A coordinated approach to the dissemination of brassica disease research and development through Better Brassicas

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VIC Department of Primary Industries

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Final report for the project VG 04014
(June 2006)

Better brassicas – a coordinated approach to the dissemination of brassica disease R&D.

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This report is the final report for the Better Brassica project (VG 04014).

Front cover picture shows Caroline Donald presenting at the Penrith workshop.

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Media Summary

The Brassica industry has made significant investment into researching pest and disease issues faced by the industry. A few years have elapsed since some of these projects finished. Results of this research are highly sought after but have not always been easy to access particularly if the project has been completed. The industry R&D committee decided they needed a better way to deliver this information to industry.

The better brassicas project was the result. It was designed to collate and deliver the most up to date information from current and recently completed disease management projects. This was done through a number of workshops in all the main production areas in Australia. To supplement the workshops a series of publications such as fact sheets, posters and newsletter articles covering the management of clubroot and white blister, in particular, but brassica diseases in general, were produced.

Workshops were held in

Victoria	**Western Australia**	**Tasmania**
Cranbourne	Perth	Devonport
Werribee	Manjimup	
Bairnsdale		
New South Wales	**Queensland**	**South Australia**
Penrith	Gatton	Virginia
Bathurst	Stanthorpe	

The topics covered at the workshops included

- management of clubroot
- white blister predictive modelling and fungicide control
- brassica IPM
- local industry issues, eg emerging disease issues, water, biosecurity, government policy etc.

The project evaluation showed that as result of information they received as part of the project, two thirds of surveyed workshop participants had made changes to their farming practices. Copies of posters and fact sheets were sent to all growers on IDO lists. One third of the surveyed growers who had received the information in the mail had also made changes. These changes included trying new varieties, improved farm hygiene, different chemical and/or irrigation practices and changing the soil pH.

There were many advantages to a coordinated approach to delivery of R & D outcomes including: economies of scale, grower willingness to participate and the elimination of state bias in information delivery. While the workshops did not reach all growers, those that attended were overwhelmingly positive in their feedback about the workshops. Extension of R&D requires a range of delivery methods. For those receptive and interested in attending workshops, this type of approach would appear to be a useful tool to deliver R&D information and achieve practice change. It is recommended that national road show type events, focused on one commodity to ensure the audience finds them relevant, should be conducted every three years. High quality supplemental publications would be needed to compliment these events because workshops are only ever going to be attended by a proportion of the industry.

Copies of the posters and fact sheets are available from the Vegetable Industry Development Officers or by contacting Caroline Donald at the Victorian Department of Primary Industries – Knoxfield.

Introduction

This project was designed to deliver information and stimulate adoption of disease management practices resulting from brassica research.

Brassicas are one of the most widely researched vegetable commodities in Australia. Clubroot has been researched for over 5 years and effective management recommendations exist. Whilst the project has been completed for several years the information is still relevant and current. The demand for information is high and ongoing however there was no mechanism to deliver project information once the research project was completed. White blister (*Albugo candida*) research is relatively new and there is a keen interest in learning about the disease as it spreads throughout Australia's growing regions and obtaining up to date information on forecasting and control.

The need for this information to be captured so that it could be made available to all growers on an ongoing basis after the completion of the research was identified as a high priority by industry and researchers. It was critical that this information be delivered in a way that was practical and user friendly. The HAL brassica commodity group requested an ongoing means of information delivery to industry and listed this in its industry R&D priorities. This could be achieved through the publication of a series of disease management fact sheets that could be referred back to as the need arose. However, due to the large amount of information that had been generated from the research projects and the complexity of some of this information there needed to be personal contact with the researchers and opportunity for discussion and sharing of grower experiences. Workshops as part of a travelling roadshow were thought to be a good method of achieving this interaction.

This series of workshops and supporting materials (fact sheets, disease notes, posters and newsletters) would also provide the first opportunity for the research findings to be presented as a complete management package. This could potentially have a great impact on the industry as growers become better equipped to implement on-farm practice change that could reduce the spread and severity of the diseases, reduce costs and environmental impacts and give them a sense of control over the disease and their futures.

Technology transfer strategy and methodology/activities

This project was designed to enhance the ability of growers to understand and use the results of research to control vegetable brassica diseases. The strategy that would give the greatest benefit to the largest number of growers was to hold workshops in each of the major growing regions of Australia. This would allow growers to meet face to face with researchers and to be able to ask questions and experience hands on demonstrations such as test strips and disease modelling.

Workshops were held between October and November of 2005 in:

		Attendance
Victoria		**34**
04-10-2005	Cranbourne	12
06-10-2005	Werribee	11
07-10-2005	Bairnsdale	11
Western Australia		**42**
12-10-2005	Perth	20
13-10-2005	Manjimup	22
New South Wales		**37**
17-10-2005	Penrith	24
18-10-2005	Bathurst	13
Queensland		**39**
24-10-2005	Gatton	13
25-10-2005	Stanthorpe	26
South Australia		**20**
04-11-2005	Virginia	20
Tasmania		**21**
10-11-2005	Devonport	21
Total		**193**

The workshops were designed and facilitated by an experienced extension facilitator. The facilitator was able to incorporate adult learning principles such as building on prior knowledge and allowing time for planning future activities, into the workshops to ensure optimum learning conditions. Having an outside facilitator also brought the benefit of allowing the researchers to present their material and not have to worry about how to structure the program and run the evaluation and planning sessions. They could concentrate on what they were good at – the science of the disease. The facilitator was able to work with presenters to ensure their presentations were pitched at the right level for growers and included all relevant information.

Researchers who worked on brassica related projects were invited to present at the workshops. There were a number of people who took up the opportunity to present in their home state although disappointingly they were not able to travel to other states.

A list of other researchers and the topics they presented is as follows

Western Australia
Andrew Reeves, Agriculture WA. Biosecurity
Queensland
Bronwyn Walsh, QDPIF. Brassica decision support tool
Jack Millbank, Vegetable IDO. National Vegetable R&D Priorities
Vanessa Kennedy, Brisbane Market Authority. Brisbane market grower services.
Margi Millgate & Jane Muller, Growcom. Environmental policy and water use.
Brendan Nolan, QDPIF. White-collared ladybird and white-fly
South Australia
Catherine Hitch, SARDI, Stem canker effecting brassica crops
Tasmania
Hoong Pung, ServeAg. Fungicide control of White blister.

Workshop Agenda

Welcome and introduction

Delivered by the facilitator or the state host for the meeting eg. IDO or DPI representative.

Disease quiz

The quiz was used as an ice breaker to help the group feel more comfortable with each other and it gave the presenters important feedback on the level of prior learning and interest in each of the presented topics. This allowed presenters to modify their talks to suit the audience.

Clubroot presentation

Presented by Caroline Donald

Local researcher's presentations

Depending on how many extra speakers there were some of these talks may have also been delivered in the second half after the break.

Break

Allowed the participants to stretch their legs, look at the exhibits and refocus their minds.

White Blister presentation

Delivered by Elizabeth Minchinton and Joanna Petkowski

Goal setting

This activity was run by the facilitator and was different for each group depending on numbers and the level of group interaction.

Examples of activities included writing out something that participants had learned, something participants wanted to implement or something they were already doing that was confirmed by the workshops. Voting on a number of listed topics and suggestions (that the audience had come up with) as to what they were likely to use in the future was another activity commonly used.

Evaluation

The facilitator also delivered this and different activities were used depending on the group dynamics. Examples of activities included Sociometery and Bulls-eyes (see the evaluation section for explanation of these techniques). Participants filled out an evaluation sheet at the completion of the event (see appendix 1). This sheet was very helpful in redesigning the early workshops to better meet industry needs.

Meal

A meal was also served as part of the workshop usually at the end but sometimes at the beginning depending on the time of the meeting.

Project Publications
The publication of newsletters and supporting materials (such as fact sheets, disease notes and posters) supplemented the workshops and allowed the project to reach those growers that were not able to attend a workshop. A series of fact sheets were produced for the management of clubroot and a disease note series for white blister. These were presented in a practical plastic pack so that industry would have a ready reference that they could refer to in future. These sheets were referred to throughout the talk and it saved growers from having to divide their attention between listening and note taking.

There were 10 clubroot fact sheets and each sheet covered a different aspect of disease management (see appendix 2-11). This was also summarised as a poster which listed the key information and could be put up on packing shed or office walls. (see appendix12). A poster on banding of fertiliser was also published (see appendix 13). A set of clubroot notes and a poster produced in a previous project, were made available to seedling growers as they have a number of different issues compared with growers. Prevention of the disease in the nursery is a major tool in stopping the spread of the disease particularly to uninfected sites.

<u>Keeping Clubroot Out Fact Sheets</u>
Sheet 1 Integrated control of clubroot – Introduction
Sheet 2 Disease Detection and Prediction
Sheet 3 Clubroot prevention – Farm hygiene
Sheet 4 Managing new and isolated outbreaks
Sheet 5 Limes and liming
Sheet 6 Nutrient amendment
Sheet 7 Chemical control of clubroot
Sheet 8 Strategic application
Sheet 9 Strategic application – machinery design
Sheet 10 Integrated control strategy – implementation

Poster - Clubroot control in the nursery
Poster – Clubroot control on the farm

There was also a series of 4 notes produced for white blister management (see appendix 14-17). Because research into white blister has only been going for a couple of years the notes covered what was known about the disease and predictive model but were not as comprehensive as the clubroot notes. It was seen as too early in the research to produce a complimentary poster for white blister.

<u>White Blister Control Notes</u>
Note 1 Introduction
Note 2 Options for control
Note 3 Control strategies for white blister
Note 4 a. White blister races
b. Seed health test

The two sets of notes were also produced in a cardboard folder as a 'mail friendly' version that was sent to all brassica growers who did not attend the workshops. This was done via the Industry Development Officers (IDOs).
The mail out was received by the following number of industry personnel as per the IDO databases.

TAS 80	VIC 280	NSW 280	
QLD 200	WA 230	SA 100	Total 1170

The number of editions of ‘Brassica IPM’ a SARDI based newsletter was doubled for the duration of the project with DPI Vic (Brassica diseases) and SARDI (Brassica pests) alternating ownership of the content. This decision to increase the number of issues of an existing publication rather than develop another newsletter was made at the beginning of the project in conjunction with the HAL Brassica commodity group. The project team wrote the following articles and were responsible for sourcing the remaining articles in the ‘disease’ issues of the newsletter: See appendix 18abc and 19abc for copies of the newsletter.

Articles

Exposing White Blister Issue 5 Sept 04
Imminent release of clubroot resistant vegetable brassicas, Issue 7 July 05
Field diagnostic testing for clubroot, Issue 7 July 05
Clubroot Management, Issue 7 July 05
Roadshow tours Australia, Issue 8 January 2006
Taking the heat out of white blister, Issue 8 January 2006
Becoming Strategic about clubroot, Issue 8 January 2006
Towards clubroot resistant brassicas, Issue 8 January 2006
A further disease based edition of the newsletter is in production.

