Precision Soil Sampling Considerations for Variable-Rate Fertilization in Georgia Row-Crops

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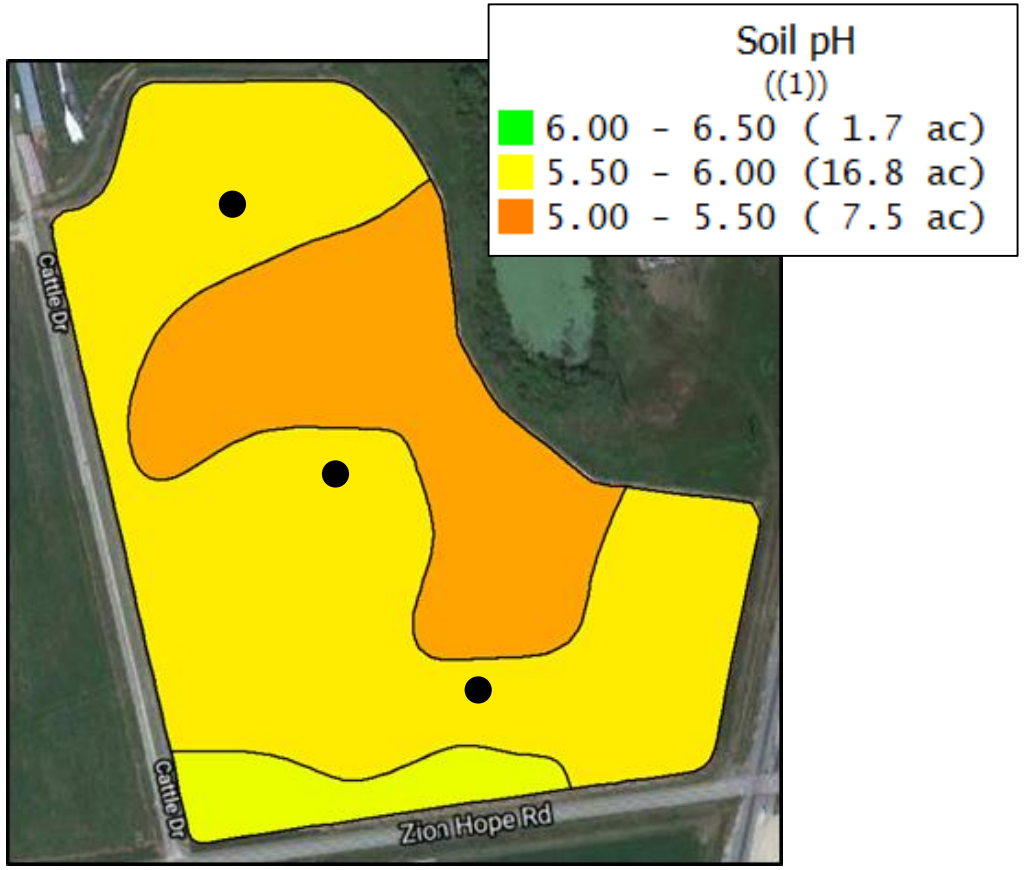
Row-Crop Fertilization

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



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)

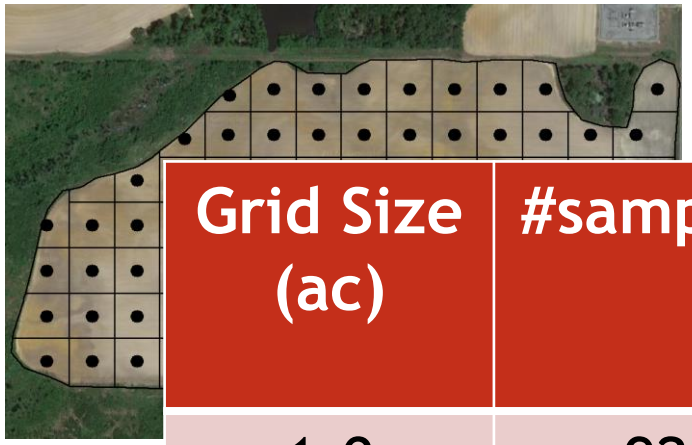
Grid Soil Sampling

(uniform sized grids)

Zone Soil Sampling

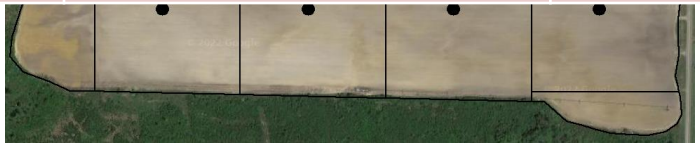
(zones based on certain soil/crop properties)

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

Investigating accuracy and economics of different grid sizes

(2022 – 9 fields across Georgia)

1.0 ac

2.5 ac

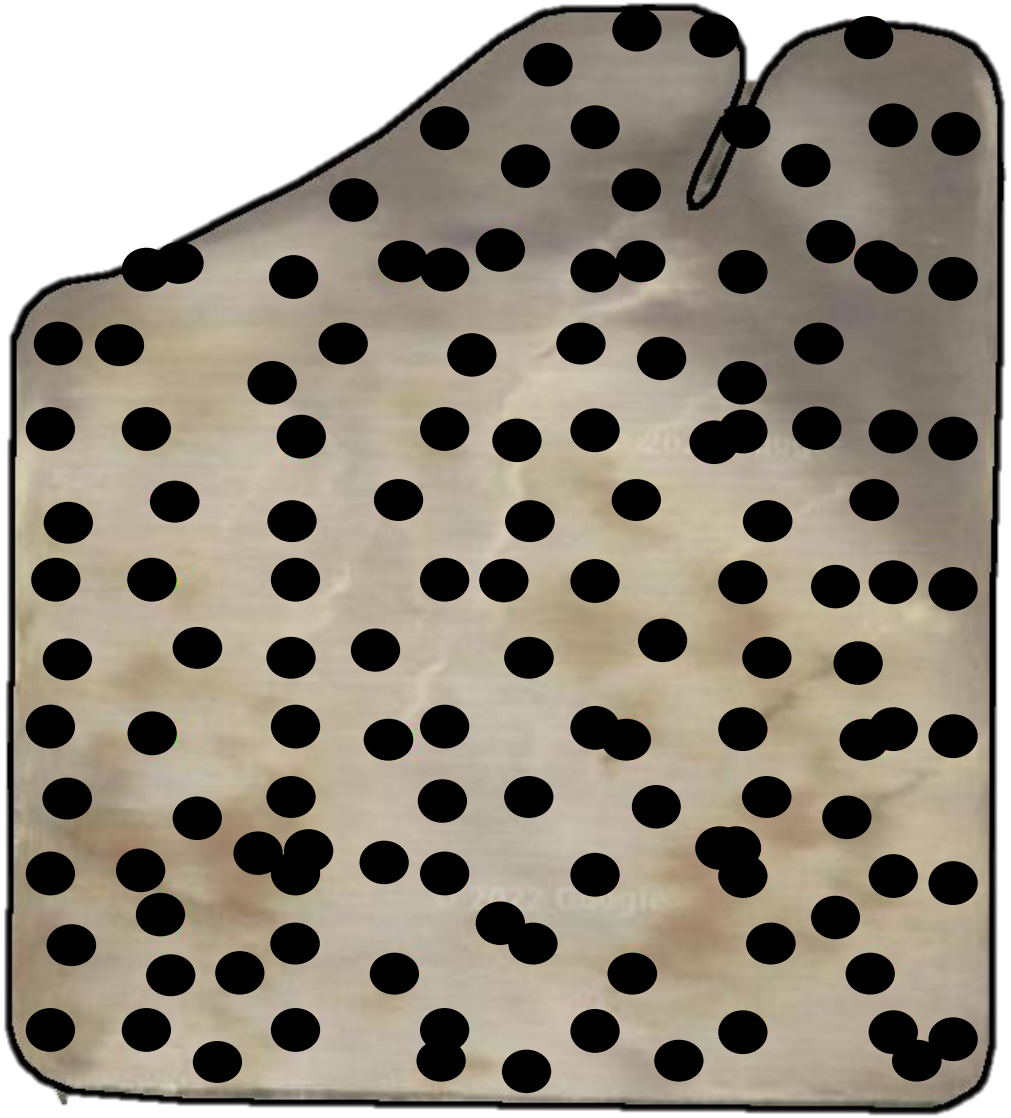
5.0 ac

7.5 ac

10.0 ac

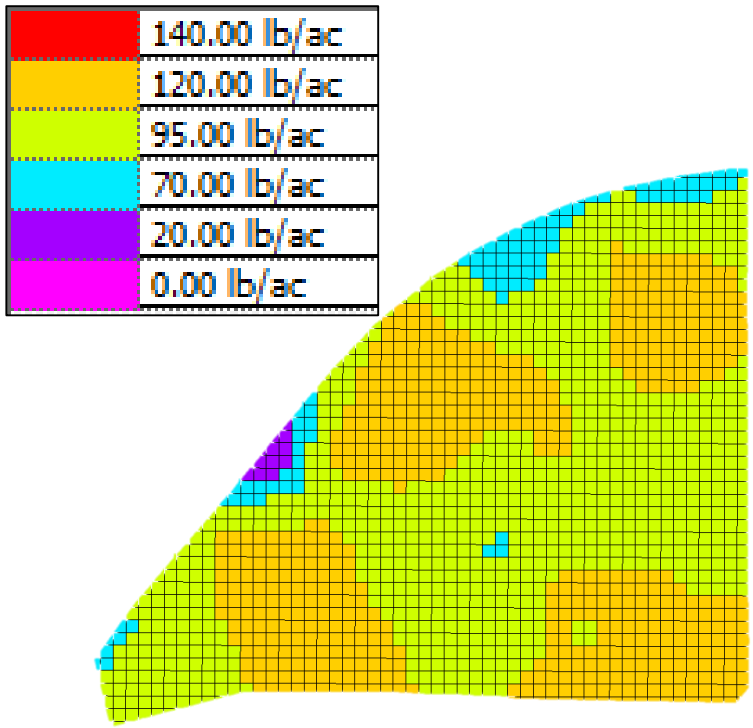
Actual Nutrient Variability

Soil sampling points from all grid sizes (1.0, 2.5, 5.0, 7.5 and 10.0 ac) were combined plus additional soil samples taken as required.

