A Greener Revolution and a No-Regrets Carbon Capture Mechanism for New Mexico

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Part 1:
Greener Revolution

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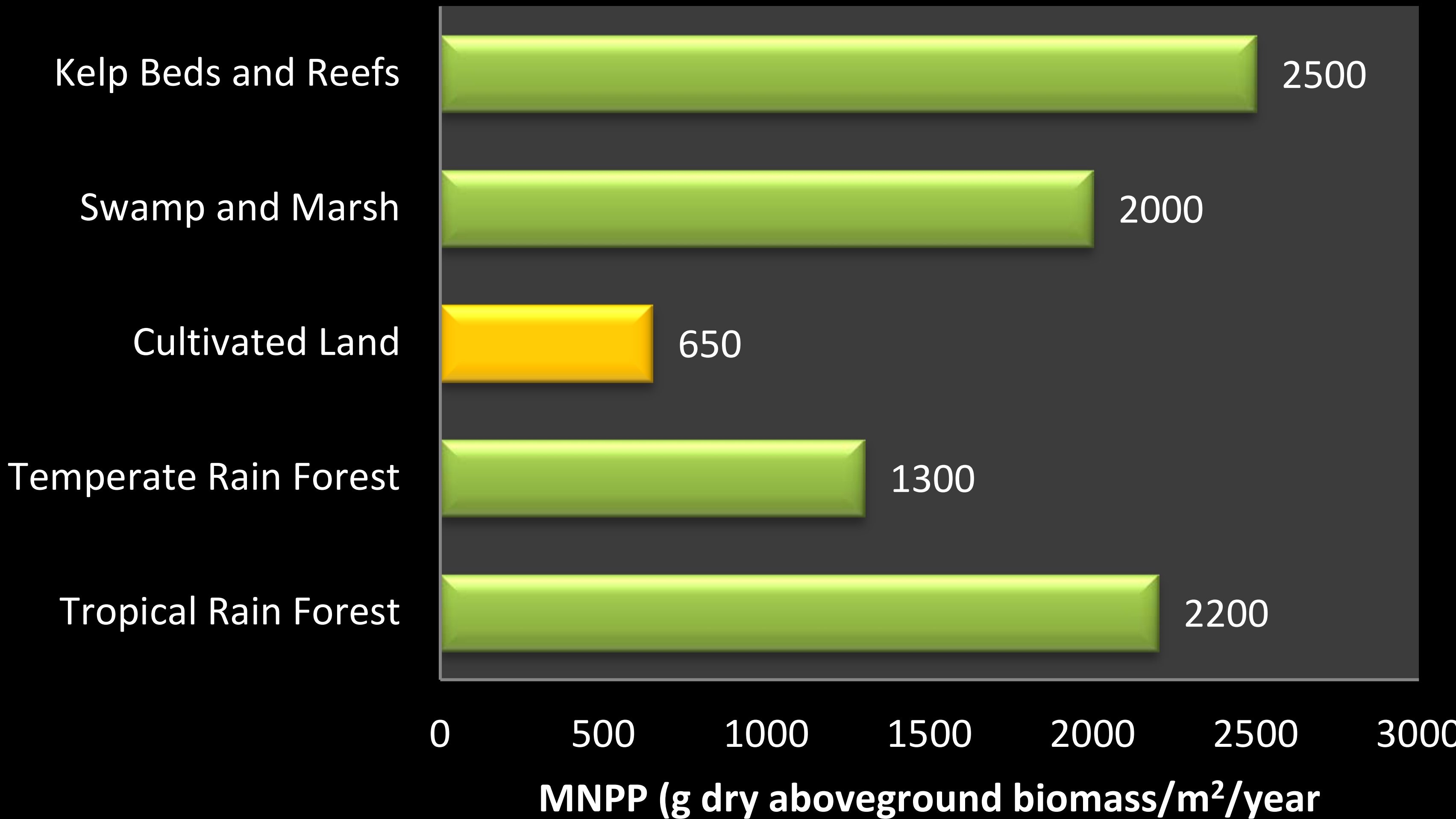

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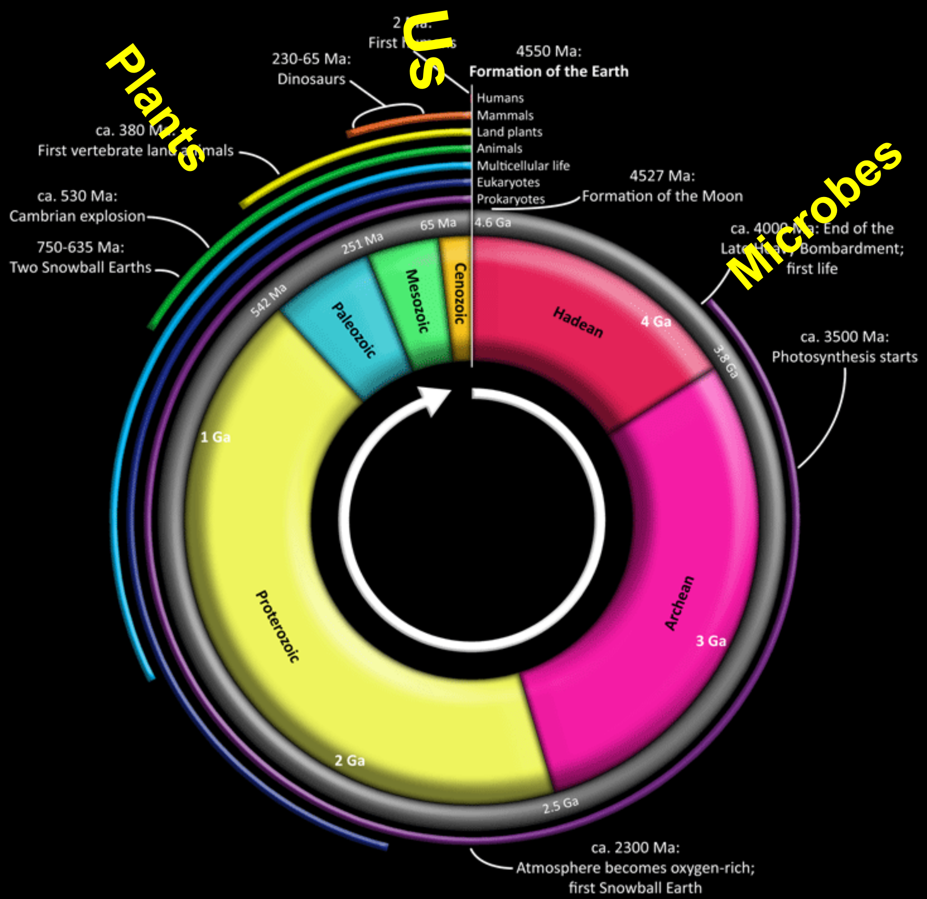
peak (s)oil...!

How Do We Reverse These Trends?



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Plants are no different from us as they are also outnumbered by their Microbial Counterpart and depend on them for nutrient acquisition, pathogen protection and gene regulation.

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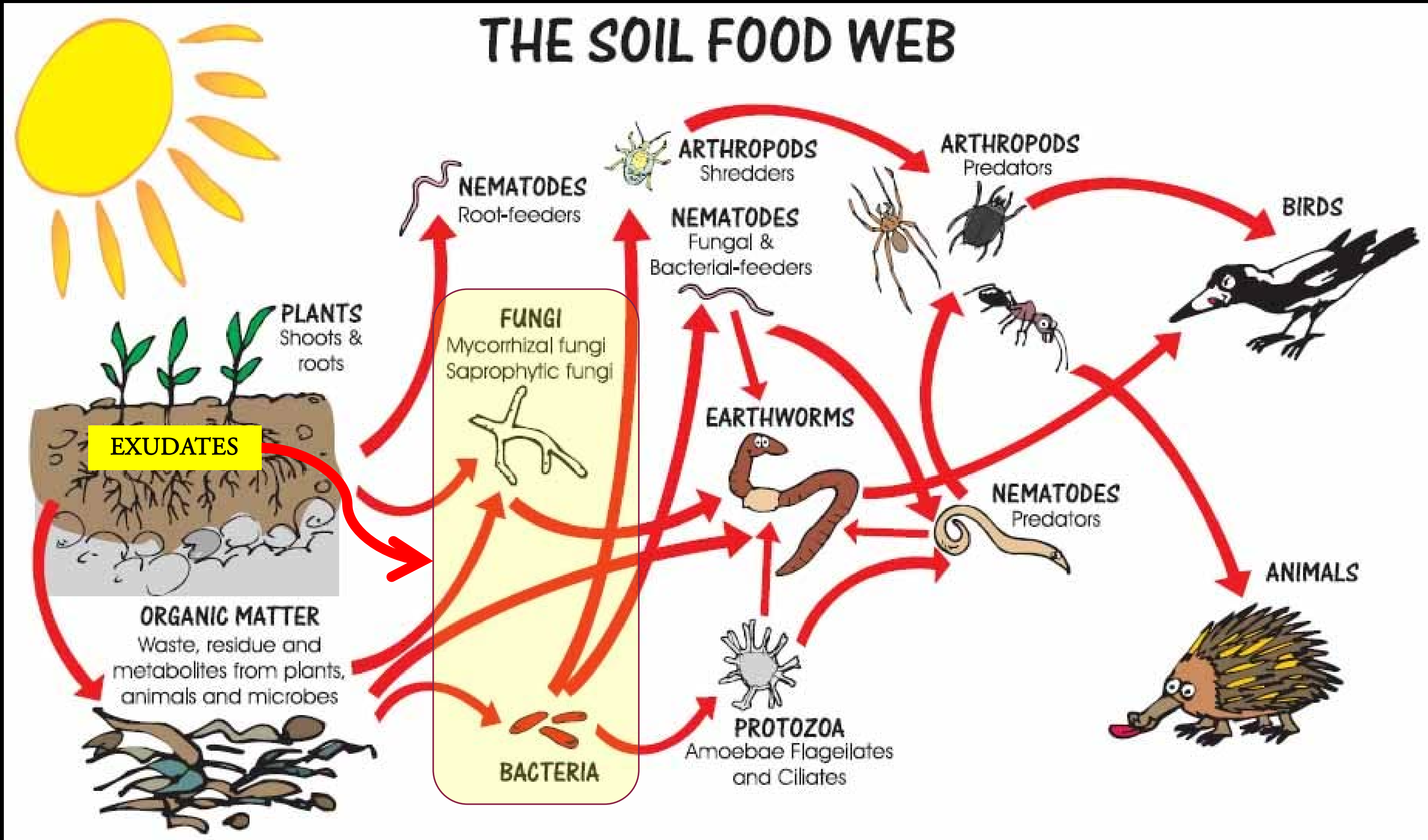

