AGRICULTURAL DEVELOPMENT AND ADVISORY SERVICE

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CONTRACT REPORT
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PROJECT FV/24 CAULIFLOWER
BACTERIAL LEAF SPOT SUSCEPTIBILITY
OF CULTIVARS AND EVALUATION
OF CONTROL MEASURES

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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Date 16 March 1992

SUMMARY

Trials were carried out in the winter of 1987/88 and of 1988/89 to evaluate the susceptibility of a range of cauliflower cultivars to Pseudomonas syringae pv. maculicola (Psm) the causal organism of bacterial leaf spot and also to evaluate the effect of copper sprays for the control of this disease.

Twenty one cauliflower cultivars, sown in the autumn and over-wintered, were artificially inoculated with various strains of Psm. In the first year trial no appreciable disease occurred and this was attributed to the plants having been raised "hard" during propagation prior to inoculation. In the second year trial moderate to high levels of disease developed. Danish Perfection was the most susceptible cultivar having significantly more disease than any other cultivar tested. There was a trend towards early summer cultivars being more susceptible than later maturing types.

Foliar sprays of copper, as Cuprokylt or Kocide 101, were applied pre- and post-inoculation and in various combinations. Copper sprays had little effect on prevention or eradication of the disease and there was no significant reduction in spread of the disease.

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INTRODUCTION

Bacterial leaf spot, bacterial blight or pepper spot caused by Pseudomonas syringae pv maculicola (Psm) can affect most brassicae but is most common on cauliflowers. It is not a very common disease in the UK although it was recorded annually on one farm in South Lincolnshire for many years. Since the mid-1980s it has been serious disease on early summer cauliflowers on both seedlings and field crops.

Symptoms

All aerial parts of the plant can be affected. The disease is most noticeable on leaves and petioles. As the bacterium grows within the tissues it produces small angular to round lesions which initially appear watersoaked (pepper spot), later becoming dead with watersoaked margins. Surrounding tissues may appear yellowish. The spots may coalesce as they expand giving rise to large irregular areas of brown, dead tissue. On curds, deep seated black rots may occur. These again may have slightly glassy watersoaked margins. Severe seedling blight may result in plant death.

Disease Biology

The disease develops most readily in wet conditions. It is primarily, but not exclusively, seedborne. Seeds become infected in the developing pods or during harvest. Some of the inoculum is within the seeds; some may be present as a surface contamination. Much of this infection remains viable during storage of the seed. After germination, a proportion of infected seeds will give rise to infected seedlings. Depending on the cultural conditions this primary inoculum will be spread through the seedlings in the glasshouse or in the field. Spread is by water droplet transmission, eg rainfall, overhead irrigation and agro-chemical sprays. Entry into the plants and subsequent disease development is also facilitated by wet conditions. Entry occurs through the stomata or through wounds created by insect or bird feeding, by abrasion by wind driven dust or soil and by frost damage. In fact, the bacteria themselves can act as precursors of frost damage, thus creating more frost damage through which they can gain access to the developing tissues. This can be important in the seedling stage and on late harvested curds.

Apart from seed infection, the bacterium can overwinter in infected roots and other plant tissues. Thus ploughing in after harvest and replanting before the complete degradation of these infected tissues can provide a source of inoculum for the next crop.

Almost continuous propagation of seedlings in commercial nurseries may also allow infection of one crop from the previous one. The bacteria survive well in any form of brassica debris and may also survive for short periods (several days or weeks) on glasshouse struts, glass, polythene floor covering, seed modules etc.

OBJECTIVES

The objectives of the work were:

(a) To assess the susceptibility of a range of cauliflower cultivars in the propagation state.

(b) To evaluate the effectiveness of foliar sprays of copper for disease control in propagation and in the field.

This project was done in collaboration with David Stead, Harpenden Laboratory.

MATERIALS AND METHODS

(A) CULTIVAR SUSCEPTIBILITY

A range of cultivars all October sown was assessed for susceptibility to Psm. In 1987/8 the following cultivars were tested in SWC 308 trays.

