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# Scoping study on the management of varnish spot in field and hydroponic lettuce

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**VG 03003(June 2005)**

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This report covers the activities undertaken during the period of the project from July 2003 till June 2005. Other relevant material that was developed before the start date has also been included.

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# MEDIA SUMMARY

There are a number of diseases that affect lettuce. *Sclerotinia*, downy mildew, Anthracnose and *Septoria* spot are examples of fungal diseases. Virus diseases such as big vein, necrotic yellows, tomato spotted wilt virus and lettuce mosaic virus also affect lettuce. Bacterial diseases include bacterial leaf spot and varnish spot. Varnish spot causes brown lesions around the midrib on leaves quite commonly under outside leaves which show no symptoms. This project looked at the awareness of this disease across the lettuce industry in Australia through a survey and industry contact. The main key points of the project were;

- The disease was reported in all states of Australia.
- Growers surveyed were able to recognise the disease and a large proportion had the disease present on there properties most only occasionally.
- Some growers reported that they only had minor losses due to this disease; others had whole blocks of lettuce rendered unmarketable.
- Losses ranged from 0-20% in crop figures or up to $200,000 in monetary figures.
- Growers generally thought that this disease was mainly seen in spring.
- Most of the respondents considered that further research should be carried out on this disease.

Varnish spot may be more noticeable on lettuces harvested for processing. This is because the outside leaves which may be symptomless are removed and the leaves below may show the typical varnish spot lesion.

The bacterium that causes varnish spot belongs to the group of bacteria that are associated with browning of cut lettuce. They are soil borne and may infect lettuce through water splash from soils that contain the bacterium. Other possible methods of infection could be seeds, transplants and insects, but these need further investigation. Varieties may be variable in their susceptibility to varnish spot.

There are no control methods for this disease. Therefore it is recommended that detection methods for the bacterium and varietal resistance should be investigated. The level of the bacterium in soil and water should be further investigated and the effectiveness of various application times and types of copper sprays should also be studied.

# TECHNICAL SUMMARY

Varnish spot is a bacterial disease that causes brown lesions around the midrib on lettuce (*Lactuca sativa* L.) leaves quite commonly under outside leaves which show no symptoms. Varnish spot of lettuce is caused by *Pseudomonas cichorii*. The disease has been found in other countries including Italy, Turkey, Brazil, North America and is common in Australia. This project was established to find the awareness and seriousness of this disease across the lettuce growing regions of Australia.

Growers and others in the industry were visited, met with at industry information nights and meetings or called by telephone to obtain information on varnish spot. In response it was found that the majority of growers had seen the disease and were able to distinguish it from other bacterial rots such as those caused by *Erwinia*. All states had growers that were affected by varnish spot. It was previously thought that only some states had this disease. Most growers surveyed had minor losses from varnish spot but some growers recorded large losses such as $200,000, $145,000 and $40,000. These growers were in three different states. It appears that varnish spot can affect a lettuce sporadically or totally wipe out a planting. One hydroponic grower had also recorded heavy losses as a result of infection by *Pseudomonas cichorii.*

Processors reported that it was an issue for lettuce processed for hearts, with one processor recording a 3% loss from this disease. Seed companies agreed that most states had the disease with one company having problems with varnish spot on some varieties in 2005.

Previous research on this disease shows that it can infect through stomata and epidermal hairs. The bacteria can survive in lettuce residue so crop rotation has been suggested as a control option. But reports through this project have indicated that varnish spot has occurred on blocks that have not had lettuce for up to three years. Other sources of inoculum include seeds, transplant and insects. Some growers in the survey considered water sources as a possible source of bacteria; this has been supported with overseas information. Other hosts of *P. cichorii* include chicory cabbage, cauliflower, celery tobacco and endive. Numerous weed hosts could also exist.

A possible management plan for varnish spot would include the following;

- Water used for seedlings should be tested for varnish spot bacteria. Transplants should be inspected for signs of disease and infected transplants destroyed.
- Irrigation should be carried out to minimize leaf wetness duration and especially reduced to a minimum within three weeks of harvesting.
- Fields are rotated for 4-5 years between lettuce crops or other hosts of the pathogen causing varnish spot.
- Hosts should not be planted in adjacent fields.
- Plant less susceptible lettuce varieties.
- Lettuce should be planted in fields with well-drained soil and good air movement to promote rapid drying.

Future research on this disease would need to;

- Investigate and develop inoculation methods to reproduce varnish spot artificially for use in field and laboratory trials.
- Developing a quick diagnostic test for *P. cichorii* and other fluorescent pseudomonads that contribute to lettuce browning.
- Investigate varietal differences to varnish spot.
- Investigate through trials the efficacy of copper treatments with the aim of controlling varnish spot but also to reduce any sensitive reactions to the copper compounds.
- Examine weeds for their potential as a source of *P. cichorii* inoculum.
- Examine seeds, transplants, alternate hosts and insects as possible sources of inoculum.
- Investigating and develop water testing methods for *P. cichorii.*

# INTRODUCTION

Lettuce production is worth A$122million (2001)(ABS Agstats). There are a number of diseases that affect lettuce. *Sclerotinia*, downy mildew, Anthracnose and *Septoria* spot are examples of fungal diseases. Virus diseases such as big vein, necrotic yellows, tomato spotted wilt virus and lettuce mosaic virus also affect lettuce. Bacterial diseases include bacterial leaf spot and varnish spot. The main symptom of varnish spot is brown discoloration of the midrib or around the midrib.

Varnish spot can be found all year but seems to be most serious in the late winter and spring months. Lettuce with varnish spot may be rejected at harvest or harvested then transported to markets without any knowledge of the disease, only to be rejected on delivery.

Typical symptoms are shown in the pictures below.

**Figure 1**

**Figure 2**

Lettuce from Hay in 1999, associated with a severe outbreak of varnish spot.

