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Lychee Pepper Spot in Australia

(Its Impact and Control)

A report for the Rural Industries Research and Development Corporation

by Henry and Jenny Drew

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Researcher Contact Details
Dr Henry Drew
283 Hunchy Road
HUNCHY QLD 4555

Phone:	07 5445 0032
Fax:	07 5445 0940
Email:	hjdrew@ozemail.com.au

RIRDC Contact Details
Rural Industries Research and Development Corporation
Level 1, AMA House
42 Macquarie Street
BARTON ACT 2600
PO Box 4776
KINGSTON ACT 2604

Phone:	02 6272 4539
Fax:	02 6272 5877
Email:	rirdc@rirdc.gov.au
Website:	http://www.rirdc.gov.au

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Foreword

This publication considers the increasing importance of a new disease of lychees in Australia.

The disease, named Lychee Pepper Spot (LPS) for its distinctive blemish to the fruit, is caused by a presumably new strain of anthracnose (*Colletotrichum gloeosporioides*) which also causes rots in several other subtropical fruits.

The report highlights the results of a telephone survey of 100 lychee growers across Queensland and northern New South Wales carried out in 1999, and of an off-season fungicide trial to control the disease. It also reports the results of a residue trial required by the National Registration Authority to facilitate the issue of an off-label minor use permit for mancozeb, which can be used as an alternative to copper sprays.

The survey results indicate that the disease has spread rapidly since its first detection in 1982 and is likely to reach all commercial lychee growers within the next few years. While losses across most orchards are currently low, below 1%, losses in individual trees can reach 25% of saleable fruit. The disease is particularly widespread and severe on the most popular commercial variety, Kwai May Pink. To date grower efforts to control the disease have had little success.

The trial results indicate that off-season spraying will not be sufficient to control the disease if conditions later in fruit development are conducive to disease development. The implications of this are that the Australian lychee industry, represented by the Australian Lychee Growers Association, must lobby for the registration or off-label approval of new more effective fungicides which can be used closer to picking. This will entail generation of further residue data.

This publication is a wakeup call to the Australian lychee industry.

This project was funded from RIRDC Core Funds which are provided by the Federal Government. The lychee industry also provided funds for the project.

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Peter Core
Managing Director
Rural Industries Research and Development Corporation

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Abbreviations

ALGA	*Australian Lychee Growers Association Inc.*
CQ	*Central Queensland*
FNQ	*Far North Queensland*
IHD	*Institute for Horticultural Development, Victoria*
LPS	*Lychee Pepper Spot*
MRL	*Maximum Residue Limit*
NSW	*New South Wales*
NNSW	*Northern New South Wales*
NRA	*National Registration Authority for Agricultural & Veterinary Chemicals*
QDPI	*Queensland Department of Primary Industries*
QFVG	*Queensland Fruit & Vegetable Growers*
QHI	*Queensland Horticulture Institute*
RIRDC	*Rural Industries Research & Development Corporation*
SCSTFA	*Sunshine Coast SubTropical Fruits Association Inc.*
SEQ	*South-East Queensland*
WHP	*Withholding period*

Executive Summary

Lychee Pepper Spot (LPS) is a newly recognised disease of lychee fruit in Australia. The disease, caused by Colletotrichum gloeosporioides, results in superficial skin blemish but has no effect on either eating quality or, apparently, on postharvest rots and shelf- life. The same species of fungus causes fruit rots in several other subtropical fruits including avocados and mangoes.

The first symptoms of LPS are brown pinhead-sized spots on the top or sides of semi-mature fruit in areas of the canopy with overhanging branches. The spots do not increase in size but rapidly turn black. More spots appear on the top and sides of the fruit and may by harvest cover 30-50% of the fruit surface. LPS affects all lychee varieties. However it appears most severe on the increasingly popular Kwai May Pink (KMP), which comprised 37% of existing plantings in 1992, and 50% in 1999.In 1999 KMP made up 58% of future planned plantings.

Initially many growers were unaware of the symptoms of LPS and it was considered as one of several types of unspecified “blemish”. A preliminary factsheet with colour photographs of LPS was prepared and distributed to growers to raise awareness of LPS prior to implementing a telephone survey. The telephone survey of 100 lychee growers spread over as wide a geographic area as possible was carried out in mid-1999. The survey found that the first reports of the disease were in 1982. By 1989 it was found in all the major growing areas including Northern New South Wales (NNSW), South East Queensland (SEQ) and Far North Queensland (FNQ). By 1999 43% of growers surveyed reported having LPS on at least one variety in their orchard.

The general picture from the survey was of hotspots of infection with some severely affected trees and fruit, but with generally low levels across the whole crop. Of those growers who had LPS in their orchards 8% reported losses of more than 60% in their worst trees but 70% reported losses of less than 1% across the whole orchard. Thirty two percent of those surveyed believed that LPS produced a noticeable increase in leaf loss and a decline in tree vigour.

A fungicide trial to test the effectiveness of a range of off-season (winter-spring) treatments was carried out in 1999/2000 and repeated in 2000/2001 in a young orchard at Mooloolah in SEQ. All the products tested, except foliar calcium, were registered for control of Colletotrichum spp. in other crops. Fruit were harvested on the 13th, 18th and 28th January 2001. Unfortunately there was high variability within treatments and none of them gave a statistically significant reduction in disease incidence or severity compared with an unsprayed control. While the average percentage of fruit with pepper spot symptoms was low in all treated trees over the first 2 picks at 0.6-7.7%, this rose dramatically in the final pick to 9.8-17.0%. The untreated control was similar in the 1st pick but 5 and 10% higher in the 2nd and 3rd picks, respectively.

The project also involved collection of residue data for mancozeb. Whilst the trial did not prove the efficacy of any winter-spring treatments the lychee industry has applied for an off-label permit from the NRA for mancozeb to control pre-harvest rots, to augment the existing registration of copper oxychloride and hydroxide for algal spot. The laboratory analysis of sprayed fruit showed that the mancozeb residue levels at 7 and 14 days after treatment were 3.5 and 1.3 mg/kg, respectively. There is no MRL for dithiocarbamates on lychees or tropical fruit (inedible peel) but based on the MRL for berries and grapes of 5 mg/kg, and on a safety factor of 100%, it is likely that a withholding period of 10 days would be required. The Queensland Fruit & Vegetable Growers have applied to the NRA for a permit.

While no fully effective off-season treatments for LPS were identified the project has identified needs and opportunities for further research, extension and industry action. These are summarised in the recommendations below.

The project has resulted in five general recommendations:

RECOMMENDATION 1.

The ALGA should support the registration of cuprous oxide by lobbying the chemical companies concerned.

RECOMMENDATION 2.

The high intensity use of foliar fertilizers, like Stopit (calcium) and Eco-Carb (potassium bicarbonate), should be further investigated.

RECOMMENDATION 3.

Growers should target autumn leaf flushes, periods of wet weather and the second half of fruit development. Spraying should be on a 2-3 weekly basis during risk periods up to 10 days before harvest.

RECOMMENDATION 4.

The ALGA needs to support the development of proven programmes with approved products to minimise the risk of desperate growers using non-approved products.

RECOMMENDATION 5.

The ALGA should support regular on-going surveys to quantify the effects of LPS on individual growers and on the industry. These surveys could include other information such as production figures and estimates of pest problems which are needed to better plan the future of the industry.

1. Introduction

1.1 Background

Lychee Pepper Spot (LPS) is a newly recognised disease of lychees in Australia. It was first noticed in South East Queensland (SEQ) in a few orchards on the Sunshine Coast in 1993 [1]. The disease causes superficial skin blemish to fruit but has no effect on eating quality or, apparently, on storage life. Since its first occurrence the disease has got steadily worse in affected orchards despite some attempts at chemical control.

The unusual development of the characteristic spotting caused by LPS led to a number of theories as to the cause, but it was not until 1997 that a type of anthracnose fungus (Colletotrichum sp.) was implicated. This identification work was carried out by Dr Hin Yip with private funding from Mr Rohan Bosworth, a major Far North Queensland (FNQ) lychee grower (Yip, 1997). The identification was confirmed by QDPI Indooroopilly, but the species of Colletotrichum had not been firmly established (Coates, 1997). Anthracnose caused by Colletotrichum spp. is recorded as a disease of lychees in Vietnam (Trung, 1999) but usually manifests itself there as a “rot” rather than as a “spot” (Trung, pers.comm.)

First symptoms of LPS are brown pinhead-size spots or freckles, usually on the top of semi-mature fruit in areas of the canopy with overhanging branches [2]. Infected fruit are generally more common on lower branches, but in severely infected trees diseased fruit occur at all heights. The spots do not increase in size but rapidly turn black. The lesions are separate or coalescent. More and more spots appear on the top and sides of the fruit and may by harvest cover 30-50% of the fruit surface. Infections appear to overwinter on leaves and leaf petioles [3].

Conidial spores of Colletotrichum germinate only in water. Upon germination they produce an appressorium and penetration peg and penetrate the host tissue directly, causing little or no visible discolouration (Agrios, 1978, p.301). Then more or less suddenly, especially when fruits begin to ripen, the fungus becomes aggressive and symptoms appear. In the case of LPS it would appear that infections become contained to the small spots, and the spreading rots seen in other fruits do not occur. This infection process has implications for appropriate control strategies.