Alice Springs	Cervinia	Elby	Oberon	White Fox
Alpha Begum	Corvilia	Gigo	Revito	White Rock
Alpha Selsto	Danish Perfection	King	Serrano	White Summer
Andes	Dok Elgon	Linas	White Ball	
Birka		Michalese		
Bravo		Carillon		
		Montano		

In 1988/89 a similar range of cultivars were tested but with Alpha Jubro, Erfu and Fortuna added and Montano, Birka, Bravo, Serrano and White Ball omitted. In both years the cultivars were raised in SWC 308 trays by Mr C Hawksworth, Frampton, Boston, Lincs

Each tray of plants was cut and divided into four sections. Three tray sections were inoculated each with a different strain of Psm (10^7 colony forming units/ml) in peptone phosphate buffers.

The trial design was 21 cultivars randomised within each treatment, ie 3 Psm strains and uninoculated controls.

The strains used in 1987/88 were:

A. Psm ex Brussels sprouts 41/A ex Cambridge ADAS
B. Psm ex cauliflower 82/B ex Cambridge ADAS
C. Psm ex cauliflower ex NCPPB 10766.

The strains used in 1988/89 were:

A. - ex cauliflower NCPPB 3572 Kirton 1988
B. - ex cauliflower ex NCPPB 1766
D. - ex Brussels sprouts 41/A ex Cambridge ADAS

In addition in both years as a control, plants were inoculated with the peptone phosphate buffer only.

Inoculation of the bacterial suspension was made using a ULV spinning disc sprayer (Micron Ulva 8). Plants were inoculated, ie sprayed to run off from above and sides to ensure wetting of the leaf undersurfaces. Also one row of plants in each tray was stab inoculated in the stems and leaves with a bacterial suspension (10^7 colony forming units/ml) from a hypodermic syringe.

Plants were inoculated on 25 January in 1988 and on 24 January in 1989 and incubated under a polythene sheet for 24 hours prior to being laid out in an unheated polythene tunnel.

The plants were assessed for leaf spots, wilting and death.

(B) THE EFFECT OF COPPER SPRAYS ON DISEASE CONTROL.

The cultivar Danish Perfection raised in Hassy 308 trays by Kirton EHS was used in both years.

Treatments 1987/88

(1) Pre-inoculation copper spray. Kocide 101 (1.1 g CP/1 @ 50ml/tray) was applied as a foliar spray one week prior to inoculation with Psm.

(2) Post-inoculation copper sprays. Eight weekly foliar sprays of Kocide 101 (1.1g/CP/1 @ 50 ml/tray) were applied starting 48 hours after inoculation with Psm, the last spray being applied on 25 April.

(3) Pre- and post-inoculation sprays - combinations of treatments 1 plus 2.

(4) Post-inoculation copper sprays. As treatment 2, but the copper spray applied was as Cuprokylt (3.75g CP/1 @ 50ml/tray plus 0.25ml/1 PBI spreader).

(5) Pre- and post-inoculation copper sprays. Kocide 101 was applied as treatment 3 but not inoculated with Psm.

(6) Psm inoculation only.

(7) Untreated control.

Each treatment was applied to one half of the plant tray, the other half remaining untreated. The strain of Psm used was strain C ex cauliflower ex NCPPB 10766. The treatments were replicated four times.

Treatments 1988/89

In this year's trial the inoculation treatments were modified. The central 16 plants (4 x 4 cells) in each Hassy 308 tray were replaced with plants which had been inoculated previously with the cauliflower NCPPB 3572 Kirton 1988 strain of Psm and were showing bacterial spot symptoms.

Four foliar sprays of copper, either of Kocide 101 at 1.1g/l and of Cuprokylt 3.75g/l were applied at 50ml/tray at weekly intervals (16 Jan, 23 Jan, 30 Jan and 7 Feb) - pre-inoculation. The disease was introduced into the trays on 8/9 February by placing affected plants in the middle 4 x 4 block. Five weekly post inoculation foliar sprays of copper were applied either as Kocide 101 or Cuprokylt on 13 Feb, 20 Feb, 28 Feb, 7 Mar and 16 Mar. The treatments were replicated four times.

