

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

**POSTHARVEST ENVIRONMENTAL FACTORS AFFECTING  
INFECTION  
OF KIWIFRUIT BY *BOTRYTIS CINEREA*.**

A thesis presented in partial fulfilment  
of the requirements for the degree of  
Doctor of Philosophy in  
Plant Science  
at  
Massey University  
Palmerston North  
New Zealand.

Silvia Bautista Baños  
May 1995

To my husband J. Raúl:  
With my deepest gratitude and love, forever.

## ABSTRACT

*In vitro* germination of *B. cinerea* isolates from diseased blueberry, camellia, grapes, kiwifruit and strawberry were compared at Massey University (Palmerston North) and pathogenicity on kiwifruit at both Massey University and at the New Zealand Institute for Crop and Food Research (Levin). An average of 74.4% of spores germinated on agar when the concentration was  $5.9 \times 10^4$  but only 62.8% when it was  $1.5 \times 10^6$ . Percentage spore germination on agar did not indicate relative pathogenicity on kiwifruit and there was no significant difference in disease incidence of fruit inoculated with different isolates.

The effect of culture medium and of age of culture from which conidial inoculum was prepared were evaluated by growing *B. cinerea* on malt agar, potato dextrose agar and autoclaved kiwifruit leaves for seven, 18 or 28 days. Each fruit was inoculated with one drop of a 0.05% Tween 20 suspension containing 1,000, 5,000, 25,000 or (Levin only) 125,000 spores per drop. Disease incidence was proportional to inoculum concentration. There was no significant effect of colony age. The highest disease incidence at Massey University was with inoculum produced on malt agar whereas at Crop and Food Research it was with inoculum produced on autoclaved kiwifruit leaves. All further inoculation work was carried out using the K3 isolate from Massey University grown on Malt agar for 10-14 days.

The ability of *B. cinerea* conidia to survive temperature/humidity regimes that could be used for curing kiwifruit was tested by exposing conidia on glass slides to combinations of 0, 10, 15, 25 or 30°C with low (<50%), medium-low (64-80%), medium-high (80-90%) or high (>90%) relative humidities for two, four, six or eight days. Both the percentage germination and the speed of germination decreased at the higher temperatures and with longer exposure times.

The effect of temperature during curing on subsequent infection levels was investigated in 1992, of humidity in 1993 and of both temperature and humidity in 1994. After harvest, each fruit was inoculated with 125,000 spores (1992) or 25,000 spores (1993 and 1994). In 1994 dry conidial application using a paintbrush was also included. The greatest curing effect was obtained at 10°C. Disease incidence increased at 0°C and the curing effect diminished at temperatures above 10°C. Fruit cured at 20°C and at 30°C softened rapidly and developed a high incidence of disease. In 1994 a three day curing period was used and 10°C again gave the lowest subsequent disease incidence. After twelve weeks coolstorage (1993) there was less disease in fruit cured at 89-95% relative humidity than at lower humidities. In 1994 comparable results were obtained.

The effect of curing regimes on fruit physiology showed that ethylene production increased and rate of respiration decreased with higher curing temperature but both increased with incubation time. There was no consistent pattern of treatment effect on ethylene production or on rate of respiration during subsequent coolstorage. Fruit firmness decreased with higher curing temperatures and as the curing period was extended. Firmness fluctuated with harvest and in general decreased with storage although a satisfactory firmness was maintained throughout coolstorage from all treatments. There was no consistent relationship between temperature/time of incubation and total soluble solids content during curing and during storage. As the period of storage increased glucose and fructose content of fruit increased. pH remained constant in fruit from all treatments and there was no consistent relationship between acid buffering capacity measured as citric acid equivalent and curing temperature/incubation times during subsequent coolstorage. For all experiments, weight loss increased with increased curing temperature or with decreased relative humidity.

Kiwifruit stem scars consisted of two main tissue systems: Ground and

vascular. Parenchyma, collenchyma and idioblasts containing raphides were the main components of the ground tissue. The vascular system consisted of xylem vessels, phloem and cambium. There was no evidence of anatomical structures blocking the xylem vessels in *Botrytis* infected fruit cured at 0°C or at 10°C. Samples from both showed some evidence of thickening of the parenchyma cell walls in contact with conidial hyphae. Positive reactions to lignin, suberin and reducing compounds were observed in all treatments. Suberin development in xylem and parenchyma scar tissue was found at 10°C but not at 0, 20 or 30°C.

