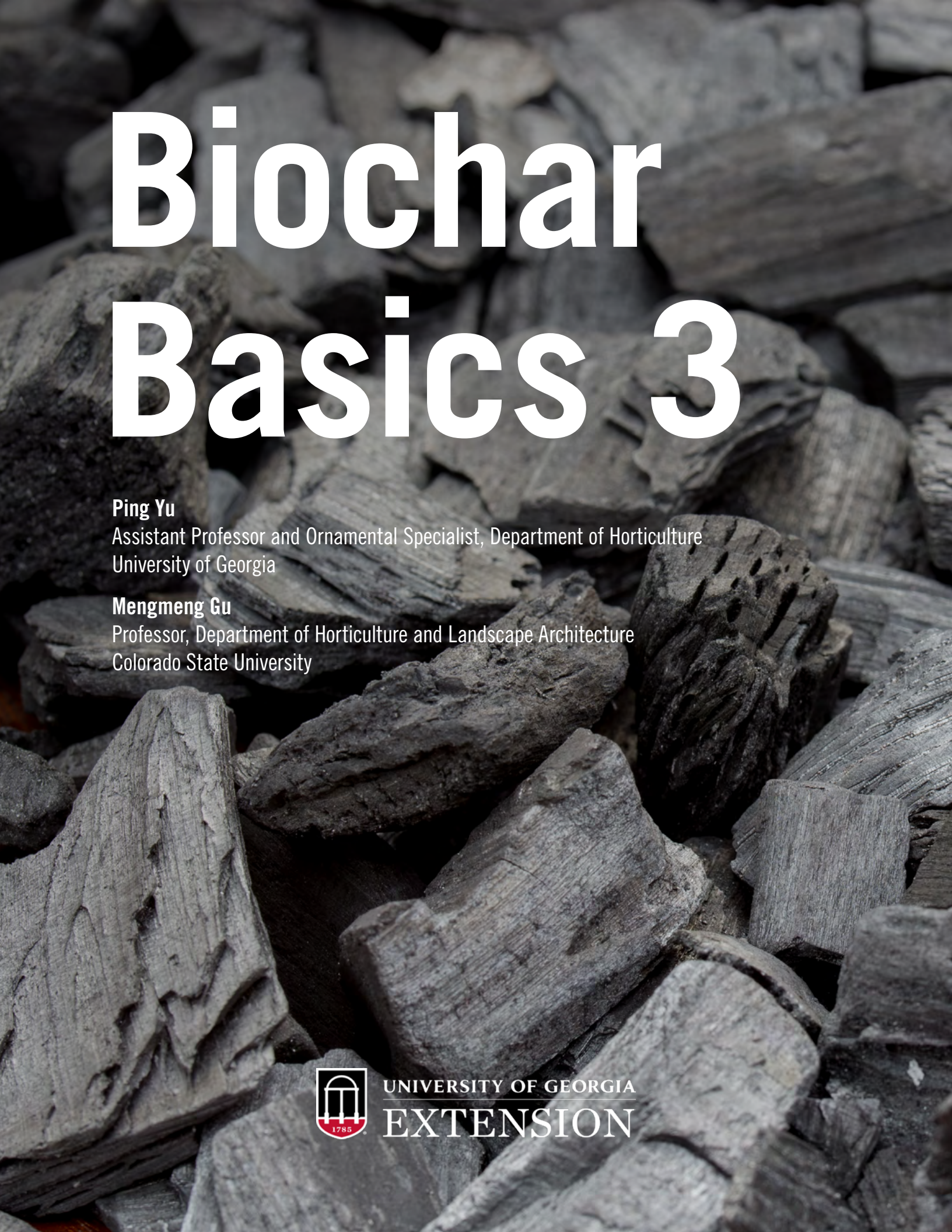

Biochar Basics 3

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Part 3: Biochar's Effects on Plant Disease

Disease Basics

Have you ever checked your plants and found brown, yellow, or white soft-tissue spots either on the roots, stems, or foliage? Those nongreen spots may indicate plant disease. Plant diseases can be broadly classified according to the nature of their primary causal agents, either infectious or noninfectious. Infectious plant diseases are caused by pathogenic organisms such as a fungus, bacterium, virus, or nematode. Infectious plant diseases can spread from plant to plant and may infect all types of plant tissues. Noninfectious plant disorders are not caused by living agents but by environmental conditions, such as nutritional deficiencies, salt injury, sun scorch, or ice damage. Noninfectious plant disease cannot spread from plant to plant (Shurtleff et al., n.d.).

