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Outdoor crisp lettuce: control of Sclerotinia
1987-89
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AUTHENTICATION

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

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OUTDOOR CRISP LETTUCE: CONTROL OF SCLEROTINIA, 1987–89

Summary

In response to growers' concern regarding losses in field lettuce due to Sclerotinia disease, risk assessment work and fungicide trials were conducted on holdings in Lancashire from 1987 to 1989.

Prediction of fields at risk from Sclerotinia was performed by extraction of sclerotia from soil samples prior to cropping at ten (1987) or twelve (1988) sites. Sites were subsequently visited to assess incidence of apothecia (fruiting bodies) and plant infection prior to harvest. The correlation between numbers of sclerotia found initially and final disease levels was poor. This was due to the greater dependence of infection on other factors, eg apothecial production, ascospore spread, crop growth stage and weather conditions. An attempt was made to correlate apothecial production, infection and weather factors in 1989 but was unsuccessful due to unfavourable infection conditions in the hot, dry summer. Further work on the epidemiology of S.sclerotiorum is required before prediction schemes can be formulated.

Six trials were carried out in 1987 to 1989 to compare fungicidal and non-fungicidal methods for control of Sclerotinia with untreated controls. Significant disease levels occurred only in 1987; weather was unfavourable for infection in 1988 and 1989 at the time of the trials. In 1987, the fungicides Corbel and Octave gave better control of Sclerotinia than standard Ronilan or Rovral WP programmes, although the latter were very effective at high rates. Corbel caused phytotoxicity in one trial in 1988, in which Benlate also gave a reduction of a low level of disease. Control of Sclerotinia resulted in increased head weights and percentage of marketable heads.

Of the non-fungicidal methods investigated, polythene mulches gave very good control of infection by acting as a physical barrier. Control was similar to that from a Ronilan programme and was improved further by addition of the latter. Perspex collars around plants as barriers were less effective. Urea foliar feeds, aimed at reducing lower leaf senescence and thus infection sites, were ineffective without an accompanying Ronilan programme.

Ringspot (Microdochium panattonianum) infection occurred in Trials III and IV in 1988 and disease assessments were carried out. Octave gave the best control of this disease and significantly increased the percentage of marketable heads. This result is in agreement with that obtained in Project FV/34. Corbel and Patrol also offered useful suppression of ringspot in Trial IV.

Added note: Since this work was performed, approval for the use of Ronilan on lettuce crops has been suspended with effect from 19 March 1991 pending a review of the active ingredient, vinclozolin.

INTRODUCTION

The fungal pathogen, Sclerotinia sclerotiorum, has a very wide host range and causes various disease problems, particularly in vegetable crops (Mordue and Holliday, 1976). In lettuce, damping-off of seedlings can be caused by S. sclerotiorum but on more mature plants a progressive wilt and rot develops from the oldest leaves upwards (Dixon, 1981).

Sclerotinia disease has caused serious losses in crisp lettuce crops in Lancashire in recent years. Disease build-up has been favoured by an increase in crisp lettuce production, close rotations of lettuce and other susceptible crops (eg celery) and wet weather in autumn, when the late-planted crops are approaching maturity. Even in dry years, many crops have a low level of infection, seen as isolated rotting plants. The American term for the disease - Lettuce Drop - aptly describes the appearance of infected plants.

A knowledge of the life cycle of Sclerotinia is essential to an understanding of the disease. The black resting bodies (sclerotia) formed in infected tissue are able to survive for many years in soil. They germinate in response to wet conditions, producing mycelium, which may infect seedlings, and fruiting bodies (apothecia) which produce infective spores (ascospores). Ascospores are the primary means of infection and can be spread some distance by wind.

It was thought that prediction of fields at risk from the disease could possibly be performed by determining the level of sclerotia present in the soil. Also, the likelihood of infection actually occurring may be predicted if the weather factors conducive to apothecial (and ascospore) production are known. Work on these aspects was undertaken in the work reported here.

Fungicidal control of the disease in the field has not been very successful due to the generally protectant activity of the fungicides available and the difficulty in delivering the chemical to the lower leaf area where protection is needed. The field trials described here were designed to compare existing and alternative products for Sclerotinia control and to investigate the feasibility of control by physical barriers to infection (polythene mulches).

MATERIALS AND METHODS

1. Disease Risk Assessment

1987 and 1988 - Ten soil samples (five at 0-25mm and five at 25-250mm depth) were taken in the spring from each of ten (1987) or twelve (1988) fields in Lancashire which were destined for lettuce cropping in the summer. The samples were wet-sieved in the laboratory and the numbers of sclerotia of *Sclerotinia sclerotiorum* were counted.

