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

John Kovar, Doug Karlen, David Laird
USDA-ARS
National Laboratory for Agriculture and the Environment (NLAE)

USDA United States Department of Agriculture
ars Agricultural Research Service

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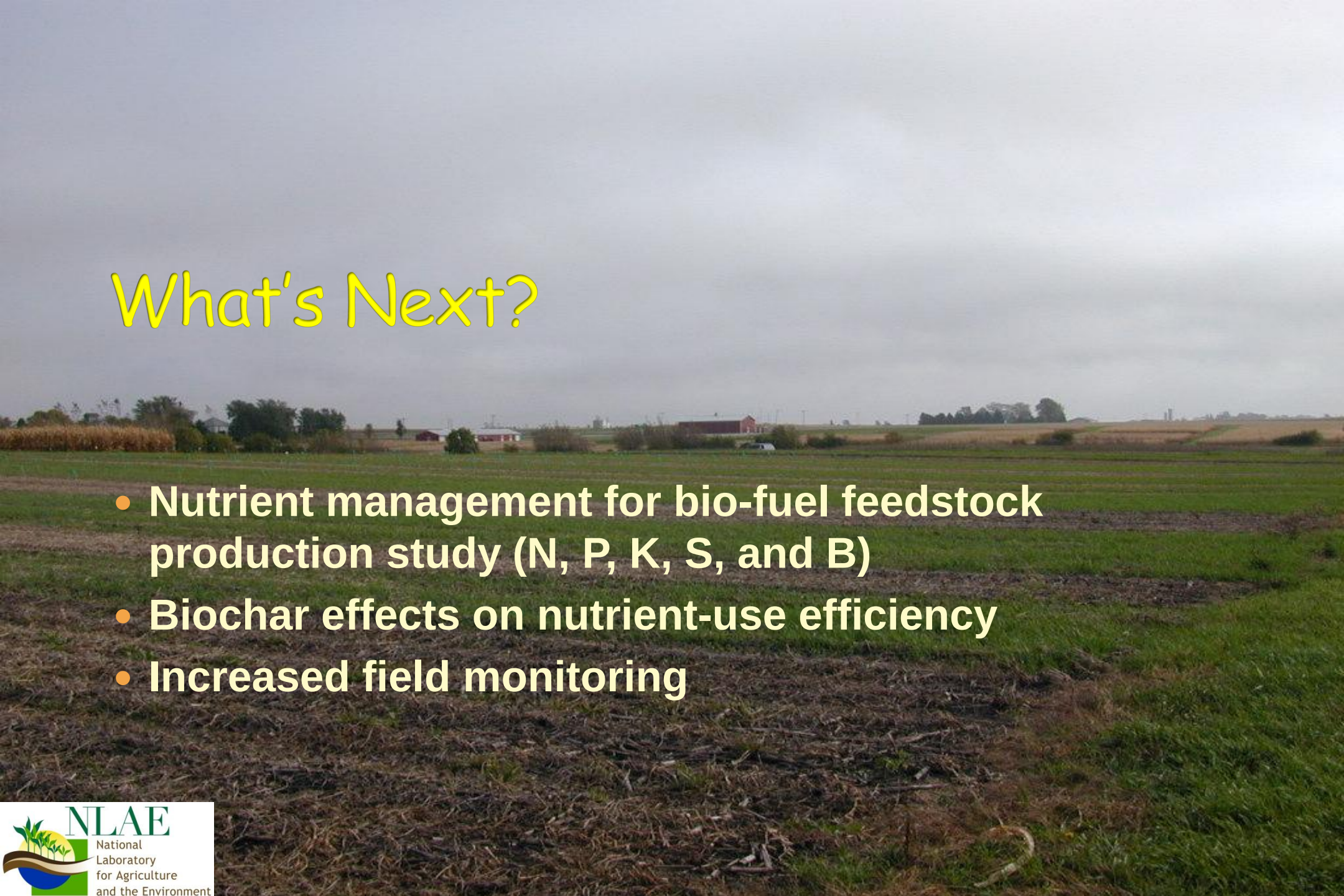

What's Next?