The treatments were as follows:-

No.	Pre inoculation copper sprays (4)	"Inoculated" with Psm	Post inoculation copper sprays (5)
1.	-	-	-
2.	-	+	-
3.	Kocide 101	-	-
4.	Kocide 101	+	Kocide 101
5.	-	+	Kocide 101
6.	Cuprokylt	-	-
7.	Cuprokylt	+	Cuprokylt
8.	-	+	Cuprokylt

In both years the copper fungicides used were as follows:

Fungicide	Active ingredient	Manufacturer
Kocide 101	copper hydrocide. 77% w/w (hydroxide)	Chiltern
Cuprokylt	copper oxychloride 50% w/w	Unicrop

The plants were assessed for mean % leaf area affected with Psm.

The plants were fed and watered as per commercial practice and routine sprays of Elvaron were applied for the control of downy mildew

Plants from the 1987/88 copper spray trial were planted out at the field trial site Kirton Area Office on 15 April 1988. Plots 1.83 x 5.52 were planted with 3 rows each of 12 plants. The seven treatments were randomised within the four replicate blocks. Four plants in each of the three rows in each plot were sprayed with Kocide 101 after planting as part of a routine spray programme, the other third were to have been sprayed after disease development and the remaining third part of each plot remained untreated. It was intended to plant out plants from the 1988/89 copper spray trial but no suitable site could be found.

RESULTS

(A) CULTIVAR SUSCEPTIBILITY

In 1988, leaf spot symptoms were first seen on 3 March. However, samples of plants showing leaf spot symptoms were sent to the Harpenden Laboratory and tested for the presence of Psm but the results proved negative. Further samples sent on 7 March proved positive from plants inoculated with A strain (ex Brussels sprouts) but little further disease development occurred and no difference between cultivars was apparent. On 25 March the plants were re-inoculated and initial symptoms were confirmed in plants inoculated with strains A and C but not B. Again no further disease developed and by this time it was felt that the weather was too warm for disease development to occur. No differences were apparent between cultivars.

In 1989 the effects of inoculation of the 3 strains of Psm on the range of cultivars tested are given in Tables 1 to 6. Leaf spot symptoms were first seen on 6 February.

Differences between the various strains was detected (Table 1).

TABLE 1 EFFECT OF STRAINS OF PSM ON % LEAF AREA AFFECTED WITH BACTERIAL LEAF SPOT (LOWEST GREEN LEAF) MEAN 21 CULTIVARS

	% Leaf Area Affected			
Assessment Date/Psm Strain	A	B	D	SED
24 February	13.6	5.2	1.7	2.62
10 March	13.4	6.0	3.7	2.54

Strain A (ex cauliflower NCPPB 3572 ex-Kirton 1988) was the most pathogenic - and strain D (ex-Brussels sprouts) was the least pathogenic.

Differences between cultivars were detected. The results showed that Danish Perfection was consistently the most significantly susceptible cultivar with a higher number of plants and more leaf area affected as assessed on 24 February and 10 March (Tables 2 and 3). Also there was significantly more plant death recorded in Danish Perfection; the results of the April 5 assessment expressed as % plant surviving are expressed in Table 4 (Table 4). Similar results were obtained when the uninoculated controls were included in the data showing that some late spread had occurred in this trial (Tables 5 and 6). No disease was recorded on the control plants on the 24 February assessment

There was a trend towards the early summer cauliflower cultivars being more susceptible than later maturing types. Apart from Danish Perfection, Michalese Carillon, Alpha Jubro and Alpha Begum were the most susceptible of the early summer cauliflowers. King, Andes and Elby appeared to be the least susceptible cultivars although not consistently so.

