

MUSTARD CUTS THE



Spectacular results of experiments to control soil disease in tobacco, and the predicament of vegetable growers in Southeast Asia seeking a defence against bacterial wilt, led to an ACIAR project which has delivered promising results in some unexpected ways, writes Robin Taylor

In 1999 former CSIRO Entomology chief Max Whitten was running the Food and Agriculture Organization (FAO) vegetable integrated pest management (IPM) program in Asia. During training exercises for farmer field schools, many of the field trials which had been set up to investigate insect pests were being devastated by bacterial wilt – a soilborne disease that is a major problem for vegetable growers throughout the tropics.

Dr Whitten approached a CSIRO colleague, John Kirkegaard, who for many years had been studying the use of brassica green-manure crops such as canola and mustard to control soilborne diseases, to see if they could have the same effect on bacterial wilt.

A few years earlier, Dr Steve Akiew, a researcher with the Queensland Department of Primary Industries and Fisheries (QDPI&F), working on tobacco in Mareeba, northern Queensland, read about the ability of brassicas to suppress disease and wondered if they could be used against bacterial wilt.

He decided to conduct his own experiment, grew some mustard and mixed it into soil infested with bacterial wilt. The results were spectacular. In the treatment with mustard leaves added to the soil, the bacterial wilt completely disappeared. In field trials there was a 77 per cent reduction in the disease.

With the demise of the tobacco industry in the area, the work stopped, but Dr Kirkegaard did not forget the results. “The effect of brassica tissues on bacterial wilt was the most spectacular impact I’d seen on any organism,” he says. “We’d seen suppression in other organisms but Steve’s work on tobacco, where he put it in the soil and then could not isolate the bacteria – I’ve never seen anything like that. When I realised that the bacterial wilt causing problems in the Asian vegetables was the same organism that Steve had worked on, we showed Max Whitten the results and he became convinced that we should investigate it as a treatment for vegetable crops in the Philippines.

“Farmers there were getting desperate, they were buying bleach and cement and applying them to the soil in an attempt to control bacterial wilt. They just seemed to have no practical options for control.”

In fact, bacterial wilt worldwide is the most serious soilborne disease of tropical solanaceous vegetables (plants such as tomatoes, eggplant and potatoes). It is a problem shared by the Philippines and northern Australia.

So began the ACIAR project, which aimed to evaluate the most promising brassica species in the field and to develop best management practices for using them. Researchers from CSIRO

BACTERIAL WILT



PARTNER COUNTRY:

Philippines
PROJECT: Biofumigation for soilborne diseases in tropical vegetable production (SMCN/2000/114)
DESCRIPTION: Biofumigation has potential as an environmentally friendly and economical method for controlling bacterial wilt in vegetable crops in the tropics
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The Philippine team inspects experimental plots at the QDPI&F Southedge research farm, near Mareeba in north Queensland. Dr John Kirkegaard (kneeling front left) and Dr Steve Akiew (standing right) demonstrate the approaches used in Australian cropping systems.



Senior plant pathologist Dr Rizaldo Bayot and research associate Mr Jaynor Dangan compare wilted and healthy tomato plants in a glasshouse experiment conducted at NCPC laboratories, Los Banos, in the Philippines. The tomatoes were grown in soil taken from different brassica treatments and used as a bioassay to determine impacts on bacterial wilt.

Plant Industry and QDPI&F are working with the National Crop Protection Center at Los Banos in the Philippines to identify suitable brassicas for tropical environments and to evaluate them in the field, initially on experimental farms and more recently on commercial farms and in smallholder farmers' fields.

The process where naturally occurring chemicals known as isothiocyanates (ITCs), released from brassica crops, suppress soilborne organisms when the plants decompose, has been termed 'biofumigation'.

The field work is being carried out at Mareeba and in the Philippines, while laboratory work on the chemistry behind the idea of biofumigation – that is, how to get the active chemicals out of the brassica green manures and into the soil – is being done in Canberra.

In Australia, horticultural industries are interested in biofumigation because of the worldwide withdrawal of soil fumigants such as methyl bromide and concern about reliance on highly toxic synthetic soil fumigants for pest control.

"Part of the project was to find out which of these chemicals might be more effective against bacterial wilt so we could select the right kind of brassica plant to use as green manure," explains Dr Kirkegaard. "Many people have tried this in the past with variable results. We tried

to take a structured approach, testing different brassicas."

There are many different brassicas – cabbage, mustard and canola are some of the more common ones in Australia, and there are many varieties of these crops. The different varieties vary enormously in the level of disease-suppressing chemicals they produce.

How do you get the chemicals out of the tissues of the plants and into the soil? The answer, says Dr Kirkegaard, is that you have to disrupt the cells. "In the same way that you have to chew a mustard seed to get the flavour, you need the cellular disruption to get the release of the ITC." The researchers have demonstrated this by freezing plant tissue. "If you freeze leaves and stems then thaw them you get complete cellular disruption – and 100 times more ITC is released from frozen plants than fresh."

This was a significant finding, as until this research was done all the studies had been carried out by chopping up the green manure with a rotary hoe, which leaves big pieces of plant material intact. But in the Philippines, suitable equipment is not available and chopping up the plants by hand takes so long that a lot of the chemicals are lost.

However, the project has also discovered that any organic matter added to the soil can provide some level of suppression, whether or

WASTE NOT, WANT NOT – SOURCING THE GREEN MANURE

In June, the project team ran a workshop in Benguet for farmers, farm trainers and farmer field school representatives, where they discussed the concept of brassica green-manure crops and constraints to their adoption. One of the issues that farmers raised was sourcing, transporting and chopping up enough green material to be effective.