1.2 Relevance and benefits

LPS was identified in the Australian Lychee Growers Association Inc. (ALGA) “Lychee Industry 5 Year Strategic Plan” as R & D Goal: 9 (Anon, 1998). A subsequent postal survey of lychee growers by the ALGA rated LPS in the top four priorities and $5000 of grower funds was allocated through the QFVG Lychee Sub-Committee to LPS research in 1998/1999 (Bronson, 1998).

The lychee industry in eastern Australia was estimated in 1996 to comprise of 250,000 trees more than 5 years old producing 3000 tonnes of fruit per year (Greer, 1996). The QDPI estimate for 1992 was a total of 247,000 trees producing 1192 tonnes (QDPI, 1992). The large increase in production between 1992 and 1996, without significant increase in tree numbers, is an indication of the high number of young trees in 1992 which had yet to come into full production. Production by 2001 is expected to be 5000 tonnes. Value of production was estimated at $5,000,000 in 1992 rising to $9,000,000 in 1996. Over the same period exports increased from 54 to more than 250 tonnes, being approximately 15% of production.

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[1] A “new” devastating type of anthracnose developed on cherimoya on the Sunshine Coast at about the same time.
[2] This type of pepper spot infection is also sometimes seen on avocados.
[3] Coates has achieved infection of both leaves and leaf petioles with Colletotrichum isolates (Coates, pers.comm.).

This research aimed to benefit the lychee industry in Australia by establishing the extent of the LPS problem, raising awareness of the incidence and damage, and evaluating some potential control measures. Since many growers were unaware of the symptoms of LPS and considered it as one of several types of unspecified “blemish”, it was felt that growers would immediately benefit from accurate identification and early intervention. Both are important factors in on-going management of LPS as once well established LPS has proved very difficult to control.

LPS affects all lychee varieties but appears most severe on the increasingly popular cultivar Kwai May Pink, which comprised 37% of plantings in 1992 and 50% in 1999. In 1999 KMP made up 58% of future planned plantings (Bronson, 1999). In the late 1990’s up to 20% of Kwai May Pink fruit were unsaleable or down-graded in the worst affected orchards and the disease now poses a significant threat to both the domestic and export markets. There is little data on the extent of the losses in different areas or different varieties.

Until the appearance of LPS, lychees in Australia were free of pre-harvest diseases affecting fruit or foliage. Greer (1990) stated that “lychee trees in south Queensland are not subject to any major diseases”, and did not mention Colletotrichum.

Control of anthracnose in other crops requires regular application of fungicides. At this stage the control of LPS is very uncertain. The objectives of any LPS, or any other disease, management plan would be to:

- **control the disease in the current crop to acceptable levels,**
- **prevent or minimise spread of the disease to uninfected orchards or portions of the orchard,**
- **reduce the spore reservoir in portions of the orchard which had high LPS levels during previous seasons.**

Observations have shown that where the disease is well established, and presumably spore levels are high, chemical control over a single season does not provide adequate control. Control may need to focus on both the source of the inoculum, and on the infection of the fruit itself. Preliminary QDPI trials have shown that while fungicide treatment (with un-named systemic + protectant combinations) significantly reduced the severity of LPS, none of the treatments reduced the overall incidence of the disease (Coates et al., 1997). This result could have been due to timing of infection rather than the control itself.

Several brands of copper hydroxide and copper oxychloride fungicides are currently registered or permitted in Queensland and New South Wales for control of algal spot in lychees. Both these products are protectant fungicides and may leave unacceptable blue residues if used close to harvest. While spraying each leaf flush with copper oxychloride after harvest may be more effective and safer than treatments in summer (no residues), the rates, frequency and number of applications required to achieve commercial control are currently not known. At the present time the only recommendation that can be given is to spray regularly between the post-harvest flush and early fruit set with copper, perhaps including a spray oil like Synertrol or Codacide.

The occurrence of LPS has resulted in grower attempts to control it using both copper oxychloride and copper hydroxide and a range of unregistered protectant and systemic fungicides. Growers may be using these fungicides wastefully, in that little control is being achieved. Use of fungicides with greater activity against Colletotrichum, compared with copper, may actually reduce the number of applications required for commercial control. There was anecdotal evidence that fungicide sprays at petal fall and at early fruit set can give season-long control and the proposed spray trials aimed to determine the effectiveness of such programmes.

2. Objectives

The principle Research and Development objectives were:

- to confirm the identity of the disease,
- to increase awareness of LPS;
- to determine the geographical distribution and extent of the LPS problem;
- to evaluate the effectiveness of several off-season chemical control measures applied over two seasons; and
- to generate residue data for mancozeb to facilitate the issuing of an off-label use permit for lychees by the National Registration Authority (NRA).

3. Methodology

3.1 Confirming the identity of LPS

LPS-affected samples of KMP and Salathiel fruit from SEQ were sent to Crop Health Services at Redlands in Queensland and IHD in Victoria in February 1999. They confirmed the presence of two forms of "anthracnose" (Glomerella cingulata, the sexual state, and Colletotrichum gloeosporioides, the asexual state) but were unable to determine whether a new race of the fungus was involved. Their report advised that "fungi producing conidia of the C. gloeosporiodes type belong to a complex of related forms which are morphologically identical but may not be genetically related" (IHD, pers.comm.). They concluded that it was "not possible to say if the cultures taken from lychee are identical to morphologically similar cultures from other hosts such as mango, avocado, etc." Yip (1997) believed that a new strain was the cause. The likelihood is that the new disease on lychee is a distinct strain of that found on other crops.

3.2 Increasing awareness of LPS

In April 1999 a preliminary A4 factsheet with colour photographs was prepared and distributed to growers to raise awareness of LPS prior to implementing a telephone survey. It was felt that the factsheet was the best means of getting the information to the growers because it provided them with basic information on the disease and also with colour photographs to help them identify the disease in their own orchards. The factsheet was produced on 100 gsm paper and in similar format to the QHI AgriLink booklet sheets.

The initial factsheet was updated in November 1999 following the telephone survey of 100 growers. The factsheet was distributed to all ALGA members and all Sunshine Coast SubTropical Fruits Association (SCSTFA) members, and was included in the Proceedings of the Fifth National Lychee Conference (Drew, 1999). They were also advertised in the Queensland Fruit & Vegetable News and posted free to any grower who requested them. Approximately 500 copies of the factsheet were distributed.

In addition to the factsheets regular updates on LPS research have been disseminated to growers. Survey and trial results were disseminated through "Living Lychee", the newsletter of the ALGA, and presentations were made at the 5th National Lychee Conference 1999 and ALGA Lychee Seminar 2001 (Drew, 1999, 2001).

The following issues of Living Lychee contained LPS Project Updates:

Living Lychee No.18, April 1999. p.17
Living Lychee No.20, October 1999. p.16
Living Lychee No.21, January 2000. p.16
Living Lychee No.23, July 2000. p.12
Living Lychee No.24, October 2000. p.20
Living Lychee No.26, April 2001. p. 16-18

3.3 Determining the extent of LPS

A telephone survey of 100 lychee growers spread over as wide a geographic area as possible was carried out in mid-1999. These 100 growers, representing approximately one third of the known lychee industry, were selected on the basis of several criteria including location, varieties grown and industry profile. A summary of the distribution of growers is given in TABLE 1. A telephone survey was preferred to a postal survey due to the higher rate of participation and the need to gather both structured and anecdotal data on this relatively unknown disease. The survey covered issues such as incidence, severity, varietal differences, nutrition, attempted controls, and sources of planting material. A copy of the first telephone survey is given in APPENDIX A.

TABLE 1. The postal codes of growers contacted in the 1st telephone survey.

Postcode areas in NSW and Queensland	Area	Number of growers contacted
24xx	Northern NSW	13
41xx	Blackbutt	1
42xx		1
45xx	Gold Coast-Sunshine Coast	28
46xx	Bundaberg-Gladstone	10
47xx	Rockhampton-Sarina-Mackay	15
48xx	Townsville-Cairns	32

A second telephone survey was then developed in which eight pairs of growers across Queensland and NSW were selected for an in-depth analysis of their nutrition and site characteristics. The pairs were made up of growers in the same locality with mature KMP, one of whom reported their orchard clear of LPS, the other affected. As part of this in-depth survey growers were asked to send copies of their most recent soil, leaf or sap analyses for comparison.

3.4 Evaluating LPS control strategies

The chemical trials involved small plot trials and conformed to trial procedures used by chemical companies in registration trials. Trial sites and potential chemical treatments (including calcium) were selected on the basis of telephone survey responses and discussions with QHI officers and local growers.

The following active ingredients were registered (July 2000) for control of anthracnose, Glomerella or Colletotrichum in at least one crop in Australia: benomyl, carbendazim, chlorothalonil, copper oxychloride, copper hydroxide, cuprous oxide, copper ammonium carbonate, dichlofluanid, dithianon, mancozeb, mancozeb + benelaxyl, mancozeb + metalaxyl, metiram, prochloraz-$MnCl_2$ complex, propineb, thiabendazole, thiram and zineb (QDPI, 2000).

An existing NRA trial permit (No. TPM0001A) covered such small plot trials and it was not anticipated that any chemical manufacturer would oppose trials of their products. However AgrEvo had strong concerns about tainting of fruit with prochloraz (Octave) and would not support further work without fruit tasting trials.

