

PROMOTING GROWTH WITH PGPR

By Stuart McMillan

Most organic growers know that a huge number of living organisms are found in just a spoonful of soil. But this diversity is not evenly distributed. Much of soil could be viewed as a desert, but occasionally one comes to an oasis filled with life. These oases are where plant roots are.

At a molecular level, plants are rather leaky. They are perpetually sloughing off cells, leaking moisture, nutrients, carbohydrates and other compounds. Because the plant roots provide food, shelter and energy, areas of very high biological diversity are found directly on roots and the areas next to them. This area is collectively called the rhizosphere [‘rhizo-’ = root].

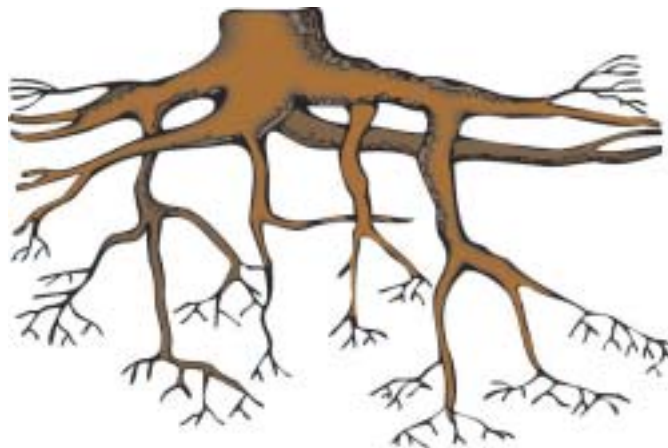
Organic farmers and gardeners have long recognized the importance of soil biology. Early on, they saw the role of rhizobia, mycorrhizae, biological control organisms, and the whole of the soil foodweb in maintaining soil quality for crop production. However, rhizobia and mycorrhizae are just a small portion of the total biodiversity in the soil. Although our knowledge has increased, we remain woefully ignorant about soil biology. There is a group of soil bacteria that few people, let alone organic growers, know about. This is a group of bacteria known as plant growth promoting rhizobacteria (PGPR).

PGPR

Plant growth promoting rhizobacteria are bacteria that colonize plant roots, and in doing so, they promote plant growth and/or reduce disease or insect

damage. There has been much research interest in PGPR and there is now an increasing number of PGPR being commercialized for crops.

Organic growers may have been promoting these bacteria without knowing it. The addition of compost and compost teas promote existing PGPR and may introduce additional helpful bacteria to the field. The absence of pesticides and the more complex organic rotations likely promote existing populations of these beneficial bacteria (see box on next page).



The rhizosphere is an area of high biodiversity.

to ensure adequate nitrogen fixation. However, it is also possible to inoculate seeds with other bacteria that increase the availability of other nutrients, including solubilizing phosphate, oxidizing sulphur, chelating iron and copper.

Phosphorus (P) frequently limits crop growth in organic production. Although rock phosphate is an approved source of phosphorus, its availability to plants is limited under most growing conditions in Canada. If you inoculate seed with the specific bacteria capable of providing P in a plant-available source, these PGPR will quickly colonize plant roots.

Inoculating seed

Organic farmers are familiar with the practice of inoculating legume seed with specific *Rhizobium* strains

Bacteria in the groups *Bacillus*, *Rhizobium* and *Pseudomonas* have proven to be the most powerful phosphate-solubilizing bacteria.

Plant growth promoting rhizobacteria (PGPR) are bacteria that colonize plant roots, promote plant growth and/or reduce disease.

The fourth major plant nutrient after N, P and K is sulphur (S). Although elemental sulphur, gypsum and other sulphur-bearing mined minerals are approved for organic production, the sulphur must be transformed (or oxidized) by bacteria into sulphate before it is available for plants. Special groups of microorganisms can make sulphur more available, and do occur naturally in most soils. Unfortunately they generally make up less than one percent of the total soil microbial biomass. On the prairies, inoculating S-oxidizing bacteria onto the seeds of high S-demanding crops, such as canola, has proven quite successful.

One of the most common ways that PGPR improve nutrient

uptake for plants is by altering plant hormone levels. This changes root growth and shape by increasing root branching, root mass, root length, and/or the amount of root hairs. This leads to greater root surface area, which in turn, helps it to absorb more nutrients.