**Figure 3**

**Figure 4**

Figures 3 and 4 are of a lettuce found in Cowra in 2004 where *Pseudomonas* bacteria were isolated. Note that the symptoms were slightly different symptoms of those in Figures 1 and 2.

Varnish spot is caused by bacteria belonging to the genus *Pseudomonas*. The disease appears close to harvest where the crop may look healthy until the lettuces are harvested. The spots may not be visible from the outside of the lettuce but when the

outer leaves are removed the brown spots are found, often along the midrib of inner leaves. These small lesions can expand rapidly from discrete spots to rotting. Other bacteria may infect through the damaged tissue and cause rotting of the whole heart. Unfortunately whole blocks of lettuce can be affected. Symptomless, but infected heads in combination with secondary rotting bacteria can develop rapidly in storage.

Varnish spot should not be confused with soft rot caused by another bacterium called *Erwinia sp* which may also occur on lettuce, usually every year, especially as summer temperatures approach. *Erwinia* enters the plant through injuries eg frost or spray damage causing heads to go slimy and unmarketable. Varnish spot can infect lettuce without these injuries.

**How does varnish spot infect and cause disease?**

A disease called varnish spot was found in California in 1977 (Grogan 1977). The disease was found to be caused by *P. cichorii.* The pathogen was isolated from soil and root samples from the field. The study also found that this disease was found only on sprinkler irrigated fields.

The Compendium of Lettuce Diseases (Davis *et al.* 1997) suggests that the disease can be soil borne and often associated with lettuce debris, but also suggests that seeds, transplants, alternate hosts and insects may also be sources of inoculum. Seeds and insects may be an important source of the bacteria in Australia. Seed health is an important issue for growers. Insects such as aphids and thrips, which are common inhabitants of lettuce hearts, could be sources of the bacteria.

The infection process is not that clear. Insects may cause injuries through which the bacteria may enter the plant. It is most likely that rain or overhead irrigation contributes to the disease. Water reservoirs are a possible source of bacteria. The bacteria may be introduced through water used for irrigation, regular sprays or by soil splashed by rain. The bacteria are spread by rain and wind.

Research has shown that *P. cichorii* was observed in stomata of leaves of the middle part of lettuce. It was also observed that there was no browning associated with the presence of the bacteria. It was also suggested that *P. cichorii* first invades the lettuce through stomata and later multiplies in the intercellular spaces of the epidermis and then progressed to colonise the intercellular spaces of the mesophyll (Hikichi *et al.* 1996).

Other work has shown that *P. cichorii* was present in seed (Ohata *et al.* 1982) and was able to be removed from seed by heat treating seed (Ohata *et al.* 1982). Unwounded lettuce tissues were readily infected through the stomata and epidermal hairs (Shirata *et al.* 1982). *P. cichorii* can be spread by aerosols when water is splashed onto soils and plants (Hikichi *et al*. 1996).

**Cold storage implications for varnish spot.**

As mentioned previously bacteria of the *Erwinia* species cause soft rot of lettuce. One important difference between *Pseudomonas* and *Erwinia* is that the latter only grows slightly at $5^0$C whereas *Pseudomonas* species have the ability to rot lettuce at temperatures close to $0^0$C (Nguyen-The and Prunier 1989).

**Control recommendations.**

Potassium sulphate applied as a fertiliser, has been reported to increase disease (Bleyaert *et al.* 1999), and treatments with copper products applied every 10-15 days after swelling of the heart was found to improve disease control (D'Ascenzo *et al.* 1997). Bordeaux mixture and copper oxychloride were found to be more effective than copper hydroxide in reducing varnish spot in field trials in Italy (Bazzi and Cazolari 1984).

**Recent report of varnish spot.**

A new disease was reported on lettuce in Turkey in 2002, the disease was caused by *P. cichorii*. There was no proof but it was speculated that contaminated seeds and/or transplants were the source of the introduction of the pathogen to the region (Aysan *et al*. 2003).

The bacterium also causes leaf spots in ornamental plants such as Geraniums and Chrysanthemum.

**Project VG 98083 "A study of post harvest bacterial rots and browning in lettuce and the development of control methods"**

A previous project VG 98083 looked at the effects of the *Pseudomonas* group on browning in cut lettuce. However, some of the information was relevant to varnish spot. Two of the aims of the project were to monitor the levels of fluorescent pseudomonads (the group that *P. cichorii* belongs to) in the soil and to measure their seasonal abundance. In the Werribee region, fluorescent pseudomonads were found higher in winter and the lowest levels in summer. In the Gippsland region levels of fluorescent pseudomonads were found to be significantly higher in spring 2001 than summer 2001. Their investigations found that fluorescent pseudomonads in soils of lettuce growing regions varied over the seasons and varied between crop types. They also found that lettuce waste left after harvest contained high percentages of *Pseudomonas* species of bacteria.

**VG 03003** "Scoping study on the management of varnish spot in field and hydroponic lettuce" developed from a research application that was submitted to look more closely at this disease. This project is an extension/ evaluation study to find the awareness and extent of the problem in all lettuce growing areas.

An extension was requested till mid 2005 as 2004 had minimal disease and also to fit in with the third lettuce conference at Werribee.

# MATERIALS AND METHODS

The project's main aim was to obtain feed back from growers and others in the industry on whether varnish spot was an issue to them. This would establish how serious the disease was thought to be by the industry and to give some direction on future research.

Firstly an information sheet with pictures and description of the disease was prepared. This was designed to give participants information that would assist them in filling out a survey form which was also developed. The survey form consisted of four questions with the option of any further comments and other disease issues. The one page survey was easy to fill out but gave the priority information required. The questions asked and the possible responses are listed below.