Evaluation and measurement of outcomes - impact and adoption

Introduction

The evaluation and monitoring for this project was undertaken by answering three key evaluation questions. The evaluation is based on Bennett's Hierarchy (Table 1) and is useful in determining if the project has been able to influence and get industry adoption of practice change, ie was the information used, and was the most appropriate delivery methods were used.

There were two Key Evaluation Questions (KEQ) established to determine the impact the project has had on industry and one to determine if the project used the best methodology. A KEQ is a broad overarching question that is used to give an evaluation context and direction. The three KEQs that were used were;

- What is the change in industry behaviour as a result of this project?
- What impact has that change had on the industry?
- Were the roadshows the best way to deliver research information?

In addition to these three larger questions there were a number of questions asked to ensure continuous improvement of the workshops. This meant that changes could be made to the workshops and individual presentations to ensure growers were getting what they wanted. The rating of sessions presented in the workshop are shown in Tables 2 – 5.

The evaluation was conducted in two parts. The first part was conducted in the workshop sessions and the second part was undertaken as a phone survey, conducted approximately six months after the workshops, to gain an understanding of what, if anything, had changed as a result of the better brassica project.

The evaluation during the workshops consisted of group activities such as Sociometery where participants line up on a continuum to represent how much they have learnt (see photo 2) and bulls-eye targets where participants put dots on a target to represent their answers. The technique used at each workshop was decided based on numbers and group dynamics. Participants also completed an evaluation form at the end of the workshop (See appendix 1). As well as giving a rating for each session the form asked for suggestions for improvement and asked what growers were likely to do in future as a result of the workshop.

Photo 2 Manjimup workshop participants lining up to represent how much they knew about white blister before the workshop.

The phone survey was conducted to get an idea of the likely impact the workshop and printed material had had on industry behaviour. A sample of growers that had attended the workshop was rung and asked a number of questions:

- Is white blister a problem on your farm?
- Is clubroot a problem on your farm?
- What can you recall from the workshops?
- What did you receive at the workshop?
- Did you get a chance to read it?
- What if anything have you done differently as a result of attending the workshop and receiving the handouts?
- What impact has this had?

A second sample of growers who had not attended the workshops were also contacted and asked a set of questions

- Is white blister a problem on your farm?
- Is clubroot a problem on your farm?
- Do you remember receiving any information about the diseases clubroot and white blister? (If growers answered no they were prompted with a description of the notes and newsletter?)
- Did you get a chance to read it?
- What if anything have you done differently as a result of this information?
- What impact has this had?

Publications

The results of these phone surveys showed very clear patterns. All of the surveyed growers who had attended the workshops (from now referred to by 'AW') remembered receiving the handouts and 16% remembered receiving the poster. By contrast the surveyed growers who did not attend the workshops (from now referred to by 'DNAW') were much less likely to

remember receiving any information. 25% did not remember receiving any information about clubroot or white blister and a further 25% did not specifically remember receiving the handouts but they did receive information about the disease in various publications. No one specifically mentioned by name the Brassica IPM newsletter. There were some growers who said

> "I get stuff in the mail all the time, from DPI and other places"

indicating that they do not differentiate between the extension publications that they receive and see it as all coming from one source. WA Grower and Vegelink were mentioned by name.

All AWs said they had read or glanced through the printed material as did all DNAWs who said they had received something. 84% of DNAWs kept the information for future reference. This was because they were only just coming into their growing season, they did not have the disease present on their land or the levels of the disease were under control. A small number of growers said they had looked at the notes recently.

Bennett's Hierarchy Level	*Comments*
Inputs and Resources	DPI and IDO staff time, computers, catering, transport, industry support, budget etc.
Project Activities	Brassica IPM newsletters Information sheets Posters Static displays Workshops Phone survey
People Involved Participation	Information packs to 1170 growers. Growers surveyed on the phone Members of the brassica industry received the Brassica IPM newsletter 193 growers and industry attended the workshops
Reaction of people involved	"That was a very well run workshop" "I had heard it all before but it is good to be refreshed" "It was good to have what I am doing confirmed as the right thing" "The handouts were very comprehensive" "Don't change anything" "Disappointing that so few growers turned up" "They have not said anything new in years so I did not bother coming"
Change in Knowledge, Attitudes, Skills, Aspirations (KASA)	There was a wide range of KASA changes reported. 17% reported being eager to try new varieties. "I want to try these new varieties that are clubroot resistant" "I learnt something about radishes getting white blister" "It was interesting to learn about how the spores drop in the dam." "You need a lot more spores than I thought for infection"
Practice Change	Two growers reported that they were no longer growing broccoli because of the disease risk. 25% of AWs had changed their chemical application "I banded my Shirlan® this season" 17% had improved their machinery cleaning program, with an additional two growers reporting they had improved their crop hygiene. "I spoke to my nursery to check on their hygiene protocols." 20% had made changes to pH or the way they raise the pH "I use hot lime now" DNAWs reported the same sorts of changes in lower numbers. 25% of DNAWs changed their irrigation practices. 1/3 of Attended Workshop growers (AW)s did nothing different (25% because they were already doing it all,) 2/3 of Did Not Attend Workshop growers (DNAW)s did nothing different (16% because they were already doing it all) 50% of DNAW did remember receiving information in the mail and of these 84% thought there was value in retaining the information. Some growers since the workshop obtain copies of the white blister forecasting and use it to help monitor crops.

Inputs

Results of Inputs

Table 1. Evaluation of Better Brassica Project according to Bennett's Hierarchy

Session ratings for the workshops.

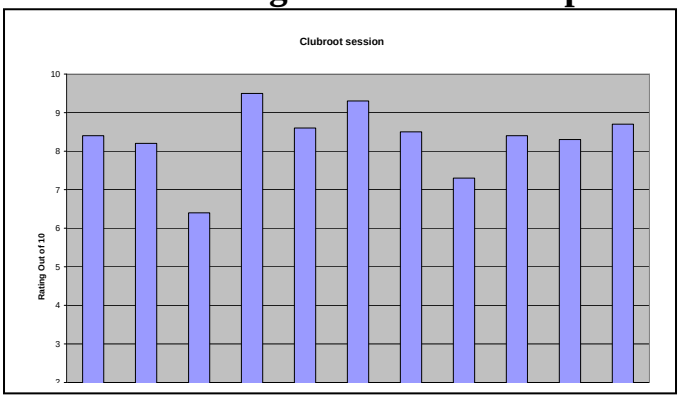

Table 2. Clubroot session

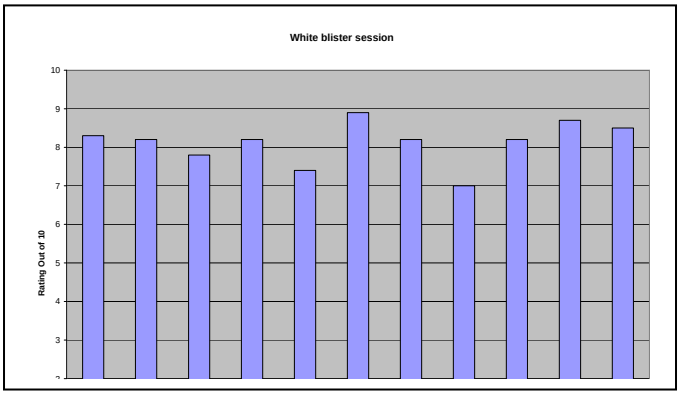

Table 3. White blister session

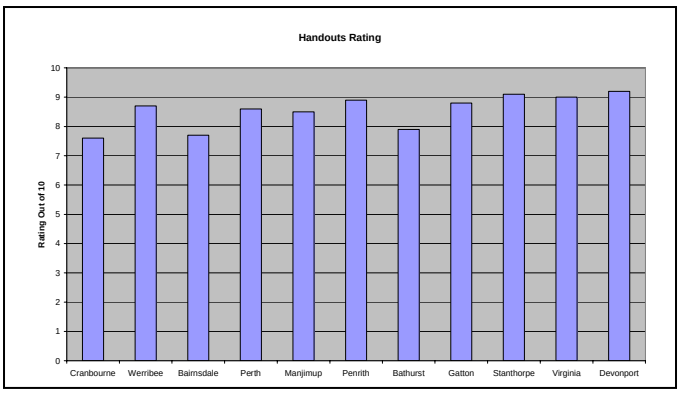

Table 4. Handouts

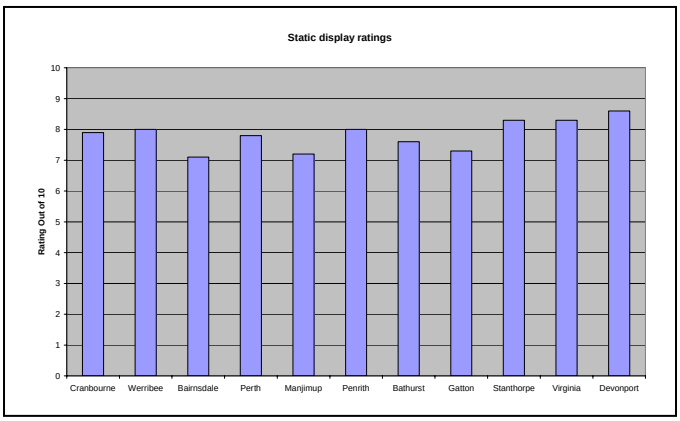

Table 5. Static displays

Key Evaluation Questions

Q1 **What is the change in industry behaviour as a result of this project?**

There were extensive changes in industry behaviour particularly considering the project may have only had a few hours contact with a grower and in many cases less than that. The scope of the change was quite wide and most growers reported multiple changes. Two thirds of surveyed participants in the workshops (AWs) and one third of the surveyed growers who received the publications (DNAWs) said they had made some change on their farm.

These changes included 25% of AWs had changed their chemical application.

"I banded my Shirlan® this season"

17% of AWs had improved their machinery cleaning program, with an additional two growers reporting they had improved their crop hygiene such as getting rid of trash quickly.

"I spoke to my nursery to check on their hygiene protocols."

20% of AWs had made changes to pH or the way they raise the pH with many growers reporting that they were already managing pH but they are now doing it differently or are more confident in doing so.

"I use hot lime now"

DNAWs reported the same sorts of changes in lower numbers although interestingly 25% of DNAWs had changed their irrigation practices compared to only two growers in the AWs group.

"I don't fertilise through sprinklers any more."

A few of the changes were unexpected such as two growers deciding not to grow broccoli any more.

"I stopped growing broccoli now and just do cauliflower."

