

A Summary of the Status of Biofertilizers
International Plant Nutrition Institute (IPNI)
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This report is a summary of the status of use, knowledge base, and outlook for biofertilizers in various regions of the world prepared by the staff of IPNI. The majority of the content is available on line via the hyperlinks included in the text. For additional information, contact either the researchers listed in the various sources or the staff of IPNI whose contact information is available on the IPNI website (<http://www.ipni.net/>).

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Region: North America

Staff observations:

General situation with the major biofertilizer classes:

RHIZOBIA: Rhizobia, principally *Bradyrhizobium japonicum*, have been used as inoculants for soybeans for decades. Inoculation has the highest chance of producing a significant yield response when applied to soils with no previous history of soybean production. Market growth in this sector is not expected to be great as inoculation is a mature practice.

MYCORRHIZAE: Mycorrhizal infection of agronomic crops is the usual condition in production agriculture. Mycorrhizae can form symbiotic relationships with host plants, providing phosphorus and zinc in exchange for carbohydrates. Brassicas and sugarbeet are the agronomic crops that are not hosts for mycorrhizal fungi. Native species of mycorrhizae have developed over the millennia that survive well under local conditions. To be effective, mycorrhizal inoculants must outperform locally adapted species. Mycorrhizal infections on host plants by native fungal populations have been shown to be reduced after 1) a season of fallow or 2) flooded soil conditions. Reduced infection rates in the crop following these conditions have been demonstrated and rectification has traditionally been through the application of higher-than-normal P rates, preferably banded near the seed at planting. Native fungal populations and host infection rates usually return to normal in subsequent seasons. For mycorrhizal inoculants to become a widely used best management practice, situations favoring higher

probabilities of crop response will need to be clearly defined. Market outlook is undetermined, although governmental funding agencies have and are continuing to provide large grants for research.

PLANT GROWTH PROMOTING RHIZOBACTERIA (PGPR): Root colonizing bacteria are being examined that provide benefits to plant development. Benefits demonstrated under laboratory and greenhouse conditions include: 1) reduced negative effects of plant pathogens and 2) enhance crop nutrition through increased availability of N, P and Fe. Like mycorrhizae, efficacy of these products depends greatly on the ability of PGPR to compete with locally adapted strains already present in soils. Field studies investigating efficacy have largely been inconclusive. This is an active area of research. Little guidance currently exists for defining conditions where PGPR will have the greatest likelihood of effectiveness. Market outlook is therefore unknown.

In some regions of North America, crop production is dominated by commodity crops such as wheat, corn, soybean, and cotton. Forages (hay, silage and pasture) are also an important component of the overall production in the region. The use of biofertilizers/microbial inoculants is relatively insignificant in these regions since most commodity crops are relatively low value and farmers are thus less likely to use them because of price sensitivity. The exception would be the inoculation of legume crops with rhizobia bacteria. In such regions, no real surge in the use of biofertilizers is expected in the foreseeable future.

Most of the biofertilizers showing up in western North America have been largely discredited, although new materials and ideas keep popping up. We know of no current research in the western part of North America on this topic, though there have been many attempts to use materials (various rhizobacteria, yeasts, free-living N₂ fixers such as azospirillum), but no consistent results. The exception is the use of Humic Acids, where the growth in the use of these products is growing rapidly. The humic materials are widely used and promoted, although recent research in California shows no positive benefits.

Staff report several biofertilizer products circulating throughout southeastern North America. Many are being marketed by small fertilizer dealers, but some of the big dealers also handle the materials. No one really has a good feel for how widespread their usage is as products come and go so rapidly from the market that they are hard to keep up with. When they are used, they are used mainly as a spray adjuvant for liquid fertilizer solutions. A couple that have been evaluated recently are Superbio Agblend and Accomplish. The most widespread commercial use appears to be in the turf and organic markets in Florida. We are aware of no research in the region demonstrating efficacy.

Microbial inoculants are an interesting area of study, but it is difficult to predict efficacy for products other than the rhizobial inoculants for legumes (e.g. soybeans, clovers and alfalfa).

Additional information:

- A database of research on biofertilizers and other non-conventional products maintained by the universities in the north central region of North America.