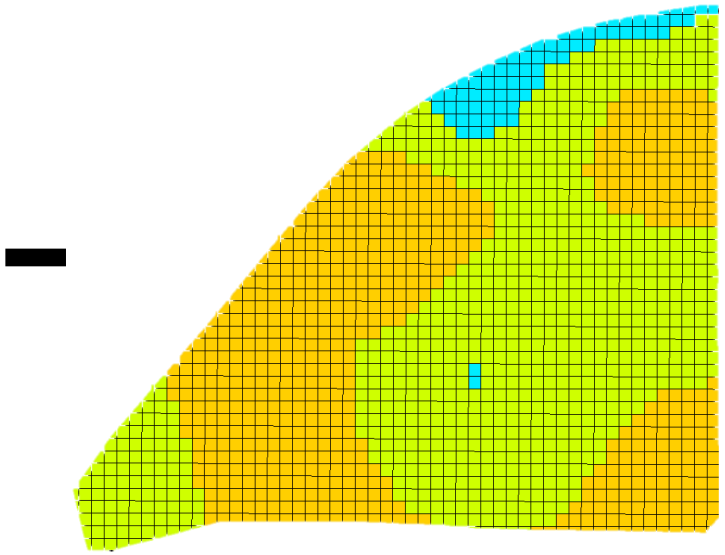


This high-density sampling map (2-4 samples/ac) was assumed to represent actual nutrient variability.

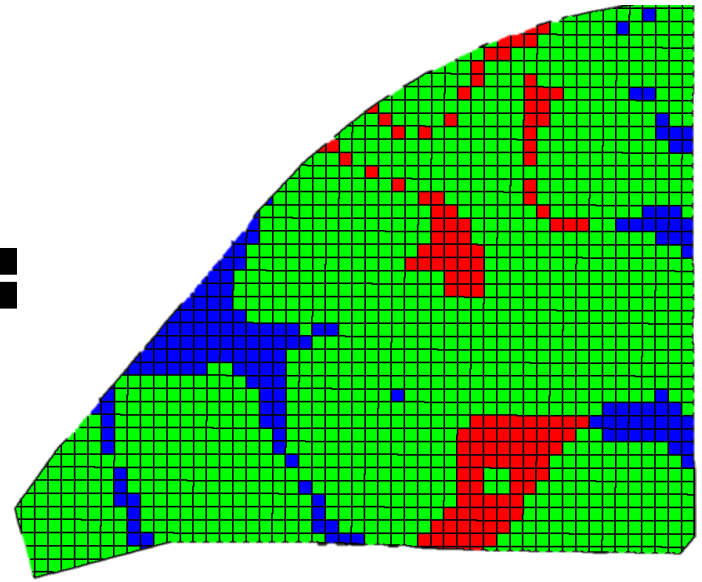
Spatial Application Accuracy



K Prescription Map
(All points representing actual nutrient variability)



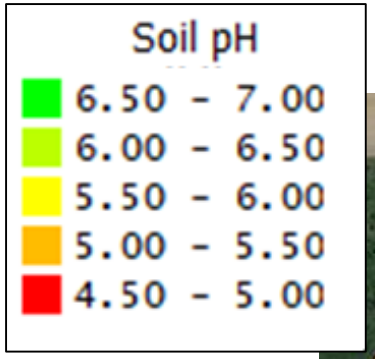
K Prescription Map
(2.5 ac grid sampling)



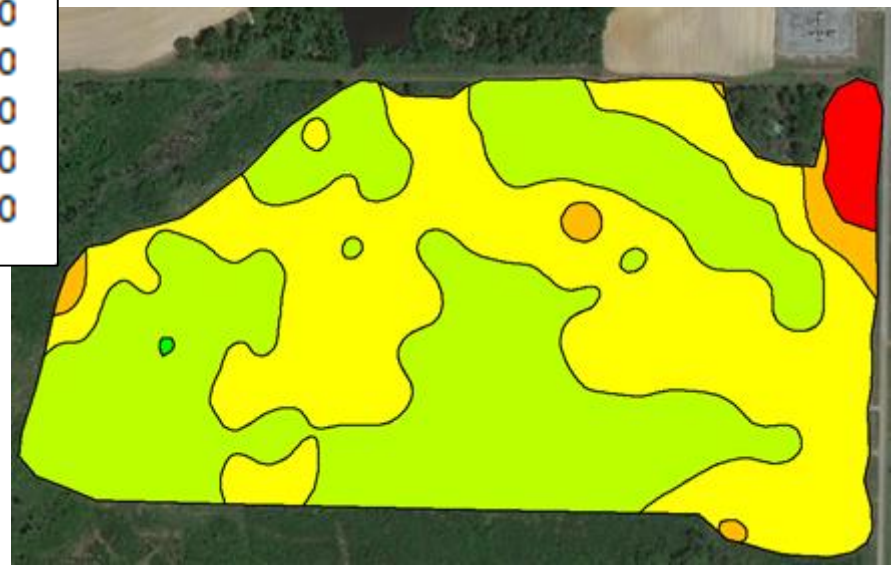
Map showing on-target, under- and over-application areas

Under Applied

Over Applied



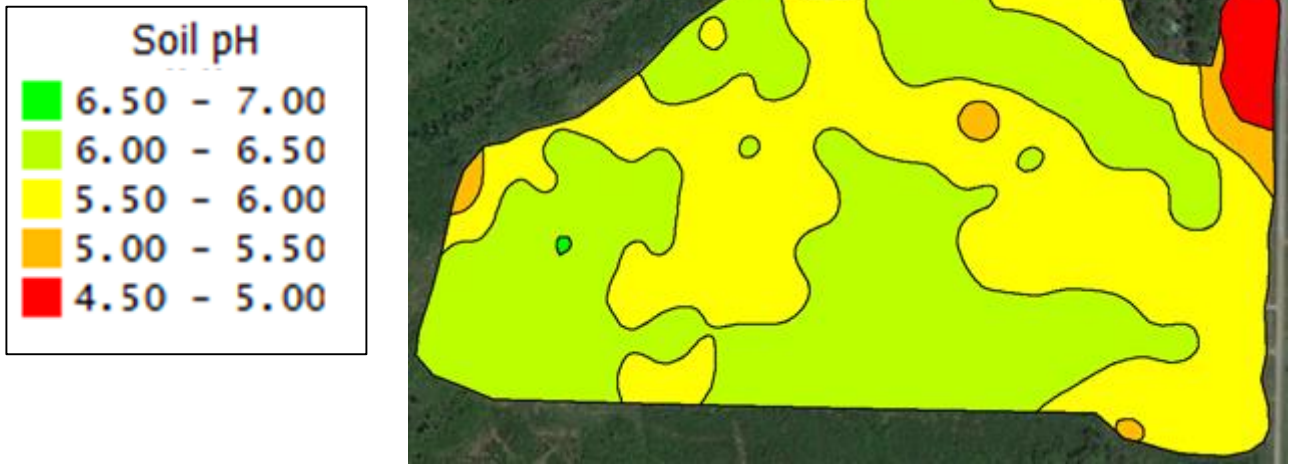
Actual Soil pH Variability (163 Samples)



1 ac (92 samples)

2.5 ac (35 samples)

5 ac (17 samples)



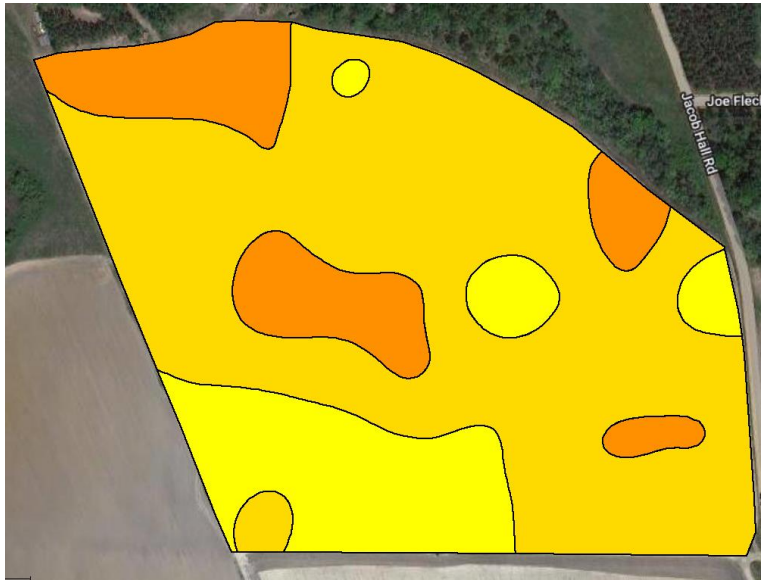
7.5 ac
(13 samples)

