Multiple Disease Protection by Rhizobacteria that Induce Systemic Resistance—Historical Precedence

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The purpose of this letter is to correct an error previously published in *Phytopathology* regarding the historical precedence for an aspect of research on induced systemic resistance (ISR) mediated by plant growth-promoting rhizobacteria (PGPR). Based on presentations at national and international meetings on plant diseases and biological control, the number of research groups working on microbially mediated ISR is rapidly increasing. We believe that researchers new to this field should have a clear understanding of previous work on which current work is based. This requires access to accurate summaries of past work, including accurate statements of historical precedence.

In July 1996, Hoffland et al. (1) presented evidence that one PGPR strain protected radish against one fungal root pathogen, one bacterial foliar "avirulent" pathogen, and two fungal foliar pathogens. The authors stated in the abstract, "We thus demonstrated, for the first time, that one PGPR strain can induce resistance against multiple pathogens." This statement is incorrect from the standpoint of historical precedence.

Immediately after demonstrating that six known PGPR strains could induce systemic protection in cucumber against anthracnose (11), our group set out to test the hypothesis that PGPR-mediated ISR was similar to classical ISR achieved with pathogens as inducers in that multiple pathogens would be protected. We viewed this as a key requirement for concluding that the systemic protection observed against a foliar fungal pathogen was the result of ISR rather than possible translocation of bacterial metabolites with antifungal properties.

At the 1992 American Phytopathological Society (APS) annual meeting, our group presented results demonstrating that the same PGPR strains that protected against anthracnose also induced resistance against cucumber mosaic virus (CMV) (3). In a 1993 book chapter (2), the same PGPR strains that demonstrated ISR in the greenhouse against anthracnose and CMV also were reported to protect field-grown cucumber against inoculated *Pseudomonas syringae* pv. *lachrymans*, causal agent of angular leaf spot disease, and, surprisingly, against naturally occurring cucurbit wilt disease caused by *Erwinia tracheiphila*. In 1993 at the APS annual meeting (4), results indicating that the same PGPR strains provided protection against angular leaf spot in greenhouse trials were reported, and the details were published in 1995 (7). At the International Plant Pathology meeting in Montreal in 1993, evidence was presented that the same PGPR strains protect cucumber against *Fusarium* wilt (5), and these results were published in detail in 1995 (6). The collective data supporting the conclusion that PGPR-mediated ISR, like classical ISR, led to multiple pathogen control with the same PGPR strains were reviewed at the Third International Workshop on PGPR in 1994 (9) and in a 1995 review article discussing PGPR as inducers of systemic resistance (10). In 1996,

results of a 2-year field study were published (12) demonstrating that the same PGPR strains protected against challenge-inoculated *P. syringae* pv. *lachrymans* and naturally occurring anthracnose. Hence, we have demonstrated and published several times that PGPR-mediated ISR protected against multiple pathogens.

In the discussion section of the paper by Hoffland et al. (1), the authors stated, "This demonstrated, for the first time, that one and the same PGPR strain can protect a plant against multiple pathogens." Perhaps this statement reflects a misconception that because our team has worked and published on several different strains of PGPR as inducers of systemic resistance we had not shown multiple-pathogen protection with any one strain. This, however, is not the case. Although we have continually assessed new strains in an effort to extend the technology of PGPR-mediated ISR to practical agricultural use, we conscientiously included one to two standard strains in each study. Hence, Liu used the same two PGPR strains (*P. putida* strain 89B-27 and *Serratia marcescens* strain 90-166) throughout her Ph.D. studies and reported that these strains, which were first selected for protection of anthracnose, also protected against angular leaf spot (4) and *Fusarium* wilt (5) in greenhouse trials. One of these same strains (90-166) also was used in field studies by our group and was reported to protect against naturally occurring cucurbit wilt (2) and challenge-inoculated *P. syringae* pv. *lachrymans* (12). Both strains were used (8) to investigate cultivar specificity and duration of protection as well as to demonstrate independence of population densities on roots from ISR activity.

We believe that the collection of previous abstracts, reviews, and manuscripts cited above demonstrate that the concept that specific PGPR strains can lead to multiple-pathogen protection via ISR was already well established before the manuscript by Hoffland et al. (1) was published. In general, we believe that historical precedents are not of high importance. Instead, it is most important to understand development of scientific concepts and how one group's research builds on the research of others. To reach this goal, it is important to have an accurate trail of previous work, and in this spirit we offer this correction.

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