Biochar in Hawaii

Josiah Hunt

Landscape Ecology

Hilo, Hawaii

http://www.landscapeecology-hawaii.com/

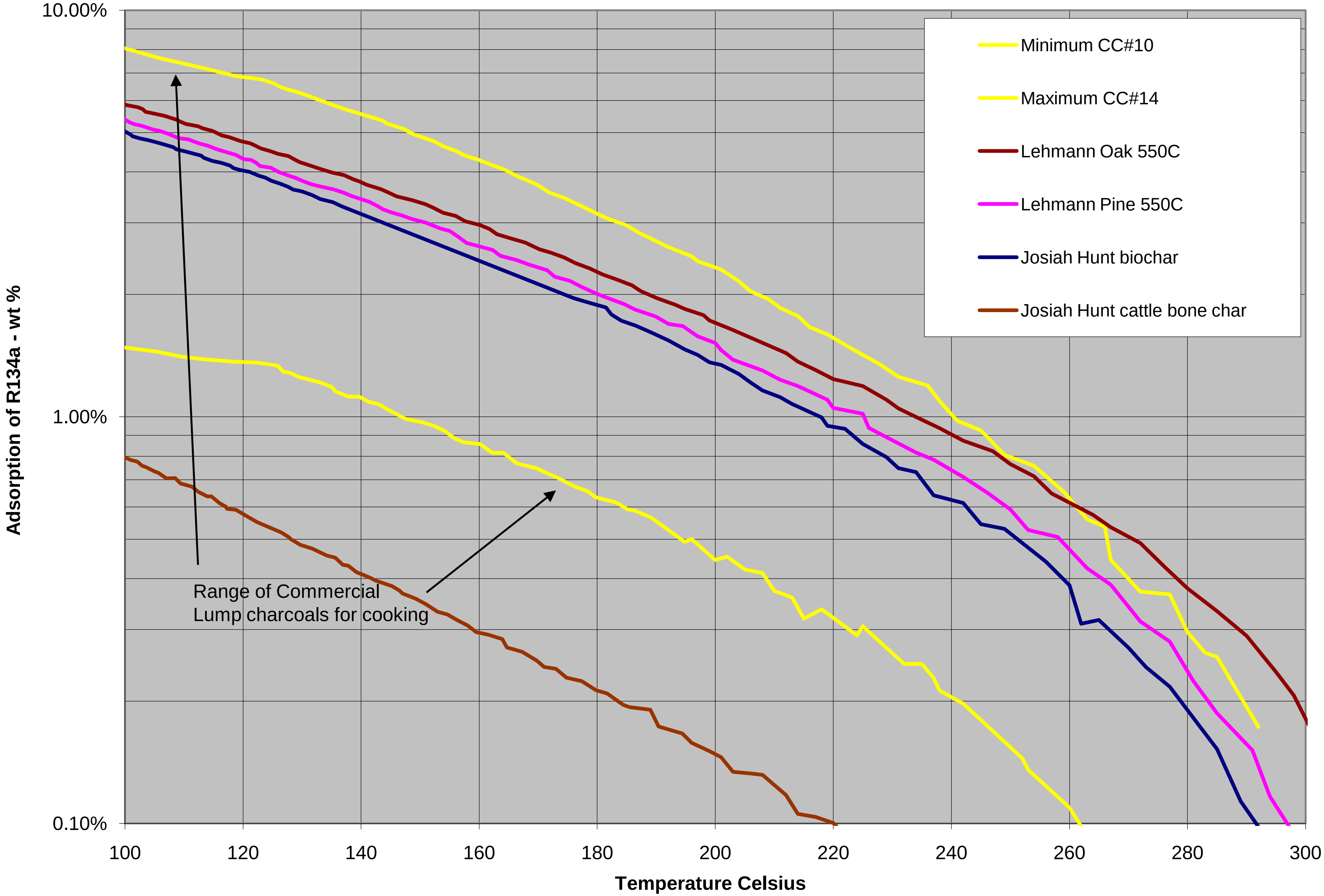
August 6, 2010

1/2" minus hardwood biochar

½” minus hardwood biochar

- All biochar used in these photos was produced by Landscape Ecology in an open pit method explained in greater detail at Biochar Hawaii’s website: http://groups.google.com/group/biochar-hawaii?hl=en
- The feedstock is mixed tropical hardwoods gathered as scrap from local sawmills.
- Some analysis are shown in the following pages.

*Adsorption analysis courtesy of Hugh Mclaughlin



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SUBMITTED FOR:
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BOWLING GREEN, Missouri 63334

SOIL REPORT

Sample:	BC 2		pH	8.50		
ACRES:			PHOSPHORUS (P)	220	lbs/a	
CEC:	34.03	me	SULFUR (SO4-S)	531	lbs/a	
SOIL TEXTURE:	Clay		CALCIUM (Ca)	8016	lbs/a	
ORGANIC MATTER:	48.00	%	MAGNESIUM (Mg)	1710	lbs/a	
			POTASSIUM (K)	7692	lbs/a	
Neut. A:	0.00		SODIUM (Na)		lbs/a	
			BORON (B)	2.43	ppm	
			IRON (Fe)	4602.00	ppm	
			MANGANESE (Mn)	105.00	ppm	
			COPPER (Cu)	3.30	ppm	
			ZINC (Zn)	28.80	ppm	
					ppm	