Initial relative humidity ranges of 34-80%, 75-90% and 100% were tested during coolstorage at 0°C in 1992 and 40-59%, 65-80% and 92-97% in 1994. Inoculum levels applied to the stem scar were 5000 and 25000 spores/ml respectively and infection levels were evaluated after 12 weeks coolstorage. There was no definite pattern in ethylene production and rate of respiration during the incubation period. In both, 1992 and 1994 experiments weight loss increased as relative humidity decreased. TSS increased during incubation for all treatments. Firmness decreased with incubation time and after three months coolstorage for all treatments. In the second experiment of 1994 there was a more marked effect of relative humidity on firmness. Fruit firmness decreased with harvest maturity. In the 1992 experiment fruit disease decreased as incubation time increased and in 1994, infection levels decreased as relative humidity increased.

## ACKNOWLEDGEMENTS

I appreciate the assistance of Dr. Peter G. Long for valuable advice on planning for the experiments and writing of this thesis and Dr. S. Ganesh for his statistical advice.

I appreciate the support of Hugh Neilson for all the laboratory work.

Special thanks to The National Council of Science and Technology (Mexico) for providing financial assistance.

My gratitude to my brothers: Alfredo, Sergio and Armando and my dear friend Charles R. Ensor for their continuous encouragement throughout my studies in this country.

## TABLE OF CONTENTS

ABSTRACT .....	iii
ACKNOWLEDGEMENTS .....	vi
TABLE OF CONTENTS .....	vii
LIST OF TABLES .....	xv
LIST OF FIGURES .....	xviii
LIST OF PLATES .....	xxiii
<b>CHAPTER ONE GENERAL INTRODUCTION .....</b>	<b>1</b>
World market and economic importance .....	1
Commercial orchards in New Zealand .....	1
Cultural, Management and Harvesting Practices for kiwifruit in New Zealand .....	1
Grading and sorting .....	7
Packing .....	7
Storage and Marketing .....	9
Diseases of kiwifruit .....	9
<i>BOTRYTIS CINEREA</i> .....	9
Taxonomy, morphology and general life cycle .....	9
Pathogenicity of <i>B. cinerea</i> on different commodities ..	12
The infection process by <i>Botrytis</i> .....	12
Effect of environment during the infection process by <i>Botrytis</i> .....	13
Kiwifruit and <i>B. cinerea</i> .....	14
CONTROL MEASURES .....	15



Alternatives for control of <i>B. cinerea</i> . . . . .	15
Chemical control . . . . .	15
Non-chemical control methods . . . . .	16
Definition of curing . . . . .	17
Impact of curing to control postharvest diseases. . . . .	18
In tubers, bulbs and roots . . . . .	18
In vegetables . . . . .	21
In leafy vegetables . . . . .	21
In tropical and subtropical fruits . . . . .	21
In temperate fruits . . . . .	22
Curing as an alternative for control of <i>B. cinerea</i> during kiwifruit storage . . . . .	22
Long-term storage conditions to reduce <i>B. cinerea</i> on kiwifruit . . . . .	22
GENERAL OBJECTIVES . . . . .	24

## **CHAPTER TWO GENERAL MATERIALS AND METHODS . . . . . 25**

Fruit harvesting . . . . .	25
Preparation of inoculum . . . . .	25
Quality measurements . . . . .	26
Defined relative humidity . . . . .	26
Measurement of ethylene and carbon dioxide production . . . . .	28
Assessment of infection . . . . .	29
Statistical analysis . . . . .	30

## **CHAPTER THREE INOCULUM VARIABLES AFFECTING PATHOGENICITY OF *BOTRYTIS CINEREA* INFECTION OF KIWIFRUIT . . . . . 31**

