# DEVELOPMENT OF PLANT GROWTH PROMOTING RHIZOSPHERE ORGANISMS TO ENHANCE PRODUCTIVITY OF CEREALS AND LEGUMES IN DRY-LAND FARMING IN SOUTHERN AUSTRALIA

**Lambert Bräu**[1], Rebecca Swift[1], Graham O'Hara[1], Giles Hardy[2] and John Howieson[1]

[1]Centre for *Rhizobium* Studies, Murdoch University, South Street, Murdoch, Western Australia 6150, Australia
[2]Centre for *Phytophora* Science and Management, Murdoch University, South Street, Murdoch, Western Australia 6150, Australia

There is a substantial and increasing effort to develop microorganisms for agricultural purposes to improve the sustainability and profitability of rural activities whilst increasing productivity. These are generically termed Plant Growth Regulating Rhizosphere organisms (PGPR), and the number of research groups that are involved in their isolation and/or characterisation is growing. Examples of PGPR organisms that have been shown to be beneficial include microbial biofertilisers, biocontrol agents for weed suppression, and plant stimulants from Actinomycetes, and the fungal and bacterial genera *Trichoderma, Penicillium, Pseudomonas, Agrobacterium, Azospirillum, Azotobacter, Acetobacter* and *Bacillus*. The use of these organisms is now seen in the fields of agriculture, horticulture, forestry and environmental restoration. The specific mechanisms of plant growth enhancement by PGPR have not been well characterised but their modes of action are broadly divided into two categories, *viz.* enhancement of plant growth by indirect and enhancement of plant growth by direct means.

Indirect mechanisms involve the ability of PGPR to reduce the deleterious effects of plant pathogens on crop yield and may be achieved by one or more of the following means:

- antibiotic production against pathogenic bacteria,
- reduction of iron available to phytopathogens in rhizospheres,
- synthesis of fungal cell wall-lysing enzymes,
- competition with detrimental microorganisms for sites on roots.

Direct mechanisms may include:

- nutrient solubilisation (P, N and K),
- production of plant growth regulators,
- suppression of plant pathogens by competition,
- release of antibiotics or siderophores.

Significant effort to date has focused on isolating PGPR organisms that are involved in the production of plant growth regulators. One of the most commonly known naturally occurring plant auxins is indole acetic acid (IAA). It is synthesised by plants from the amino acid tryptophan and is produced in the apical meristem of shoots from where it diffuses downward, suppressing the growth of lateral buds. Bacterial IAA has been shown to enhance root development. Thus, the ability of bacteria to produce IAA has been used as an assay to identify potential PGPR.

The ability of rhizosphere organisms to produce the enzyme ACC deaminase has also been more recently adopted as a means of isolating PGPR organisms. 1-amino-cyclopropane-1-carboxylate (ACC) is the plant ethylene precursor. Sustained high levels of ethylene can inhibit root elongation in developing seedlings. ACC deaminase cleaves this compound to produce ammonia and 2-oxobutanoate, thereby lowering the levels of ethylene in a developing or stressed plant and thus potentially enhancing growth. The bacteria benefit by being able to use the ammonia produced as a nitrogen source. Screening techniques have therefore been developed where potential PGPR are selected for by their ability to grow on ACC as their sole nitrogen source.

Since 2002, our group has conducted field trials on a small number of PGPR on various legumes, including clover, peas and lupins, where the PGPR organisms have been co-inoculated with the appropriate legume micro-symbiont. Results have shown on a number of occasions that co-inoculation of legumes with PGPR results in better nodulation (Figs 1 and 2) than *Rhizobium* only inoculant. These results have been very encouraging and we are currently trying to understand the mechanism responsible for this increased nodulation when both PGPR and rhizobia are co-inoculated.

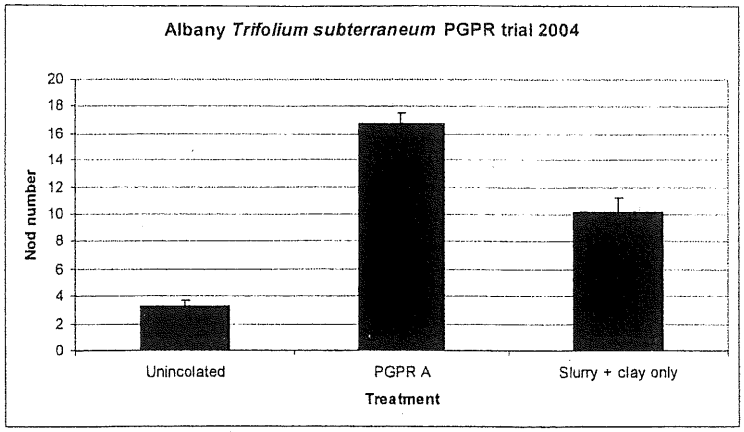


**Figure 1.** Nodulation of clover enhanced as a result of PGPR co-inoculation by comparison with *Rhizobium* only inoculated plants and uninoculated controls.

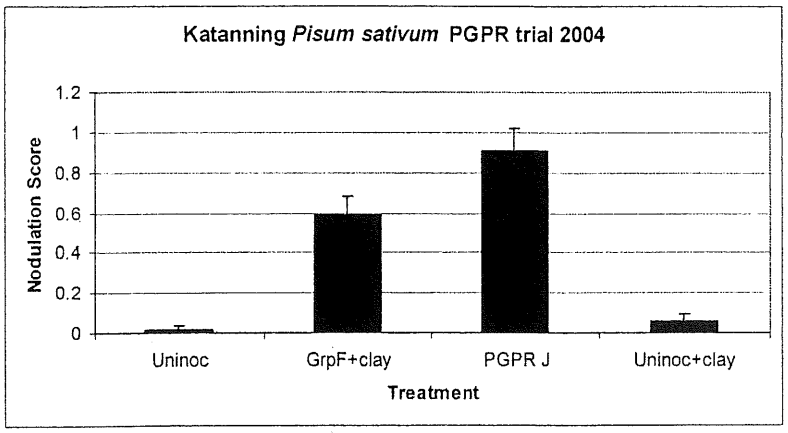


**Figure 2.** Nodulation of peas enhanced as a result of PGPR co-inoculation by comparison with *Rhizobium*-only inoculation and uninoculated controls. The clay control refers to use of ALOSCA™ as a delivery system.

Efforts within our group in the last 12 months have also focused on isolating a number of new micro-organisms with plant growth promoting potential from soils in various location in Western Australia. To date, 166 strains have been isolated and purified, with 118 of them assayed for IAA production. Fourteen have been selected for their capacity to produce high levels of IAA, and a subset of these is currently under trial at three Western Australian locations at Kojonup and Wongan Hills on peas (*Pisum sativum* cv. Parafield) and wheat (*Triticum aestivum* cv. Wyalkatchem). Shoot and root dry weights, yields and seed nitrogen, as well as treatment effect on the nodulation of the peas, will be determined from these trials. Trials using growth pouches as well as glasshouse pot trials are being conducted concurrently on this subset of isolates to measure their plant growth promoting ability *in planta.*

A further 13 isolates with ACC deaminase-producing ability are also currently under test in growth pouches and glasshouse pots. Promising isolates from these tests will be included in extended field trials to be conducted in 2006.