RATING

BASE SATURATION PERCENT	
CALCIUM:	58.90
MAGNESIUM:	20.94
POTASSIUM:	28.98

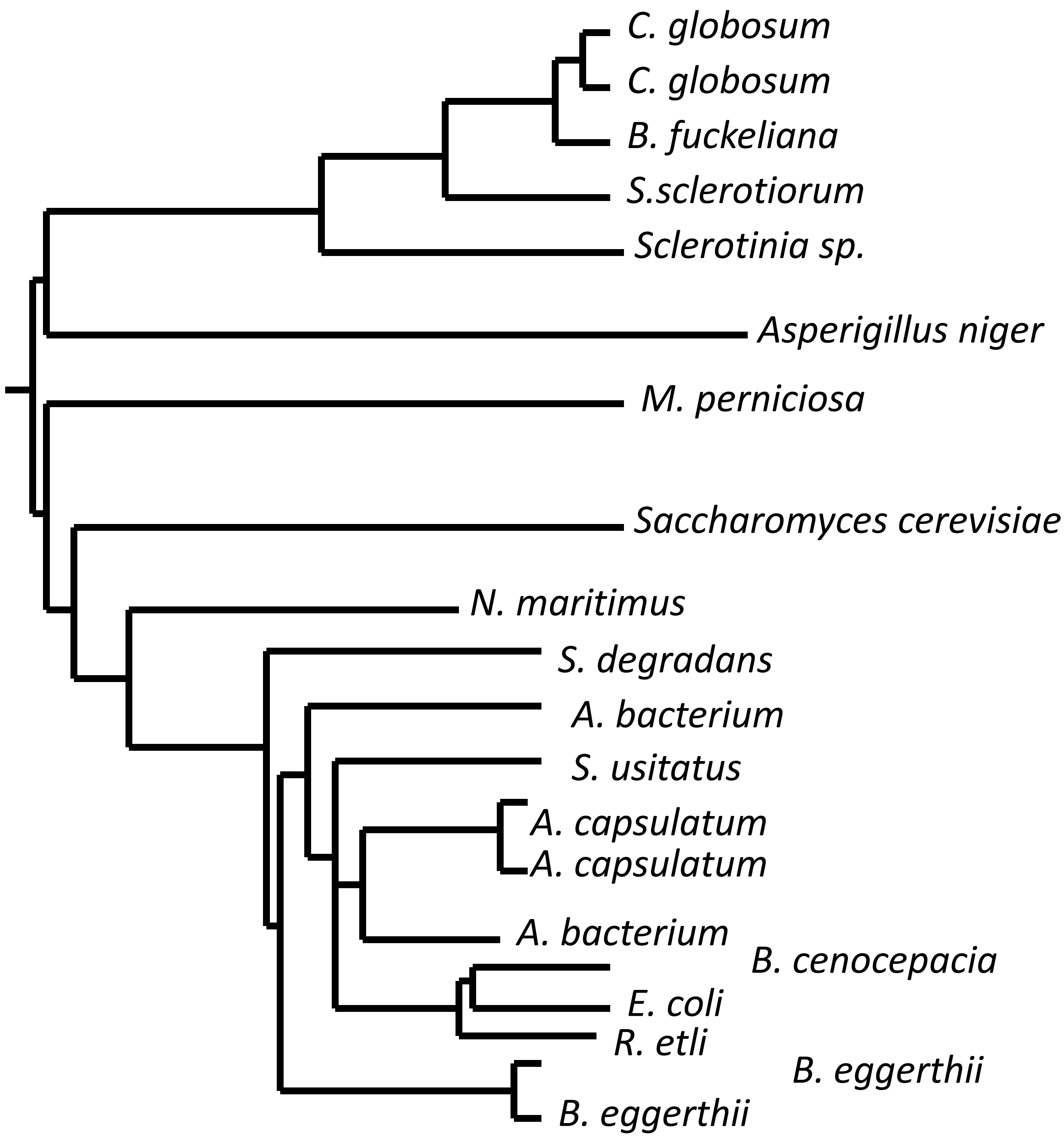
SOIL FERTILITY RECOMMENDATIONS

CROPPING OPTIONS		YIELD GOAL	NITROGEN N	PHOSPHATE P2O5	POTASH K2O	SULFUR S	BORON B	IRON Fe	MANGANESE Mn	COPPER Cu	ZINC Zn
			SUGGESTED TREATMENT				POUNDS / ACRE				
GARDEN CROP	ESTAB	1	30	0	0	0	0	0	0	0	0

Biochar compost

Biochar Compost

- Composted with coconut and guava chips and horse manure. Allowed 4 months to mature. Maintained a temperature of 135^{o}F on average. Approximately 40% biochar by volume when applied. Biochar was never mechanically ground. Too wide a C:N was found in compost as seen in initial trials. C:N ratio was corrected for later other trials.
- Bioassay done by Professor Jonathan Awaya of UHH shown in next slides.
- Nutrient analysis of biochar compost available by request.