Subsequently, the sites were visited when cropped with lettuce and observed for presence of apothecia of *S.sclerotiorum* and plant infection on one (1987) or two (1988) occasions.

Apothecial incidence was scored as:

0	=	Apothecia not present
1	=	Apothecia scarce
2	=	Apothecia frequent
3	=	Apothecia abundant

Plant infection was assessed as percentage of plants infected.

1989 - Following the relative lack of success of the soil sampling technique for predicting crops at risk from *Sclerotinia* in 1987 and 1988, an attempt was made in 1989 to study apothecial production of the fungus. (This change was authorised by H.D.C.).

The six control (untreated) plots in the two fungicide trials at Irlam (Trial V) and Southport (Trial VI) (see below) were utilised for this study. During the life of these trials, weekly (approximately) visits were made to the trials and the number of apothecia present in all six control plots was counted. An attempt was made to relate the figures to daily records of

temperature and rainfall from the nearest synoptic Meteorological Stations. These were Ringway for the Irlam site and Squire's Gate for the Southport site.

2. Field Trials

Sites - Two trials were performed in each of the three years, giving a total of six trials. All were located on growers' holdings in Lancashire. In 1987 both trials were situated near Southport; in 1988, one was near Southport and one at Hesketh Bank and, in 1989, one was near Southport and the other at Irlam, Manchester. Site details are shown in the Appendix.

Design - The six trials were all of a randomised block design with six replicate blocks. The plot size was approximately 3.5m long by 1.5m (4 rows) wide, giving a total of 48 plants per plot.

Fungicides - Fungicide treatments varied from year to year. The products used are detailed in Table 1.

Table 1. Fungicides, active ingredients (a.i.) and dose rates

Fungicide	a.i.	Amount a.i. in product	Dose rate product/ha
Ronilan	vinclozolin	500g/litre	0.5 or 5 kg
Rovral WP	iprodione	500g/litre	0.5 or 5 kg
Octave	prochloraz-Mn	50% w/w	0.5 or 1 kg
Basilex	tolclofos-methyl	50% w/w	5 kg
Corbel/Mistral	fenpropimorph	750g/litre	1 l
Patrol	fenpropidin	750g/litre	1 l
Benlate	benomyl	50% w/w	1.1 kg
Compass	iprodione + thiophanate-methyl	167 + 167g /litre	3 kg

Non-fungicide and combined treatments

Plots covered with polythene mulch.

Plot covered with polythene mulch and Ronilan (standard rate) programme applied.

100mm perspex collars around plants at planting.

150mm perspex collars around plants at planting.

Urea solution (0.5%) foliar feed at 14 day intervals.

Urea solution (0.5%) foliar feed at 14 day intervals and Ronilan (standard rate) programme applied.

Treatments - These varied from year to year. The treatments applied in each year are shown in Table 2.

Table 2. Treatments employed in field trials, 1987-89

Treatment		1987	1988	1989
Untreated control		√	√	√
Water	x4			√
Ronilan (standard rate)	x4	√	√	√
Ronilan (high rate)	x4	√	√	
Ronilan (high rate) 7d post-planting				√
Rovral WP (standard rate)	x4	√	√	√
Rovral WP (high rate)	x4	√		
Octave (higher rate)	x4	√	√	√
Octave (lower rate)	x4		√	
Basilex	x4	√		
Corbel/Mistral	x4	√	√	√
Corbel/Mistral 7d post planting			√	√
Corbel/Mistral 4wk post planting			√	
Corbel/Mistral 8wk post planting			√	
Patrol	x4		√	
Benlate	x4		√	√
Compass	x4			√
Polythene mulch		√	√	√
Polythene mulch + Ronilan (s.r.)x4		√	√	√
100mm perspex collars		√		
150mm perspex collars		√		
Urea solution		√		
Urea solution + Ronilan (s.r.) x4		√		

x4 = Treatment applied 7 days post-planting + 3 further treatments at 14 day intervals.

Fungicide application - The fungicides were applied in 100ml water (standard rate of product) or in 500ml water (high rates)

per square metre using a knapsack sprayer. They were applied either in a four-spray programme starting 7 days after planting with 3 further treatments at 14-day intervals or as various single post-planting treatments (see above).

Disease assessments - Continuous observation of disease development was carried out and a full assessment of disease incidence and severity was performed on 20 plants per plot at harvest.