**Have you ever seen this disease before?**

Yes ☐ No ☐

**Have you lost yield due to this disease? If yes can you give a loss figure in dollars.**

Yes ☐ No ☐ Estimated Loss $ ☐

**How often do you see this disease on your farm?**

Every year ☐ Occasionally ☐

**Would you like research done on this disease with funds from your levy?**

Yes ☐ No ☐

The full Disease Information Sheet and Survey can be found in the appendix. Both the information sheet and survey forms were forwarded to all Vegetable Industry Development Officers. An article was placed in Good Fruit and Vegetables as well as The National Vegetable Industry Centre's "Vegie Bites" Newsletter.

The aim was to obtain feedback from at least 10% of the growers from each state. Lettuce growing regions were also visited in South Australia, New South Wales, Western Australia and Victoria, where growers and industry representatives were asked for their feedback. In Queensland, chemical resellers were contacted and they gave information on behalf of the growers. Other growers were contacted by telephone.

In this report results of the survey have been documented with some case studies being examined in more detail. The overall aim was to examine the impact of this disease on growers and in doing so maintain their privacy.
For background information, Table 1 lists the main lettuce growing regions and their times of harvest. Approximate grower numbers have also been listed. More detailed information has been included in the appendix.

Where growers were visited that had symptoms on lettuce, infected hearts were tested to identify the bacteria present.

| **State** | **Regions** | | |
|---|---|---|---|
| **NSW** | **Hay** | **Central West** | **Sydney Basin** |
| Time of Harvest | Early February to late July | Mid June to the end of March | All year |
| Grower Numbers(Approximate) | 14 | 7-8 | 100+ |
| **Victoria** | **Cranbourne** | **Werribee** | **Lindenow** |
| Time of Harvest | Oct to mid May | Oct to mid May | All year. |
| Grower Numbers | 10 | 100 | 8 |
| **Western Australia** | **Perth Metropolitan** | **Gin Gin** | **Manjimup** |
| Time of Harvest | All year. | All year. | All year. |
| Grower Numbers | 64 | 5 | 7 |
| **South Australia** | **Adelaide Hills** | **Adelaide Plains** | **Murray Bridge** |
| Time of Harvest | Mid-November to late June | All year | All year |
| Grower Numbers | 6 | 6 | 2 |
| **Queensland** | **Lockyer Valley** | **Darling Downs/Stanthorpe** | |
| Time of Harvest | April-October | September to June | |
| Grower Numbers | 89 | 21 | |

**Table 1.** Lettuce growing regions, times of harvest and approximate grower numbers.

**Diagnostic tests.**

Samples of lettuce heads showing symptoms were collected and sent to Orange Agricultural Institute where the bacteria were identified through initially detecting bacterial ooze and then by FAME (fatty acid methyl ester) analysis. FAME analysis distinguishes bacteria through analysis of the fatty acid content.

# RESULTS

The numbers of respondents from each state are represented in Table 2.

| State | Number |
|---|---|
| NSW | 23 |
| QLD | 5 |
| SA | 2 |
| TAS | 1 |
| VIC | 13 |
| WA | 8 |
| Total | 52 |

**Table 2**. Replies from each growing region.

Varnish spot was reported from all states; previously it was thought to be an issue for south eastern states only. It appeared sporadically in each state and was reported to cause just small losses or occasionally reasonably huge losses. The general figures of between 3-20% were the losses recorded for this disease. Where growers recorded losses in monetary terms one grower recorded a $200,000 loss to this disease. However the disease appears in two ways, it may appear sporadically across a planting or may wipe out a whole planting as in case study one. In case study two, a hydroponic grower had severe losses when growing iceberg type lettuce. This was the only report of this disease in hydroponic lettuce.

A number of replies were collected from the meetings that were attended, some growers replied by reading the article in Good Fruit and Vegetables. In total 52 replies were received. At least one response was obtained from every lettuce growing region and therefore gave a reasonable picture of the occurrences of varnish spot. As with most diseases those that did not have the disease were more reluctant to fill out the forms. The numbers are low from Queensland because resellers in the Lockyer Valley did not consider varnish spot an issue for their growers.

The results from the questions are represented below graphically as a percentage of the figures Table 2. Remember that only one reply was collected from Tasmania and two from South Australia but this is within the limits of 10% of the number of growers per state.