C. globosum
C. globosum
B. fuckeliana
S.sclerotiorum
Sclerotinia sp.
Asperigillus niger
M. perniciosa
Saccharomyces cerevisiae
N. maritimus
S. degradans
A. bacterium
S. usitatus
A. capsulatum
A. capsulatum
A. bacterium
B. cenocepacia
E. coli
R. etli
B. eggerthii
B. eggerthii

Isolate	Sequence length (bp)	Top match (accession number)	Nucleotide Identity (%)
JA1	805	Saccharophagus degradans 2-40 (AF055269	88
JA2	801	Acidobacteria bacterium (CP000360.1)	90
JA3	844	Acidobacteria bacterium (CP000360.1)	92
JA4	806	Acidobacterium capsulatum (NC012483)	89
JA5	864	Solibacter usitatus (NC008536)	89
JA6	708	Pseudomonas putida	88
JA7	780	Bacteriodes eggerthii (NZABV001000045	88
JA8	781	Bacteriodes eggerthii (NZABV001000045)	88
JA9	809	Acidobacterium capsulatum (NC012483)	89
JA10	784	Nitrosopumilus maritimus (NC010085)	90
JA11	804	Sclerotinia sclerotiorum (665079)	94
JA12	783	Botryotinia fuckeliana (AM491888)	92
JA13	776	Sclerotinia sclerotiorum (665079)	94
JA15	743	Chaetomium globsum (NT166001)	92
JA16	785	Chaetomium globsum (NT166001)	92
JA17	783	Moniliophthora perniciosa (NW002487063)	89

Table 1. BLAST analysis of isolates on the basis of partial 16s rDNA and 18s rDNA gene sequences.

Figure 1. Neighbor-joining tree of 16s and 18s ribosomal genes from bacteria and fungi.

DNA isolation and sequencing

Total microbial DNA was extracted from biochar microsample by molecular procedures for sediment (Mol Bio Soil DNA extraction Kit). The bacterial 16s rDNA gene and fungal 18s rDNA were amplified from these extracts using universal 16 and 18s DNA primers that amplified partial ribosomal genes. The amplified PCR products were cloned in to pGEM –T Easy vector system (Promega) and ligated overnight at 4°C. Successful transformants were screened through restriction digestion (EcoRI) and 10 plasmids for each bacterial and fungal PCR products were sequenced with M-13 (20) sequencing primers. Sequences were analyzed through JGI's Integrated Microbial Genome Database.

" I expected a lot of difficulties in extracting microbial DNA from the biochar. However, I encountered NO problems extracting high concentration and good quality total DNA using standard genomic DNA extraction from sediment. There seems to be a lot of diverse microbes as well."

Root ball with biochar: Not much for comparison but beautiful none the less. This plant was pulled from the edge of our biochar vermicompost bin. The biochar was never ground up so a size reference would have been nice. We estimate that the large square chunk in the foreground is about 3/4".

Biochar Trials

In 2009 Landscape Ecology was awarded a grant to produce biochar amended compost and observe plant growth responses. Instead of conducting the growth trials ourselves we donated the material to a series of local Ag businesses to conduct in their systems. Fertilizer use and such vary with the different systems. There are still more results coming in and a few we have yet to follow up on being that many of the recipients were late to apply the material and are just now getting results. We will have several more in coming weeks including palms in nursery, wetland (flooded field) taro, and more of the tomato/cucumber series.

Conditions
Corn - My Backyard

- Plants – Corn
- Soil – Naturally occurring black cinder mixed with Histosol subsoil.
- Location - Kapoho
- Application rate – 2 gallons biochar (with or without amendments) for approximately 12sq.ft. tilled in 6-8”.
- Biochar – ½ minus
- Fertilizers - stated
- Growing Period - 4 weeks
- Yield – NA
- Note – Plants were never watered and rain was low. Goal was not to harvest but to observe relative growth.

Clockwise from top right: 0 biochar, biochar with wheat mill run, plain biochar, biochar with fish hydrolysate

Clockwise from top right: 0 biochar, biochar with wheat mill run, plain biochar, biochar with fish hydrolysate.

0% biochar

2 gallons biochar

2 gallons biochar

2 gallons biochar
+ 2 gallons inoculated
wheat mill run

2 gallons biochar

2 gallons biochar
+ 1/4 gal fish hydrolysate

Corn at Loeffler Farms

- Plants - Corn
- Soil – Andisol
- Location – Pepe'ekeo
- Application rate – from foreground; ¾", ½", ¼". Tilled with a rotary hoe.
- Biochar – Biochar compost (un-amended)
- Fertilizers - ?
- Growing Period - stated
- Yield - ?
- Notes – This was the first test in the biochar compost series. I was really excited at first then devastated when N deficiencies (due to wide C:N ratio in compost) were seen in small pot tests then confirmed in the field. Later tests where N deficiencies were accounted for by ensuring plenty N in both control and biochar all showed positive results. There will be follow up on this field in the coming months.

Biochar compost application at Loeffler Farms in Pepe’ekeo

Loefflers corn at a couple of weeks

Loefflers corn at several weeks

Loefflers corn at maturity.

Corn at the Weinert's Garden

- Plants – Corn
- Soil – Andisol – under intensive sugar cane production for decades until the '90s.
- Location - Onomea
- Application rate – Approximately ¾" to 1" though not formally measured. Tilled approximately 6-8".
- Biochar – Rough biochar ground only by stirring with a shovel and tilling. As large as 2" minus.
- Fertilizers – Compost where stated was a wheat mill run compost done in the Korean Natural Farming Method (IMO).
- Growing Period - Stated
- Yield – "Great" "What was also amazing was the difference in the thickness of the stalks" – Mr. Weinert
- Notes