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

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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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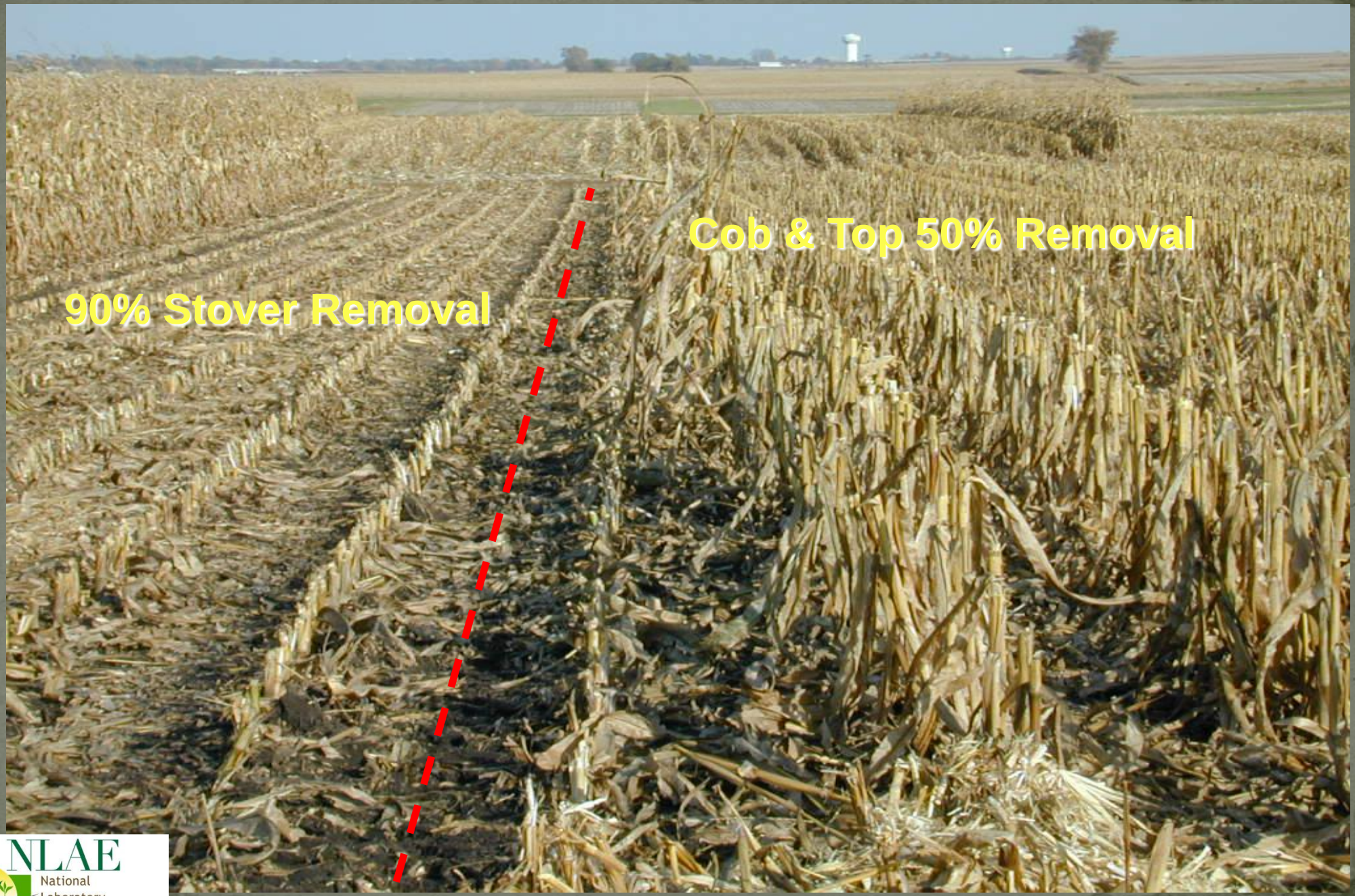