In 1987, Sclerotinia was assessed on a 0-3 scale:

0 = No infection
1 = Slight infection
2 = Moderate infection
3 = Severe infection

In 1988 and 1989, the assessment key was revised as the distinction between moderate and severe infection was considered to be artificial:

0 = No infection
1 = Slight infection (sparse mycelium under lower leaves)
2 = Moderate/severe infection (profuse mycelium and sclerotia under lower leaves; plants wilted or collapsed).

Plants in categories 0 and 1 were considered to be "marketable"; plants in categories 2 and 3 (1987) or 2 (1988 and 1989) were considered to be "unmarketable".

In the 1988 trials, ringspot (Microdochium panattonianum) infection developed and the opportunity was taken to assess this disease on the 20 plants per plot, using the following key:

0 = No infection

1 = Slight infection (very few lesions; no leaf holing)

2 = Moderate infection (most leaves with lesions, mainly on undersides; no leaf holing)

3 = Severe infection (lesions on both leaf surfaces; holes present or appearing)

For both Sclerotinia and ringspot diseases, infection was recorded as percentage plants infected in each disease category and a Disease Index was calculated accordingly.

Yields - The untrimmed and trimmed weights of the 20 plants per plot were recorded and means calculated.

The percentage of marketable heads was calculated on the basis of the disease severity of the plants (see above).

Statistical analysis - The disease assessment and yield data were subjected to an analysis of variance. The treatment means were separated using Duncan's Multiple Range Test.

RESULTS

1. Disease Risk Assessment

1987 and 1988 - The results of the sclerotial sieving from soil samples and subsequent field assessments for apothecia and plant infection for 1987 (Table 3) and 1988 (Tables 4 and 5) are given below.

Table 3. Numbers of sclerotia extracted from soil samples and field observations of disease, 1987

Site No.	No. sclerotia/kg dry wt soil 0-25mm depth	25-250mm depth	Presence of apothecia (0-3 scale)	% plant infection
1	2.2	2.5	3	9.5
2	0.9	2.0	3	1.7
3	0.0	0.5	3	3.2
4	0.0	0.0	0	3.0
5	0.0	0.0	Alternative cropping	
6	0.0	0.0	Alternative cropping	
7	0.3	1.0	0	5.8
8	0.5	0.0	1	2.5
9	0.0	0.0	0	0.0
10	0.4	0.8	Alternative cropping	

Table 4. Numbers of sclerotia extracted from soil samples and field observations of disease in summer, 1988

Site No.	No. sclerotia/kg dry wt soil 0-25mm depth	25-250mm depth	Presence of apothecia (0-3 scale)	% plant infection
1	0	0.5	0	0
2	0.4	0.9	0	0
3	1.5	0	0	0
4	0	0	0	1.5
5	0.4	0.5	0	0.5
6	0	0	0	0
7	1.0	0.4	0	0
8	0.7	0	0	1.0
9	0.9	0.8	0	0
10	0	0.3	0	0
11	0.4	2.5	0	0.5
12	0.3	3.6	0	0

Table 5. Numbers of sclerotia extracted from soil samples and field observations of disease in autumn, 1988

Site No.	No. sclerotia/kg dry wt soil 0-25mm depth	25-250mm depth	Presence of apothecia (0-3 scale)	% plant infection
1	0	0.5	Alternative	cropping
2	0.4	0.9	3	0
3	1.5	0	Alternative	cropping
4	0	0	Alternative	cropping
5	0.4	0.5	1	0.5
6	0	0	Alternative	cropping
7	1.0	0.4	Alternative	cropping
8	0.7	0	Alternative	cropping
9	0.9	0.8	1	1.0
10	0	0.3	1	0
11	0.4	2.5	3	6.5
12	0.3	3.6	Alternative	cropping

The correlation between numbers of sclerotia present in soil samples taken prior to cropping and subsequent apothecial and disease development was generally poor. However, some sites, for example, No.1 in 1987 and No. 11 in 1988 did show a higher level of apothecial presence and Sclerotinia infection where numbers of sclerotia previously recovered were slightly higher. In 1988, most fields were no longer being cropped with lettuce by the autumn and no further results could be obtained.

In view of the lack of success in predicting crops at risk from Sclerotinia by prior soil sampling and sieving to detect sclerotia, an alternative approach was adopted in 1989.

1989 - The results of the weekly apothecial counts in the untreated plots of the two field trials are shown in Table 6. An attempt was made to relate the results to daily temperature and rainfall records from the nearest synoptic meteorological station. These were Manchester-Ringway for the Irlam site and Blackpool-Squires Gate for the Southport site.