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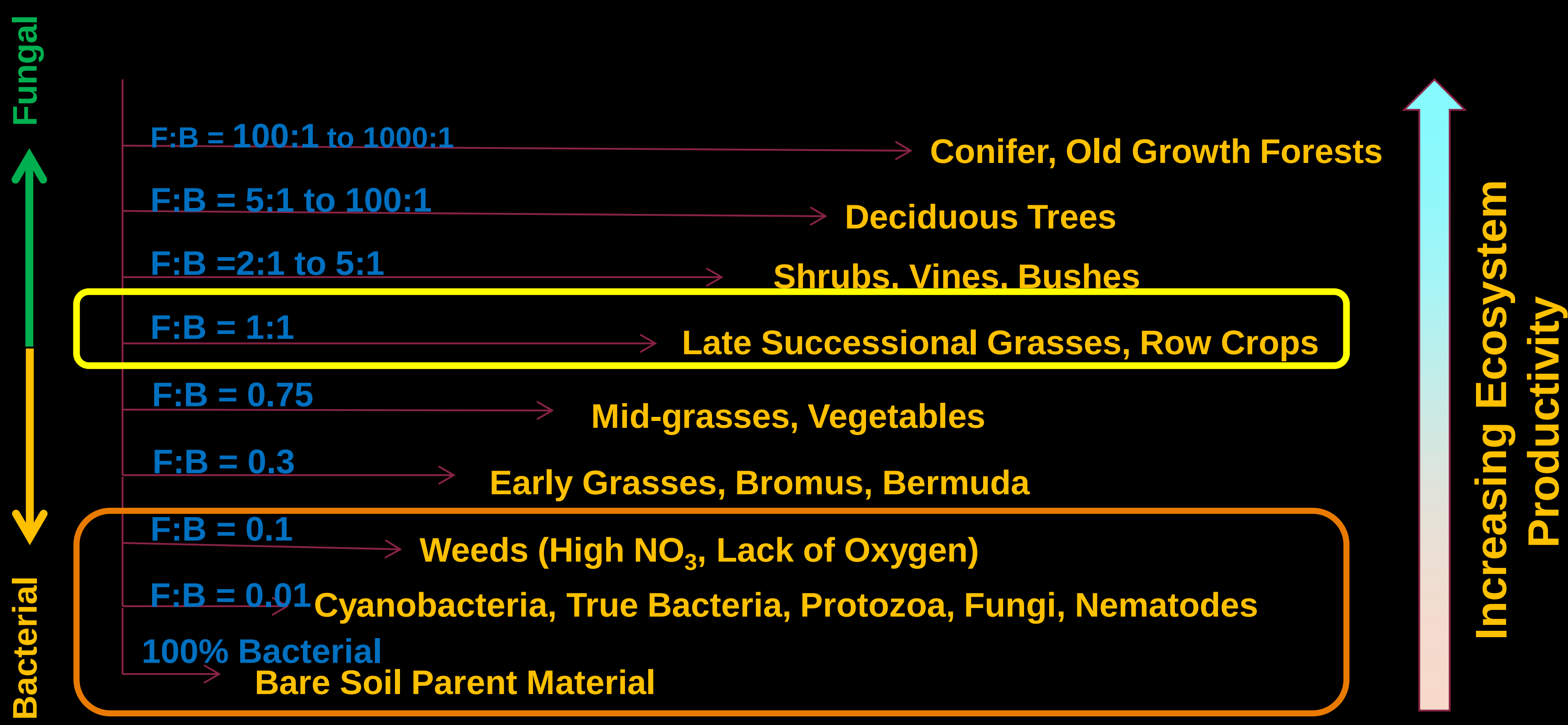
Plant Succession Ladder as a Function of Fungal:Bacterial Ratio (F:B)



Elaine Ingham- www. soilfoodweb.com

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The Beginning to this research path….

Dairy Cow Manure

United States Department of Agriculture (USDA) needed a composting system that allowed:

- ***minimum infrastructure & labor investment,***
- ***an efficient and low-cost process,***
- ***a most importantly….. a <u>superior end product.</u>***

Johnson-Su Composting Bioreactor

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Johnson/Su Static Composting Technology

- Reduces water usage by a factor of 6 times
- Reduces composting time by 66%
- Results in a low salinity compost (~2-3 mS/cm)
- Amenable to incorporation of vermicomposting after thermophilic phase (observed 10X N increase in end product)

Produces a "HIGH QUALITY" nutrient rich, fungal dominated, high-microbial-biomass & bio-diverse compost

Biological Analysis
Soil

earthfort

~5 times more fungal mass

Report prepared for:
WERC / NMSU
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Report Sent: 8/15/2013
Sample#: 01-117115 | Submission:01-023294
Unique ID: 130805-6
Plant: Not Indicated
Invoice Number: 0
Sample Received: 8/7/2013

For interpretation of this report please contact:
Earthfort Labs
info@earthfort.com
(541) 257-2612

Consulting fees may apply

Organism Biomass Data		Dry Weight	Active Bacteria (µg/g)	Total Bacteria (µg/g)	Active Fungi (µg/g)	Total Fungi (µg/g)	Hyphal Diameter (µm)
Results		0.480	89.5	621	82.7	2682	2.85
Comments		In Good Range	Above range	Above range	Above range	Above range	
Expected Range	Low	0.45	30	300	30	300	
	High	0.85	60	600	60	600	

		Protozoa (Numbers/g) Flagellates	Amoebae	Ciliates	Total Nematodes #/g	Mycorrhizal Colonization (%) ENDO	ECTO
Results		28858	577176	2816	23.0	Not Ordered	Not Ordered
Comments		Good	High	High	High		
Expected Range	Low	10000	10000	0	10	10%	10%
	High	100000	100000	200	20	50%	50%

Organism Biomass Ratios		Total Fungi to Tot.Bacteria	Active to Total Fungi	Active to Total Bacteria	Active Fungi to Act.Bacteria	Nitrogen Cycling Potential (lbs/ac)
Results		4.32	0.03	0.14	0.92	300+
Comments		High	Low	Good	Low	
Expected Range	Low	1	0.1	0.1	1	
	High	2	0.15	0.15	2	

Nematode detail (# per gram or # per mL) Classified by type and identified to genus. (If section is blank, no nematodes identified.)

Bacterial Feeders	18.62		
Butlerius			1.10
Cephalobus			4.93
Cuticularia			0.55
Diplogasterius			7.12
Diploscapter			2.19
Prodesmodora			2.19
Rhabditidae			0.55
Fungal/Root Feeders	4.38		
Ditylenchus		Stem & Bulb nematode	3.29
Filenchus			1.10

Experiment 1

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Plant Growth Comparison to Eight Local Composts Using Chile Plants

Standard Soil Tests: % Saturation through Zn (ppm)

Biological Test: Fungal:Bacterial

	Peat Humus	Omni	Miracle Grow	Premium Org Potting Soil	Sterilized Manure	Composted Cow Manure	Organic Top Soil Top Choice	Potting Soil Natures Way	Charcoal Compost	Charcoal Compost (watered 4 months)
Trial Number	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***10***	***12***
% Saturation	122	110	237	121	91.4	111	115	117	126	156
Calcium (meq/L)	96.6	7.48	7.34	43.6	5.44	43.7	72.8	7.59	6.9	10.1
ESP (%)	27.3	21.3	12.1	32.3	39.3	30.9	28.4	21.7	1	3.2
Copper (ppm)	3.96	9.39	1.8	4.4	15.29	9.72	2.77	5.57	1.43	1.81
EC (mmhos/cm)	58.1	15.3	11.7	40.5	39.9	66.3	60.3	6.05	2.92	3.84
Fe (ppm)	65.1	194.9	39.58	52.05	146.5	59.23	41.16	74.44	7.97	15.49
K (ppm)	13300	3640	4450	7480	102	15600	11700	975	945	1010
Mg (meq/L)	65.1	8.02	8.01	31.3	3.71	55.7	57.8	3.83	3.53	10.8
Mn (ppm)	5.66	24.19	45.17	6.74	13.61	6.26	7.64	16.4	12.89	22.16
NO3-N (ppm)	3052.7	12.2	30.5	74.7	1057.6	1971.9	2115.3	5.1	19.1	20.13
Org Matter (%)	21.35	19.23	38.5	20.98	15.27	20.05	18.44	20.1	14.57	16.54
pH	7.2	8.5	7.8	7.5	9.6	7.8	7.1	7.7	7.9	7.78
P (ppm)	752.6	482.1	869.4	957.8	2285.9	434.7	365.6	298.9	656.9	835.4
Na (meq/L)	237	53.4	28.2	203	95.6	220	224	47	6.21	10.1
SAR	26.36	19.18	10.18	33.17	44.7	31.21	27.72	19.67	2.72	3.12
Zn (ppm)	32.9	63.67	24.34	26.52	43.82	29.11	28.72	30.8	16.32	27.88
Fungal:Bacterial	0.027	0.007	0.031	0.003	0.067	0.060	0.194	0.070	0.404	0.420
Growth Volume (mL)	**3804**	**732**	**2994**	**1680**	**1096**	**7984**	**8923**	**325**	**15626**	**17579**

Greenhouse Trial

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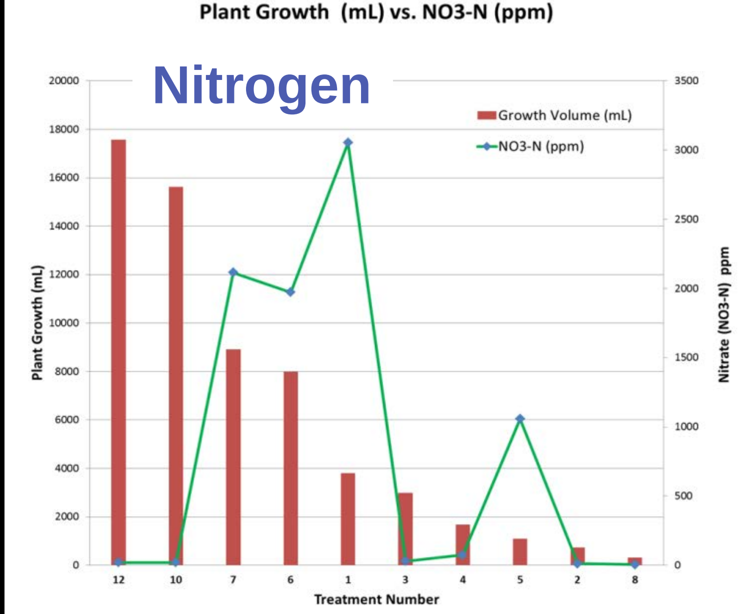

