The brussel sprout vs. the silver bullet

Garth Lamb

Brassica vegetables are an acquired taste because they produce sulphur compounds that usefully kill crop scourges such as bacterial 'wilt'.

For many of us, a mouthful of brussel sprouts or cabbage awakens vibrant childhood memories of 'eat them or you'll get no dessert!' But research has recently shown that the same chemicals responsible for the strong tastes in these members of the brassica plant family could also efficiently suppress some soil-borne crop diseases.

While crop rotation as an agricultural control has been around for as long as 3000 years, no one fully understands its potential benefits. A few years ago, CSIRO Plant Industry agronomist Dr John Kirkegaard re-discovered that certain rotation crops are much more advantageous after investigating why higher wheat yields follow brassica crops like canola, compared to non-brassicas like linseed or lupins. He found, 'a body of anecdotal evidence that brassicas were doing something extra'.

In 1994 the CSIRO, through Dr Muhammad Sarwar, started to seriously look at what makes brassicas better break crops. Research showed a range of sulphur-containing compounds called glucosinolates (GSL) are common throughout the brassica family. GSLs differ, however, between brassica species in terms of type, concentration and distribution throughout the plant.

As brassica tissues break down in the presence of water, GSLs are converted to isothiocyanates (ITC), the chemicals responsible for such strong tastes in brassicas. Mustard seeds, for example, release their hot flavour after chewing breaks them down to produce ITCs.

It turns out that ITCs are also highly toxic to a range of plant pathogens, and those found in brassicas can be up to 50 times more toxic than similar compounds in commercial fumigants. In fact, the use of plants containing biologically active compounds to suppress soil-borne pests and diseases has come to be termed 'biofumigation'.

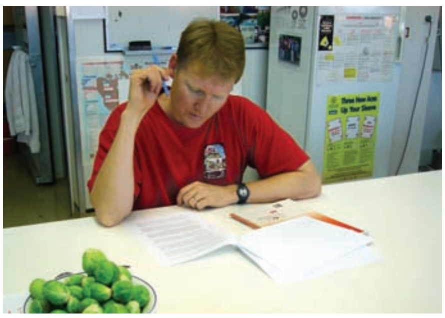
'In the cereal rotation we have evidence that biofumigation occurs, but benefits to the following wheat crops only arise in specific circumstances, and there are probably not enough effects to warrant a big investment in a breeding program … Biofumigation appears to have a lot more potential in the horticultural industry,' says Dr Kirkegaard.

In horticulture the choice of brassica is not limited to canola or mustard. Cabbage, broccoli, brussel sprouts, radish, cauliflower and turnips all contain GSLs. And in cereal crop rotation use, only the mature brassica roots, containing about 5% of total plant GSL, remain in the soil. In horticulture the entire plant can be ploughed in.

Choosing when to plough in crops for maximum impact also gives horticulturalists more control than is possible while waiting for canola roots to break down after harvest.

Plants grown and incorporated specifically to benefit the soil are called 'green manures'. Brassicas used as green manures could provide pest and disease suppression and reduce the need for synthetic pesticides.

The horticulture industry currently has very reliable solutions for soil disease – 'silver bullet' synthetic chemicals that can achieve 100% pathogen kills. The main factor limiting uptake and adoption of biofumigation is that it can probably only provide 60–70% suppression. Used in conjunction with other chemical or cultural controls, biofumigation may increase this suppression.



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John Kirkegaard says work to increase the productivity of Filipino farms is yielding lessons about how biofumigation could play an important role in Australian horticulture.

'In developed countries like Australia, the problem with biofumigation is that we can't promise the same level of control as the current chemicals. Of course, the problem for growers is those chemicals, one by one, are being removed from the market – either by law, or because consumers are saying we don't want to buy vegetables that are being grown with pesticides,' says Dr Kirkegaard.

Chemicals, while effective, are also expensive. Growers can spend $2000 a hectare on commercial fumigation. The cost of biofumigation is around $50 to $100 a hectare.

The current three-year biofumigation project at CSIRO, due to end in 2004, is funded by the Australian Centre for International Agricultural Research (ACIAR). Brassicas are being field tested in north Queensland and the Philippines for their ability to suppress plant disease, particularly bacterial wilt and root knot nematodes.