1/3 of Attended Workshop growers (AW)s did nothing different (25% because they were already doing it all,)

2/3 of Did Not Attend Workshop growers (DNAW)s did nothing different (16% because they were already doing it all)

There were many growers who reported that they were more confident in what they were already doing as a result of the project, or that it was a good reminder of what they should be doing. Although this does not indicate a change in industry behaviour it is still a very good outcome as it builds the capacity of the whole industry and reinforces grower confidence.

Because the white blister research has not progressed to the point of a set of management principles, the changes that growers have adopted are more in the area of monitoring and disease prediction. As a result of the information presented at the workshop a number of growers have been able to make spray decisions based on the likelihood of the disease occurring.

Case Study 1 *– A grower who attended the workshop is now determining when to spray based on the predictive model that was presented in the workshop. He receives information from a locally based weather station on a near-by grower's property. This information is compared with a set of risk factors to determine when the disease is likely to appear. This has encouraged him to closely monitor his crops in the danger periods and to apply a preventative/control spray when necessary.*

Q2 **What impact has that change had on the industry?**

It is perhaps too early to answer this question in full. There are a number of changes that have been reported and some growers were able to indicate what impact that had made but many were not. Many growers said it was too early to say what impact the changes had made and some said they were soon to harvest their crop so would wait until then to decide.

Case Study 2 *-Perhaps the most dramatic change reported was from a grower who in his first planting had not had time to band and incorporate his Shirlan® as per the recommendations in the workshop and notes. But he did do it in subsequent plantings. He reported loses of 60-70% because of clubroot in the un-banded first planted crop compared with 4-5% losses in the other crops where he had used the banding technique.*

Growers who had made changes in hygiene practices were usually doing so because they were trying to stop the spread of the disease or because they did not yet have it on their property. None of these growers had noticed the disease spread this season. This is a positive impact for their farm and while it cannot be demonstrated it is likely that improved hygiene practices have at least been in part responsible.
Both growers that have stopped producing Broccoli said it had had a big impact on their farming operation but were not able to quantify to what degree.

Another grower said that the changes he had made meant that he had an increased workload. He did comment that it was worth it from an economic point of view.

The general opinion was that there were positive changes made to most farming businesses as a result of the change and they could perhaps be summed up by these three growers' quotes…

> "I can grow over a longer period, it's given a long term perspective on how I can be growing for the next 30 years."
>
> "every little bit helps"
>
> "if I didn't do it (hygiene) and I got an infection, it would be a bloody disaster."

Q3 **Were the roadshows the best way to deliver research information?**

The workshop evaluation asked the question "Do you think a workshop is the best way to keep the industry informed about disease research?" There were no NO responses and only two respondents out of the 134 who answered said they were NOT SURE. On the face of it that may seem like an outstanding success rate and we could be quite confident that we had chosen the correct delivery method. But it must be remembered that we are using a sample of people who attended the workshop. Therefore these people are already biased because they are the ones who attend workshops.

The number of mail-out packages compared with the number who came to the workshops shows that there is a large number of growers who did not attend the workshops. In fact only 10% per cent of industry attended a workshop. There may be many reasons for this such as other commitments, distance to the venue or they are no longer growing brassicas. But it should also be considered that many growers do not attend meetings and workshops. Information delivery and particularly in relation to getting industry adoption requires a range of delivery methods to suit the differing requirements of growers. One size does not fit all.

It was beyond the scope of this project to determine the best methods of delivery for all growers, however, anecdotally the number of growers attending this type of multi topic based workshop tends to be greater than a single issue workshop. Workshops may only reach the most receptive growers but they are likely to provide maximum impact for these growers.

The evaluation asked for other ideas for delivering information and the most common response was to incorporate a field day or in-field demonstration.

"Incorporate a field walk if possible" Manjimup

The second most common response was to do a mail-out of information, but there was no clear pattern of what format that should take. Suggestions offered were

"Plenty of information sent out as pamphlets or discs." Werribee

"DVDs / videos." Perth

and a number of people who suggested mail-outs but did not specify what sort. This again reinforces the idea that a range of approaches is important.

"Most issues need a combination of extension strategies to be successful" Gatton

Discussion

As a result of this project all known brassica growers nationally were presented with the latest research findings from brassica disease projects using a variety of delivery methods. An evaluation of the project indicated industry practice change, with two thirds of surveyed workshop participants and one third of surveyed growers that received project publications but did not attend a workshop indicating that they had made some change on their farm as a result of the project.

Information was sent to all stakeholders and 50% remembered receiving it and 84% of those indicated that it was valued. This project did not evaluate the format of the printed information but we know that presentation is critical with growers preferring to receive information in short concise publications which stick to the facts of what they need to know or do on the farm. (VegCheque Triennial Project Report 2000-2003, Peter J Carr (2004))

The phone survey showed that there are more growers with clubroot on their property than white blister. Of the surveyed growers attending the workshops 54% had white blister and 58% had clubroot. Of the surveyed growers who had not attended the workshops 25% had white blister and 33% had clubroot. The higher levels of disease amongst workshop participants shows that growers who consider they don't have a problem are far less likely to come to a workshop even though there was a strong focus in the workshop about preventing the disease from getting onto the farm. Perhaps this disease prevention message needs to be more clearly spelt out in the workshop advertising material so that growers who don't have the disease see that it is relevant to them also.

Of interest is the low turnout in the strong brassica production areas of Werribee (3 growers and 1 nursery) and Gatton (2 nursery). This may be because the growers have had more exposure to the issues and did not believe the workshops would have additional information to offer and thought that they were managing the problems. A different approach may be needed for these areas, and it should also be remembered that overall only 10% of industry attended a workshop. This again demonstrates that it is difficult to reach all sectors of the industry with one delivery method and workshops are not going to do this on their own. Information delivery requires a range of methods but information delivery alone does not ensure adoption and practice change.

Evaluation of this project (indeed most agricultural extension/adoption projects) is hampered by the need to report back on those findings before there has been the necessary time for the results to be trialed by growers. In some of the places where workshops were presented there has not yet been a complete growing season to assess the impact of changes made as a result of this project. Therefore it is difficult to give an accurate picture of the likely impact of change. In places where there has been a growing season, disease pressure may have been higher or lower than usual due to weather conditions, this also makes evaluation of the impact difficult.

It is important to remember that there is a range factors that will influence the adoption of technology. There are always going to be sectors of the vegetable community that are not able to change their practises. There could be many reasons for this such as economic constraints, limited resources or existing technology and infrastructure.

It needs to be recognised that there are a range of reasons that farmers change practices and they are not solely technical or economic but are also cultural and social. Vanclay (2004) lists 27 principals as the basis for action or behaviour. It should therefore not be seen as a failure of

the delivery method if recommendations are not automatically taken up by all sectors of the industry. Adoption could proceed over a number of years as grower's circumstances change.

Recommendations

Workshops

In general although only 10% of industry attended, the brassica road shows (workshops and take home material) indicate that a coordinated response is an effective way to deliver information and engage growers in discussion and planning for future action on their property. It makes sense to have a number of researchers present their work at one big event rather than expect growers to attend numerous smaller 'single issue' meetings. This must be balanced, for there is a risk of losing the audience if it is too long or has too much information. A larger attendance is likely as growers feel it is worth their while to come along as a number of topics are being covered and one is sure to be useful to their situation. It is also cost effective to send out one invite, hire the venue and provide a meal for participants and use it for more than one presenter. This type of event also builds links between interstate researchers working on the same crops and provides opportunity for review and discussion of current work and identification of emerging industry problems.

It is quite important that the meeting is well facilitated so that it does not become long and tedious if many people are presenting. Include a range of activities in shorter chunks to keep people interested. Awareness of an issue does not automatically lead to practice change and so there needs to be an incorporation of adult learning principles into all events. This would include sessions building prior knowledge, allowing time for reflection and review and incorporating a time for planning future actions. From the workshop evaluations it is clear that future events should incorporate a paddock based session where possible and lots of hands on activities if a paddock session is not possible. High quality follow-up resources are also needed so that growers are able to refer back to what was presented at the road show.

Coordinated delivery

A key finding of this project is that there are many advantages to using a coordinated approach to the delivery of R & D outcomes including economies of scale. Both growers and researchers are time poor. Attendance at a single, well organised event for each commodity is much more attractive to growers than requests to attend many small 'single issue' meetings. Similarly, researchers are more willing to present to a larger, enthusiastic audience. Perhaps the IDO network could be involved in organising commodity road shows every three years to travel around Australia and present R&D work. This would not only force all researchers to be involved in delivery of research outcomes, it would also eliminate any state bias from projects. This could be done for any crop not just brassicas, assuming there was enough work to present.

Other techniques

Static displays at workshops such as these need to, where ever possible, include something that is referred to in the talk. They tend to get passed over in favour of chatting if there is not something to catch people's attention. Another good way to draw attention to them is to have something that can be experienced, this may be through being able to pick it up, have a go at using it or watching it being demonstrated. Posters of farm machinery were a practical way of showing what could be done but they would have been far surpassed by being able to see the machine working in the paddock.

Although not tried in this project there could be a range of other techniques that could be used to deliver information to growers and help to facilitate adoption. These techniques would

depend on the information being presented and would also depend on how wide the relevant audience was. Examples of other techniques include the use of on-farm trials, recommendations to chemical resellers, training programs, adoption of findings into apprenticeships and TAFE training courses, study tours, conference presentations and instruction manuals.

- Carefully consideration should be undertaken of the best approach and the likely drivers of adoption when choosing the appropriate technique.
- It should also be noted that information delivery requires a range of methods but information delivery alone does not ensure adoption and practice change.

Acknowledgments

The author and members of the project team wish to thank the Industry Development Officers in each state Patrick Ulloa, Alison Anderson, David Ellement, Jack Millbank, Craig Feutrill and Stephen Welsh for their excellent support and assistance in organising the workshops, inviting growers and distributing materials. Each of the researchers and industry personnel who also presented their work deserve acknowledgment for adding to the range of topics presented to growers. They were Andrew Reeves, Agriculture WA., Bronwyn Walsh, QDPIF, Vanessa Kennedy, Brisbane Market Authority, Margi Millgate & Jane Muller, Growcom, Brendan Nolan, QDPIF, Catherine Hitch, SARDI, Hoong Pung, ServeAg.
In addition Robert Dimsey, Rachel Lancaster, Clinton McGrath, Christine Horlock and Leigh James assisted in organising the workshops.

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Appendix 1

Brassica Disease Workshop

1. Which of the following sectors of the industry best describes your role?

o Grower o Agriculture Supplier o Other (please detail) _____

2. Rate each session out of 10. (with 10 being perfect for your needs)

Session	Rating
Disease quiz to see what you already know Comments?	
Clubroot presentation Comments?	
White blister presentation Comments?	
Planning future actions Comments?	
Handouts Comments?	
Static displays and demonstrations Comments?	

