BIOCHAR

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Why Biochar
What is the biochar?

- Biochar is a stable form of charcoal produced from heating (pyrolysis) natural organic materials (crop and other waste, woodchips, manure) in a high temperature and low oxygen.

- Biochar is obtained from the pyrolysis or thermal decomposition (350-700 °C) of surplus and readily accessible biomass which has been proved to be an effective means in immobilization of organic contaminants in soil.
Pyrolysis (500 °C)
FIGURE 1: PYROLYSIS OF BIOMASS

- Biomass: manure, organic wastes, bioenergy crops (grasses, willows), crop residues
- Pyrolysis: Biofuel - bio-oil, hydrogen
- Transport, energy, coproducts (oil, cosmetics), industry
- Residual heat
- Optionally, N₂, NOₓ, SOₓ, CO₂ can be added to increase C sink and nutrient content
- Returned to soil as biochar

(C) 100% - Biomass
(C) 50% - Biofuel
(C) 50% - Returned to soil as biochar
Samples of Biochar Production units
## Preliminary Studies to Compare Chars from Different Thermal Processes

<table>
<thead>
<tr>
<th>Process</th>
<th>Air filtration</th>
<th>Heat Source</th>
<th>Temperature</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow pyrolysis</td>
<td>None</td>
<td>External</td>
<td>500 °C</td>
<td>30 minutes</td>
</tr>
<tr>
<td>Fast pyrolysis</td>
<td>None</td>
<td>External</td>
<td>500 °C</td>
<td>Few seconds</td>
</tr>
<tr>
<td>Gasification</td>
<td>20% equivalence ratio</td>
<td>Combustion of infiltrated air</td>
<td>750 °C</td>
<td>Few minutes</td>
</tr>
</tbody>
</table>
Typical product yields (dry basis) for different modes of pyrolysis

<table>
<thead>
<tr>
<th>Mode</th>
<th>Conditions</th>
<th>Liquid</th>
<th>Char</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast</td>
<td>Moderate temperature $\sim 500^\circ$C&lt;br&gt;short vapor residence time $\sim 1\text{ s}$</td>
<td>75%</td>
<td>12%</td>
<td>13%</td>
</tr>
<tr>
<td>Moderate</td>
<td>moderate temperature $\sim 500^\circ$C&lt;br&gt;moderate vapor residence time $\sim 10-20\text{ s}$</td>
<td>50%</td>
<td>20%</td>
<td>30%</td>
</tr>
<tr>
<td>Slow</td>
<td>moderate temperature $\sim 500^\circ$C&lt;br&gt;very long vapor residence time $\sim 5-30 \text{ min}$</td>
<td>30%</td>
<td>35%</td>
<td>35%</td>
</tr>
<tr>
<td>Gasification</td>
<td>high temperature $&gt; 750^\circ$C&lt;br&gt;moderate vapor residence time $\sim 10-20\text{ s}$</td>
<td>5%</td>
<td>10%</td>
<td>85%</td>
</tr>
</tbody>
</table>
Importance of Biochar

- Reduced NH$_3$ loss by 36 to 63% with surface incubation and by 43 to 60% with incorporated incubation.

- There are many new studies have shown that biochar is capable of absorbing metals such as lead, and organics that contaminate soils which harm people, plants and animals.

- This is because biochar as an additive to a soil can be expected to improve its overall absorption capacity impacting toxicity because there is a decrease in transportability and depletion of the presence of metals.
Other benefits of adding biochar to soils

- Increase C sequestration
- Increase crop yields
- Increase nutrient retention
- Increase mineral nutrition
- Increase mycorrhizal fungal activity
- Reduce acidity
- Reduce irrigation requirement
- Reduce leaching loss of chemicals
  - A ‘supersorbent’ to adsorb organic contaminants in soils
Influence of biochar (SC and BC) amendment on rice productivity
Biochar might be used as an ideal amendment for retarding vertical movement of NH$_4^+$-N and minimizing the nitrogen loss through leaching.

Biochar amendment in paddy field is able to significantly increase rice productivity and reduce N fertilizer input. Thus, it may prevent N fertilizer run-off from paddy field.

Rice straw biochar-based slow released fertilizer can not only increase rice productivity, but also reduce N fertilizer run-off from paddy field.

Rice straw biochar with proper properties might be an ideal material for improving low fertility paddy field.
Biochar and roots
Application of Biochar at rate 2-4 ton/ac

Test for crop yield, leaching of nutrients, nitrogen cycling, emissions of CH$_4$ & N$_2$O

Preliminary results indicate reduction in emissions of N$_2$O with applications of 10t/ha green-waste biochar

High sulphate soils

High N$_2$O with normal cultivation

No agronomic benefit found to char

Trails continuing with reduced N
Biochar field site in sugarcane, Tweed Valley NSW Australia.

Biochar properties:

<table>
<thead>
<tr>
<th>pH</th>
<th>%C</th>
<th>%N</th>
<th>Sol-C</th>
<th>Sol-N</th>
<th>A%</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.0</td>
<td>50</td>
<td>1.4</td>
<td>3.74</td>
<td>0.75</td>
<td>0.364</td>
</tr>
<tr>
<td>10.2</td>
<td>48</td>
<td>1.6</td>
<td>4.20</td>
<td>0.69</td>
<td>0.361</td>
</tr>
<tr>
<td>9.7</td>
<td>52</td>
<td>1.6</td>
<td>3.36</td>
<td>0.83</td>
<td>0.366</td>
</tr>
</tbody>
</table>

N fertiliser and animal wastes plant N

Increased soil aeration from biochar addition reduces denitrification and increases sink capacity for CH₄.

Biochar adds electron acceptors and increases soils’ redox potential to decrease N₂O source capacity of soil.

Biochar addition induces microbial immobilisation of available N in soil, thereby decreasing N₂O source capacity of soil.

Increased pH from biochar addition drives N₂ formation from N₂O.

Green waste biochar plot (5-15cm profile)
Mechanisms and technology development for N run-off control in agriculture
Impact of manure biochar on N$_2$O emissions

N$_2$O flux, µg N$_2$O -N m$^{-2}$ hr$^{-1}$

Biochar g kg$^{-1}$

Control
Manure

0                   5                  10                 20
Biochar addition had significant impact on soil bulk density.
Some potential “adverse” effects of biochar that strongly retain organic chemicals

- Accumulation of organic contaminants in soils because of less accessibility by decomposers
- Biochar-assisted offsite migration of organic contaminants through surface runoff
- Reduction in efficacy of pesticides
  - May result in higher herbicide application rates
Conclusions

• Biochar production holds great promise for bioenergy, a value-added manure product, and a soil conditioner.

• Biochar comes with the appeal of being a low cost and low-environmental-impact strategy for remediation of common and health concerning environmental pollutants.

• With the studying, monitoring, and understanding of biochar, real world application to benefit environmental concerns will be in the near future.
THANKS