10 ac
(8 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)

+

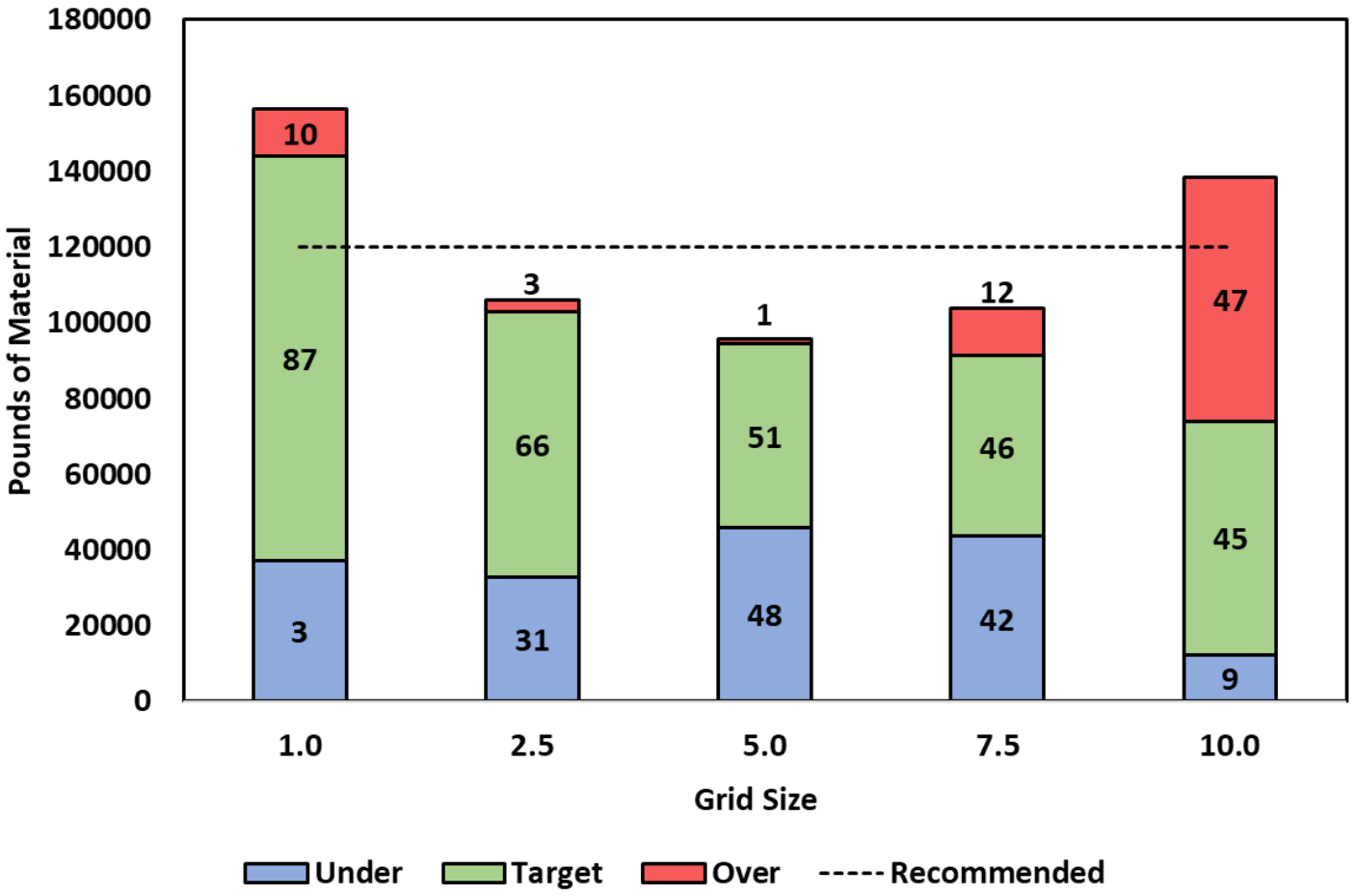
Soil Analysis Cost ($/ac)

+

Fertilizer Cost ($/ac)

Application Accuracy and Cost

Field 1 - Lime



Grid Size (ac)	Analysis Cost ($/ac)	Lime Cost ($/ac)	Total Cost ($/ac)
1.0	10	33	43
2.5	6	29	35
5.0	5	26	31
7.5	5	28	33
10.0	5	37	41

***Sampling cost ($4-6/ac) was constant among all grid sizes.**

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

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

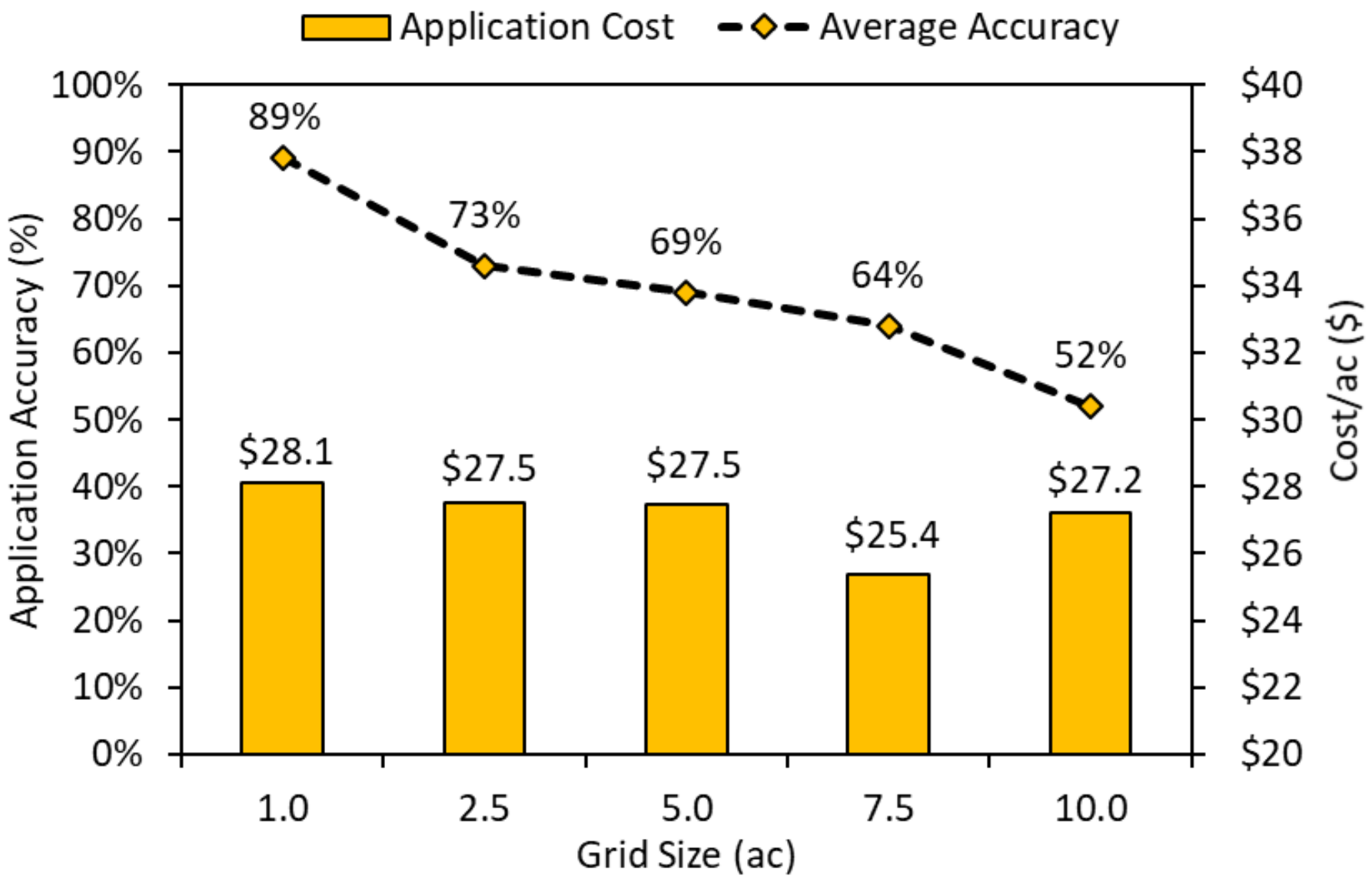
Grid Size	Accuracy (%)	Cost ($/ac)
1.0	92	16
2.5	82	15
5.0	70	13
7.5	74	14
10.0	77	10