In the Philippines, if farmers grow a large crop, be it mustard or cabbage, they will want to sell it and make money, rather than ploughing it in. In some places, suitable material is available at markets as waste. For example, when farmers sell cabbages they cut off the outside leaves, creating

a municipal waste disposal problem.

Usually, farmers load the leaves on the back of their trucks and dump them by the side of the road on the way home. In the field, when they grow crops like cabbages and cauliflowers, they cut off quite a lot of leaves and stalks, so that is another source of material.

Some larger farms, particularly in Mindanao, will consider growing a brassica crop solely for green manure. If they can control bacterial wilt in their following potatoes, the economics will add up.

“We did some quick budgeting with one of the farmers and it does pay, but it is the practical

aspects of collecting, moving and incorporating so much material around that is the main issue,” says Dr Kirkegaard.

Several ideas emerged at the workshop to find practical ways to integrate biofumigation into the farming system. For example, after a cabbage crop is harvested, a lot of stalks and other residues remain.

It is some time before the next crop of potatoes is planted, so one opportunity the researchers identified would be to broadcast rapidly-growing mustard or radish seed which, together with the old cabbage residues, could generate enough biomass to get an effect.

not the biofumigation effect is occurring.

“In the Philippines, where we know we haven’t been able to chop the tissue up really effectively and in some cases we have used sweet potato leaves (not a brassica) as a control, we have actually got very good suppression (up to 50 per cent) of bacterial wilt.”

Although the researchers were initially suspicious about this result, the more they have come to understand, the more they realise that it makes sense and is actually quite exciting. “It means that those farmers can achieve significantly better yields from using any source of organic matter and without the need for complete tissue maceration,” Dr Kirkegaard explains.

In the Australian experiments, where the plant tissues were being very efficiently macerated, they were getting additional benefits from the biofumigation. But in the Philippines, even just using a rotary hoe, or covering the material using bullock ploughs, is giving some significant suppression from the organic matter effect.

As part of the next stage of the project, the researchers are looking at developing equipment for small-scale use. The project has bought a mulching machine for one of the farmer cooperatives, but it is not clear whether this will achieve sufficient maceration and mixing through the soil.

The leader of the project in the Philippines, Ms Valeriana Justo, an extension specialist who has worked on the FAO vegetable IPM program, is using her networks to run trials in farmers’ fields.

There is no doubt about the economics – with synthetic soil fumigation, which completely sterilises the soil, growers may spend \$1000 to \$2000 a hectare compared to a biofumigation approach, which costs about \$70 a hectare. While synthetic fumigants give broad-spectrum pest control in one hit, biofumigation will need to be part of an integrated approach. “By growing one or two mustard crops a year in a paddock infested with bacterial wilt, you can get the disease levels down to a point where you can get on top of it with other strategies,” Dr Kirkegaard explains.

As consumers continue to demand less chemical approaches to pest control, growers in Australia are looking for alternatives. In recent years, Australian banana growers, for example, have started growing brassica green manures for nematode control.

In the US, farmers are using mustard green-manure crops to replace synthetic fumigation on potatoes, with a saving of US\$125 to \$269 a hectare. They are also finding other benefits such as reduced soil erosion, increased soil organic matter and fertility.

In north Queensland, results in some of the field trials have been excellent. A paddock with high-level infection of bacterial wilt at Mareeba was planted with tomatoes. An untreated block yielded less

than two tonnes of tomatoes, while the area where a brassica green-manure treatment had been applied yielded up to 20 tonnes of tomatoes and had correspondingly lower levels of bacterial wilt.

However, when this experiment was repeated on a farm with heavier soils in Mareeba, the results were not so clear-cut. The researchers believe that biofumigation is much more effective on sandy soils, where clay and organic matter cannot tie up the ITCs.

In the Philippines, trials have been planted at a range of field sites, from high-elevation areas in Benguet, with cabbages, potatoes and other temperate crops, down to lowland areas in Mindanao, where eggplants and tomatoes are the major crops.

The researchers are satisfied that they have proved the concept of using brassicas as green manure to control bacterial wilt in tomatoes in Australia and developed ‘best-bet’ management strategies for adoption. In the Philippines, difficulties in achieving adequate maceration and the loss of some trials due to typhoons, insects or drought have resulted in more variable results.

However, the most promising treatments (radish, mustard and broccoli) have reduced bacterial wilt significantly (50 to 60 per cent) in most of the experiments.

In the latest experiments the team took particular care to ensure everything was right – plants were macerated and the chopped plant material was mixed into the soil before irrigating – to try to achieve on small farmer plots what they had done in Australia.

“In June 2005 we decided to focus on one cropping system, so we are working on controlling bacterial wilt in potatoes grown in the medium- to high-elevation areas of Mindanao and Benguet,” Dr Kirkegaard says.

When potatoes become infected with bacterial wilt it is doubly devastating, because the infected potato becomes the seed for the next potato crop. Bacterial wilt in the fields of Mindanao is forcing farmers to move higher into the mountains, destroying important areas of remnant forest in the process. So controlling bacterial wilt in potato could have a large impact. In the most recent experiments, the best brassica treatments reduced infection by 50 to 70 per cent and yields at the Bukidnon site (Mindanao) increased from 7.4 tonnes to 11.1 tonnes.

While the field trials are continuing, Ms Justo is already out talking to farmer field schools and thinking about how some of the constraints to adoption can be overcome. The final experiments in farmers’ fields are under way and a field manual for biofumigation is being prepared for use in Asian vegetable farming.

The work has also been extended through the FAO IPM program into Thailand, Vietnam and China. ◀