Treatments concentrated on 3 crop stages, namely the post-harvest flush, flowering, and early fruit set. These stages were selected because treatments at these times would be practical and would minimise risks of residues at harvest. Sprays close to harvest would likely leave unacceptable visible residues and require generation of comprehensive MRL data. In the event that a particular treatment proved effective, the manufacturer was to be approached to establish MRL's.

The trial plot was situated at Mellum View Orchards, Old Gympie Road, Mooloolah, and was owned by Bob and Jill Houser and Chris Salta. The trial block (known to the grower as "Block D") was situated at the back of the orchard on a protected north-easterly slope. It consisted of fifty 4-6 year old KMP trees from which 36 trees were initially selected for treatment. All treatments were applied as high volume sprays (minimum 3 litres per tree) at dilute rates. The dilute rates selected were those registered for use on other sub-tropical fruits for anthracnose / Colletotrichum control.

In 1999/2000 six treatments were applied (TABLE 2). In 2000/2001 Mancozeb alone (for MRL determination) and Eco-Carb (an organic foliar fertilizer) treatments were added to the original six treatments.

TABLE 2. Fungicide trial treatments in 1999/2000 and 2000/2001 (all rates are per 100L).

Treatment Colour code	**Ingredient 1**	**Ingredient 2**	**Wetter**
1. Black	200 g Mancozeb *800g/kg mancozeb*	100 g Octave > *462g/kg prochloraz*	15 ml Agral *non-ionic surfactant*
2. Blue	200 g Mancozeb	200 g Coppit-OH *500g/kg cupric hydroxide*	15 ml Agral
3. Green	200 g Coppit-OH	100 ml Codacide *860g/L vegetable oil*	15 ml Agral
4. Red CONTROL	---	---	---
5. White	1000 ml Stopit x *16% calcium*	---	15 ml Agral
6. Yellow	40 g Amistar 500WG + *500g/kg azoxystrobin*	---	---
7. Wide Red #	200 g Mancozeb	---	15 ml Agral
8. Wide Blue #	300 g Eco-Carb * *potassium bicarbonate*	250 ml Synertrol * *850g/L botanical oil*	---

2000/01 only (4 trees)

> Thanks to AgrEvo for supplying a sample of Octave free of charge.
+ Thanks to Crop Care Australia for supplying a sample of Amistar free of charge.
x Thanks to Bob Houser for supplying a sample of Stopit free of charge.
* Thanks to Organic Crop Protectants for supplying samples of Eco-Carb and Synertrol free of charge.

FIGURE 1 shows the layout of the trial block. The 1999/2000 treatments (Black, Blue, Green, Red, White & Yellow) were assigned to the most uniform trees. In 2000/2001 eight smaller trees at the ends of rows were added for the Wide Red and Wide Blue treatments. Replicates in the 1999/2000 treatments were assigned randomly.

FIGURE 1. Trial block plan with individual treatment colours and replicate numbers.

					Top						
		x	red 1	black 1	green 1						
	white 1	green 2	white 2	yellow 1	red 2	black 2	red 3	yellow 2	blue 1	black 3	x
w.blue	w.red	yellow 3	blue 2	white 3	black 4	green 3	blue 3	black 5	white 4	yellow 4	w.blue
x	red 4	white 5	green 4	red 5	blue 4	yellow 5	white 6	red 6	green 5	w.red	w.blue
w.blue	w.red	blue 5	yellow 6	black 6	green 6				blue 6	w.red	x
									x	x	

x = spare smaller trees in the block

Sprays were applied over the autumn-winter-spring period, but not within 8 weeks of picking (TABLE 3). No sprays were applied during flowering to avoid any deleterious effects on pollination and fruit set. All insecticide sprays were applied as required but without fungicide sprays. The only exception was an application of foliar calcium applied on 27/10/00 to <u>all</u> trees for nutritional purposes.

The 2nd season can be divided into 3 distinct weather phases as shown in TABLE 3. July-September was extremely dry followed by wet weather in October and, particularly, November. December and January were mostly dry. Flowering occurred in September when conditions were generally good for pollination, and all trees set well. After flowering the weather was very favourable for fungus development in October-November and some other fruit crops in the local area suffered catastrophic losses (eg. to brown rot in stonefruit) at this time. It was thought likely that LPS would be severe in the unsprayed trees. Fruit were harvested on the 13th, 18th and 28th January 2001.

TABLE 3. Timing of Sprays – 1999/2000 (1st season) and 2000/2001 (2nd season).

	1st season	**2nd season**		
Month	**Trial sprays**	**Trial sprays**	**Insect sprays**	**Weather**
June	07/06/99 *	---		Wet
July	19/07/99	07/07/00		Dry
August	04/08/99	11/08/00	C+D 01/08/00	Very dry
September	flowering	flowering	E 25/10/00	V. dry/windy
October	---	28/10/00	E+ca 27/10/00	Wet
November	17/11/99	18/11/00 #	E+G 11/11/00	Wet/windy
December	trial abandoned	31/12/00 @	G as required	Mostly dry
January	---	7 & 15/01/01 @	G as required	Mostly dry
February	---	all fruit picked	---	

Insect sprays C=carbaryl, D=dimethoate, E=endosulfan, ca=LigCalcium, G=Gusathion 200.
@ Mancozeb only
* Light rain one hour after spraying.
# Spray due 12/11/00 but delayed by rain.

3.5 Generating mancozeb residue data

In addition to the five fungicide treatments in the replicated trial, four trees were treated with Mancozeb to generate residue data to support an off-label permit application by QFVG to the NRA. The QDPI passed on detailed advice from the NRA that a composite sample of fruit from 2 treated trees would be adequate at this time (Bowles, pers.comm.). To ensure adequate fruit on each picking date four trees were sprayed with the dilute rate (200g per 100L) of Farmoz Mancozeb 800 over winter and spring and continued up to picking. Final treatments were 7 and 14 days before picking as indicated in TABLE 2. Sampled fruit were immediately frozen and later despatched by courier to the Queensland Health Scientific Services laboratory in Brisbane for analysis.

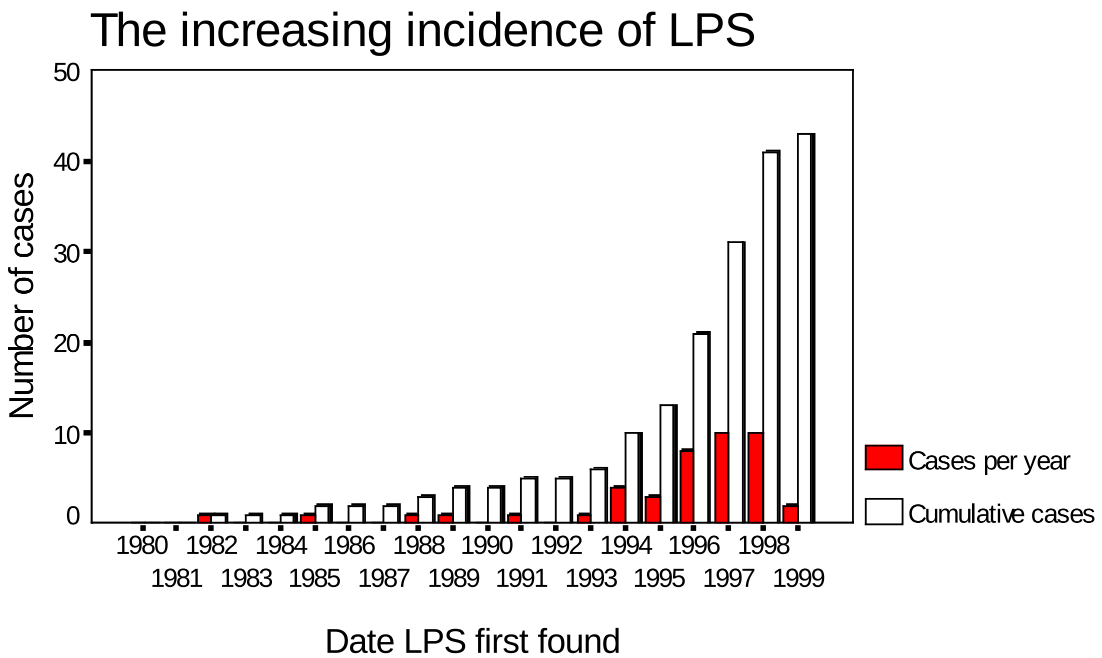
4. Results and discussion

4.1 Telephone surveys

4.1.1 General survey

Although not widely recognised until 1993, the disease had been recorded by growers in Northern NSW, the Sunshine Coast and Far North Queensland by 1989. The reported first instance of LPS was in 1982. The incidence appears to be increasing rapidly, possibly exponentially, as shown in FIGURE 2. At current rates of growth the disease will have spread to, and been noted by, every lychee grower in Queensland within 5 years. The reasons for the rapid spread are unclear but wind and transfer by marcotts are probably the most important factors in long-distance movement. There was however no clear link between sources of marcotts and the first detection or incidence of the disease.

FIGURE 2. The increasing number of cases of LPS noted since 1982



* The two new cases for 1999 were only for the first quarter.

By 1999 43% of growers reported having LPS on at least one variety in their orchard. A breakdown of incidence by area is given in TABLE 4. The disease was not reported north of Gordonvale at the time of the survey.

