PT023

An investigation of black dot disease of potatoes and its control

Ian Macleod, et al
Serve-Ag Pty Ltd

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PT023

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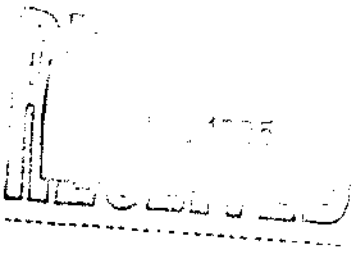

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An investigation of Black Dot disease of potatoes and its control

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PROJECT PT023

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CONTENTS

CONTENTS (CONT.)

SUMMARY

Two pot trials were conducted in a semi controlled environment in the 1993-1994 season to investigate the pathogenicity of *Colletotrichum coccodes* and the implication the disease has in premature senescence and yield reduction of potatoes. The two trials compared different isolates and different methods of inoculation of *C. coccodes.* Data generated from this work has provided evidence of *C. coccodes* as one of the primary factors in premature dying of potato plants. In addition *C. coccodes* was shown to significantly increase the incidence of tubers with black ends and to cause a 12 % reduction in yield. Soil-borne infection was identified as important to premature dying of potato plants.

This study also investigated the role of *Gliocladium roseum*, a fungus frequently found in association with *C. coccodes* affected tissues. *G. roseum* inoculated plants appeared visually similar to plants in the untreated control. Interestingly, *G. roseum* has shown potential as a biological control against *C. coccodes.*

INTRODUCTION

Colletotrichum coccodes has been observed in many potato growing areas in Tasmania. In many instances the disease was suspected to cause premature senescence of potato crops. A loss of efficacy in root function due to *C. coccodes* infection is proposed as the reason for the early dying symptoms.

Previous attempts to demonstrate premature senescence of potato plants due to *C. coccodes* infection in field trials have not been successful. The field trials revealed that eliminating the disease is difficult and varying pathogenicity of isolates of *C. coccodes* could exist.

Two field trials and a pot trial were conducted in 1992-1993. Data regarding yield in the form of total tuber numbers, mean tuber weight, and total yield have shown to be inconsistent and very difficult to interpret in relation to black dot infection. This has been despite all efforts to enhance pathogen establishment in soil, ie., sterilising soil with methyl bromide, using sterile mini tubers, introduction of pure isolate of *C. coccodes* with substrate carrier (Japanese millet), or booster-inoculation of already infested soil. Although our data has confirmed the presence of the black dot pathogen where inoculum was present or introduced, the data does not provide adequate information as to the level of inoculums present. This may be one of the reasons for such a discrepancy in the results. It has been well established from our early field surveys and in the literature that for *C. coccodes* to operate as an economically important plant pathogen it has to be present at high levels in soil. What adds to this limitation is its relatively weak competitive capacity in soil. The complexity of surrounding field conditions relating to soil microflora, soil pH, soil texture , soil content of organic matter, and other factors may make conditions even harder to conduct experiments.

Therefore the need for more controlled experimental conditions has become a necessity if any more meaningful results are to be obtained. A pot trial with a more controlled environment has been the choice. Data from it has shown some signs of improvement in terms of correlating some yield parameters to black dot infection. Where *C. coccodes* has been introduced by tuber and soil inoculation of infested soil, a considerable increase in dry weight of root and tuber numbers have been noticed while mean tuber weight was shown to be the lowest. This finding has established the principles upon which the current season trials are being designed.

In current work, efforts have been put into having more controls over purity of pathogen isolates and soil and tuber hygiene. Two pot trials in a semi controlled environment, with sterilised soil mix and sterile mini tubers are being used.

AIMS

1. To investigate the implication of *Colletotrichum coccodes* in the premature senescence of potatoes.

2. To investigate the effect of infection by *C. coccodes* on root biomass, yield, and quality of potatoes.

3. To compare the pathogenicity or virulence of different isolates of *C. coccodes*.

4. To compare different methods of inoculation by *C. coccodes*.

5. To investigate the possible involvement of other fungi in the premature senescence phenomenon of potatoes.

TRIAL DETAILS

	TRIAL 1 (Y)	TRIAL 2 (R)
LOCATION	Devonport (Serve-Ag Complex)	Devonport (Serve-Ag Complex)
SOIL TYPE	Sterile Potting Mix	Sterile Potting Mix
TRIAL DESIGN	Latin Square	Latin Square
REPLICATES	Five x Five	Four x Four
PLOT SIZE	Four Pots	Four Pots
CROP	Potato	Potato
VARIETY	Burbank Clone 5 (Sterile Minitubers)	Burbank Clone 5 (Sterile Minitubers)
SEEDING RATE	One Whole Tuber Per Pot	One Whole Tuber Per Pot
SOWING DATE	25-Nov-93	25-Nov-93
HARVEST DATE	14-April-94	15-April-94

TREATMENTS

TRIAL 1 (Y)		
No.	Inoculum / Pathogen	Application
1	*Colletotrichum coccodes*, Pure Culture (Frampton)	Soil, Drench, Soil
2	*Gliocladium roseum*, Pure Culture	Drench, Soil
3	*C. coccodes*, Field Infested Haulms	Soil, Soil
4	*C. coccodes*, Pure Culture (Badcock)	Drench, Soil
5	Untreated Control	
TRIAL 2 (R)		
1	*C. coccodes*, Pure Culture (Frampton)	Foliar
2	*C. coccodes*, Pure Culture (Frampton)	Soil, Drench, Soil
3	*C. coccodes*, Pure Culture (Frampton)	Soil, Drench, Soil + Foliar
4	Untreated Control	

TRIAL LAYOUT

Y-Rep 1	R-Rep 1	Y-Rep 2	R-Rep 2	Y-Rep 3	R-Rep 3	Y-Rep 4	R-Rep 4	Y-Rep 5
Y1		Y2		Y3		Y4		Y5
	R1		R2		R3		R4	
Y4		Y1		Y5		Y3		Y2
	R2		R4		R1		R3	
Y3		Y5		Y4		Y2		Y1
	R4		R3		R2		R1	
Y2		Y4		Y1		Y5		Y3
	R3		R1		R4		R2	
Y5		Y3		Y2		Y1		Y4

N ←

INOCULATION SUMMARY

Date	Inoculums	Concentration (CFU x 1000)	Application
25-Nov-93	*C. coccodes*, Frampton	1.15 / ml soil	soil mix, 5L / pot
	C. coccodes, (haulms)	33 / ml soil	soil mix, 5L / pot
2-Dec-93	*C. coccodes*, Frampton	22.5 / ml	drench, 250 ml / pot
	C. coccodes, Badcock	15.7 / ml	drench, 250 ml / pot
	G. roseum	355 / ml	drench, 500 ml / pot
23-Dec-93	*C. coccodes*, Frampton	1.29 / ml soil	soil mix, 5L / pot
	C. coccodes, Badcock	1.35 / ml soil	soil mix, 5L / pot
	C. coccodes, (haulms)	26.2 / ml soil	soil mix, 5L / pot
	G. roseum	16.6 / ml soil	soil mix, 5L / pot
4-Jan-94	*C. coccodes*, Frampton	50 / ml	foliar spray, 50 ml / plant

ASSESSMENTS AND RESULTS

Destructive Assessments

1. **DISEASE ASSESSMENTS**

DATES - 7-Jan, 17-Jan, 27-Jan, 14-March

SAMPLE SIZE - One Pot (One Plant) Per Plot

METHOD - Specimens from leaves, leaf petioles, nodes, stems, stolons, tubers or roots were plated out on acidified half strength PDA medium and examined ten days later for the presence of either *C. coccodes* or *G. roseum*. The number of infected specimens was recorded.

SUMMARISED RESULTS - Tables 1 - 4

2. **FRESH WEIGHT / DRY WEIGHT / TUBER NUMBER**

DATES - 7-Jan, 17-Jan, 27-Jan, 14-March

SAMPLE SIZE - One Pot (One Plant) Per Plot

METHOD - Plants were lifted. Tubers were counted and weighed. Roots and haulms (leaves, stems, and stolons, all together) were weighed fresh, and air-dried and weighed again. Data from weighing and tuber counts wre recorded.

SUMMARISED RESULTS - Table 5

Premature Senescence Assessments

DATES - 18-Feb, 13-March, 22-March,31-March

SAMPLE SIZE - Whole Plot

METHOD - A subjective rating on 1 - 9 scale, 1 = healthy; 9 = dead plants.

SUMMARISED RESULTS - Table 6

COMPLETE DATA - Appendices i - ii

PHOTOGRAPH - Plates 2 - 5

Harvest Disease Assessments

DATE - 27-May

SAMPLE SIZE - Five randomly selected tubers per treatment (Plots from each treatment were pooled in one sample).

METHOD - Five specimens, representing a strip extending from the stem end to the apical bud, were excised from each tuber, surface sterilised in 0.5 % NaOCl, plated out on acidified half strength PDA medium, and examined ten days later for the presence of either *C. coccodes* or *G. roseum*. The number of infected specimens was recorded.

SUMMARISED RESULTS - Table 7

PHOTOGRAPH - Plate 9

Naturally Infested Seeds and Disease Development

DATE - 14-April

SAMPLE SIZE - Four randomly choosen tubers per treatment before planting and at harvest (Plots from each treatment were pooled in one sample at harvest).

METHOD - Four specimens, representing a strip extending from the stem end to the apical bud, were excised from each tuber, surface sterilised in 0.5 % NaOCl, plated out on acidified half strength PDA medium, and examined ten days later for the presence of either *C. coccodes*. The number of infected specimens was recorded.

SUMMARISED RESULTS - Table 8

Yield Assessment

DATES - 14-April (Trial 1,Y), 15-April (Trial 2, R)

SAMPLE SIZE - Whole Plot

METHOD - Potatoes were hand-lifted, washed, counted, and weighed. Haulms were air-dried and weighed later.

SUMMARISED RESULTS - Table 9

COMPLETE DATA - Appendices iii, iv, ix, & x

Quality Assessments

DATES - 14-April (Trial 1,Y), 15-April (Trial 2, R)

SAMPLE SIZE - Whole Plot

METHOD - Percentages of tubers with retained stolons, internal colour (0-4 scale, Edgell), and dark ends (Edgell) were estimated. Also the specific gravity of tubers was determined at Edgell.

