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

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USDA United States Department of Agriculture

ARS Agricultural Research Service

NLAE National Laboratory for Agriculture and the Environment

~450°C
$-O_2$

+

+

Corn stover

(~1.5 GJ m^{-3})

Bio-oil

(~22 GJ m^{-3})

Biochar

(~21 MJ kg^{-1})

Syngas

(~6 MJ kg^{-1})

Fast pyrolysis is optimized for production of bio-oil. Product yields are typically ~65% bio-oil, 20% biochar, 15% syngas.

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Project Objective

- **To investigate N, P, K, and S dynamics in a comprehensive residue removal, tillage, and nutrient management study**

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Project Treatments

- ✓ **Residue removal: 0, 50%, 90%**
- ✓ **Tillage: chisel plow, no-till**
- ✓ **Nutrient management: conventional (30K plants/A), high input (44K plants/A)**
- **Bio-char: 0, 4.32 tons/A, 8.25 tons/A**
- **Cover crops: annual, perennial**

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2009 Soil Test Levels

Soil Test	Surface (0-2”)		Subsurface (2-6”)	
	Composite	Range	Composite	Range
Bray-1 P, ppm	39	17 - 104	24	12 - 54
Exch. K, ppm	199	106 - 307	142	100 - 218
Exch. Ca, ppm	2112	1400 - 2830	2276	1545 - 3020
Exch. Mg, ppm	301	179 - 440	310	195 - 489
Extract. S, ppm	1.1	0.5 - 4.1	0.9	0.5 - 2.8
pH	6.5	5.9 - 7.4	6.5	5.9 - 7.0
O. M.*, %	3.8	2.8 - 5.3	3.7	2.9 - 4.6
CEC, cmol(+)/kg	16.0	11.0 - 22.3	16.3	11.3 - 24.9

* Ignition Method

2009 Nutrient Management

System	Percent Removal	Timing	Source
Conventional		Fall 2008	11-52-0 + 0-0-60
160+75+60+20S	0	Pre-Plant	3-18-18
199+162+147+20S	50		12-0-0-26S
202+177+162+20S	90	Sidedress	32-0-0 (UAN)
Twin- Row		Fall 2008	11-52-0 + 0-0-60
167+75+60+30S	0	Pre-Plant	3-18-18
211+162+147+30S	50		12-0-0-26S
214+177+162+30S	90	Starter	3-18-18 + UAN
		Sidedress	32-0-0 (UAN)

Field Measurements

- Stand counts
- Whole-plant samples at V6
- Ear-leaf samples at mid-silk
- Grain yield and moisture
- Stover yield and moisture
- Grain and stover nutrient content

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Nutrient critical values and concentrations in whole plants at the V6 growth stage for five management scenarios in 2009

Nutrient	Critical Value	Control	Biochar 1†	Biochar 2‡	Twin-Row	Perennial CC§	Annual CC
N	3.50	3.82	3.93	3.69	3.79	3.68	3.65
		(0.28)	(0.19)	(0.23)	(0.30)	(0.21)	(0.23)
P	0.30	0.46	0.46	0.46	0.45	0.41	0.40
		(0.06)	(0.06)	(0.02)	(0.07)	(0.06)	(0.06)
K	2.50	4.81	5.18	5.03	4.75	4.15	3.88
		(0.61)	(1.13)	(0.94)	(1.11)	(0.53)	(0.59)
S	0.15	0.22	0.21	0.21	0.21	0.19	0.19
		(0.01)	(0.02)	(0.02)	(0.02)	(0.03)	(0.01)

†4.32 tons biochar/A; ‡8.25 tons biochar/A; §CC = cover crop

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Nutrient critical values and concentrations in ear-leaf tissue at anthesis for five management scenarios in 2009

Nutrient	Critical Value	Control	Biochar 1†	Biochar 2‡	Twin-Row	Perennial CC§	Annual CC
N	2.70	2.41	2.29	2.42	2.30	2.42	2.45
		(0.22)	(0.18)	(0.14)	(0.18)	(0.12)	(0.17)
P	0.25	0.27	0.27	0.28	0.27	0.27	0.27
		(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.01)
K	1.70	1.96	1.88	2.04	1.92	1.81	1.84
		(0.21)	(0.25)	(0.22)	(0.26)	(0.28)	(0.27)
S	0.21	0.17	0.16	0.17	0.16	0.17	0.16
		(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)

†4.32 tons biochar/A; ‡8.25 tons biochar/A; §CC = cover crop

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Effect of Management System, Tillage, and Residue Removal on Corn Grain and Stover Yields in 2009

