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

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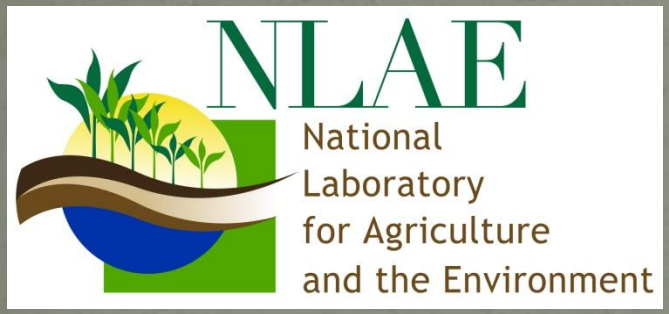

Project Objective

- **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 crop: annual (winter rye)
- Rotation: corn-soybean, rye cover crop

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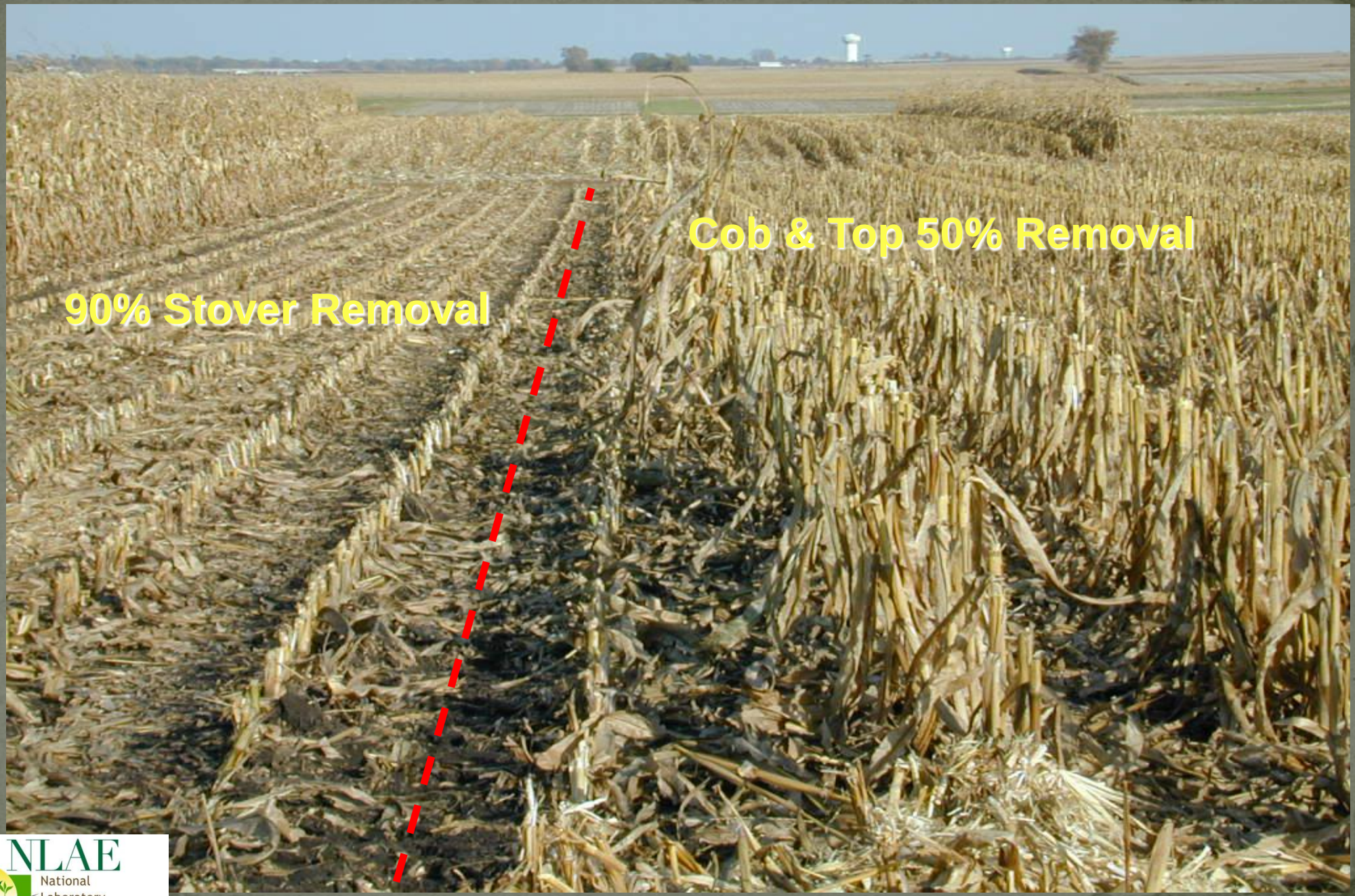