Corn at 3 wks without biochar or compost

Corn at 3 wks with biochar and compost

Corn at 6 wks without biochar or compost

Corn at 6 wks with compost

Corn at 6 wks with biochar and compost

Corn at harvest without biochar or compost

Corn at harvest with compost

Corn at harvest with biochar and compost

Beans, Bok Choi and Sweet Peas

- Plants – Stated
- Soil – Andisol – "Cane Wash" topsoil washed off sugarcane from Hilo area and imported to the site. Soil was only 3-4" deep covering ripped and leveled Pahoe'hoe Lava. Thick layer of wood chips from previous year were still noticeable and decaying.
- Location – Hawaii Island Master Gardeners Association's garden in Hilo.
- Application rate – ½" tilled only 3-4" due to shallow soil.
- Biochar – ½" minus
- Fertilizer – 5,000lb per acre equivalent of fish meal (approximately 9-7-1) for both control and biochar plots
- Growing Period - Stated
- Yield – The yield was eaten by many and measurements were never taken.
- Notable quote – "How do I get my garden to look like that?" made by gardener working adjacent to the biochar plot.
- Many thanks to HIMGA and specifically Laureen Campbell for doing the most comprehensive and photogenic test so far of all the people who received biochar donations.

Beans at 1 week without biochar

Beans at 1 week with biochar

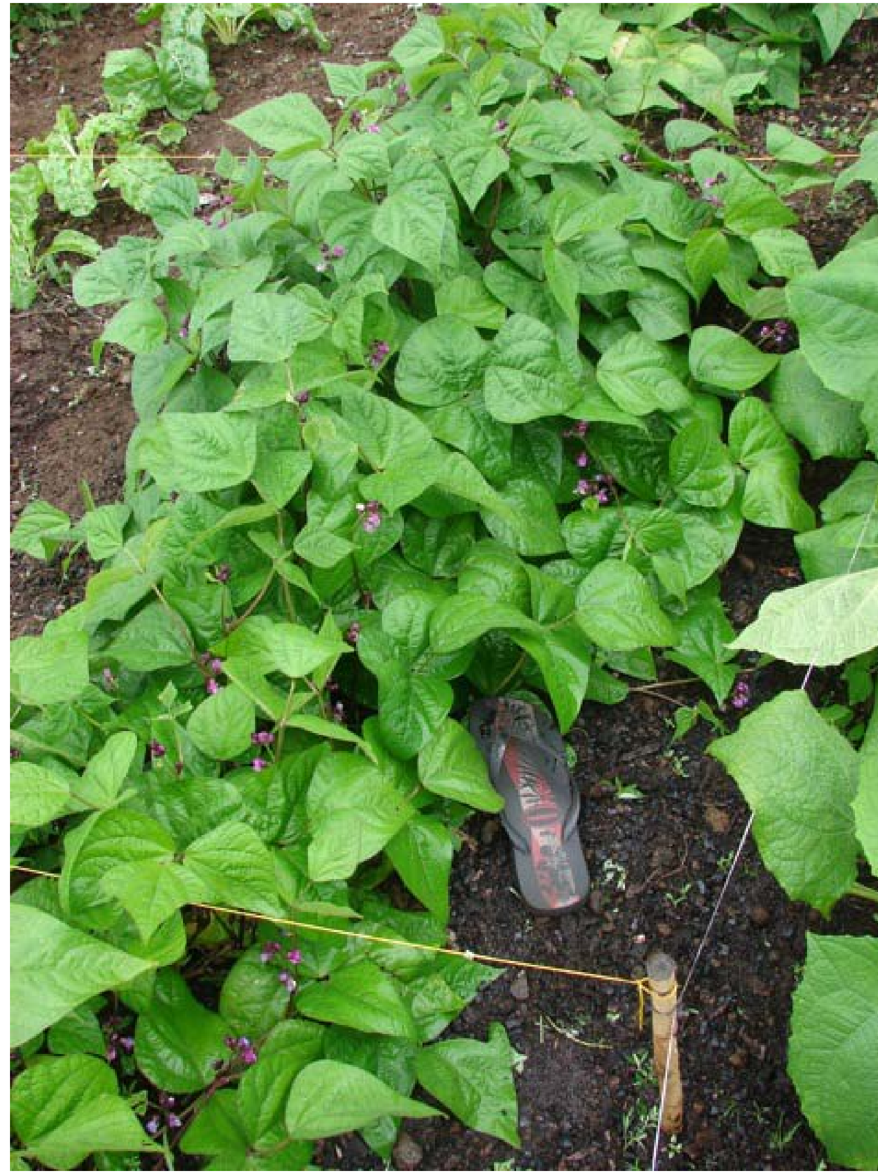
Beans at 2 weeks
without biochar

Beans at 2 weeks
with biochar

Beans at 3 weeks
without biochar

Beans at 3 weeks
with biochar

Beans at 5 weeks
without biochar



Beans at 5 weeks
with biochar

Bok Choi at 2 weeks
without biochar

Bok Choi at 2 weeks
with biochar

Bok Choi at 3 weeks without biochar

Bok Choi at 3 weeks with biochar

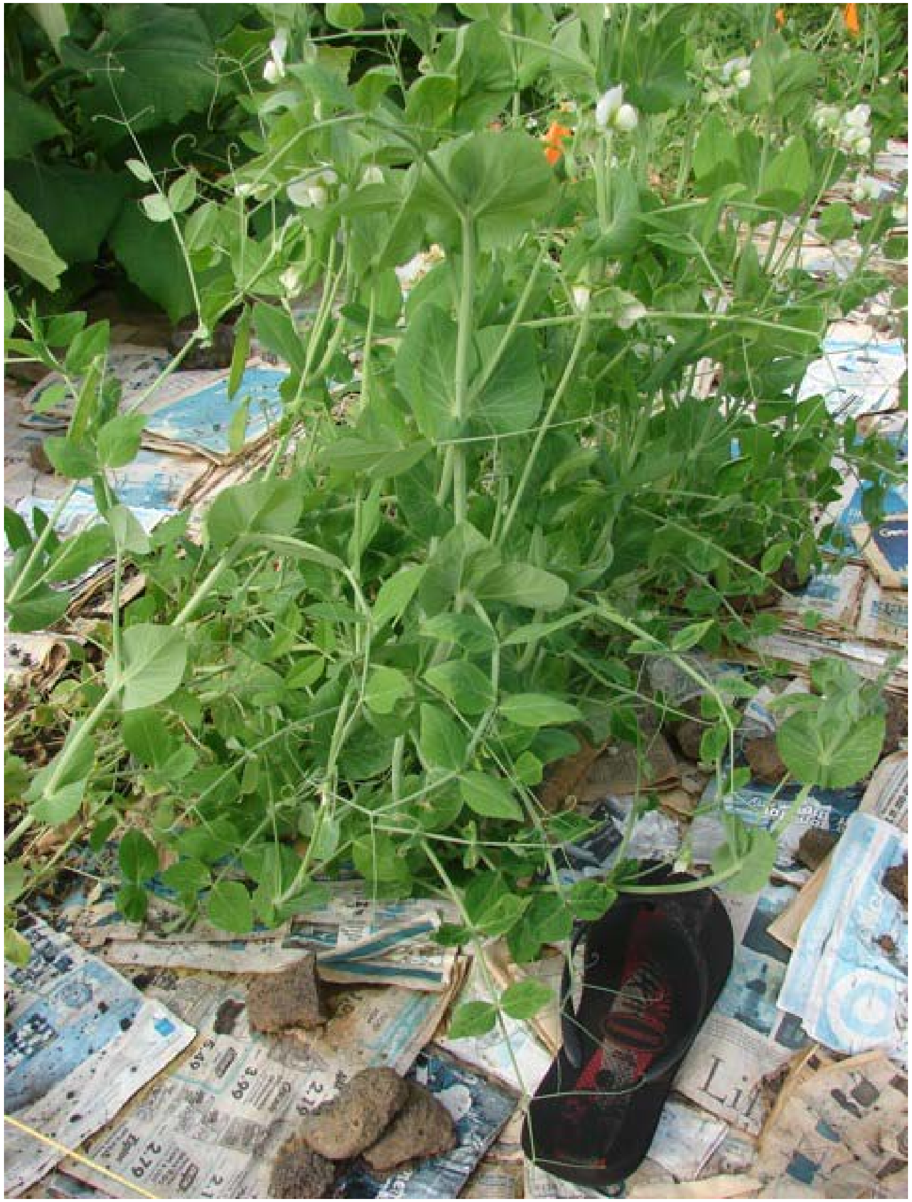
Bok Choi without biochar at harvest

Bok Choi with biochar at harvest

Sweet Peas without biochar

Sweet Peas with biochar

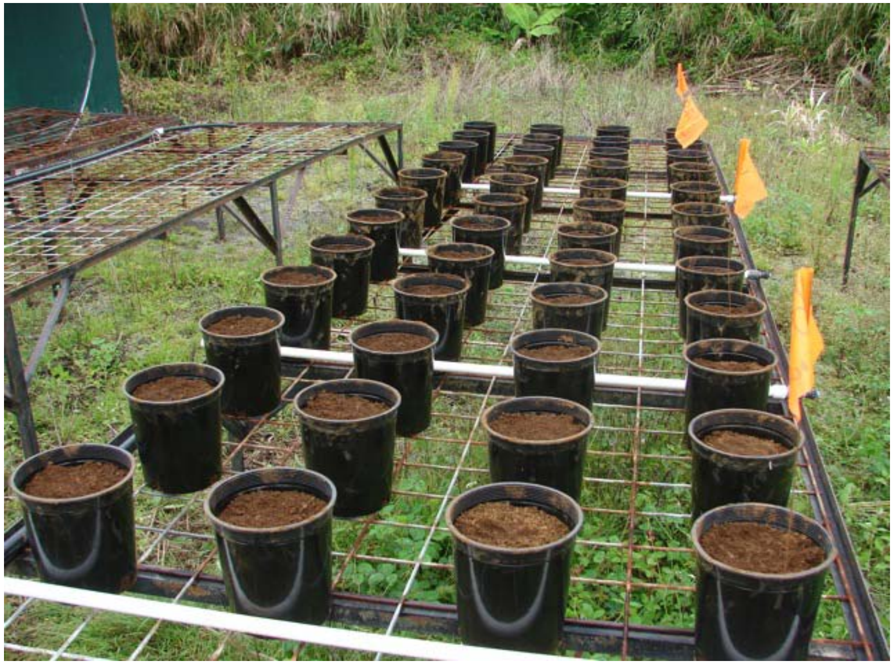
Sweet Peas without biochar

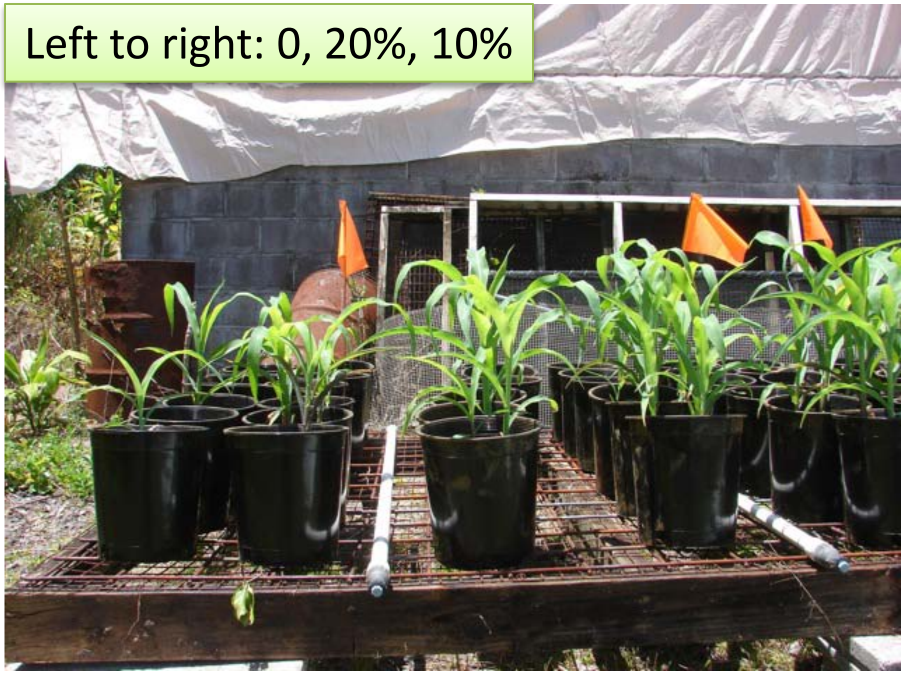


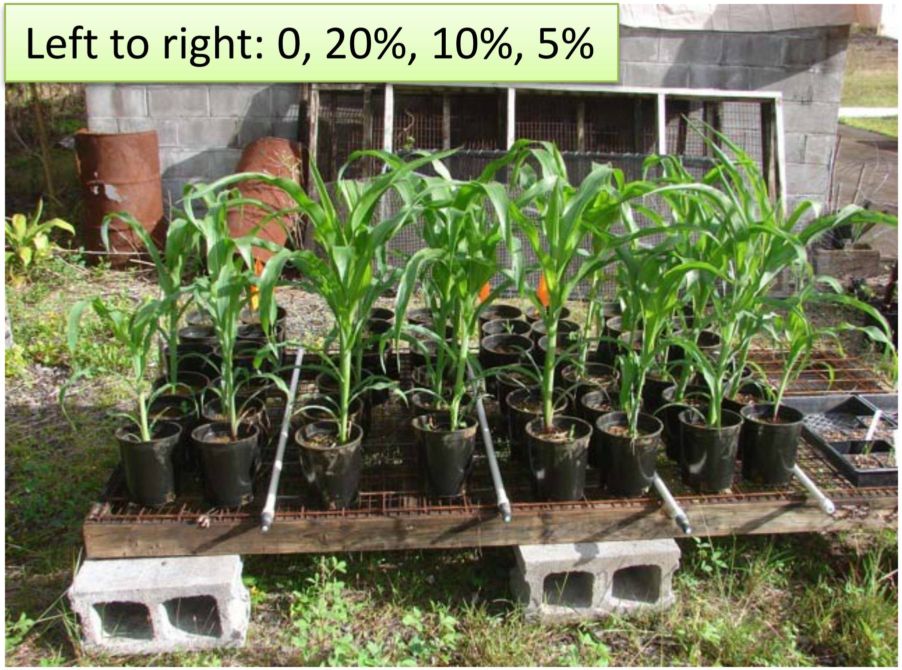
Sweet Peas with biochar

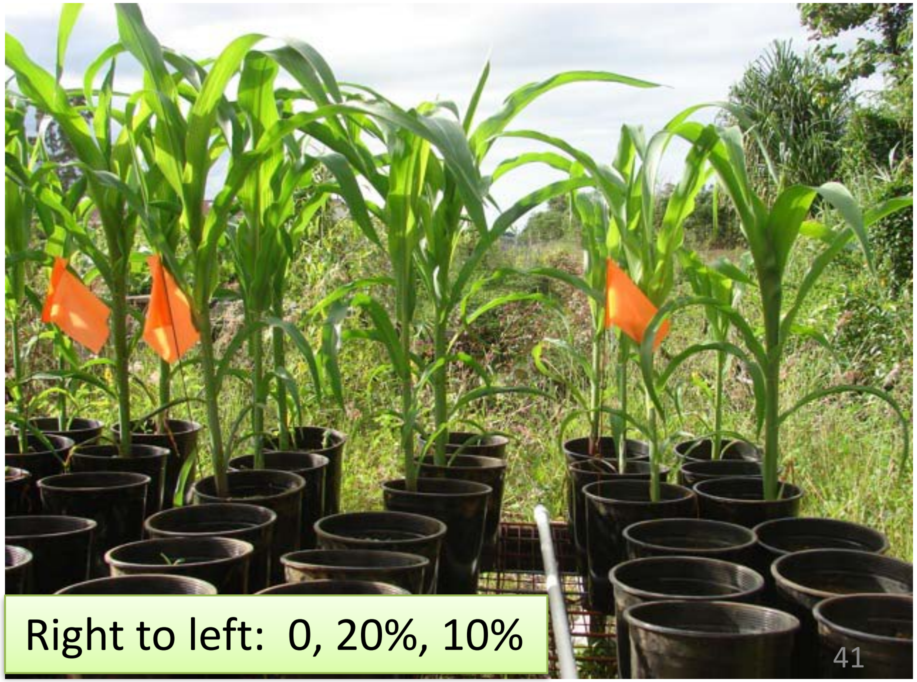
Pot Tests

- Plants - Corn