INTRODUCTION . . . . .	31
OBJECTIVE . . . . .	33
MATERIALS AND METHODS . . . . .	33
Experiment No. 1 Title: Effect of <i>B. cinerea</i> isolates, culture age and inoculum concentration on <i>in vitro</i> conidial germination. . . . .	33
Statistical analysis . . . . .	34
Experiment No.2 Title: Pathogenicity of <i>B. cinerea</i> isolates from a variety of sources on kiwifruit. . .	34
Statistical analysis . . . . .	35
Experiment No.3 Title: Effect of growth media, culture age and inoculum level on pathogenicity of <i>B. cinerea</i> to kiwifruit. . . . .	35
Statistical analysis . . . . .	36
RESULTS . . . . .	36
Experiment No.1 . . . . .	36
Experiment No.2 . . . . .	39
Experiment No.3 . . . . .	44
DISCUSSION . . . . .	49

**CHAPTER FOUR EFFECT OF RELATIVE HUMIDITY AND TIME OF EXPOSURE AT DIFFERENT TEMPERATURES ON SURVIVAL OF CONIDIA OF *BOTRYTIS CINEREA*. . . . . 54**

INTRODUCTION . . . . .	54
OBJECTIVE . . . . .	55
MATERIALS AND METHODS . . . . .	55
Statistical analysis . . . . .	56
RESULTS . . . . .	56
DISCUSSION . . . . .	64

<b>CHAPTER FIVE CURING OF KIWIFRUIT TO CONTROL</b>	
<b><i>BOTRYTIS CINEREA</i> DURING STORAGE. . . . .</b>	<b>71</b>
INTRODUCTION . . . . .	71
Physiological considerations of curing . . . . .	71
Control of postharvest diseases by curing . . . . .	76
OBJECTIVE . . . . .	77
MATERIALS AND METHODS . . . . .	77
Experiment No.1 Title: Curing temperatures, physiological changes and incidence of <i>B.</i> <i>cinerea</i> stem-end rot during subsequent coolstorage in 1992 . . . . .	77
Fruit harvesting . . . . .	77
Inoculum . . . . .	78
Preparation of treatments . . . . .	78
Assessments . . . . .	78
Assessment period . . . . .	79
Statistical analysis . . . . .	80
Experiment No.2 Title: Curing temperature and incidence of <i>B. cinerea</i> stem-end rot of kiwifruit during subsequent coolstorage in 1994. . . . .	80
Fruit harvesting . . . . .	80
Inoculum . . . . .	80
Preparation of treatments . . . . .	80
Assessments . . . . .	81
Statistical analysis . . . . .	81
Experiment No. 3 Title: Relative humidity during curing and <i>B. cinerea</i> stem-end rot incidence in kiwifruit during subsequent coolstorage in 1993. . . . .	81
Fruit harvesting . . . . .	81
Inoculum . . . . .	81

Treatment preparation . . . . .	81
Assessments . . . . .	82
Statistical analysis . . . . .	82
Experiment No. 4 Title: Relative humidity, type of inoculum and harvest maturity on incidence of <i>B. cinerea</i> stem-end rot in kiwifruit during subsequent coolstorage in 1994. . . . .	82
Fruit harvesting . . . . .	84
Inoculum . . . . .	84
Treatments and experimental procedure . . . . .	84
Statistical analysis . . . . .	84
RESULTS . . . . .	85
Experiment No.1 . . . . .	85
Physiological changes of fruit during curing and coolstorage in 1992 . . . . .	85
Chemical composition of fruit . . . . .	90
Infection levels during coolstorage . . . . .	92
Experiment No. 2 . . . . .	95
Fruit quality after the curing and coolstorage in 1994 . . . . .	95
Infection levels during fruit coolstorage . . . . .	98
Experiment No.3 . . . . .	102
Relative humidity behaviour during curing period in 1993 . . . . .	102
Fruit quality after the curing period . . . . .	102
Infection levels during coolstorage . . . . .	102
Experiment No. 4 . . . . .	110
Relative humidity behaviour during curing in 1994 . . . . .	110
Fruit quality after the curing period . . . . .	110
Infection levels during coolstorage . . . . .	113
DISCUSSION . . . . .	119

