Fluid Fertilizer's Role in Sustaining Soils Used for Bio-fuels Production

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National Soil Tilth Laboratory
Creating Agricultural Success

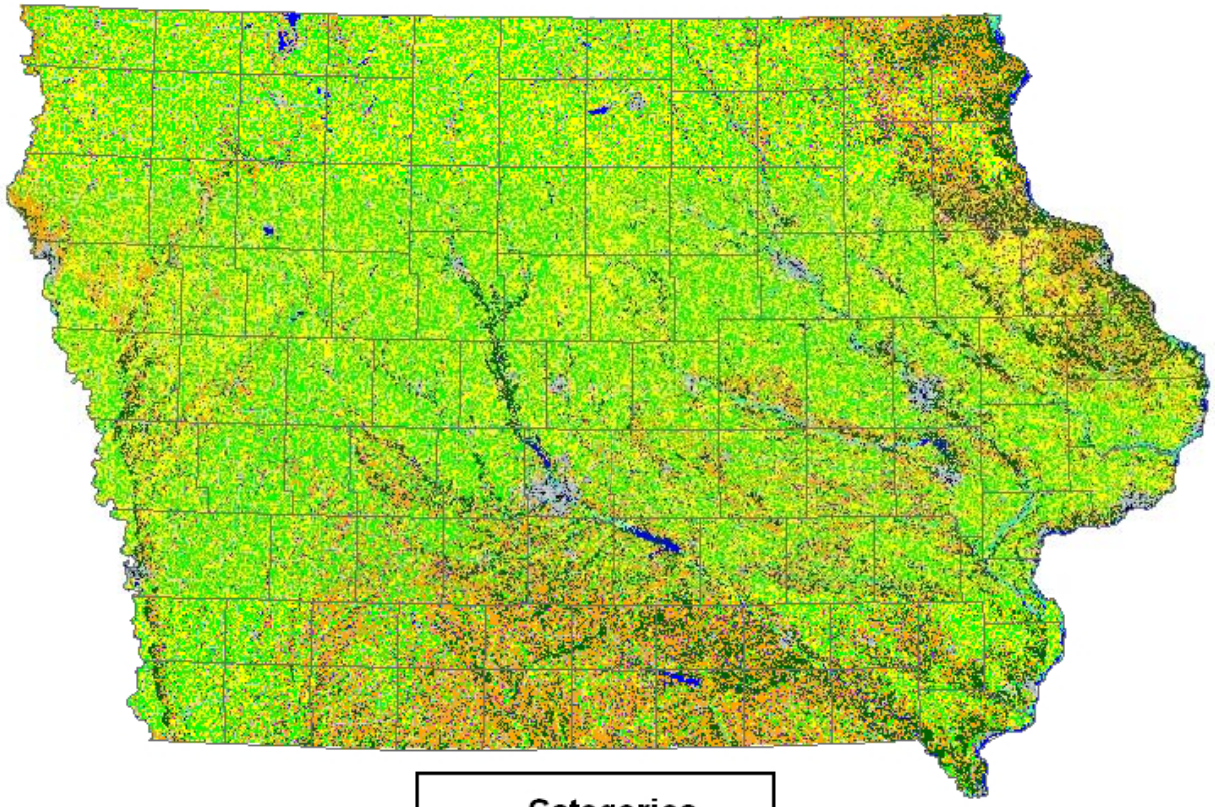
Some Challenges:

- **Nutrient management problems (esp. K and S) in Midwestern soils will likely increase as producers reduce tillage, increase the frequency of corn production, and/or harvest crop residues for bio-fuels production**

- **The bio-fuels industry is currently using estimates to determine the amount of crop residue that must remain on the land to sustain both the farming and ethanol production enterprises**

- **To provide more quantitative guidelines, soil management studies focusing on tillage, fertilizer rates and placement, cover crops, and other management questions are needed**

2006 Iowa Cropland Data Layer



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USDA

Objectives for 2007

- **To evaluate the performance of several S fertilizers as S sources for corn grown on low organic matter soils in Iowa**
- **To initiate a comprehensive tillage, nutrient management, and crop residue removal study**

