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

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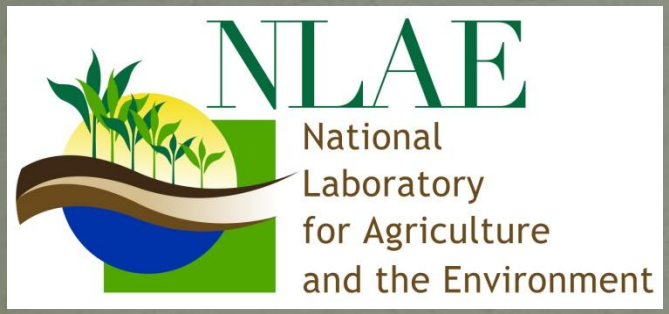

Project Objective

- **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, 4.3 tons/A, 8.3 tons/A
- Cover crop: annual (winter rye)
- Rotation: corn-soybean, rye cover crop

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2012 Soil Test Levels

Soil Test	Surface (0-2”)		Subsurface (2-6”)	
	Composite	Range	Composite	Range
Bray-1 P, ppm	38	18 – 72	21	7 – 49
Exch. K, ppm	149	104 – 196	89	67 – 126
Exch. Ca, ppm	2326	1593 – 3231	2427	1723 – 3599
Exch. Mg, ppm	256	166 – 376	268	166 – 396
Extract. S, ppm	4	1 – 8	5	2 – 8
pH	5.5	4.7 – 6.2	5.7	4.9 – 6.5
O. M.*, %	3.5	2.5 – 5.1	3.3	2.3 – 4.5
CEC, cmol(+)/kg	19.8	14.6 – 26.8	19.6	15.3 – 27.6

* Ignition Method

High P: >20 ppm (6”)

High K: >170 ppm (6”)

2012 Nutrient Management

System	Percent Removal	Timing	Source
Conventional		**Fall 2011**	**11-52-0 + 0-0-60**
200+72+51+20S	0	Planting	32-0-0 (UAN)
200+85+90+20S	50		12-0-0-26S
200+93+110+20S	90	Sidedress	32-0-0
Twin- Row		**Fall 2011**	**11-52-0 + 0-0-60**
225+73+52+30S	0	Planting	32-0-0
225+87+97+30S	50		12-0-0-26S
225+90+109+30S	90	Sidedress	32-0-0

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Recommended Fertilizer: 0 lb P_2O_5/A; 45 lb K_2O/A

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 2012

Nutrient	Critical Value	Control	Biochar 1†	Biochar 2‡	Twin-Row	C-S Rotation§
N	3.50	2.78	2.76	2.87	2.82	2.92
		(0.21)¶	(0.19)	(0.23)	(0.20)	(0.22)
P	0.30	0.35	0.37	0.36	0.35	0.36
		(0.03)	(0.04)	(0.03)	(0.05)	(0.03)
K	2.50	3.15	3.34	3.32	3.14	3.29
		(0.38)	(0.38)	(0.27)	(0.41)	(0.24)
S	0.21	0.20	0.20	0.20	0.20	0.21
		(0.02)	(0.02)	(0.02)	(0.02)	(0.02)

†4.32 tons biochar/A in 2007; ‡8.25 tons biochar/A in 2007; §soybean in 2011;
¶Standard deviation

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Nutrient critical values and concentrations in ear-leaf tissue at anthesis for five management scenarios in 2012

Nutrient	Critical Value	Control	Biochar 1†	Biochar 2‡	Twin-Row	C-S Rotation§
N	2.70	2.52	2.50	2.47	2.47	2.53
		(0.16)¶	(0.14)	(0.15)	(0.13)	(0.12)
P	0.25	0.27	0.27	0.29	0.27	0.28
		(0.03)	(0.04)	(0.02)	(0.03)	(0.03)
K	1.70	1.40	1.39	1.48	1.35	1.57
		(0.12)	(0.16)	(0.08)	(0.19)	(0.17)
S	0.15	0.15	0.15	0.15	0.15	0.16
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)

†4.32 tons biochar/A in 2007; ‡8.25 tons biochar/A in 2007; §soybean in 2011;
¶Standard deviation

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Effect of Management System, Tillage, and Residue Removal on Corn Grain and Stover Yields in 2012