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2011 Soil Test Levels

Soil Test	Surface (0-2”)		Subsurface (2-6”)	
	Composite	Range	Composite	Range
Bray-1 P, ppm	40	13 – 72	29	11 – 62
Exch. K, ppm	171	114 – 278	115	79 – 198
Exch. Ca, ppm	2723	1954 – 3903	2935	1962 – 4041
Exch. Mg, ppm	285	186 – 424	313	185 – 504
Extract. S, ppm	6	4 – 7	4.2	2 – 10
pH	5.8	5.2 – 6.4	6.0	5.2 – 6.6
O. M.*, %	3.3	2.5 – 4.9	3.1	2.4 – 4.0
CEC, cmol(+)/kg	20.2	14.2 – 28.1	20.6	15.2 – 28.3

* Ignition Method P: >20 ppm (6”) K: >170 ppm (6”)

2011 Nutrient Management

System	Percent Removal	Timing	Source
Conventional		**Fall 2010**	**11-52-0 + 0-0-60**
200+68+49+20S	0	Planting	32-0-0 (UAN)
200+79+124+20S	50		12-0-0-26S
200+88+188+20S	90	Sidedress	32-0-0
Twin- Row		**Fall 2010**	**11-52-0 + 0-0-60**
225+65+46+30S	0	Planting	32-0-0
225+76+118+30S	50		12-0-0-26S
225+82+165+30S	90	Sidedress	32-0-0

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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 (V6 growth stage) for five management scenarios in 2011

Nutrient	Critical Value	Control	Biochar 1†	Biochar 2‡	Twin-Row	Annual CC§
N	3.50	3.82	3.69	3.66	3.93	4.00
		(0.25)	(0.16)	(0.21)	(0.27)	(0.18)
P	0.30	0.44	0.42	0.45	0.45	0.47
		(0.04)	(0.04)	(0.05)	(0.03)	(0.04)
K	2.50	3.94	3.82	4.15	4.01	4.14
		(0.30)	(0.35)	(0.28)	(0.31)	(0.28)
S	0.21	0.29	0.28	0.29	0.30	0.29
		(0.02)	(0.02)	(0.02)	(0.02)	(0.01)

†4.32 tons biochar/A in 2007; ‡8.25 tons biochar/A in 2007; §CC = cover crop

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Nutrient critical values and concentrations in ear-leaf tissue at anthesis for five management scenarios in 2011

Nutrient	Critical Value	Control	Biochar 1†	Biochar 2‡	Twin-Row	Annual CC§
N	2.70	3.06	3.07	2.99	3.01	3.11
		(0.13)	(0.12)	(0.11)	(0.13)	(0.13)
P	0.25	0.44	0.45	0.47	0.44	0.45
		(0.03)	(0.04)	(0.03)	(0.04)	(0.05)
K	1.70	1.80	1.83	1.90	1.81	1.82
		(0.11)	(0.09)	(0.14)	(0.15)	(0.09)
S	0.15	0.19	0.19	0.19	0.19	0.19
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)