Physiological response during curing and coolstorage periods . . . . .	119
Chemical composition of fruit . . . . .	124
Infection levels during coolstorage . . . . .	126
<b>CHAPTER SIX ANATOMICAL AND HISTOCHEMICAL STUDY OF INOCULATED KIWIFRUIT STEM SCARS DURING CURING . . . . .</b>	<b>131</b>
INTRODUCTION . . . . .	131
Curing and wound healing . . . . .	131
Anatomical and/or histochemical responses during wound healing . . . . .	132
Factors affecting response to wound healing . . . . .	133
OBJECTIVE . . . . .	134
MATERIALS AND METHODS . . . . .	134
Fruit samples . . . . .	134
Tissue preparation for anatomical and histochemical study . . . . .	135
Anatomical and Histochemical staining . . . . .	135
RESULTS . . . . .	137
Anatomical components of stem scar tissues . . . . .	137
Histochemical tests . . . . .	142
DISCUSSION . . . . .	147
<b>CHAPTER SEVEN INITIAL COOLSTORAGE RELATIVE HUMIDITY OF KIWIFRUIT AND INFECTION BY <i>BOTRYTIS CINEREA</i> . . . . .</b>	<b>153</b>
INTRODUCTION . . . . .	153
Storage temperature and relative humidity . . . . .	154
OBJECTIVE . . . . .	155
MATERIALS AND METHODS . . . . .	155

Experiment No.1 Title: Relative humidity at 0°C, physiological changes and incidence of <i>B.</i> <i>cinerea</i> stem-end rot during coolstorage in 1992. . . . .	155
Fruit harvesting . . . . .	155
Inoculum . . . . .	156
Preparation of treatments . . . . .	156
Assessments . . . . .	156
Statistical analysis . . . . .	156
Experiment No.2 Title: Effect of initial coolstorage relative humidity and fruit maturity on fruit quality and infection of kiwifruit by <i>B. cinerea</i> in 1993. . . . .	158
Fruit Harvesting . . . . .	158
Inoculum . . . . .	158
Preparation of treatments . . . . .	158
Assessments . . . . .	158
Statistical analysis . . . . .	159
RESULTS . . . . .	159
Experiment No. 1 . . . . .	159
Relative humidity behaviour during treatment . . .	159
Fruit quality and physiological changes during incubation and storage periods. . . . .	159
Infection levels during coolstorage . . . . .	162
Experiment No.2 . . . . .	168
Relative humidity behaviour . . . . .	168
Fruit quality after initial relative humidity coolstorage period . . . . .	168
Infection levels during coolstorage . . . . .	178
DISCUSSION . . . . .	178
Fruit quality and physiological changes during incubation time . . . . .	178

Infection levels during coolstorage ..... 184

**CHAPTER EIGHT GENERAL DISCUSSION AND FUTURE**

**RESEARCH ..... 187**

**REFERENCES ..... 195**

**APPENDIX ..... 242**

**PUBLICATIONS ..... 245**

## LIST OF TABLES

TABLE		PAGE
1-1	Diseases of kiwifruit.	10
3-1	Summary of <i>in vitro</i> germination of <i>B. cinerea</i> conidia after 12h incubation at 20°C on MA.	37
3-2	Summary of effect of <i>B. cinerea</i> isolates and spore concentrations on percentage infection of kiwifruit after storage at 0°C at Massey University Fruit Crops Orchard.	42
3-3	Summary of the effect of different <i>B. cinerea</i> isolates and spore concentrations on percentage infection of kiwifruit after storage at 0°C at Crops and Food Research Levin.	43
3-4	Summary of the effects of media, culture ages and inoculum levels on incidence of stem end rot caused by <i>B. cinerea</i> at Massey University Fruit Crops Orchard after storage at 0°C.	46
3-5	Summary of the effects of media, culture ages and inoculum levels on incidence of stem end rot caused by <i>B. cinerea</i> at Crops and Food Research Levin after storage at 0°C.	47
4-1	Summary of <i>B. cinerea</i> conidial survival at different temperatures and humidities as assessed by subsequent germination on MA.	60