SUMMARISED RESULTS - Table 10

COMPLETE DATA - Appendix v - viii

PHOTOGRAPH - Plates 6 - 9

TABLE 1
DISEASE INCIDENCE (%) AT 44 DAYS

TRIAL 1						
No.	Treatments	Stem Above	Stem Below	Stolons	Tubers	Roots
1	*C. coccodes*, Pure (Frampton)	100	100	100	25	0
2	*G. roseum*, Pure (Badcock)	100	100	75	75	0
3	*C. coccodes*, Infested Haulms	25	75	0	0	0
4	*C. coccodes*, Pure (Badcock)	50	100	25	0	0
5	Untreated Control	0	0	0	0	0

TABLE 2
DISEASE INCIDENCE (%) AT 54 DAYS

TRIAL 1						
No.	Treatments	Stem Above	Stem Below	Stolons	Tubers	Roots
1	*C. coccodes*, Pure (Frampton)	100	100	50	100	100
2	*G. roseum* Pure (Badcock)	100	75	100	100	66
3	*C. coccodes*, Infested Haulms	0	0	0	0	50
4	*C. coccodes*, Pure (Badcock)	100	100	100	75	100
5	Untreated Control	0	0	0	0	0

TRIAL 2								
No.	Treatments	Leaves	Petioles	Stem Above	Stem Below	Stolons	Tubers	Roots
1	Foliar	0	0	0	0	0	0	0
2	Soil	NT	NT	100	100	100	75	100
3	Soil+Foliar	0	25	100	100	100	50	83
4	Untreated Control	NT	NT	0	0	0	0	0

NT = Not Tested

Foliar inoculation was applied at 41 days after planting

TABLE 3

DISEASE INCIDENCE (%) AT 64 DAYS

TRIAL 1						
No.	Treatments	Stem Above	Stem Below	Stolons	Tubers	Roots
1	*C. coccodes*, Pure (Frampton)	100	100	75	75	66
2	*G. roseum*, Pure (Badcock)	25	50	25	100	17
3	*C. coccodes*, Infested Haulms	0	100	50	50	50
4	*C. coccodes*, Pure (Badcock)	100	100	50	50	100
5	Untreated Control	0	0	0	0	0

TRIAL 2								
No.	Treatments	Leaves	Petioles	Stem Above	Stem Below	Stolons	Tubers	Roots
1	Foliar	0	0	25	25	0	0	0
2	Soil	NT	NT	100	100	75	100	100
3	Soil+Foliar	0	50	75	100	100	75	100
4	Untreated Control	NT	NT	0	0	0	0	0
NT = Not Tested								
Foliar inoculation was applied at 41 days after planting								

TABLE 4
DISEASE INCIDENCE (%) AT 109 DAYS

TRIAL 1							
No.	Treatments	Node 1	Node 2	Stem Below	Stolons	Tubers	Roots
1	*C. coccodes*, Pure (Frampton)	0	0	NT	NT	NT	100
2	*G. roseum*, Pure (Badcock)	NT	NT	100	100	100	100
3	*C. coccodes*, Infested Haulms	0	0	NT	NT	NT	100
4	*C. coccodes*, Pure (Badcock)	0	25	NT	NT	NT	100
5	Untreated Control	0	0	0	0	0	0

TRIAL 2									
No.	Treatments	Leaves	Node 1	Node 2	Stem Above	Stem Below	Stolons	Tubers	Roots
1	Foliar	0	0	0	100	100	100	75	100
2	Soil	NT	0	25	NT	NT	NT	NT	100
3	Soil+Foliar	0	0	25	NT	NT	NT	NT	100
4	Untreated Control	0	0	0	0	0	0	0	0

NT = Not Tested (microsclerotia of *C. coccodes* were abundant and easily visible in all samples)

TABLE 5

MEAN FRESH AND DRY WEIGHT / MEAN TUBER NO. PER POT

TRIAL 1							
No.	Treatments	Fresh Weight (g)			Dry Weight (g)		Tuber No.
		Tubers	Roots	Haulms	Roots	Haulms	
1	*C. coccodes*, Pure (Frampton)	380.1	54.9	236.9	3.8	89.2	44
2	*G. roseum*, Pure (Badcock)	489.8	67.7	323.6	5.4	135.3	41.5
3	*C. coccodes*, Infested Haulms	414.3	53.8	221.9	4	89.6	37
4	*C. coccodes*, Pure (Badcock)	508.7	55.1	281.1	5.3	109.2	53.5
5	Untreated Control	404.2	62.7	254.5	4.1	94.8	42.2
Averages of 4 destructive assessments							
TRIAL 2							
No.	Treatments	Fresh Weight (g)			Dry Weight (g)		Tuber No.
		Tubers	Roots	Haulms	Roots	Haulms	
1	Foliar	605	37.8	286.9	7.1	21.9	44
2	Soil	597.1	29.2	278.2	5.2	23.4	40
3	Soil+Foliar	598.5	30.2	290.5	6.3	23.4	47.6
4	Untreated Control	541.2	30.2	243.6	4.7	20.8	33.3
Averages of 3 destructive assessments							

TABLE 6
MEAN PREMATURE SENESCENCE

TRIAL 1					
No.	Treatments	85 Days	109 Days	117 Days	126 Days
1	*C. coccodes*, Pure (Frampton)	3	4.7 b	6.9 b	8.8 c
2	*G. roseum*, Pure (Badcock)	2.3	2.8 a	3.9 a	8.1 ab
3	*C. coccodes*, Infested Haulms	3.1	5.5 b	7.2 b	8.5 bc
4	*C. coccodes*, Pure (Badcock)	2.9	4.9 b	7.4 b	8.6 bc
5	Untreated Control	1.6	2.8 a	3.3 a	7.7 a
Within each column means followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.					
TRIAL 2					
No.	Treatments	85 Days	109 Days	117 Days	126 Days
1	Foliar	1.6 a	2.9 ab	5.2 ns	8.5 ns
2	Soil	3.3 b	4.6 bc	6.4 ns	8.3 ns
3	Soil+Foliar	2.8 ab	5 c	7.1 ns	8.8 ns
4	Untreated Control	1.4 a	2 a	3.8 ns	8 ns
Within each column means followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test; ns denotes no significance.					

TABLE 7
C. COCCODES ON TUBERS AT HARVEST (%)

Trial No.	Treatments	Location on tuber				
		Stem End	Mid 1	Mid 2	Mid 3	Apical Bud
1	*C. coccodes*, Pure (Frampton), Soil	100	100	100	100	80
1	*G. roseum*, Pure (Badcock), Soil	0	40	20	20	80
1	*C. coccodes*, Infested Haulms, Soil	100	100	80	80	100
2	*C. coccodes*, Pure (Frampton), Foliar	100	100	100	100	100
1	Untreated Control	60	60	60	40	20
Five tubers per treatments were checked for *C. coccodes* on 1/2 strength PDA						

TABLE 8
INFESTED SEED AND DISEASE DEVELOPMENT

Russet Burbank						
	C. coccdes		Premature Senescence (Scale 1-9)			
	% Tuber Infected	% Area Covered	85 Days	109 Days	117 Days	126 Days
Mother	100	81	3.5	5.5	7	8.7
Daughter	100	69				
Coliban						
Mother	75	58	2.5	3	5.5	8.5
Daughter	75	75				

TABLE 9
MEAN YIELD

TRIAL 1					
No.	Treatments	Tubers			Dry Haulms
		No. / Plant	g / Tuber	Kg / plant	g / Plant
1	*C. coccodes*, Pure (Frampton)	35.4 bc	29.8	1.05 b	22.6 b
2	*G. roseum*, Pure (Badcock)	39.6 c	30.9	1.21 c	23.3 b
3	*C. coccodes*, Infested Haulms	27.1 a	30.2	0.76 a	15.4 a
4	*C. coccodes*, Pure (Badcock)	37.8 bc	29.1	1.06 b	21.6 b
5	Untreated Control	32.5 ab	32.7	1.05 b	19.7 ab
TRIAL 2					
No.	Treatments	Tubers			Dry Haulms
		No. / Plant	g / Tuber	Kg / plant	g / Plant
1	Foliar	27.3 ns	37.8 ns	1.02 ab	19.5 ns
2	Soil	28.4 ns	35.8 ns	0.87 a	17.2 ns
3	Soil+Foliar	31.9 ns	32.5 ns	1 ab	16.7 ns
4	Untreated Control	32.9 ns	36.5 ns	1.15 b	19.8 ns

Within each column means followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test; ns denotes no significance.

Note:

An additional analysis, T- test, was conducted by combining yield data from identical treatments in both trials (Trial 1- treatment 1 *plus* Trial 2 - treatment 2 *vs.* Trial 1- control *plus* Trial 2- control). The T- test indicated a significant reduction in yield by 12 % (*T= -2.15; P= 0.49*) in the Black Dot inoculated treatments.

TABLE 10
QUALITY ASSESSMENT (MEANS)

TRIAL 1

No.	Treatments	% SR	SG	Colour (0: White; 4: Brown)					% DE
				0 (%)	1 (%)	2 (%)	3 (%)	4 (%)	
1	*C. coccodes*, Pure (Frampton)	37.9	1.09	52	42	4	2	0	76 c
2	*G. roseum*, Pure (Badcock)	38.1	1.09	94	6	0	0	0	20 a
3	*C. coccodes*, Infested Haulms	34.6	1.09	90	0	10	0	0	60 bc
4	*C. coccodes*, Pure (Badcock)	31.2	1.09	86	14	0	0	0	44 ab
5	Untreated Control	40.3	1.09	96	4	0	0	0	32 ab

Within each column means followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

TRIAL 2

No.	Treatments	% SR	SG	Colour (Scale 0-4)					% DE
				0 (%)	1 (%)	2 (%)	3 (%)	4 (%)	
1	Foliar	38.7	1.09 b	100	0	0	0	0	32.5 a
2	Soil	26.8	1.07 a	100	0	0	0	0	42.5ab
3	Soil+Foliar	40.3	1.09 b	97.5	2.5	0	0	0	75 b
4	Untreated Control	50.5	1.09 b	97.5	2.5	0	0	0	17.5 a

Within each column means followed by the same letter are not significantly different at the 5% level according to Duncan's New Multiple Range Test.

SR: Stolons Retention; SG: Specific Gravity (Unacceptable Below 1.07); DE: Dark End.

CHRONOLOGY OF EVENTS

Date	DAS	Event
25-Nov-93	0	Planting and Soil Inoculation With *C. coccodes*
2-Dec-93	8	Drench Inoculation With *G. roseum*
13-Dec-93	19	Emergence Count 1
23-Dec-93	29	Emergence Count 2
4-Jan-94	41	Foliar Inoculation With *C. coccodes*
5-Jan-94	42	Emergence Count 3
7-Jan-94	44	Destructive Assessment 1
17-Jan-94	54	Destructive assessment 2
27-Jan-94	64	Destructive Assessment 3
18-Feb-94	85	Visual Disease Assessment 1
13-March-94	108	Destructive Assessment 4
14-March-94	109	Visual Disease Assessment 2
22-March-94	117	Visual Disease Assessment 3
31-March-94	126	Visual Disease Assessment 4
14-April-94	140	Harvest / Trial 1 (Y)
15-April-94	141	Harvest / Trial 2 (R)

METEOROLOGICAL DETAILS

Complete meteorological data from the Forthside research Station for the months of November, 1993, to April, 1994, are included as appendices to this report. The Serve-Ag Pty. Ltd. compound, where the pot trials are conducted, is situated about 14 km East of Forthside.

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DISCUSSION

The early recovery of *C. coccodes* from below ground parts (stems, stolons, tubers, and roots) at a stage where neither symptoms nor any signs of the pathogen can be seen (Tables 1 - 3) suggests a latent phase of infection. During this period, which coincides with the active growth stage of the potato plants (over a period of about 12 weeks from planting), *C. coccodes* can only be detected by plating out on a nutrient medium.