†4.32 tons biochar/A in 2007; ‡8.25 tons biochar/A in 2007; §CC = cover crop

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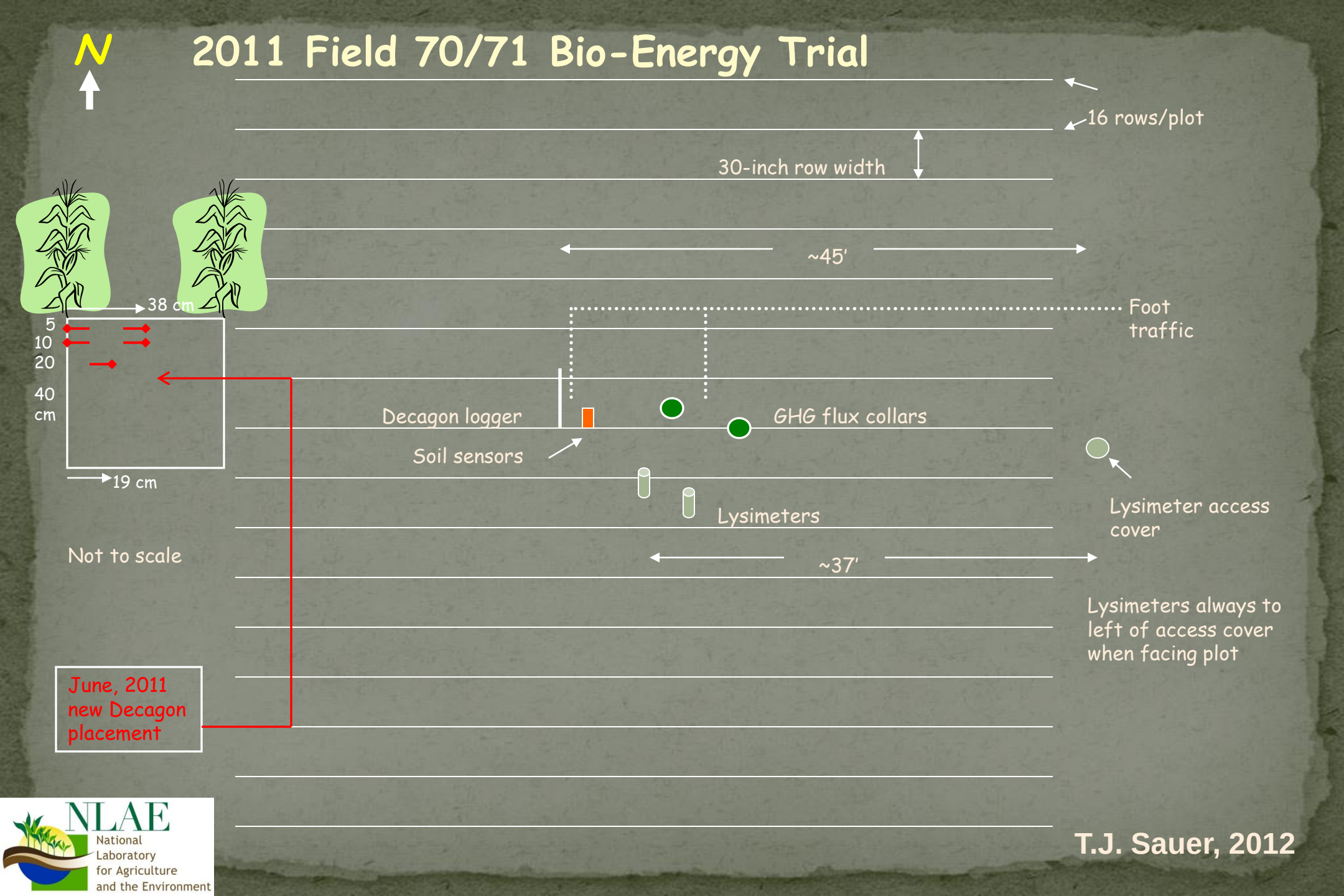
2011 Field 70/71 Bio-Energy Trial



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T.J. Sauer, 2012

Soil Water NO_3-N Summary - 2011

- Residue removal impacted nitrate concentrations: NO_3-N was greatest (avg. 27.6 mg/L) where all residue was removed, and least (avg. 19.9 mg/L) where no residue was removed.
- Dry summer of 2011 resulted in fewer sampling dates (9) than in 2010 (13). No sampling was conducted after late July (< half lysimeters yielding samples).
- In contrast to 2010, biochar amendments had no impact on NO_3-N concentration, neither among nor within residue-removal levels.

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Effect of Management System, Tillage, and Residue Removal on Corn Grain and Stover Yields in 2011

Treatment	Tillage	Percent Removal	Grain Yield†	Dry Stover Yield
			bushels acre^{-1}	tons acre^{-1}
Conventional	No-tillage	0	178 (6.1)	0
Conventional	No-tillage	50	177 (5.9)	1.34 (0.34)
Conventional	No-tillage	90	178 (2.8)	2.48 (0.59)
Conventional	Chisel Plow	0	173 (2.8)	0
Conventional	Chisel Plow	50	182 (2.9)	1.58 (0.37)
Conventional	Chisel Plow	90	176 (3.7)	2.79 (0.76)
Twin-Row	No-tillage	0	177 (6.1)	0
Twin-Row	No-tillage	50	182 (4.4)	1.72 (0.39)
Twin-Row	No-tillage	90	175 (10.6)	2.78 (0.57)
Twin-Row	Chisel Plow	0	172 (2.7)	0
Twin-Row	Chisel Plow	50	179 (5.8)	1.74 (0.30)
Twin-Row	Chisel Plow	90	170 (7.0)	2.34 (0.12)