K

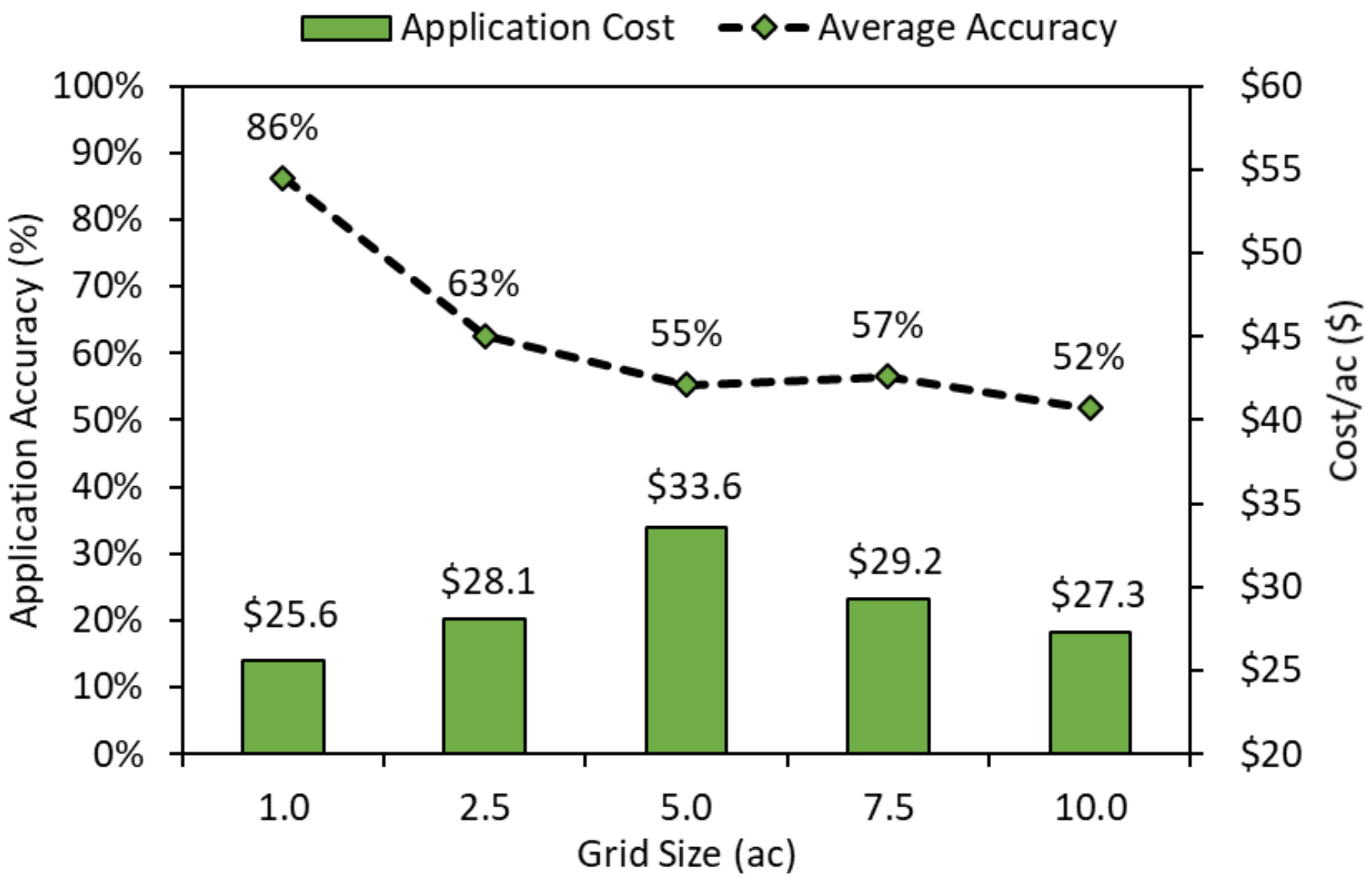
Grid Size	Accuracy (%)	Cost ($/ac)
1.0	88	89
2.5	72	85
5.0	66	82
7.5	49	86
10.0	44	86

How do we make a grid size decision here?

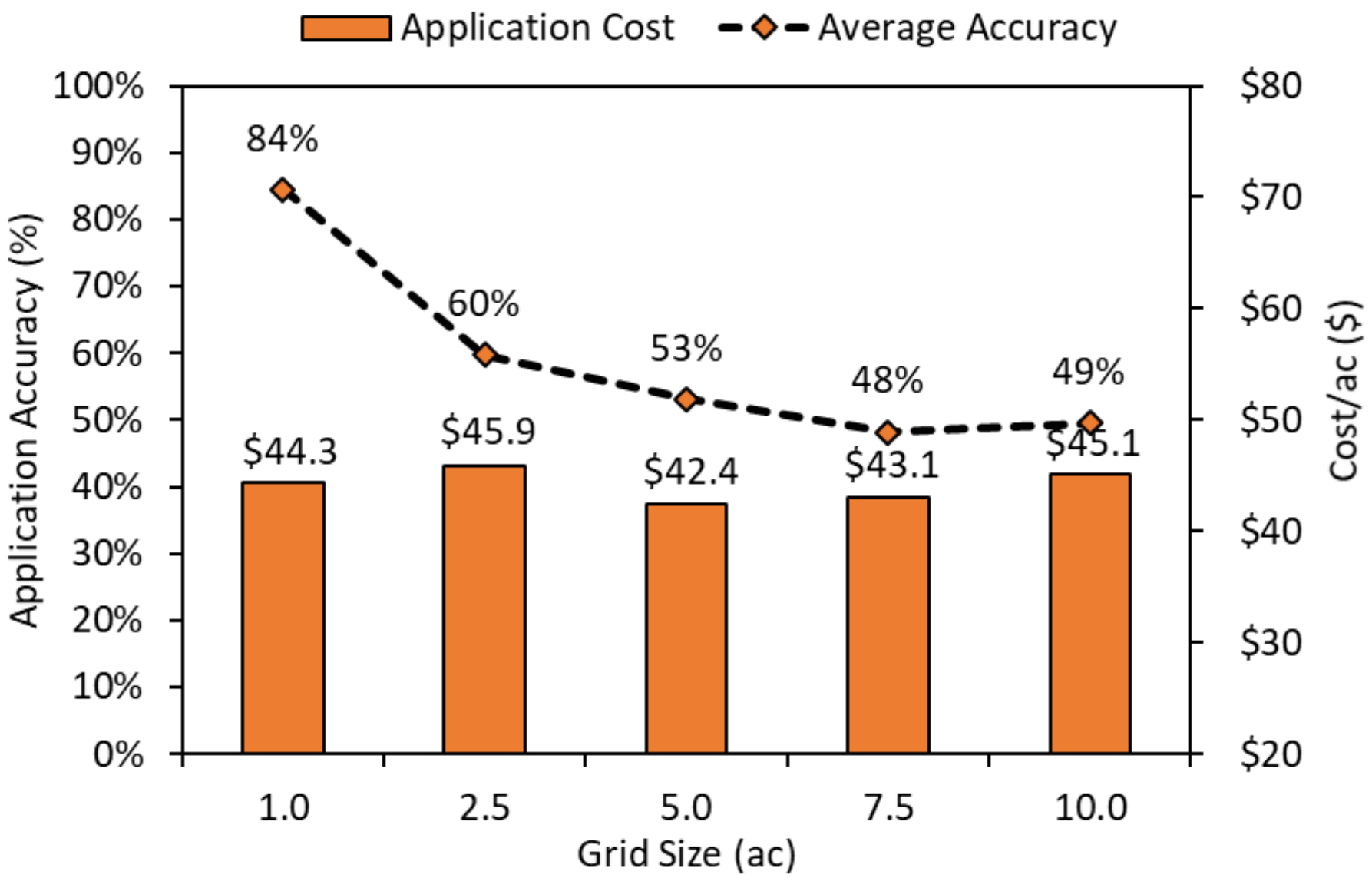
Lime


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)

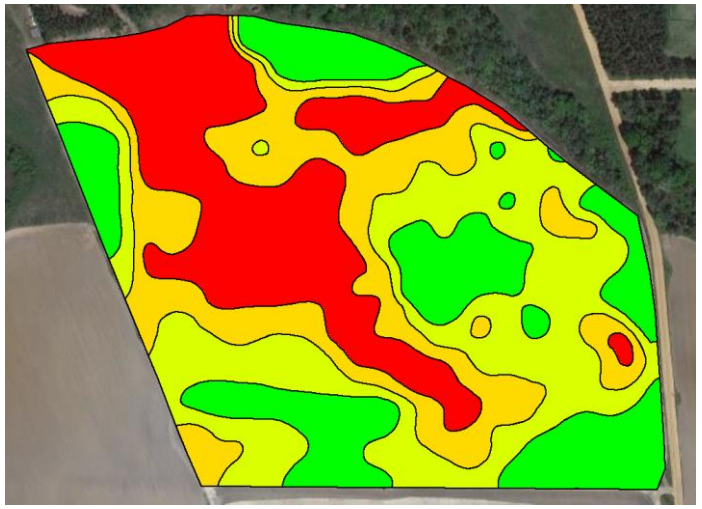
Phosphorus


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)