3. What would you have liked more of or could have been explained in more detail?

_____
_____
_____
_____

4. What could we leave out?

_____
_____
_____
_____

5. In what way if any has this workshop inspired you to reassess or alter the way you control disease in the future?

_____
_____
_____
_____
_____

6. Do you think a workshop is the best way to keep the industry informed about disease research?

o Yes
o No

Any suggestion of better ways?

_____
_____

Thanks for your input!-

Appendix 2 Clubroot fact sheet 1

Clubroot Factsheet

Series 1 for farms — sheet 1

Integrated Control of Clubroot - Introduction

Fact: OPTIONS ARE AVAILABLE THAT WILL PREVENT OR CONTROL CLUBROOT

'Integrated control' is the implementation of a combination of methods that are cost effective and provide effective disease control.

Recognising clubroot:

The first symptom of clubroot is usually wilting. Severely diseased plants are generally stunted and foliage colour may change. Root galling indicates that infection has occurred.

Infection:

Decaying root galls release many resting spores into the soil which are potentially infective for up to twenty years. Infection can occur on the plant root at any growth stage. Clubroot is mainly a summer disease in Australia.

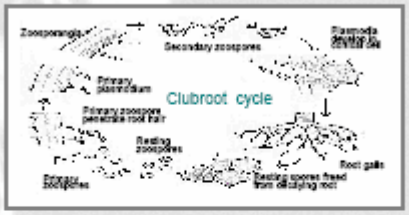
Clubroot spore infecting root hair.

Resting spores in gall cells that will be released into the soil when galls decay.

Galls developing on roots in young brassica weed.

Infection depends on:

- A source of *P. brassicae* spores.
- High soil moisture.
- Acidic soil, pH less than 7.
- Warm conditions (20-25°C).



Key elements in the development of an integrated control strategy include:

A. *Estimating disease risk;* (see factsheet 2)

The first step in developing an integrated control strategy is to know the disease risk of each site. This can be estimated from farm records or by using a molecular diagnostic test. When the disease risk has been estimated, a management strategy can be tailored to prevent or manage clubroot using the methods listed below and detailed in this series of factsheets.

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Appendix 3 Clubroot factsheet 2

Clubroot Factsheet

Series 1 for farms — sheet 2

Disease Detection and Prediction

Fact: CLUBROOT MANAGEMENT IS BASED ON UNDERSTANDING DISEASE RISK

The first step towards developing an effective integrated control strategy is accurately estimating the disease risk.

Disease risk can be estimated using farm records or tested using a molecular diagnostic test;

Farm Records Checklist:

- Have you ever seen clubroot on your property?
- How large is the area affected?
- Determine if the risk is high, medium or low.

Use this table to estimate overall disease risk;

		LOW RISK	MEDIUM RISK	HIGH RISK
1	Severity of last observed clubroot infection	Mild	Moderate	Severe
2	Time since last observed clubroot infection.	More than 5 years	2-5 years	0-2 years
3	Intended sowing time for brassicas.	May-Aug	March/April and Sept/Oct	Nov-Feb
4	Have brassica weeds been seen on the site since last infection?	Never	Infrequently	Often
5	Intended crop	Non-brassica	Broccoli, Brussel sprouts, cabbage, other Asian veg brassica	Cauliflower, Chinese cabbage
6	Soil pH	7-8	6-7	Less than 6
7	Source of planting material	Cell grown transplants - reputable nursery	Seed bed on farm	Direct seeded onto site
8	Variety	Tolerant/resistant	Susceptible	Highly susceptible
9	Drainage	Excellent	Fair	Poor
10	Soil type	Sand	Loam	Clay

It is important to try to quantify clubroot as disease severity (yield loss) is related to inoculum concentration.

Molecular diagnosis:

- Early and accurate diagnosis is vital to making informed disease management decisions to prevent or contain new clubroot outbreaks.
- A technique that extracts DNA of the clubroot pathogen from a soil or water sample has been developed to quantify the amount of *P. brassicae* in a sample.
- This technique is rapid and sensitive but it is also expensive and requires sophisticated equipment and diagnosis in a laboratory.
- A more user-friendly commercial diagnostic kit that is sensitive, inexpensive and rapid is being developed for on site testing.

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Appendix 4 Clubroot factsheet 3

Clubroot Factsheet

Series 1 for farms — sheet 3

Clubroot Prevention – Farm Hygiene

Fact: CLUBROOT SPORES PERSIST IN SOIL AND CAN BE TRANSFERED VIA SOIL OR WATER

Sources of contamination include:

- *Soil* carried onto the farm (eg. on machinery, bins, reused transplant trays etc) and dust blown in on the wind.
- *Water* particularly from dams receiving runoff from infected paddocks.

Consider the following:

- Restrict unnecessary movement into production areas by vehicles, people, stock and machinery.
- Clearly sign post to limit access.
- Purchase high pressure washing equipment and use it routinely to minimise the movement of soil on equipment and machinery.
- Provide a foot bath for visitors.
- Identify and eliminate sources of contamination.

Check that;

- ✓ Seedlings are of high quality and from a reputable source.
- ✓ Dams are free of the clubroot pathogen and not receiving runoff from infected fields.
- ✓ Shared equipment is thoroughly cleaned before entering your property.
- ✓ All workers and visitors are aware of hygiene protocols.

- Keep seedling trays off the ground.
- Return empty trays to a pallet or rack.

High pressure wash

Seedling trays kept off the ground in racks

- Where possible always work from the cleanest (least likely to contain the clubroot pathogen) to dirtiest (most likely to contain the clubroot pathogen) parts of the farm.
- Use high pressure washing equipment at the end of the day.

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Appendix 5 Clubroot factsheet 4

Clubroot Factsheet

Series 1 for farms — sheet 4

Managing New and Isolated Outbreaks

Fact: ISOLATED OR SMALL SPOT OUTBREAKS OF CLUBROOT CAN BE ERADICATED

Dealing with an isolated or spot outbreak of clubroot:

- *Identify* the disease.
- *Contact* local departments of Primary Industries or if required use diagnostic services (eg. Crop Health Services ph: (03) 92109222) for some assistance.

Typical spot outbreak of clubroot

- *Quarantine* by marking off an area at least 3 metres from the outer edge of the infected plants.
- *Remove* all plants within this area.
- *Dispose* by digging up diseased plants and bagging the roots and attached soil.
- *Discard* diseased plants by burning or disposing in an industrial landfill.

Fungicides will not kill established disease.

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Appendix 6 Clubroot factsheet 5

Clubroot Factsheet

Series 1 for farms — sheet 5

Limes and Liming

Fact: CLUBROOT THRIVES IN ACIDIC SOILS WITH A PH LESS THAN 7.0
USE OF LIME INCREASES THE SOIL PH

Liming is an effective preventative measure and is cheap and easy to apply.

Monitor soil pH to maintain a pH of 7.0 to 7.5.

Important factors that influence the effectiveness of lime applcation:

- *pH* of the liming material which can vary from 7.0 (unprocessed limes) to 12.0 (processed limes).
- *Neutralising Value (NV).* Indicates the acid reducing ability of a lime and is expressed relative to calcium carbonate (NV 80 - 100%).
- *Particle size.* This influences the rate of reactivity ranging from days or weeks (fine limes) to months or years (coarse limes).
- *Timing* of application. Regardless of the type of lime used, aim to reach maximum soil pH at the time of transplanting to protect the young transplant from infection (see table overleaf).

Field application of lime to the growing zone

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Appendix 7 Clubroot factsheet 6

Clubroot Factsheet

Series 1 for farms — sheet 6

Nutrient Amendment

Fact: CLUBROOT IS INHIBITED WITH THE ADDITION OF CALCIUM AND BORON

Both calcium and boron reduce the severity of clubroot gall formation.

The interaction between calcium and pH ;

The effect of calcium on clubroot development depends on pH and is more effective at neutral (6.5-7.5) pH. Calcium nitrate together with lime is better at controlling clubroot than either of these products used alone. Calcium cyanamide breaks down in soil to calcium oxide (lime) and urea and since it already contains lime, should not be applied together with lime.

Timing is important ;

- Aim to have soil pH between 6.5 and 7.5 at planting. Time application of lime to achieve this (see factsheet 5).
- To protect young transplants from infection apply formulations of calcium nitrate (containing boron) within the first three weeks after planting.
- To avoid burning and destroying young transplants, incorporate calcium cyanamide into the soil and irrigate at least 7-10 days before transplanting. Incorporate it into the soil in two bands 23 cm wide and 15cm deep along the planting row to protect the young transplant. Only very low rates of this product (approx 60kg/ha) can be safely applied at planting.

Cost effective;

The effective rate of 1000kg/ha of calcium cyanamide is reduced by two thirds by band incorporation of the product into the transplant row (see factsheet 8). This reduces the cost of treatment by more than $1000/ha.

Other Factors that influence efficacy;

Formulations of calcium cyanamide with smaller particles are more effective against clubroot. Limes with a high neutralising value and small particles are generally more effective against clubroot.
Although successful, these formulations are more hazardous to apply.
Take precautions to avoid inhalation of these particles using personal protective gear (see factsheet 5).

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Appendix 8 Clubroot factsheet 7

Clubroot Factsheet

Series 1 for farms — sheet 7

Chemical Control of Clubroot

Fact: STRATEGICALLY APPLIED CHEMICALS ARE AN IMPORTANT MEANS OF CONTROLLING CLUBROOT ON HEAVILY INFESTED SITES

Chemical application may be necessary on high risk (heavily infested) soils to achieve adequate control of clubroot.

Fungicides:

At the time of publication registered chemicals for suppression of clubroot on cruciferous crops include PCNB (Terraclor®, Barmac Chloroturf®, Barmac Chloroturf DG® Purasoil®) and Fluazinam (Shirlan®).
These products are most effective when applied at transplanting into the plant root zone (see factsheet 8). Drench applications don't sufficiently penetrate the soil to provide adequate protection.

Strategic application:

In trials, control of clubroot was optimised by incorporation of fluazinam into the transplant row at a rate of 3L product (Shirlan® 50% a.i.)/ha in 500L/ha of water immediately before transplanting.

- A number of machines have been developed that incorporate chemicals into the transplant row immediately before planting.
- This cut costs substantially as only 1/3 of the lane is treated and ensures that the products are in exactly the right place for early crop protection (see factsheet 8).

Machine used for incorporation into transplant rows

Always follow the precautions and application restrictions on the label.

Fumigation:

A properly applied soil fumigant gives good disease control acting as a general biocide (see factsheet 4). Metham sodium and Dazomet (Basamid®) have registration for use on soils for food crops. Fumigation is expensive and is not recommended as a routine practice because of potential effects on soil structure and biology.