The latent phase seems to be a pre-requisite for *C. coccodes* to be pathogenic. Only those plants with soil inoculation by *C. coccodes*, which took place early at planting exhibited early dying symptoms (Table 6; Plates 2 - 5) and showed significantly higher levels of tubers with dark stem ends (Table 10). Dark stem end is a quality defect that may adversely affect the marketability of both processing and fresh market potatoes.

Foliar inoculation (treatment 1, trial 2), which took place about 6 weeks after planting, failed to induce any significant pathological effect. This can be attributed to two main reasons. Firstly it may not be possible for *C. coccodes* to invade actively growing foliar parts, especially leaves (Tables 2 - 4). Secondly it might have been too late for the pathogen to invade below ground parts and roots (it was only detectable from stems at 25 % after 64 days, Table 3) by the time of the foliar inoculation. Again this may emphasise the importance of early invasion and from soil (the latent phase) of below ground parts, especially roots, for the induction of premature dying. Early colonisation of roots may result in shortages in nutrient and water uptake by the plants. Consequently, plants start to senesce and die prematurely.

Similarly, Mohan et al (1992), in two field experiments with spray inoculation of *C. coccodes* where plants were blown with sand prior to inoculation, were unable to observe any distinct symptoms on aerial parts until later stage of senescence and death of stems. Their result is consistent with our finding in that *C. coccodes*, although it was introduced aerially, was consequently able to invade below ground parts including tubers. Foliar infection by *C. coccodes*, however, has been reported to occur naturally on other crops like tomato (Mordue, 1967), causing fruit anthracnose, or on weeds, causing foliage blight of eastern black nightshade (Anderson, 1985) and velvetleaf (Wymore et al, 1988).

In any case for foliar infection to be potentially significant, foliar damage may be required. Except for the frequently occurring strong wind, sand storms are not common in Tasmania. Sands produces wounds which serve as points of entries for the pathogen. However, wind along with rain storms may play an important role later during the saprophytic phase in disseminating conidia of *C. coccodes* within and in-between potato paddocks.

It appears that for foliar spread to be effective in causing disease to the currently growing potato crops it should "attack from soil". This may be possible only if *C. coccodes* from foliar spread has enough time to latently invade below ground parts. It can be perceived, and has been indicated earlier, that such an invasion should take place during the active growth stage of potato plants, which may be no later than 64 days from the time of planting. However, the likelihood of this occurring is probably minimal. This is mainly due to the late development of inoculum on aerial parts, at senescence and stem death (the saprophytic phase).

Plants inoculated with infested haulms produced similar levels of premature dying (Table 6) and tuber dark ends (Table 10) to those treated with pure cultures of *C. coccodes*. This may indicate an important role of infested haulms in carrying-over Black Dot to successive crops and in serving as a source of infection in successive potato crops. Proportion of tubers, especially from the infected haulm treatment, were already decayed at harvest, and this continued to happen during storage. This may indicate further implications of *C. coccodes* in predisposing tubers to invasion by secondary organisms or perhaps by other pathogens. Using naturally infested haulm as an inoculum may well represent what is actually happening in the field. Our field observations also suggests a possibility that *C. coccodes* may predispose potato crop to infection by other pathogens such as target spot. Field infection with target spot was more intense in crop patches where *C. coccodes* was present.

Pure culture inoculums of Black Dot or inoculation with naturally infested haulms, both seem to be effective in causing significant reductions in tuber yield (Table 9). To confirm this an additional analysis was done by combining yield data from identical treatments in both trials and comparing them to the combined data of the untreated control treatments. The result from this analysis has indicated a significant reduction in yield by 12 % *(T= -2.15; P= 0.49)*. This result is in agreement with work by Barkdoll et al. (1992), reporting a reduction of 14 % in tuber yield due to infection with Black Dot in the greenhouse.

Potato seeds naturally infested with *C. coccodes* were as efficient in producing disease as inoculating with either infested haulms or with pure cultures. The levels of premature dying and of black dot-infested tubers at harvest (Table 8) were similar to those treatments with artificial Black Dot inoculations. This finding indicates a very important role of infested tubers in disease initiation and spread. Therefore, pathogen-free potato seeds should be given a top priority in any effort to develop effective control strategies for Black Dot.

Interestingly, *Gliocladium roseum* produced no pathological effect. *G. roseum* inoculated plants looked as normal as those in the untreated with respect to senescence (Table 6) and to the percentage of tubers with dark ends (Table 10). Moreover, stem ends of tubers from *G. roseum* infected plants, unlike the untreated control, did not pick up *C. coccodes* at harvest (Table 7), suggesting a possible biological control mechanism.

CONCLUSIONS

1. *C. coccodes* is shown to be one of the primary factors responsible for the premature senescence of potato plants in Tasmania.

2. Infection with Black Dot has significantly reduced the yield by at least 12 %.

3. *C. coccodes* seems to predispose potato plants to infection by other pathogens or by secondary microorganisms, thus, contributing to more reduction in yield (the infected haulm treatment).

4. *C. coccodes* decreased tuber quality by significantly increasing percentage of tubers with dark end, an undesirable characteristic for potato processing.

5. *C. coccodes* acts mainly as a soil-borne pathogen of potatoes in Tasmania. It tends to establish itself on below ground parts of the plant regardless of the method of inoculation. It first infects the stems at soil line after which infection spreads to stolons, tubers, and roots within a ten day period.

6. *C. coccodes* attacks potato plants by two modes. The latent / pathogenic mode which is soil-borne and chronic occurring during the active growth stage of potato plants. The saprophytic / secondary mode occurring later, especially on necrotic tissues of stems haulms or roots.

7. The latent infection, which is soil-borne, appears to be the most important factor in inducing pathological effects. These include premature senescence and tuber internal discolouration or dark end.

8. The saprophytic stage does not appear to be significant in producing pathological effects. However, it can play an important role in *C. coccodes* survival and inoculum build up and spread.

9. Naturally infested seed tubers are as important as infested haulms in initiating infection with black dot and in carrying over disease between seasons. Therefore pathogen-free seed should be given a top priority in any scheme for an effective control of Black Dot.

10. The isolate of *Gliocladium roseum* used in this work has not shown any effect in inducing premature senescence nor in reducing yield or quality of potatoes.

11. *G. roseum* showed a strong antagonistic effect against *C. coccodes*. Tubers at harvest were provided with complete protection against *C. coccodes*, especially at the stem ends, thus suggesting *G. roseum* as a possible biological control agent.

DIAGRAMMATIC REPRESENTATION OF BLACK DOT DISEASE CYCLE ON POTATO

Time Scale (DAS)	Disease Stages	Inoculum Source	Importance
0 - 85	**The Latent / Pathological Phase / Soil-Borne** - No Symptoms - No Signs of the Pathogen - Pathogen Detectable Only on Culture Media	-Infested Haulms From Previous Crops -Infested Seed -Volunteer Potato (Infested Haulms) -Other Hosts (Infested Stubbles)	-Primary -Primary -Secondary -Secondary
85 - 109	**Early Senescence / The Intermediate Phase** - Induced By and a Product of the Latent Phase - No Signs of the Pathogen Other Than Few Sunken Lesions with Black Dots on Lower Parts at Petioles and Stem Joints	-Initially Soil Infected Plants	-Primary
109 - 126 Lasts Till Harvest	**The Saprophytic Phase / Air-Borne** - Microsclerotia / Black Dots are Present and Visually Recognised on All Aerial and Below Ground Parts - Eventually All Stems Become Infested and Turn Black - Air-Borne / Secondary Dissemination and Infestation of Dead Stems of Originally Healthy Plants	- Initially Soil Infected Plants -Infested Haulms / Current Crops or Other Hosts	-Primary -Secondary

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BLACK DOT POT TRIAL 1 (Y), 1994

VISUAL DISEASE ASSESSMENT / PREMATURE DYING

COLLETOTRICHUM COCCODES, FRAMPTON				
	18-Feb-94	13-Mar-94	22-Mar-94	31-Mar-94
REP	DAY 85	DAY 108	DAY 117	DAY 126
1	3.67	5.33	6.67	9.00
2	5.00	5.33	7.00	9.00
3	1.50	3.50	6.50	8.75
4	2.00	3.33	5.67	8.66
5	3.00	6.00	9.00	9.00
Mean	3.03	4.70	6.97	8.88
GLIOCLADIUM ROSEUM				
1	3.00	2.33	3.00	8.00
2	2.00	2.67	4.00	8.33
3	2.67	3.00	4.00	8.66
4	2.25	3.75	4.50	8.50
5	1.75	2.25	4.33	7.33
Mean	2.33	2.80	3.97	8.16
COLLETOTRICHUM COCCODES, HAULMS				
1	3.00	5.50	7.50	9.00
2	3.00	5.67	7.67	9.00
3	4.00	5.67	7.67	8.33
4	2.50	5.00	5.75	7.50
5	3.25	5.75	7.67	8.66
Mean	3.15	5.52	7.25	8.50
COLLETOTRICHUM COCCODES, BADCOCK				
1	2.33	3.33	4.67	7.33
2	3.33	6.00	8.00	9.00
3	3.50	5.00	8.00	9.00
4	3.33	5.00	8.33	9.00
5	2.25	5.25	8.33	9.00
Mean	2.95	4.92	7.47	8.67
UNTREATED CONTROL				
1	1.33	1.67	2.67	8.33
2	2.00	1.67	4.00	8.33
3	2.00	2.00	2.33	6.33
4	1.25	2.00	4.00	8.50
5	1.50	2.50	3.67	7.33
Mean	1.62	1.97	3.33	7.77

BLACK DOT POT TRIAL 2 (R), 1994

VISUAL DISEASE ASSESSMENT / PREMATURE DYING

REP	COLLETOTRICHUM COCCODES, FRAMPTON			
	18-Feb-94	13-Mar-94	22-Mar-94	31-Mar-94
	DAY 85	DAY 108	DAY 117	DAY 126
F O L I A R				
1	1.33	3.33	5.33	8.00
2	1.67	2.33	5.67	9.00
3	1.50	2.75	5.00	8.75
4	2.00	3.50	5.00	8.33
Mean	1.63	2.98	5.25	8.52
S O I L				
1	5.00	6.00	7.50	9.00
2	3.00	4.67	7.00	9.00
3	3.50	5.25	8.00	8.75
4	1.75	2.50	3.33	6.66
Mean	3.31	4.60	6.46	8.35
FOLIAR + SOIL				
1	3.00	5.33	8.00	9.00
2	2.67	4.00	6.00	8.33
3	3.50	5.50	6.25	9.00
4	2.25	5.25	8.33	9.00
Mean	2.85	5.02	7.15	8.83
UNTREATED CONTROL				
1	2.00	1.67	2.00	6.33
2	1.00	1.67	4.67	9.00
3	1.25	2.25	3.75	8.75
4	1.50	2.50	5.00	8.00
Mean	1.44	2.02	3.85	8.02

YIELD ASSESSMENT - TRIAL 1 (Y)
(April 14, 1994)

