Preparing Biochar for Success in Soil
materials & methods for rapid results & optimum yields

Illinois Biochar Association
Friday, November 14, 2014

The 4 M’s
of Carbon-Smart Farming
with Biochar

David Yarrow
TERRA
The Earth Restoration & Regeneration Alliance
www.dyarrown.org/CarbonSmart
Seedling Trials
Saratoga Apple, Fall 2010
2000 assorted greens
8 types of biochar
0% - 5% - 10% - 20%

5 - 10% biochar → 25-50% greater growth

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Confronting Climate Change

PARADIGM SHIFT

1. Soil Tests
   annual increase in measured carbon, up to 9%
2. Mineral Ratios
   program to adjust major minerals & trace elements
3. Biochars
   minimum annual application: initial 1000 lbs./acre
4. Composts
   organic matter digestion & feeding program
5. Inoculants
   microbe inoculation & feeding for The Soil Food Web
6. Cover Crops
   continuous ground cover & minimum tillage
7. Rotations
   long-term, rapid rotations of crops & livestock
8. Marketing
   low carbon, eco-local distribution & sale

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Local farmers prize Terra Preta greater yields than adjacent soils sustained fertility in intensive use

Age 6000 years, east Andes foothills radio-carbon dating with charcoal

Terra Preta

“Dark Earth”

adjacent non-Terra Preta

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Any strategy to increase arable land, or improve yields on existing arable land, should be a global research priority.
Effect of bark biochar & fertilizer on plant growth & soil
south Sumatra, Yamato 2004
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Preparing Biochar for Success in Soil Farming

USDA Research
ARS, Beltsville Maryland

8 to 20 tons/acre
Hardwood charcoal
No compost or inoculant
Conventional agricultural dirt
Applied all at once
Continued chemical fertilizers

Biochar as Battery (electron capture)
Raw, fresh biochar is like battery with no electrons
Electrons cooked out with oxygen, hydrogen, nitrogen, sulfur, etc.
Primary Source of charge for the soil battery are Cations.
Results from First Year

First year test plots showed very encouraging results. The previous Fall (applications) had remarkable differences:

• Untreated soil was sticky and heavy.
• Composted animal manure was also sticky.
• Biochar (only) was slightly less gooey, soil clumped a little less.
• Biochar (plus) manure was perfectly friable, a garden fork slid easily into the soil, broke into beautiful seedbed with a twist of the wrist.

I broadcast edible beans, just to get something growing. All plots germinated about the same.

Problem keeping chickens out of biochar + compost plot; they loved to scratch it & ignored all other plots.

BEFORE

AFTER

FY 2010-12
FNC10-807
$3,893

farmer:
John Topic
St. Paul, MN
Preparation Biochar for Success in Soil
Carbon-Smart Farming

*Is biochar a nutrient?*

In soil, charcoal breaks down very slowly

- 100 Carbon remaining (%)
- 10 Centuries?
- 50 Millennia?
- 100 Biochar isn’t consumed by soil life
- Fresh from a burner, biochar is sterile, with no biological activity – no microbes – and hydrophobic – it repels water

Biochar isn’t affected by weathering, oxidation & digestion

- Retards plant growth 1 or 2 years
- Fertilizers must be added with charcoal

Biochar supplies three important soil services:

- **Sponge**: Absorb, hold & conserve soil water
- **Storehouse**: Adsorb nutrient ions (C.E.C. & A.E.C.)
- **Substrate**: Habitat and housing for microbes

Adding only raw charcoal to soil retards plant growth 1 or 2 years

Fertilizers must be added with charcoal

Dr. Johannes Lehman
## Rate Calculator

(1 gallon = 1 pound)  (6-inch deep tillage)  

<table>
<thead>
<tr>
<th>gal/100 sq.ft.</th>
<th>tons/acre</th>
<th>% of soil</th>
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</thead>
<tbody>
<tr>
<td>30</td>
<td>26.1</td>
<td>8.0</td>
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<tr>
<td>20</td>
<td>17.1</td>
<td>5.3</td>
</tr>
<tr>
<td>10</td>
<td>8.7</td>
<td>2.7</td>
</tr>
<tr>
<td>5</td>
<td>4.3</td>
<td>1.3</td>
</tr>
<tr>
<td>2</td>
<td>1.7</td>
<td>.5</td>
</tr>
</tbody>
</table>

2% minimum soil Carbon  
4 - 5% certified organic  
10% optimum = 5% biochar + 5% compost

Apply 5 gal/100 sq.ft./year (1%) for 5 years  
Apply 2 gal/100 sq.ft./year (.5%) for 10 years  
Apply at least twice each year: fall & spring

### BIOSCHAR APPLICATION DATA

<table>
<thead>
<tr>
<th>WEIGHT</th>
<th>0.80 per quart</th>
<th>per pound</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOLUME</td>
<td>5.00 per test bed</td>
<td>gallons</td>
</tr>
<tr>
<td>AREA</td>
<td>100 per test bed</td>
<td>sq. foot</td>
</tr>
<tr>
<td>TILLAGE</td>
<td>6 depth</td>
<td>inches</td>
</tr>
<tr>
<td>ACRES</td>
<td>1 field total</td>
<td>acres</td>
</tr>
<tr>
<td>COST</td>
<td>$0.50 per pound</td>
<td></td>
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### APPLICATION RATE CALCULATOR