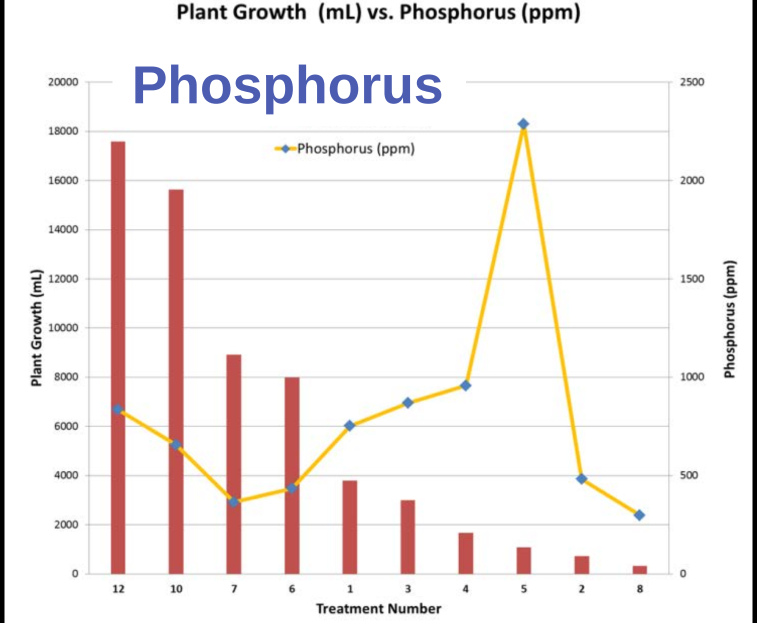

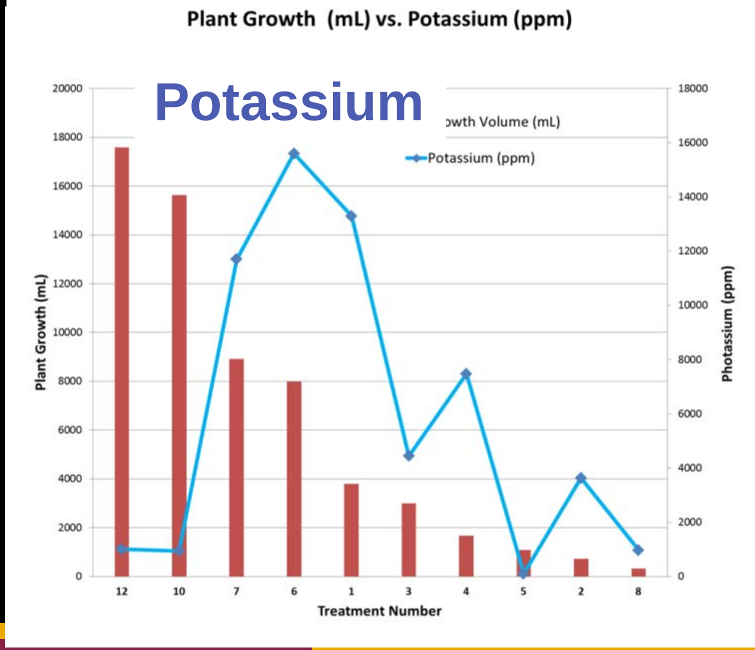

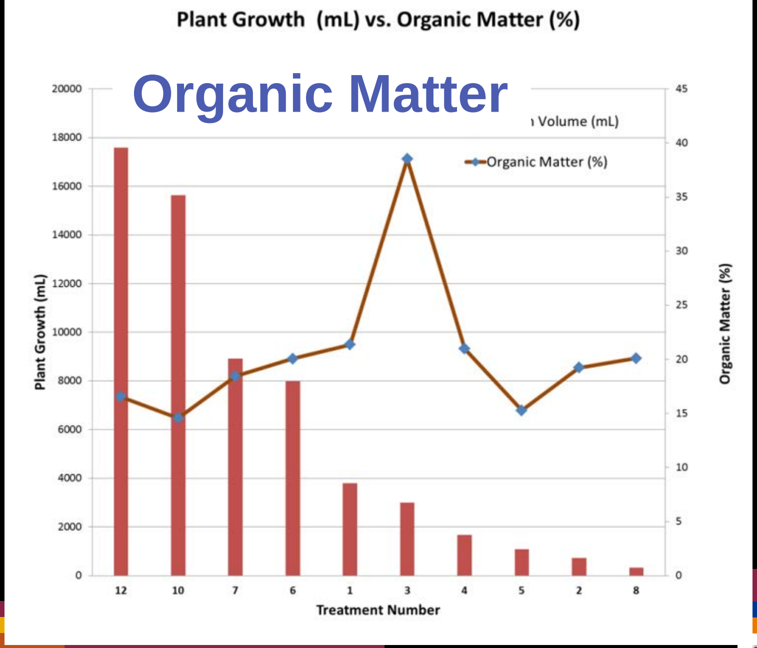

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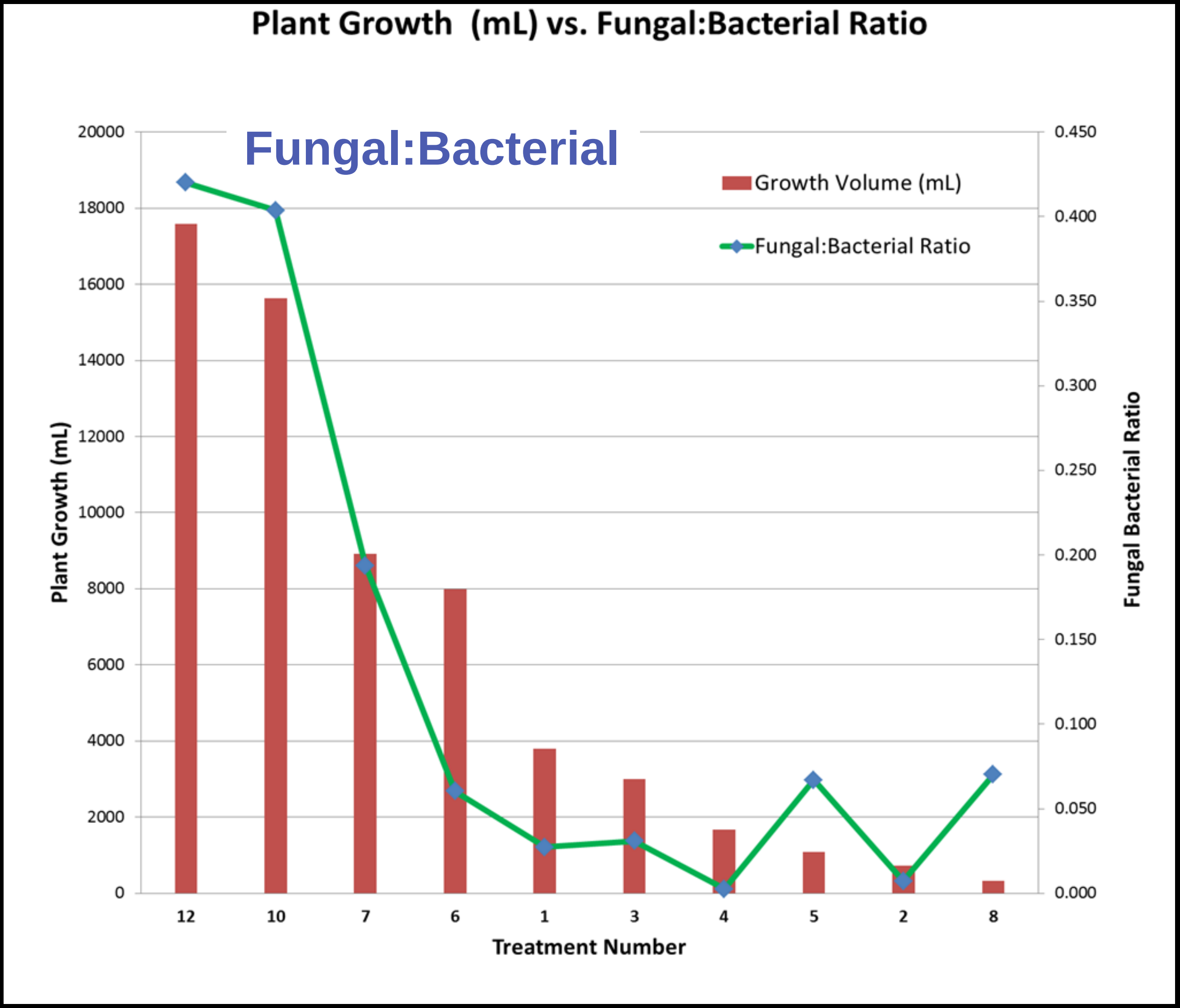

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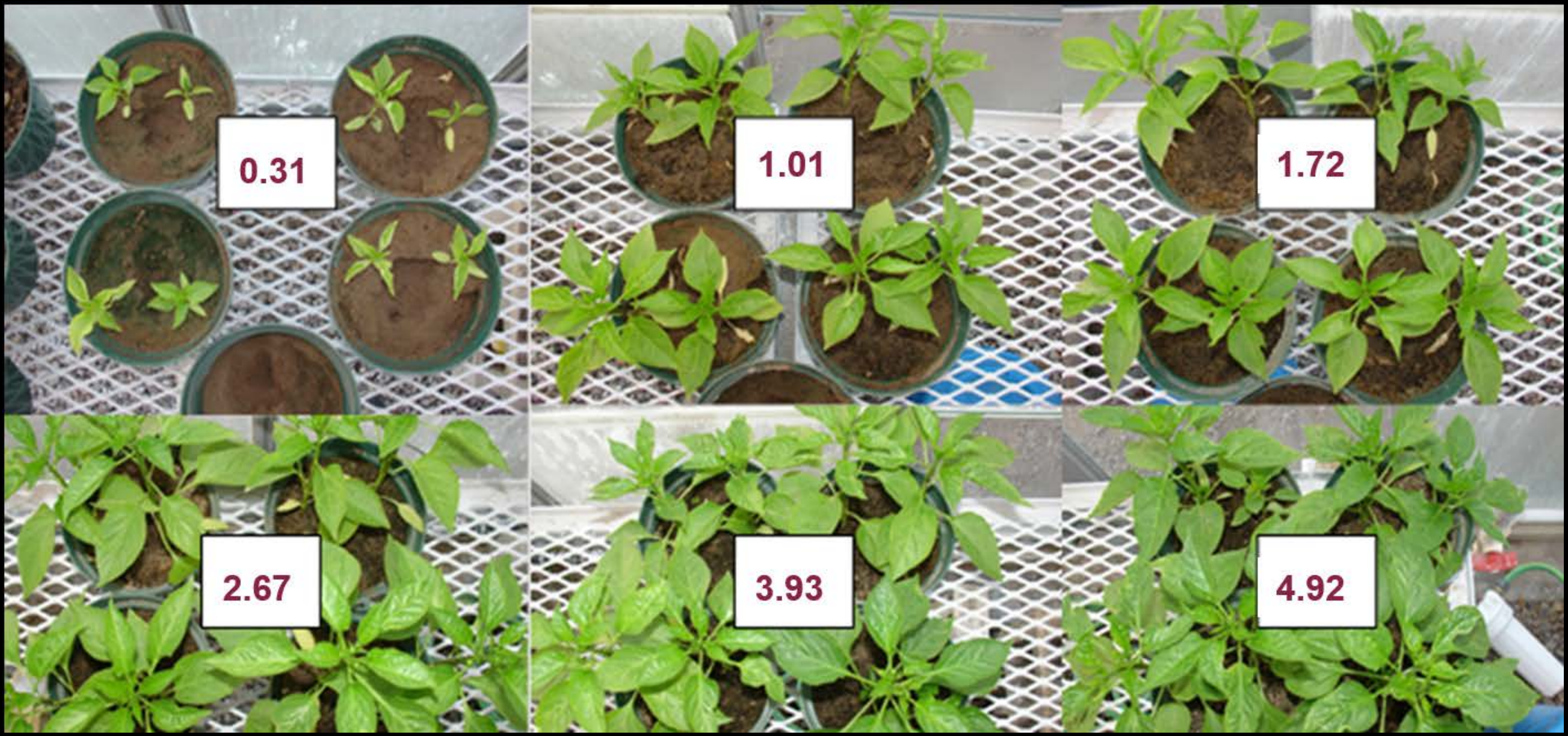
Experiment 2