- Soil - Andisol – “Cane Wash” topsoil washed off sugarcane from Hilo area and imported to the site.
- Location – HIMGA site in Hilo
- Application rate – 0, 5%, 10%, 20% by volume
- Biochar – ½” minus
- Fertilizer – Bioflora “dry crumbles”- 1/8th of a cup per gallon.
- Growing period – lost track.
- Notes: Germination was noticeably better with all biochars. Three seeds were planted in each pot and were thinned to one later. For the single plant picture the largest plant from each group was chosen. The plants were not thinned early enough and crowding definitely affected later results (especially in the biochar pots where germination was higher). It was interesting to see that the difference in percent did not equally influence growth. The 5% was obviously better than the control but the difference between 5, 10 and 20% was much more subtle. For this soil type, 20% was the winner (much more noticeable before thinning). For the average interested gardener/farmer though 5% may be a more economical place to start, followed by small incremental applications.




Left to right: 0, 20%, 10%


Left to right: 0, 20%, 10%, 5%


Right to left: 0, 20%, 10%

0% biochar on left,
20% biochar on right

Nursery Trials

- Plants – Tomatoes, Cucumbers
- Soil – Peat moss, black cinder, “pro-mix”.
- Application rate – Approximately 12% biochar compost with the Tomatoes and 10% (?) plain biochar with the Cucumbers.
- Biochar – biochar compost used with Tomatoes was same as pictured and mentioned before but was amended with a couple gallons of fish meal (9-5-1) blended into one cubic yard, to overcome N deficiencies found in other tests. Biochar used for cucumbers was ½” minus.
- Fertilizer – Cal-phos and bone meal added in growing media all other nutrients applied in irrigation.
- Growing period - Stated
- Yield – NA
- Notes – The Tomatoes surprised me. In such a highly managed greenhouse I was not expecting to see that much difference. The Cucumbers did show a nicer color (control showed some deficiencies) and better flowering but not as drastic as the Tomatoes.

Tomatoes at 5 weeks without biochar compost

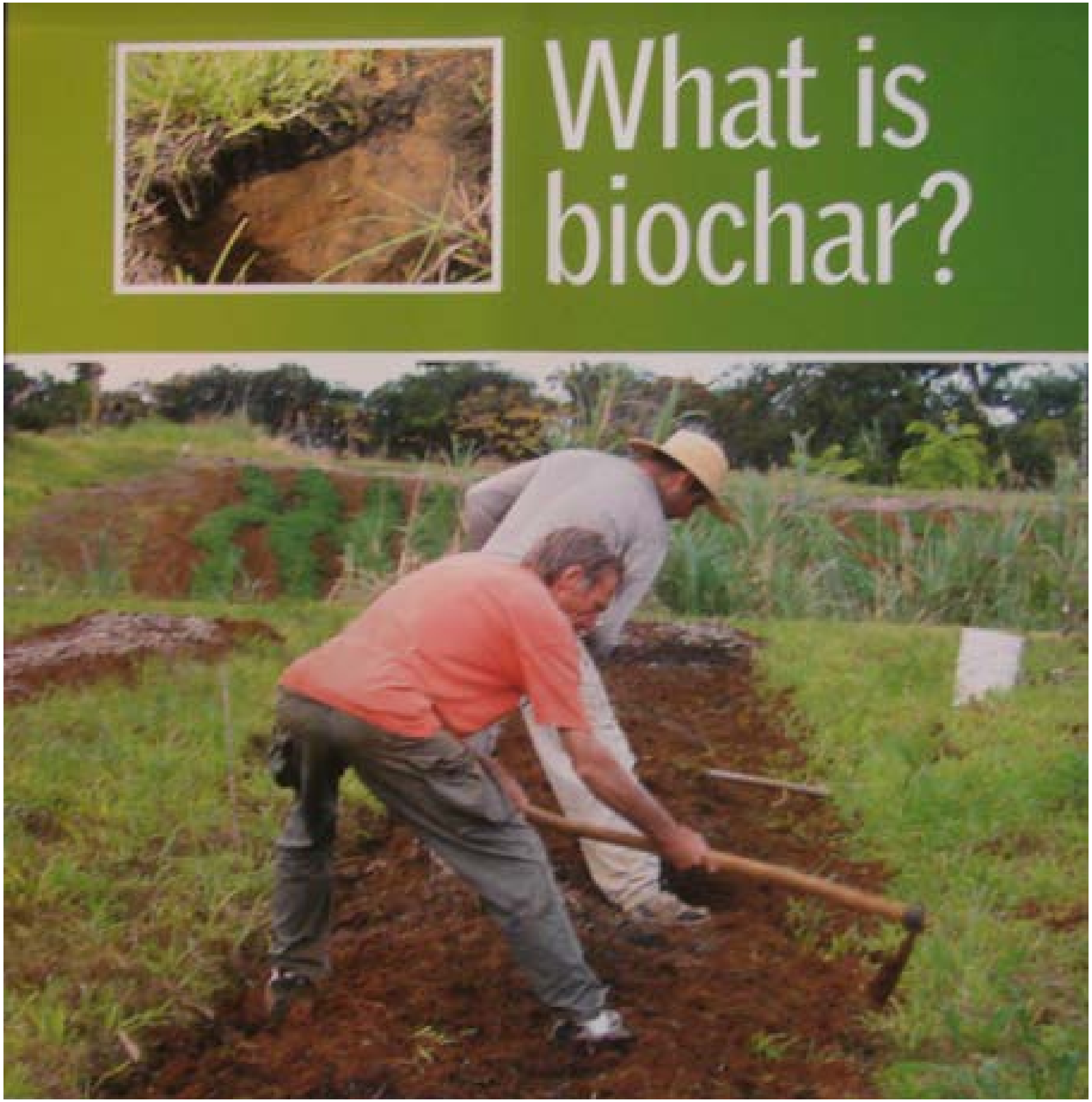
Tomatoes at 5 weeks with biochar compost