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2010 Soil Test Levels

Soil Test	Surface (0-2”)		Subsurface (2-6”)	
	Composite	Range	Composite	Range
Bray-1 P, ppm	50	21 – 103	23	7 – 52
Exch. K, ppm	229	133 – 364	138	76 – 339
Exch. Ca, ppm	2569	1680 – 4120	2730	1510 – 3890
Exch. Mg, ppm	318	212 – 509	334	171 – 547
Extract. S, ppm	5	1 – 10	5.5	2 – 12
pH	5.9	5.4 – 6.6	6.0	5.1 – 6.7
O. M.*, %	3.7	2.8 – 5.1	3.4	2.6 – 4.8
CEC, cmol(+)/kg	22.3	14.9 – 29.3	22.8	17.0 – 30.9

* Ignition Method P: >20 ppm K: >130 ppm

2010 Nutrient Management

System	Percent Removal	Timing	Source
Conventional		Fall 2009	11-52-0 + 0-0-60
190+68+49+30S	0	Pre-Plant	3-18-18
215+79+124+30S	50		12-0-0-26S
230+88+188+30S	90	Sidedress	32-0-0 (UAN)
Twin- Row		Fall 2009	11-52-0 + 0-0-60
220+65+46+40S	0	Pre-Plant	3-18-18
245+76+118+40S	50		12-0-0-26S
260+82+165+40S	90	Starter	3-18-18 + UAN
		Sidedress	32-0-0 (UAN)

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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 six management scenarios in 2010

Nutrient	Critical Value	Control	Biochar 1†	Biochar 2‡	Twin-Row	Perennial CC§	Annual CC
N	3.50	3.99	3.96	3.90	4.04	3.44	4.03
		(0.21)	(0.14)	(0.16)	(0.14)	(0.18)	(0.23)
P	0.30	0.53	0.55	0.55	0.54	0.54	0.58
		(0.03)	(0.04)	(0.05)	(0.03)	(0.06)	(0.07)
K	2.50	4.24	4.13	4.46	4.13	3.56	4.15
		(0.37)	(0.34)	(0.35)	(0.45)	(0.40)	(0.32)
S	0.15	0.28	0.29	0.28	0.29	0.27	0.27
		(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)

†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 six management scenarios in 2010

Nutrient	Critical Value	Control	Biochar 1†	Biochar 2‡	Twin-Row	Perennial CC§	Annual CC
N	2.70	2.49	2.56	2.55	2.45	2.58	2.57
		(0.19)	(0.45)	(0.21)	(0.18)	(0.13)	(0.13)
P	0.25	0.31	0.30	0.31	0.32	0.33	0.33
		(0.03)	(0.03)	(0.03)	(0.04)	(0.02)	(0.02)
K	1.70	2.14	2.13	2.24	2.13	2.20	2.18
		(0.24)	(0.29)	(0.20)	(0.24)	(0.11)	(0.18)
S	0.21	0.17	0.17	0.17	0.17	0.17	0.18
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)