4-2	Survival of <i>B. cinerea</i> conidia as indicated by germination on MA after 8h or 24h following incubation at various combination of relative humidities and temperatures for different period of time ( $P < 0.001$ ).	61
5-1	1992: Percentage weight loss (Mean $\pm$ SE) of kiwifruit cured at four temperatures for up to six days.	85
5-2	1992: Firmness (Mean $\pm$ SE) of kiwifruit cured at four temperatures for up to six days.	86
5-3	1992: Firmness (Lsmean $\pm$ SE) of kiwifruit cured for up to six days then stored at 0°C for up to six months.	87
5-4	1992: Ethylene production (Mean $\pm$ SE) of kiwifruit cured at four temperatures for up to six days.	87
5-5	1992: Ethylene production (Lsmean $\pm$ SE) of kiwifruit cured for up to six days then stored at 0°C for up to six months.	88
5-6	1992: Rate of respiration (Mean $\pm$ SE) of kiwifruit cured at four temperatures for up to six days.	89
5-7	1992: Rate of respiration (Lsmean $\pm$ SE) of kiwifruit cured for up to six days then stored at 0°C for up to six months.	90
5-8	1992: Total soluble solids (Mean $\pm$ SE) of kiwifruit cured at four temperatures for up to six days.	91
5-9	1992: Total soluble solids (Lsmean $\pm$ SE) of kiwifruit cured for up to six days then stored at 0°C for up to six months.	91

5-10	1992: Sugar content of cured kiwifruit during subsequent storage at 0°C.	93
5-11	1992: Acidity of cured kiwifruit during subsequent storage at 0°C.	94
5-12	1992: Percentage infection (Mean $\pm$ SE) of cured kiwifruit after 12 weeks storage.	95
5-13	1994: Daily percentage weight loss of inoculated kiwifruit from three harvests cured at five temperatures.	96
5-14	1994: Cumulative percentage weight loss of inoculated kiwifruit from three harvest after curing and coolstorage at 0°C.	97
5-15	1994: Firmness of inoculated kiwifruit from three harvests after curing and coolstorage at 0°C.	99
5-16	1994: Weight loss, firmness and total soluble solids of inoculated kiwifruit harvested at different maturities and cured for three days at 10°C and one of three relative humidities.	112
5-17	1994: Infection levels of <i>B. cinerea</i> developed during coolstorage of kiwifruit inoculated with spore suspension or dry conidia before curing at 10°C and a range of relative humidities.	115
6-1	Histochemical tests of kiwifruit stem scars inoculated with <i>B. cinerea</i> and incubated at various temperatures for up to six days.	146

## LIST OF FIGURES

FIG.		PAGE
1-1	Kiwifruit growing areas in New Zealand	2
1-2	T-bar support system for kiwifruit. a) Standard T-bar and b) Winged T-bar.	4
1-3	Pergola support system for kiwifruit.	5
1-4	Kiwifruit pruning methods.	6
1-5	Kiwifruit handling system.	8
3-1	Interaction between isolates and spore concentration during <i>in vitro</i> conidial germination on MA. Vertical bar indicates overall standard error of the mean (SEM).	38
3-2	Interaction between isolates and culture age during <i>in vitro</i> conidial germination on MA. Vertical bar indicates overall standard error of the mean (SEM).	40
3-3	Interaction between culture age and spore concentration during <i>in vitro</i> conidial germination on MA. Vertical bar indicates overall standard error of the mean (SEM).	41
3-4	Interaction between isolates and spore concentration on storage rot incidence at MUFCO. Vertical bar indicates overall standard error of the mean (SEM).	45
3-5	Interaction between media and <i>B. cinerea</i> culture age on storage rot incidence at MUFCO. a) 6 weeks, b) 12 weeks of storage. Vertical bars indicate overall standard error of the mean (SEM).	48
4-1	Relative humidity system.	57
4-2	Actual relative humidities attained at six temperatures.	58

5-1	Relative humidity system.	83
5-2	1994: Percentage infection of kiwifruit from three harvests after curing at a range of temperatures and coolstorage for six weeks. Letters a, b, c, d & e refer to Duncan's test ( $P < 0.05$ ). Vertical bars indicate SEM.	100
5-3	1994: Percentage infection of kiwifruit from three harvests after curing at a range of temperatures and coolstorage for 12 weeks. Letters a, b, c, d & e refer to Duncan's test ( $P < 0.05$ ). Vertical bars indicate SEM.	101
5-4	1993: First harvest relative humidity during a three day incubation time at 10°C (Mean $\pm$ SE).	103
5-5	1993: Second harvest relative humidity during a three day incubation time at 10°C (Mean $\pm$ SE).	104
5-6	1993: Weight loss of inoculated kiwifruit after curing for three days at 10°C and one of three relative humidities. Letters a, b & c refer to Duncan's test ( $P < 0.05$ ). Vertical bars indicate SEM.	105
5-7	1993: Firmness of inoculated kiwifruit after curing for three days at 10°C and one of three relative humidities. Letters a & b refer to Duncan's test ( $P < 0.05$ ). Vertical bars indicate SEM.	106
5-8	1993: TSS of inoculated kiwifruit after curing for three days at 10°C and one of three relative humidities. Letter a refers to Duncan's test ( $P < 0.05$ ). Vertical bars indicate SEM.	107