Treatment	Tillage	Percent Removal	Grain Yield†	Dry Stover Yield
			bushels acre^{-1}	tons acre^{-1}
Conventional	No-tillage	0	130 (20)	0
Conventional	No-tillage	50	142 (14)	1.55 (0.57)
Conventional	No-tillage	90	143 (28)	2.36 (0.36)
Conventional	Chisel Plow	0	106 (35)	0
Conventional	Chisel Plow	50	148 (15)	1.45 (0.27)
Conventional	Chisel Plow	90	146 (25)	2.10 (0.50)
Twin-Row	No-tillage	0	131 (13)	0
Twin-Row	No-tillage	50	146 (17)	1.44 (0.48)
Twin-Row	No-tillage	90	147 (11)	2.40 (0.21)
Twin-Row	Chisel Plow	0	118 (23)	0
Twin-Row	Chisel Plow	50	139 (20)	1.85 (0.36)
Twin-Row	Chisel Plow	90	146 (14)	2.39 (0.37)

†15.5 % moisture basis

Rotation Effect on No-till Corn Grain Yield, Grain Moisture, and Stover Yield in 2012

Treatment	Grain Yield†	Grain Moisture	Dry Stover Yield
	bushels acre^{-1}	%	tons acre^{-1}
Continuous	143 (28)	15.5	2.35 (0.36)
C-S Rotation	174 (8)	15.4	2.18 (0.19)

†Yields adjusted to 15.5% moisture.

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Main Points:

- At V6, N concentrations below sufficiency level in whole plants, all treatments
- At mid-silk, both N and K concentrations below sufficiency levels, all treatments
- Corn grain yields significantly increased in rotation
- Grain yields generally not affected by tillage; tended to be higher when stover removed or under no-till with no stover removal
- No advantage to twin-row system in 2012
- K management remains a challenge

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2011

2012

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Project Objective

Evaluate the effect of legacy (2007) biochar, fresh biochar, and P fertilizer applications on soil P supply and early-season corn (*Zea mays* L.) growth in central Iowa soils.

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Project Treatments

- Clarion loam (fine-loamy, mixed, mesic Typic Haplaquolls)
- Control, legacy (2007) biochar, fresh biochar (slow-pyrolysis, hardwood)
- Biochar (0.5 mm) application: 0, 8 tons/A
- Liquid APP fertilizer application: 0, 100 lb P_2O_5/A
- Sufficient N (90 lb/A), K (100 lb K_2O/A), S (30 lb/A)
- Treatments incubated ~8 weeks at 25°C
- Completely randomized design with 4 replications

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Project Protocols

- Pre-germinated corn (Pioneer Brand 36V75) planted 2 per pot
- Controlled-climate chamber: 13 h light, 22/12°C day/night temperatures
- Plants harvested 20 d after planting, shoots, roots separated
- Dry matter accumulation, P uptake, and water use measured
- Process repeated 4 additional cycles

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Initial Soil Test Levels

Soil Test	Control	Legacy Biochar†
Bray-1 P, mg kg^{-1}	65 (VH)	50 (VH)
Exch. K, mg kg^{-1}	159 (H)	119 (Opt)
Exch. Ca, mg kg^{-1}	2034	1981
Exch. Mg, mg kg^{-1}	206	213
Extract. S, mg kg^{-1}	4	4
pH	5.6	5.7
O. M.‡, %	2.8	2.8
CEC, cmol(+) kg^{-1}	15.1	14.8