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

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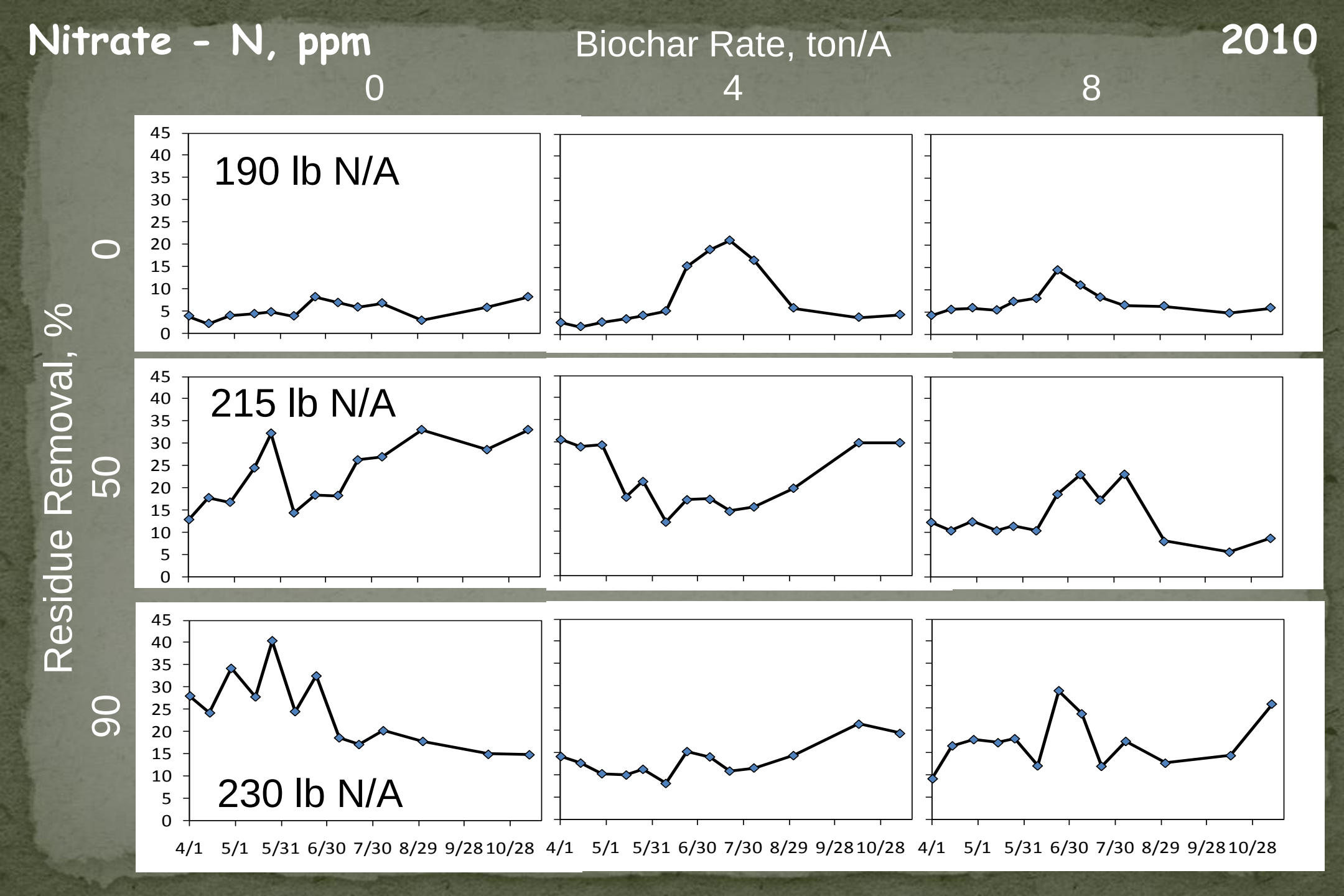
Nitrate - N, ppm
Biochar Rate, ton/A
2010
0
4
8
Residue Removal, %
0
50
90
190 lb N/A
215 lb N/A
230 lb N/A
45
40
35
30
25
20
15
10
5
0
4/1
5/1
5/31
6/30
7/30
8/29
9/28
10/28