**Question 1.** Have you ever seen this disease before?

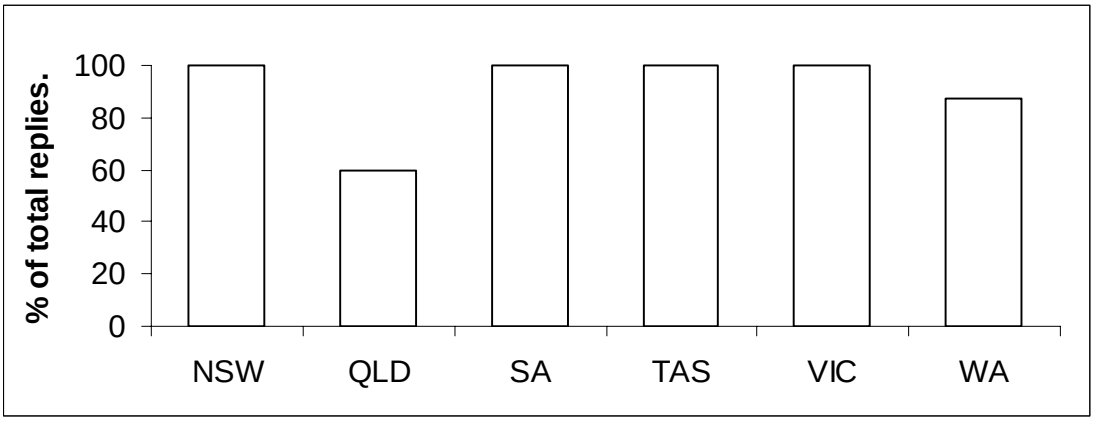



**Figure 5**. Percentage overall that recognised varnish spot.

**Question 2.** Have you lost yield due to this disease?

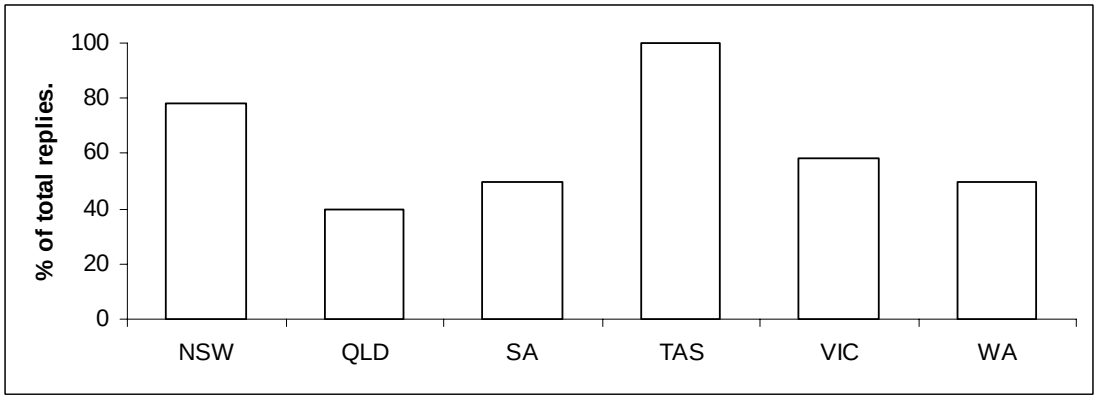



**Figure 6.** Percentage overall that had lost yield

**Question 3.** How often do you see this disease on your farm?

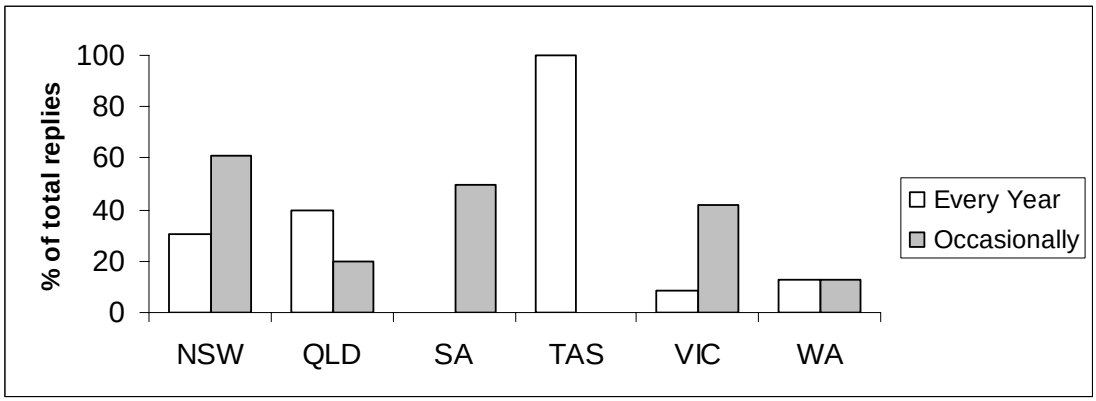



**Figure 7.** Percentage of overall that see the disease every year or occasionally.

**Question 4.** Would you like research done on this disease with funds from your levy?

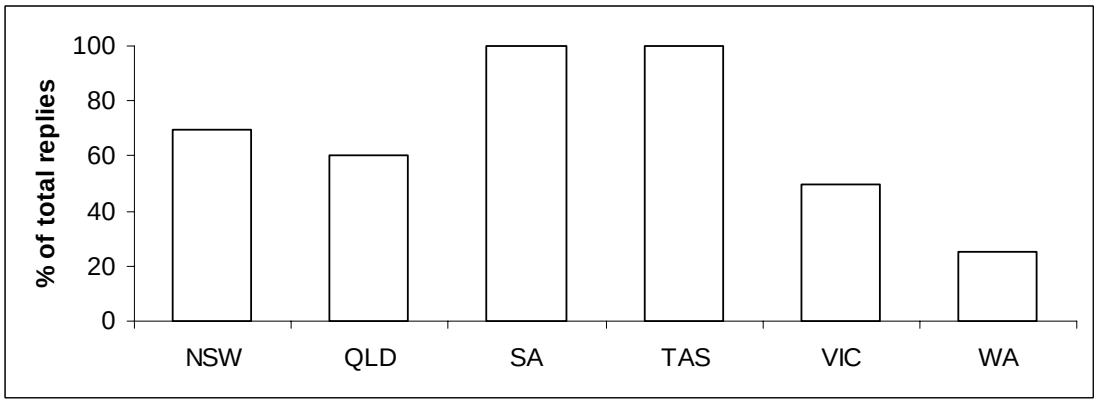



**Figure 8**. Percentage overall that consider research should be carried out on this disease.

**Other disease issues.**

The majority of growers considered that *Sclerotinia* was their main disease issue, followed by lettuce big vein with other diseases such as *Septoria*, Necrotic Yellows, Downy Mildew and Anthracnose occasionally mentioned. There was a noticeable reluctance to provide “too much information” as growers understandably preferred to keep any issues they had private.