†8 tons/A, Fall 2007 ‡ Ignition Method

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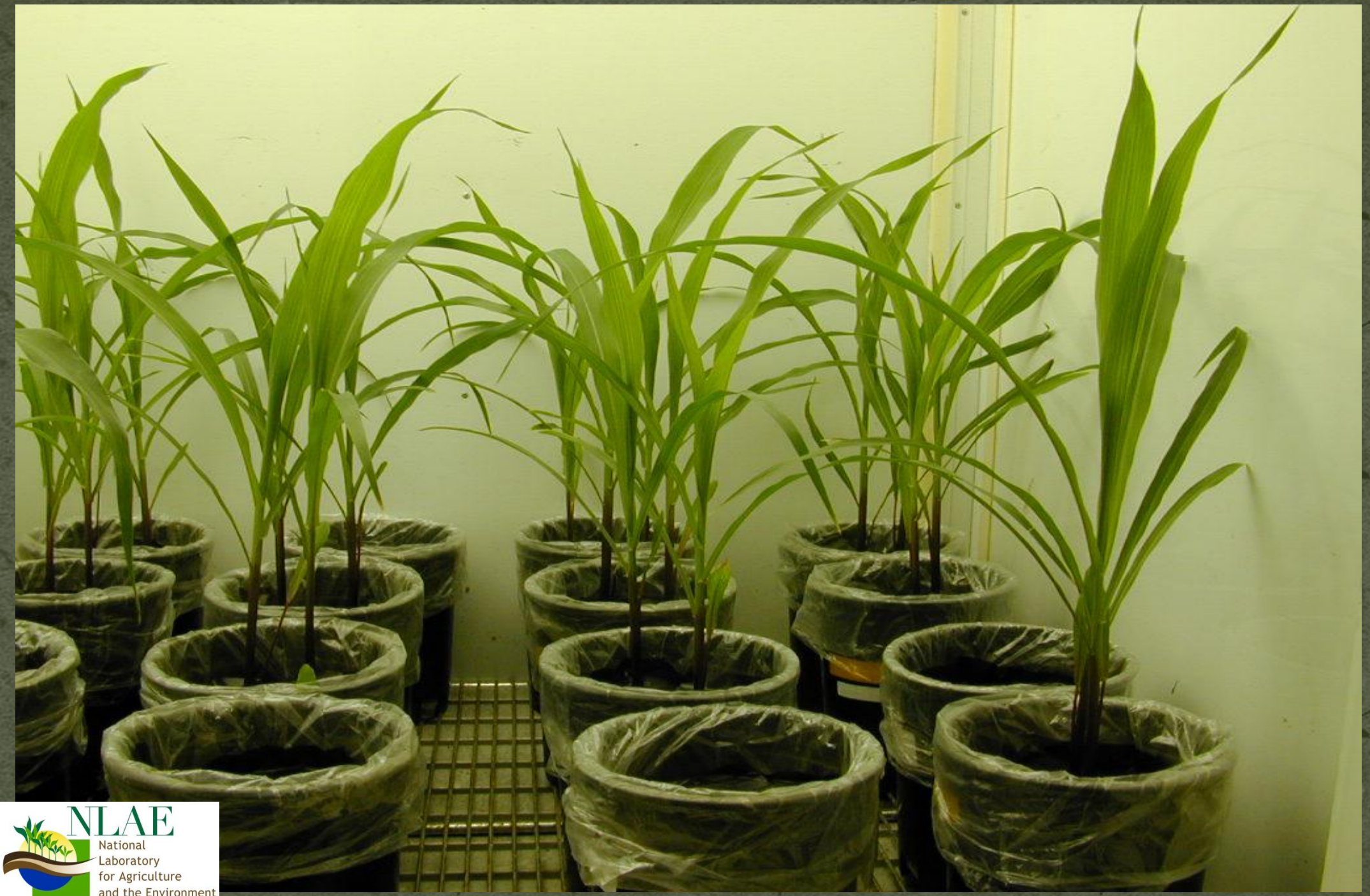
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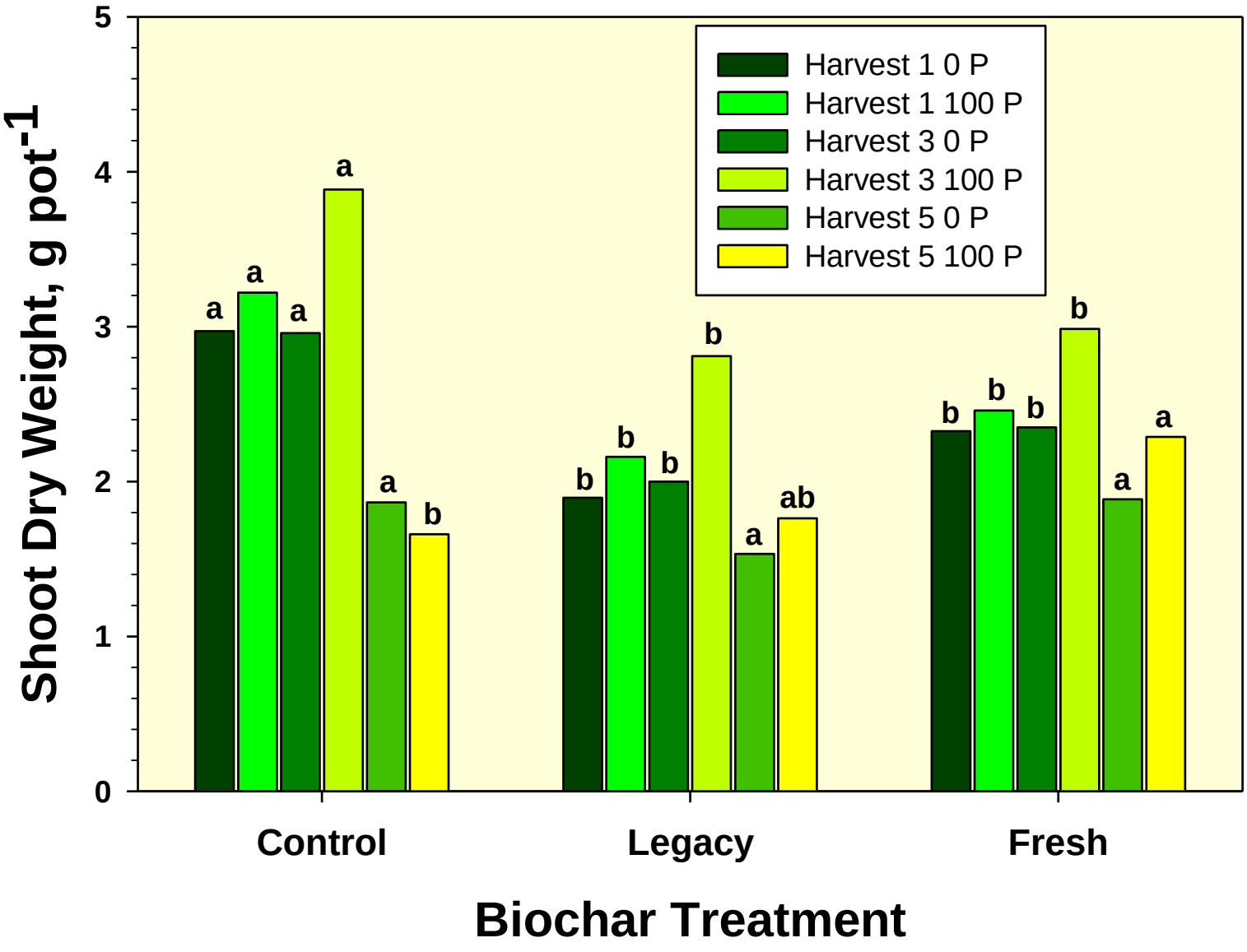
Effect of Biochar and P Fertilizer on Corn Shoot Growth