- <http://extension.agron.iastate.edu/compendium/index.aspx>
- Sources of additional information on mycorrhizal inoculation
 - Fungal Ecology and Biology Lab (FEABL), University of Montana
http://dbs.umt.edu/research_labs/rilliglab/
 - International Culture Collection of Vesicular Arbuscular Mycorrhizal Fungi, West Virginia University
<http://invam.caf.wvu.edu/collection/generalinfo/generalinfo.htm>
 - Mycorrhizal Fungi/Nursery Crop Physiology Laboratory, Texas A&M University
<http://aggie-horticulture.tamu.edu/faculty/davies/ResearchHomepg.html>
 - Sources of additional information on PGPRs.
 - Dr. Louise Nelson, University of British Columbia Okanagan
http://soilmicrobialecolgy.ok.ubc.ca/Group_Site/Faculty/Entries/2010/6/26_Louise_Nelson%2C_Ph.D..html
 - Canada's fertilizer regulatory system has efficacy data requirements for biofertilizers and other products. A list of registered products can be found at
http://active.inspection.gc.ca/scripts/database/fereng_submit.asp?lang=e&CName=all&TCategory=1
 - The efficacy data requirements for registering such products can be found at
<http://www.inspection.gc.ca/english/plaveg/fereng/tmemo/t-4-108e.shtml>
 - Vessey. Plant growth promoting rhizobacteria as biofertilizers. Article 01 at
<http://info.ipni.net/biofertilizers>
 - Gambino et al. Determination plant hormone in fertilizers HPLC JAOAC 2008. Article 02 at
<http://info.ipni.net/biofertilizers>
 - Karnock. Golf course management promises of biostimulants 2000. Article 03 at
<http://info.ipni.net/biofertilizers>
 - Kelting. Humate biostimulant not consistent growth promotion in hazelnut J Environ Hort 1997. Article 04 at
<http://info.ipni.net/biofertilizers>
 - Journal of Biofertilizers & Biopesticides. <http://www.omicsonline.org/jbfbphome.php>
 - Company promotional materials
 - <http://www.organicsa.co.za/Products/Fertilizer/fertilizer.html>
 - <http://www.agrofill.com/>
 - <http://www.microlifefertilizer.com/resource.htm>
 - <http://www.pro-soil.com/index.html>
 - <http://www.ecocatalysts.com.au/>

Regional contacts:

- University scientists who study microbial inoculants and microbial ecology in depth.
 - Kari Dunfield: University of Guelph (<http://www.uoguelph.ca/ses/users/dunfield>)
 - Janice Theiss: Cornell University
(<http://gradededucation.lifesciences.cornell.edu/faculty/individual5412>)
 - Joann Whalen: McGill University (<http://nrs-staff.mcgill.ca/whalen/>)
 - Rhae Drijber: University of Nebraska
(<http://agronomy.unl.edu/web/agronomy/drijber>)

Region: Brazil

Staff observations:

The report referenced below was prepared by IPNI Brazil. It is based on questions and answers for objectiveness. Much of the content in this report is based on information from companies working with biofertilizers in Brazil. IPNI Brazil does not endorse technical information on these products unless it is published or is our own research. In case of any doubt please do not hesitate to contact IPNI in Brazil.

Additional information:

- Prochnow and Casarin. Biofertilizers in Brazil. Article 05 at <http://info.ipni.net/biofertilizers>

Region: Southern Cone

Staff observations:

Regarding information on the use of inoculants in Argentina, Paraguay, Bolivia and Uruguay, most of the soybean crops are inoculated with *Bradyrhizobium* inoculants. It is estimated that 70% of the area is being inoculated. This is a large soybean market of more than 30 million ha. In Argentina, a summary of 708 experiments between 1990 and 2006, has shown a yield difference of 7.5% between inoculated and non-inoculated treatments. To a much lesser extent, new inoculants or biofertilizers have been released in the last years, most of them growth promoters such as *Pseudomonas sp.* and *Azospirillum brasilense*. These products are recommended mainly for wheat and maize, Responses are quiet variable but, in responsive situations, yield increases are of 4-9%.

Additional information:

- Soybean Rizobia Inoculation Has a Positive Contribution to Argentine Grain Production (A recent poster). Article 06 at <http://info.ipni.net/biofertilizers>
- The importance of BNF for soybean production in Argentina. 2004. Peticari, A. 22nd Latin-American Conference on Rhizobiology - 1st Brazilian Conference on Biological Nitrogen Fixation. Brasil.
- Effect of the bacterial concentration of *Azospirillum brasilense* in the inoculum and its plant regulator compounds in crop yield of corn (*Zea mays* L.) in the field. 2009. Puente, M., García, J. and Peticari, A. World J. Agricult. Sciences 5 (5): 604-608.
- Field inoculation of wheat (*Triticum aestivum* L.) and corn (*Zea mays* L.) with *Azospirillum brasilense* in the Pampas region, Argentina. 2004. Díaz-Zorita, M.; Baliña, R.; Fernández-Canigia, M.; Penna, C. and Peticari, A. 22nd Latin-American Conference on Rhizobiology - 1st Brazilian Conference on Biological Nitrogen Fixation. Brasil.