Table 6. Total number of apothecia present in Control plots in trials at Irlam and Southport, 1989

Date	Irlam	Southport
3. 8.89	0	0
18. 8.89	0	0
31. 8.89	0	0
7. 9.89	–	0
11. 9.89	0	–
14. 9.89	–	0
21. 9.89	3	1
4.10.89	0	0
11.10.89	–	12

–, not assessed on this date

The numbers of apothecia recorded were very low and also the life of the crops was shorter than expected. Both these factors were due to the hot, dry weather present at the time of the trials. This favoured rapid plant development and was not conducive to development of any phase of Sclerotinia infection. No correlation could be found between the low numbers of apothecia and the meteorological parameters recorded; the latter data are therefore not included.

2. Field Trials

1987 - The results of the two trials employing a mid-August planting (Trial I, Table 7) and a late August planting (Trial II, Table 8) are given below.

Table 7. Results of *Sclerotinia* and yield assessments, Trial I, 1987.

	Treatment	% plant infection	Disease index	% marketable heads
1	Untreated	39.0 gh	25.6 efg	80.0 ab
2	Ronilan (standard rate)	19.0 bcde	10.3 abcd	92.0 cde
3	Rovral WP (standard rate)	32.0 fg	18.0 cde	80.0 ab
4	Ronilan (high rate)	4.0 a	1.7 a	99.0 e
5	Rovral WP (high rate)	16.0 abcd	7.0 ab	96.0 de
6	Octave	16.0 abcd	8.7 abc	93.0 cde
7	Basilex	25.0 def	17.3 cde	80.0 ab
8	Corbel	6.0 a	5.3 a	90.0 cde
9	Polythene mulch	12.0 abc	7.7 ab	93.0 cde
10	Polythene mulch +Ronilan	9.0 ab	6.0 ab	94.0 cde
11	100mm perspex collar	29.0 efg	19.3 def	83.0 abc
12	Urea solution + Ronilan	24.0 cdef	15.3 bcd	86.0 bcd
13	Urea solution	41.0 gh	28.0 fg	74.0 a
14	150mm perspex collar	45.0 h	29.3 g	74.0 a
SED		5.41	4.17	4.80
d. of freedom		52	52	52
CV %		37.8	46.2	8.7

Figures with the same letter in the suffix within each column do not differ significantly (P = 0.05).

Table 8. Results of Sclerotinia and yield assessments, Trial II, 1987

	Treatment	% plant infection	Disease index	% marketable heads
1	Untreated	71.0 f	53.0 g	48.0 a
2	Ronilan (standard rate)	30.0 bcd	22.3 cde	79.0 bcde
3	Rovral WP (standard rate)	50.0 e	35.7 f	65.0 b
4	Ronilan (high rate)	9.0 a	6.0 a	95.0 e
5	Rovral WP (high rate)	12.0 a	7.4 ab	91.0 de
6	Octave	21.0 ab	20.3 bcde	83.0 cde
7	Basilex	38.0 cde	31.0 ef	71.0 bc
8	Corbel	6.0 a	5.3 a	94.0 de
9	Polythene mulch	31.0 bcd	17.3 abcd	86.0 cde
10	Polythene mulch +Ronilan	16.0 ab	10.7 abc	90.3 de
11	100mm perspex collars	50.0 e	37.3 f	65.3 b
12	150mm perspex collars	49.0 e	36.7 f	66.0 b
13	Urea solution (1%)	46.0 de	33.0 ef	67.0 b
14	Urea solution (1%) + Ronilan	29.0 bc	25.0 def	78.0 bcd
SED		7.37	5.87	7.00
d. of freedom		50	50	50
CV %		35.6	38.1	14.4

Figures with same letter in the suffix within each column do not differ significantly (P = 0.05).

Disease levels in the earlier trial (trial I) planted in mid-August were moderate-high (Untreated - 39% plant infection). Infection levels in the later planted trial were exceptionally high (Untreated - 71% plant infection). Treatments performed similarly in both trials and encouraging results were obtained.