TABLE 4. Incidence of LPS in the different areas surveyed.

Geographical areas in Queensland and new South Wales	Number of growers surveyed	Number of growers reporting LPS	Percentage incidence
Gordonvale-Mareeba-Daintree	14	1	7
Babinda-Cardwell	13	7	54
Townsville	4	1	25
Mackay-Sarina	7	3	43
Rockhampton-Yeppoon	9	4	44
Bundaberg-Childers-Tiaro	9	5	55
Gympie-Nambour-Caboolture	26	17	65
Brisbane hinterland	5	0	0
Northern NSW	13	6	46

The disease appears to be spread evenly from NNSW to FNQ, although orchards in the furthest north and in the Brisbane hinterland are relatively free. The general picture of infection, as shown in TABLE 5, is of hotspots of infection with severely affected trees and fruit, but with generally low levels across the whole crop. Of those growers who had LPS in their orchards 8% reported losses of more than 60%, and 57% reported losses of less than 10%, in the worst trees. Similarly 3% reported losses of more than 10%, and 72% reported losses of less than 1%, across the whole orchard.

TABLE 5. Reported losses in orchards with LPS.

Losses in the worst affected trees	Percentage of growers reporting
0-10%	57
10-30%	22
30-60%	13
60-100%	8

Losses across the whole orchard	Percentage of growers reporting
0-1%	72
1-3%	10
3-10%	15
>10%	3

Affected cultivars included Kwai May Pink (KMP or Bos 3), Bengal, Salathiel, Wai Chee, Haak Yip, Tai So and Bos 10.

KMP made up more than half of the reports of affected cultivars, as shown in TABLE 6. However of the 57% of growers not reporting LPS in their orchards 64% were growing KMP, some of which were up to 11 years old. It can be concluded from this that approximately 45% of all KMP growers are not yet infected. While KMP seems to be the most susceptible variety, and most prone to downgrading of fruit, fruit colour may affect the growers perceptions of susceptibility, eg. Bengal and Wai Chee can be quite severely affected without reduction in grade as the dark red fruit colour masks the spots. KMP and Salathiel are more prone to downgrading.

TABLE 6. Reported occurrence by variety in orchards with LPS.

Variety	Percentage of ALGA members existing plantings (Bronson, 1999) Total = 76,157 trees	Percentage of growers reporting occurrence of LPS on that variety
KMP	50	63
Bengal	4	13
Salathiel	7	10
Wai Chee	12	8
Tai So	17	4
Other	10	2

TABLE 6 highlights the vulnerability of the lychee industry to LPS because of the predominance of the variety KMP and its high susceptibility to LPS.

Other general findings of the survey were that:

- 32% of those affected by LPS believed that LPS produced a noticeable decline in tree vigour. This decline involved heavier than usual leaf drop and a reduction in panicle size. In SEQ lychees may also be affected by a variant of "sudden death" which can cause "slow decline". Growers in this area may be confusing this with any decline due to LPS.

- 14% of those affected by LPS believed that the incidence of LPS was linked to tree nutrition. The most commonly reported link was with calcium levels. Calcium nutrition is critical, but poorly managed, in many subtropical crops.

- The following fungicidal products had been tried by growers:

  Copper oxychloride, Copper hydroxide, Cuprous oxide, Bordeaux mixture
  Mancozeb
  Benlate (benomyl)
  Galben M (benelaxyl + mancozeb)
  Octave (prochloraz)
  Phosphorous acid
  Neem oil and Neem soap
  Sporekill
  Wettable sulphur

  None of these had proven highly effective although some growers believed their intensive programmes of spraying every 10-14 days from fruit set had reduced the disease to an insignificant level. Most growers were spraying irregularly and haphazardly.

4.1.2 Nutrition pair survey

Eight pairs of growers across Queensland and NSW were selected for an in-depth analysis of their nutrition and site characteristics. The pairs were made up of growers with mature Kwai May Pink in the same locality, one of whom reported their orchard clear of LPS, the other affected.

Soil, leaf or sap analyses were received from 12 growers but some of these dated back to 1992. The results of this survey are given in APPENDIX B. While the results are incomplete and inconclusive it is interesting to note that the levels of leaf calcium (Ca) for trees without LPS were 48% higher than those of affected trees. Other major nutrients (N, P, K, Mg, B) were all within 17%. The difference in

Ca was not reflected in soil samples where there was only a 3% difference in averages. Interestingly soil Boron levels in trees without LPS were 58% higher than those of affected trees.

This survey highlighted the fact that many growers do not make regular use of soil, leaf or sap analyses to manage their nutrition programmes. The QDPI recommendation is to carry out soil analysis every 2 years and leaf analysis every year (Greer, 1990).

4.2 Fungicide spray trial

4.2.1 First season

The first season did not start well. Flowering at 7/06/99 was very low and highly variable. Some 78% of the trees in the trial were flushing heavily at this time. By 19/07/99 (FIGURE 3) flowering had improved slightly but some trees were still flushing.

FIGURE 3. Flowering at 19/07/99 (flowering trees indicated by XXX).

					Top						
		x	red XXX	black	green						
	white XXX	green	white	yellow XXX	red XXX	black	red XXX	yellow	blue XXX	black XXX	x
w.blue	w.red	yellow XXX	blue	white	black	green	blue XXX	black XXX	white XXX	yellow	w.blue
x	red XXX	white	green XXX	red XXX	blue	yellow XXX	white XXX	red XXX	green XXX	w.red	w.blue
w.blue	w.red	blue XXX	yellow XXX	black XXX	green				blue XXX	w.red	x
									x	x	

FIGURE 4 shows the number of trees carrying fruit in mid-November. More than half the trees which flowered failed to set fruit. By 7/01/00 only 46 pieces of fruit were left on a total of 7 trees and a decision was made to abandon the trial.

FIGURE 4. Fruit set at 17/11/99 (fruiting trees indicated by XXX).

					Top						
		x	red XXX	black	green						
	white	green	white	yellow	red	black	red XXX	yellow	blue XXX	black	x
w.blue	w.red	yellow	blue	white	black	green	blue	black	white	yellow	w.blue
x	red	white	green	red	blue	yellow XXX	white	red	green	w.red	w.blue
w.blue	w.red	blue	yellow XXX	black XXX	green				blue XXX	w.red	x
									x	x XXX	

The reasons for the poor flowering and high fruit drop are believed to have been climatic and nutritional. The trees were overly vigorous that season.

4.2.2 Second season

The second season started very promisingly. FIGURE 5 shows that at 9/08/00 all trees were flowering heavily. A comparison with FIGURE 3 highlights the highly variable nature of lychee production. In 2000/2001 trees flushed and flowered relatively uniformily but the variability in cropping still confused the trial results.

FIGURE 5. Flowering at 9/08/00 (flowering trees indicated by XXX).

					Top						
		x XXX	red XXX	black XXX	green XXX						
	white XXX	green XXX	white XXX	yellow XXX	red XXX	black XXX	red XXX	yellow XXX	blue XXX	black XXX	x
w.blue XXX	w.red XXX	yellow XXX	blue XXX	white XXX	black XXX	green XXX	blue XXX	black XXX	white XXX	yellow XXX	w.blue XXX
x XXX	red XXX	white XXX	green XXX	red XXX	blue XXX	yellow XXX	white XXX	red XXX	green XXX	w.red XXX	w.blue XXX
w.blue XXX	w.red XXX	blue XXX	yellow XXX	black XXX	green XXX				blue XXX	w.red XXX	x
									x	x	

At 1/12/00 every tree that had flowered was still carrying fruit. There was little fruit drop despite a relatively wide range of fruit sizes which may have been competing with each other. The final crop harvested is shown in FIGURE 6. The two 2000/2001 treatments (wide red and wide blue) were not individually counted (nc).

FIGURE 6. Production (number of fruit per tree)

					Top						
		x	red 93	black 692	green 1123						
	white 1812	green 1259	white 1524	yellow 1819	red 1074	black 494	red 1299	yellow 1403	blue 371	black 704	x
w.blue nc	w.red nc	yellow 105	blue 2577	white 1635	black 1355	green 1641	blue 1650	black 799	white 533	yellow 1248	w.blue nc
x	red 966	white 555	green 755	red 192	blue 1264	yellow 319	white 490	red 1379	green 699	w.red nc	w.blue nc
w.blue nc	w.red nc	blue 655	yellow 124	black 1670	green 535				blue 250	w.red nc	x
									x	x	

4.2.3 Fruit assessment

Fruit were harvested by the grower on three different dates. These were the 13th (3,021 fruit), 18th (9,115 fruit) and 28th (22,927 fruit) January 2001. The third and final harvest was delayed due to the Australia Day holiday on 26th January and all trees were strip-picked. At the final harvest there was a greater range of maturity than in the first two harvests. It would have been preferable to have 4 picks on 13th, 18th, 23rd and 28th to get a clearer picture of the disease build-up process, but this was not possible. Fruit were kept moist, but not hydro-cooled, and assessed as soon as possible. Fruit were sorted first on the basis of ANY LPS symptoms, and affected fruit were then graded by the project leader according to United Lychee Marketing Association standards. The 3 grades were 1st grade (Yellow carton), 2nd grade (Red carton) and 3rd grade (Generic carton).