No.	Treatment	Rep	Mean Pot Yield (g)			Mean Tuber Weight (g)			Mean Tuber No./ Pot		
			Mature	Immature	Total	Mature	Immature	Total	Mature	Immature	Total
1	C.coccodes - Frampton	1	1077.87	6.27	1084.13	31.09	2.09	28.78	34.67	3.00	37.67
	(tuber distorted)	2	990.80	5.33	996.13	30.96	3.20	29.59	32.00	1.67	33.67
		3	1214.35	4.30	1218.65	28.91	2.87	28.01	42.00	1.50	43.50
		4	929.00	9.77	938.77	36.19	3.26	32.75	25.67	3.00	28.67
		5	1005.63	8.00	1013.63	32.79	2.67	30.11	30.67	3.00	33.67
		Mean	**1043.53**	**6.73**	**1050.26**	**31.99**	**2.82**	**29.85**	**33.00**	**2.43**	**35.43**
2	G. roseum	1	1288.20	24.70	1312.90	39.04	3.29	32.42	33.00	7.50	40.50
		2	1102.77	17.87	1120.63	35.96	3.35	31.13	30.67	5.33	36.00
		3	1283.63	35.90	1319.53	32.09	4.31	27.30	40.00	8.33	48.33
		4	1169.40	23.00	1192.40	38.34	4.38	33.35	30.50	5.25	35.75
		5	1136.05	17.25	1153.30	36.65	2.65	30.75	31.00	6.50	37.50
		Mean	**1196.01**	**23.74**	**1219.75**	**36.41**	**3.60**	**30.99**	**33.03**	**6.58**	**39.62**
3	Infected Haulms	1	715.55	2.50	718.05	42.09	1.67	38.81	17.00	1.50	18.50
		2	860.77	0.97	861.73	26.90	0.48	25.35	32.00	2.00	34.00
		3	768.27	5.83	774.10	25.90	1.17	22.33	29.67	5.00	34.67
		4	719.63	0.00	719.63	39.98	0.00	39.98	18.00	0.00	18.00
		5	743.70	13.07	756.77	31.87	1.87	24.95	23.33	7.00	30.33
		Mean	**761.58**	**4.47**	**766.06**	**33.35**	**1.04**	**30.28**	**24.00**	**3.10**	**27.10**
4	C.coccodes - Badcock	1	1070.70	18.25	1088.95	40.40	4.56	35.70	26.50	4.00	30.50
		2	1047.67	24.30	1071.97	26.86	7.29	25.32	39.00	3.33	42.33
		3	1093.55	4.30	1097.85	37.71	2.87	36.00	29.00	1.50	30.50
		4	964.53	0.00	964.53	26.07	0.00	26.07	37.00	0.00	37.00
		5	1109.33	9.80	1119.13	23.94	3.68	22.84	46.33	2.67	49.00
		Mean	**1057.16**	**11.33**	**1068.49**	**31.00**	**3.68**	**29.19**	**35.57**	**2.30**	**37.87**
5	Untreated Control	1	1015.20	17.33	1032.53	36.69	3.25	31.29	27.67	5.33	33.00
		2	1085.53	14.90	1100.43	38.31	3.19	33.35	28.33	4.67	33.00
		3	1108.65	7.00	1115.65	41.84	2.00	37.19	26.50	3.50	30.00
		4	1117.43	16.85	1134.28	33.36	3.74	29.85	33.50	4.50	38.00
		5	906.40	8.37	914.77	36.26	2.28	31.91	25.00	3.67	28.67
		Mean	**1046.64**	**12.89**	**1059.53**	**37.29**	**2.89**	**32.72**	**28.20**	**4.33**	**32.53**

YIELD ASSESSMENT - TRIAL 2 (R)
(April 15, 1994)

No.	Treatment	Rep	Mean Pot Yield (g)			Mean Tuber Weight (g)			Mean Tuber No./ Pot		
			Mature	Immature	Total	Mature	Immature	Total	Mature	Immature	Total
1	Foliar	1	991.90	0.00	991.90	41.33	0.00	41.33	24.00	0.00	24.00
		2	1099.47	3.77	1103.23	35.85	2.83	34.48	30.67	1.33	32.00
		3	1048.78	6.03	1054.80	39.58	4.82	38.01	26.50	1.25	27.75
		4	942.37	1.37	943.73	38.20	2.05	37.25	24.67	0.67	25.33
		Mean	**1020.63**	**2.79**	**1023.42**	**38.74**	**2.42**	**37.77**	**26.46**	**0.81**	**27.27**
2	Soil	1	908.10	0.00	908.10	24.54	0.00	24.54	37.00	0.00	37.00
		2	833.47	1.83	835.30	36.77	5.50	36.32	22.67	0.33	23.00
		3	1032.63	8.35	1040.98	26.82	3.34	25.39	38.50	2.50	41.00
		4	714.15	0.00	714.15	57.13	0.00	57.13	12.50	0.00	12.50
		Mean	**872.09**	**2.55**	**874.63**	**36.32**	**2.21**	**35.85**	**27.67**	**0.71**	**28.38**
3	Soil+Foliar	1	1101.27	1.77	1103.03	26.86	2.65	26.47	41.00	0.67	41.67
		2	902.10	7.63	909.73	37.07	4.58	34.99	24.33	1.67	26.00
		3	992.25	4.98	997.23	37.80	9.95	37.28	26.25	0.50	26.75
		4	1025.77	0.00	1025.77	31.08	0.00	31.08	33.00	0.00	33.00
		Mean	**1005.35**	**3.59**	**1008.94**	**33.20**	**4.30**	**32.46**	**31.15**	**0.71**	**31.85**
4	Control	1	1325.35	0.00	1325.35	51.97	0.00	51.97	25.50	0.00	25.50
		2	1100.37	21.77	1122.13	38.84	4.35	33.66	28.33	5.00	33.33
		3	1105.65	14.63	1120.28	38.13	2.93	32.95	29.00	5.00	34.00
		4	1043.93	14.67	1058.60	32.62	2.20	27.38	32.00	6.67	38.67
		Mean	**1143.83**	**12.76**	**1156.59**	**40.39**	**2.37**	**36.49**	**28.71**	**4.17**	**32.88**

QUALITY ASSESSMENT TRIAL 1 (Y)
(April 14, 94)

No.	Treatment	Rep	No. Pots / Plot	Stolon Retention			Distorted Tuber		
				No. / Plot	Mean / Plot	Percentage	No. / Plot	Mean / Plot	Percentage
1	C.coccodes - Frampton	1	3.00	38.00	12.67	33.63	1.00	0.33	0.88
		2	3.00	40.00	13.33	39.60	33.00	11.00	32.67
		3	4.00	44.00	11.00	25.29	0.00	0.00	0.00
		4	3.00	42.00	14.00	48.84	1.00	0.33	1.16
		5	3.00	43.00	14.33	42.57	0.00	0.00	0.00
		Mean	**3.25**		**13.07**	**37.99**		**2.33**	**6.94**
2	G. roseum	1	2.00	34.00	17.00	41.98	1.00	0.50	1.23
		2	3.00	39.00	13.00	36.11	0.00	0.00	0.00
		3	3.00	50.00	16.67	34.48	1.00	0.33	0.69
		4	4.00	45.00	11.25	31.47	0.00	0.00	0.00
		5	2.00	35.00	17.50	46.67	3.00	1.50	4.00
		Mean	**2.80**		**15.08**	**38.14**		**0.47**	**1.18**
3	Infected Haulms	1	2.00	18.00	9.00	48.65	0.00	0.00	0.00
		2	3.00	33.00	11.00	32.35	0.00	0.00	0.00
		3	3.00	20.00	6.67	19.23	1.00	0.33	0.96
		4	3.00	17.00	5.67	31.48	0.00	0.00	0.00
		5	3.00	38.00	12.67	41.76	0.00	0.00	0.00
		Mean	**2.80**		**9.00**	**34.69**		**0.07**	**0.19**
4	C.coccodes - Badcock	1	2.00	30.00	15.00	49.18	0.00	0.00	0.00
		2	3.00	38.00	12.67	29.92	2.00	0.67	1.57
		3	2.00	24.00	12.00	39.34	0.00	0.00	0.00
		4	3.00	14.00	4.67	12.61	37.00	12.33	33.33
		5	3.00	37.00	12.33	25.17	0.00	0.00	0.00
		Mean	**2.60**		**11.33**	**31.25**		**2.60**	**6.98**
5	Untreated Control	1	3.00	46.00	15.33	46.46	0.00	0.00	0.00
		2	3.00	35.00	11.67	35.35	0.00	0.00	0.00
		3	2.00	29.00	14.50	48.33	1.00	0.50	1.67
		4	4.00	54.00	13.50	35.53	0.00	0.00	0.00
		5	3.00	31.00	10.33	36.05	0.00	0.00	0.00
		Mean	**3.00**		**13.07**	**40.34**		**0.10**	**0.33**

QUALITY ASSESSMENT- CONT. TRIAL 1 (Y)
(April 14, 94)

No.	Treatment	Rep	No. Pots / Plot	Specific Gravity	Colour					Dark End	
					0.00	1.00	2.00	3.00	4.00	Percentage	Remarks
1	C.coccodes - Frampton	1	3.00	1.091	10.000	90.000	0.000	0.000	0.000	90.00	
		2	3.00	1.088	20.000	60.000	20.000	0.000	0.000	80.00	
		3	4.00	1.076	100.000	0.000	0.000	0.000	0.000	60.00	
		4	3.00	1.088	100.000	0.000	0.000	0.000	0.000	50.00	
		5	3.00	1.130	30.000	60.000	0.000	10.000	0.000	100.00	
		Mean	**3.25**	**1.095**	**52.000**	**42.000**	**4.000**	**2.000**	**0.000**	**76.00**	
2	G. roseum	1	2.00	1.097	100.000	0.000	0.000	0.000	0.000	40.00	
		2	3.00	1.094	80.000	20.000	0.000	0.000	0.000	20.00	
		3	3.00	1.098	100.000	0.000	0.000	0.000	0.000	0.00	
		4	4.00	1.083	100.000	0.000	0.000	0.000	0.000	0.00	
		5	2.00	1.093	90.000	10.000	0.000	0.000	0.000	40.00	
		Mean	**2.80**	**1.093**	**94.000**	**6.000**	**0.000**	**0.000**	**0.000**	**20.00**	
3	Infected Haulms	1	2.00	1.077	90.000	0.000	10.000	0.000	0.000	80.00	
		2	3.00	ND						ND	
		3	3.00	1.133	80.000	0.000	20.000	0.000	0.000	60.00	sugary
		4	3.00	ND						ND	
		5	3.00	1.081	100.000	0.000	0.000	0.000	0.000	40.00	sugary
		Mean	**2.80**	**1.097**	**90.000**	**0.000**	**10.000**	**0.000**	**0.000**	**60.00**	
4	C.coccodes - Badcock	1	2.00	1.092	100.000	0.000	0.000	0.000	0.000	50.00	sugary
		2	3.00	1.092	100.000	0.000	0.000	0.000	0.000	50.00	
		3	2.00	1.094	90.000	10.000	0.000	0.000	0.000	0.00	sugary
		4	3.00	1.084	50.000	50.000	0.000	0.000	0.000	80.00	
		5	3.00	1.092	90.000	10.000	0.000	0.000	0.000	40.00	
		Mean	**2.60**	**1.091**	**86.000**	**14.000**	**0.000**	**0.000**	**0.000**	**44.00**	
5	Untreated Control	1	3.00	1.091	90.000	10.000	0.000	0.000	0.000	60.00	
		2	3.00	1.092	100.000	0.000	0.000	0.000	0.000	20.00	
		3	2.00	1.095	90.000	10.000	0.000	0.000	0.000	0.00	sugary
		4	4.00	1.086	100.000	0.000	0.000	0.000	0.000	20.00	sugary
		5	3.00	1.090	100.000	0.000	0.000	0.000	0.000	60.00	
		Mean	**3.00**	**1.091**	**96.000**	**4.000**	**0.000**	**0.000**	**0.000**	**32.00**	