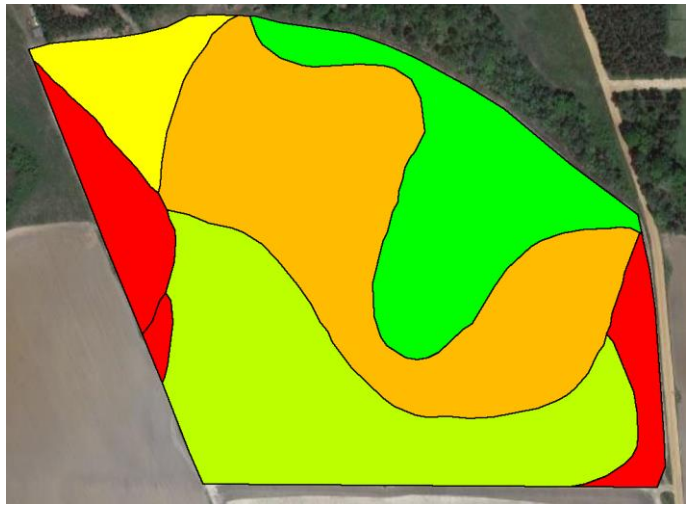
Potassium


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)

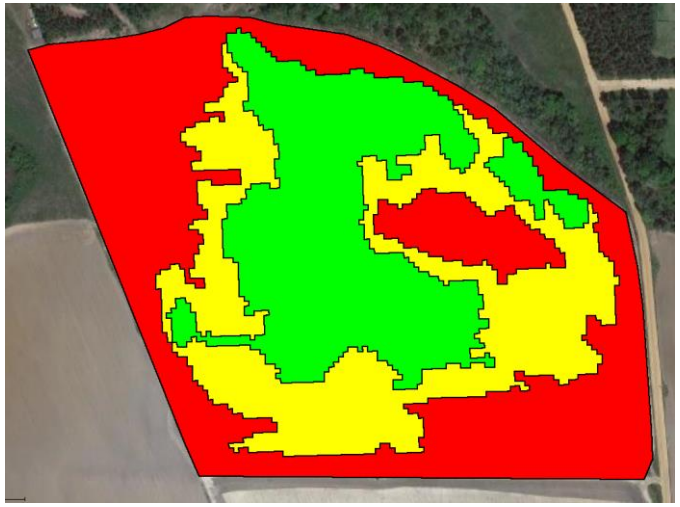
Zone Sampling
(Management Zones for Soil Sampling)



Soil EC (4 zones)

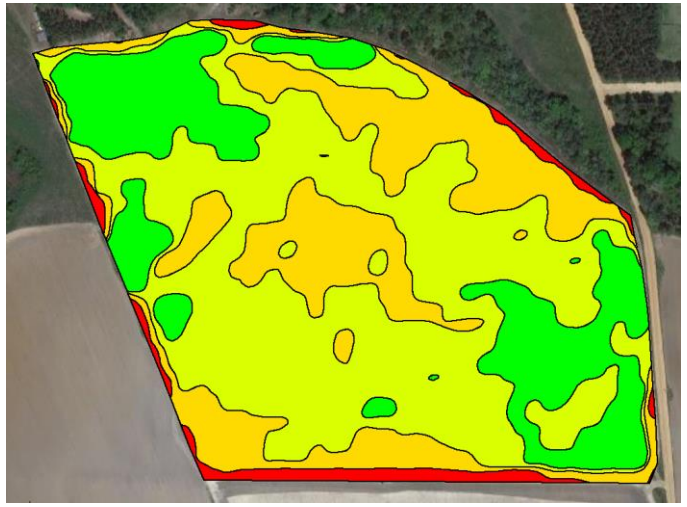


Soil Type (5 zones)

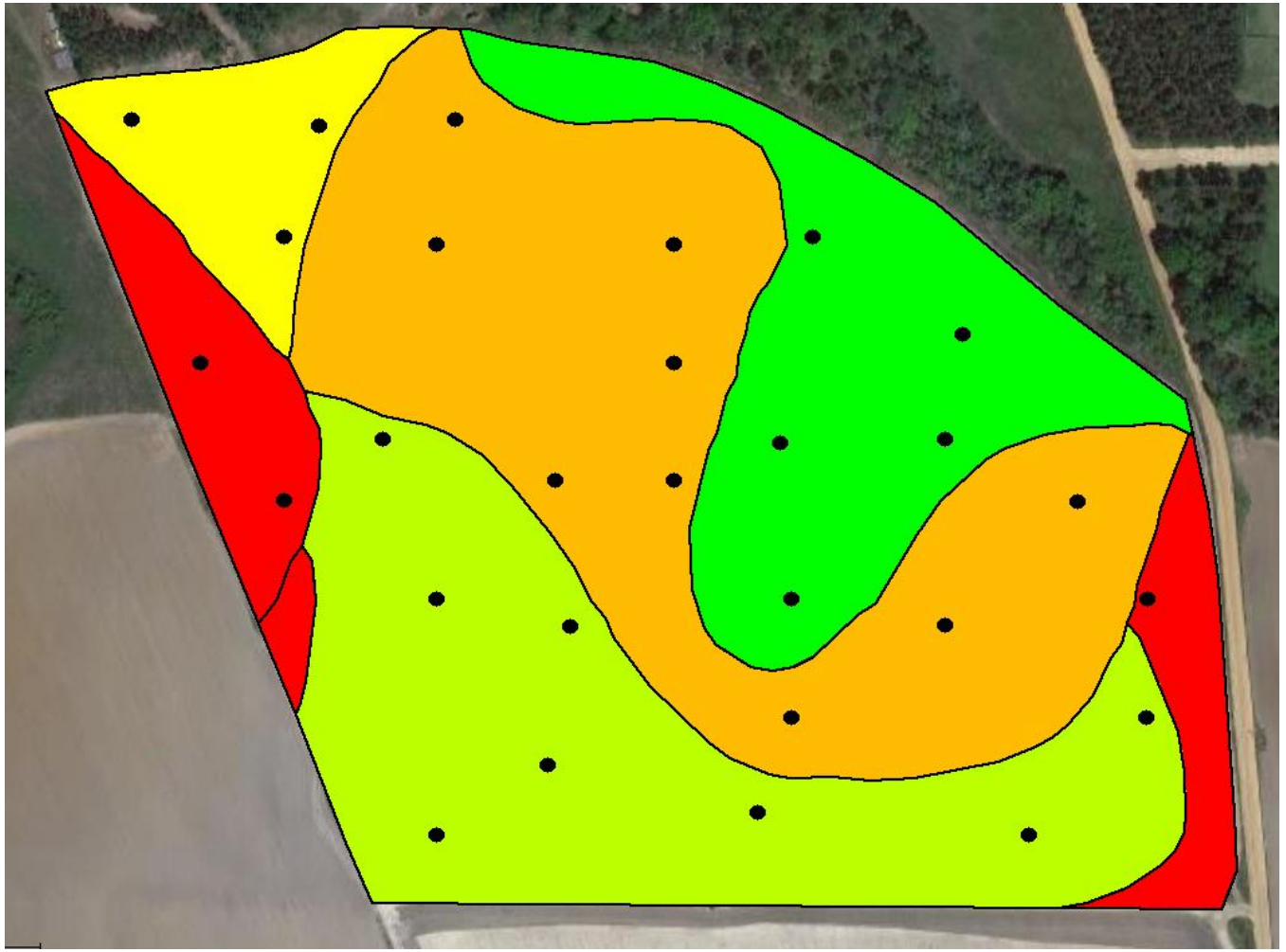


In-Season Crop Imagery/NDVI
(3 zones)

Soil Color/Brightness
(3 zones)