# VARNISH SPOT OUTBREAKS-CASE STUDIES.

## CASE STUDY ONE

**State**-New South Wales
**Lettuce production type**-Field
**Type of lettuce**-Iceberg.
**Previously grown on the same block**- no lettuces for 3 years.
**Irrigation type**-Furrow.
**Market**-Fresh market.
***Pseudomonas cichorii* confirmed**-Yes
**Loss**-$30,000

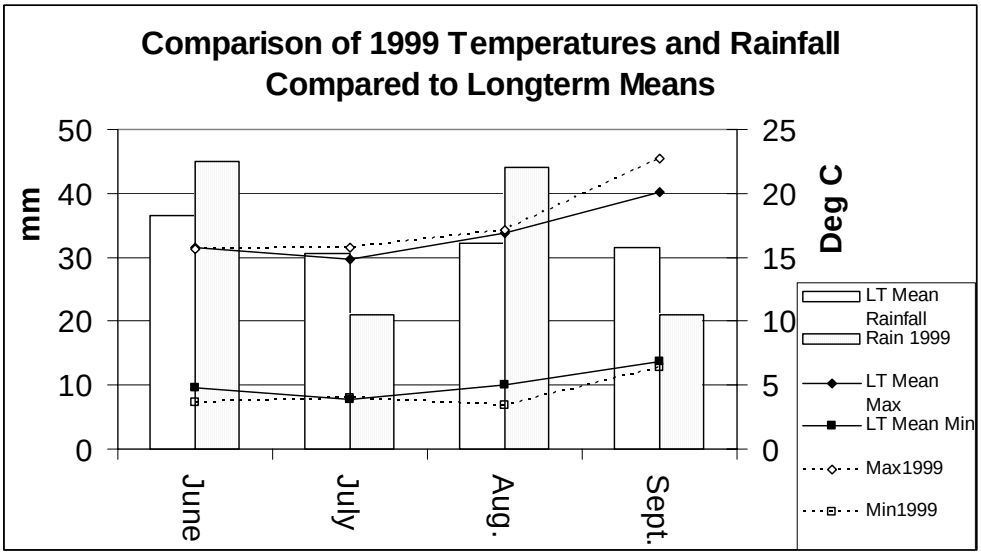
The initial contact by the author with the disease was in Hay in September 1999. A grower had whole plantings affected with other growers having sporadic outbreaks.

Lettuces had become infected in the field and some had gone slimy during transit or in some cases during cold storage. The crop was growing on soil that had not had lettuces grown in it for 3 years previously. More importantly the disease was associated with furrow irrigation whereas it is more generally considered as being more associated with overhead irrigation.

Plant samples were collected and the bacteria *Pseudomonas cichorii* and *Pseudomonas marginalis* were isolated. The identification of *P. cichorii* was able to confirm that the disease was varnish spot. As *P. marginalis* was isolated another leaf spot called marginal leaf spot was also identified as being present. This organism is very widespread and is often associated with post harvest breakdown of vegetables.

Weather conditions were examined for the period to see if it could explain the problem. The average maximum temperature for September was $22.7^0$C which was higher than the long term average of $20.1^0$C. This observation matches many of the comments from survey respondents that higher spring temperatures can result in the higher incidence of this disease. This in combination with above average rainfall in September could explain the occurrence.

Another observation on this outbreak was that growers discovered that even when the lettuces were placed in cool storage the rot became worse.



# CASE STUDY TWO

**State**-Queensland
**Lettuce production type**-Hydroponic
**Type of lettuce**-Iceberg.
**Irrigation type**-Hydroponic
**Market**-Fresh market.
***Pseudomonas cichorii* confirmed**-Yes
**Loss-** Up to 50% of the crop.

This grower lost 50% of his lettuce crop and had the organism causing the disease identified as *P. cichorii.* His comments were that the problem occurred when there was a lot of moisture in the atmosphere due to dew or rain followed by heat or humidity.

## CASE STUDY THREE

**State**-Victoria
**Lettuce production type**-Field
**Type of lettuce**-Iceberg
**Previously grown on the same block**- no lettuces for 3 years.
**Irrigation type**-Overhead
**Market**-Processing.
***Pseudomonas cichorii* confirmed**-No
**Loss**-$40,000 per year

In one block that had not grown lettuce for 3 years, there was 50% infection. The grower's comments were that it was worse in Greenway, worse around weeds and weedy riser lines. It was also worse as heads were allowed to get heavy and appeared to be related to pinking of stored lettuce.

The main bacterium usually associated with varnish spot was not confirmed at this site, organisms found included *Pseudomonas marginalis* and *Pseudomonas putida*. The normal causal organism *P. cichorii* was not detected. A photograph of an affected lettuce typical of those found at the site is shown below. The brown marking was not as clear on the midrib as the normal varnish spot symptom.

Isolating the correct causal organism can be difficult so the non detection of *P. cichorii* may be considered an anomaly however the symptoms did not appear as severe as varnish spot observed previously. It's quite possible that these organisms could have been contributing to this symptom expression.

### Variety trial

A variety trial was conducted on this site by a third party and their response was that of the 15 varieties replicated twice in the July transplanted trial four varieties recorded moderate for varnish spot when assessed. The four varieties were Grenadier, Patagonia, RZ 45-98 and Greenway. All are Salinas or (Salinas x Vanguard) types and none of the straight Vanguard types recorded varnish spot.

## SOME SELECTED COMMENTS FROM THE SURVEY.

"We are a reseller of fertilisers, chemicals, seeds and agronomy to growers. (It) affects many of our growers and often wipes out a planting in winter. Lettuce rather sensitive to copper sprays so between a rock and hard place." Reseller- Western Australia.

"Varnish spot is not a big concern in the Lockyer Valley." Reseller- Gatton, Queensland.

"Varnish spot not a major concern in my limited experience" Grower- Bacchus Marsh, Victoria.

"We are a research company developing new varieties. Varnish spot is occasionally damaging and we would like to have a variety sensitivity testing protocol." Seed Company-Victoria.

"I have seen it in all growing regions around Australia." Seed Company Representative, New South Wales.

"When found in the crop it is very devastating on the crop." Agronomist, Murray Bridge (South Australia) after referring to a crop that was lost at a cost of $145,000.

"We do lettuce processing; this is a significant problem for us." Processor reflecting an estimated 3% loss.

"Not such an issue on this farm at this stage-most years see some ……..I always believed it came from infected water in dams." Grower-Queensland.

"I see it mainly in autumn or spring when the temperature is around 19-21 $^{0}$C" Grower -Western Australia.

