

Statistical framework for analyzing heterogeneous response patterns within microbial treatments for agriculture

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Abstract

Agricultural biologicals are microbial products that can increase crop yield and reduce chemical usage, offering sustainable solutions to food security. However, discovering biological products has several unique challenges. Unlike chemical products, microorganisms form complex three-way interactions with plants and environments. This often results in heterogeneous responses, due to some microbes are inactive or only partially active. Basic statistical methods might not be able to identify promising candidates with heterogeneous responses. A mixture model framework was developed to address heterogeneous treatment response and model it as two components: active and inactive microbes. The model estimates the proportion of active microorganisms and the effect size of microorganisms. Simulation studies demonstrated that the model can identify treatments with only a moderate proportion of active microbes, where these treatments are often missed by basic statistical approaches. Experimental validation using tomato experiments confirmed the robustness and accuracy of this model. This model provides a more efficient screening approach for potential biological products compared to conventional methods. By accounting for heterogeneous biological behaviours and responses, it accelerates the discovery of effective products for sustainable agriculture.

Keyword: Agricultural biologicals, microbial product, heterogeneous responses, mixture model, simulation results.