TABLE 2 CAULIFLOWER CULTIVARS AFFECTED WITH BACTERIAL SPOT (MEAN OF 3 STRAINS)

Cultivar		Plants affected 24 February		Leaf Area affected of lowest green leaf 24 February	
		%	AT*	%	AT*
1.	Danish Perfection	96.7	83.9e**	37.6	37.1e
2.	Michalese Carillon	70.0	58.1abcde	9.7	15.9ab
3.	Alpha Jubro	63.3	53.9abcd	15.9	18.3b
4.	Alpha Begum	50.0	40.1ab	11.6	16.0ab
5.	Alpha Selsto	73.3	64.9bcde	6.5	13.4ab
6.	Oberon	50.0	44.7abc	7.2	14.3ab
7.	Corvilia	50.0	45.0abc	2.9	8.7ab
8.	Erfu	53.3	47.2abc	6.7	12.4ab
9.	King	43.3	40.9ab	2.6	8.8ab
10.	Fortuna	60.0	51.1abcd	2.5	8.9ab
11.	White Summer	83.3	75.0de	5.8	12.3ab
12.	Andes	36.7	31.9a	1.4	5.1a
13.	White Fox	50.0	40.8ab	4.1	9.5ab
14.	Linas	53.3	46.9abc	2.7	8.2ab
15.	Dok Elgon	73.3	59.7abcde	5.5	12.3ab
16.	Cervinia	66.7	60.0bcde	5.1	10.7ab
17.	Revito	60.0	56.2abed	4.9	12.7ab
18.	Gigo	43.3	40.8ab	3.2	9.7ab
19.	Elby	50.0	49.2abcd	1.7	6.3ab
20.	White Rock	83.3	70.1cde	4.5	11.8ab
21.	Alice Springs	90.0	75.0de	5.9	13.5ab
SED			11.5		5.2

* Data Angular Transformed

**abcde:Treatment means followed by the same letter do not differ significantly (P=0.05) Duncan's Multiple Range Test.

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TABLE 3 CAULIFLOWER CULTIVARS AFFECTED WITH BACTERIAL SPOT (MEAN OF 3 STRAINS)

Cultivar	Plants affected 10 March		Leaf Area affected of lowest green leaf 10 March	
	%	AT*	%	AT*
1. Danish Perfection	100.0	90.0b	68.7	57.2d
2. Michalese Carillon	63.3	57.3a	25.2	26.9c
3. Alpha Jubro	60.0	51.1a	19.7	20.4bc
4. Alpha Begum	56.7	48.4a	4.4	10.9ab
5. Alpha Selsto	40.0	38.2a	2.2	7.7a
6. Oberon	40.0	34.9a	2.1	6.8a
7. Corvilia	40.0	28.9a	2.0	6.6a
8. Erfu	36.7	36.1a	2.6	6.5a
9. King	33.3	30.0a	1.7	4.4a
10. Fortuna	43.3	41.1a	3.0	7.9a
11. White Summer	50.0	49.9a	3.1	9.5ab
12. Andes	43.3	45.0a	4.7	9.1ab
13. White Fox	23.3	24.1a	1.5	5.7a
14. Linas	36.7	36.1a	1.6	7.2a
15. Dok Elgon	40.0	38.9a	2.3	8.0a
16. Cervinia	43.3	40.4a	1.9	7.3a
17. Revito	36.7	36.1a	1.3	5.9a
18. Gigo	50.0	45.0a	2.0	6.6a
19. Elby	40.0	38.9a	1.5	5.4a
20. White Rock	40.0	38.9a	1.5	6.9a
21. Alice Springs	53.3	42.8a	4.5	9.8ab
SED		14.4		5.3

* Data Angular Transformed

**abcde:Treatment means followed by the same letter do not differ significantly (P=0.05) Duncan's Multiple Range Test.

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TABLE 4 CAULIFLOWER CULTIVARS AFFECTED WITH BACTERIAL SPOT (MEAN OF 3 STRAINS)

Cultivar	Plant survival 5 April %	AT*
1. Danish Perfection	61.0	51.8a**
2. Michalese Carillon	82.6	65.7bc
3. Alpha Jubro	83.0	66.8bc
4. Alpha Begum	87.0	69.1bcd
5. Alpha Selsto	84.0	66.7bc
6. Oberon	88.3	70.2bcd
7. Corvilia	83.7	66.4bc
8. Erfu	94.3	76.8cd
9. King	83.7	66.2bc
10. Fortuna	86.7	68.8bcd
11. White Summer	95.4	80.0d
12. Andes	93.7	75.7bcd
13. White Fox	81.0	64.4b
14. Linas	92.3	74.2bcd
15. Dok Elgon	87.7	69.9bcd
16. Cervinia	88.0	69.9bcd
17. Revito	96.3	78.9d
18. Gigo	90.0	71.9bcd
19. Elby	86.7	68.7bcd
20. White Rock	89.0	71.3bcd
21. Alice Springs	86.7	68.6bcd
SED		4.7

