zones	65%	56%	70%
SoilOptix	57%	53%	69%
SWAT Maps	67%	55%	61%

Soil Sampling Considerations – Grid vs Zone

- **Grid sampling** – grid size should not be greater than 2.5 ac in most fields. All newly cropped fields should be sampled at least once on 1-ac to understand variability. What about variable grid size?.....
- **Zone sampling** – Simple and practical is the key. Incorporate important data layers (e.g. field knowledge/history) to refine management zones. What about grid within zones?.....
- **Grid vs Zone** – start with grid sampling and gradually transition to zone sampling to be efficient with site-specific nutrient management and cost-effective.

Remember…..Soil Sampling is just one part of VR application



Thanks!

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