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Appendix 9 Clubroot factsheet 8

Clubroot Factsheet

Series 1 for farms — sheet 8

Strategic Application

Fact: STRATEGIC APPLICATION TARGETS PRODUCTS TO THE PLANT ROOT ZONE

The benefits:

- *Efficacy* of some products is increased with distribution at the root zone.
- *Cost* is reduced as less than a third of the broadcast area is treated.
- *Targets* the root zone where protection is needed.
- *Distributes* treatments evenly to the transplant root zone.
- *Saves* time as treatment and transplanting can be simultaneous provided the treatments used do not pose a health risk to the operators.
- *Suits* a range of soil types and liquid or granule application.

Existing machinery can be adapted. Reduces run off and phytotoxicity. Treatment and planting can be done in a single tractor pass for non- hazardous products such as calcium nitrate.

Demonstration models showing application of granules or liquids to soil with modified equipment.

For more information or photographs of commercial models (see factsheet 9).

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Appendix 10 Clubroot factsheet 9

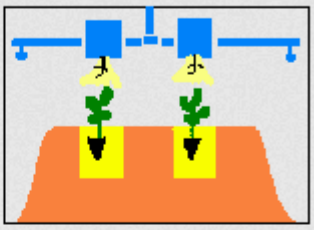
Clubroot Factsheet

Series 1 for farms — sheet 9

Strategic Application – Machinery Design

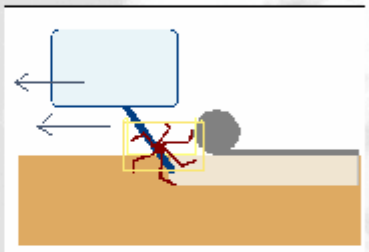
Fact: EXISTING MACHINERY CAN BE MODIFIED FOR STRATEGIC APPLICATION

Commercial banding machines called 'precision incorporators' have been designed to incorporate treatments into the transplant row.



Application immediately before transplanting ensures products are evenly distributed around the transplants root zone where protection from infection is required.

Purpose built machines for strategic application have a small tool bar to which two spray jets, and/or granular chutes and two small rotary hoes are fitted. Each rotary hoe is mounted in a 'metal' (or other) box approximately 23cm wide to retain the treated soil in the planting row following tillage.



Within these bands the soil is tilled to an approximate depth of 15-20cm. Transplanting equipment can be mounted directly behind the 'precision incorporator'(see overleaf) to enable treatment and transplanting to occur in a single tractor pass provided the selected treatments do not pose a health and safety risk to the user.

Research prototypes of 'precision incorporators'

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Appendix 11 Clubroot factroot 10

Clubroot Factsheet

Series 1 for farms — sheet 10

Integrated Control Strategy - Implementation

Fact: INTEGRATED CONTROL INCLUDES THE USE OF PREVENTION AND MANAGEMENT TECHNIQUES TO PROVIDE COST EFFECTIVE DISEASE CONTROL

There are two elements of integrated control:

PREVENTION

HYGIENE
Good farm sanitation and hygiene protocols are your responsibility and your right.
Develop a hygiene strategy and ensure all staff and visitors implement it.
(see factsheet 3)

SOURCE
Use uncontaminated;
Water.
Seedlings.
Trays.
Equipment.

CLUBROOT THRIVES
in warm, moist, acid soils.
Increase pH to 6.5-7.5 with lime. (see factsheet 5)

CULTURAL PRACTICES
Improve drainage.
Rotate with non-brassica crops.
Control brassica weeds.
Use beneficial nutrients.
(see factsheet 1)

MANAGEMENT

IDENTIFY
Determine disease risk.
(see factsheet 2)
Identify and eliminate the source.
(see factsheet 3)

QUARANTINE
Remove affected plants.
Dispose of diseased material.
Isolate the area.
(see factsheet 4)

DECIDE
upon a management strategy based on the disease risk category.
(see table overleaf)

IMPLEMENT
the elements of the strategy.
Consider appropriate rates, timing and method of application.
(see factsheet 8)

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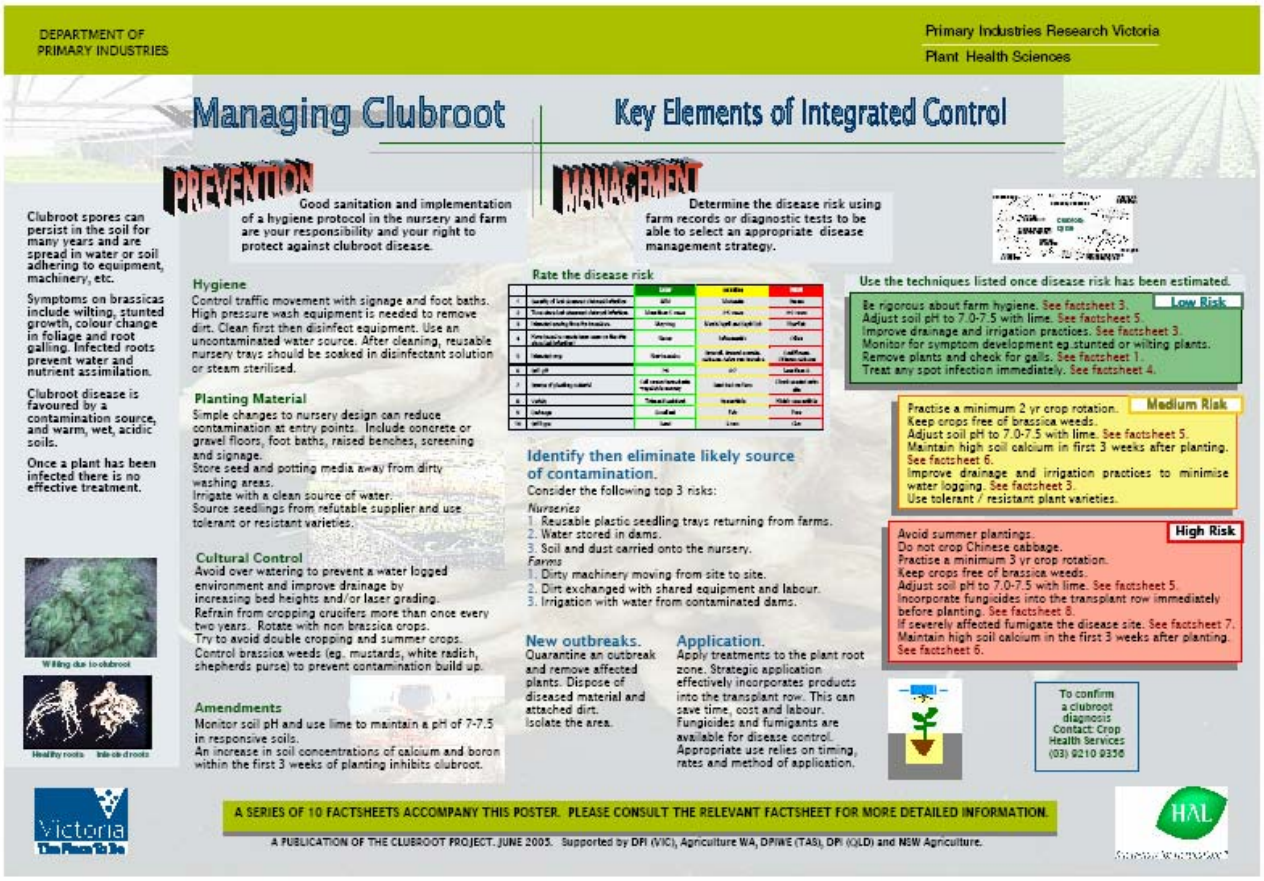
Appendix 12 Clubroot poster



DEPARTMENT OF PRIMARY INDUSTRIES

Primary Industries Research Victoria
Plant Health Sciences

Managing Clubroot

Key Elements of Integrated Control

Clubroot spores can persist in the soil for many years and are spread in water or soil adhering to equipment, machinery, etc.

Symptoms on brassicas include wilting, stunted growth, colour change in foliage and root galling. Infected roots prevent water and nutrient assimilation.

Clubroot disease is favoured by a contamination source, and warm, wet, acidic soils.

Once a plant has been infected there is no effective treatment.

Wilting due to clubroot

Healthy roots Infected roots

PREVENTION

Good sanitation and implementation of a hygiene protocol in the nursery and farm are your responsibility and your right to protect against clubroot disease.

Hygiene

Control traffic movement with signage and foot baths. High pressure wash equipment is needed to remove dirt. Clean first then disinfect equipment. Use an uncontaminated water source. After cleaning, reusable nursery trays should be soaked in disinfectant solution or steam sterilised.

Planting Material

Simple changes to nursery design can reduce contamination at entry points. Include concrete or gravel floors, foot baths, raised benches, screening and signage.
Store seed and potting media away from dirty washing areas.
Irrigate with a clean source of water.
Source seedlings from refutable supplier and use tolerant or resistant varieties.

Cultural Control

Avoid over watering to prevent a water logged environment and improve drainage by increasing bed heights and/or laser grading.
Refrain from cropping crucifers more than once every two years. Rotate with non brassica crops.
Try to avoid double cropping and summer crops.
Control brassica weeds (eg. mustards, white radich, shepherds purse) to prevent contamination build up.

Amendments

Monitor soil pH and use lime to maintain a pH of 7-7.5 in responsive soils.
An increase in soil concentrations of calcium and boron within the first 3 weeks of planting inhibits clubroot.

MANAGEMENT

Determine the disease risk using farm records or diagnostic tests to be able to select an appropriate disease management strategy.

Rate the disease risk

	Low	Medium	High
1	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]

Identify then eliminate likely source of contamination.

Consider the following top 3 risks:

Nurseries
1. Reusable plastic seedling trays returning from farms.
2. Water stored in dams.
3. Soil and dust carried onto the nursery.

Farms
1. Dirty machinery moving from site to site.
2. Dirt exchanged with shared equipment and labour.
3. Irrigation with water from contaminated dams.

New outbreaks.

Quarantine an outbreak and remove affected plants. Dispose of diseased material and attached dirt.
Isolate the area.

Application.

Apply treatments to the plant root zone. Strategic application effectively incorporates products into the transplant row. This can save time, cost and labour.
Fungicides and fumigants are available for disease control.
Appropriate use relies on timing, rates and method of application.

Use the techniques listed once disease risk has been estimated.

Low Risk
Be rigorous about farm hygiene. See factsheet 3.
Adjust soil pH to 7.0-7.5 with lime. See factsheet 5.
Improve drainage and irrigation practices. See factsheet 3.
Monitor for symptom development eg stunted or wilting plants.
Remove plants and check for galls. See factsheet 1.
Treat any spot infection immediately. See factsheet 4.