* Data Angular Transformed

**abcde:Treatment means followed by the same letter do not differ significantly (P=0.05) Duncan's Multiple Range Test.

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TABLE 5 CAULIFLOWER CULTIVARS AFFECTED WITH BACTERIAL SPOT (MEAN OF 3 STRAINS AND UNINOCULATED CONTROL)

Cultivar	Plants affected 10 March		Leaf Area affected of lowest green leaf 10 March	
	%	AT*	%	AT*
1. Danish Perfection	87.5	58.8c	51.6	43.9c
2. Michalese Carillon	70.0	60.9bc	19.2b	21.8a
3. Alpha Jubro	62.5	52.6abc	15.0ab	16.6ab
4. Alpha Begum	60.0	50.5abc	3.7ab	9.9a
5. Alpha Selsto	50.0	44.5ab	1.7	6.2a
6. Oberon	47.5	40.4ab	1.8a	6.2a
7. Corvilia	50.0	45.0ab	1.7a	6.2a
8. Erfu	50.0	45.0abc	2.3	6.6a
9. King	50.0	45.0ab	1.6	4.8a
10. Fortuna	37.5	37.4ab	2.3	6.8a
11. White Summer	55.0	51.6abc	2.5	8.3a
12. Andes	37.5	40.4ab	3.6	7.4a
13. White Fox	25.0	26.4a	1.2	4.9a
14. Linas	40.0	38.4ab	1.3	6.3a
15. Dok Elgon	47.5	43.3ab	1.9	7.2a
16. Cervinia	37.5	36.9ab	1.4	6.0a
17. Revito	47.5	43.0ab	1.2	5.8a
18. Gigo	50.0	45.0ab	1.6	5.9a
19. Elby	35.0	35.8ab	1.2	4.7a
20. White Rock	30.0	29.1ab	1.2	5.2a
21. Alice Springs	60.0	47.9ab	3.6	8.8ab
SED		13.3		5.5

* Data Angular Transformed

**abcde:Treatment means followed by the same letter do not differ significantly (P=0.05) Duncan's Multiple Range Test.

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TABLE 6 CAULIFLOWER CULTIVARS AFFECTED WITH BACTERIAL SPOT (MEAN OF 3 STRAINS AND UNINOCULATED CONTROL)

Cultivar	Plant survival 5 April %	AT*
1. Danish Perfection	66.5	55.3a**
2. Michalese Carillon	83.3	66.1bc
3. Alpha Jubro	83.0	65.5bc
4. Alpha Begum	87.8	69.7bcde
5. Alpha Selsto	82.5	65.5bc
6. Oberon	84.5	67.3bc
7. Corvilia	81.0	64.5b
8. Erfu	92.8	74.8cde
9. King	82.5	65.4bc
10. Fortuna	85.0	67.4bc
11. White Summer	94.0	77.9e
12. Andes	91.8	73.8bcde
13. White Fox	82.8	65.7bc
14. Linas	92.3	74.0bcde
15. Dok Elgon	83.5	66.8bcd
16. Cervinia	85.5	67.9bcd
17. Revito	94.8	77.1de
18. Gigo	87.8	69.9bcde
19. Elby	85.5	67.8bcd
20. White Rock	88.3	70.5bcde
21. Alice Springs	86.3	82.2bcd
SED		3.9

* Data Angular Transformed

**abcde:Treatment means followed by the same letter do not differ significantly (P=0.05) Duncan's Multiple Range Test.

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(B) THE EFFECT OF COPPER ON DISEASE CONTROL

In 1988 plants showing pepper spotting symptoms from treatments 5 and 7 (uninoculated controls) on 3 March were sent to Harpenden Laboratory for Psm testing but the results were negative. On 7 March samples of plants showing leaf spotting were tested and Psm was detected in plants from all treatments that had been inoculated, ie treatments 1, 2, 3, 4 and 6.