How do pathogens infect plants and how do diseases develop? A pathogen is a type of microorganism that enters plants and interferes with plant growth. For a disease to occur, we need an environment that favors pathogen growth, a susceptible host plant, and a virulent pathogen (Graber et al., 2014)—these three factors represent the disease triangle.

In any given soil sample, there are two types of microorganisms: pathogenic microorganisms ("bad guys") and beneficial microorganisms ("good guys"). These microorganisms maintain a balanced relationship under normal conditions. Once the environment favors the "bad guys," they can outgrow the "good guys." When the environment is favorable for the pathogen and the pathogen is virulent, then plant disease may start to develop if the plant is susceptible to the pathogen.

Biochar and Plant Disease

As we mentioned before, every element in the disease triangle needs to be present for disease to occur. Therefore, any interference in the disease triangle could affect disease development. How does biochar play a role in a plant-disease system? Before the pathogen infects plants, biochar can improve plant growth by increasing water and nutrient uptake; a healthier plant may be more resistant to attack. On the other hand, after a pathogen infects a plant, biochar could absorb the toxins, enzymes, and other compounds produced by the pathogen.

Certain types of biochar could contain chemical compounds which are bad for pathogen growth. When incorporating this biochar into a substrate, the growth environment may become toxic to pathogens so they cannot grow well enough to attack plants. For instance, water extracts from eucalyptus biochar were found to inhibit *Pythium* growth in a lab setting. This finding indicates that substrates containing certain chemical extracts may impede plant infection by inhibiting the growth of *Pythium* (Bonanomi et al., 2015). Many types of biochar can improve plant growth, making the host plant stronger to fight against pathogens, thus reducing disease occurrence.

Some studies have shown that incorporating biochar into growing media can suppress plant disease. For instance, amending a substrate with 30% softwood bark biochar produced at 475 °C reduced disease development. In addition, mixing in 3% of pine biochar produced between 550–600 °C reduced pepper blight caused by *Phytophthora capcisi* (Gravel et al., 2013). Reports indicate that biochar influences other plant diseases, such as asparagus root rot, tomato bacterial wilt, red oak and red maple seedling stem canker, and strawberry gray mold caused by different pathogens. Table 3.1 summarizes biochar's effect on plant-disease systems.

Table 3.1. Biochar's Effects on Soilborne Plant Disease Development.

Plants	Diseases	Pathogens	Biochar raw material	Biochar temperature in °C	Biochar rate†	Influence on plant disease incidence or severity
Tomatoes	Bacterial wilt	*Ralstonia solanacearum*	Municipal biowaste	N/A	20% (v/v)	Reduces
Red oak and red maple	Stem rot	*Phytophthora cinnamomi* and *P. cactorum*	Pine	550–600	5%, 10%, 20% (v/v)	Reduces
Cucumbers	Root rot	*Rhizoctonia solani*	Eucalyptus wood and greenhouse wastes	350, 600	0%–3% (w/w)	Reduces
Lettuce	Root rot	*Rhizoctonia solani*	Holm oak wood	650	1%, 3% (w/w)	Reduces
Peppers	Root rot	*Rhizoctonia solani*	Maple wood bark	700	1%, 3%, 5% (w/w)	Reduces
Beans	Root rot	*Rhizoctonia solani*	Eucalyptus wood and greenhouse wastes	350, 600	0%–3%	Mixed
Asparagus	Fusarium root rot	*Fusarium oxysporum* f. sp. *asparagi*	Coconut fiber (mixed with coffee compost)	N/A	10%, 30% (v/v)	Reduces

† v/v means volume per volume; w/w means weight per weight.

We must remember that every biochar is different. Among the studies listed in Table 3.1, most of them used low biochar rates (0%–5%) and the highest rate was 30% by volume. Also, the field of biochar plant disease research is small. More greenhouse research needs to be done on this topic for the following reasons: (a) the humid and warm environment could favor a lot of pathogenic organisms; (b) monocultivation could make the plants more susceptible to pathogens; and (c) pathogens are resistant to fungicides, pesticides, and bactericides.

How Do We Measure Biochar's Influence on Disease?

Biochar influence on plant disease was measured according to the following parameters: (a) when the first symptom appears; (b) percentage of diseased plants; and (c) disease severity. Biochar alone may not be capable of stopping diseases, but it may delay the appearance of symptoms.

For instance, in previous trials, adding mixed hardwood biochar delayed the first symptom of poinsettia root rot by 5 days. Also, adding biochar may reduce *disease incidence* (the total number of diseased plants). Biochar may also reduce disease severity in infected plants. Poinsettias produced with biochar in the growing media may exhibit reduced disease symptoms, such as a reduction in the size of a necrotic spot.

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