The world of nitrogen fixation series

Part 1 – Types of nitrogen fixation

By ADAM WILLSON

Following photosynthesis, nitrogen fixation is the second most important process in crop production. Photosynthesis captures sunlight and produces energy, and nitrogen fixation uses nitrogen gas to form ammonium.

For the organic producer, other than organic fertilisers, nitrogen fixation is a major source of nitrogen for crop production. If managed correctly, nitrogen fixation can provide for free up to 300-400kgN/ha/yr. Unfortunately, most producers don't understand how to maximise nitrogen fixation and pay dearly in either yield or quality decline.

NITROGEN FIXATION AND PROKARYOTES: The process of fixing nitrogen from the air is carried out by a broad group of microbes called prokaryotes. These include a number of bacteria, cyanobacteria (blue green algae) and the actinomycete, Frankia.

These nitrogen fixing microbes can exist as either symbiotic, associative or free living organisms, differing mainly in energy source and fixing ability. A simplified table (from K Isermann) explaining the differences is set out below.

SYMBIOTIC NITROGEN FIXATION: Symbiotic nitrogen fixation is a mutual relationship between the plant and a microbe. The microbe firstly invades the root and later forms nodules in which nitrogen fixation takes place.

The plant or host supplies the microbes with plant sugars (sucrose) and the nitrogen fixing microbe supplies the host with a highly available form of nitrogen. The most common symbiotic relationship occurs in legumes (like white clover, lucerne and mung beans).

ASSOCIATIVE NITROGEN FIXATION: In associative nitrogen fixation, certain nitrogen fixing bacteria establish themselves close to the root or can be found on the leaf surface.

They use root exudates, secretions and sloughed cells as an energy source. Some bacteria like *Acetobacter* can occupy internal root tissues of sugarcane. The amount of nitrogen fixed by these microbes is indirect, as 90% of the nitrogen only becomes available when the bacteria die.

A good sign that your legume is performing well is even crop emergence and a healthy root system. Since farming first began, growers have known of the benefits of using quality compost.

FREE LIVING NITROGEN FIXATION: A number of nitrogen fixing microbes do not require symbiosis, leaf or root exudates as a primary source of essential energy. These microbes are free living and live on either plant residues or photosynthesise themselves. As a result, the amount of nitrogen fixed is relatively small.

SUMMARY: There are three main ways in which nitrogen fixing microbes convert nitrogen gas into ammonium. Each system requires a different source of energy to drive the chemical reactions.

Over the next two issues we will see how nitrogen fixation works, and how farm managers can best manage this critical process. ■

Adam Willson is the director of Soil Systems Australia based in south-east Queensland. Soil Systems Australia specialises in agronomic advice for professional organic growers; phone (07) 3716 0688.

System of N fixation	Symbiosis	Associations	Free living	
Microbes involved	Rhizobium Actinomycetes	Azospirillium Azobacter Acetobacter	Azobacter, Klebsiella, Rhodospirillum	
Where fixation occurs	Inside root	Around roots	In soil	In soil
Energy soure (carbon)	Sucrose & metabolites from host plant	Sucrose & metabolites from host plant	Plant residues	Photosynthesis
N fixation (kgN/ha/yr)	Legumes 50-400 Non legumes 20-300	10-200	1-2	10-80