There was subsequent disease development and spread. The plants were assessed on the inoculated halves of the trays on 17 March and on the uninoculated halves on 25 March; the latter would give an indication of spread within trays. The results of the two assessments are given in Table 7 below:-

TABLE 7 MEAN % LEAF AREA AFFECTED WITH PSEUDOMONAS FOLLOWING INOCULATION AND COPPER FUNGICIDE TREATMENTS

Treatment	Inoculated half tray 17 March 1988 (based on 32 plants/ treatment)	Uninoculated half tray 25 March 1988 (based on 15 plants/treatment)
1. Copper spray (Kocide 101) pre-inoculation	5.85ab*	3.3b
2. Inoculation followed by copper (Kocide 101) sprays	7.78ab	2.6b
3. Copper sprays (Kocide 101) pre and post inoculation	5.16ab	1.3ab
4. As 2. with copper as Cuprokylt	15.28c	0.8ab
5. Copper only (as Kocide 101), not inoculated	0.0a	0.0a
6. Inoculation only	10.13bc	1.7ab
7. Control - not inoculated or treated	0.0a	0.0a

*Treatment means with similar letters did not differ significantly (P=0.05) Duncan's Multiple Range Test.

No disease was detected in trays which had not been inoculated. On the 17 March assessment the most severe symptoms seen were in plants in the inoculated half trays following Cuprokylt sprays. Disease levels in this treatment were significantly higher than those which had received the similar treatment of Kocide 101, (treatment 4 compared with treatment 2). However, disease was recorded in all inoculated trays treated with copper. None of

the copper treatments significantly controlled the disease; compare treatment 6 (inoculation only) with treatments 1, 2, 3 and 4 (inoculation plus various copper spray treatments).

The uninoculated tray halves were assessed on 25 March. No disease spread was recorded in the uninoculated treatments (treatments 5 and 7). Foliar sprays of copper failed to prevent disease spread (treatments 1, 2, 3 and 4 compared with the inoculation only treatment 6). No significant differences between the two copper formulations were detected.

No disease development occurred in the field trial, consequently no further Kocide sprays were applied apart from the initial one after planting.

In the 1988/9 trial inoculated plants in the middle 4 x 4 cells showed severe bacterial spot symptoms. On 13 March (planting out stage) there was significant spread recorded in trays containing the inoculated plants albeit at a low level (treatment 2 compared with treatment 1), see table 8 below. There was no significant control of bacterial spot with either copper formulation applied pre- and post-inoculation or applied post-inoculation (treatments 4, 5, 7 and 8 and compared with treatment 2.) Limited cross infection occurred but there was no significant difference between the two copper controls (treatments 3 and 6) and the uninoculated control (treatment 1.)

The trial continued for another 3 weeks and by 5 April no significant differences were detected between treatments. However, there was a trend that where copper had been applied plants showed more severe symptoms.

TABLE 8 MEAN % LEAF AREA AFFECTED WITH PSEUDOMONAS FOLLOWING INOCULATION AND COPPER FUNGICIDE TREATMENTS

No.	Pre inoculation copper sprays	Inoculated with Psm	Post inoculation copper sprays	Mean % leaf area affected 13 March	5 April
1.	-	-	-	0a*	1.9a
2.	-	+	-	2.4cd	2.3a
3.	Kocide 101	-	-	0.43abc	0.8a
4.	Kocide 101	+	Kocide 101	2.2bcd	4.0a
5.	-	+	Kocide 101	2.9d	5.6a
6.	Cuprokylt	-	-	0.2ab	1.1a
7.	Cuprokylt	+	Cuprokylt	1.5abcd	3.3a
8.	-	+	Cuprokylt	2.3bcde	3.3a

* Treatment means with similar letters did not differ significantly (P=0.05) Duncan's Multiple Range Test.