In total 35,063 pieces of fruit from the first six treatments were individually checked, of which 4,059 (11.6%) had some LPS symptoms. Results for individual trees are given in APPENDIX C.

The numbers of fruit with and without LPS, and a breakdown by grade of infected fruit, are given in TABLE 7.

The Eco-Carb and Mancozeb treatments (wide blue & wide red) were not individually assessed as they were not comparable to the other six treatments. However a quick assessment suggested that they were similarly affected by LPS. The very high variability in the small trees treated meant that it was not possible to gather meaningful data for the Eco-Carb treatment. This product may be particularly useful for treatments close to harvest since, like calcium applications, residues should not be an issue.

There was considerable variation between trees in their fruit maturity, with the yellow (Amistar) treatment showing the least early fruit. Production per tree ranged from 93 to 2,577 fruit/tree or about 2 to 55 kg/tree. The treatments with the lowest and highest productions overall were red (Unsprayed control) and blue (Mancozeb + Copper) with 5,003 fruit and 6,767 fruit, respectively.

TABLE 7. Number of fruit by grade, picking date and treatment (totals for six trees).

Harvest date	**Treatment**	**No LPS**	**With LPS**			
		Total 1st *	**Total**	**Yellow 1st**	**Red 2nd**	**Generic 3rd**
13th January	black	725	45	39	5	1
	blue	313	2	2	0	0
	green	433	23	22	1	0
	red	734	48	40	5	3
	white	497	36	24	2	10
	yellow	156	9	8	1	0
	SUBTOTAL	***2858***	***163***	***135***	***14***	***14***
18th January	black	1649	86	72	4	10
	blue	1711	143	118	15	10
	green	1520	113	86	13	14
	red	1623	249	195	25	29
	white	1410	110	69	11	30
	yellow	465	36	23	5	8
	SUBTOTAL	***8378***	***737***	***563***	***73***	***101***
28th January	black	2665	544	247	114	183
	blue	3959	639	322	135	182
	green	3443	480	256	94	130
	red	1800	549	270	97	182
	white	4055	441	255	70	116
	yellow	3846	506	284	95	127
	SUBTOTAL	***19768***	***3159***	***1634***	***605***	***920***
All dates	***TOTAL***	***31004***	***4059***	***2332***	***692***	***1035***

* All fruit with "No LPS" were considered to be Yellow 1st Grade

TABLE 8 shows that while the average percentage of fruit with LPS symptoms was low in all treated trees over the first 2 picks (0.6-7.7%) this rose dramatically in the final pick (9.8-17.0%). The untreated control was similar to sprayed treatments in the first pick but 5 and 10% higher in the 2nd and 3rd picks, respectively. A comparison of the untreated control (4. red) and Copper + Mancozeb treatment (2. blue) over the 3 picking dates is given in FIGURE 7.

TABLE 8. Percentage of fruit by grade, picking date and treatment.

Harvest date	Treatment	No LPS	With LPS				good 1st grade	down graded
		Total 1st *	Total	Yellow 1st	Red 2nd	Generic 3rd	All 1st	2nd + 3rd
13th January	black	94.2	5.8	5.1	0.6	0.1	99.3	0.7
	blue	99.4	0.6	0.6	0	0	100	0
	green	95.0	5.0	4.8	0.2	0	99.8	0.2
	red	93.9	6.1	5.1	0.6	0.4	99.0	1.0
	white	93.2	6.8	4.5	0.4	1.9	97.7	2.3
	yellow	94.5	5.5	4.8	0.6	0.0	99.4	0.6
	AVG.	***94.6%***	***5.4%***	***4.5%***	***0.5%***	***0.5%***	***99.1%***	***0.9%***
18th January	black	95.0	5.0	4.1	0.2	0.6	99.2	0.8
	blue	92.3	7.7	6.4	0.8	0.5	98.7	1.3
	green	93.1	6.9	5.3	0.8	0.9	98.3	1.7
	red	86.7	13.3	10.4	1.3	1.5	97.2	2.8
	white	92.8	7.2	4.5	0.7	2.0	97.3	2.7
	yellow	92.8	7.2	4.6	1.0	1.6	97.4	2.6
	AVG.	***91.9%***	***8.1%***	***6.2%***	***0.8%***	***1.1%***	***98.1%***	***1.9%***
28th January	black	83.0	17.0	7.7	3.6	5.7	90.7	9.3
	blue	86.1	13.9	7.0	2.9	4.0	93.1	6.9
	green	87.8	12.2	6.5	2.4	3.3	94.3	5.7
	red	76.6	23.4	11.5	4.1	7.7	88.2	11.8
	white	90.2	9.8	5.7	1.6	2.6	95.8	4.2
	yellow	88.4	11.6	6.5	2.2	2.9	94.9	5.1
	AVG.	***86.2%***	***13.8%***	***7.1%***	***2.6%***	***4.0%***	***93.3%***	***6.7%***

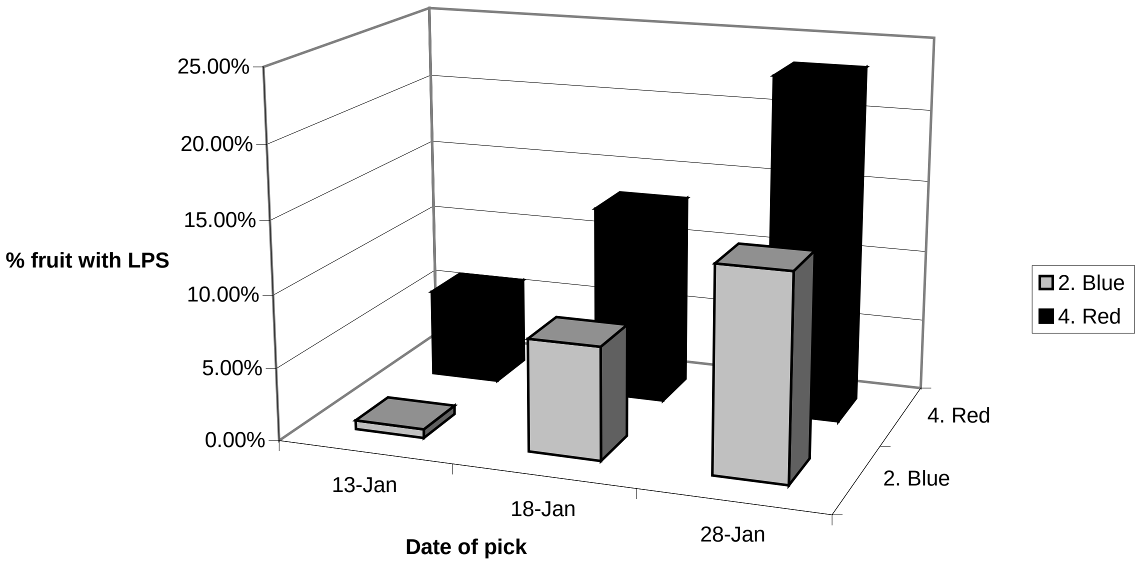
* All fruit with "No LPS" were considered to be Yellow 1st Grade

The reasons for this are unclear but there are two possible interpretations of the differing results on early and later fruit.

THEORY 1 - Later fruit are inherently more susceptible to the disease. This is consistent with experience from other crops and would be expected from an understanding of the fungal spore germination process (Agrios, 1978). While the fruit in the 3rd pick did have a wider range of maturity, the LPS seemed to be evenly spread across maturity groups. This is consistent with other orchards visited where LPS suddenly appeared even in relatively immature fruit and suggests that THEORY 1 is incorrect.

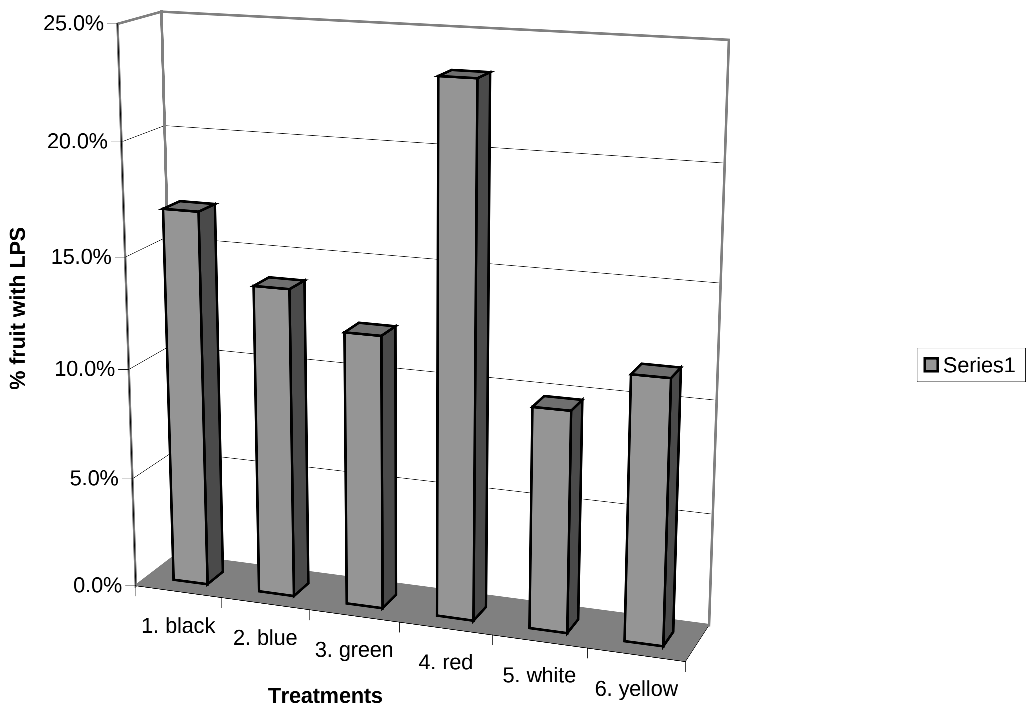
THEORY 2 - Conditions did not favour development of the disease on early fruit.
The lack of early infections could have been due to "poor conditions" for germination of spores or of development of the mycelia early in fruit development. These "poor conditions" could have been due to climatic conditions or to the presence of fungicide residues.