<table>
<thead>
<tr>
<th>volume</th>
<th>weight</th>
<th>area</th>
<th>$/pound</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0 gallons</td>
<td>16 pounds</td>
<td>100 sq. feet</td>
<td>$8.00</td>
</tr>
<tr>
<td>1 cup</td>
<td>.20 pound</td>
<td>1.25 sq. feet</td>
<td>$0.10</td>
</tr>
<tr>
<td>1 quart</td>
<td>.80 pound</td>
<td>5 sq. feet</td>
<td>$0.40</td>
</tr>
<tr>
<td>1 gallon</td>
<td>3.2 pounds</td>
<td>20 sq. feet</td>
<td>$1.60</td>
</tr>
<tr>
<td>1.25 quart</td>
<td>1 pound</td>
<td>6.25 sq. feet</td>
<td>$0.50</td>
</tr>
<tr>
<td>.05 gallon</td>
<td>.16 pound</td>
<td>1 sq. foot</td>
<td>$0.08</td>
</tr>
<tr>
<td>.80 cup</td>
<td>2.6 ounces</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.00 gallon</td>
<td>16.00 pound</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80.00 cup</td>
<td>256.0 ounces</td>
<td>100 sq. feet</td>
<td>$8.00</td>
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<tr>
<td>2178 gallons</td>
<td>6970 pounds</td>
<td>1 acre</td>
<td>$3,484.80</td>
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1,337 % char  
3.5 tons

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How do we assure success and rapid results?

The 4 M’s
four steps to prepare char for soil

Moisten
Fresh char is bone dry and sterile
Hydrophobic, due to tar & resin residues
Excess moisture is soggy, heavy, anaerobic

Micronize
Crush, grind, screen to maximize surface area
Size diversity: rice grain, down to dust
Water-soluble, very low-weight carbons

Mineralize
Huge internal ion & electron adsorption capacity
Major Cations (Ca, Mg, K) & Anions (N, P, S)
Charge char with sea minerals (trace elements)

Microbial Inoculation
Assure colonization by microbial diversity
Simplest method: blend with bioactive compost
Man-made culture: BD preps, EM, SumaGrow, SCD BioAg, Trichoderma, Mycorrhizae...
Preparing Biochar for Success in Soil

Moisten

Absorption

Micropore Sponge

moisture eliminates dust & wind-blown losses
moist char easier to handle & reduces fire risk
water encourages microbial colonization
char is lightweight because is empty inside
immense internal storage capacity
soak up and hold water to keep soil wetter
gradual release & return of water
keeps microbiology active in drought

Tar & Resin Residues

new char is hydrophobic from oily hydrocarbons
VOCs & PAHs: multi-ring carbons eaten by microbes
biochar preparation must remove oily residues

PHOTO: Bob Cirino, University of Delaware
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"goldilocks"
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Micronize

Reduce Particle Size: half-inch down to dust
Increase Surface Area: square inches vs. square miles
External vs. Internal: thousands times more internal surfaces
Increase Adsorption Potential: remarkable ion capture capacity

Fly Ash “Biochar”
60% carbon incinerator ash

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Mineralize

Energy Flow

Adsorption

\[ \text{Adsorption} = \text{electric attraction} \]

Cations (+)

Anions (-)

Hydronium ions (H\(^+\), H\(_3\)O\(^+\))

Electrons

Electrolytes

Infrared Radiation

Cook feedstock with extra minerals

limestone, manure, clay, ash, dirt

Minerals burned into micropore matrix

Increases ion capture capacity (CEC & AEC)

Creates additional Adsorption sites

Improves soil performance of biochar

Cations

Sodium, Potassium, Calcium, Magnesium

most Trace Elements

Anions

Phosphorus, Sulfur, Chlorine

Nitrogen, Boron, Iodine
Preparing Biochar for Success in Soil

Microbe Inoculation

**Microbes**
Bacteria, Fungi, archaea, actinomycetes, protozoa, algae, mites, nematodes.....

**Living Cultures** - not inert dirt
- special handing & conditions
- temperature, air, moisture, nutrients

Inoculation
Incubation
Colonization
Propagation
Population explosions

**Biodiversity of species & functions**
- Nitrogen-fixing bacteria
- Nitrogen-cycle bacteria
- Phosphorus-dissolving fungi
- Lactobacillus
- Phototrophic bacteria
- Yeasts

The Underground Economy
carbon trading

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TerraChar’ge Kits
TerraChar’ge your Soil Battery

contains

5 gallons Terra Char™ biochar
1 pint Magma Dust rock powder
1 cup SEA-90® sea minerals
3 oz. SumaGrow™ inoculant

to which you add

2 gallons structured water
5 gallons manure compost

to cover a
100 sq. foot test plot

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Conclusions

1) develop blended products & protocols for various markets
2) establish uniform product standards for biochar industry
3) develop blended products for varied markets
4) develop blended processes & equipment for farm-scale bulk batches
5) step up to a higher mission:
   Address climate change?
   Original purpose of Terra Preta: feeding the community
   Create Fertile Soil & Arable Farmland
   “Neuvo Terra Preta”
   Not merely sequester carbon:
   Regenerate soil Biology
   Keystone Component of planet’s atmosphere generation & composition
“Despite our artistic pretensions, sophistication and accomplishments, humans owe our existence to a six-inch layer of topsoil, and the fact that it rains.”

Jeff Wallin, CEO
The Biochar Company
Berwyn, Pennsylvania

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