DISCUSSION

(A) CULTIVAR SUSCEPTIBILITY

In the 1987/88 trial insufficient disease symptoms developed to establish differences between cultivars. During propagation the plants were grown very "hard" and it was felt that softer grown ones may have been more susceptible. Slight differences between strains were apparent. Despite re-inoculation at the end of March no further disease developed. However at this time the weather was very warm. Temperature and relative humidity are critical for inoculation and disease symptom expression; cool dull weather being the most favourable.

In the 1988/89 trial, the cultivar which was the worst affected was Danish Perfection which had significantly the most leaf area affected as assessed on 23 February and 10 March and also the most dead plants as recorded as number of plants surviving on 5 April. The next most susceptible cultivars were Michalese Carillon, Alpha Jubro and Alpha Begum, but these did not differ significantly from each other except in that the latter had significantly less disease on the lowest green leaf than Michalese Carillon on 10 March (Table 2).

There was a trend that the early summer cauliflower cultivars were the most susceptible, however, Erfu and Alpha Selsto were the least affected of this group. In the table of results the cultivars were arranged in order of maturity and this reflects to some extent their susceptibility to bacterial spot.

However, it was of practical interest that young plants of Michalese Carillon in this trial were moderately susceptible. Observations made in 1987 of field outbreaks of Psm revealed that where Michalese Carillon was grown adjacent to Danish Perfection in the same field, Michalese Carillon was only slightly affected compared with severely affected crops of Danish Perfection.

Large differences between strains were recorded with strain A (ex-cauliflower PCPBB 3572 Kirton 1988) being the most pathogenic and 41/A (ex-Brussels sprout ex-Cambridge ADAS) the least pathogenic.

(B) EFFECT OF COPPER SPRAYS ON DISEASE CONTROL IN PROPAGATION

The results of the 1987/88 trial showed that copper sprays had little effect on eradication of the disease. They may have had a beneficial effect on controlling secondary spread but this was not significant.

It was felt that this trial should be repeated with more copper sprays applied pre-inoculation and post-inoculation. Additional treatments should include plants inoculated in the tray to resemble what might happen under field conditions. Therefore the trial design was modified in 1988/89 to include groups of inoculated plants to increase the likelihood of disease spread. Although disease spread occurred there was no significant reduction in bacterial leaf spot with the copper sprays applied. No differences in disease levels were found despite copper sprays applied pre- and post-inoculation.

No disease development occurred in the field trial in 1988. This possibly was due to the hot dry weather after planting.

CONCLUSION

(1) Differences between cultivars in their susceptibility to bacterial spot have been detected in the propagation stage.

(2) Early summer cauliflower cultivars were the most susceptible group and these are the ones that are at most risk in the field.

(3) The early summer cauliflower Danish Perfection was the most susceptible cultivar tested.

(4) Differences between strains of Pseudomonas syringae pv maculicola were found. The isolate from early summer cauliflowers was the most aggressive and the one from Brussels sprouts the least.

(5) No eradication or significant reduction in the spread of bacterial spot was detected with the use of copper sprays applied in propagation either as pre- and/or post inoculation treatments.

Recommendations for future work

During late spring/early summer of 1989 outbreaks of bacterial spot were confirmed on early summer cauliflower crops of Danish Perfection which were planted out and covered with polythene. Bacterial spot symptoms were seen on the plants when the polythene cover was removed. However, the disease was not apparent in the 1990 or 1991 seasons. This may reflect the diligence of both seedsmen and propagators to supply disease free seed and achieve a high standard of hygiene respectively. In the future, should further outbreaks occur, more work is required on the biology and epidemiology of bacterial spot specifically:-

(1) There is a need to investigate further, early summer cauliflower cultivars protected initially under polythene and their susceptibility to bacterial spot. It would appear this growing technique favours disease development and could be considered a good way to evaluate differences between cultivars.

(2) Other potentially susceptible crops which are initially covered with polythene should be evaluated, ie early calabrese and possibly Chinese cabbage.

(3) The survival of Pseudomonas syringae pv maculicola should be investigated further. It is not known whether the bacteria can overwinter in debris and carry over from season to season either in the field or under glass.

(4) In the first year cultivar trial little disease developed on plants that had been grown "hard". This should be further evaluated.

(5) A rapid confirmatory test for Psm would aid further investigation and advisory work especially that of testing seeds.