Trading carbon for nitrogen

By Graeme Jennings

'No-till Bill' Crabtree is an agricultural scientist and mainstream agricultural consultant. He is also a keen observer of cropping and natural systems and some of his – and others' –observations suggest non-legume rotations might be more sustainable than previously thought.

Growers in regions for which there is no profitable legume option may not be as badly off as some may think.

It has long been recognised that there are 'free-living soil organisms with the ability to 'fix' atmospheric nitrogen (N) into forms available to plants. The question is how much N these organisms can provide for cropping systems.

"Australian scientists like Gupta Vadakattu, David Roget and Margaret Roper have found clues and have talked about free living N-fixing bacteria giving us about 20 kgN/ha but we often see much more than this," said WA-based consultant Bill Crabtree.

"After 26 years I have become very confident that 'free-living' soil organisms can provide 40 to 80 kgN/ha a year given the right conditions."

Four years ago he bought 2,800 hectares of cropping land in the Morawa district, about 190 kilometres inland from Geraldton. Since then he has seen soil N levels quadruple under a regime of wheat on wheat on wheat on wheat and application of just enough N fertiliser to replace the amount of N taken off in grain.

"I have applied N at rates from six to 30 kg/ha, depending on soil type and the paddock, and most paddocks look like yielding two to three tonnes a hectare this year.

"When we bought the property we measured 30 kgN/ha in the top metre of soil. Now I have measured 120-220 kgN/ha to the same depth. And that is with soil carbon levels of only 0.5 to 0.6% that have remained static through this time in my hot, dry district. Our average rainfall is 305 mm and we are on the same latitude as Brisbane. But it seems we only need 25 mm or so of summer rainfall for N-fixing organisms to fire up and I have had quite a few of these events since buying the farm.

"The exciting thing is that I have been seeing this for 15 years on other farms all over the globe.

"Wherever I go I have growers come up to talk about this. They are seeing this happening in their paddocks.

"One farmer who had been growing wheat on wheat for eight years in 600 mm rainfall country without any major problems decided to put the 'full' rate of urea on a paddock but found it made no difference to his yields; he harvested 8 t/ha where he used 40 kg/ha of urea and where he applied 300 kg/ha.

"I have talked with Australian and overseas scientists, farmers and agronomists who are seeing the same sort of results, in crops like sugar cane as well as cereals. Most are still reluctant to talk about them but I think now it is time to let people know what we are seeing."

These high soil N levels under non-legume rotations such as wheat on wheat or wheat/canola are being reported in the context of no-till but the key issues appear to be increased carbon inputs from stubble retention and no legumes.

In a rotation that includes legumes inoculated with the appropriate rhizobial bacteria the rhizobia will fix N that will become available to soil organisms. This will have the effect of suppressing the activity of 'free-living' N-fixing organisms because they will be out-competed by general soil biota that can access the N fixed through the legumes.

"Nature has a vast array of micro-organisms that digest carbon and they are constantly adapting to our new no-till environments," Bill said.

"Give them a carbon-dominated diet and the bug population will find a way to use this free energy."

In most instances that is likely to require N, an essential element in the proteins that are integral to all organisms.

"There are numerous N-fixing bugs in the soil, in the rhizosphere and in the gut of larger creatures and those of us with a science background need to talk about this so farmers have the information they need to make good decisions on inputs and the confidence to believe what they are seeing in their paddocks.

"I don't fully understand exactly what is going on but there is no doubt that, given the right conditions, soil organisms can fix and make available a lot of N without legumes in the rotation.

"And it is very clear this can be achieved with standard farming management and inputs. There is no need to add microbes or other exotic stimulants."

The number of years of stubble retention, the size of those stubbles, the specific rotation, soil type, temperature and moisture will all influence the activity of soil microbes including those that 'fix' N, Bill said.

He advocates that growers looking to encourage the activity of free-living N-fixing soil bacteria band N fertiliser close to crop rows.

This will ensure the plants have sufficient N to produce good early crop growth without increasing N levels in the inter-row space; maximising the potential for build-up and activity of N-fixing micro-organisms in that lower-N soil.

Insects could also have a role in the crop N equation.

"An interesting study by CSIRO scientist Theo Evans showed the value of termites in the region where I farm, about 100 kilometres north-east of Geraldton.