Sulfur Response: Site Characteristics

- Eroded side slopes
- Clarion loam/silt loam (Typic Haplaquolls)
- previous crop was soybean
- plot size 12.5 ft. (5 rows) x 250 ft. (x 90 ft. in 2007)
- RCBD with 4 reps
- Spring tillage: disk + field cultivator
- N fertilizer applied at planting + spoke wheel UAN (supplemental to 155 lb/A)
- Corn (Pioneer 36N71) planted 21 April 2006 at 30,000 plants/A
- Corn (Fontanelle 4693) planted 2 May 2007 at 32,000 plants/A

S Fertilizer Treatments

Control

30 lb S/A; 13-33-0-15S; 2x3

30 lb S/A; 21-0-0-24S; 2x3

30 lb S/A; 12-0-0-26S; 2x0

2006 Initial Soil Test Levels

Soil Test	Composite	Range
Bray 1 P, ppm	35 (VH)	15 (OPT) – 60 (VH)
Exch. K, ppm	180 (VH)	123 (OPT) – 304 (VH)
Exch. Ca, ppm	2320	1881 – 2585
Exch. Mg, ppm	232	192 – 275
Extractable S, ppm	3.6	1 – 7
pH	6.9	6.2 – 7.2
Organic Matter*, %	2.2	1.9 – 2.5

