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Shifted-Rmax-Effect: Biochar dose tradeoffs between plant growth response and disease reduction

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Many biochar/crop systems have been reported to exhibit inverted U-shaped biochar dose/plant growth relationships, with optimum growth at intermediate biochar concentrations. Indeed, we anticipate that most, if not all, cropping systems would eventually show such inverted U-shaped biochar dose/growth response relationships if biochar concentration would be sufficiently increased. Likewise, biochar has been reported to affect the progress of diseases caused by foliar and soilborne pathogens in a number of systems, and an observation common to most is that disease reduction also exhibits inverted U-shaped curves versus biochar dose. Such dose/response curves illustrate the inherent difficulties in deciphering mechanisms responsible for biochar impacts on both plant growth and disease reduction. Some possible mechanisms, acting alone, would not be expected to produce U-shaped dose/response curves. For example, if adsorption of soilborne pathogen-produced toxins was the dominant factor in disease suppression, severity of the disease would be expected to decrease monotonically to a minimum asymptotic value with increasing biochar dose. However, any given effect does not operate in an isolated vacuum. Rather, it generally results in a cascade of further impacts on the chemistry and biology of the rhizosphere, which plays a pivotal role in plant functioning and health. Biochar impacts on plant growth and health may result from its varied influences on the soil-rhizosphere-pathogen-plant system. These influences can involve myriad biochar properties such as nutrient content, water holding capacity, redox activity, adsorption ability, pH, and content of toxic or hormone-like compounds. The direct and indirect impacts of biochar on the soil environment, host plant, pathogen and the rhizosphere microbiome can have domino effects on both plant development and disease progress. Yet more confounding is that biochar dose-dependent disease reduction and crop response inverted U-shape curves may be shifted relative to each other along the biochar dose abscissa, and may also be different in their breadth. We term this the “Shifted Rmax-Effect”, where Rmax refers to maximum growth response (G-Rmax) or maximum disease reduction (D-Rmax). To now, we have observed that G-Rmax values usually occur at higher biochar doses than D-Rmax values, but they may coincide or even potentially be reversed, perhaps depending on the energy tradeoffs involved in plant growth versus disease resistance. The outcome is that for any cropping system, the possible effect of biochar addition should consider not only plant growth, but also effect on disease, as there is no simple rule-of-thumb for crop/soil/biochar/dose/pathogen combinations either in detached media or in field applications, where crop rotations may complicate the situation still further.