"I use low rates of copper oxychloride as a tank mix with each spray applied; I don't have a problem with varnish spot". Grower-Western Australia.

"I have more of a problem in my lettuces that go for processing compared to those that go for the fresh market" Grower –Victoria.

# DISCUSSION

It was encouraging to see that growers were aware of the disease called varnish spot caused by *Pseudomonas cichorii* and were able to distinguish it from the other bacterial rot caused by *Erwinia*. They often reported that they didn't see the disease until they removed a few outside leaves. It was unfortunate to see that some growers received large losses from this disease (one a loss of $200,000 and another at $145,000). The case studies highlighted some interesting anomalies. For example case study one highlighted that the varnish spot occurred on lettuce that received no overhead irrigation but did receive rain around the critical period ie close to harvest. Also the ground had not been used for lettuce for three years previous. Weeds have been identified as carriers of the bacterium in Japan (Ohata *et al.* 1982). The carrying potential of weeds in Australia has not been identified.

The project highlighted that varieties vary in their resistance to the disease with a variety trial at the site of case study three showing variability in disease expression. An independent comment from a seed company representative stated that they would like a sensitivity testing protocol developed for their varieties and the different reactions to varnish spot.

One reply from a processor gave a figure of 3 % losses at the factory due to varnish spot. As the figure is "at the factory" it would be assumed that some lettuces affected would have been culled out by growers so the actual on-farm figure would have been higher. The problem as mentioned before is that varnish spot may not be detectable until after the outside leaves are removed. With normal fresh head lettuce many would go to market with undetected varnish spot. However lettuces that go to processors as hearts have a higher frequency of varnish spot and therefore the highest losses.

There were some regional differences that appeared during the survey. In the Perth Metropolitan area which is north of Perth, varnish spot is not as common as the South of Perth. Two reasons for this could be the sandier soils of the former region and also the common occurrence of applying metham sodium, a soil fumigant.

**Australian research on the source of *Pseudomonas cichorii.***

Through work on the bacterium through Project VG 98083 "A study of post harvest bacterial rots and browning in lettuce and the development of control methods", *P. cichorii* was commonly isolated from soil. Previous to this the fluorescent pseudomonads had been found in soil, usually associated with organic matter (Rovira and Sands 1971).

The infection sources of fluorescent pseudomonads have been documented as plant debris, water, seeds and soil. It is unknown if insects may play a role in infection. A number of respondents indicated that they considered water as a source of the bacteria. If this is the case then it may be possible for the disease to develop in the field where overhead irrigation is used or also on seedlings in nurseries that may be irrigated with infected water. As *P. cichorii* is found in soil how its actual mode of transmission/infection is not clear.

**Controlling varnish spot with copper.**

As mentioned in the introduction copper has been trialled in other countries as a control option. A surveyed grower considered that he did not have the disease because of applications of copper oxychloride. Unfortunately some growers find lettuce sensitive to copper and so therefore application of copper using different types, rates and time of application to reduce damage should be considered as a research priority. There are no curative chemical control methods for these bacteria. Any research on copper would also benefit management of bacterial leaf spot.

**Conclusion**

This project has highlighted that this disease is found in each state. It can be damaging, often severely. Previous work has shown that the bacterium is found in soil. Infection is possible through stomata. Lettuce produce leaves from the outside towards the inside, that is the inside leaves are the youngest which has implications on not only how the inner lettuce leaves are infected but also the efficacy of any chemical treatment that may be applied to the outside of the heart. It may be carried in water and may be transferred through seedlings. An important task would be to develop a rapid test for this bacterium, examine water supplies and soils used for lettuce production.

Could other bacteria produce similar symptoms such as in case study 3 where *Pseudomonas marginalis* and *Pseudomonas putida* were found in a similar lesion as varnish spot? Other investigations that would benefit the lettuce industry would be to develop infection methods and to study the potential of the copper compounds to control this problem. Also to evaluate varietal differences that exists to varnish spot.

This project has shown the sporadic but sometimes devastating nature of this disease. Australia consists of lettuce growing regions that cover a range of climates. Lettuce are grown in different times of the year, using different varieties and different growing methods, however varnish spot appears to cover all these regions.

A management plan for varnish spot should include the following.

- Water used for seedlings should be tested for varnish spot bacteria. Transplants should be inspected for signs of disease and infected transplants destroyed (Do we have this ability without a quick test? Also could it be seed borne?).

- Irrigation should be carried out to minimize leaf wetness duration and especially reduced to a minimum within three weeks of harvesting (What about case study one with no overhead irrigation?).

- Fields are rotated for 4-5 years between lettuce crops or other hosts of the pathogen causing varnish spot (other hosts include cabbage, cauliflower, celery, chicory, chrysanthemum, endive and tobacco). Weeds also may harbour the bacterium in Australia

- Hosts should not be planted in adjacent fields.

- Plant less susceptible lettuce varieties (do we have this information for Australia?).

- Lettuce should be planted in fields with well-drained soil and good air movement to promote rapid drying (are Australia's planting densities too high?).

# TECHNOLOGY TRANSFER

This project was essentially a technology transfer project however other activities included.

- Article in Good Fruit and Vegetables. April 2004, 14: 14
- Article in the National Vegetable Industry Centre's Vegie Bites.
- Poster at the 3rd Lettuce Conference in Werribee, 2005.

# RECOMMENDATIONS

Future research on this disease would need to;

- Investigate and develop inoculation methods to reproduce varnish spot artificially for use in field and laboratory trials.
- Developing a quick diagnostic test for *P. cichorii* and other fluorescent pseudomonads that contribute to lettuce browning.
- Investigate varietal differences to varnish spot.
- Investigate through trials the efficacy of copper types (there are a number of different formulations) with the aim of controlling varnish spot but also to reduce any sensitive reactions to the copper compounds.
- Examine weeds for their potential as a source of *P. cichorii* inoculum.
- Examine seeds, transplants, alternate hosts and insects as possible sources of inoculum.
- Investigating and develop water testing methods for *P. cichorii.*

# ACKNOWLEDGEMENTS

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# APPENDIX 1

## VARNISH SPOT OF LETTUCE

Fact sheet

This fact sheet has been compiled to help growers with identifying this disease. The questionnaire attached will be important for assessing the need and direction of a research project on the disease.