Region: Africa

Information sources:

- Ken Giller. Biological Nitrogen Fixation (BNF) in Africa. A current research project. Article 07 at <http://info.ipni.net/biofertilizers>

- Joyce Jefwa. Benefits and potential use of Arbuscular Mycorrhizal Fungi (AMF) in banana and plantain (*musca* spp.) systems in Africa. A current research project. Article 08 at <http://info.ipni.net/biofertilizers>

Region: Russia

Staff observations

Included in staff review papers by Drs. Ivanova and Nosov.

Additional information:

- Ivanova. Bio fertilizers in Central Russia region. Article 09 at <http://info.ipni.net/biofertilizers>
- Nosov. Efficiency of biofertilizers in Southern and Eastern Russia. Article 10 at <http://info.ipni.net/biofertilizers>

Region: South Asia

Staff observations:

Biofertilizers have received special attention in arid zones of India, and in horticultural, medicinal, and oilseed crops.

Additional information:

- A book entitled "Bio-fertiliser Statistics" published by the Fertilizer Association of India (Price: Rs. 350) has relevant information for India in one place. Biofertilizer Statistics – India (2006-07). Article 11 at <http://info.ipni.net/biofertilizers>
- FAO article on "Greening Agriculture in India" that starts with potential demand for biofertilizers in India etc.: http://www.fao.org/DOCREP/ARTICLE/AGRIPPA/658_en-03.htm
- Some more biofertilizer statistics from Govt. of India: http://fert.nic.in/production/bio_fertilizers.asp
- Two reviews on promoting biofertilizers in Indian agriculture
 - Promoting Bio-fertilizers in India Agri. Article 12 at <http://info.ipni.net/biofertilizers>
 - Need of Biofertilizers in India. Article 13 at <http://info.ipni.net/biofertilizers>
- A research paper highlighting the positive effect of using biofertilizers as fertilizers in a medicinal plant, and making another significant statement "such increased effects have been found to be further enhanced significantly due to dual or other compatible mixtures of inoculants resulting from their strong synergistic relationships among themselves". Biofertilizer Effect on Yield and Nutr Content of a Medicinal Plant. Article 14 at <http://info.ipni.net/biofertilizers>
- Biofertilizer production units in India. <http://www.dacnet.nic.in/ncof/PRODUCTIONUNIT.htm>
- List of some biofertilizer manufacturers and suppliers, with a research lab in Pune producing nine (9) different kinds of biofertilizers: http://www.indiaagronet.com/indiaagronet/Technology_Upd/niku_bio%20res%20lab2.htm AND <http://www.indianindustry.com/pesticides/1116.html>

- A newspaper report on Indian Biofertilizer Industry's market and its potential: India's Bio Fertilizer Firms on High. Article 15 at <http://info.ipni.net/biofertilizers>
- Biofertilizer prices in India: <http://www.indianprices.com/fertilizerprice.html>

Region: China

Staff observations:

In China, in a narrow sense, bio-fertilizers are defined as microbe fertilizers or microbe inoculate preparations. In a broad sense, they are defined as types of biological preparations made by biological technology that have special fertilizer effects or stimulatory effect on crops. China has over 300 bio-fertilizer producing enterprises with annual product output of about half million tones. The bio-fertilizer application area in China has reached 167 million hectares at present. Staff have not seen evidence that any bio-fertilizers, beyond the standard Rhizobium inoculants, work well in China.

Additional information:

- Cheng. Issues related to development of bio-fertilizers in China. This paper, by Prof. GE from CAAS who was the leader in this field for years and served as the director in MOA's Bio-fertilizer Inspection and Quality Control Center for several years, is in Chinese. The China program staff translated the main points of the paper into English. Article 16 at <http://info.ipni.net/biofertilizers>
- Five of the most comprehensive review papers are included here that remain in Chinese for those that can read the language. Article 17 at <http://info.ipni.net/biofertilizers>

Region: SE Asia

Information sources:

- Current Status and Future Direction of Commercial Production and Use of Bio-Fertilizers in **Japan**: <http://www.agnet.org/library/eb/600/>
- Current Status of Bio-Fertilizers and Bio-Pesticides Development, Farmer's Acceptance and Their Utilization in **Korea**: <http://www.agnet.org/library/eb/601/>
- Bio-Fertilizers and Bio-Pesticides Research and Development at Uplb, **Philippines**: <http://www.agnet.org/library/eb/602/>
- Current Status of Bio-Fertilizers Development, Farmers' Acceptance and Utilization, and Future Perspective in **Taiwan**: <http://www.agnet.org/library/eb/603/>