QUALITY ASSESSMENT TRIAL 2 (R)
(April 15, 1994)

No.	Treatment	Rep	No Pots/ Plot	Stolon Retention			Distorted Tubers		
				No. / Plot	Mean / Pot	Percentage	No. / Plot	Mean / Pot	Percentage
1	Foliar	1	3	36.00	12.00	50.00	0.00	0.00	0.00
		2	3	39.00	13.00	40.63	1.00	0.33	1.04
		3	4	35.00	8.75	31.53	2.00	0.50	1.80
		4	3	25.00	8.33	32.89	0.00	0.00	0.00
		Mean	**3.25**		**10.52**	**38.76**		**0.21**	**0.71**
2	Soil	1	2	3.00	1.50	4.05	0.00	0.00	0.00
		2	3	19.00	6.33	27.54	0.00	0.00	0.00
		3	4	52.00	13.00	31.71	0.00	0.00	0.00
		4	2	11.00	5.50	44.00	0.00	0.00	0.00
		Mean	**2.75**		**6.58**	**26.82**		**0.00**	**0.00**
3	Soil+Foliar	1	3	45.00	15.00	36.00	0.00	0.00	0.00
		2	3	44.00	14.67	56.41	0.00	0.00	0.00
		3	4	39.00	9.75	36.45	0.00	0.00	0.00
		4	3	32.00	10.67	32.32	0.00	0.00	0.00
		Mean	**3.25**		**12.52**	**40.30**		**0.00**	**0.00**
4	Control	1	2	27.00	13.50	52.94	0.00	0.00	0.00
		2	3	49.00	16.33	49.00	0.00	0.00	0.00
		3	4	66.00	16.50	48.53	0.00	0.00	0.00
		4	3	60.00	20.00	51.72	20.00	6.67	17.24
		Mean	**12**		**16.58**	**50.55**		**1.67**	**4.31**

QUALITY ASSESSMENT- CONT. TRIAL 2 (R)
(April 15, 1994)

No.	Treatment	Rep	No Pots/ Plot	Specific Gravity	Colour					Dark End	
					0	1	2	3	4	Percentage	Remarks
1	Foliar	1	3	1.090	100.00	0.00	0.00	0.00	0.00	0.00	
		2	3	1.093	100.00	0.00	0.00	0.00	0.00	0.00	
		3	4	1.090	100.00	0.00	0.00	0.00	0.00	70.00	
		4	3	1.090	100.00	0.00	0.00	0.00	0.00	60.00	
		Mean	**3.25**	**1.091**	**100.00**	**0.00**	**0.00**	**0.00**	**0.00**	**32.50**	
2	Soil	1	2	1.067	100.00	0.00	0.00	0.00	0.00	50.00	
		2	3	1.081	100.00	0.00	0.00	0.00	0.00	30.00	
		3	4	1.070	100.00	0.00	0.00	0.00	0.00	50.00	sugary
		4	2	1.087	100.00	0.00	0.00	0.00	0.00	40.00	
		Mean	**2.75**	**1.076**	**100.00**	**0.00**	**0.00**	**0.00**	**0.00**	**42.50**	
3	Soil+Foliar	1	3	1.091	100.00	0.00	0.00	0.00	0.00	70.00	
		2	3	1.089	100.00	0.00	0.00	0.00	0.00	70.00	
		3	4	1.090	90.00	10.00	0.00	0.00	0.00	80.00	
		4	3	1.089	100.00	0.00	0.00	0.00	0.00	80.00	
		Mean	**3.25**	**1.090**	**97.50**	**2.50**	**0.00**	**0.00**	**0.00**	**75.00**	
4	Control	1	2	1.096	100.00	0.00	0.00	0.00	0.00	0.00	
		2	3	1.092	90.00	10.00	0.00	0.00	0.00	60.00	
		3	4	1.086	100.00	0.00	0.00	0.00	0.00	0.00	
		4	3	1.091	100.00	0.00	0.00	0.00	0.00	10.00	
		Mean	**12**	**1.091**	**97.50**	**2.50**	**0.00**	**0.00**	**0.00**	**17.50**	

TRIAL 1 TRIAL 1 (Y) HAULMS DRY WEIGHT (G)
(April 14, 1994)

No.	Treatment	Rep	No. Pots / Plot	Haulms	
				Weight / Plot	Mean / Pot
1	C.coccodes - Frampton	1	3.00	84.40	28.13
		2	3.00	61.10	20.37
		3	4.00	91.40	22.85
		4	3.00	50.20	16.73
		5	3.00	74.70	24.90
		Mean	**3.25**		**22.60**
2	G. roseum	1	2.00	52.60	26.30
		2	3.00	59.40	19.80
		3	3.00	79.70	26.57
		4	4.00	91.40	22.85
		5	2.00	42.70	21.35
		Mean	**2.80**		**23.37**
3	Infected Haulms	1	2.00	26.40	13.20
		2	3.00	47.70	15.90
		3	3.00	47.30	15.77
		4	3.00	43.00	14.33
		5	3.00	53.80	17.93
		Mean	**2.80**		**15.43**
4	C.coccodes - Badcock	1	2.00	53.60	26.80
		2	3.00	57.00	19.00
		3	2.00	39.30	19.65
		4	3.00	53.70	17.90
		5	3.00	75.30	25.10
		Mean	**2.60**		**21.69**
5	Untreated Control	1	3.00	62.80	20.93
		2	3.00	58.10	19.37
		3	2.00	37.20	18.60
		4	4.00	85.80	21.45
		5	3.00	54.50	18.17
		Mean	**3.00**		**19.70**

Appendix x

TRIAL 2 (R) HAULMS DRY WEIGHT (G)
(April 15, 1994)

No.	Treatment	Rep	No Pots/ Plot	Haulms	
				Weight / Plot	Mean / Pot
1	Foliar	1	3	68.00	22.67
		2	3	58.50	19.50
		3	4	73.40	18.35
		4	3	53.10	17.70
		Mean	**3.25**		**19.55**
2	Soil	1	2	38.50	19.25
		2	3	46.70	15.57
		3	4	85.30	21.33
		4	2	25.70	12.85
		Mean	**2.75**		**17.25**
3	Soil+Foliar	1	3	57.20	19.07
		2	3	49.00	16.33
		3	4	61.00	15.25
		4	3	49.00	16.33
		Mean	**3.25**		**16.75**
4	Control	1	2	43.20	21.60
		2	3	59.30	19.77
		3	4	77.30	19.33
		4	3	56.40	18.80
		Mean	**12**		**19.87**

METEOROLOGICAL RETURN FROM FORTHSIDE VEGETABLE RESEARCH STATION

NOVEMBER 1993

DATE	MIN	DRY	WET	MAX	10 cm	20 cm	RAIN mm	TERR	EVAP	WIND km	SUN hrs
1	08.9	11.9	10.3	15.1	12	13	00.0	06.0	04.0	351	10.9
2	11.3	11.3	11.0	13.8	12	13	56.6	11.0	02.0	174	11.0
3	04.4	09.0	07.4	15.6	10	12	00.4	01.3	02.0	164	13.5
4	03.9	07.7	06.9	13.6	10	12	01.2	02.0	02.2	304	05.4
5	03.0	08.0	06.0	12.7	09	11	00.0	00.0	03.2	221	08.2
6	07.5	11.6	10.2	16.9	11	13	00.0	07.0	03.0	201	04.0
7	05.2	09.0	05.7	16.0	10	12	00.0	02.0	03.0	352	08.7
8	05.0	09.3	07.1	15.2	11	13	00.0	03.0	05.2	224	11.5
9	04.5	08.7	04.9	15.2	11	12	00.2	01.5	04.2	275	10.7
10	03.6	08.1	05.5	15.1	11	12	00.0	01.0	04.0	143	12.0
11	04.4	11.5	09.7	14.0	12	13	00.0	02.1	04.0	135	11.7
12	10.5	12.5	11.1	15.5	14	14	00.4	08.9	04.4	156	10.7
13	10.5	13.5	12.2	16.1	12	15	00.8	09.0	00.8	118	01.5
14	09.2	12.8	10.3	17.0	13	15	00.0	05.5	03.6	234	08.5
15	10.0	12.7	09.5	21.0	12	15	00.0	06.4	07.2	275	13.1
16	07.9	12.5	11.0	21.6	14	16	00.0	04.7	04.6	152	10.6
17	10.1	13.7	11.7	16.1	12	16	00.0	09.3	04.0	138	07.5
18	12.5	15.1	15.0	15.2	15	15	34.0	13.0	02.0	113	00.0
19	10.0	13.0	11.0	20.1	14	15	00.0	08.7	01.4	083	05.6
20	08.7	12.0	09.0	18.0	12	15	00.0	05.0	03.6	221	05.8
21	10.4	13.1	11.3	18.0	15	16	00.0	08.6	04.8	202	10.3
22	08.0	10.0	07.2	14.1	12	15	12.2	06.0	04.2	384	09.0
23	04.6	08.0	06.0	12.7	11	14	00.6	02.0	04.6	277	11.8
24	07.9	11.3	09.4	16.5	13	15	00.0	06.0	05.6	208	11.7
25	05.0	10.2	08.0	17.1	12	14	00.0	02.0	04.0	204	09.3
26	06.6	13.7	11.6	15.0	14	15	00.0	03.7	04.6	151	12.9
27	09.9	14.5	10.0	17.7	15	16	00.0	07.3	04.0	121	12.5
28	09.0	12.1	08.5	18.7	13	15	00.0	05.5	06.2	307	13.0
29	06.6	12.5	09.0	19.4	14	16	00.0	03.0	06.8	220	13.3
30	07.1	12.1	10.0	20.5	14	16	00.0	03.0	05.6	187	13.0
TOT	226.2	341.4	276.5	493.5	370	424	106.4	154.5	118.8	6295	287.7
MNS	7.5	11.4	9.2	16.5	12.3	14.1					
28 YEAR AVE	8.6	12.4	10.5				74.5			6225	224.8