Treatment	Tillage	Percent Removal	Grain (bu/A)	Stover (t/A)
Control	No-tillage	0	146	0
Control	No-tillage	50	174	2.16
Control	No-tillage	90	195	3.59
Control	Chisel Plow	0	146	0
Control	Chisel Plow	50	196	1.89
Control	Chisel Plow	90	188	3.35
		$LSD_{(0.05)}$	12	0.84
Twin-Row	No-tillage	0	132	0
Twin-Row	No-tillage	50	188	2.46
Twin-Row	No-tillage	90	176	2.81
Twin-Row	Chisel Plow	0	135	0
Twin-Row	Chisel Plow	50	193	1.82
Twin-Row	Chisel Plow	90	192	3.26
		$LSD_{(0.05)}$	14	0.42

Effect of Biochar Application and Residue Removal on Corn Grain and Stover Yields in 2009

Treatment	Tillage	Percent Removal	Grain (bu/A)	Stover (t/A)
Control	Chisel Plow	0	146	0
Control	Chisel Plow	50	196	1.89
Control	Chisel Plow	90	188	3.35
		$LSD_{(0.05)}$	12	0.84
Biochar (4 t/A)	Chisel Plow	0	136	0
Biochar (4 t/A)	Chisel Plow	50	195	2.03
Biochar (4 t/A)	Chisel Plow	90	196	2.96
		$LSD_{(0.05)}$	12	0.80
Biochar (8 t/A)	Chisel Plow	0	156	0
Biochar (8 t/A)	Chisel Plow	50	188	2.24
Biochar (8 t/A)	Chisel Plow	90	194	3.23
		$LSD_{(0.05)}$	8	0.78

Main Points:

- At V6, nutrient concentrations above sufficiency range in whole plants, all treatments
- At mid-silk, N and S concentrations below sufficiency range, P and K sufficient
- Corn grain and stover yields not affected by management scenario or tillage (problem with N?)
- No advantage to twin-row system in 2009
- Nutrient removals within each system will guide 2010 fertilizer applications

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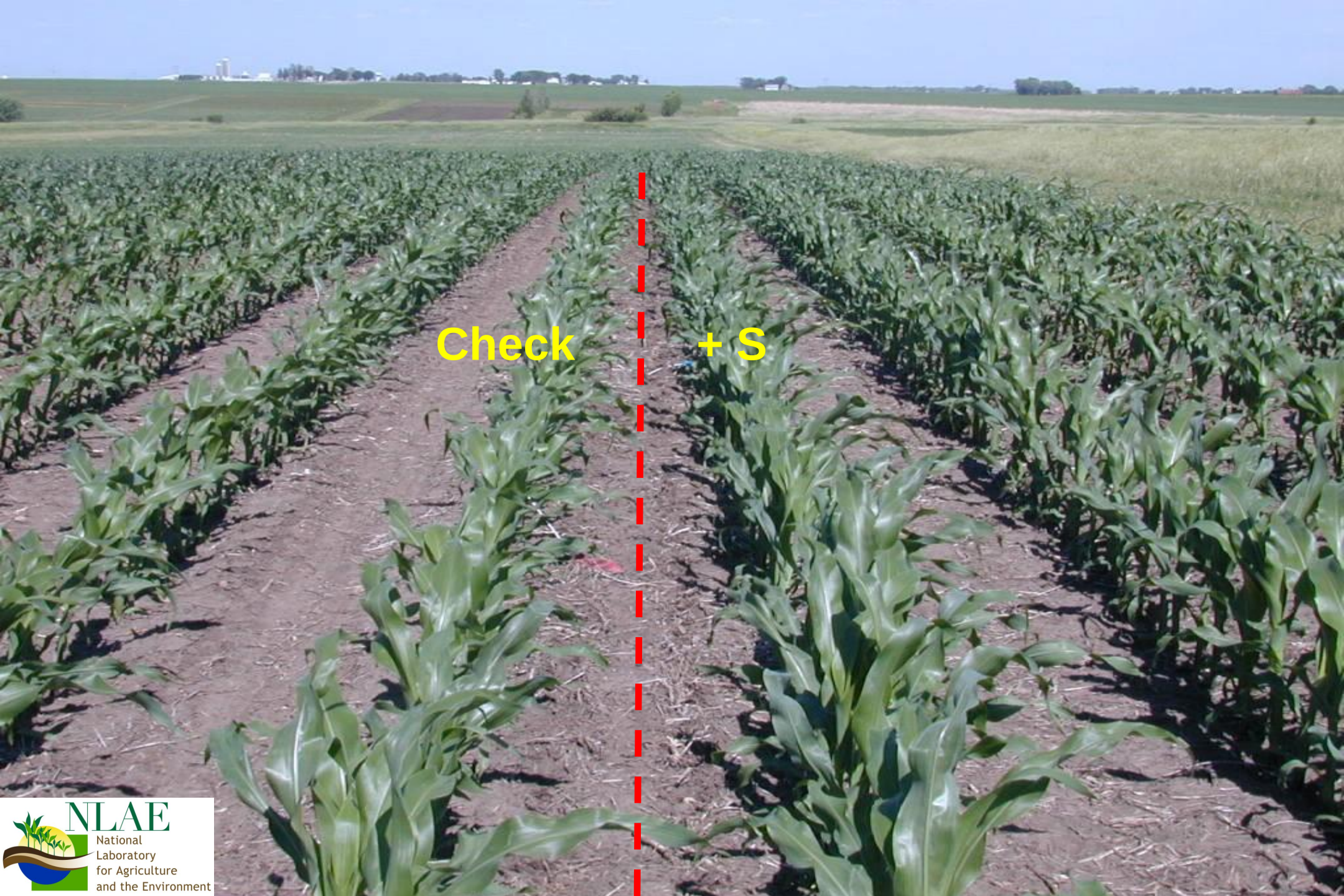