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Cumulative Corn Shoot and Root Dry Matter, Root to Shoot Ratios, and Agronomic Efficiency of P Fertilizer

Treatment	P Fertilizer	Shoot Dry Weight	Root Dry Weight	Root:Shoot	Agronomic Efficiency
	lb P_2O_5 Ac^{-1}	g pot^{-1}	g pot^{-1}		g shoot DM (g P)$^{-1}$
Control	0	10.13a	7.40ab	0.73b	
	100	10.87a	8.03a	0.74b	17.1 (6.9)‡
Legacy Biochar†	0	7.71c	6.57bc	0.85a	
	100	8.93b	5.81c	0.65bc	28.3 (12.1)
Fresh Biochar	0	9.10b	6.14bc	0.67bc	
	100	10.08ab	6.17bc	0.61c	22.7 (6.7)

† 8 tons biochar A^{-1} in 2007; ‡ Standard deviation in parentheses.

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Main Points:

- Biochar application did not increase shoot dry matter production
- Biochar and P fertilizer had little effect on shoot P concentrations (low temperature?)
- For cumulative DM production, biochar increased agronomic efficiency (DM / unit applied P) of P fertilizer : unamended=17.1; legacy (2007)=28.3; fresh=22.7
- At 8 ton acre^{-1} rate, biochar had little effect on water-holding capacity of soil: unamended=22.6%; legacy=20.4%; fresh=21.4% at field capacity
- Effect of biochar application on soil supply of nutrients and water is complex – research suggests “marginal soils” will benefit most

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