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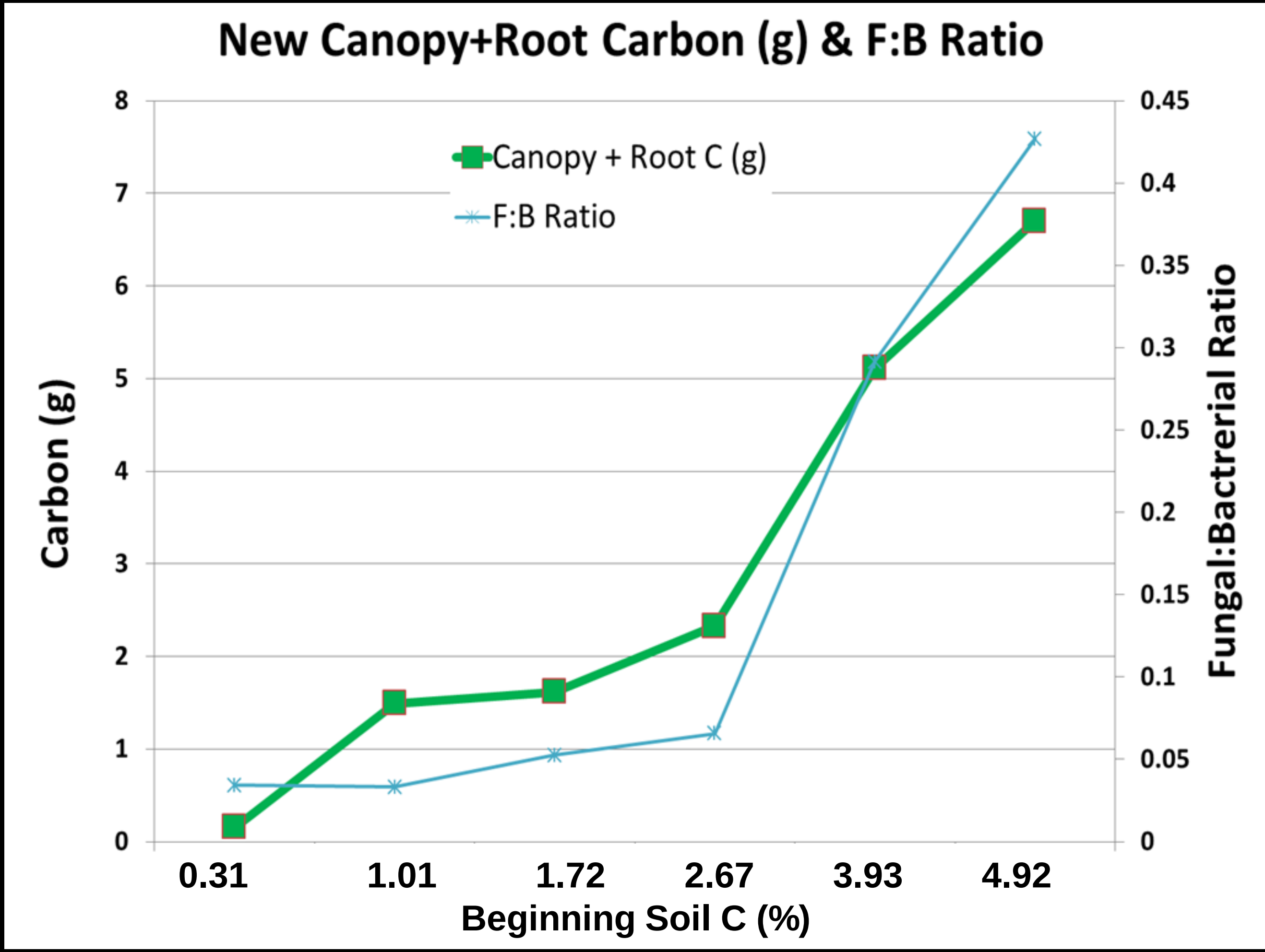

$r^2 = 0.91$

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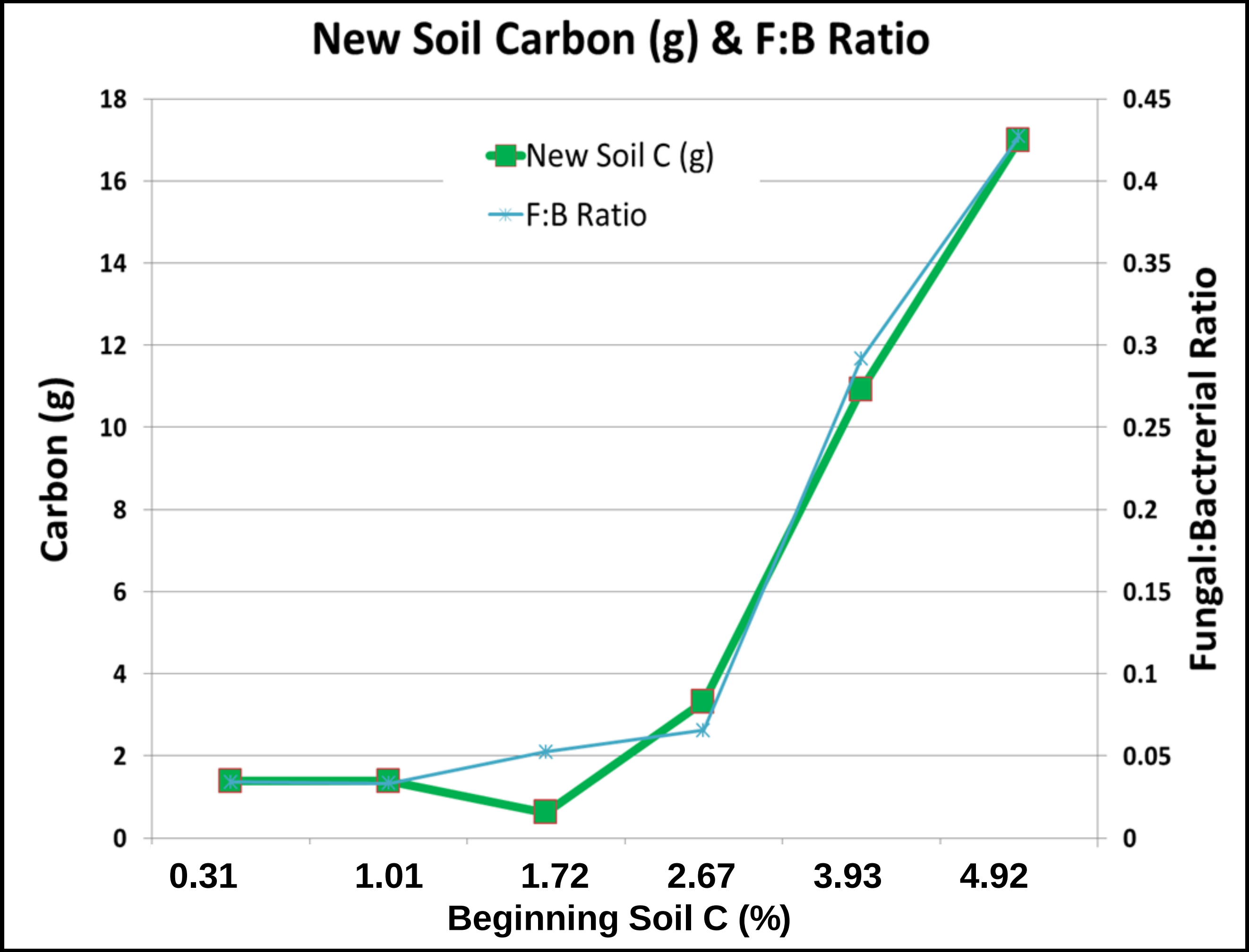

$r^2 = 0.99$

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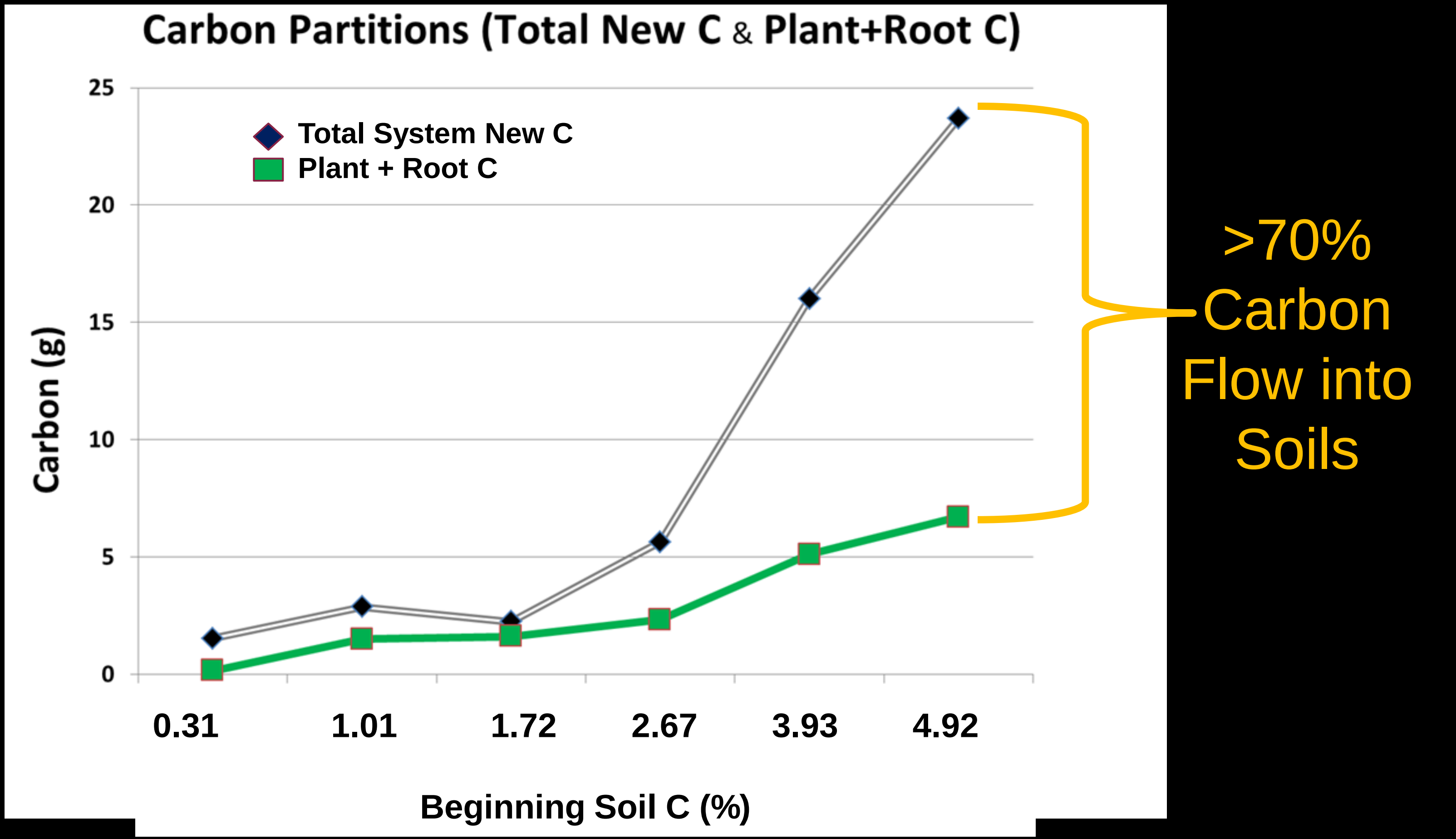