Ronilan (vinclozolin) applied at the standard rate (Treatment 2) gave a good suppression of Sclerotinia and performed better than the equivalent rate of Rovral (Treatment 3). However, high rates of both fungicides were markedly superior to the standard rates and these warrant further investigation particularly in relation to the timing of applications. All the remaining fungicides tested reduced infection levels significantly. Corbel (fenpropimorph) proved outstanding in both trials reducing infection levels from 39% to 6% in trial I and from 71% to 6% in trial II (Treatment 8). Octave (prochloraz-manganese) performed as well as, and significantly better in trial II, than Ronilan at the standard rate, and again this fungicide warrants further assessment for its efficacy against S.sclerotiorum. Increases in yield and marketability were well correlated with control of the disease.

The use of a foliar feed (1% urea solution) did not appear to have a marked effect on lower leaf senescence. These leaf tissues are considered to be a primary infection point for S.sclerotiorum and therefore it is not too surprising that infection levels in this treatment without the addition of a fungicide remained high.

Of the physical barrier treatments, only the polythene mulch was effective and with the development of newer biodegradable materials offers considerable scope for future work on high risk Sclerotinia sites.

1988 - Sclerotinia was present at low levels only in Trial III and was virtually absent in Trial IV. Ringspot levels were assessed in both trials. Severe frost at the end of October damaged plants and yields were not taken. The percentage of marketable heads was estimated (discounting the effects of frost). The results are shown in Tables 9 and 10.

Table 9. Results of disease and yield assessments, Trial III, 1988

	Treatment	Disease Index Sclerotinia	Disease Index Ringspot	% Marketable Heads
1	Untreated	6.33 abc	18.87 abc	75.0 c
2	Ronilan WP (standard rate)	6.33 abc	16.47 abc	68.0 c
3	Rovral WP (standard rate)	3.33 abc	20.00 abc	80.0 c
4	Ronilan WP (high rate)	2.67 abc	22.73 bc	77.0 c
5	Benlate	0 abc	16.33 abc	83.0 c
6	Octave (higher rate)	3.33 ab	11.93 a	68.0 c
7	Octave (lower rate)	1.33 ab	14.33 abc	73.0 c
8	Corbel	1.67 ab	19.13 abc	38.0 ab
9	Patrol	1.67 ab	23.53 bc	37.0 ab
10	Polythene mulch	11.00 bc	19.60 abc	63.0 bc
11	Polythene mulch+Ronilan	0 abc	14.00 ab	21.0 a
12	Corbel (1 wk post-planting)	1.33 ab	16.00 abc	64.0 bc
13	Corbel (4 wk post-planting)	5.00 abc	23.60 c	59.0 bc
14	Corbel (8 wk post-planting)	14.33 c	20.20 abc	61.0 bc
SED		5.91	3.413	8.24
df		52	52	52
CV (%)		136.2	21.8	24.7

Figures followed by the same letter do not differ significantly (P = 0.05)

Table 10. Results of ringspot and yield assessments, Trial IV, 1988

Treatment		Ringspot Index	% Marketable Heads
1	Untreated	95.6 efg	50.0 a
2	Ronilan WP (standard rate)	96.1 efg	55.8 a
3	Rovral WP (standard rate)	92.2 ef	65.8 a
4	Ronilan WP (high rate)	97.8 g	60.0 a
5	Benlate	96.9 fg	57.5 a
6	Octave (higher rate)	69.2 ab	94.2 c
7	Octave (lower rate)	78.3 bc	87.5 c
8	Corbel	62.5 a	89.2 c
9	Patrol	83.1 cd	84.2 bc
10	Polythene mulch	94.4 efg	55.0 a
11	Polythene mulch+Ronilan	90.6 de	55.0 a
12	Corbel (1 wk post-planting)	90.0 def	68.3 ab
13	Corbel (4 wk post-planting)	92.5 def	69.2 ab
14	Corbel (8 wk post-planting)	94.7 efg	61.7 a
SED		3.814	6.14
df		65	65
CV (%)		9.1	18.6

Figures followed by the same letter do not differ significantly (P = 0.05)

In Trial III, there were no significant differences in Sclerotinia levels between treatments; the level of disease incidence and severity was very low. Low levels of ringspot were present in the trial but no treatments significantly reduced the disease index. The two morpholine fungicides, Corbel and Patrol, caused some phytotoxicity in this trial only and this was reflected in an associated reduction in the percentage of marketable heads. In Treatment 11 (polythene mulch) some plants failed to root well and were rather stunted, thus reducing marketability.

In Trial IV, Sclerotinia did not cause sufficient infection for assessments to be made. However, ringspot was severe and assessments of this disease were performed. Ringspot was significantly reduced by both rates of Octave, Corbel and Patrol. These treatments also significantly increased the percentage of marketable heads. These results are comparable with those found in Project FV/34 'Control of lettuce ringspot'.