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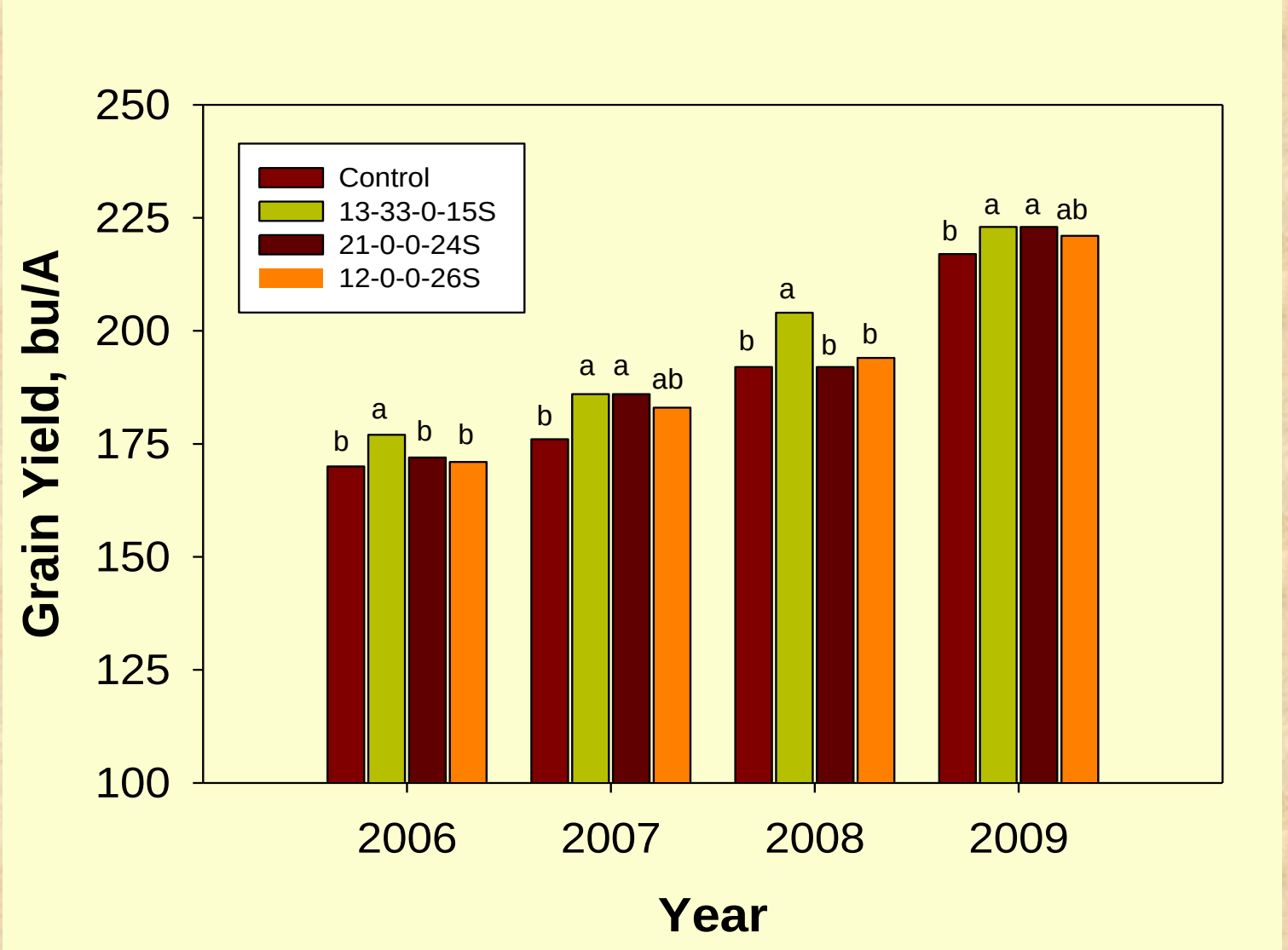
Effect of 30 lb S/A on Corn Grain Yield