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Experiment 3

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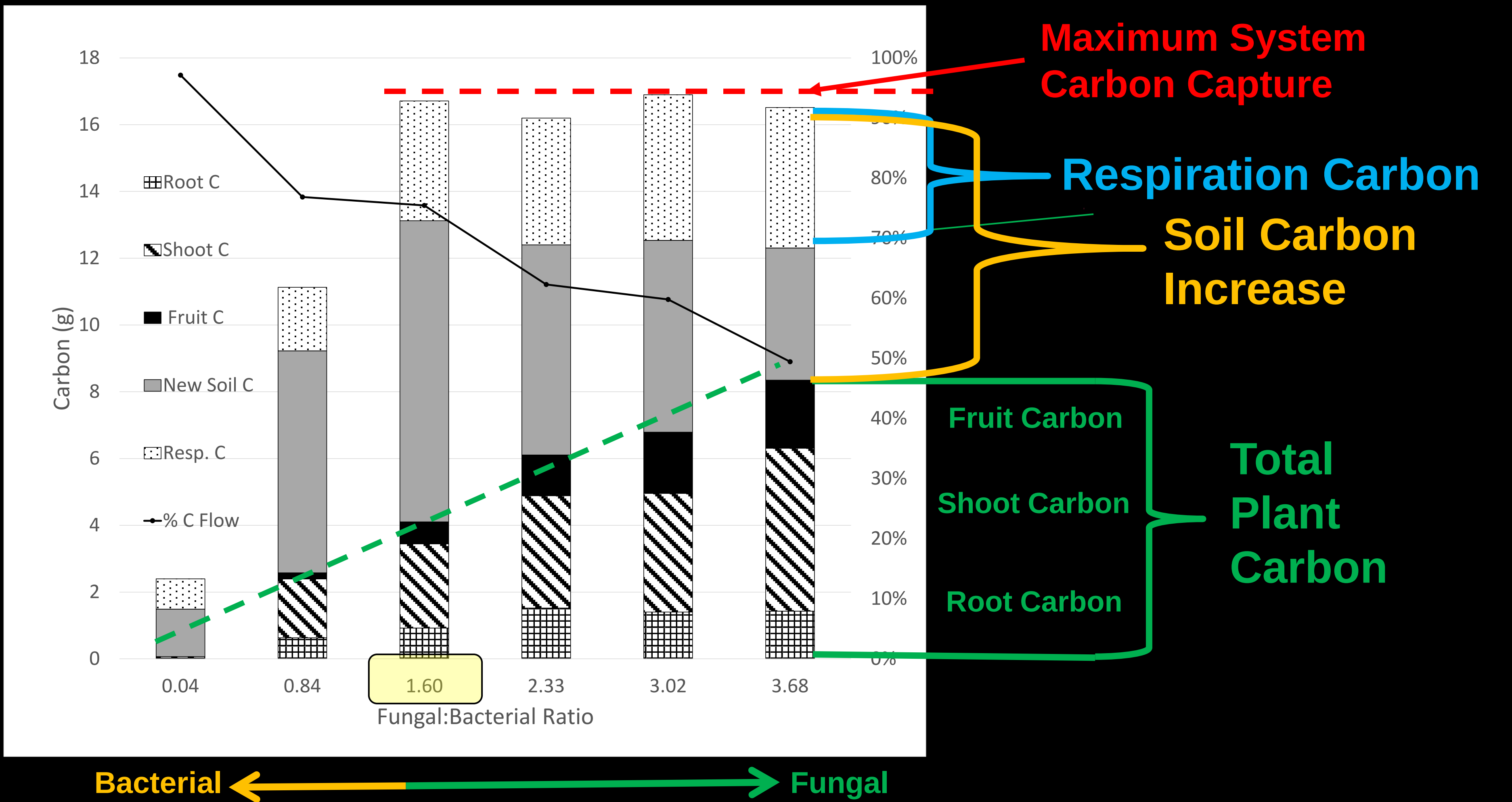
Carbon Partitioning vs. increasing F:B Ratio



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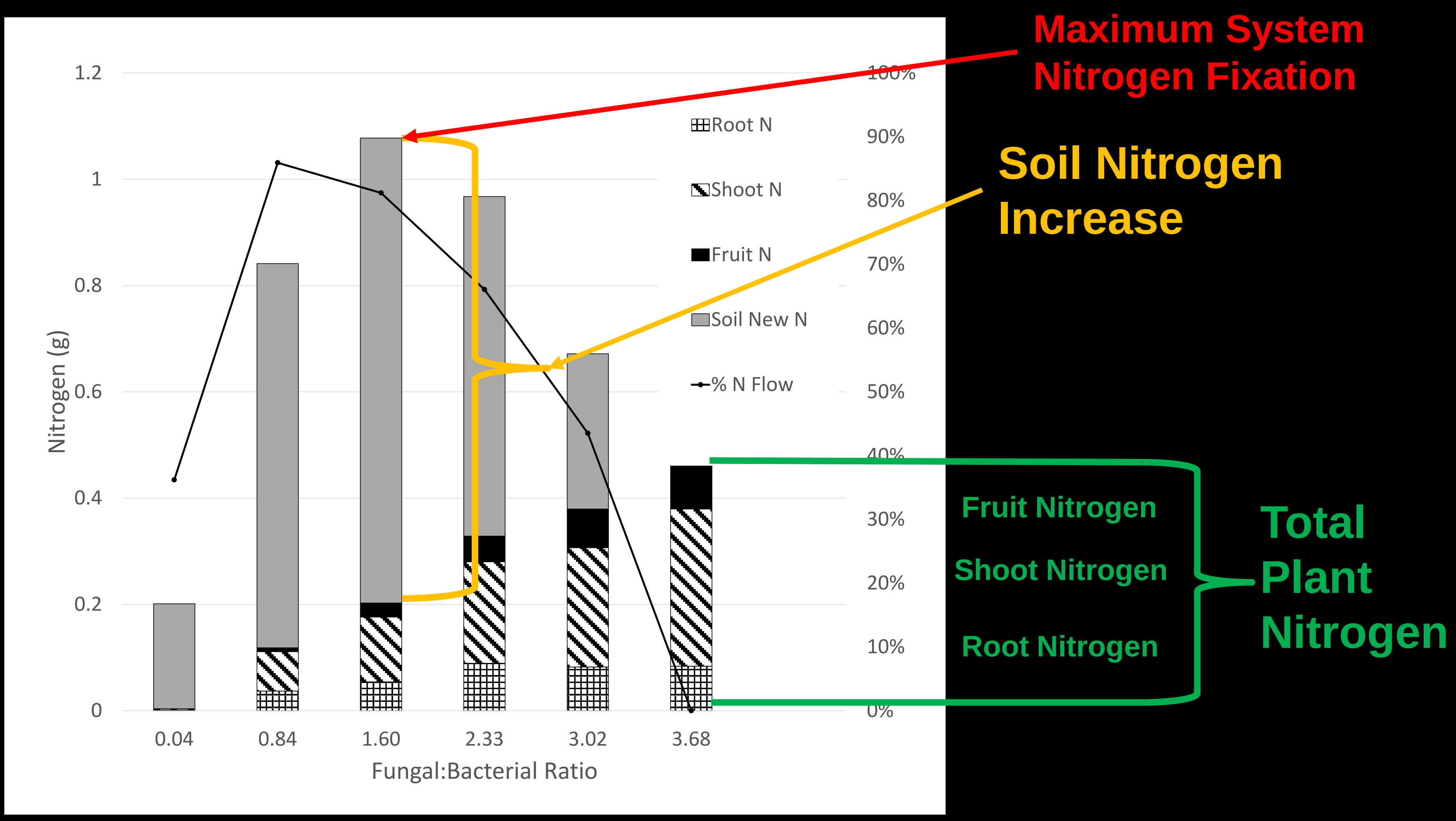
Nitrogen Partitioning vs. increasing F:B Ratio



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Field Trials of a Biologically Enhanced Agricultural Management (BEAM) Approach

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Control (No Previous Covercrop Application) Total Dry Biomass Production = 1 ton/Acre

1 Year's Previous Covercrop Application Total Dry Biomass Production = 5 tons/Acre

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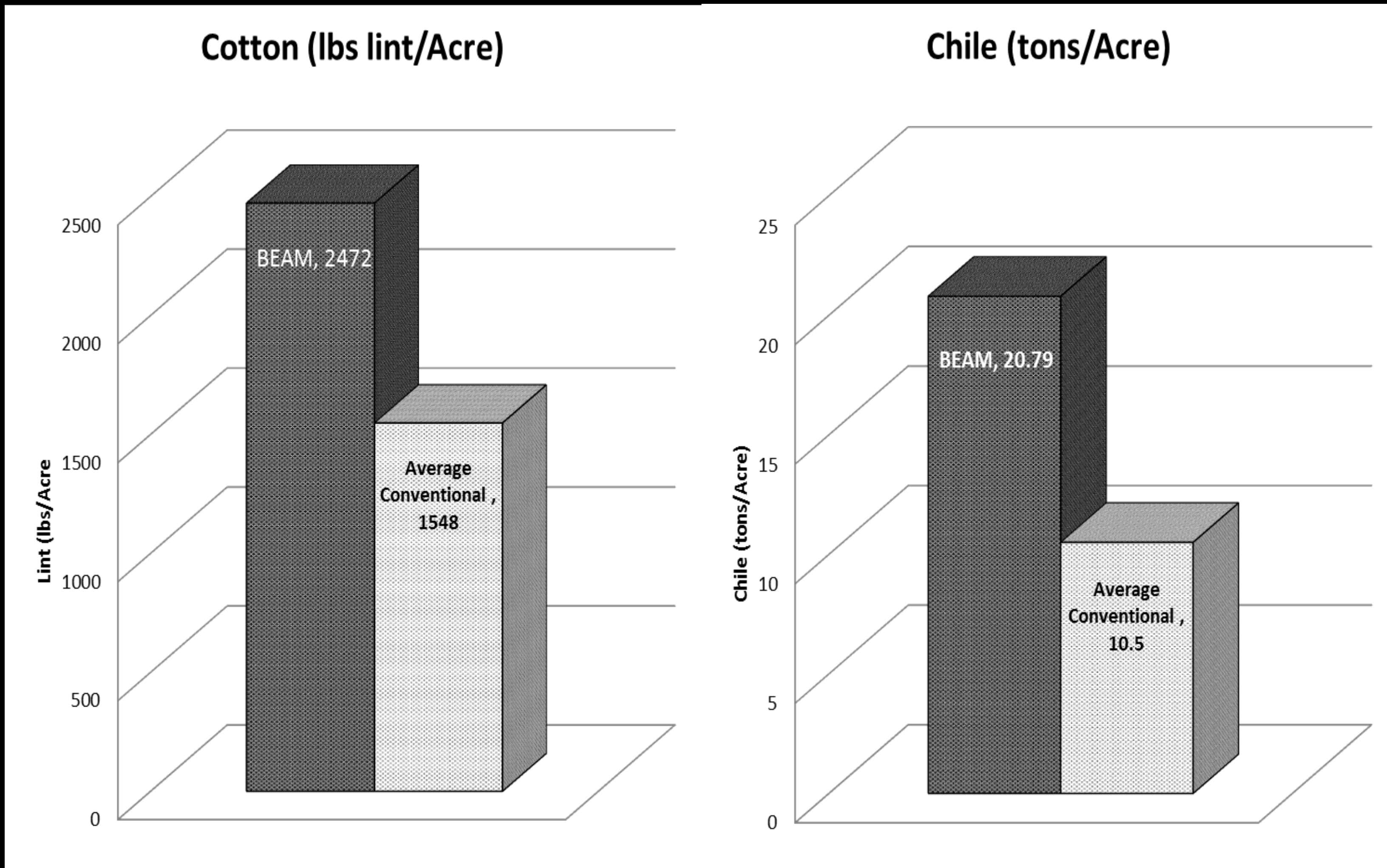

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What Does BEAM Offer Towards Soil Carbon Sequestration?