Zone-Based Soil Sampling

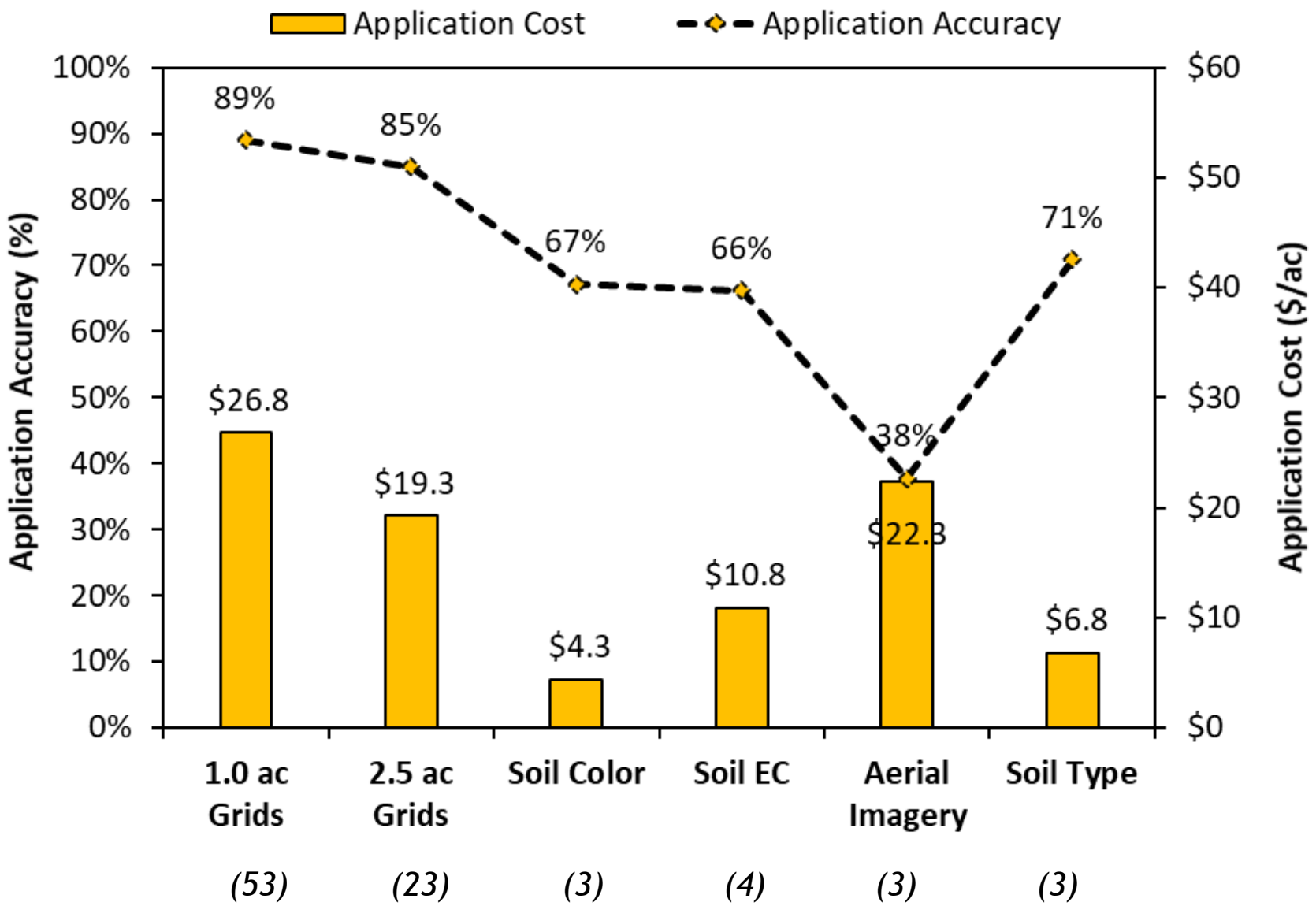


5 Zones = 5 Soil Samples *(composite for each zone)*

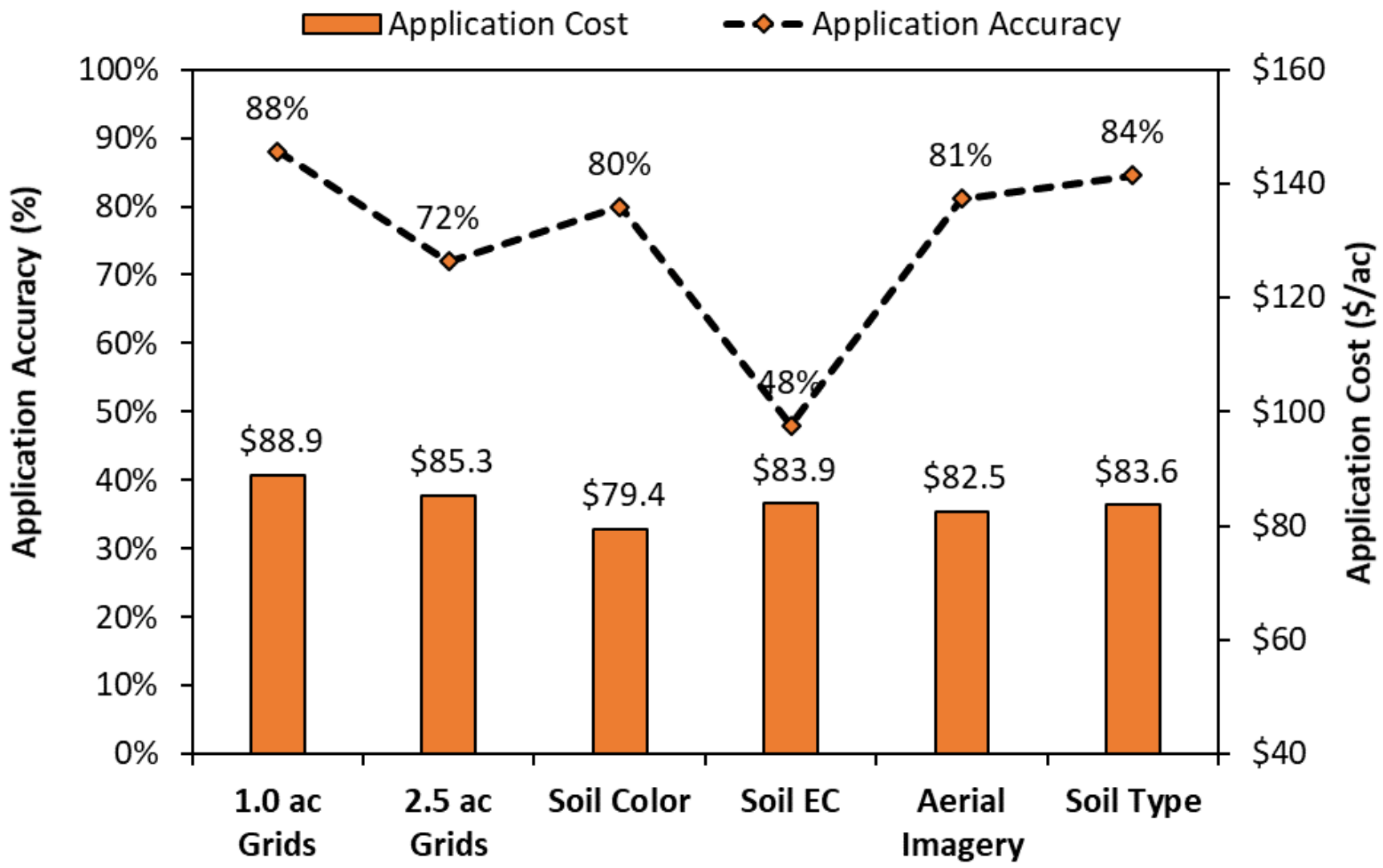
Each zone = 3 – 10 soil cores mixed together to make a composite sample

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

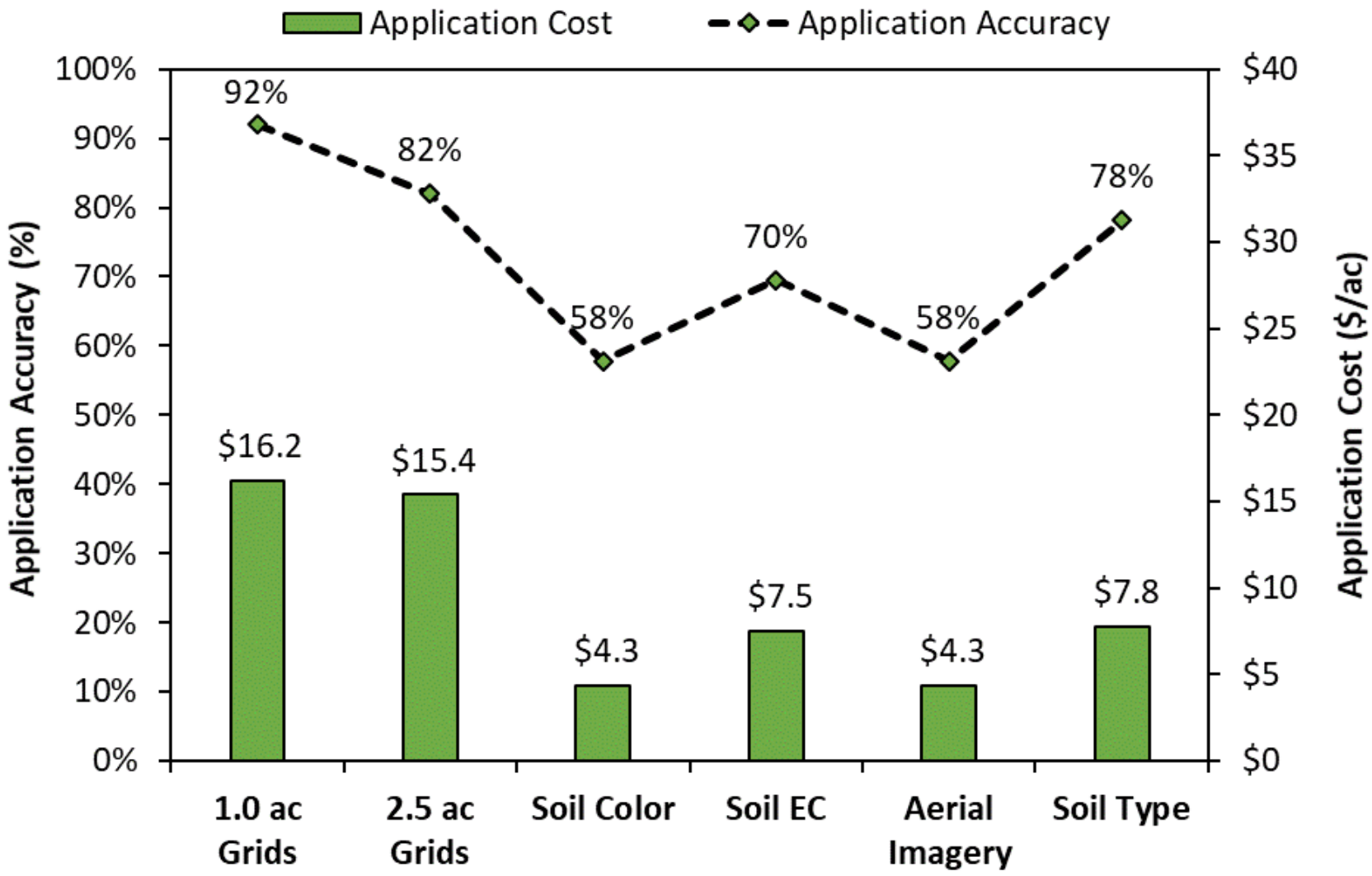
Lime


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)