1989 - The trials were assessed for incidence and severity of Sclerotinia infection in October 1989. Due to the very low levels of Sclerotinia present, harvesting was restricted to weights of trimmed or untrimmed plants and percentage of marketable heads. The results are shown in Tables 11 (Trial V) and 12 (Trial VI).

Table 11. Results of Sclerotinia and yield assessments, Trial V, 1989

	Treatment	Disease Index	Mean Wt. 20 trimmed plants (kg)	% Marketable Heads
1	Untreated	0.83 ab	16.8 a	99.2 a
2	Water x 4	3.33 ab	16.2 a	95.0 a
3	Ronilan x 4 (standard rate)	4.17 b	15.6 a	95.8 a
4	Ronilan x 1 (high rate)	2.58 ab	15.3 a	97.5 a
5	Rovral WP x 4	3.33 ab	16.9 a	95.8 a
6	Benlate x 4	1.67 ab	16.5 a	98.3 a
7	Octave x 4	0 a	15.4 a	98.3 a
8	Mistral x 4	0.83 ab	16.5 a	99.2 a
9	Mistral x 1	1.25 ab	14.9 a	97.5 a
10	Compass x 4	1.67 ab	16.2 a	97.5 a
11	Polythene mulch	0 a	15.4 a	98.3 a
12	Polythene mulch + Ronilan x4	0 a	16.1 a	98.3 a
SED		1.744	1.104	1.944
df		55	55	55
CV (%)		184.3	12.0	3.5

Figures followed by the same letter within each column do not differ significantly (P = 0.05).

Table 12. Results of Sclerotinia and yield assessments, Trial VI, 1989

	Treatment	Disease index	Mean wt.20 untrimmed heads (kg)	% Marketable Heads
1	Untreated	1.3 a	17.4 ab	92.5 a
2	Water x 4	0 a	17.2 ab	90.0 a
3	Ronilan x 4 (standard rate)	1.3 a	18.5 bc	95.8 a
4.	Ronilan x 1 (high rate)	1.9 a	19.6 cd	92.5 a
5	Rovral x 4	0 a	18.6 bc	95.8 a
6	Benlate x 4	0 a	18.5 bc	99.2 a
7	Octave x 4	0 a	18.0 abc	94.2 a
8	Mistral x 4	0 a	18.3 abc	92.5 a
9	Mistral x 1	0 a	16.8 a	92.5 a
10	Compass x 4	0 a	17.2 ab	95.0 a
11	Poly. mulch	1.3 a	19.5 cd	95.0 a
12	Poly.mulch + Ronilan x 4	0 a	20.3 d	98.3 a
SED		0.466	0.743	3.755
df		55	55	55
CV (%)		2.4	7.0	6.9

Figures followed by the same letter within each column do not differ significantly (P = 0.05).

Disease incidence was very low at both sites. In Trial V the application of water (Treatment 2) increased disease severity slightly compared with the untreated control. No significant differences between the control treatments (1 and 2) and any of the other treatments were found. However, it is noteworthy that the low level of disease was reduced to zero by the Octave, polythene mulch and polythene mulch plus Ronilan treatments (7 , 11 and 12 respectively). No significant differences in trimmed

head weight or percentage of marketable heads between treatments were recorded.

In Trial VI, very few infected plants were present in the trial and no significant differences in Disease Index were found between treatments. Ronilan at high rate (Treatment 4) and the polythene mulch treatments with or without Ronilan (Treatments 11 and 12) all significantly increased the mean untrimmed head weight. However, this effect was not related to control of disease. No significant differences in percentage marketable heads were found between treatments.

DISCUSSION

The prediction of fields at risk from Sclerotinia disease by extraction of sclerotia from soil samples proved to be rather unsatisfactory. The numbers of sclerotia retrieved were not well correlated with later infection levels in the crop. It is apparent that, despite widespread infestation of a field with sclerotia, infection will only arise if conditions are favourable for their germination, apothecial production, ascospore dispersal and subsequent infection. The latter will also depend upon crop growth stage as senescing lower leaf tissue is necessary for colonisation. A prediction scheme will therefore need to consider weather, soil and crop conditions which favour the apothecial and infection phases of the fungus life cycle. An attempt was made to do this at the two field trial sites in 1989 but was unsuccessful due to a general lack of the disease in the hot, dry weather. Further investigation of these aspects is thus necessary.