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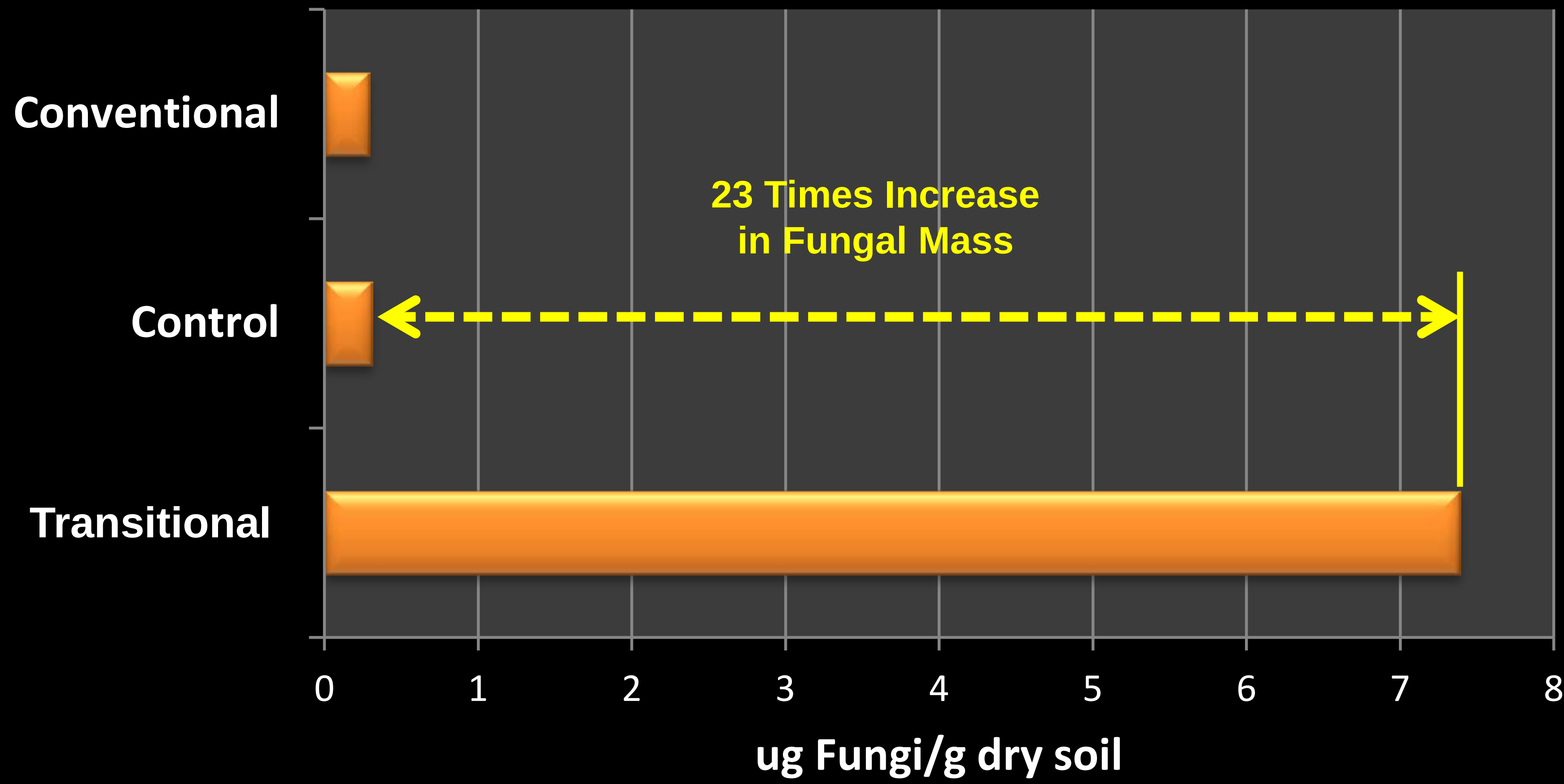
Shift to Fungal Dominant Soils



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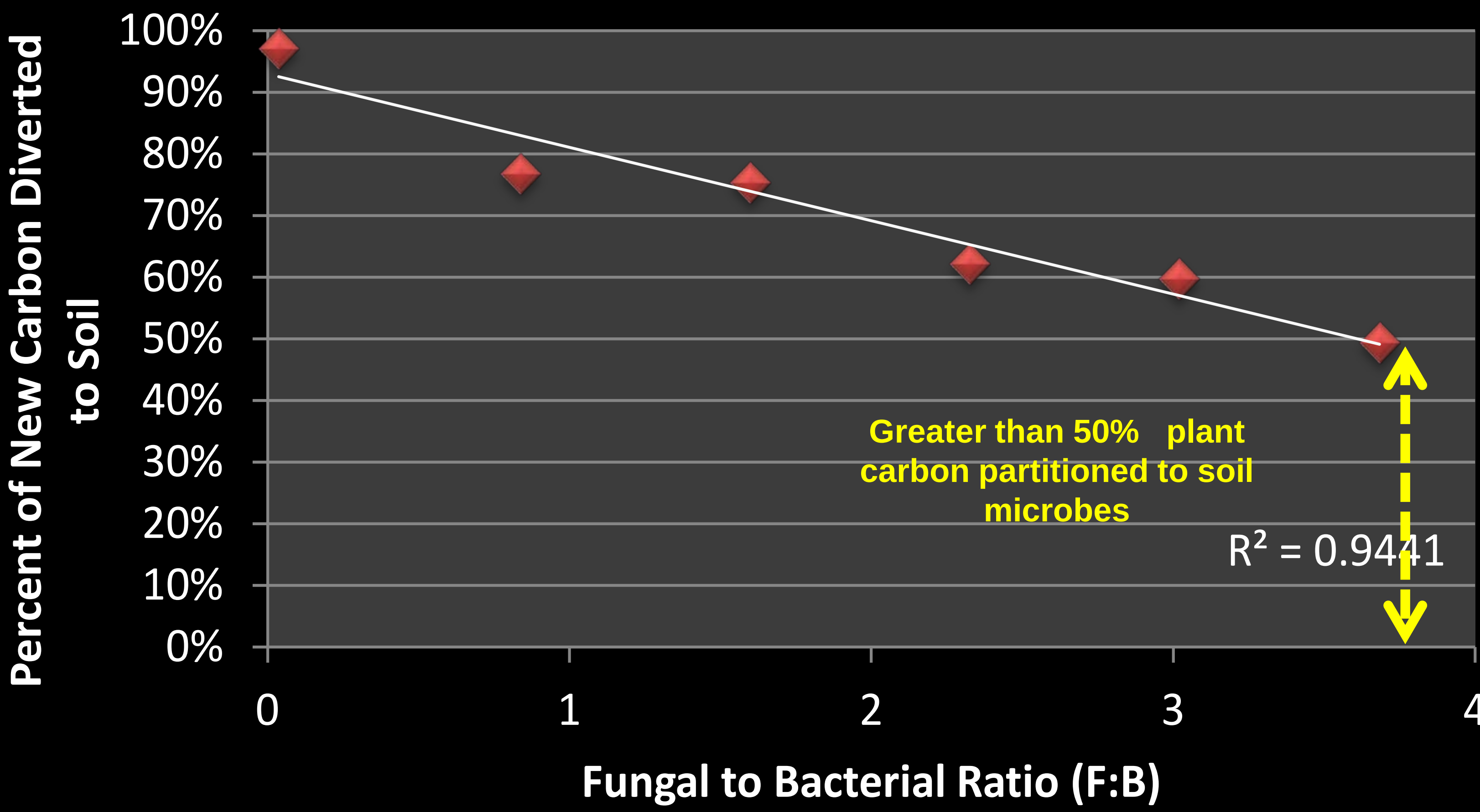
Exudate Based Soil Carbon



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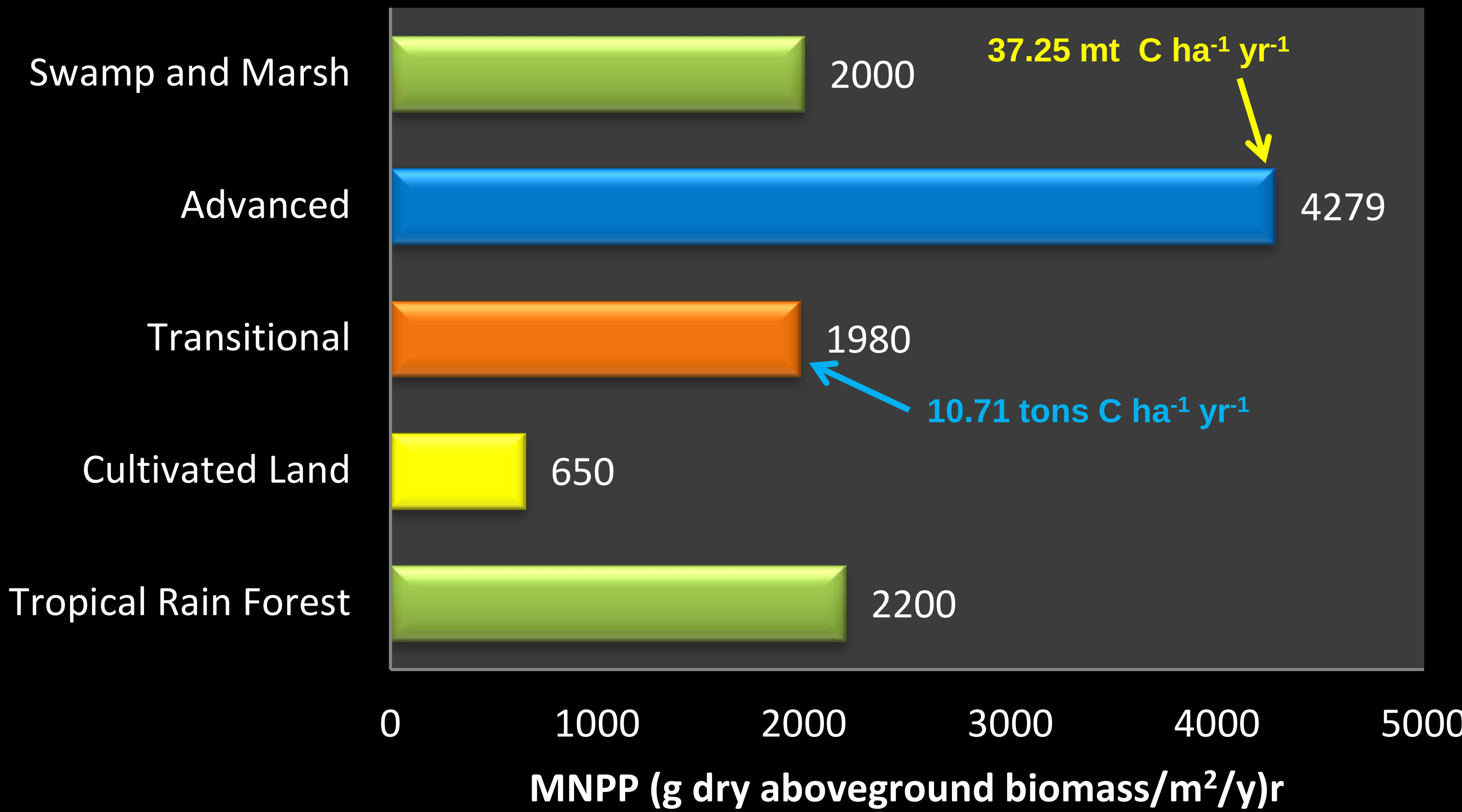
Higher Biomass Production