Every year there are reports of outbreaks of varnish spot in some lettuce growing area with some years worse than others. In 1999 and 2000 there were a number of reports of serious problems in crisphead lettuce caused by what has been identified as varnish spot from Hay and the Sydney Basin. **Whole plantings were not harvested as a result of this disease.** Lettuces became infected in the field and often went slimy during transit or in some cases during cold storage.

**What is it?**

Varnish spot is caused by bacteria belonging to the genus *Pseudomonas*. The crop may look healthy until the lettuces are picked. The spots may not be visible from the outside of the lettuce but when the outer leaves are removed the brown spots are found, often along the midrib of inner leaves. These small lesions can expand rapidly from discrete spots to rotting of the whole heart. Other bacteria may then infect through the damaged tissue. Unfortunately whole blocks of lettuce can be affected. Symptomless, but infected heads can develop the disease rapidly in storage.

**This disease should not be confused with soft rot which may also occur on lettuce, usually every year, especially as the weather warms up.** This bacterium enters the plant through injuries eg frost or spray damage.

**How does varnish spot infect and cause disease?**

Varnish spot can be found all year but seems to be most serious in the late winter and spring months. These bacteria survive in crop debris, other hosts and in the soil. They are spread by rain and wind. The infection process is not that clear. Maybe insects are involved or frost. Insects can cause injuries through which the bacteria may enter the plant. It is most likely that rain or overhead irrigation contributes to the disease. Water reservoirs are probably a source of the bacteria. The bacteria may be introduced through water used for irrigation, regular sprays or by soil splashed by the rain.

There are gaps in the knowledge of this disease and hence there are no control recommendations. It is very difficult to control bacterial diseases, so a better understanding of their source and build up is the only way to manage them.

# APPENDIX 2

## SURVEY FORM

We would like to know about your experiences with varnish spot. Please answer this survey and return either to the person who handed it to you or **fax to 0269 512719**.

Have you ever seen this disease before?

Yes ☐ No ☐

Have you lost yield due to this disease? If yes can you give a loss figure in dollars.

Yes ☐ No ☐ Estimated Loss $ ☐

How often do you see this disease on your farm?

Every year ☐ Occasionally ☐

Would you like research done on this disease with funds from your levy?

Yes ☐ No ☐

Any comments.

……

……

Any other disease issues.

……

……

Name……Location……Phone……

For any further information contact Andrew Watson at Yanco Agricultural Institute on (02) 6951 2647

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# APPENDIX 3

## AUSTRALIAN LETTUCE PRODUCTION

Tony Napier, District Horticulturist, NSW Agriculture

The Australian lettuce industry is now valued at over 90 million dollars annually with 130 000 tonnes produced each year from approximately 555 growers. Lettuce is grown in all states of Australia with most production concentrating in Queensland and Victoria. Growing times, pest problems and production technologies can vary considerably between growing districts. The following tables give an overview of the main growing districts for each state.

### New South Wales

Approximately 1100ha of lettuce are grown annually from three distinct growing areas.

| | **MIA** | **Central West** | **Sydney Basin** |
|---|---|---|---|
| Area (Ha) | 320 | 180 | 600 |
| Growers | 14 | 7-8 | 100+ |
| Sowing times | Early February to Late July | Mid Jan to end March<br>Also<br>Mid Jun to end Aug | 12 Months |
| Harvesting Times | Early April to early November | End Feb to end May<br>Also<br>End Aug to mid Dec | 12 Months |
| Sowing methods | Direct seeded | Transplants | Transplants<br>Some direct seeding |
| Weed control | Cultivation and hand weeding | Mainly stomp | Kerb and Stomp |
| Bed size | 1.4 to 1.5m centres | 1.5 to 1.6m centres | 1.6 to 1.8m centres |
| Rows per bed | All 2 | Majority 3 | 3 and 4 |
| Plants per Ha | 45 000 to 50 000 | 55 000 to 60 000 | 65 000 to 70 000 |
| Irrigation | Flood | Overhead | Overhead |
| Main insect pests | *Helicoverpa* | Aphids in Winter and Spring<br>*Helicoverpa* in Summer and Autumn | Aphids in Winter and Spring<br>*Helicoverpa* in Sumer and Autumn |
| Main disease pests | Varnish Spot in Spring & *Sclerotinia* and Big vein in winter | Viruses and Downy Mildew in Spring | Many including *Sclerotinia*, Big vein, Anthracnose, Downy and Varnish spot |
| Main varieties | 60+% Greenway<br>Also Target & Magnum | 60 to 70% Target<br>Also Assassin & Magnum | Extensive range |

Source:- Tony Napier (NSW Agriculture)

## Victoria

Approximately 3350ha of lettuce are grown annually from three distinct growing areas.