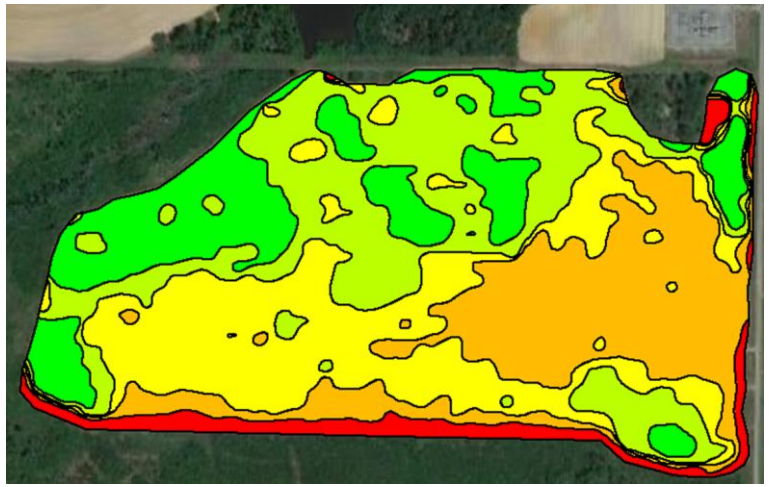
Potassium


Application Cost
Application Accuracy
Application Accuracy (%)
Application Cost ($/ac)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
$160
$140
$120
$100
$80
$60
$40
88%
72%
80%
48%
81%
84%
$88.9
$85.3
$79.4
$83.9
$82.5
$83.6
1.0 ac Grids
2.5 ac Grids
Soil Color
Soil EC
Aerial Imagery
Soil Type

Phosphorus

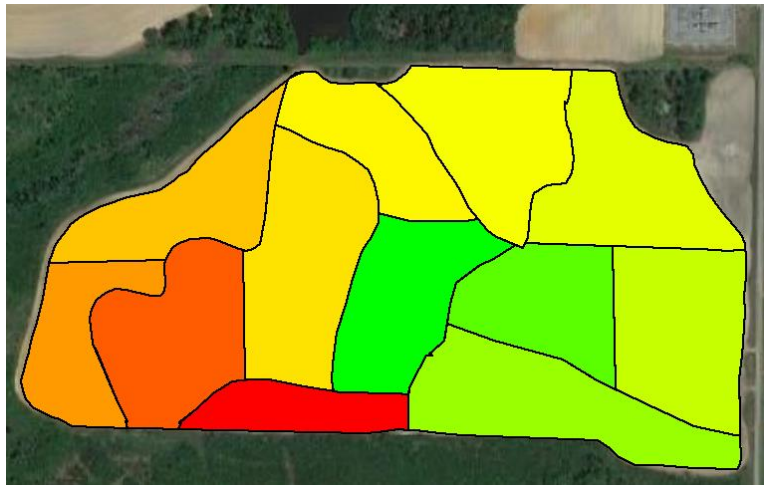

Application Cost
Application Accuracy
Application Accuracy (%)
Application Cost ($/ac)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
$40
$35
$30
$25
$20
$15
$10
$5
$0
92%
82%
58%
70%
58%
78%
$16.2
$15.4
$4.3
$7.5
$4.3
$7.8
1.0 ac Grids
2.5 ac Grids
Soil Color
Soil EC
Aerial Imagery
Soil Type

Zone Sampling - Field 2

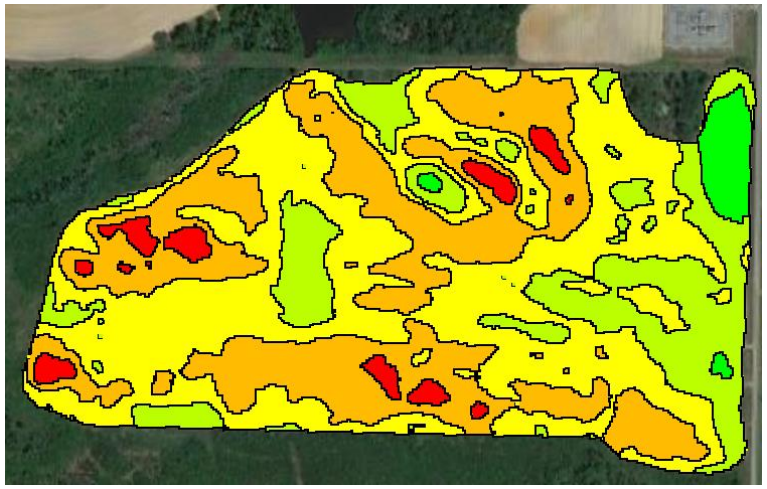


Soil Color/Brightness (5 samples)

Soil EC (4 samples)

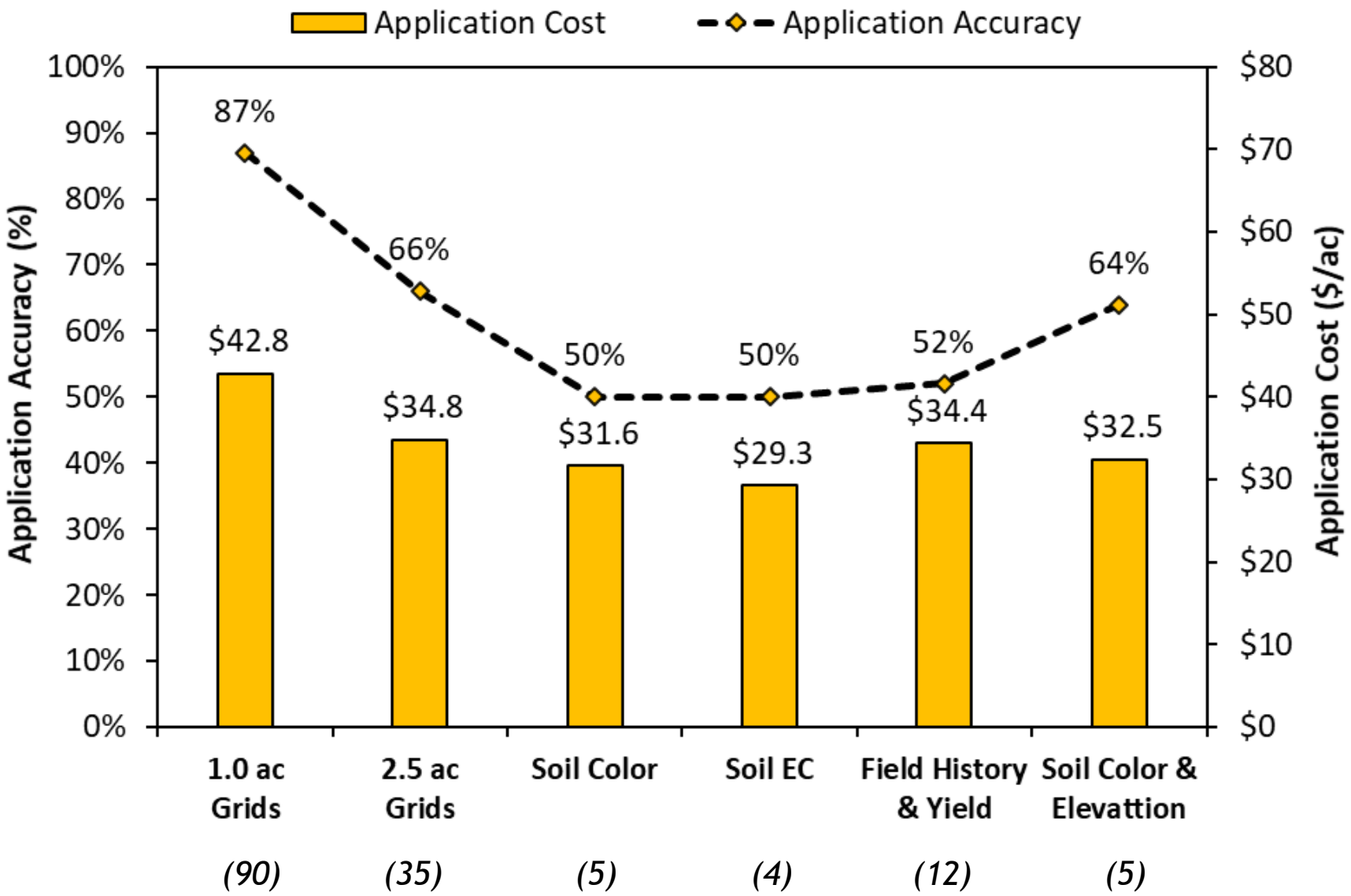


Field Knowledge and Yield (12 samples)