Appendix xii

METEOROLOGICAL RETURN FROM FORTHSIDE VEGETABLE RESEARCH STATION

DECEMBER 1993

DATE	MIN	DRY	WET	MAX	10 cm	20 cm	RAIN mm	TERR	EVAP	WIND km	SUN hrs
1	11.5	13.7	11.5	17.3	16	17	00.4	10.7	05.4	235	10.4
2	10.4	13.7	09.8	18.0	13	15	01.4	05.9	01.8	278	02.1
3	11.6	13.5	11.6	02.3	16	17	00.0	09.0	06.0	18.0	12.3
4	08.6	13.5	11.6	17.6	14	16	00.0	06.0	03.0	178	05.2
5	05.2	08.5	06.7	15.4	13	15	00.0	02.0	05.0	298	11.7
6	08.1	11.7	09.8	17.0	14	15	00.0	06.2	03.0	243	04.6
7	08.0	13.5	10.1	19.5	13	15	00.0	02.5	04.0	255	10.8
8	11.9	15.0	12.3	18.5	17	17	00.0	11.0	05.8	186	11.3
9	10.6	15.7	13.5	18.9	16	17	00.0	07.6	05.2	163	13.0
10	15.8	17.0	15.1	20.1	18	18	00.0	15.9	04.0	141	04.7
11	14.0	19.7	16.4	21.4	19	20	00.0	11.5	06.2	113	10.9
12	09.7	11.3	08.3	19.9	15	17	31.0	07.7	02.0	236	02.0
13	07.0	11.0	09.0	17.0	14	16	00.2	06.0	06.6	257	12.1
14	11.0	12.5	11.3	16.7	15	17	00.0	13.0	03.8	175	00.2
15	11.5	13.2	09.5	16.0	13	15	50.9	09.1	02.7	371	01.5
16	07.7	10.0	07.2	16.0	13	15	02.6	04.9	03.8	321	08.8
17	06.6	11.8	07.5	09.5	13	15	00.0	04.5	05.8	218	12.5
18	08.5	13.1	10.5	19.2	14	16	00.0	06.0	04.0	168	13.6
19	11.5	14.0	12.8	18.3	17	18	00.0	09.9	06.4	147	12.3
20	08.0	13.3	10.8	22.0	15	18	00.0	05.2	07.0	224	13.9
21	12.8	14.1	12.0	18.2	17	18	00.0	12.7	05.2	207	10.9
22	12.6	13.5	13.1	19.2	17	19	05.0	12.5	06.2	279	09.5
23	13.2	15.2	13.5	15.5	15	16	69.4	12.6	04.0	329	00.0
24	11.7	15.0	12.0	22.1	15	17	04.0	09.0	04.0	172	04.3
25	11.3	13.0	12.0	19.2	16	18	00.0	10.0	05.0	174	13.2
26	12.0	13.0	11.5	15.6	16	18	01.2	11.6	04.2	214	05.6
27	08.4	15.2	12.6	16.8	13	15	20.2	08.5	03.8	188	00.8
28	12.0	16.0	12.7	19.2	14	15	03.8	09.2	02.8	151	03.0
29	10.0	17.0	14.0	21.6	15	16	00.0	08.2	04.0	084	08.5
30	11.8	14.1	13.3	19.5	16	17	00.8	10.3	02.8	099	05.0
31	10.3	14.0	10.8	21.2	16	18	00.0	08.4	04.0	185	12.9
TOT	323.3	425.8	352.8	548.7	468	516	190.9	267.6	137.5	6307	247.6
MNS	10.4	13.7	11.4	17.7	15.1	16.6					
28 YEAR AVE	9.8	15.1	12.8	18.9			78.2			6699	241.6

Appendix xiii

METEOROLOGICAL RETURN FROM FORTHSIDE VEGETABLE RESEARCH STATION

JANUARY 1994

DATE	MIN	DRY	WET	MAX	10 cm	20 cm	RAIN mm	TERR	EVAP	WIND km	SUN hrs
1	07.0	10.6	08.5	19.2	14	17	01.2	05.5	05.2	247	12.1
2	07.9	09.0	08.1	17.9	15	17	00.6	06.1	06.6	192	12.3
3	08.9	12.6	10.1	17.7	14	16	00.6	07.5	05.2	231	03.4
4	06.0	11.5	09.7	16.5	13	16	01.4	04.5	01.4	176	06.6
5	11.1	14.0	12.5	16.9	15	16	03.4	09.0	05.0	396	07.1
6	08.5	09.5	07.9	14.8	12	15	04.4	06.0	02.8	458	05.4
7	08.4	12.4	10.5	16.0	13	15	01.4	05.5	05.4	353	09.1
8	06.5	08.0	07.0	15.5	11	13	25.4	04.9	02.0	342	02.7
9	06.6	10.2	07.7	13.0	10	13	05.4	04.5	01.4	318	08.5
10	06.2	08.5	08.0	16.7	12	14	00.0	04.6	06.8	184	11.8
11	08.1	13.9	13.0	14.5	13	14	01.0	07.5	01.0	154	01.0
12	08.0	12.1	11.0	19.3	13	15	00.0	07.0	04.0	110	06.8
13	11.9	15.5	14.0	17.8	16	17	01.4	13.0	04.8	176	11.3
14	08.5	11.7	08.0	23.5	15	17	00.0	06.0	05.8	246	13.8
15	06.3	10.2	07.4	18.3	14	16	00.0	04.2	07.2	257	13.3
16	09.8	15.5	13.7	17.6	17	17	00.0	13.0	04.8	223	10.4
17	09.6	12.1	09.0	17.5	13	15	05.2	07.5	01.4	278	02.1
18	11.7	14.6	12.0	17.6	15	16	00.6	10.7	04.8	462	10.0
19	10.7	11.9	09.7	17.7	14	16	00.0	08.0	05.6	376	08.8
20	11.6	13.5	12.1	20.5	16	17	00.0	11.3	05.6	301	10.3
21	07.1	10.5	07.8	18.1	14	16	00.0	04.5	04.0	264	06.8
22	05.9	09.5	07.0	17.0	13	16	00.0	03.1	05.4	210	13.3
23	09.5	13.6	11.3	16.9	16	17	00.0	07.0	05.0	177	12.9
24	10.0	14.0	13.0	19.0	17	18	00.0	07.9	05.4	185	13.1
25	11.0	14.7	13.0	20.2	17	19	00.0	08.4	05.2	104	12.8
26	13.0	16.7	15.0	24.5	18	20	00.0	11.0	04.6	098	13.2
27	12.7	14.0	09.5	26.0	18	20	00.0	10.0	06.4	236	12.3
28	07.1	10.7	09.0	22.4	17	19	00.0	04.6	07.0	193	13.2
29	05.9	10.1	10.0	19.5	16	19	00.0	03.5	05.4	101	13.0
30	10.0	13.5	11.4	21.6	17	19	00.0	11.8	03.6	201	12.0
31	08.7	11.7	09.7	19.6	16	18	00.0	06.8	04.0	146	05.6
TOT	274.2	376.3	316.6	573.3	454	513	52.0	224.9	142.8	7395	295
MNS	8.8	12.1	10.2	18.5	14.6	16.5					
29 YEAR AVE	11.0	26.9	13.2	20.6			46.1			6411	253.1

Appendix xiv

METEOROLOGICAL RETURN FROM FORTHSIDE VEGETABLE RESEARCH STATION

FEBRUARY 1994

DATE	MIN	DRY	WET	MAX	10	20	RAIN	TERR	EVAP	WIND	SUN
		cm	cm	mm			km	hrs			
1	11.2	17.0	16.5	18.0	17	18	08.0	12.9	02.0	103	01.7
2	12.5	13.6	11.0	23.5	17	19	00.2	12.6	07.0	195	11.1
3	10.8	12.0	10.0	18.5	16	18	00.0	11.3	04.4	169	03.2
4	11.5	14.5	12.5	14.0	16	18	00.0	09.0	04.0	129	11.2
5	14.5	19.0	16.5	22.2	19	20	00.0	16.0	04.0	142	07.0
6	17.3	17.6	17.1	22.5	19	19	01.4	16.9	02.6	162	04.7
7	12.0	14.5	13.5	22.4	17	19	01.2	16.8	03.0	162	05.4
8	14.4	15.2	13.6	21.0	19	20	00.0	15.3	05.6	175	11.8
9	15.0	17.9	17.5	20.6	19	19	48.2	17.8	09.0	214	07.1
10	10.4	12.2	11.8	22.6	16	18	00.0	13.0	05.0	226	01.0
11	11.5	14.4	12.4	19.2	16	18	00.0	14.0	02.0	112	03.3
12	14.4	16.0	15.5	22.0	18	19	00.0	14.1	03.6	136	09.5
13	13.4	15.7	13.5	19.6	18	19	00.0	11.5	04.0	147	07.9
14	15.4	19.2	18.0	23.7	19	20	00.2	15.5	03.2	156	06.5
15	18.8	19.1	18.6	24.5	20	20	03.2	18.4	03.8	174	07.2
16	12.5	13.9	12.7	20.2	17	19	03.2	09.0	02.2	219	02.1
17	09.1	12.9	11.1	18.2	14	17	16.4	06.6	04.8	331	07.3
18	07.6	10.8	08.7	17.2	13	16	00.0	05.0	05.4	211	11.5
19	06.1	07.9	06.5	18.0	13	15	00.0	03.6	03.4	163	07.6
20	07.3	12.5	10.0	18.6	15	17	00.0	07.0	05.0	133	12.4
21	11.9	13.4	11.5	17.0	16	17	00.0	10.2	02.4	142	04.0
22	13.0	15.6	14.8	19.5	17	18	00.0	12.0	03.2	095	06.7
23	12.8	16.0	15.2	22.0	17	19	00.0	10.0	02.8	108	06.9
24	11.0	11.0	11.0	20.4	16	18	00.0	07.2	03.8	095	10.7
25	08.6	10.9	09.4	14.9	13	16	07.2	06.0	01.8	087	02.2
26	10.7	13.2	12.6	20.0	16	17	00.0	08.6	04.0	081	11.7
27	12.9	14.6	14.3	21.9	17	17	08.2	12.2	04.0	093	10.7
28	05.7	09.5	06.3	20.7	13	15	01.0	10.2	05.0	208	09.4
TOT	332.3	400.1	362.1	562.9	463	505	98.4	322.7	111	4368	201.8
MNS	11.9	14.3	12.9	20.1	16.5	18.0					
29 YEAR AVE	11.6	16.2	13.5	21.2			50.2			5390	223.1