Six fungicide trials were performed from 1987 to 1989 but infection levels were only high enough to test the efficacy of various products adequately in 1987. In 1988 and 1989, little infection occurred due to much drier weather conditions. The two 1987 trials showed that a standard Ronilan programme gave good suppression of Sclerotinia and was superior to Rovral WP. Higher rates of both fungicides improved control substantially but are not likely to be available commercially. Octave gave good control also and merits further study. Surprisingly, the morpholine fungicide, Corbel, gave excellent disease control and also warrants further trial work. However, some phytotoxicity was encountered with Corbel, and Patrol, in Trial III in 1988, possibly due to local weather factors. Approval for the product is unlikely to be pursued on lettuce by the agrochemical company. Benlate has some activity against S.sclerotiorum and a reduction in the low level of disease in Trial III was found in 1988.

The 1987 trials also indicated that physical barriers to infection could offer very useful non-chemical control. Polythene mulches alone gave similar control to a Ronilan programme and improved control was achieved by a combination of the two methods. The use of perspex collars around plants gave some reduction in disease but was less successful.

The use of foliar feeds alone to reduce leaf senescence, and therefore infection sites, was unsatisfactory. A fungicide programme was also found to be necessary.

In the 1987 trials increased yields of lettuce, measured as untrimmed and trimmed weights, were well correlated with control of Sclerotinia by the most efficacious fungicides. Importantly, from the grower's standpoint, the number of marketable heads was greatly increased by controlling the disease.

Ringspot disease was a major problem in Lancashire in the wet conditions of 1987. The disease occurred in the two 1988 trials and the opportunity was taken to assess the effects of fungicides on its control. This partly compensated for the lack of Sclerotinia infection! In both trials, Octave performed best and, in Trial IV, Corbel and Patrol also offered useful suppression of ringspot. Octave was also found to be the most effective fungicide against the disease in other HDC funded work (Project FV/34). An increase in percentage of marketable heads was well correlated with ringspot control.

CONCLUSIONS

After three years' work, this project has increased our knowledge of the biology and control of Sclerotinia disease of outdoor crisp lettuce. The disease risk assessment work has shown that it is possible to sample soil and extract the sclerotia of S.sclerotiorum but that the sclerotial numbers are not well correlated with subsequent apothecial production and plant infection. As the latter is so dependent on weather conditions (particularly rainfall), it is this aspect which would merit further research work. An attempt was made to study this in 1989 but was thwarted by a lack of disease in the predominantly warm, dry weather.

Clearly, further work is required on the epidemiology of Sclerotinia disease before a prediction scheme can be formulated.

The fungicide trials, particularly in 1987, have provided useful comparative information on the efficacy of various fungicides. Unfortunately only low levels of disease occurred in 1988 and 1989, due to dry weather conditions in late summer. The trials have reinforced previous results showing the effectiveness of Ronilan and, to a lesser extent, Rovral for Sclerotinia control. They also showed how better control could be achieved with high rates of Ronilan and with Octave and Corbel/Mistral. The use of a polythene mulch, with or without a follow-up Ronilan programme, has also shown considerable promise. It should be noted that, at present, only Rovral and Benlate of the fungicides used in this work, have approval for use on lettuce. Increased yield and number of marketable heads were recorded when Sclerotinia was controlled by fungicides.

Ringspot can be controlled by the fungicide Octave. A great increase in marketable product can be achieved from a programme of sprays under favourable infection conditions.

RECOMMENDATIONS

1. More detailed work on the biology of the causal organism, S. sclerotiorum, is required. The relationship between various phases of its life cycle, eg apothecial production, ascospore dissemination, infection, and weather factors should be quantified. This could lead to a prediction scheme being formulated eventually.

2. A literature survey on the epidemiological research work on the pathogen should be conducted.

3. Further work on fungicidal control should be performed. To avoid lack of field infection due to unfavourable weather, sclerotia could be introduced into soil at an experimental station site. Agar plate tests of fungicide efficacy could be carried out in the laboratory.

4. The work should extend to other horticultural crops, eg celery, which are at high risk from Sclerotinia disease.

5. The above work should comprise a major research project on 'Biology and Control of Sclerotinia Disease in Horticultural Crops'. The more fundamental aspects could perhaps be funded by Government or LINK and the applied aspects by HDC. Previous work on oilseed rape could be valuable.

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Dixon, G. R. (1981). Vegetable Crop Diseases. pub. MacMillan Publishers Limited, London and Basingstoke.

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STORAGE OF DATA

The raw data will be stored by the author at ADAS, Wolverhampton for a period of 10 years. HDC will be consulted before disposal of the data.