Disease control

PGPR have attracted much attention in their role in reducing plant diseases. Although the full potential has not been reached yet, the work to date is very promising and may offer organic growers some of their first effective control of serious plant diseases.

Some PGPR, especially if they are inoculated on the seed before planting, are able to establish themselves on the crop roots. They use scarce resources, and thereby prevent or limit the growth of pathogenic microorganisms. This is a common way that PGPR reduce the severity of damping-off (*Pythium ultimum*) in many crops. Even if nutrients are not limiting, the establishment of benign or beneficial organisms on the roots limits the chance that a pathogenic organism that arrives later will find space to become established.

Numerous rhizosphere organisms are capable of

Ways that PGPR promote plant growth

- Increasing nitrogen fixation in legumes
- Promoting free-living nitrogen-fixing bacteria
- Increasing supply of other nutrients, such as phosphorus, sulphur, iron and copper
- Producing plant hormones
- Enhancing other beneficial bacteria or fungi
- Controlling fungal diseases
- Controlling bacterial diseases
- Controlling insect pests

producing compounds that are toxic to pathogens (plant diseases). *Bacillus subtilis* is one such commercialized PGPR organism, and it acts against a wide variety of pathogenic fungi.

Challenges with PGPR

One of the challenges of using PGPR is natural variation. It is difficult to predict how an organism may respond when placed in the field (compared to the controlled environment of a laboratory). For example, an organism may perform well in the lab, but not have the ability to compete with the existing organisms when put in the field.

Another challenge is that PGPR are living organisms. They must be able to be propagated artificially and produced in a manner to optimize their viability and biological activity until field application. Like *Rhizobia*, PGPR bacteria will not live forever in a soil, and over time growers will need to re-inoculate seeds to bring back populations. Some PGPR

Average number of organisms in 1 cubic centimetre of agricultural soil

Bacteria	90 000 000
Actinomycetes	4 000 000
Fungi	200 000
Algae	30 000
Protozoa	5 000
Nematodes	30
Earthworms	< 1

need to be re-inoculated every season. This can be seen as a benefit since it shows that the amount of naturally occurring bacteria quickly goes back to normal after a season.

In theory one could try to culture PGPR like a sourdough starter, save a portion and regrow a new batch. However, they are very difficult organisms to grow and maintain, and it is likely best left to a laboratory with the right tools and a sterile workspace.

An additional challenge is regulatory. Each country has different risk assessment and efficacy testing policies and Canada has very stringent controls. A huge number of biological control products for common pathogens are commercially available, but only a handful of them are listed for use and registered in Canada. Certainly, the unregulated release of potentially damaging biological organisms should not occur, but the procedure could be simplified to the benefit of organic and sustainable growers.

Availability

Currently there are only a few PGPR available commercially in Canada.

- BioBoost is made by Brett-Young in Winnipeg for use on canola. In the prairies, farmers found that applying BioBoost to canola seed led to yield increases of an average of eight bushels per acre.
- Mycostop controls a wide range of soilborne seed and root diseases and is registered for many vegetables and field crops. It is applied as a liquid to potting soil, garden beds or mature plants. It is available from a number of on-line gardening suppliers and from

some garden stores.

- Subtilex is a *Bacillus subtilis* based biofungicide that has also been found to increase nitrogen fixation. It is distributed in Canada by Premier Horticulture based in Quebec. It is blended with water, compost tea or a nutrient solution and sprayed on soil before planting or transplanting.

In general, most PGPR would fit with the new Canadian organic regulation, and the organic regulations in other countries. The main concerns are that the PGPR are not genetically modified in any way, and that all of the stickers, carriers and other materials are natural and meet the allowed substances list. Of course, growers should always contact their certification bodies before using any substance.

While there are challenges for the use of PGPR on organic farms, the possibility of tremendous benefit does exist. Growers are encouraged to do their homework to understand their specific needs: which organisms could help them and the limitations of those organisms. While the list of PGPR organisms available in Canada remains small, it is likely to increase in the future and growers

should keep their eyes open for them as they become available.

Stuart McMillan works as an organic inspector in Manitoba and frequently can be found in a field with his nose in a flower or close to the ground. He welcomes questions and feedback at salmagundiag@hotmail.com.

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