METEOROLOGICAL RETURN FROM FORTHSIDE VEGETABLE RESEARCH STATION

MARCH 1994

DATE	MIN	DRY	WET	MAX	10 cm	20 cm	RAIN mm	TERR	EVAP	WIND km	SUN hrs
1	07.4	09.0	07.5	15.6	13	16	00.0	03.9	04.4	132	11.8
2	08.5	11.8	10.5	18.2	13	16	00.0	05.6	03.6	187	11.3
3	10.0	12.2	10.2	18.2	14	16	00.0	06.9	03.4	232	10.2
4	04.9	07.0	05.6	18.6	12	15	00.0	00.9	03.4	160	07.5
5	07.0	10.6	09.8	17.5	13	15	00.0	06.5	03.6	193	08.3
6	09.6	11.3	09.5	18.1	14	16	00.0	07.3	05.2	253	11.6
7	08.0	09.5	07.6	18.6	14	16	00.0	04.7	05.2	184	11.6
8	08.3	11.0	10.4	18.0	13	16	00.0	05.0	01.6	073	06.6
9	10.8	14.8	13.5	20.2	15	17	00.0	08.3	03.6	091	11.1
10	13.6	14.5	13.9	22.1	16	17	01.4	13.0	02.4	100	02.6
11	11.0	13.9	11.1	20.8	16	17	00.8	11.0	01.8	090	00.1
12	04.7	07.4	05.7	18.6	12	16	00.0	01.6	05.4	131	09.0
13	08.5	08.5	06.1	16.0	12	15	00.0	03.7	02.0	105	03.1
14	08.0	11.5	09.0	17.2	12	15	00.0	04.0	03.2	119	10.7
15	07.8	09.7	08.5	15.4	13	15	00.0	04.2	03.6	128	10.3
16	09.5	10.3	07.0	20.6	14	16	00.0	05.6	04.4	157	08.8
17	04.2	06.6	04.9	17.5	11	15	00.0	00.3	03.8	171	09.6
18	05.8	07.7	07.5	16.7	12	15	00.0	02.5	03.6	100	10.4
19	06.6	07.0	06.6	17.5	12	14	00.0	02.1	02.6	089	09.6
20	06.9	12.8	11.7	18.0	14	15	00.0	06.6	03.0	091	09.8
21	09.9	11.5	11.0	18.6	14	16	00.0	06.0	03.0	092	07.1
22	11.3	13.0	12.5	19.5	15	16	00.0	09.4	02.4	066	08.0
23	12.5	15.2	14.4	21.9	15	16	00.0	10.1	01.2	056	00.6
24	14.4	14.6	14.4	19.2	16	17	00.2	14.3	02.6	101	02.9
25	08.6	11.1	11.0	17.1	14	16	00.0	05.5	01.4	039	00.0
26	08.6	10.2	09.7	19.3	14	16	00.0	05.2	02.6	081	08.1
27	09.4	11.0	10.5	21.0	14	16	00.0	05.8	02.4	061	08.5
28	10.4	15.0	13.4	21.3	15	16	00.0	07.0	03.4	069	10.6
29	12.0	16.4	15.0	20.8	15	17	00.0	07.5	03.8	071	10.6
30	14.3	15.9	15.5	20.5	16	17	00.0	11.0	02.0	057	05.4
31	12.0	15.4	14.5	20.5	16	17	00.0	08.0	02.8	078	09.0
TOT	284.5	356.4	318.5	583.1	429	493	02.4	193.5	97.4	3557	244.8
MNS	9.2	11.5	10.3	18.8	13.8	15.9					
29 YEAR AVE	10.4	15.2	12.6	19.7			54.4			5391	197.9

METEOROLOGICAL RETURN FROM FORTHSIDE VEGETABLE RESEARCH STATION

APRIL 1994

DATE	MIN	DRY	WET	MAX	10 cm	20 cm	RAIN mm	TERR	EVAP	WIND km	SUN hrs
1	15.0	16.4	16.1	19.5	NR	NR	09.0	15.2	01.4	NR	NR
2	07.6	12.6	11.0	20.1	NR	NR	00.0	04.1	03.6	NR	NR
3	02.9	09.0	07.0	18.0	NR	NR	00.0	00.0	04.0	NR	NR
4	08.7	14.5	12.6	19.3	NR	NR	00.0	05.3	02.0	NR	NR
5	10.7	12.5	12.0	18.7	NR	NR	00.0	07.0	01.8	NR	NR
6	11.8	13.7	12.8	18.7	NR	NR	04.8	09.1	02.4	NR	NR
7	09.7	11.2	07.5	18.3	NR	NR	06.8	05.5	03.2	NR	NR
8	09.3	12.5	11.5	15.7	NR	NR	00.0	05.9	01.4	NR	07.7
9	10.5	13.5	12.4	18.1	NR	NR	00.0	06.6	02.0	NR	02.3
10	09.9	13.6	12.9	18.0	NR	NR	02.6	08.0	02.2	NR	03.4
11	05.6	07.8	05.2	17.2	NR	NR	02.6	00.9	02.6	NR	05.1
12	01.6	05.6	04.1	15.9	NR	NR	00.0	-00.5	02.4	NR	10.0
13	05.6	10.5	09.5	15.5	NR	NR	00.0	04.4	02.4	NR	09.6
14	10.2	11.8	10.9	19.2	NR	NR	00.0	06.5	02.4	NR	09.3
15	09.6	10.1	09.6	19.3	NR	NR	00.0	07.1	01.8	NR	05.9
16	09.5	11.6	11.1	17.4	NR	NR	00.0	06.5	01.6	NR	08.2
17	07.1	11.7	11.2	15.8	NR	NR	00.0	04.1	01.6	NR	05.2
18	06.2	09.6	08.0	17.9	NR	NR	02.8	04.0	02.0	NR	02.8
19	09.5	12.5	09.5	16.4	NR	NR	00.0	06.5	02.0	NR	08.0
20	06.4	09.5	06.5	16.7	NR	NR	00.0	01.6	03.4	NR	08.2
21	02.9	07.5	06.1	15.6	NR	NR	00.0	-00.6	02.6	NR	09.8
22	07.2	10.2	09.0	17.1	NR	NR	00.0	04.1	02.4	NR	08.0
23	08.5	11.2	11.0	17.1	NR	NR	00.6	06.4	01.2	NR	05.5
24	11.0	12.5	12.2	16.8	NR	NR	00.0	07.4	00.6	NR	01.3
25	12.3	13.5	12.5	18.8	NR	NR	00.0	11.0	02.0	NR	06.1
26	07.6	08.7	08.5	20.1	NR	NR	00.0	01.0	01.6	NR	05.9
27	08.2	16.1	14.9	20.5	NR	NR	00.0	07.0	02.6	NR	08.8
28	04.8	14.7	14.1	16.2	NR	NR	04.0	01.8	03.2	NR	04.7
29	08.0	10.2	06.6	15.7	NR	NR	01.5	04.5	02.5	NR	01.5
30	04.2	07.2	06.5	14.2	NR	NR	00.0	01.4	01.4	NR	NR
TOT	242.1	342	302.8	527.8	NR	NR	34.7	151.8	66.3	NR	137.3
MNS	8.1	11.4	10.1	17.6	NR	NR					
29 YEAR AVE	6.2	11.6	9.5	14.8			80.3			6248	198.2

NR = Not Recorded

PLATE1

30-Dec-93 - General view of the Black Dot Trial complex.

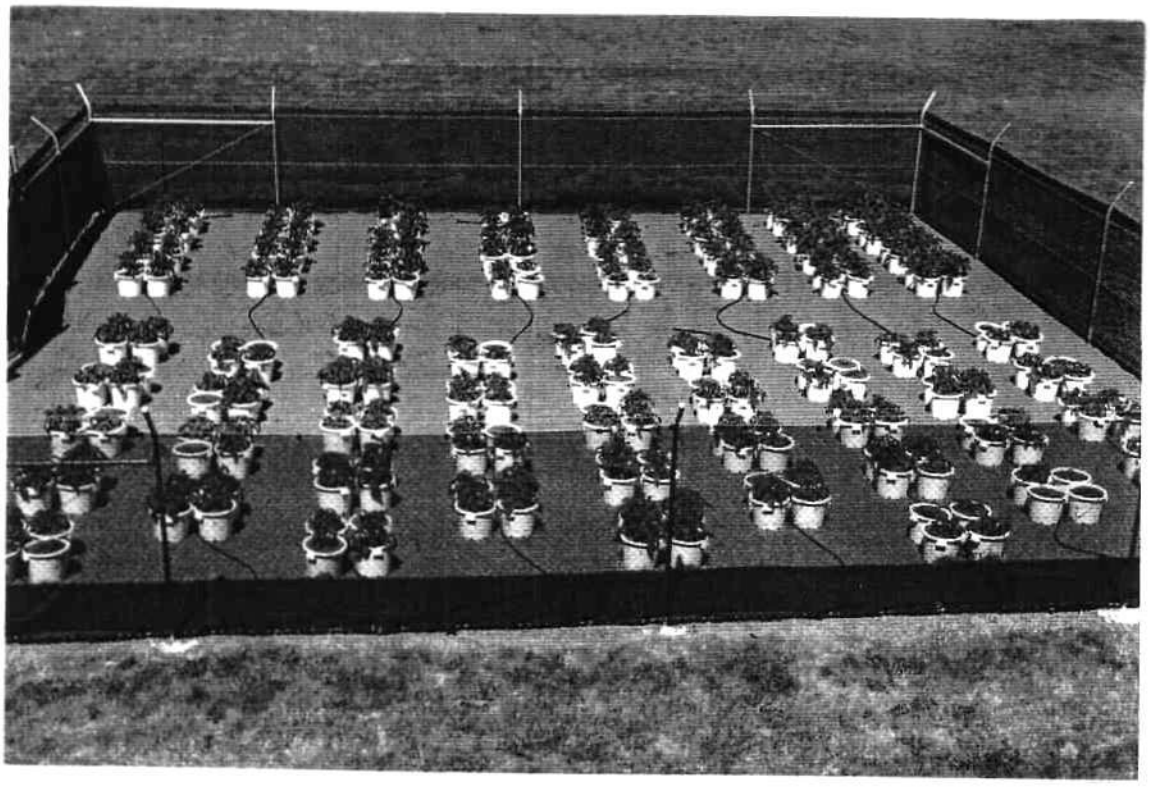

PLATE 2

11-March-94 - General view of potato plants starting to show premature senescence.

PLATE 3

18-March-94- Top: *C. coccodes* inoculated potato plants dying prematurely.
Bottom: Untreated control.

PLATE 4

25-March-94 - The saprophytic phase of *C. coccodes* can be seen as microsclerotia (blackened areas) on potato haulms.