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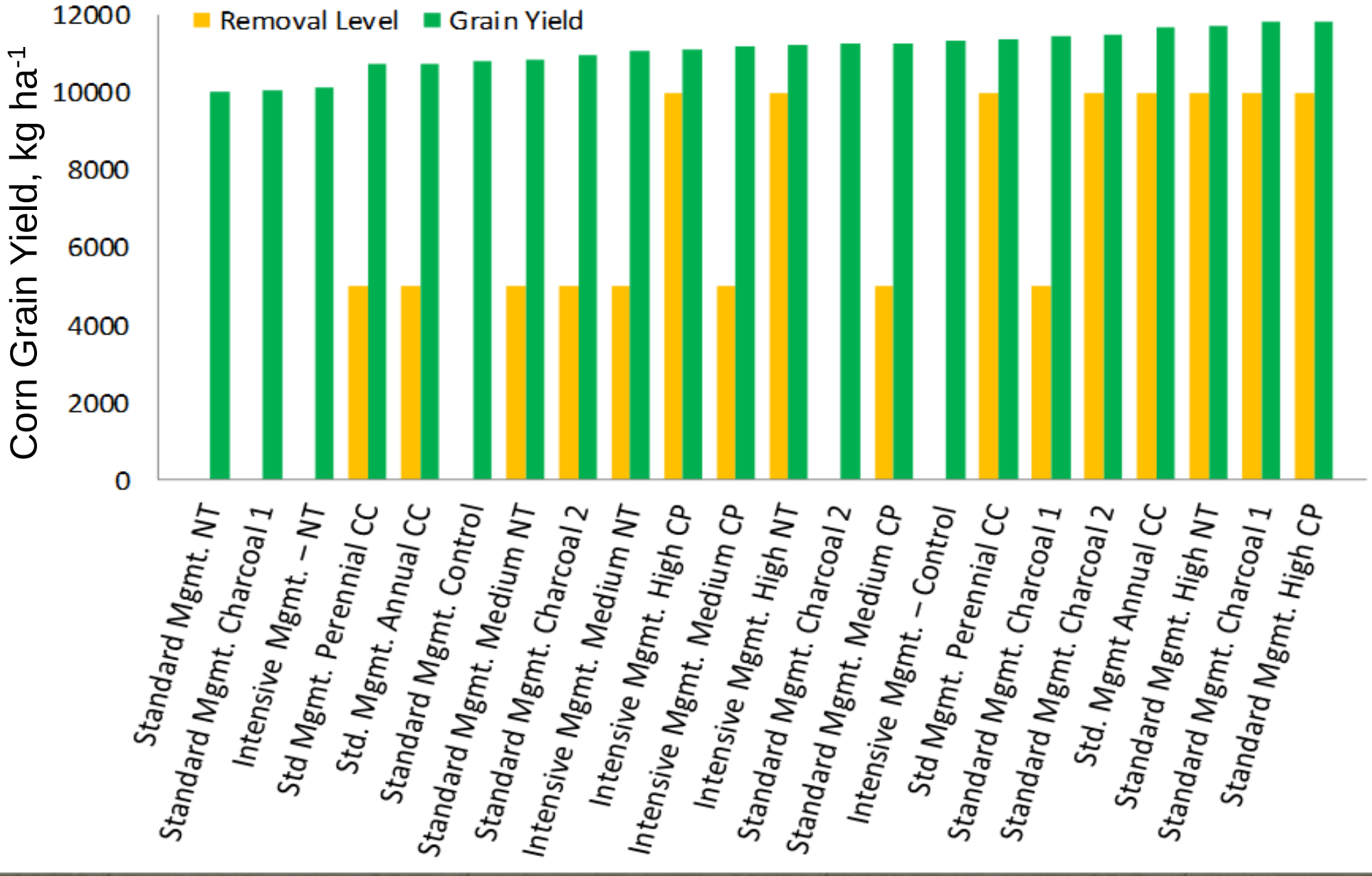
Effect of Management System, Tillage, and Residue Removal on Corn Grain Yields in 2010



Main Points:

- At V5, 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 yields not affected by tillage; tended to be higher when stover removed (short-term trend)
- No advantage to twin-row system in 2010
- Nutrient removals within each system will guide 2011 fertilizer applications

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~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.

Dynamotive Energy Systems Co.
West Loren Ontario CA

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Project Protocols

- Control, legacy biochar, fresh biochar
- Biochar application: 0, 8 tons/A
- P fertilizer application: 0, 100 lb P_2O_5/A
- Sufficient N, K, and S
- Corn grown 20 days in controlled climate
- Measure dry matter accumulation, nutrient-use efficiency, water-use efficiency
- Repeat three to four cycles

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Corn seedling dry matter as affected by legacy (2007) and fresh (2010) biochar and P fertilizer

Treatment	P Fertilizer	Plant Dry Weight	Root Dry Weight	Root:Shoot
	lb. P_2O_5/A	g	g	
Control	0	2.97 (0.17)	1.68 (0.14)	0.57
	100	3.22 (0.10)	2.08 (0.08)	0.65
2007 Biochar†	0	1.90 (0.10)	1.49 (0.08)	0.78
	100	2.16 (0.15)	1.60 (0.06)	0.74
2010 Biochar†	0	2.33 (0.16)	1.51 (0.05)	0.65
	100	2.46 (0.14)	1.57 (0.18)	0.64

†8 tons biochar/A

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