Medium Risk
Practise a minimum 2 yr crop rotation.
Keep crops free of brassica weeds.
Adjust soil pH to 7.0-7.5 with lime. See factsheet 5.
Maintain high soil calcium in first 3 weeks after planting. See factsheet 6.
Improve drainage and irrigation practices to minimise water logging. See factsheet 3.
Use tolerant / resistant plant varieties.

High Risk
Avoid summer plantings.
Do not crop Chinese cabbage.
Practise a minimum 3 yr crop rotation.
Keep crops free of brassica weeds.
Adjust soil pH to 7.0-7.5 with lime. See factsheet 5.
Incorporate fungicides into the transplant row immediately before planting. See factsheet 8.
If severely affected fumigate the disease site. See factsheet 7.
Maintain high soil calcium in the first 3 weeks after planting. See factsheet 6.

To confirm a clubroot diagnosis Contact: Crop Health Services (03) 9210 9356

Victoria The Place To Be

A SERIES OF 10 FACTSHEETS ACCOMPANY THIS POSTER. PLEASE CONSULT THE RELEVANT FACTSHEET FOR MORE DETAILED INFORMATION.

A PUBLICATION OF THE CLUBROOT PROJECT. JUNE 2005. Supported by DPI (VIC), Agriculture WA, DPIWE (TAS), DPI (QLD) and NSW Agriculture.

HAL

Appendix 13 Strategic banding application poster

DEPARTMENT OF PRIMARY INDUSTRIES

Primary Industries Research Victoria
Knoxfield

Strategic Application - Band Incorporation

Band incorporation improves product distribution and efficacy with reduced treatment cost and minimises the impact of residues on the environment. It is important to protect the roots of establishing transplants early in the life of the crop.

The Benefits:

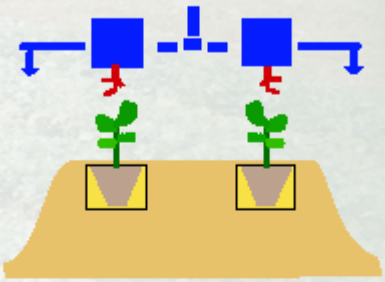
The efficacy of products is increased with an even distribution at the root zone.

Cost can be reduced as less than a third of the broadcast area is treated.

The root zone is targeted where protection is needed.

A single pass treatment is possible.

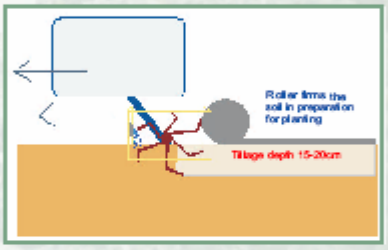
Suits a range of soil types and liquid or granular applications.



Applications:

Incorporate treatments into the soil in bands 23cm wide along the transplant row to a depth of 15-20cm immediately before transplanting.

Banding machines or 'precision incorporators' have been developed for mechanically distributing the treatment into the plant root zone.



Transplanting equipment can be mounted directly behind the precision incorporator to enable treatment and transplanting to occur in a single tractor pass provided the selected treatments do not pose a health and safety risk to the operators.

Application immediately before transplanting ensures products are evenly distributed around the root zone of the transplant where protection from infection is required.

Transplant mounted for treatment with planting

Commercial banding machines called precision incorporators have been designed to incorporate treatments to the transplant row.
Existing farm machinery can be modified.

A single pass treatment can save fuel, tractor wear and labour

Victoria The Place To Be

A PUBLICATION OF THE NATIONAL CLUBROOT PROJECT. JUNE 2005.
Supported by DPI (VIC), Agriculture WA, DPI WE (TAS), DPI (QLD) and NSW Agriculture.

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Appendix 14 White blister note 1

Research Notes

Introduction

Recognising White Blister

White blister was first reported to cause economic losses in broccoli and cauliflower during the summer of 2001/02 in Victoria. Within 18 months it had spread rapidly throughout southern Australia. It was recently detected on broccoli in Queensland, during August 2005.

Recognising white blister

The disease white blister (rust) is caused by the 'fungus' *Albugo candida*. It affects many economically important brassica crops including broccoli, cauliflower, Brussels sprouts, rocket and radish as well as many common brassica weeds.
The fungus produces two types of symptoms: blisters and distorted plant parts.

Blisters

White blisters generally develop on the undersurface of leaves but can cover entire plant parts such as leaves, stems, heads and seedpods. The blister contains spores that develop under the plant epidermis, which eventually breaks from the pressure of the expanding spores. These are vegetative or asexually produced spores. White, powdery or dust-like spores are released at any time of the day or night and spread by wind. As blisters on the underside of leaves age they can be seen on the upper leaf surface as light green to yellow spots which may also produce spores.


White blisters


Aged blisters


White powdery dust like spores

Distorted plant parts

Galls on stems, distorted or enlarged stems, leaves, inflorescences and pods contain the oospores (sexually produced spores). These symptoms are often stunning, such as 'stag heads'. At this stage the fungus enters the systemic phase and grows within host tissues, making it harder to control. The oospores are capable of being carried in crop debris and on seed, thus having the potential to infect future crops.


albugo zoosporangia

Victoria Department of Primary Industries

HAL

Appendix 15 White blister note 2

Research Notes

Control Strategies for White Blister

Control white blister with a combination of management practices and a fungicide spray program

Controlled watering

Avoid long periods of leaf wetness as spores need water to germinate and wet leaf surfaces to infect plants.

- A **short,** heavy watering is preferable to a **long,** light watering.
- Time irrigation to when leaves will dry off quickly, such as at dawn.
- Avoid watering in the evening as leaves will stay wet for a longer period of time.

Ventilation

Maintain good air movement to dry leaves off quickly and reduce infection.

- Orientate crop rows in the direction of the prevailing wind.
- Increase plant spacing.
- Avoid planting crops in high humidity where fogs persist, such as near the coast or river valleys.

Nutrition

- Increased nitrogen may increase susceptibility to white blister.
- Increased levels of phosphorous (P) and potassium (K) may increase resistance to white blister, however, high rates of these fertilisers can stunt plants.

Resistant varieties

- The variety Greenbelt was very susceptible to white blister in Victoria and is no longer grown.
- Field observations have shown that Viper/Atomic, a summer variety, has tolerance to white blister. Bellstar, a winter variety, also has tolerance to white blister. Seed companies are actively selecting for white blister resistance in broccoli varieties.

Victoria Department of Primary Industries

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Appendix 16 White blister note 3

Research Notes

Options for Control

White blister predictive model reduces sprays and controls disease

Brassica^{Spot} is a computer based, disease-forecasting system for some fungal diseases and insect pests of brassicas. Dr Roy Kennedy, Horticulture Research International, developed the model in the UK. Over 50% of UK growers now use this model to time their fungicide sprays for white blister control.

The model predicts the risk of white blister infection periods for broccoli and other vegetable brassica crops using weather data such as temperature, leaf wetness, relative humidity and rainfall. The model indicates the time to inspect crops for white blister and, depending on the results, a decision is made whether or not to spray.

The Brassica^{Spot} model was evaluated in two trials at Dandenong and Werribee, Victoria, during autumn and winter 2005. In both trials white blister was kept in check using only 1-4 chemical applications compared with up to 8 applications under a conventional spray program. The model was an excellent decision support tool that helped to reduce the applications of fungicides for crop protection.

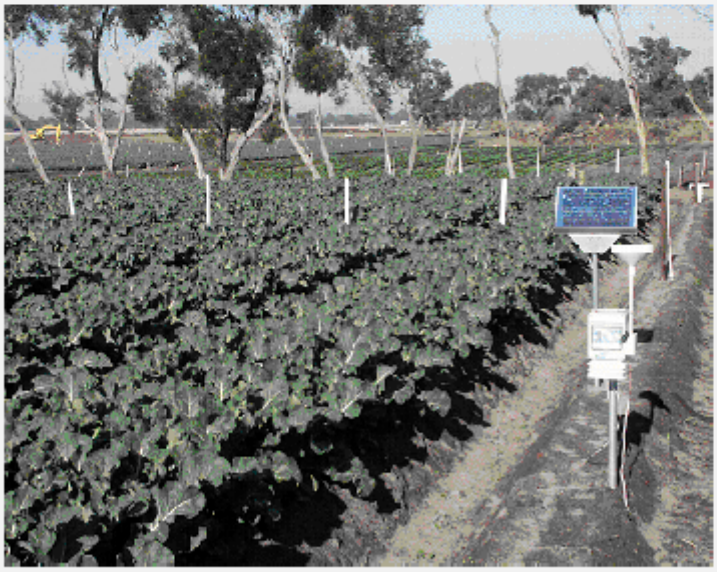


Photo 1.
Weather station in the broccoli trial site at Dandenong.
The weather station collects

- temperature,
- rainfall,
- leaf-wetness and
- relative humidity data every half an hour.

State Government Victoria Department of Primary Industries

HAL

Appendix 17 White blister note 4

Research Notes

White Blister Races

The causal organism of white blister is *Albugo candida*. It has been classified into 17 races. The first 11 are the most important for vegetable production and the remaining 6 are found on mustards (Table 1). However, under glasshouse conditions, when plants are at the seedling stage, spores from one host may infect another host. Scientists use this phenomenon to diagnose races of white blister.

Race of *A.candida* (Ac)	Primary host common name	Primary host scientific name
1	radish	*Raphanus sativus*
2	Indian mustard	*Brassica juncea*
3	horse radish	*Armoracia rusticana*
4	Shepherds purse	*Capsella bursa-pastoris*
5	hedge/tumble mustard	*Sisymbrium officinale*
6	marsh/yellow watercress	*Rorippa islandica*
7	oilseed turnip, Chinese cabbage, spinach mustard	*Brassica rapa (campestris)*
8	black mustard	*Brassica nigra*
9	cabbage, Brussels sprout, kale, cauliflower, broccoli, cohlrabi	*Brassica olearacea*
10	charlock	*Brassica kaber (Synapsis arvensis)*
11	Ethiopian mustard	*Brassica carinata*

Studies on white blister disease in Australian *B.olearacea* crops showed that:

- The disease does not affect cabbage, although it does in Europe.
- Spores from white blister on Shepherds purse (Ac4) and from Chinese cabbage (Ac7) do not cause white blister on broccoli.
- White blister on broccoli in Australia (Ac9) differs from that found on this crop in Europe as it does not form white blisters on cabbage and does cause white blisters on black mustard.

State Government Victoria Department of Primary Industries

HAL Know-how for horticulture

TAKING THE HEAT OUT OF WHITE BLISTER continued...

Variety trials for white blister resistance in broccoli
During 2006 broccoli variety trials will be established in Western Australia, Tasmania and Victoria to identify varieties with resistance to white blister. There will be 12 varieties in each trial and a field day will be held at harvest to view the outcome. These trials are being organised in collaboration with the Western Australian Department of Agriculture and with Serve-Ag Research.