FIGURE 7. The increasing incidence of LPS with picking date: An illustrative comparison - red (Unsprayed control) and blue (Mancozeb + Copper) treatments.



The average percentage of fruit affected by LPS for each treatment in the third pick (28th) is given in FIGURE 8.

FIGURE 8. Average percentage (six trees) of fruit with LPS on 28th January.



The unsprayed red treatment had twice the level of LPS compared with the white (Calcium) treatment on that date. While this was not statistically significant it would warrant further investigation and perhaps an increase in dose or frequency to be more effective. This product, being a registered foliar fertiliser would not require generation of residue data to allow its use close to picking.

However the severity of symptoms in the early picks was low and only 1-2% of fruit were downgraded from 1st grade (Yellow carton, “good”). In the third pick this increased significantly with 5-10% of fruit downgraded. At the final pick the worst affected untreated tree had 57.1% of fruit with LPS symptoms and 21.4% of fruit downgraded (14.3% Red carton, 7.1% Generic carton). However five individual treated trees had more than 20% of fruit downgraded and, conversely, eleven trees had less than 5%. These results are consistent with the findings of the telephone survey that individual trees may be severely infected without significant losses across the whole orchard.

While the untreated trees had consistently higher averages of infection and downgraded fruit, the result was not significantly different from any of the treatments due to the very high variability between trees. For example, in the final pick (28-Jan) for the black (Mancozeb and Octave) treatment the percentages of downgraded fruit for six individual trees were 1.9, 9.2, 13.3, 24.3, 12.8 and 1.7% (average 9.3%). All treatments showed similar variation in the final pick.

The significance values for each category shown in TABLE 8 are given in TABLE 9. For treatments to be statistically different, p must be < 0.05 for a particular category. Such variability suggests that factors other than the spray treatments were the main determinants of the level of fruit infection.

TABLE 9. Statistical tests of between subjects effects for percentage of fruit

Category	No LPS	LPS	yellow	red	generic	good	downG
Type of test	ANOVA	ANOVA	Kruskal Wallis	ANOVA	ANOVA	Kruskal Wallis	ANOVA
p	0.642	0.642	0.627	0.771	0.921	0.842	0.901
SE	4-9%	4-9%	2-5%	1-3%	1-5%	3-6%	3-6%

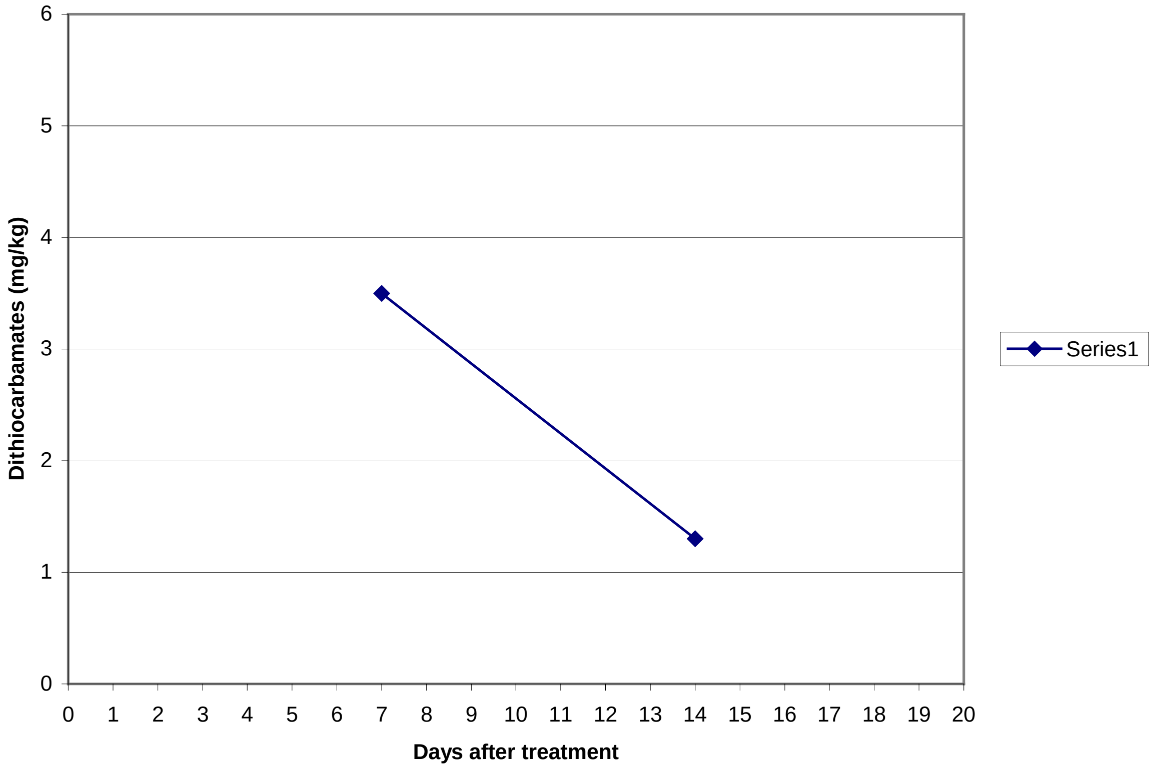
4.3 Mancozeb residues

Fruit were harvested 7 and 14 days after treatment and frozen prior to despatch to Brisbane for analysis. Bulked samples of 2-3 kg of frozen fruit were sent by same-day courier to Queensland Health Scientific Services.

No mancozeb residues were visible on the fruit. The laboratory analysis showed that the residue levels at 7 and 14 days after treatment were 3.5 and 1.3 mg/kg, respectively. The levels are shown in FIGURE 9. There is no MRL for dithiocarbamates (CS_2) on lychees or tropical fruit (inedible peel) but the MRL for berries (and other small fruits except strawberries) and grapes is 5 mg/kg. Based on a safety factor of 100% it is likely that a withholding period of 10 days would be acceptable to the NRA. The results were sent to QFVG and incorporated into an off-label permit application to the NRA. At this time it seems likely that the NRA will issue an off-label permit for use at 2-3 week intervals after fruit set up to 7-10 days before harvest.

While this study has not proven the efficacy of regular mancozeb sprays it is likely, based on experience in other crops, that regular sprays up to 10 days before harvest would be effective in reducing the severe infections which result in downgraded fruit, but not in completely eliminating the disease.

FIGURE 9. Mancozeb (dithiocarbamate, CS_2) decay in LPS trial lychees



5. Implications and recommendations

There is no doubt that the spread of LPS has occurred rapidly since the mid-1980's. Given its rapid spread and the very limited effectiveness of current control measures there is little prospect of halting its spread to uninfected orchards. The Australian lychee industry is going to have to learn to live with the disease.

While infection may be spreading via infected marcotts it is too late to implement any type of LPS-free accreditation scheme for nurseries. In any case, as found in the telephone survey, considerable trade in marcotts occurs between growers themselves.

The current project, and the increasing impact of LPS itself, have raised the awareness of commercial growers. Many growers are still relatively unaffected, in terms of downgraded fruit, but this is likely to change. Favourable weather conditions in SEQ in 2000/2001 may have lulled many growers into a state of complacency. However anecdotal reports from CQ suggest that in unfavourable weather conditions the losses can be catastrophic. The increase in the disease is particularly significant given the increasing importance of the most susceptible variety, KMP. With replacement of older trees, particularly removal of Tai So and Bengal, KMP is set to become even more dominant in the industry due to its reliable cropping characteristics and ready acceptance in export markets. While KMP will continue to make up about 50% of trees planted the proportion of production and exports is likely to be higher, probably nearer 70%.

Based on optimistic prices of $6, $5 and $4 per kg for Yellow, Red and Generic grades, respectively, the loss of income per kg caused by LPS in the untreated trees in the trial can be calculated for each picking date. The reduction in average price per kg of fruit would have been approximately 1.4 cents, 4.9 cents and 20.1 cents per kg on the 13th, 18th and 28th January, respectively. The first two may be acceptable to growers, but 20 cents per kg represents a significant erosion of profits. Based on a production of 5000 tonnes of fruit, this level of LPS would result in a loss of value of production of the industry of approximately $725,000. In the near future it is likely that LPS will be costing the Australian lychee industry more than $1,000,000 per year in downgraded product alone. This quantity of 2nd and 3rd grade product may contribute to lower prices for 1st grade product on the domestic market.