†15.5 % moisture basis

Main Points:

- At V6, nutrient concentrations above sufficiency range in whole plants, all treatments
- At mid-silk, nutrient concentrations above sufficiency range, all treatments
- Corn grain yields not affected by tillage; tended to be higher when stover removed (short-term trend)
- No advantage to twin-row system in 2011
- Nutrient removals within each system will guide 2012 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, Canada

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Project Protocols

- Control, legacy (2007) 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, P-use efficiency, water-use efficiency
- Repeat three to four cycles

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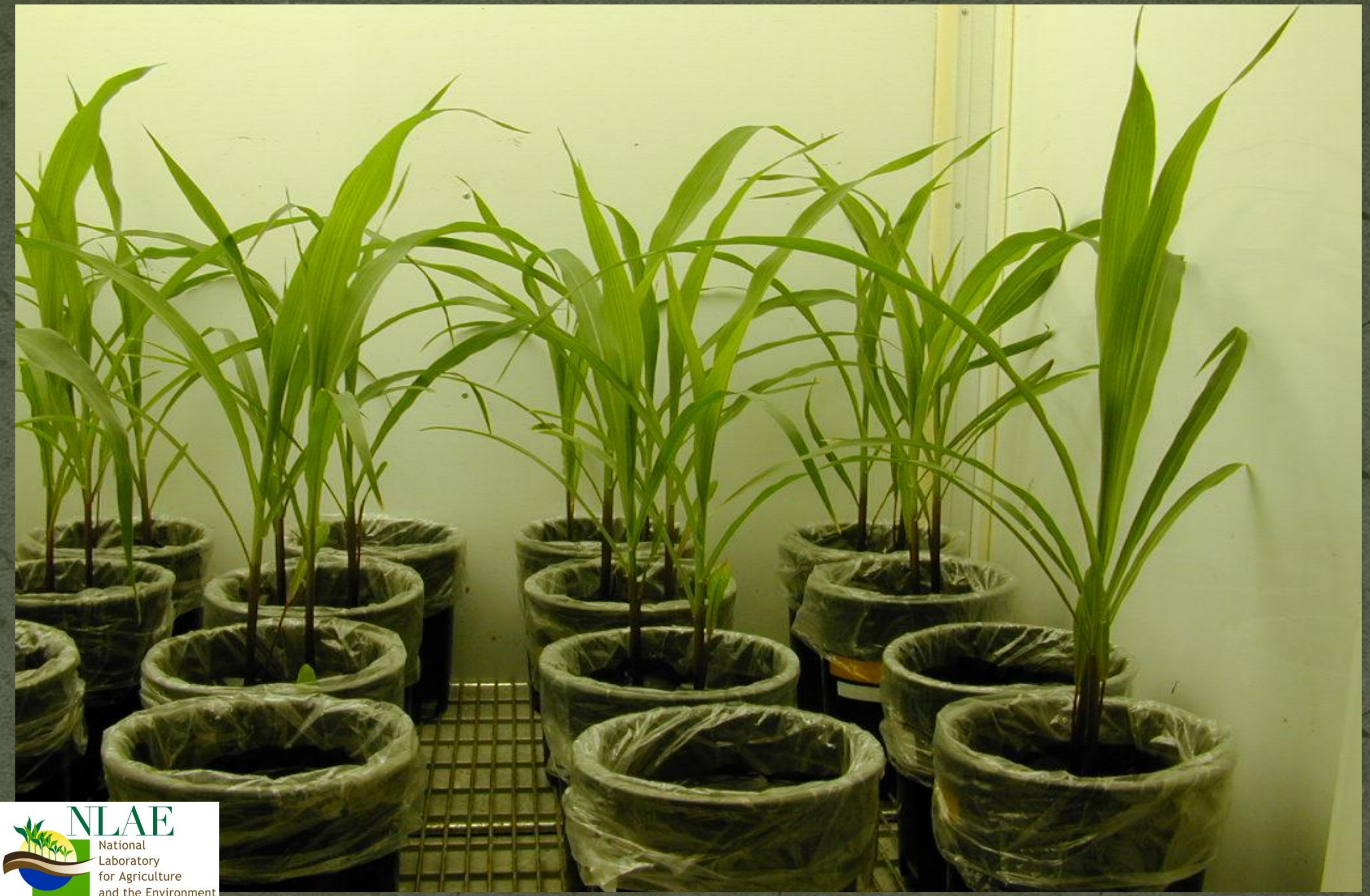
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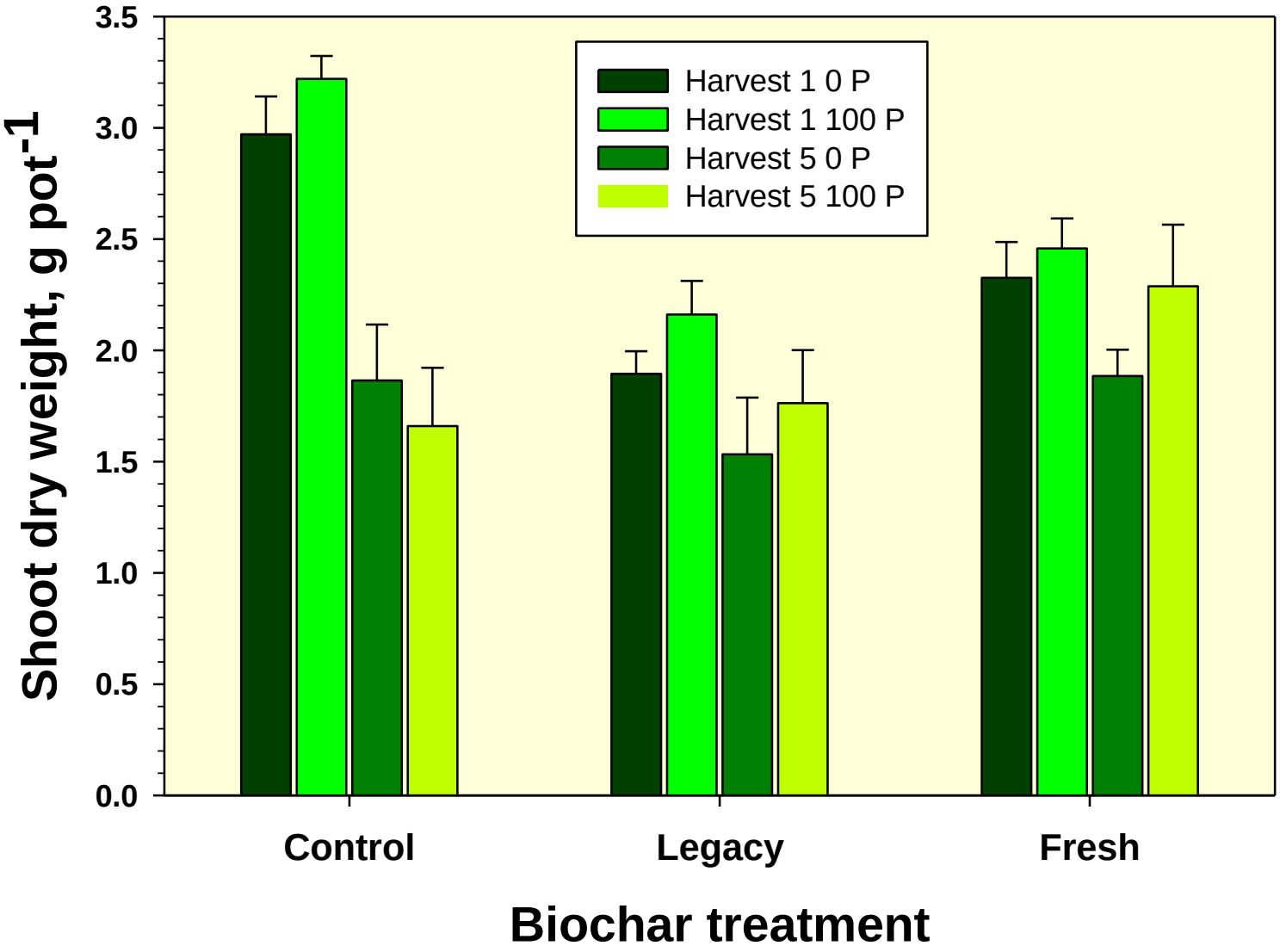
Effect of Biochar (8 ton/A) and P Fertilizer on Corn Shoot Growth