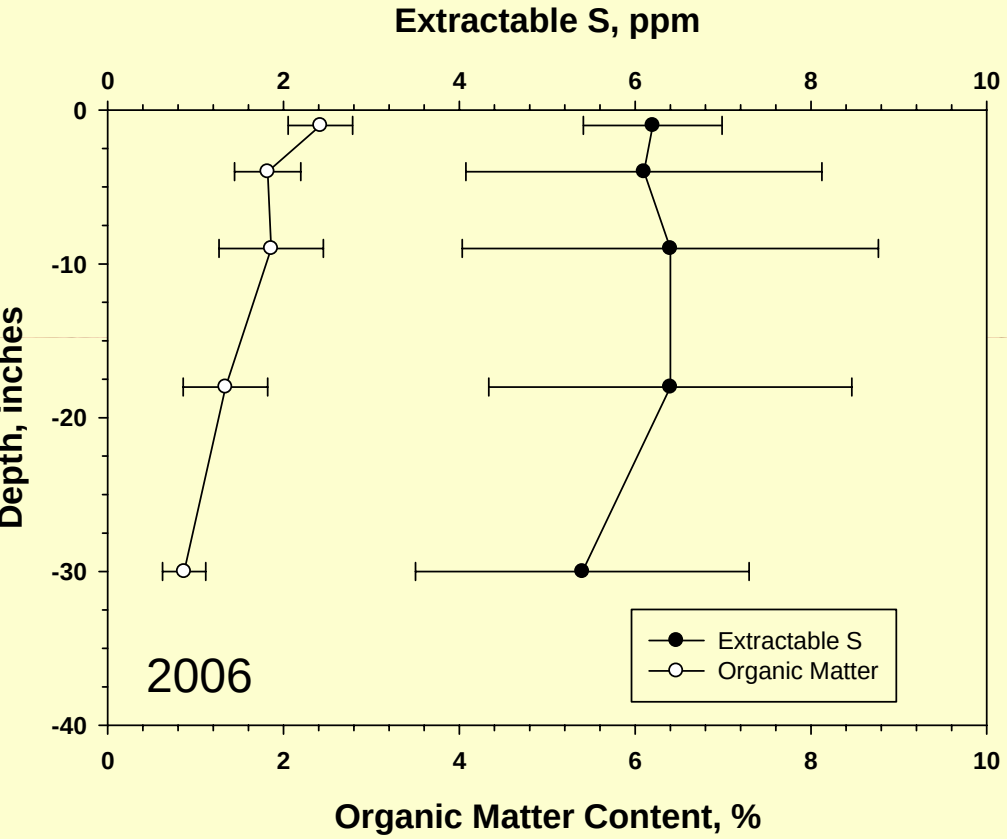
* Ignition Method

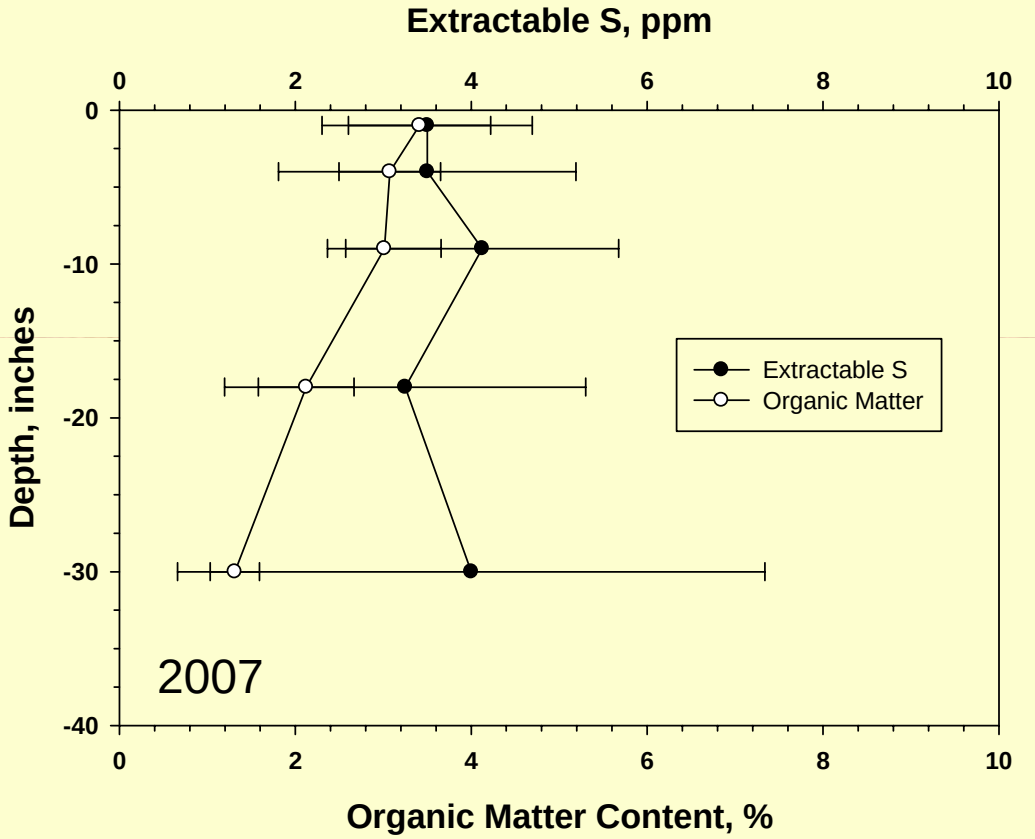
2007 Initial Soil Test Levels

Soil Test	Composite	Range
Bray 1 P, ppm	30 (VH)	13 (OPT) – 55 (VH)
Exch. K, ppm	123 (OPT)	98 (L) – 146 (OPT)
Exch. Ca, ppm	2933	2178 – 4052
Exch. Mg, ppm	437	322 – 540
Extractable S, ppm	8.5	7 – 13
pH	6.2	5.5 – 7.4
Organic Matter*, %	3.2	2.4 – 4.4

* Ignition Method

Extractable S and Organic Matter in the Soil Profile





Sulfur Response: Measurements

- Stand counts
- Whole-plant samples at V5
- Ear-leaf samples at mid-silk
- Grain yield and moisture
- Stover yield (whole-plant hand harvest)
- Statistical analysis with GLM procedure of SAS

Effect of 30 lb S/A on Whole-Plant Dry Weight, and S, N, and P Tissue Concentrations at V5 in 2006

Treatment	Dry Weight	Nutrient		
		S	N	P
	g plant $^{-1}$	---------- % ----------		
Control	4.3b†	0.17b	3.13b	0.47a
13-33-0-15S (SEF)	7.4a	0.21a	3.43a	0.46a
21-0-0-24S (AMS)	6.1ab	0.21a	3.49a	0.44a
12-0-0-26S (ATS)	5.8ab	0.23a	3.18b	0.42b

†Values followed by the same letter are not significantly different at the 0.05 level.