Australian races of white blister

There are 17 named and described races of white blister. The races of white blister occurring on many minor crops, such as rocket (Eruca sativa), are yet to be described. To date we have found that white blister from the weed Shepherds purse (Capsella bursa-pastoris, Race 4) and from Chinese cabbage (B. rapa, Race 7) will not infect broccoli and cauliflower (B. oleracea). This finding suggests that white blister has not transferred from these plants to broccoli. Interestingly we have not found white blister on cabbage in Australia, although cabbage is susceptible in Europe. At present the white blister on broccoli in Australia differs from that described on broccoli (B. oleracea Race 9) overseas.

Molecular (DNA) test to distinguish races

A rapid DNA test is available to identify A. candida, but it does not distinguish the different races.
A number of genes are now being sequenced to identify genetic differences between races. The ability to distinguish the different races will enable the development of a rapid diagnostic test for screening seeds and seedlings and to track populations of the fungus in soils.

AUSVEG, Horticulture Australia Ltd, the Federal Government and the Victorian State Government are supporting this three-year project, VG04013. For more information contact Elizabeth Minchinton, Joanna Petkowski or Robert Faggian via DPI Victoria Tel: (03) 9210 9222.

TOWARDS CLUBROOT RESISTANT BRASSICAS

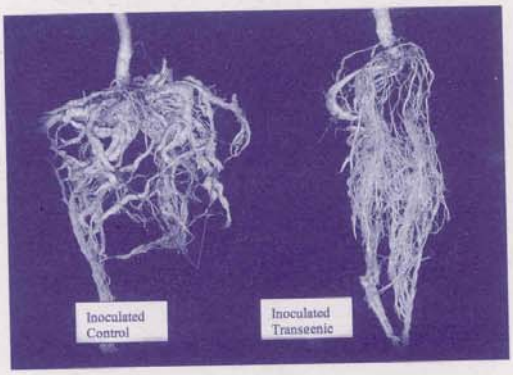
By Dr. Vijay Kaul, Department of Primary Industries, LaTrobe University, Victoria.

Scientists are using new DNA techniques to create clubroot resistant brassicas. Dr Vijay Kaul, at Primary Industries Research Victoria, has spent the past seven years working on ways to genetically modify vegetable brassicas to control clubroot and other important diseases, as well as extend the shelf life of produce.

A range of new DNA-based techniques was developed to facilitate the rapid introduction of new traits into vegetable brassicas. These included methods to transfer genes into a number of commercial and parental lines of cauliflower and broccoli. Tissue culture methods were also developed for six parental lines, allowing the reliable and rapid propagation of genetically modified plants.

As a result of this project, a population of genetically modified plants has been produced that contain a range of genes for disease control. These plants were assessed in glasshouse trials after being challenged with clubroot spores. Several demonstrated very encouraging levels of resistance to clubroot. The results represent a successful proof-of-concept for the genetic modification of brassica parental lines and will provide the brassica industry with a rapid means of introducing new traits into popular cultivars in the future.

Arati Agarwal, a PhD student with Deakin University, is investigating the molecular basis of clubroot resistance. His research utilises micro-array technology to assess genome-wide changes during the infection process and to identify new plant defence pathways. This will help to target new and novel resistance genes that can be quickly introduced into parental lines using Dr Kaul's methods.



Clubroot inoculated broccoli - showing non-transgenic control plant and a transgenic plant.

BECOMING STRATEGIC ABOUT CLUBROOT

By Caroline Donald and Denise Wite, DPI Knoxfield, Victoria.

What is strategic application?

Strategic application is all about placing treatments where they will be most effective. In terms of clubroot control this means targeting the plant root zone. Incorporation of treatments in bands along the transplant rows before transplanting ensures that products are evenly distributed around the transplant root zone where protection from infection is required.

What are the benefits of strategic application?

This method of application targets the root zone placing treatments only where they are needed. Less product is required, there is no wastage due to run off into the press wheel tracks or treatment of the inter row area and phytotoxicity is less likely since the product is evenly distributed in the treated band. Other benefits of this method of application over traditional spray, drop spray (drench) or broadcast applications include:

1. Increased effectiveness

Some products are more effective when applied in this way. The fungicide fluazinam (Shirlan®) binds quickly to organic matter in soils so it is very difficult to irrigate it through the soil profile to the rootzone. Traditional surface spray or drop spray (drench) methods of application often result in uneven distribution of the fungicide around the transplant root zone leading to poor control or phytotoxicity.

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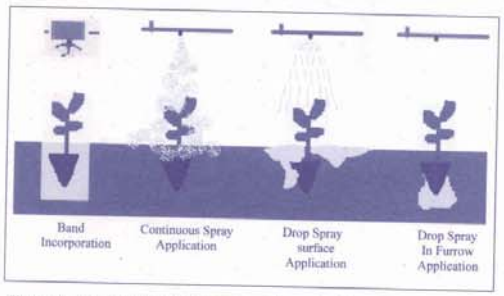

Figure 1: Distribution of fluazinam through the soil profile as a result of various methods of application.

Incorporation of fluazinam (Shirlan®) into the transplant row immediately before transplanting improves the distribution of this product thereby increasing its efficacy (Fig. 2).

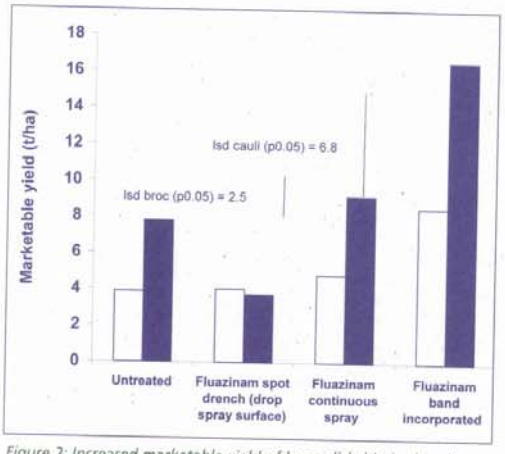

Figure 2: Increased marketable yield of broccoli (whitebar) and cauliflower (black bar) as a result of strategic application (band incorporation) of fluazinam. Data courtesy of Rachel Lancaster, Agriculture Western Australia.

2. Reduced cost

Since only one third of the total area is treated by incorporation of treatments into the planting row the cost of treatment is approximately two thirds less than broadcast application. Where the cost of the treatment is high (for example calcium cyanamide, Perlka®) this amounts to significantly increased profitability.

3. Saves time

Provided the treatments used do not pose a health risk to the operators and are safe to apply at planting (not phytotoxic) this method of application saves time as treatment and transplanting can be done simultaneously. A single pass treatment and planting saves fuel, tractor wear and labour, ensuring that the plants are always placed in the centre of the treated row. Some products such as liquid fungicides may pose a health and safety risk to workers and are best applied separately, immediately before transplanting. Other products such as calcium cyanamide must be applied 7-10 days before transplanting so are not suited to simultaneous treatment and transplanting.

4. Suits a range of soil types, liquid and granule application

Since the products are mechanically distributed into the treated bands, soil type is eliminated as a factor influencing infiltration and distribution and therefore efficacy. Machines can be built to apply liquids and/or granules in this way (Fig. 4).

Figure 4: Purpose built machine designed to incorporate liquids and granules into the transplant row.

How can existing machinery be modified for strategic application?

Existing machines can be modified for strategic application by the addition of a small tool bar to which two spray jets, and/or granular chutes and two small rotary hoes are fitted (Figs 5 and 6).

Each rotary hoe is mounted in the centre of a 'metal' box approximately 23 cm wide to retain the treated soil in the planting row following tillage. Attach a flap to the back of these boxes that will swing open to release stones and other objects. Allow sufficient space between the blades and the inside of the box to allow stones to pass through. The nozzles and fertiliser chute need to be angled into the box at a position to avoid blocking the jets. Cover nozzles with a protective flap to prevent spray drift (Fig 5).

Within the treated bands the soil is tilled to an approximate depth of 15-20 cm. Transplanting equipment may be mounted directly behind the tool bar.

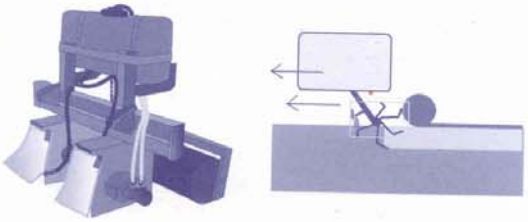

Figure 5: Schematic diagrams illustrating the concept of strategic application of treatments by incorporation into the transplant row.

Figure 6: Transplant machinery modified to strategically apply fertilisers at transplanting. Photographs courtesy of Rachel Lancaster, Agriculture Western Australia.

Appendix 18c Brassica IMP newsletter Issue 8

LADYBIRD'S ROLE IN IPM BEING MEASURED

By Brendan Nolan, Researcher, Queensland Dept of Primary Industries and Fisheries.

In a two year project supported by Horticulture Australia Ltd, Queensland Department of Primary Industries and Fisheries (QDPI&F) entomologist Brendan Nolan has investigated whether the white-collared ladybird (Hippodamia variegata) has a role in integrated pest management strategies used by Australian brassica growers to reduce chemical insect control and crop damage.

The white collared ladybird (WCL) is native to Western Europe and was first discovered in Queensland's Gatton district in 2000 by QDPI&F entomologists and has since spread throughout Australia.

Mr Nolan said the goals of this project are to better understand how the WCL interacts with its food resources and how this influences its ability to be an effective biological control agent in brassica agroecosystems.

This research will improve our understanding of naturally occurring bio-control agents, thereby providing information useful for augmenting biological control, improving conservation efforts, and increasing pest management options.

Early results investigating prey choice, prey consumption and the relative foraging success for WCLs indicate mixed results. While, WCL can predate on a range of brassica insect pests, including aphids (Lipaphis erysimi, Brevicoryne brassicae and Myzus persicae), thrips (Thrips palmi), whitefly (Bemisia tabaci), moths eggs and neonates (Helicoverpa spp, Crocodilomia pavonana, Plutella xylostella, Pieris rapae), their rate of development and survivorship varies between prey species.

For example, WCL body mass and weight is lower, take twice the time to complete their lifecycle, and have very low survivorship when fed whitefly compared with aphids.

The research project will monitor changes in ladybird numbers in-crop throughout the season, identify which climates are best suited to the ladybird, and assess their potential for production by commercial insectaries. "Insect pests are a major challenge for Brassica crop growers. Biological control agents are an attractive option because of the high cost of pesticides, environmental concerns about their use and insect resistance."

Vegetable growers are welcome to contact Brendan to discuss non-chemical insect control strategies for their production systems on 07) 5466 2222.