APPENDIX Site and Crop Details

Trial 1, 1987

Site:	L O Jeffs Ltd, Moss Farm, Birkdale Cop, Lancs
Soil Texture:	Peat
Soil Analysis:	P Index
	K Index
	Mg Index
	pH
Cultivar:	Saladin
Planting date:	14 August 1987
Design:	Randomised block, 6 replicates
Plot size:	3.5m x 1.5m (4 rows x 12 plants)
Fertiliser:	Standard farm practice
Herbicides:	Standard farm practice
Insecticides:	Standard farm practice
Fungicides:	Standard farm practice

Fungicide application dates (trial):	19 August 1987
	2 September 1987
	22 September 1987
Harvest/final assessment date:	19 October 1987

Trial II, 1987

Site:	L O Jeffs Ltd, Moss Farm, Birkdale Cop, Lancs
Soil Texture:	Peat
Soil Analysis:	P Index
	K Index
	Mg Index
	pH
Cultivar:	Saladin
Planting date:	22 August 1987
Design:	Randomised block, 6 replicates
Plot size:	3.5m x 1.5m (4 rows x 12 plants)
Fertiliser:	Standard farm practice
Herbicides:	Standard farm practice
Insecticides:	Standard farm practice
Fungicides:	Standard farm practice

Fungicide application dates (trial):	27 August 1987
	2 September 1987
	15 September 1987
	30 September 1987
Harvest/final assessment date:	3 November 1987

Trial III, 1988

Site:	L O Jeffs Ltd, Moss Farm, Birkdale Cop, Lancs
Soil Texture:	Loamy peat
Soil Analysis:	P Index 3
	K Index 1
	Mg Index 5
	pH 6.3
Cultivar:	Saladin (Curly 20)
Planting date:	15 August 1988
Design:	Randomised block, 6 replicates
Plot size:	3.5m x 1.5m (4 rows x 12 plants)
Fertiliser:	Standard farm practice
Herbicides:	Standard farm practice
Insecticides:	Standard farm practice
Fungicides:	Standard farm practice

Fungicide application dates (trial): 22 August 1988
8 September 1988
21 September 1988
11 September 1988

Harvest/final assessment date: 7 November 1988

Trial IV, 1988

Site:	R A Baybutt & Sons, Moss Lane, Hesketh Bank,Lancs
Soil Texture:	Peat
Soil Analysis:	P Index 4
	K Index 2
	Mg Index 5
	pH 6.0
Cultivar:	Saladin
Planting date:	28 August 1988
Design:	Randomised block, 6 replicates
Plot size:	3.5m x 1.5m (4 rows x 12 plants)
Fertiliser:	Standard farm practice
Herbicides:	Standard farm practice
Insecticides:	Standard farm practice
Fungicides:	Standard farm practice

Fungicide application dates (trial): 6 September 1988
16 September 1988
3 October 1988
21 October 1988

Harvest/final assessment date: 4 November 1988

Trial V, 1989

Site:	S Hamer & Son, Moss Brow Farm, Irlam, Manchester
Soil Texture:	Loamy peat
Soil Analysis:	P Index 7
	K Index 3
	Mg Index 4
	pH 6.6
Cultivar:	Saladin
Planting date:	29 July 1989
Design:	Randomised block, 6 replicates
Plot size:	3.5m x 1.5m (4 rows x 12 plants)
Fertiliser:	Standard farm practice
Herbicides:	Standard farm practice
Insecticides:	Standard farm practice
Fungicides:	Standard farm practice (Fubol, Ronilan)

Fungicide application dates (trial): 7 August 1989
21 August 1989
5 September 1989
21 September 1989

Harvest/final assessment date: 4 October 1989

Trial VI, 1989

Site:	L O Jeffs Ltd, Moss Farm, Birkdale Cop, Lancs
Soil Texture:	Loamy peat
Soil Analysis:	P Index 4
	K Index 1
	Mg Index 5
	pH 6.2
Cultivar:	Zodiac
Planting date:	4 August 1989
Design:	Randomised block, 6 replicates
Plot size:	3.5m x 1.5m (4 rows x 12 plants)
Fertiliser:	Standard farm practice
Herbicides:	Standard farm practice
Insecticides:	Standard farm practice
Fungicides:	Standard farm practice (Ronilan, zineb)

Fungicide application dates (trial): 18 August 1989
1 September 1989
14 September 1989
28 September 1989

Harvest/final assessment date: 12 October 1989