The results of the fungicide trial suggest that off-season treatment alone will not have a significant impact on the level of LPS at harvest. It suggests that fungicide sprays will need to be continued at regular intervals up to picking. This should not significantly increase the number of sprays applied, as most growers are already calendar spraying for macadamia Nutborer [4] with Gusathion which is compatible with both copper and mancozeb.

Other implications of an increase in fungicide use up to picking can be divided into three groups:

- Problems linked to increased costs including:
  - increased cost of fungicides
  - increased sorting costs to ensure fruit with visible residues do not reach the market.
- Problems linked to residues on fruit including:
  - increased risk of unsightly residues
  - increased risk of exceeding MRL's.
- Long-term environmental/social impacts including:
  - increased levels of copper in the soil
  - a reduction in lychee's image as a low pesticide crop.

[4] Macadamia nutborer (Cryptophlebia ombrodelta) is known in Hawaii as Lychee Fruitborer. In fact here in Australia it prefers lychees and is the major insect pest.

1. Problems linked to increased costs.

The costs of pesticides are relatively low (about 3% of production value [5]) but would be significant in poor cropping years or in years of heavy crop loss to birds, bats or extreme weather.
The increased costs of sorting fruit for visible residues cannot be quantified at this time.

2. Problems linked to residues on fruit.

At present several brands of copper hydroxide and copper oxychloride are registered for use in lychees to control algal spots. It is perfectly legal for growers in Queensland (under the Chemical Usage (Agricultural & Veterinary) Control Act), but not in NSW, to use these for control of other diseases such as LPS. One problem is that both of these products may leave blue residues on fruit that are difficult to remove prior to packing. Sprayers should be properly set up and calibrated to ensure that the minimum effective dose is applied evenly over the crop. Approval to use cuprous oxide (eg. Norshield or Nordox) would be an advantage since residues are red and would not be so visible on fruit. However this hidden residue could possibly result in growers exceeding MRL's without "seeing" residues.

RECOMMENDATION 1.

The ALGA should support the registration of cuprous oxide by lobbying the chemical companies concerned.

RECOMMENDATION 2.

The high intensity use of foliar fertilizers like Stopit (calcium) and Eco-Carb (potassium bicarbonate) should be further investigated.

3. Long-term environmental/social impacts.

Copper is a heavy metal that can accumulate in soils. While regular use is unlikely to result in toxic levels in the short term, other industries have reached environmental action levels within the lifetime of the crop. Alternating sprays of copper with mancozeb could reduce the long-term build up of copper in the soil. However mancozeb contains manganese that may also accumulate in soil [6]. Long-term regular use of either fungicide is likely to cause elevated levels of copper or manganese in soils. To minimise copper or manganese build up growers should target sprays to the periods of maximum risk. At this stage it is not possible to say whether sprays early or late in fruit development give better results.

RECOMMENDATION 3.

Growers should target autumn leaf flushes, periods of wet weather and the second half of fruit development. Spraying should be on a 2-3 weekly basis during risk periods up to 10 days before harvest.

Whether this is sufficient to completely reduce infections as fruit ripen is currently impossible to say but spraying closer to harvest has significant risks of unsightly residues which could compromise export markets.

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[5] Based on 10 sprays per year with 3 products, and production of 20kg fruit/tree @ $5/kg fruit.
[6] Some growing areas, eg. on the Sunshine Coast at Amamoor and Kandanga, are known to have very high levels of naturally occurring manganese in soils.

RECOMMENDATION 4.

The ALGA needs to support the development of proven programmes with approved products to minimise the risk of desperate growers using non-approved products.

This will require funding for independent research or the management of a coordinated "DOOR" project by growers.

While none of the potentially effective non-approved products are likely to constitute a risk to the operator or the consumer, they are not legal to use on lychees in Australia. There are significant penalties in each State for using non-approved products. Such cases could also result in bad publicity for the industry and erode consumer confidence in the product. In addition, if residues were detected this could be used by importing countries as an excuse for trade barriers.

Finally the Australian industry needs to put in place some monitoring system to regularly assess the impact of LPS on growers. This is particularly important over the next few years during the expansion phase of the disease when LPS is likely to reach all growers within the industry and to worsen in effect.

RECOMMENDATION 5.

The ALGA should support regular on-going surveys to quantify the effects of LPS on individual growers and on the industry. These surveys could include other information such as production figures and estimates of pest problems which are needed to better plan the future of the industry.

6. Appendices

6.1 Appendix A. Telephone survey questionnaire

NAME...

PHONE NO..

DATE...

Have you received LPS factsheet?...

Have you had a good look at it?...

1) MEMBER OF ALGA...

2) MEMBER OF SUNLYCHEE..

3) ORCHARD SITE - Where is it?..

Distance to nearest producing lychee farm (Km)..

4) NUMBER OF TREES

Total...

Age (oldest) trees..

Age (youngest) trees..

Number of Kwai May Pink..

Age (oldest) trees..

5) SOURCES OF MARCOTTS - (if defensive, numbers only)

Nurseries (names)...

Other growers (names)...

Own..

6) PRESENCE OF LYCHEE PEPPER SPOT ON LYCHEES

Do you think you have it?..

ID confirmed by 3rd party...

Date first detected..

Variety first detected...

Source of those plants..

7) PRESENCE OF LPS ON LONGAN OR RAMBUTAN..

8) VARIETIES CURRENTLY AFFECTED...

V. high incidence...

High incidence...

Medium incidence...

Low incidence...

V. low incidence..

Are there other growers you know affected in your area?..

If yes, names..

9) EFFECTS ON QUALITY

Have you noted any effects on tree vigour?.....................…...

If yes, which varieties?...

Estimated % losses in worst trees...

Estimated % losses overall...

Normal total production (cartons)..

Estimated no. of cartons downgraded 1 to 2 (Sunlychee)...

Estimated no. of cartons downgraded to generic..

Estimated no. of cartons rejected..

10) CONTROL ** CONFIDENTIAL **

Past efforts...

Success...

Effect of pruning................……………...

Chemical treatments...

Other..

Current efforts ....…...

Success...

Pruning...

Using registered and non-registered chemicals............................…..

Using non-chemical controls..

Other...

11) ANY SUSPECTED LINKS WITH TREE NUTRITION ....

Soil or leaf analysis in KMP in 1998 ....

Willing to post us a copy..

12) SUDDEN DEATH OF TREES

Have you had any cases of mature trees which have died suddenly or declined over 2-3 months from some unknown cause...

If so, which variety KMP Wai Chee Salathiel

How many have died..

Did they decline or die suddenly?...

How many sick?..

How old were trees when they started to die..

Were they growing on the flat or on ridges..……..........

Have replacement trees also died...

Do you know of any other growers in region similarly affected?..

6.2 Appendix B. Pair survey results

6.2.1 Leaf analysis results.

Y/N = Reported presence of LPS and number of grower "pair".
eg. **n2** = No LPS, pair number 2, or **y6** = Yes LPS, pair number 6

Date = date of sample
Type = type of sample, eg. soil, leaf or sap

Ca = calcium
Mg = magnesium
B = boron
N = nitrogen
P = phosphorus
K = potassium

Y/N	Date	Type	Ca	Mg	B	N	P	K
		LEAF	%	%	mg/kg	total %	%	%
n2	1999	leaf	0.67	0.35	47.00	2.10	0.27	1.50
n2	1999	leaf	0.92	0.38	36.00	2.60	0.31	1.30
n2	1999	leaf	0.82	0.29	65.00	1.70	0.28	1.00
n2	1999	leaf	0.52	0.31	41.00	1.60	0.15	0.87
n2	1999	leaf	0.67	0.29	60.00	2.00	0.27	1.10
n6	1997	leaf	0.53	0.35	44.00	1.42	0.24	0.99
n6	2000	leaf	1.23	0.48	50.00	1.65	0.16	0.63
n7	1999	leaf	0.88	0.28	46.00	1.60	0.23	0.73
n8	1998	leaf	0.85	0.37	48.00	1.36	0.11	0.56
y1	1997	leaf	0.80	0.45	44.00	1.53	0.21	0.91
y3	1992	leaf	0.80	0.35	66.00	1.72	0.17	0.83
y3	1992	leaf	0.50	0.37	55.00	1.70	0.21	1.18
y4	1999	leaf	0.34	0.24	26.00	1.80	0.24	1.16
y6	1999	leaf	0.86	0.35	88.00	1.99	0.26	1.00
y8	1999	leaf	0.64	0.30	38.00	2.05	0.26	1.18
y8	1999	leaf	0.18	0.18	16.00	1.65	0.26	1.33
y8	1999	leaf	0.15	0.11	20.00	1.47	0.24	1.53
		"No"	***0.79***	***0.34***	***48.56***	***1.78***	***0.22***	***0.96***
		"Yes"	***0.53***	***0.29***	***44.13***	***1.74***	***0.23***	***1.14***
			148%	117%	110%	102%	97%	85%

6.2.2 Soil analysis results.

Y/N = Reported presence of LPS and number of grower "pair".
eg. **n2** = No LPS, pair number 2, or **y4** = Yes LPS, pair number 4

Date = date of sample
Type = type of sample, eg. soil, leaf or sap

pH= soil acidity/alkalinity
Ca = calcium
Mg = magnesium
B = boron
N = nitrogen
P = phosphorus
K = potassium