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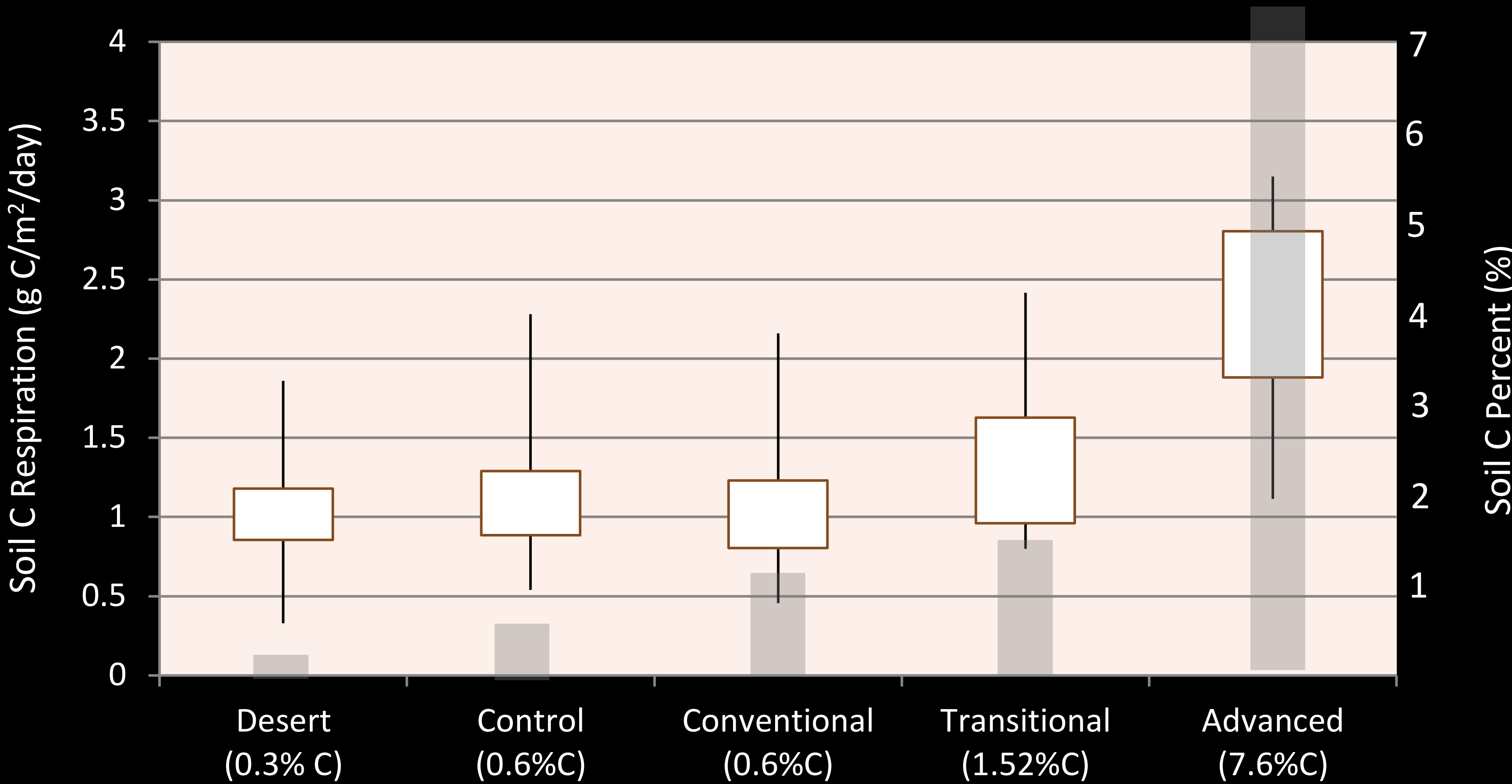
Reduced Soil Respiration



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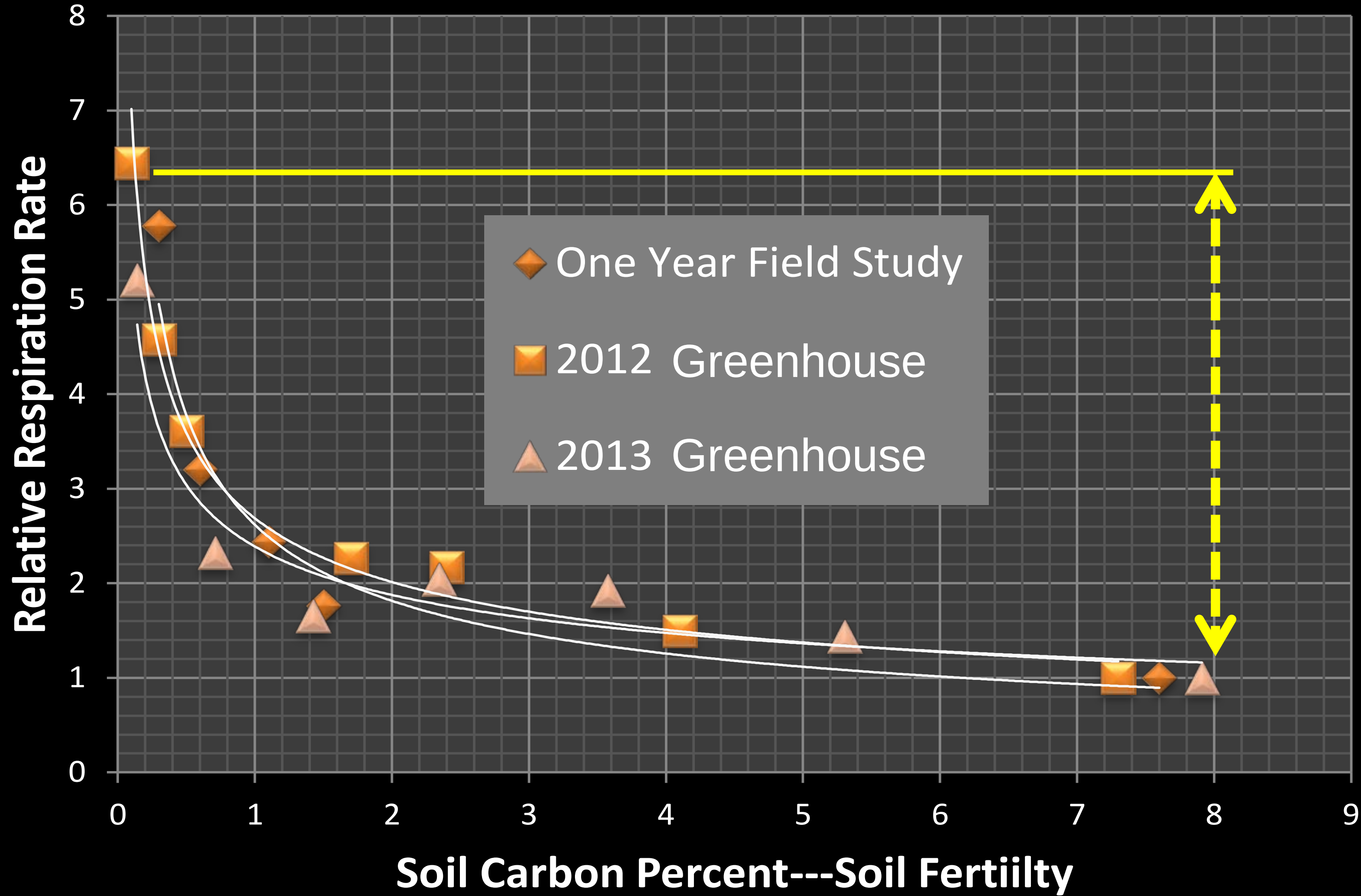
Reduced Soil Respiration



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Changes in Soil Nutrients Over a 20 Month "BEAM" Application Period

	Polynomial/GLM Model	R^2	% Increase/Reduction
Macro Nutrients			
Total Kjeldhal Nitrogen (TKN)	$y = 1.0585x^2 - 2.8141x + 658.59$	0.84	58.30%
Nitrate (NO3-N)	$y = 0.105x + 1.4887$	0.91	111.70%
Phosphorus (P)	$y = 0.2783x + 8.468$	0.46	64.70%
Potassium (K)	$y = 0.6847x + 29.027$	0.87	44.80%
Meso and Micro-nutrients			
Calcium	$y = 0.025x^2 - 0.2805x + 3.8998$	0.94	144.40%
Copper	$y = 0.0353x + 0.9988$	0.66	65%
Iron	$y = 2.297x$	0.72	800%
Magnesium	$y = 0.0697x + 0.458$	0.49	214.80%
Manganese	$y = 0.2006x^2 - 2.0596x + 4.4929$	0.97	900%
Zinc	$y = 0.0213x + 0.4654$	0.67	83.30%

5 sampling periods

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Practicing a Biologically Enhanced Agriculture Management (BEAM) Approach Offers:

- Faster and Greater Biomass Growth (>10 tons C/Hectare/year with potential to 37 tons C/Hectare/year).
- More efficient transfer of carbon from plant photosynthates to soil microbes as exudates (bypassing a plant signature carbon vehicle).
- Greater populations of microbial biomass plus a shift from plant signature to a longer duration fungal dominant soil carbon.
- Reduced soil respiration rates as soil fertility along with soil carbon increases.
- Increased soil fertility in macro-, meso- and micro-nutrient profiles.