S Fertility Management (4-yr)

- Greatest benefit on eroded hill slopes
- 30 lb S/A increased plant dry weight and S at V5
- At mid-silk, S concentrations often < sufficiency range
- Corn grain and stover yield increased, grain moisture decreased
- S fertilizers comparable
- Agronomic efficiency: 10 lb grain per lb S applied

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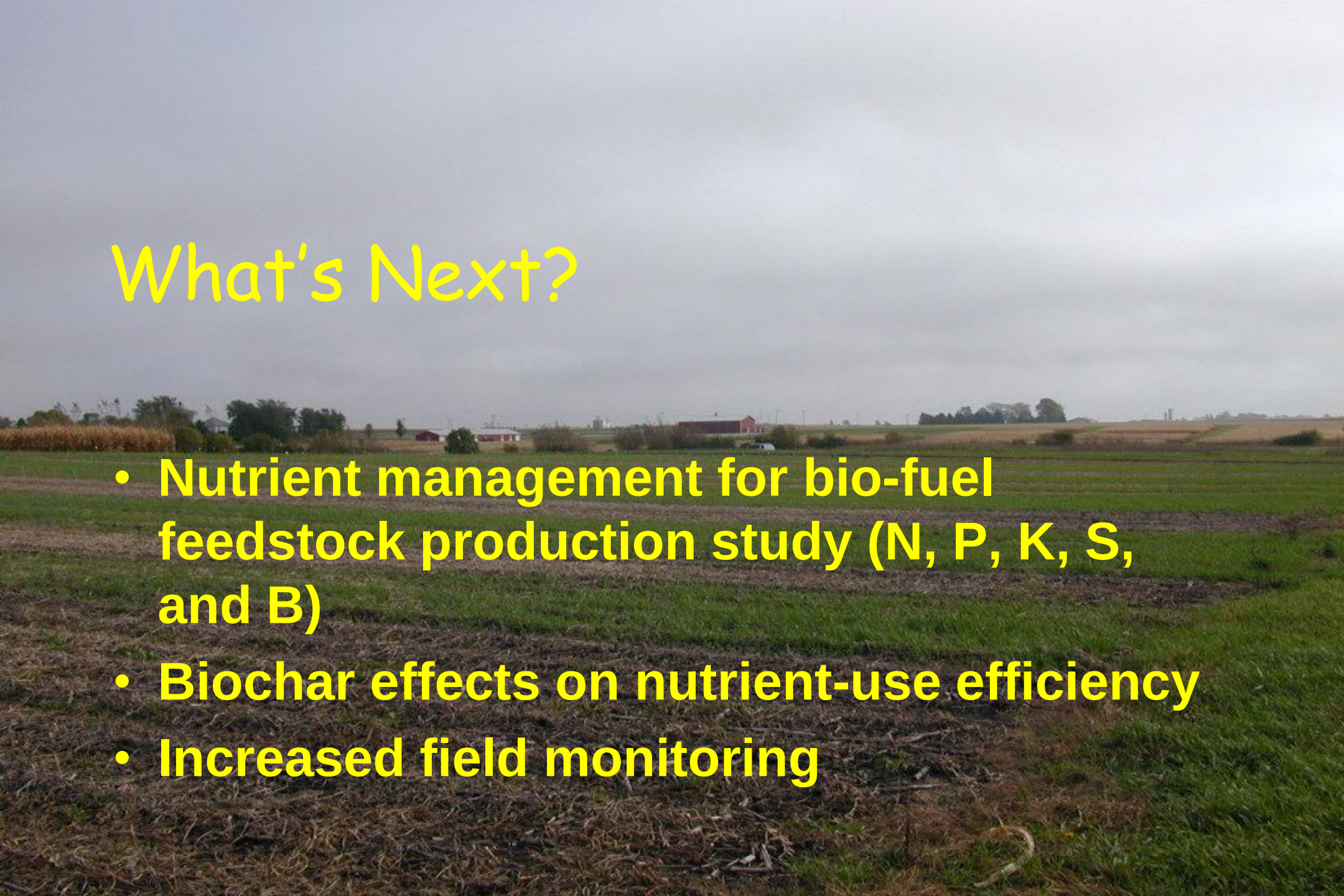

What's Next?

- **Nutrient management for bio-fuel feedstock production study (N, P, K, S, and B)**
- **Biochar effects on nutrient-use efficiency**
- **Increased field monitoring**