Y/N	Date	Type	pH	Ca	Mg	B	N	P	K
		SOIL	Water	meq/100	meq/100	hotCaCl2	nitrate	BSES	meq/100
n2	1999	soil	5.90	5.00	1.42	1.37	4.70	110c	0.38
n2	1999	soil	7.60	9.30	2.17	1.33	12.00	83c	0.64
n2	1999	soil	6.40	6.30	1.13	0.93	2.60	100c	0.36
n2	1999	soil	6.10	4.90	0.83	1.21	8.70	38c	0.35
n2	1999	soil	6.20	4.30	0.83	0.93	5.40	49c	0.42
n3	1996	soil	5.90	3.26	1.46	0.11	2.00	67.00	0.20
n5	2000	soil	6.00	2.10	0.49	x	x	33.00	0.12
n6	1997	soil	5.60	3.29	3.00	1.07	1.10	12.00	0.42
n6	2000	soil	6.00	5.21	2.91	1.50	3.70	22.00	0.64
n7	1999	soil	5.00	0.95	0.42	0.30	2.60	94c	0.29
n8	1999	soil	5.40	4.88	2.83	1.80	53.80	59.00	0.94
y1	1997	soil	5.70	7.39	7.86	0.84	4.10	40.00	0.58
y3	1992	soil	6.20	7.01	4.09	0.24	9.60	200.00	0.61
y3	1992	soil	5.80	4.58	1.05	0.26	6.70	140.00	0.35
y4	1999	soil	5.50	2.56	1.54	1.20	4.80	33.00	0.42
y7	2000	soil	6.00	1.10	0.54	0.50	0.80	12.00	0.11
		"No"	*6.01*	*4.50*	*1.59*	*0.96*	*8.78*	*17.55*	*0.43*
		"Yes"	*5.84*	*4.53*	*3.02*	*0.61*	*5.20*	*85.00*	*0.41*
			103%	99%	53%	158%	169%	21%	105%

Results for Phosphorus are not comparable as some figures were for BSES analysis, others for Colwell (c). The figure for Nitrate Nitrogen for n8 was doubtful (53.80) as the consultant recommended further application of N.

6.2 Appendix C. LPS fungicide trial results (number of fruit per replicate)

treatment treatments as per FIGURE 1.
rep. replicate trees numbered 1-6
date harvest date of 13th, 18th or 28th January 2001
No LPS total number of fruit with no detectable LPS (considered 1st grade)
LPS total number of fruit with LPS
yellow number of fruit with LPS in 1st grade (ULMA Yellow carton)
red number of fruit with LPS in 2nd grade (ULMA Red carton)
generic number of fruit with LPS in 3rd grade (Generic carton)

treatment	rep.	date	NoLPS	LPS	yellow	red	generic
black	1	13-Jan	236	4	4	0	0
black	2	13-Jan	93	3	3	0	0
black	3	13-Jan	21	0	0	0	0
black	4	13-Jan	225	36	30	5	1
black	5	13-Jan	146	2	2	0	0
black	6	13-Jan	4	0	0	0	0
1. black	**total**	**13-Jan**	**725**	**45**	**39**	**5**	**1**
black	1	18-Jan	334	10	8	1	1
black	2	18-Jan	179	12	9	0	3
black	3	18-Jan	148	2	2	0	0
black	4	18-Jan	525	43	34	3	6
black	5	18-Jan	230	16	16	0	0
black	6	18-Jan	233	3	3	0	0
1. black	**total**	**18-Jan**	**1649**	**86**	**72**	**4**	**10**
black	1	28-Jan	99	9	7	1	1
black	2	28-Jan	168	39	20	5	14
black	3	28-Jan	414	119	48	28	43
black	4	28-Jan	333	193	65	52	76
black	5	28-Jan	277	128	76	19	33
black	6	28-Jan	1374	56	31	9	16
1. black	**total**	**28-Jan**	**2665**	**544**	**247**	**114**	**183**
blue	2	13-Jan	29	0	0	0	0
blue	3	13-Jan	40	0	0	0	0
blue	4	13-Jan	197	2	2	0	0
blue	5	13-Jan	47	0	0	0	0
2 .blue	**total**	**13-Jan**	**313**	**2**	**2**	**0**	**0**
blue	2	18-Jan	613	6	5	0	1
blue	3	18-Jan	314	12	10	2	0
blue	4	18-Jan	489	108	87	13	8
blue	5	18-Jan	164	0	0	0	0
blue	6	18-Jan	131	17	16	0	1
2. blue	**total**	**18-Jan**	**1711**	**143**	**118**	**15**	**10**
blue	1	28-Jan	290	81	39	18	24
blue	2	28-Jan	1776	153	81	20	52
blue	3	28-Jan	1141	143	88	25	30
blue	4	28-Jan	288	180	72	60	48
blue	5	28-Jan	393	51	23	8	20
blue	6	28-Jan	71	31	19	4	8
2. blue	**total**	**28-Jan**	**3959**	**639**	**322**	**135**	**182**

Appendix C continued

treatment	rep.	date	NoLPS	LPS	yellow	red	generic
green	2	13-Jan	6	0	0	0	0
green	3	13-Jan	14	0	0	0	0
green	4	13-Jan	122	0	0	0	0
green	5	13-Jan	62	2	2	0	0
green	6	13-Jan	229	21	20	1	0
3. green	**total**	**13-Jan**	**433**	**23**	**22**	**1**	**0**
green	1	18-Jan	266	5	5	0	0
green	2	18-Jan	244	0	0	0	0
green	3	18-Jan	218	9	6	2	1
green	4	18-Jan	304	24	21	1	2
green	5	18-Jan	289	54	39	8	7
green	6	18-Jan	199	21	15	2	4
3. green	**total**	**18-Jan**	**1520**	**113**	**86**	**13**	**14**
green	1	28-Jan	767	85	54	15	16
green	2	28-Jan	987	22	14	3	5
green	3	28-Jan	1185	215	132	41	42
green	4	28-Jan	251	54	20	10	24
green	5	28-Jan	201	91	26	23	42
green	6	28-Jan	52	13	10	2	1
3. green	**total**	**28-Jan**	**3443**	**480**	**256**	**94**	**130**
red	1	13-Jan	46	0	0	0	0
red	2	13-Jan	54	0	0	0	0
red	3	13-Jan	164	17	12	3	2
red	4	13-Jan	121	3	3	0	0
red	5	13-Jan	136	6	4	1	1
red	6	13-Jan	213	22	21	1	0
4. red	**total**	**13-Jan**	**734**	**48**	**40**	**5**	**3**
red	1	18-Jan	42	5	5	0	0
red	2	18-Jan	218	3	2	1	0
red	3	18-Jan	560	71	57	5	9
red	4	18-Jan	284	28	21	4	3
red	5	18-Jan	25	11	7	1	3
red	6	18-Jan	494	131	103	14	14
4. red	**total**	**18-Jan**	**1623**	**249**	**195**	**25**	**29**
red	2	28-Jan	771	28	21	4	3
red	3	28-Jan	288	199	91	56	52
red	4	28-Jan	395	135	71	12	52
red	5	28-Jan	6	8	5	2	1
red	6	28-Jan	340	179	82	23	74
4. red	**total**	**28-Jan**	**1800**	**549**	**270**	**97**	**182**

Appendix C continued

treatment	rep.	date	NoLPS	LPS	yellow	red	generic
white	1	13-Jan	19	0	0	0	0
white	3	13-Jan	12	0	0	0	0
white	4	13-Jan	32	1	1	0	0
white	5	13-Jan	172	2	2	0	0
white	6	13-Jan	262	33	21	2	10
5. white	**total**	**13-Jan**	**497**	**36**	**24**	**2**	**10**
white	1	18-Jan	462	2	2	0	0
white	2	18-Jan	245	4	4	0	0
white	3	18-Jan	285	17	15	1	1
white	4	18-Jan	117	13	12	1	0
white	5	18-Jan	201	26	13	7	6
white	6	18-Jan	100	48	23	2	23
5. white	**total**	**18-Jan**	**1410**	**110**	**69**	**11**	**30**
white	1	28-Jan	1236	93	48	15	30
white	2	28-Jan	1212	63	42	7	14
white	3	28-Jan	1198	123	82	20	21
white	4	28-Jan	278	92	60	15	17
white	5	28-Jan	109	45	17	8	20
white	6	28-Jan	22	25	6	5	14
5. white	**total**	**28-Jan**	**4055**	**441**	**255**	**70**	**116**
yellow	3	13-Jan	27	0	0	0	0
yellow	4	13-Jan	25	1	1	0	0
yellow	5	13-Jan	104	8	7	1	0
6. yellow	**total**	**13-Jan**	**156**	**9**	**8**	**1**	**0**
yellow	3	18-Jan	40	6	3	1	2
yellow	4	18-Jan	228	9	8	0	1
yellow	5	18-Jan	135	19	10	4	5
yellow	6	18-Jan	62	2	2	0	0
6. yellow	**total**	**18-Jan**	**465**	**36**	**23**	**5**	**8**
yellow	1	28-Jan	1730	89	51	14	24
yellow	2	28-Jan	1205	198	114	30	54
yellow	3	28-Jan	23	9	5	2	2
yellow	4	28-Jan	815	170	98	38	34
yellow	5	28-Jan	25	28	11	5	12
yellow	6	28-Jan	48	12	5	6	1
6. yellow	**total**	**28-Jan**	**3846**	**506**	**284**	**95**	**127**

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