Effects of Different Charcoal Types on Plant Growth and Soil Properties
Over Two Consecutive Plantings.

Yudai Sumiyoshi*, J. L. Deenik, and A. Diarra.
Department of Tropical Plant and Soil Sciences. CTAHR. University of Hawaii at Manoa

Introduction
- Potential benefits of charcoal as a soil amendment include:
  - Effective reuse of by-product from modern pyrolysis methods for biofuel production
  - Alternative to slash and burn agricultural practice
  - Long term sequestration of carbon in soil
  - Enhanced soil fertility and crop productivity (i.e., Terra Preta of Amazonia)
- Previous studies have shown that high volatile matter (VM) charcoals combined with fertilizer induced nitrogen (N) immobilization (N tied up by microbes) causing poor plant growth, whereas low VM charcoal combined with fertilizers increased plant growth compared with fertilized control (Deenik et al., 2009).

Objective and Hypotheses
- Objective
  To investigate the influence of time on the performance of charcoal as a soil amendment
- Hypotheses
  - The negative effect of high VM charcoal on plant growth will disappear due to the exhaustion of the labile carbon pool.
  - The positive effect of low VM charcoal will persist upon second planting

Methodology
- Soil: infertile Ultisol (very fine, ferruginous, karstic podzol)
- Twelve treatments with 4 replicates arranged in a randomized complete block design
- Exp1: Corn was planted on Oct. 23 and harvested on Nov. 26, 2008
- Exp2: Corn was planted on Feb 17th and harvest on March 20th, 2009
- Data collection and Laboratory Analyses
  - Fresh and dried above ground biomass were measured at harvest
  - Soils were analyzed at the Agricultural Diagnostic Service Center (ADSC) at the University of Hawaii, Manoa, for pH, available cations and phosphorus.
- Statistical Analysis
  - Treatment effects were analyzed using analysis of variance (ANOVA) and means were compared using Fisher’s protected LSD (P=0.05)

Results

1. Treatment Effects on Plant Growth

   First Planting
   - Low VM charcoal had significantly higher corn biomass production compared to fertilizer control
   - High VM charcoal had significantly lower corn biomass production compared to fertilizer control

   Second Planting
   - There was no significant effect of high or low VM charcoals on the corn biomass production

2. Treatment Effects on Soil Properties

   First Planting
   - Low VM charcoal significantly improved plant growth due to improved K nutrition.
   - Gasification charcoal improved plant growth due to a liming effect.
   - High VM charcoal had a negative effect on plant growth due to immobilization of N (McClellan et al., 2009).

   Second Planting
   - Positive effect of low VM charcoals (corn cob and gasification) on plant growth did not persist with time.
   - These findings are puzzling, and we are currently analyzing soil and plant tissues.

   Negative effect of high VM charcoal on plant growth did not persist in the second planting indicating that the labile carbon pool fueling N immobilization was exhausted (McClellan et al., 2009).

Discussion
- VM content of charcoals influenced plant growth and soil properties in the short term.
- However, no long term effect of VM content on plant growth and soil properties was observed.
- Further research is needed to investigate the interaction of charcoal type, soil and time and its effect on plant growth and soil properties at the field scale.

Conclusions
- VM content of charcoals influenced plant growth and soil properties in the short term.
- However, no long term effect of VM content on plant growth and soil properties was observed.
- Further research is needed to investigate the interaction of charcoal type, soil and time and its effect on plant growth and soil properties at the field scale.

References

Acknowledgements
Many thanks to Dr. Michael J. Antal (Hawaii Natural Energy Institute) for supplying charcoal and conducting proximate analysis for the study. This study was made possible by support provided by Department of Tropical Plants and Soil Science at University of Hawaii at Manoa.

For additional information, contact Yudai Sumiyoshi:
3180 Maile Way St. John 102, Honolulu, Hawaii 96822
E-mail: yudais@hawaii.edu Phone: (808)956-2636

Table 1. Types of charcoal used in the experiments and selected chemical properties.

<table>
<thead>
<tr>
<th>Proximate Analysis (%)</th>
<th>HVM</th>
<th>LVM</th>
<th>Cob</th>
<th>Kiawe</th>
<th>Binchothan</th>
<th>Gasification (LaucSemso)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash</td>
<td>1.67</td>
<td>5.19</td>
<td>1.17</td>
<td>1.67</td>
<td>18.1</td>
<td></td>
</tr>
<tr>
<td>Fixed Carbon</td>
<td>35.1</td>
<td>87.1</td>
<td>75</td>
<td>96.1</td>
<td>79.7</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Treatments tested in the two greenhouse experiments.

| 1 | Control (Soil Alone) | 7 | Control + lime + NPK + Micronutrients |
| 2 | Control + HVM charcoal + NPK | 8 | Control + HVM charcoal + NPK |
| 3 | Control + LVM charcoal + NPK | 9 | Control + LVM charcoal + NPK |
| 4 | Control + Kiawe + NPK | 10 | Control + Kiawe + NPK |
| 5 | Control + Binchothane + NPK | 11 | Control + Binchothane + NPK |
| 6 | Control + Gasification + NPK | 12 | Control + Gasification + NPK |


Figure 2. Corn dry biomass production in first planting

Figure 3. Corn dry biomass production in second planting

Figure 4. Corn growth before harvest in first planting

Figure 5. Corn growth before harvest in second planting

Figure 6. pH measured after first harvest

Figure 7. Extractable soil aluminum after first harvest

Figure 8. Extractable soil potassium after first harvest