ROADSHOW TOURS AUSTRALIA

By Caroline Donald and Denise Wite, DPI Knoxfield, Victoria.

Hundreds of vegetable Brassica growers across Australia have recently participated in a series of road show events, funded by the National Vegetable Levy, Horticulture Australia Limited, and the Department of Primary Industries Victoria, called 'Better Brassicas'. Developed to improve the exchange of information between researchers and industry and to enhance the uptake of research outcomes, the events have meant five weeks on the road for the team from Victoria. 'It has been a long five weeks', said project leader Caroline Donald, 'but judging from the feed back from growers and other members of the industry, it has been well worth it.

The roadshow, developed together with the vegetable industry development officers in each state, was a package of events that included industry workshops, farm visits and meetings with local researchers.

Free Fact Sheets

If you missed the workshops, copies of the material presented including, a series of ten clubroot fact sheets, nursery and farm posters and four white blister control notes can be obtained by contacting your local vegetable industry development officer.

DBM WEBSITE

The website of the National Diamondback moth project has been revamped with all the latest tools and information you need to get on top of this dominant pest.

You will find the improved version of the Electronic Crop Sampling Plan of the project as well as full explanations of key practices of IPM for controlling DBM as well as past copies of this newsletter and so much more. The direct way to find it is to type the following address and then save it into your favourites. It can be found at:
http://www.sardi.sa.gov.au/dhtml/ss/section.php?sectID=2&tempID=2

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This newsletter compiled and edited by Dijana Jevremov with Caroline Donald, and Denise Wite.
Items for future editions are welcome from other Brassica related projects. Contact Dijana using details above.

This newsletter is facilitated by HAL in partnership with AUSVEG and is funded by the National Vegetable Levy. The Australian Government provides matched funding for all HAL's R&D activities.

This newsletter printed on recycled paper using vegetable based inks.

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Appendix 19a Brassica IMP newsletter Issue 7

Brassica IPM
NATIONAL NEWSLETTER

MANAGING CLUBROOT

By Caroline Donald and Denise Wite, Primary Industries Research Victoria.

July 2005

FARM AND NURSERY HYGIENE

Clubroot continues to plague vegetable brassica growers with reports of significant losses during the 2004/2005 growing season. In this article we get 'back to basics', review what is known about the way the clubroot pathogen moves and survives, and how this information can be used to limit the spread of clubroot.

Plasmodiophora brassicae, the cause of clubroot, has a reputation for being difficult to control because it can survive for long periods as dormant spores in soil and water. These spores are often unknowingly spread and can contaminate nursery or farm production systems.

Understanding the potential 'hygiene risks' is the first step in preventing the spread of clubroot. Any activity that introduces soil or water onto the property can also bring in the organism that causes clubroot. Clubroot can be introduced on farm machinery, contract labour and equipment, nursery stock and irrigation water. Always purchase seedlings from a reputable source.

Farm hygiene signage

NURSERY STOCK

In Victoria the organism causing clubroot has been detected in dams, bores and on-farm nurseries in a brassica production region using a DNA based diagnostic test. Of particular concern was detection of ***P. brassicae*** on plastic seedling trays being returned to the nursery for reuse.

This contamination is usually due to a coating of mud or dust on the tray that reduces the effectiveness of disinfectants. Where possible plastic seedling trays should not leave the nursery. Where this is not possible, high-pressure washing of returned trays is necessary to remove traces of dirt before disinfection or steam sterilisation to reduce the risk of contamination.

DAMS

Dams can be contaminated by runoff from nearby affected fields. In controlled studies, spores remained viable in water for three years, and daily irrigation with as few as 10 spores/ml has been shown to result in infection.

Dams should not be used for irrigation of nursery stock, particularly if the nursery is located within a brassica growing region. Ultimately use of 'clean' mains water (town water) is the preferred option, however, where this is not possible, water should be drawn from that part of the dam that is least likely to contain spores of ***P. brassicae.***

In an undisturbed body of water such as a dam, most of the spores are likely to be contained in the sediment at the bottom of the dam. Spores of ***P. brassicae*** settle in water at a rate of approximately 25 cm/day. The impact of contaminated dam water on the spread of clubroot within a farm or from farm to farm (where a dam may receive recharge water from a neighbouring property) could be minimised by avoiding this sediment layer.

Locate the irrigation intake pipe in the stillest part of the dam, mount it on a float to ensure that water is collected near the surface of the dam where the concentration of resting spores is likely to be lowest.

IN CONCLUSION:

Simple (and often inexpensive practices) can make a big impact on the spore load (clubroot risk) entering your property. Don't be overwhelmed by the number of hygiene tips provided in this article. Instead, seek to identify the risks that apply to your property and work systematically, beginning at the top of the list with the highest risk activity, and working towards implementing procedures to minimise these risks *(See over the page)*.

Appendix 19b Brassica IMP newsletter Issue 7

Brassica IPM
NATIONAL NEWSLETTER

MANAGING CLUBROOT

July 2005

TOP THREE HYGIENE RISKS

NURSERIES

1. Reusable plastic seedling trays returning from farms to the nursery (easily the biggest potential risk).
2. Water stored in dams (mainly a problem for small 'on-farm' nurseries).
3. Soil carried into the nursery on delivery vehicles, visitors, birds, rodents and wind blown dust.

FARMS

1. Dirty machinery moving from site to site.
2. Shared equipment and labour with an associated organic (dirt) load.
3. Irrigation with water from dams receiving runoff from affected paddocks.

TOP TIPS FOR BETTER HYGIENE

1. Purchase high pressure washing equipment and use it. Routinely prewash reusable plastic seedling trays, equipment and farm machinery.
2. Work clean parts of the farm early in the day. Work from the 'cleanest' (least likely to contain *P. brassicae* spores) to the 'dirtiest' (most likely to contain *P. brassicae* spores) parts of the farm each day. High-pressure wash machinery and equipment at the end of each day.
3. Request that all visitors report to reception, the farmhouse or provide a mobile number for them to call before entering the property.
4. Clearly signpost limited access areas.
5. Keep plastic seedling trays off the ground to prevent potential contamination.
6. Insist on the cleanliness of shared bins, trays and other equipment being returned to your property.
7. Separate delivery and production areas.
8. Make sure all staff are aware of hygiene protocols.

ADDITIONAL TIPS FOR NURSERIES

1. Protect the nursery from dust carried on the prevailing wind using screens and/or vegetation.
2. Cover bare earth with concrete or gravel (eg. Blue metal).
4. Create separate delivery and loading areas.
5. Place a footbath containing bleach or other type of disinfectant at the entrance to a glasshouse or shade house to prevent the transfer of the pathogen on human foot traffic.
6. Request that trays, pallets or delivery racks, which are sent to farms, are kept off the ground and are clean on return.
7. Control rodents.

END OF AN ENTOMOLOGICAL ERA continued...

The team sadly misses him for both his wealth of knowledge and personable manner. He has worked with a broad range of agricultural pests since 1974 with his most recent major research interests centred on improving management strategies for corn earworm (Helicoverpa armigera) in sweet corn and diamondback moth (Plutella xylostella) in vegetable brassicas.

He has become well known to the international diamondback moth research community and convened the fourth international workshop on the management of diamondback moth and other crucifer pests in Melbourne in 2001. Most recently, Peter has worked on projects to control leafminer flies in Indonesia and on integrated pest management training programs.

At his farewell function, colleagues paid tribute to Peter's great passion for entomology, his role as a mentor, his support for the taxonomy unit and his unsurpassed knowledge of applied entomology in Australia. Peter thanked the Department for allowing him to indulge his entomological passion over the years.

IMMINENT RELEASE OF CLUBROOT RESISTANT VEGETABLE BRASSICAS

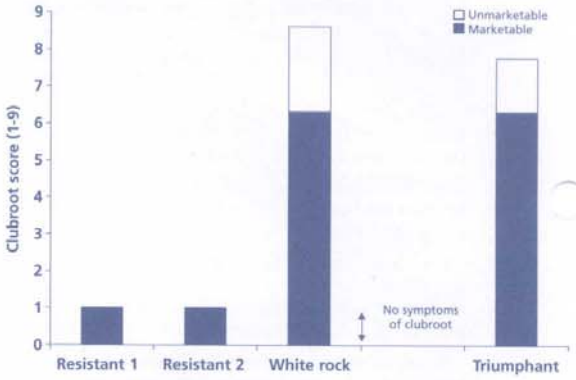
Australian growers will be amongst the first in the world to add resistant varieties of vegetable brassicas to their existing arsenal of weapons to fight clubroot. The result of several decades of work by Syngenta Seeds brassica breeder, Peter Tjeertes, means that commercial release of the varieties in Australia is likely to begin in the next two years.

The link between Australian clubroot researchers and Dutch brassica breeders was established five years ago during a chance meeting at a brassica conference in the UK. Since that time, members of the National Clubroot Research team in Victoria and Western Australia have conducted extensive evaluation of several of Syngenta's clubroot resistant cauliflower lines against populations of the clubroot pathogen in Australia.

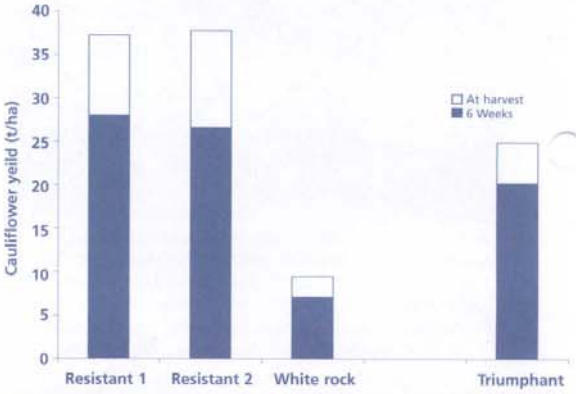
In all of the trials conducted in the glasshouse and at field sites in Victoria and Western Australia, the resistant lines remained completely free of any root galling due to clubroot, whereas the susceptible control plants and surrounding commercial crops were severely affected.

The source of the resistance is a naturally occurring clubroot resistant gene that was bred by conventional plant breeding methods into Syngenta cauliflower, cabbage and Brussels sprout varieties. Agronomic evaluation of the varieties in Australia was conducted last season with the help of a number of growers in Victoria and South Australia. This work will continue next season.

Any growers with a clubroot problem that would like to see how these varieties might perform on their property should contact Caroline Donald, DPI Victoria (03) 9210 9299) who will pass their details on to Syngenta field staff.



Root galling and yield of clubroot resistant (F308 and F311) and susceptible (White rock and Triumphant) cauliflower cultivars in a field trial from Werribee South, Victoria. (Note that roots were assessed 6 weeks after transplanting and at harvest. Root galling was measured on a 1-9 scale where 1=no root galling observed).



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