"Termites have bacteria in their gut that fix N. They get carbon from the organic matter they eat and use the energy from that to split inert N_2 nitrogen molecules from the air to obtain the N they need to grow and multiply. This N then becomes available organic N that can be recycled.

"I can see termites almost everywhere I look in my medium to heavier soils."

Dr Evans, a CSIRO scientist studying the roles of ants and termites in the environment, is part of a team that found that the presence of ants and termites in dryland cropping systems increased wheat yields by an average of 36% in low-tillage cropping systems.

He sees two main reasons for this yield increase.

“First, tunnels dug by ants and termites let more rain penetrate deeper into the soil where plants can access it, which also reduces runoff and evaporation. Second, the insects improve soil N, probably because termites have N-fixing gut bacteria that are functionally similar to those in the root nodules of legumes.”

The role and impact of termites in cropping systems is explored in Bill’s latest book, ‘Search for Sustainability’, and will be part of presentations he will deliver in the US and Canada in January.

But, he cautions, growers should not expect miracles and need to measure what is happening in their soils and crops.

He advocates deep nitrate tests to measure how much N there is in the soil and where it is positioned in the root zone and tissue tests or NVDI measurements to monitor the N status of crops. If in-crop measurement shows a crop is N-deficient at a significant growth stage the crop can be top-dressed with N fertiliser to maintain yield potential; though applying high rates of N may discourage free N fixation.

He also suggests growers also monitor sulphur levels.

“Sulphur is an essential element in amino acids, which are the ‘building blocks’ of protein.

“Since free-living N-fixing organisms are, in general terms, fixing N to build protein, a lack of sulphur could inhibit the biological processes that are seeing N become available to crops.”

Bill acknowledges that N contribution is only one of the potential benefits of legumes in a cropping; with a ‘disease break’ and weed control options also important management considerations.

But canola provides a disease break and grass control options, particularly where growers have access to GM herbicide-resistant canola, he said.

“There are several herbicide tolerant canola options but growers who have access to Roundup Ready technology can be very confident about achieving very good weed control during the canola year.

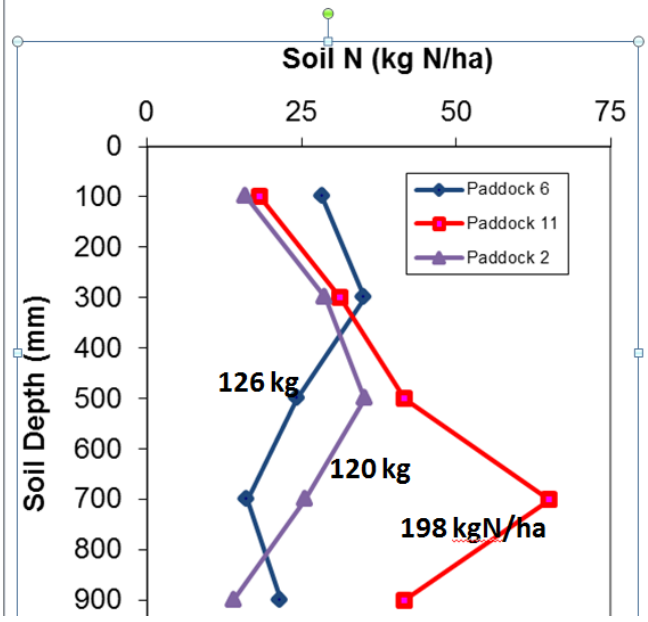
“And not all legumes provide a good disease break. Medic, for example, is a very good host of pratylenchus so growing a medic where pratylenchus is present encourages a potential nematode problem the following year.

“More power to growers who can grow good crops of grain legumes and make money out of them while gaining the other benefits but it is becoming increasingly clear that this is not the only option.

“Building up carbon levels so soils can support large populations of bacteria and fungi and avoiding high N inputs from fertilisers or legumes can provide the same N benefits as a good legume, which opens the way for use of other broadleafed crops for ‘break’ and weed control benefits.”

ENDS.

3 years continuous wheat [08/09/10] at Morawa
4 t/ha wheat at 12% prtn exported over 3 years



Applied:

40 L UAN	17
105 kg DAP	18
50 kg urea	23
20 kg AmSul	4
	= 62 kgN total

Removed 4 t = 100 kgN/ha

Net result = - 38 kgN

Yet OC unchanged at 0.6%

N result: +120-198 Plus 38

Equals 53-75 kgN/ha/yr!!