Effect of 30 lb S/A on Whole-Plant Dry Weight, and S, N, and P Tissue Concentrations at V5 in 2007

Treatment	Dry Weight	Nutrient		
		S	N	P
	g plant $^{-1}$	---------- % ----------		
Control	6.0b†	0.16b	2.89b	0.34a
13-33-0-15S (SEF)	8.9a	0.20a	3.24ab	0.37a
21-0-0-24S (AMS)	7.2ab	0.19a	3.27a	0.31a
12-0-0-26S (ATS)	5.5b	0.18a	2.94ab	0.33a

†Values followed by the same letter are not significantly different at the 0.05 level.

Effect of 30 lb S/A on Corn Grain Yield, Grain Moisture, and Stover Yield in 2006

Treatment	Grain Yield†	Grain Moisture	Stover Yield
	bu/A	%	ton/A
Control	170	14.5	2.67
13-33-0-15S (SEF)	177	14.6	2.80
21-0-0-24S (AMS)	172	14.5	2.51
12-0-0-26S (ATS)	171	14.4	2.79
$LSD_{(0.05)}$	7.5	0.54	0.62
$LSD_{(0.10)}$	6.1	0.44	0.53

†Yields adjusted to 15.5% moisture.

Effect of 30 lb S/A on Corn Grain Yield, Grain Moisture, and Stover Yield in 2007

Treatment	Grain Yield†	Grain Moisture	Stover Yield
	bu/A	%	ton/A
Control	176	14.9	2.90
13-33-0-15S (SEF)	186	14.6	3.29
21-0-0-24S (AMS)	186	14.7	2.82
12-0-0-26S (ATS)	183	14.6	2.80
$LSD_{(0.05)}$	13	0.4	0.78
$LSD_{(0.10)}$	10	0.3	0.67

†Yields adjusted to 15.5% moisture.

Main Points:

- Based on two years of field trials, application of 30 lb S/A increased mean plant dry weight and whole-plant concentrations of S at the V5 growth stage.
- At mid-silk, S concentration in the tissue was below the sufficiency range of 0.21% to 0.50%, even when S fertilizer had been applied.
- Corn grain and stover yields were not increased, and grain moisture at harvest was not reduced ($p<0.05$) by S fertilizer application.
- No one S fertilizer source outperformed the others.
- The cost of replacing S removed with the grain and residue is relatively low.
- Eroded hill slopes, as found at these sites, often have relatively low levels of soil organic matter and extractable SO^{-4}


STS


Whole Plant Removal
Cob & Top 50% Removal

Macro-nutrient Removal through Various Stover Harvest Scenarios in 2005

Stover Harvest Scenario	Continuous (DeKalb DKC-52-45)			Rotated (Fontanelle 5393)		
	N	P	K	N	P	K
	---------- kg ha^{-1} ----------					
Whole plant	30.7	2.5	38.6	50.2	3.5	42.8
Bottom 50%	7.8	0.8	13.2	12.6	0.7	12.8
Cob & top 50%	18.5	1.5	28.9	31.2	2.6	26.4
LSD $_{(0.05)}$	3.6	0.5	11.5	8.6	1.0	10.3

Total Nutrient Replacement Cost

Stover Harvest Scenario	Average for Three Hybrids ('05 & '06)		
	$ ac^{-1}	$ ton^{-1}	$ gal EtOH^{-1}
Whole plant	$ 27.71	$ 9.67	$0.121†
Cob & top 50%	$ 18.47	$ 9.49	$0.118
Bottom 50%	$ 7.39	$ 10.10	$ 0.126