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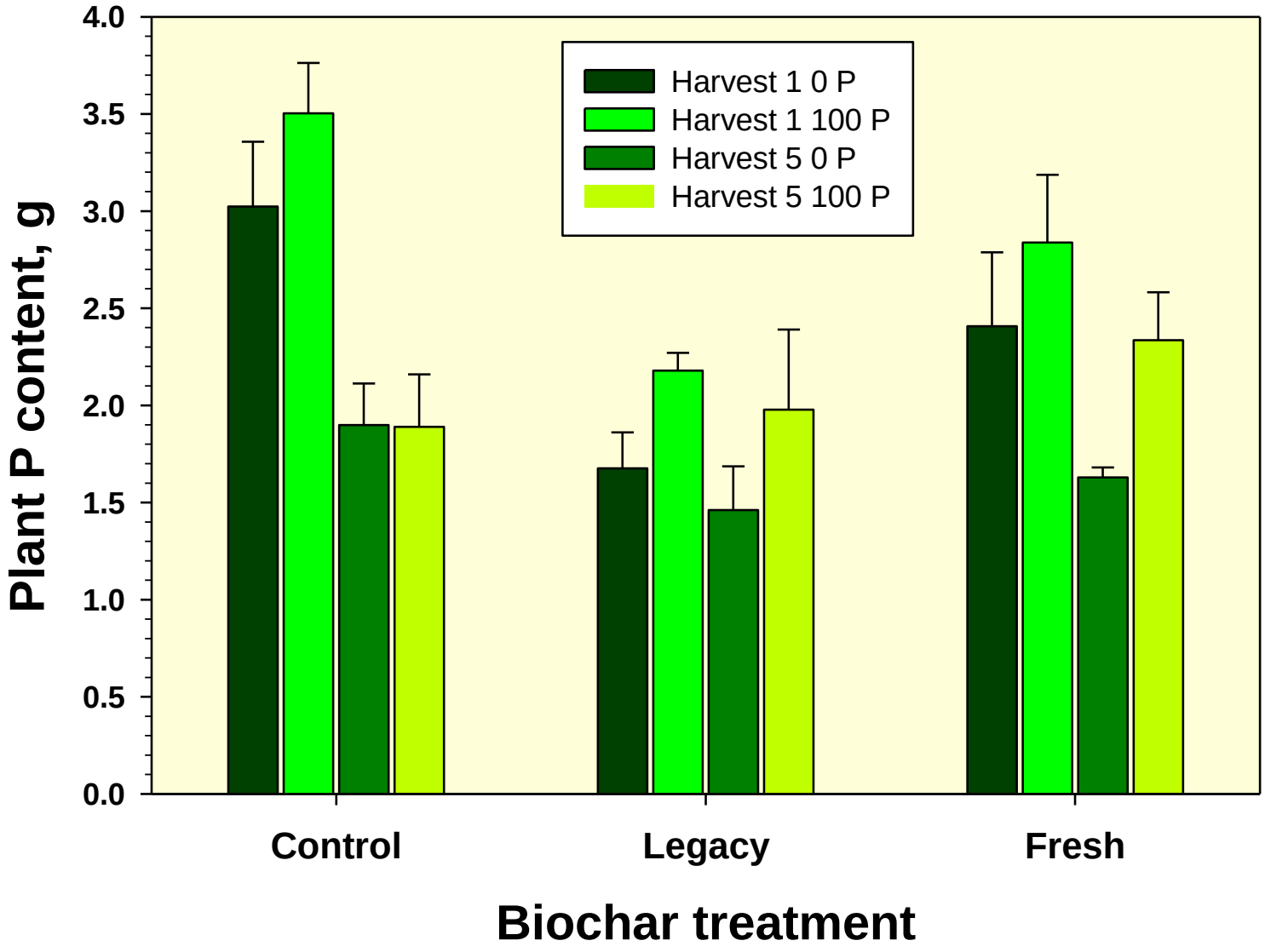
Effect of Biochar (8 ton/A) and P Fertilizer on Plant P Content



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Main Points:

- Biochar application did not increase shoot dry matter production
- Biochar did not increase agronomic efficiency (g DM / g applied P) of P fertilizer : unamended=5.8; legacy (2007)=6.2; fresh=3.2
- At 8 ton/A rate, biochar had little effect on water-holding capacity of soil
- Effect of biochar application on soil supply of nutrients and water is complex!

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