Cucumbers at 4 weeks
without biochar

Cucumbers at 4 weeks
with biochar

Taro

- Plants – *Colocasia esculenta*
- Soil – Andisol
- Location - Onomea
- Application rate – ¾”
- Biochar – biochar compost (same as pictured)
- Fertilizer – Dairy manure, Basalt rock powder, crushed coral, and top-dressed with municipal green waste.
- Growing period - Stated
- Yield – not for five more months
- The handsome size reference that you see is my son Noah.



Preparing the bed before planting Taro

Taro (Colocaisa) at 4 months without biochar

Taro (Colocasia) at 4 months with biochar compost

Taro on left without biochar compost (first 20ft.)
Taro on right with biochar compost

Soil Orders In Hawaii

Prepared by Ike Ikawa, Nguyen Hue and Russell Yost

College of Tropical Agriculture and Human Resources

University of Hawai'i at Mānoa

Andisol

Kula Series, Maui

Hilo Series, Hawaii

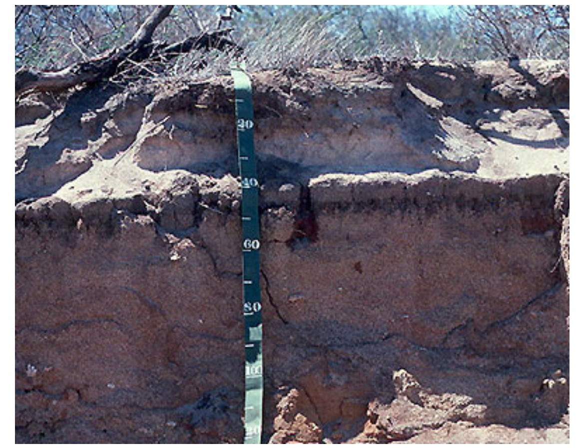
Andisols are soils derived from volcanic ash. The less weathered Kula soil on Maui is quite productive, while the Hilo soil on the Big Island is highly weathered and requires lots of fertilizers for crop production.

Aridisol

Kawaihae Series, Hawaii

Aridisols are soils of the arid areas or soils with high salt content. The Kawaihae soil of the Big Island has features of an arid area of light color, low organic matter, and shallow depth.

Entisol



Jaucas Series, Maui

Entisols are least-developed soils showing only a weak surface development. The calareous Jaucas soil on Maui is an example with sandy texture, and excessive drainage.

Histosol

Papai Series, Hawaii

Alakai Series, Oahu

Histosols are organic soils with a high organic matter content in the surface horizon. The Papai soil on the Big Island has lost almost all of the surface organic matter (OM), but the Alakai soil atop Mt. Kaala on Oahu is high in OM.

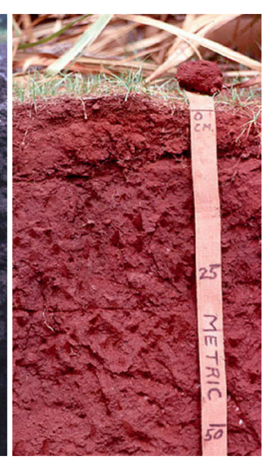
Inceptisol

Kolekole Series, Oahu

Inceptisols are soils showing minimal development of soil horizons. The Kolekole soil on Oahu is an example.

Mollisol

Kawaihapai Series, Oahu



Makawele Series, Kauai

Mollisols are fertile soils with high organic C and high base saturation. Although the Kawaihapai soil on Oahu is dark, the Makawele soil on Kauai is red because of Fe oxides.

Oxisol

Halii Series, Kauai

Oxisols are the most weathered soils of the tropics with low nutrient holding capacity and high Fe and Al oxides. The Halii soil on Kauai is an example.

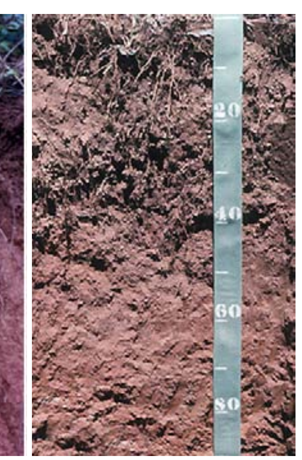
Spodosol-like soil

Oahu

Spodosols are soils with leached Al, Fe, and organic materials in the subsoil, showing a distinct layer.

Ultisol

Alaeloa Series, Oahu



Haiku Series, Maui

Ultisols are highly weathered infertile soils with clay accumulation in the subsoils. Examples are Alaeloa soil on Oahu and Haiku soil on Maui.

Vertisol

Lualualei Series, Oahu

Vertisols are soils that shrink when dry and swell when wet. They usually occur in valleys with poor drainage. They are fertile, but pose severe limitations for roads, housing, and related uses. The Lualualei soil on Oahu is an example.