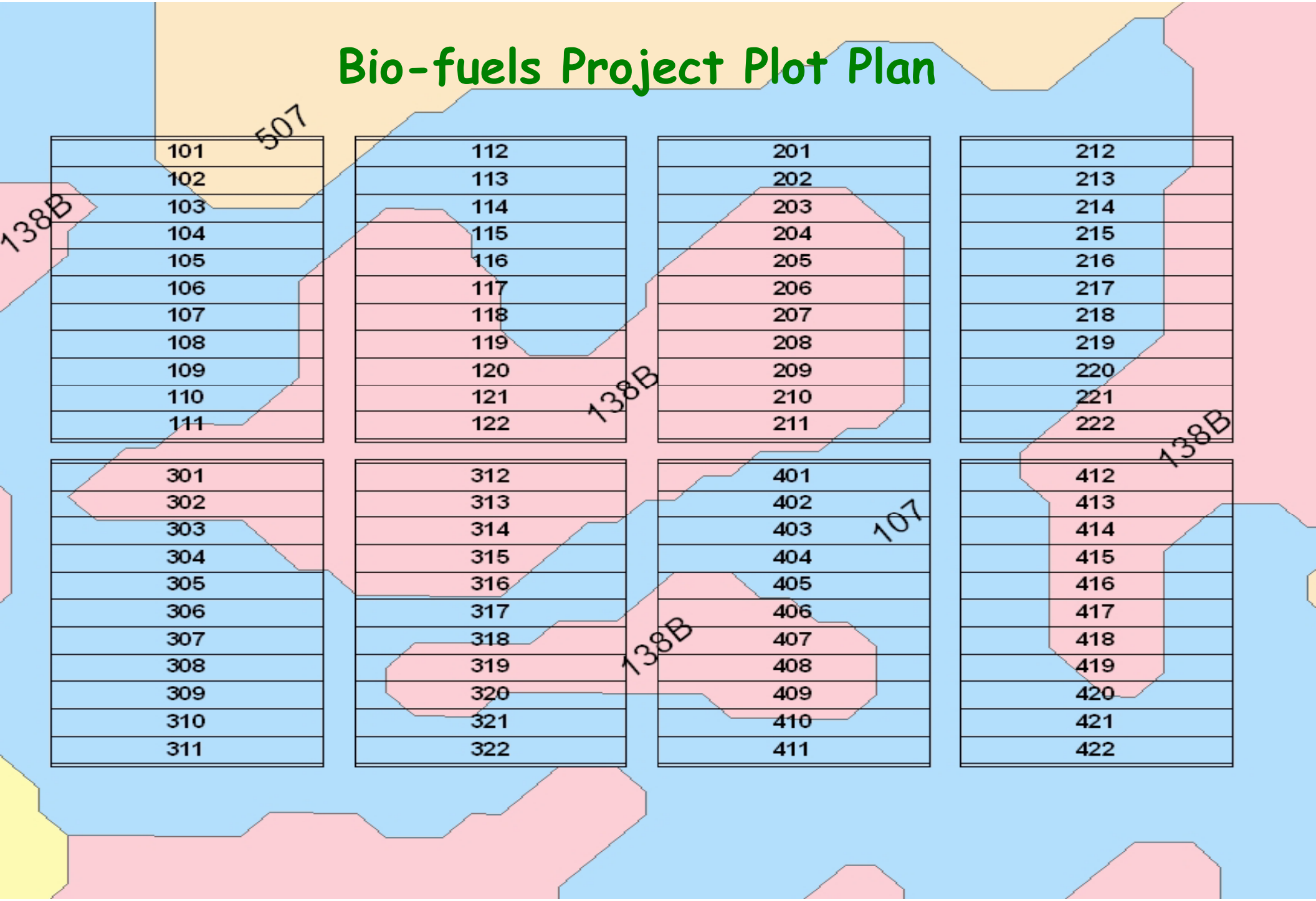
† Assumes 80 gal EtOH ton^{-1} biomass

REAP

Bio-fuels Project Treatments

- **Residue removal: 0, 50%, 90%**
- **Tillage: chisel plow, no-till**
- **Nutrient management: standard (30K plants/A), high input (45K plants/A)**
- **Charcoal: 0, 8700 lb/A, 16,500 lb/A**
- **Cover crops: annual, perennial**

Bio-fuels Project Plot Plan



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110	121	210	221
111	122	211	222

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303	314	403	414
304	315	404	415
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306	317	406	417
307	318	407	418
308	319	408	419
309	320	409	420
310	321	410	421
311	322	411	422

What's Next?

- **Continue S research**
- **Move forward with comprehensive tillage, nutrient management, and crop residue removal study**