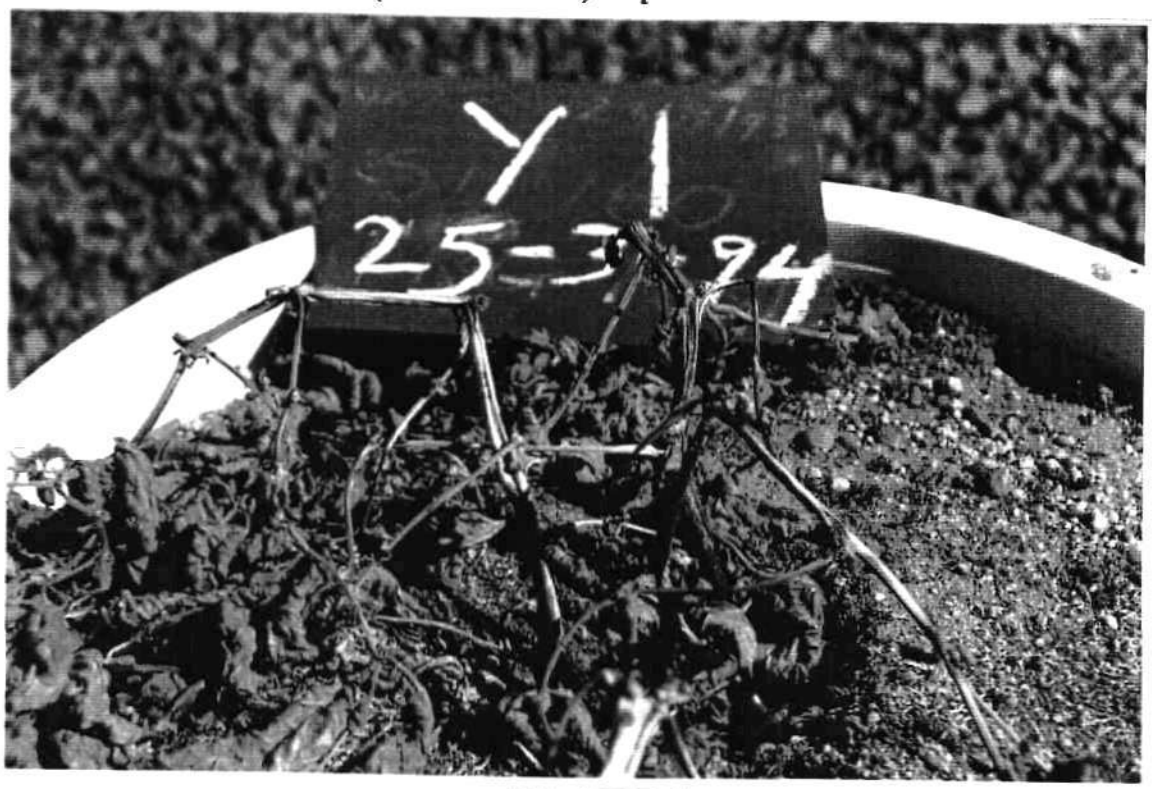

PLATE 5

31-March-94 General view of the Black Dot Trial complex two weeks before harvest.

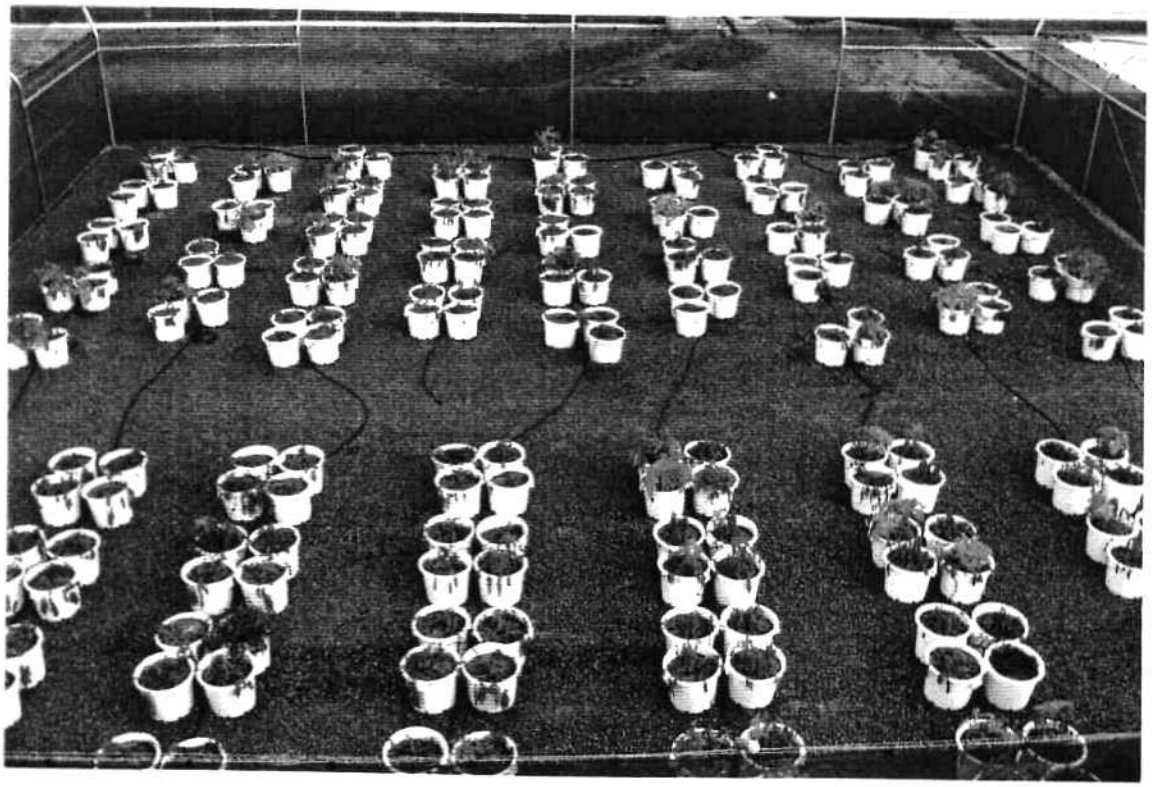

PLATE 6

11-Feb-94 - Bottom tubers from *C. coccodes* inoculated plants, showing necrotic spots two weeks after incubation at 4° C in a plastic bag.
Top tubers from the untreated control.

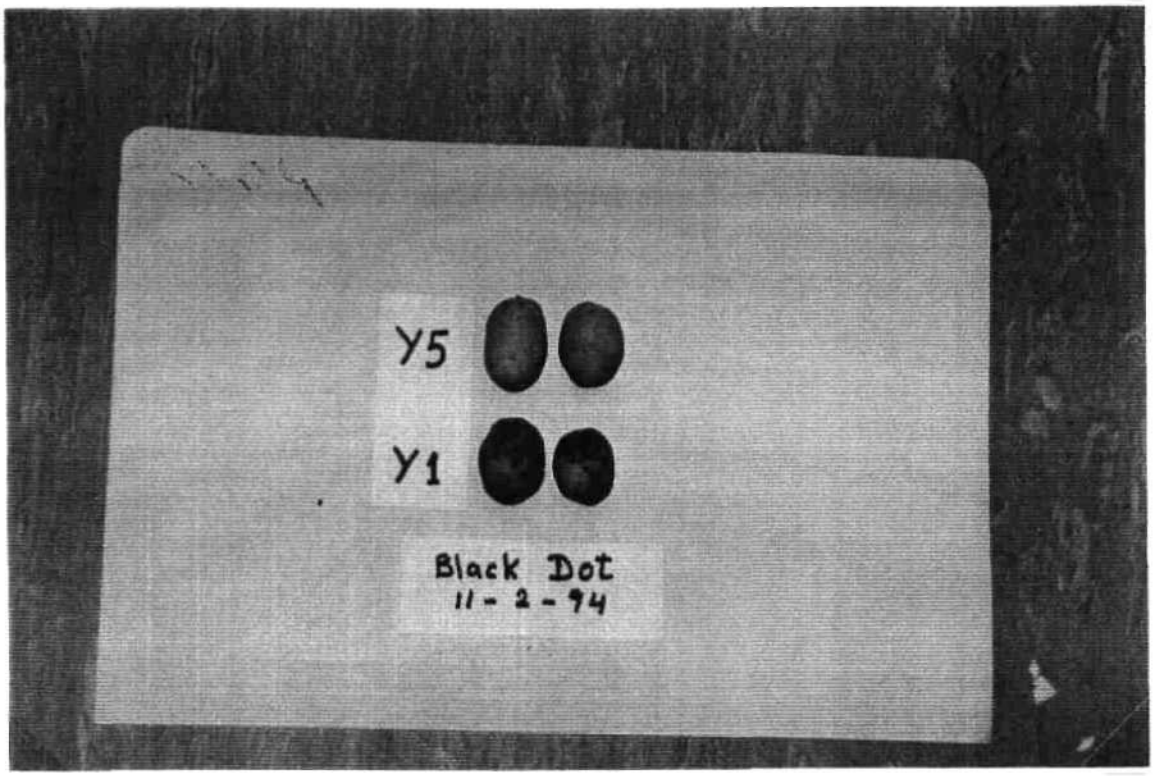

PLATE 7

14-April-94- Tubers from potato plants inoculated with *C. coccodes* infested haulms showing varying degrees of necrotic spotting and decay.

PLATE 8

14-April-94- Deformed tubers found in two *C. coccodes* inoculated plots.

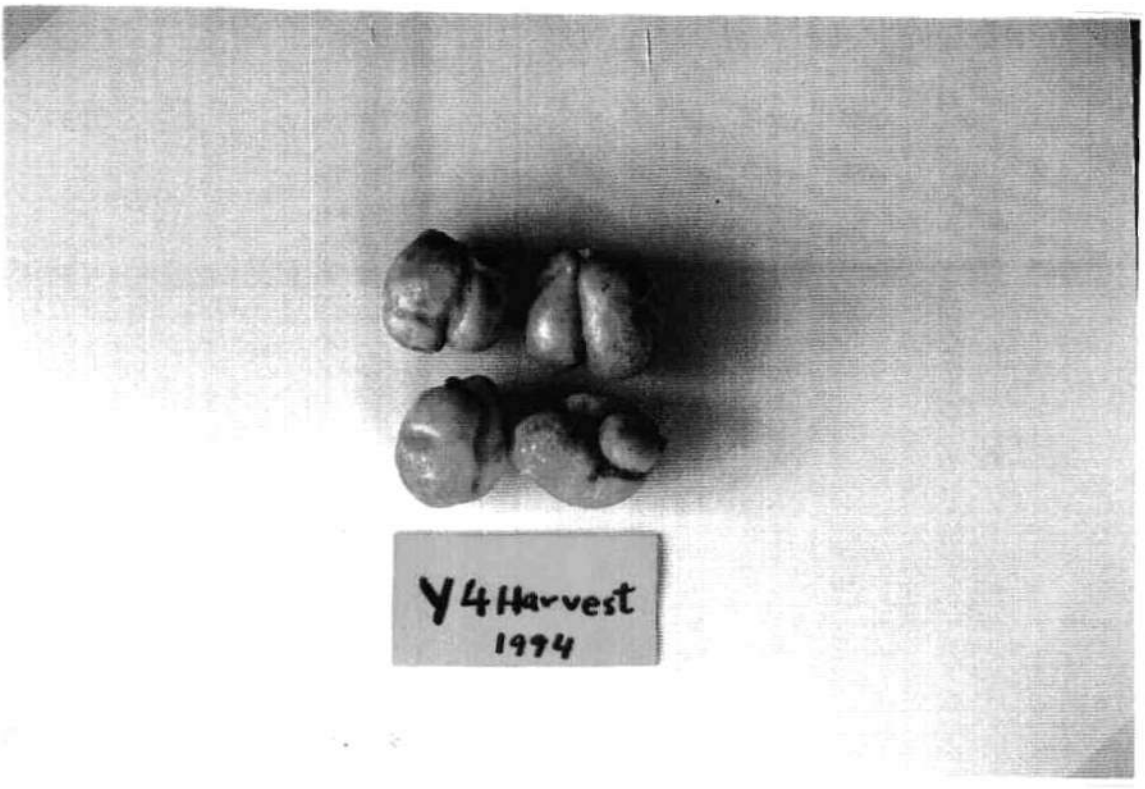

PLATE 9

Detection of *C. coccodes* from tuber stem ends at harvest.
Y1, inoculated with *C. coccodes* (all stem ends were infested,)
Y2, inoculated with *G. roseum*(all stem ends were free of C. coccodes)
Y5, the untreated control (three stem ends were infested by secondary spread).