5-9	1993: Effect of curing at 10°C on incidence of <i>B. cinerea</i> infection of kiwifruit after six weeks of coolstorage. Letters a, b & c refer to Duncan's test ( $P < 0.05$ ). Vertical bars indicate SEM.	108
5-10	1993: Effect of curing at 10°C on incidence of <i>B. cinerea</i> infection of kiwifruit after 12 weeks of coolstorage. Letters a, b & c refer to Duncan's test ( $P < 0.05$ ). Vertical bars indicate SEM.	109
5-11	1994: Range of relative humidities attained during three days incubation at 10°C for each of four harvests.	111
5-12	1994: Interaction between maturity and relative humidity on firmness and total soluble solids of inoculated kiwifruit cured at one of three rh's and four harvest maturities. Vertical bars indicate overall standard error of the mean (SEM).	114
5-13	1994: Interaction between maturity and relative humidity on <i>B. cinerea</i> storage rot incidence of kiwifruit cured at 10°C. Vertical bars indicate overall standard error of the mean (SEM).	116
5-14	1994: Interaction between maturity and type of inoculum on <i>B. cinerea</i> storage rot incidence of kiwifruit cured at 10°C. Vertical bars indicate overall standard error of the mean (SEM).	117
5-15	1994: Interaction between relative humidity and type of inoculum on <i>B. cinerea</i> storage rot incidence of kiwifruit cured at 10°C. Vertical bars indicate overall standard error of the mean (SEM).	118
7-1	Relative humidity system.	157

7-2	1992: Input and output relative humidity over a six week period at 0°C.	160
7-3	1992: Percentage weight loss of inoculated kiwifruit over a six week period at 0°C and one of three relative humidities. Letters a, b, c & d refer to Duncan's test ( $P < 0.05$ ). Vertical bars indicate SEM.	161
7-4	1992: Firmness of inoculated kiwifruit over a six week period at 0°C and one of three relative humidities. Letters a & b refer to Duncan's test ( $P < 0.05$ ). Vertical bars indicate SEM. Firmness at harvest 9.9.	163
7-5	1992: Mean ( $\pm$ SE) firmness of inoculated kiwifruit stored at 0°C after incubation at different relative humidities for up to six weeks. (Overall $P < 0.001$ ).	164
7-6	1992: Total soluble solids of inoculated kiwifruit over a six week period at 0°C and one of three relative humidities. Letters a & b refer to Duncan's test ( $P < 0.05$ ). Vertical bars indicate SEM. TSS at harvest 6.9%.	165
7-7	1992: Ethylene production of inoculated kiwifruit over a six week period at 0°C and one of three relative humidities. Letters a, b & c refer to Duncan's test ( $P < 0.05$ ). Vertical bars indicate SEM.	166
7-8	1992: Rate of respiration of inoculated kiwifruit over a six week period at 0°C and one of three relative humidities. Letters a, b & c refer to Duncan's test ( $P < 0.05$ ). Vertical bars indicate SEM.	167
7-9	1992: Mean percentage infection of inoculated kiwifruit over a six week period at 0°C and one of three relative humidities after 12 weeks coolstorage.	169