| | **CRANBOURNE** | **WERRIBEE** | **LINDENOW** |
|---|---|---|---|
| Area (Ha) | 350 | 2800 | 202 |
| Growers | 10 | 100 | 8 |
| Sowing times | Jun to end Jan | Jun to end Jan | Year round (summer lettuce sown August to Feb) |
| Harvesting Times | Oct to mid May | Oct to mid May | Year round (summer lettuce sown Oct – April) |
| Sowing methods | Mainly transplants | Transplants | Transplants |
| Weed control | Kerb, Dacthal Ramrod | Kerb, Stomp | Scarifying Kerb, stomp, ramrod |
| Bed size | 1.8m centres | 1.6 to 1.8m centres | 1-1.2m centres some grown on the flat |
| Rows per bed | 3 & 4 | 3 & 4 | 3 |
| Plants per Ha | 65 000 – 70 000 | 65 000 – 70 000 | 50 000 |
| Irrigation | Overhead | Overhead | Overhead Moveable pipe Travelling spray irrigator |
| Main insect pests | *Helicoverpa*, Aphids, Rutherglen bugs | *Helicoverpa* in summer | Aphids *Helicoverpa* |
| Main disease pests | *Sclerotinia* *Septoria* Anthracnose Downy mildew | *Sclerotinia* Big Vein Anthracnose Downy mildew Corky root | *Sclerotinia* Varnish spot Anthracnose Downy mildew Occasionally viruses such as Lettuce necrotic yellows, cucmber mosiac |
| Main varieties | Target, Magnum, Marksman, Sheeba | Marksman, Casino | Magnum, Silverado Marksman and Magic. |

Source:- Craig Murdoch (Victoria Agriculture)

## Western Australia

Approximately 410ha of lettuce are grown annually from three growing areas.

| | **Perth Metro (mainly Wanneroo)** | **Gin Gin** | **Manjimup/Albany** |
|---|---|---|---|
| Area (Ha) (Est'd) | 260 | 50 | 10 |
| Growers | 64 | 5 | 7 |
| Sowing times | Year round | Year round | Transplanting November - February |
| Harvesting Times | Year round | Year round | January- April |
| Sowing methods | Mostly mechanical transplanting with some airseeders (Agricola) | Mostly mechanical transplanting with some airseeders (Agricola) | Transplanting with Cup and finger transplanters |
| Weed control | Metham, Kerb and Hand Weeding | Metham, Kerb and Hand Weeding | Stomp, Kerb and hand weeding |
| Bed size | 1.5m - 1.8m | 1.5m - 1.8m | 1.5m - 1.8m |
| Rows per bed | 4 | 4 | 4 |
| Plants per Ha | 70 000 - 80000 | 70 000 – 80 000 | 50 000 – 70 000 |
| Irrigation | Fixed sprinkler | Fixed sprinkler | Fixed and moveable sprinkler |
| Main insect pests | Western Flower Thrip, Aphids and *Helicoverpa* | Aphids *Helicoverpa* | Aphids Birds &Ducks |
| Main disease pests | *Sclerotinia*, Spotted Wilt Virus, Dry Leaf Spot, Big Vein and other viruses | S*clerotinia*, Dry Leaf Spot, and Big Vein | None |
| Main varieties (Iceberg) | Raider, Magnum, Silverado, Titanic, Oxley, Marksman, Blanco, Coolbreeze, Nepean, and Target | Raider, Magnum, Silverado, Titanic, Oxley, Marksman, Blanco, Coolbreeze, Nepean, and Target | Saboteur |

Source:- Dennis Phillips (WA Agriculture)

## South Australia

Approximately 300ha of lettuce are grown annually from three growing areas.

| | **Adelaide Hills** | **Adelaide Plains** | **Murray Bridge** |
|---|---|---|---|
| Area (Ha) | | | |
| Growers | 6 | 6 | 2 |
| Sowing times | August to mid March | All year round | All year round |
| Harvesting Times | Mid November to late June | All year round | All year round |
| Sowing methods | Transplants | Transplants | Transplant |
| Weed control | Stomp | Kerb<br>Dacthal | Dacthal<br>Kerb<br>Stomp |
| Bed size | 1.5 to 1.8m centres | 1.5 to 1.8m centres | 1.5 to 1.8m centres |
| Rows per bed | 4 | Majority 4 | 4 |
| Plants per Ha | 55 000 | 50 000 | 50 000 |
| Irrigation | Overhead | Overhead & Drip | Overhead |
| Main insect pests | Thrips<br>Slugs | Aphids<br>*Helicoverpa*<br>Western flower thrip | *Helicoverpa*<br>Western Flower thrip |
| Main disease pests | TSWV<br>Anthracnose<br>Downy Mildew Big Vein | TSWV<br>Bacterial leaf spot<br>Big Vein<br>Downy mildew | Downy Mildew<br>Big Vein<br>TSWV<br>Anthracnose |
| Main varieties | Marksman<br>Magnum | Greenway<br>Magnum<br>Target | Greenway<br>Magnum<br>Target<br>Kingsway<br>Raider |

Source:- Greg Bragg (Yates)

## Queensland

Approximately 1320ha of lettuce are grown annually from two growing areas.

| | **Bris/Morton/Widebay (includes the Lockyer Valley)** | **Darling Downs/Stanthorpe areas** |
|---|---|---|
| Area (Ha) | 1019 | 301 |
| Growers | 89 | 21 |
| Sowing times | Mid Feb to Aug. | Early July to end April |
| Harvesting Times | April to October | September to June |
| Sowing methods | Seedlings | Seedlings |
| Weed control | Kerb/ Stomp/ Hand chipping | Kerb/Stomp/Hand chipping |
| Bed size | 1.5m centres | 1.8m centres |
| Rows per bed | 2-3 | 3-4 |
| Plants per Ha | 50 000 | 70 000 |
| Irrigation | Overhead/trickle | Overhead |
| Main insect pests | *Helicoverpa*<br>Lucerne leaf roller | *Helicoverpa* |
| Main disease pests | DM/ Bacterial spot/ *Sclerotinia* | DM/ *Sclerotinia*/ *Septoria*/ *Rhizoctonia* |
| Main varieties | Raider/Titanic | Sea Green/ Raider |
| Tonnes | 30632 | 10752 |
| $value | $21+M | $7.5M |

Source:- John Duff (QDPI)

## Tasmania

Approximately 100ha of lettuce are grown annually in Tasmania from four major growers. Lettuce is grown for about 9 months of the year with no production during winter.

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