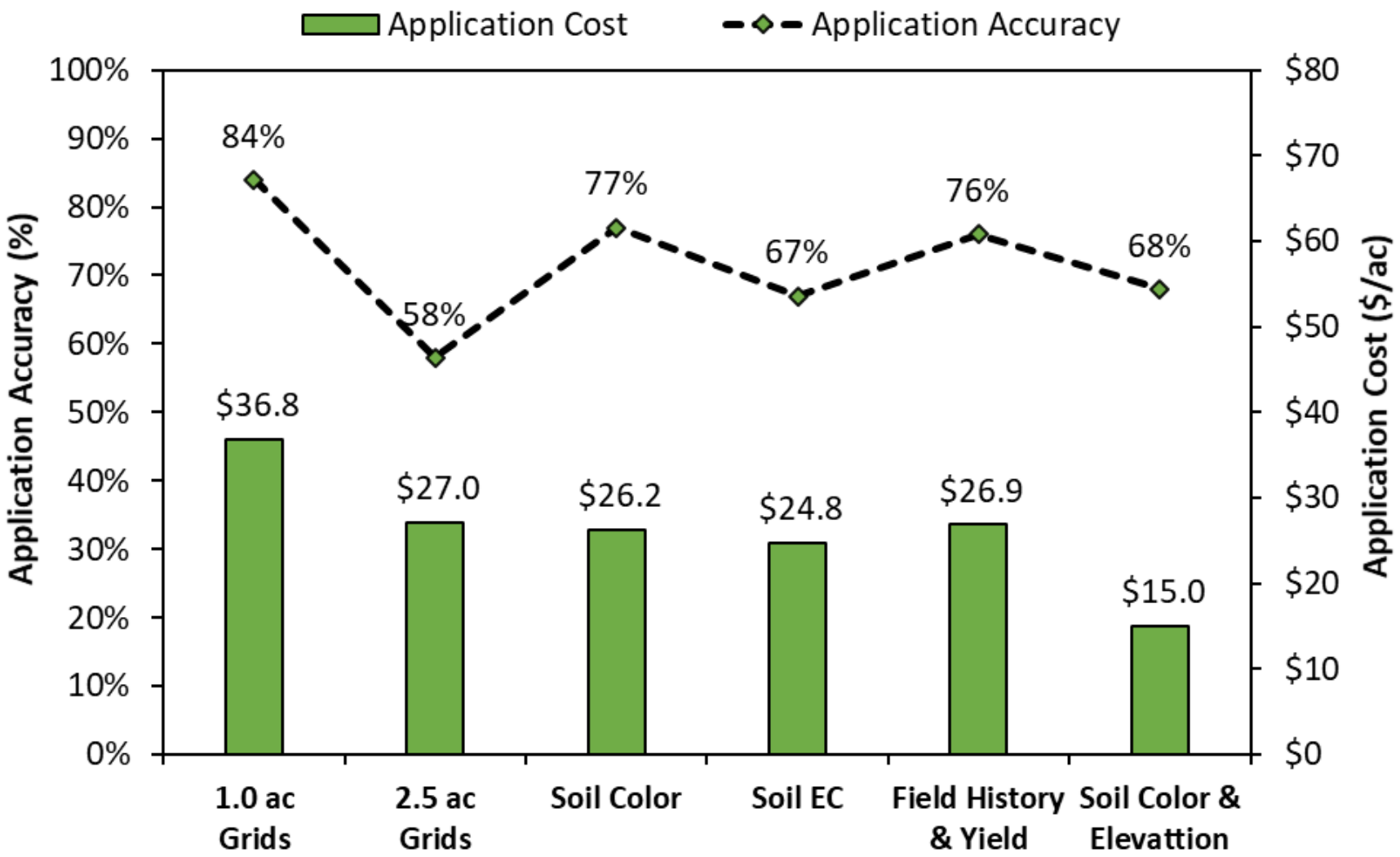


Soil Color and Elevation (5 samples)

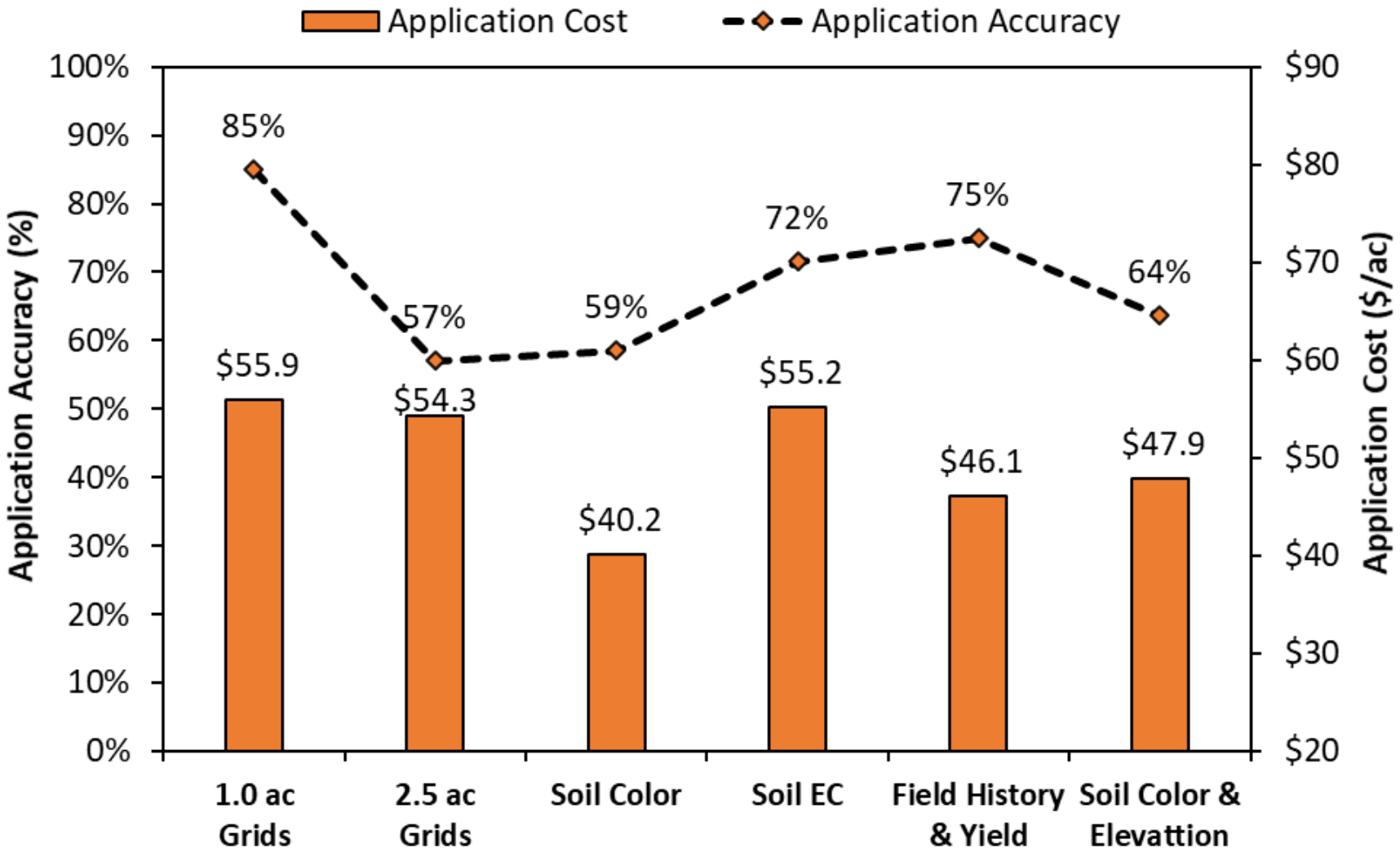
Lime


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


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
84%
58%
77%
67%
76%
68%
$36.8
$27.0
$26.2
$24.8
$26.9
$15.0
1.0 ac Grids
2.5 ac Grids
Soil Color
Soil EC
Field History & Yield
Soil Color & Elevattion

Potassium


Application Cost
Application Accuracy
Application Accuracy (%)
Application Cost ($/ac)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
$90
$80
$70
$60
$50
$40
$30
$20
85%
57%
59%
72%
75%
64%
$55.9
$54.3
$40.2
$55.2
$46.1
$47.9
1.0 ac Grids
2.5 ac Grids
Soil Color
Soil EC
Field History & Yield
Soil Color & Elevattion

Our Current Recommendations in Georgia

- **Grid sampling** – grid size should not be greater than 2.5 ac. All new and existing fields should be sampled at least once on 1-ac to understand variability.
- **Zone sampling** – keep it simple and practical. Incorporate important data layers (e.g. field knowledge/history) to refine management 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.

Thanks!

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Georgia Plant Food Educational Society, Inc.

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