The research has great potential benefits for the environment, farmers and consumers. One aspect Dr Kirkegaard

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considers particularly important is ‘the humanitarian side of just helping people out of a bit of a bind’. Most Filipino farmers cannot often afford farm chemicals, and soil diseases like bacterial wilt can wipe out 60% of crops every year.

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Numerous factors are pushing people away from harsh synthetic chemicals, and Dr Kirkegaard is pleased that biofumigation research has provided some practical solutions. A number of commercial seed companies now sell mixtures of brassica plants under the label ‘biofumigant’. Pelletised mustard-seed meal is also being used in areas of horticulture where people want to minimise exposure to synthetic chemicals, such as the cut-flower industry and on golf courses.

One major recent development has been increasing the amount of ITC released. Compared to using a rotary hoe, mulching plant tissue and then irrigating can provide as much as a 100-fold increase in ITC release. As understanding of the mechanisms behind biofumigation develops, the next step is selecting and marketing the best plants to use as biofumigants.

‘We’ve taken a lot of the guess work out of it and started other researchers on a path that’s liable to lead to other success … Growers can now trial options for themselves to test the effectiveness of biofumigation for their particular pest and crop combination,’ says Dr Kirkegaard.

Questions remain as to which brassica plants are most suitable for controlling various pests in different farming systems. Funding may become available for further research looking at more diseases, in more areas and other crops. With increasing concerns over synthetic chemical use, biofumigants may have a significant role in integrated pest management.

● **Garth Lamb**

More information
Biofumigation research overview
www.ento.csiro.au/research/pestmgmt/ biofumigation/newsletter_list.html

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Enticing mat cleans up – fast

PRECIOUS BODIES of groundwater are vulnerable to contamination by fertilisers, pesticides, industrial waste and other pollutants. Cleaning them up is usually a very complex and costly business.

But Dr Bradley Patterson of CSIRO Land and Water and Dr Allan McKinley of The University of Western Australia have developed a polymer-mat system which, when immersed in the groundwater, can be used to deliver oxygen, ethanol or other reagents to beneficial microbes which will quickly decontaminate polluted water free of charge.

The inputs promote the action of the countless harmless bacteria in the water because the oxygen and the energy in the carbon-rich ethanol allows them to multiply and increases their metabolic activity. This means they can be enticed to remove a range of contaminants.

In six-month long laboratory experiments on columns of slow-moving groundwater, the researchers found that addition of these substances via a series of permeable polymer-mat barriers led to sequential remediation of water that had suffered contamination with ammonium.

As the water passed through the barriers, the additional oxygen induced microbes on the mats to convert the ammonium (NH_4) to nitrates (NO_3) and nitrites (NO_2), while infusion of ethanol caused the microbes to then turn these into nitrogen gas – a completely benign product. This left the water largely free of the original contaminant within just days of the system stabilising.

CSIRO Land and Water

In field trials, mat barriers of woven polymer tubing (shown) were installed in flow-through treatment boxes dug into groundwater-bearing sand.

The conventional solution when groundwater is contaminated with ammonium or nitrates due to industry, sewage treatment lagoons, or fertiliser use, is to pump large volumes of the dirty water to the surface and subject it to prolonged treatment, before returning it underground. ‘Permanent reactive barriers’, however, such as the CSIRO–University of WA system, can be used underground and should be cheaper overall because natural hydraulic pressure gradients push the water through the cleansing barriers, removing the need for pumping.

‘We have now completed a field trial using our system and this successfully removed 90% of the ammonium from an underground plume of badly polluted water at a site in Perth,’ says Patterson. ‘It entailed burying, by vibration, a 20-metre-long barrier system in saturated sand to a depth of seven metres and letting the bugs do their work. We are confident that the technique can be further scaled-up by use of many such modules.’

Wider tests have shown that the system can also deal with herbicide contamination.

Wider tests have shown that the system can also deal with herbicide (atrazine) contamination. With some further refinement of the innovative method, Patterson and McKinley say it will be ready for commercial application.

● **Steve Davidson**

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