7-10	1993: Input and output relative humidity for fruit from the first harvest over a seven day period at 0°C.	170
7-11	1993: Input and output relative humidity for fruit from the second harvest over a seven day period at 0°C.	171
7-12	1993: Input and output relative humidity for fruit from the third harvest over a seven day period at 0°C.	172
7-13	1993: Percentage weight loss of inoculated kiwifruit incubated for seven days at 0°C and one of three relative humidities. Letters a, b & c refer to Duncan's test ( $P < 0.05$ ). Vertical bars indicate SEM.	173
7-14	1993: Firmness of inoculated kiwifruit incubated for seven days at 0°C and one of three relative humidities. Letters a & b refer to Duncan's test ( $P < 0.05$ ). Vertical bars indicate SEM.	174
7-15	1993: Total soluble solids of inoculated kiwifruit incubated for seven days at 0°C and one of three relative humidities. Letters a & b refer to Duncan's test ( $P < 0.05$ ). Vertical bars indicate SEM.	175
7-16	1993: Percentage infection of inoculated kiwifruit incubated for seven days at 0°C and one of three relative humidities after six weeks coolstorage. Letters a & b refer to Duncan's test ( $P < 0.05$ ). Vertical bars indicate SEM.	176
7-17	1993: Percentage infection of inoculated kiwifruit incubated for seven days at 0°C and one of three relative humidities after 12 weeks coolstorage. Letters a & b refer to Duncan's test ( $P < 0.05$ ). Vertical bars indicate SEM.	177

## LIST OF PLATES

PLATE		PAGE
6-1	Longitudinal section of a fresh kiwifruit (Plate 6-2	136
6-2	stained with Phloroglucinol-HCl.(mg. x1.8).	
6-3	Longitudinal section of a fresh kiwifruit with pedicel attached stained with Phloroglucinol-HCl.(mg. x0.7). Positions of the cross-section shown in Plates 6-4 - 6-7 are indicated with horizontal lines. Section A1 (Plate 6-4), section A2 (Plate 6-5), section A3 (Plate 6-6), section A4 (Plate 6-7) and section A5 (Plate 6- 7).	138
6-4	Cross section (A1) of a fresh kiwifruit stem scar stained with Phloroglucinol-HCl.(mg. x4.0). At the union between pedicel and fruit, there is a circular arrangement of three vascular bundles (v) surrounded by, parenchyma and the suberized tissue from the fruit shoulder.	139
6-5	Cross section (A2) of a fresh kiwifruit stem scar stained with Phloroglucinol-HCl.(mg. x1.8). The original three vascular bundles (v) have divided to form five. The upper most point of the sclerified plug (p) can be seen in the centre.	139
6-6	Cross section (A3) of a fresh kiwifruit stem scar stained with Phloroglucinol-HCl.(mg. x0.7), showing radial development of sclerified tissue (s) on the upper surface of the plug and vascular bundles (v).	140



- 6-7 Cross section (A4) of a fresh kiwifruit stem scar stained with Phloroglucinol-HCl.(mg. x0.7). The sclerified plug (p) is well defined and vascular bundles (v) are diverging between the inner and outer pericarp. 140
- 6-8 Cross section (A5) of a fresh kiwifruit stem scar stained with Phloroglucinol-HCl.(mg. x0.7). The lower, compacted region of the sclerified plug (p) is surrounded by well defined vascular bundles (v) and seeds (s). 141
- 6-9 Longitudinal section of a kiwifruit stem scar stained with safranin-fast green showing parenchyma (p), sclereids (s) and collenchyma (q) cells. Bar indicates 0.2 mm. 141
- 6-10 Longitudinal section of a kiwifruit stem scar stained with methyl violet eosin showing idioblast containing calcium oxalate crystals (raphides) (r) and parenchyma (p) cells. Bar indicates 0.2 mm. 143
- 6-11 Longitudinal section of a kiwifruit stem scar stained with methyl violet eosin showing xylem vessels (x) with helicoidal secondary wall thickening and parenchyma (p) cells. Bar indicates 0.02 mm. 143
- 6-12 Longitudinal section of a kiwifruit stem scar stained with methyl violet eosin after two days curing at 20 or 30°C. Most of the spores (s) scattered on the surface of the xylem vessels (x) have germinated. Bar indicates 0.2 mm. 144

- 6-13 Longitudinal section of a kiwifruit stem scar stained with methyl violet eosin after two days curing at 10°C. Most of the spores (s) scattered on the surface of the xylem vessels (x) have not germinated. Bar indicates 0.2 mm. 144
- 6-14 Longitudinal section of a kiwifruit stem scar cured at either 0 or 10°C for two days stained with methyl violet eosin. Parenchyma cell walls (p) in contact with hyphae (h) are thicker than normal. Bar indicates 0.2 mm. 145