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What Impact Does Our Current Agricultural Approach Have on the Environment?

- Each year, **agriculture emits** 10 to 12 percent of the total estimated GHG emissions, some **1.4 to 1.7 Gt C per year**. (Smith, et al. 2007, Bellarby, et al. 2008)
- Conversion from plough to no-till in 67 long term field experiments **captured 0.570 ± 0.140 tons C ha^{-1} yr^{-1}** (West 2002)

Current Viewpoint on Carbon Capture Capability of Agriculture

- Arable and permanent cropping systems can **capture** **0.2 t C ha^{-1} yr^{-1}** and pasture systems **0.1 t C ha^{-1} yr^{-1}** (Niggli 2009)
- Global SOC **capture** potential of 0.4-1.2 Pg C yr^{-1} or 5-15% of global fossil fuel emissions or about **0.7 tons C ha^{-1} yr^{-1}**.(Lal 2004)

BEAM Results

Using **BEAM approaches** for the previous 4.5 years on beginning soils (0.43% C increase/year) ISAR has averaged soil C increases

of **10.71 tons C ha^{-1} yr^{-1}**

This rate is from 20 to 50 times soil C capture rates observed by other agriculture management methods.

Part 2:
No-Regrets Carbon Capture in New Mexico

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EPA's Rule 111(d)

- Requires a ~30% reduction in electrical power plant CO_2 emissions beginning 2020 to 2050.
- Approximately 6 million tons CO_2/year reduction required in NM
- Individual States and Power Companies are responsible and liable for these reductions.
- The language in Rule 111(d) promotes implementation of Carbon Capture and Storage (CCS) technologies; however, the costs are high.

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Rule 111(d) Allows:

- Outside the fence solutions for atmospheric carbon reduction.
- Adoption of currently existing mechanisms being used for carbon reduction.
- Assistance from the U.S. Department of Agriculture for agricultural solutions towards carbon reduction.

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CAPEX Costs of CCS Pilot Power Plants

Kemper County Coal
Mississippi
$6.1 Billion
3 Mtpa
$81.33/ton CO_2
+ Financing (2.4 X Capex)
+Parasitic Load Costs ($24-40/t)
+O&M ($9.51/MWh)

SaskPower- Boundary Dam
$1.467 Billion
1 Mtpa
$58.68/ton CO_2
+ Financing (2.4 X Capex)
+Parasitic Load Costs ($24-40/t)
+O&M ($9.51/MWh)

Petra Nova-Texas
$6 Billion
3 Mtpa
$80.00/ton CO_2
+ Financing (2.4 X Capex)
+Parasitic Load Costs($24-40/t)
+O&M($9.51/MWh)

Estimated Upfront Costs of $180-$234/ton CO_2

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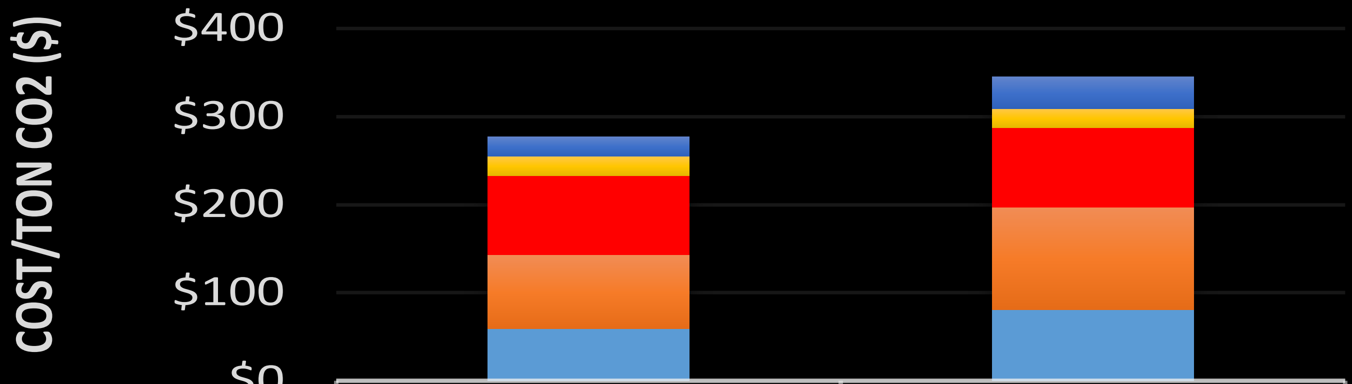
Costs of CCS



	Low	High
Transportation and Storage[1]	$22	$36
Overhead and Maintenance[1]	$22	$22
Parasitic Loads[2]	$90	$90
Financing	$84	$116
CAPEX[3]	$59	$81
Total Cost/Ton CO_2	$276	$345

1 United States Carbon Sequestration Council, Enhanced Oil Recovery & CCS, January 14, 2011.

2 The Costs of CO2 Capture, Transport and Storage, Post-demonstration CCS in the EU, www.zeroemissionsplatform.edu

3 http://www.carbonbrief.org/blog/2014/10/around-the-world-in-22-carbon-capture-projects/

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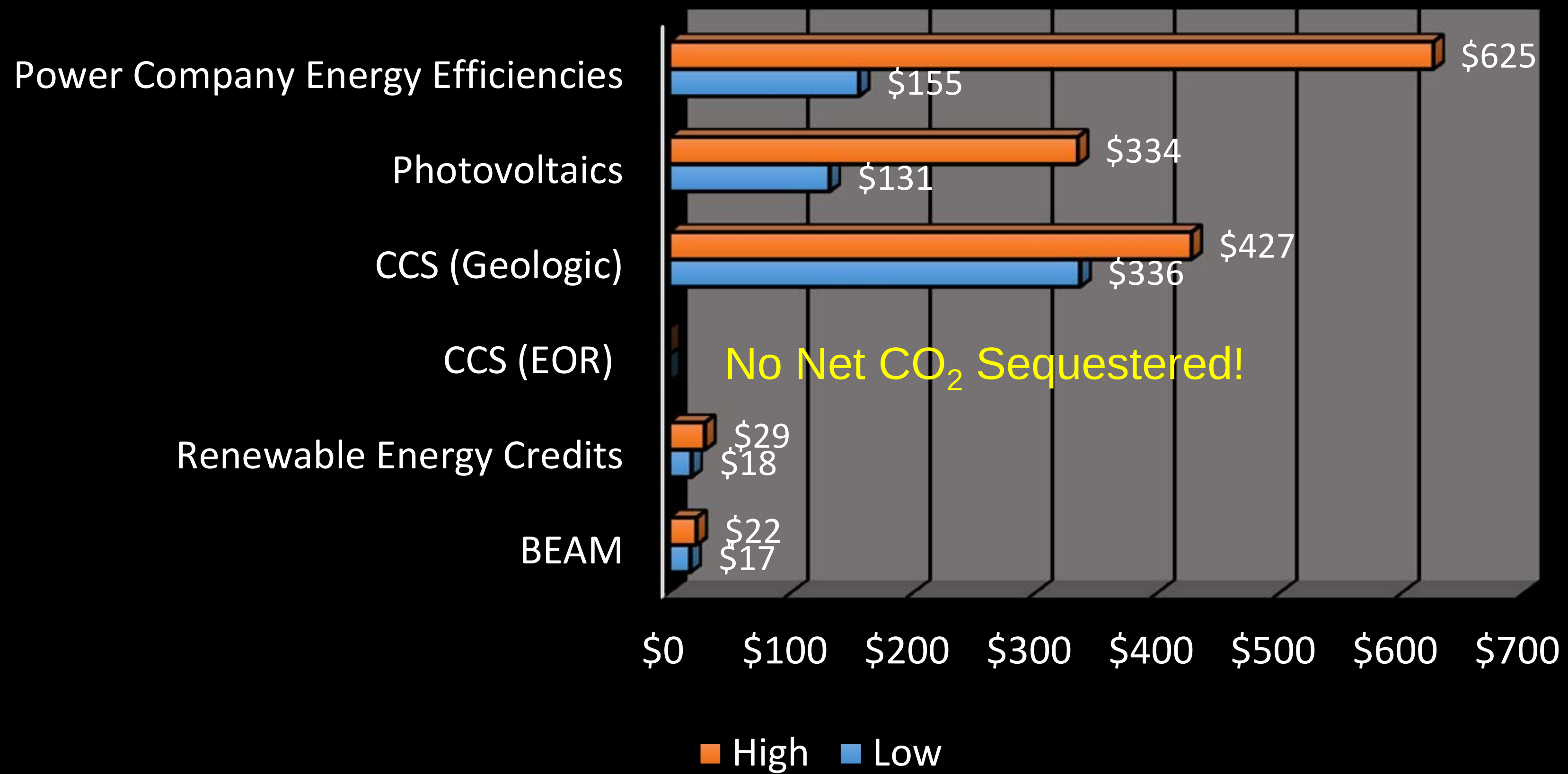
CO_2 Sequestration Costs



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CCS Liabilities

- Migration of injected CO2,
- Unintended leaks,
- Seismic activity,
- Acidification of aquifers driving up contaminant concentrations, and
- Long term monitoring
- <u>No Measurable Co-Benefits!</u>

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CCS Liabilities

- Civil Liabilities where third parties have suffered harm and seek compensation.
- Administrative liability where authorities are given powers to serve some form of enforcement or clean-up order.
- Emissions trading liability where an emissions trading regime provides a benefit for CO_2 storage and an accounting mechanisms is in place should there be a subsequent leakage.

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BEAM Liabilities and Co-Benefits

Few Liabilities and Multiple Co-Benefits

- Increases
  - Soil fertility.
  - Water Storage in soils
  - Plant water use efficiencies
  - Soil nutrient availability
- Reduces
  - Plowing and heavy tillage
  - Fertilizer Application
  - Downstream pollution of streams, rivers, lakes, aquifers, estuaries, oceans and coral reefs

Allows farmers to transition to a Sustainable and Ecosystem-friendly agricultural approach.

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Pair Soil Carbon Capture with a Voluntary Carbon Market in New Mexico

- Money goes directly to participating farmers.
- Improves New Mexico's farm and ranch communities.
- Money stays and recirculates in New Mexico.
- Promotes satellite businesses for seed production, farm equipment and other support industries.
- Brings in out-of–state revenue for energy produced in New Mexico being shipped to other states.

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Cost to Accomplish Reduction of the World's Annual GHG Emissions = $617 Billion/year

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Legislative Efforts Needed to Recognize Soil Carbon as a Carbon Offset

- States must submit their implementation plans for reducing carbon dioxide emissions by June 2016
- As of April 20th, Utah is the only state that has signed a law (Resolution 8) recognizing soil carbon increases in range, farm and forestry lands for carbon offsets in a carbon market
- New Mexico's Senator Sapien introduced a similar bill (SB630) in the 2015 Legislature and the action was postponed indefinitely.

Legal recognition of soil carbon in NM is necessary for industry participation in a carbon market!

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Employing BEAM on NM farmlands will help the State of New Mexico and energy producers comply with EPA 111(d) in an economically feasible way while greatly improving New Mexico's economy, agricultural lands and farmers livelihoods.

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Align your self with nature!

Tao Te Ching

Questions?

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