Biol Fertil Soils (2016) 52:283–284
DOI 10.1007/s00374-016-1091-y

LETTER TO THE EDITOR

A need for disclosure of the identity of microorganisms, constituents, and application methods when reporting tests with microbe-based or pesticide-based products

Yoav Bashan[1,2,3] · **Joseph W. Kloepper**[1] · **Luz E. de-Bashan**[1,2,3] · **Paolo Nannipieri**[4]

Published online: 22 January 2016

Plant growth-promoting microorganisms, biological control agents, pesticides, and a variety of stimulants to enhance plant performance are commonly tested and commercially applied worldwide on increasing scales each year (Bashan et al. 2014; Calvo et al. 2014; Lugtenberg and Kamilova 2009). In recent years, inoculation of plants with microorganisms to enhance productivity has become widespread, with more sophisticated and complex formulations and application methods. These formulations use a variety of application techniques, such as using natural and synthetic polymers or add more than one microorganism to the inoculants. These microbial consortia in inoculants may have over ten different microorganisms. Inoculants may have synthetic vitamins, plant hormones, and humic and fulvic acids. Other inoculants add different plant or algae or seaweed extracts, protein hydrolytes and amino acids as stimulants, as well as bulking materials, such as clays, minerals (vermiculite and perlite), talcum, or undisclosed soil fractions. Numerous adhesives, surfactants, stabilizing and dispersing materials, and preservatives to enhance survival and dispersal of the microorganisms are commonly added. The identity of these components in microbial formulations is often not disclosed in the product label. Specific details of application are usually explained by the manufacturer on the container label, but rarely in a formal publication.

As product formulations change, performance of bacterial strains in the product may change. Hence, it might not be possible to objectively compare the effects of an inoculated microorganism in laboratory experiments with the effects of the same microbe in a commercial formulation. This results from some components in the formulations having synergistic bioactivities that are greater than a single strain of microorganism. As an example, the plant growth-promoting bacterium *Azospirillum brasilense* strain AZ39 is one of the most common *Azospirillum* strains used in Latin America. Yet, its performance significantly varies, depending on the specific formulation and the method of inoculation. Similar phenomenon occurs with rhizobia.

Pesticides are commonly used in agriculture and are classified, according to the pest organism, in insecticides, fungicides, herbicides (weeds killers), nematocides, and rodenticides. The first three pesticides are those most used. Pesticides differ greatly for their chemical structures, and this result in a great variety of toxicological properties, most of them contain aromatic rings and some are chlorinated, just to mention a few chemical characteristics. Field rates depend on several factors including soil type (Bremner and Mulvaney 1976; Cervelli et al. 1976). Usually, pesticides are applied in formulations containing several other constituents often not disclosed in the product label, as mentioned above for the microbial inocula. These additives may include solvents, by-products of the target compounds, salts, chemical vehicles of the target compound, etc. Obviously toxicological studies of the target pesticide should also consider the effect of all other constituents; these effects may be synergic or antagonist with those by the target pesticide (Cervelli et al. 1976).

✉ Yoav Bashan
ybb0001@auburn.edu

[1] Department of Entomology and Plant Pathology, Auburn University, 301 Funchess Hall, Auburn, AL 36849, USA

[2] The Bashan Institute of Science, 1730 Post Oak Ct., Auburn, AL 36830, USA

[3] Environmental Microbiology Group, Northwestern Center for Biological Research (CIBNOR), Calle IPN 195, La Paz B.C.S. 23096, Mexico

[4] Department of Agrifood Production and Environmental Sciences, University of Florence, P. le delle Cascine 28, 50144 Florence, Italy

For the economic benefit of the grower, it makes little difference if the formulation or the application method of the inoculant is disclosed. However, for the scientific community engaged in research with these microorganisms or pesticides, this is an important hurdle that must be addressed. Failure to know all the ingredients in a product at the time of an experiment makes it very difficult to compare results done without any formulation or with a subsequent change in a product formulation.

In recent years, many manuscripts have been submitted to scientific journals, where commercial inoculants or commercial pesticides and commercial methods are part of the study. However, these studies frequently list the commercial name of the inoculant or pesticide and the method of application as: "according to the manufacturer's instructions," as printed on the product label. However, this statement likely creates a problem for continuity of research on the same microorganism(s) or pesticide(s). For example, if an investigator wishes to repeat a highly successful inoculant study, it would be impossible without the details of the commercial formulation used in the first study.

Another problem occurs when the product originates and is tested in one country and the experiment is repeated in another country. The biological product sometimes cannot be legally imported, if it lacks any of the specific requirements of the customs declarations for importing microbial products or when the company ceases to exist or when the original label has been changed to reflect a newer formulation. This is a particular strong concern for inoculants originating in developing countries that were intended to be exported, but never exported. This creates a dead-end scenario when a "successful" specific strain or inoculation method "exists" only as a scientific publication and cannot be repeated elsewhere.

In most countries, the species of microorganism is disclosed, but sometimes the specific strain is not mentioned. In literature about biological control agents (PGPR), it is customary to state the identity of the strain because it directly impacts efficacy. However, in general, in plant growth promotion by PGPB, especially in agriculturally oriented journals, it is common to find ambiguities regarding the identity of the microorganisms when a consortia of microorganisms is used or the species is unidentified and only the genus is provided.

To add clarity to studies of microorganisms or pesticides in agriculture, such that studies of the same microbial strains or pesticide can be compared, we propose several guidelines for manuscripts.

- In each new manuscript, the precise formulation of the inoculants or pesticide should be disclosed in quantitative details, including all non-active materials and active supplements. The URL of the website where the product label exists and the date of the product label should be indicated. In cases where the inoculant is proprietary or is intellectual property, the serial registration number of the patent or the intellectual property and the country of registration must be disclosed. All bacterial species, not only the genus name, should be disclosed and be available from microbial collections available to the public. The bacterial strain designation in a specific collection should be included. When strains are intellectual property of an organization, the name of the organization holding the rights should be disclosed. If specific sequence(s) of a strain is publically known, this should be disclosed as the definitive identification of the strain.
- All microbial strains in a consortium must be listed.
- Inoculation techniques must be described in sufficient detail to allow repetition of the experiment. Accordingly, statements such as "Inoculation was done according to the manufacturer's instructions" are not acceptable.
- The name and physical address of the manufacturer of the inoculants or pesticide product should be disclosed. The URL of the manufacturer's website is preferred. The distributor or sales agency is not acceptable for formal publication.

In summary, we propose that new manuscripts that do not contain the above information on identification, formulations, and application methods of microorganisms or pesticides should not be considered for publication.

References

Bashan Y, de-Bashan LE, Prabhu SR, Hernandez J-P (2014) Advances in plant growth-promoting bacterial inoculant technology: formulations and practical perspectives (1998–2013). Plant Soil 378:1–33

Bremner J, Mulvaney RL (1976) Urease activity in soil. In: Burns RG (ed) Academic Press London, pp 149–197

Calvo P, Nelson L, Kloepper JW (2014) Agricultural uses of plant biostimulants. Plant Soil 383:3–41

Cervelli S, Nannipieri P, Sequi P (1976) Interactions between agrochemicals and soil enzymes. In: Burns RG (ed) Academic Press London, pp 251–293

Lugtenberg B, Kamilova F (2009) Plant-growth-promoting rhizobacteria. Annu Rev Microbiol 63:541–556