FINAL REPORT : CONTROL OF LATE SEASON FOLIAR DISEASES [2000-07]

Executive Summary

Background and Objectives

In recent years, a significant proportion of the growth of the beet crop has taken place during the late summer and autumn and it has therefore become increasingly important to maintain the crop in a healthy condition during this period. The most important foliar diseases are powdery mildew and rust. Up to 1998, mildew had been almost exclusively controlled with sulphur. However, two new triazoles have been introduced since then which give good control of both diseases and, according to preliminary observations, could offer additional yield benefits by delaying leaf senescence.

The objectives of the project were to (a) examine the yield and hence economic benefits to be obtained from the effective control of powdery mildew and rust with these new triazoles during this autumn period and (b) to establish whether additional yield benefits, over and above disease control, can be obtained with these products. To achieve this, field trials were conducted over the four years of the project to study the efficacy, yield responses and cost effectiveness of the new products applied on one vs two occasions, and harvested either early, mid-campaign or late. In addition, to achieve a representative overview, products were compared in a series of trials sited in the different beet growing regions of the UK.

Key findings

- During the period 1999-2003, 5 fungicide trials were carried out at Broom's Barn; 2 were severely infected with powdery mildew (30-60% leaf area infected on Untreated controls) and 2 were moderately infected (18-25%). Only very low levels of disease were encountered in 16 trials conducted on outside sites over the years 2001-2003.

- Under moderate/severe disease pressure the triazoles Punch C (flusilazole + carbendazim) and Alto/Fort (cyproconazole) gave average yield increases over Untreated plots of 8.0 (11%) and 5.3 (7%) adjusted tonnes per hectare, respectively. This difference reflects the greater persistence of Punch in controlling mildew.

- In low/no disease situations, Punch and Alto/Fort gave average yield increases of 5.3 and 4.2 adj. t. per ha, respectively. These yield benefits are likely to be due largely to direct physiological effects on the plant, investigated in an associated project "Physiology of beet growth in the autumn".

- Using these data cost-benefit analysis indicated that margins of £160-£215 per ha could be obtained with a single triazole spray in the presence of moderate/severe disease, at the prevailing A/B quota price of £30 per tonne. At a 'C' price of £5 per tonne, small net margins were still obtained.

- In the absence of disease, the yield boosting properties of the triazoles produced margins of £100 - £125 per ha at the A/B price and no net loss at the 'C' price.

- Recommendations to growers arising out of this project include the following conclusions :

  (a) Except for the earliest lifted crops, control of disease appearing up to the middle of September will almost always give an economic return when triazoles are used, even at 'C' prices.

  (b) Even where disease risk is low, a triazole fungicide can be part of a managed strategy to ensure quota and maximise yield.

- Benefits to the industry from triazole use in 2003, a low disease year, have been calculated to be an additional 360K tonnes, worth £11M nationally.

Future developments

Further supporting data is required to confirm the disease control potential of both triazoles and the newly approved strobilurin fungicides in more severe disease situations and against a broader spectrum of diseases. This forms part of a recently established project "Optimizing yield benefits from triazole and strobilurin fungicides". Varying the rates of application, examining optimum timing and exploring mixtures of different a.i.'s are also included in this study.

M.J.C.Asher
May 2004

CONTENTS

INTRODUCTION

In recent years crop growth in the late summer and autumn months has made a significant contribution to overall national yields. Estimates from successive samplings suggest that in some years, as much as 45 per cent of the crop's final yield is achieved from August onwards (Scott and Jaggard, 1993). An important feature of this has been the widespread use of fungicides to control powdery mildew, and to a lesser extent rust and rumularia, during this late summer/autumn period. Increased efforts by the industry to heighten grower awareness of the yield benefits to be obtained has ensured that the area treated with fungicide has largely matched the national area affected by mildew in recent years (Asher and Dewar, 1999).

Up until 1998, sulphur was used almost exclusively to control powdery mildew and yield responses averaging 7 per cent were recorded with this product in over 50 trials conducted in the late 70's and 80's. However, the subsequent approval of two broad spectrum systemic triazoles, cyproconazole (Alto) and flusilazole + carbendazim (Punch C) for use on sugar beet offered growers a viable alternative to sulphur that would effectively control all foliar diseases. Preliminary trials at Broom's Barn in 1997 suggested that in the presence of mildew these triazoles gave yield benefits of *ca*. 2.5 – 3.8 adjusted tonnes per hectare over and above those achieved with sulphur and, in the case of Punch C, showed equivalent (6 – 8 weeks) persistence. Since no other diseases were present in the trials, the superiority of the triazoles compared to sulphur must have been due either to their more effective control of mildew or to additional physiological benefits to the plant.

The objectives of the project were to (a) examine the yield and hence economic benefits to be obtained from the effective control of powdery mildew and rust with these new triazoles during this autumn period and (b) to establish whether additional yield benefits, over and above disease control, can be obtained with these products. To achieve this, field trials were conducted over the four years of the project to study the efficacy, yield responses and cost effectiveness of the new products applied on one *vs* two occasions, and harvested either early, mid-campaign or late. In addition, to achieve a representative overview, products were compared in a series of trials sited in the different beet growing regions of the UK.

The research findings were intended to lead to revised and more targeted advice to growers on control strategies with these new products and to provide a more up-to-date assessment of the actual and potential economic benefits to be obtained from foliar disease control in the UK crop.

The trials carried out each year are reported on in some detail, followed by a general summary and conclusions based on the results from all years of the project. An economic analysis is attempted at the end of the report.

1999 Trial

Although this trial was carried out in the year preceding the project it is included in the report as it was one of the few over the past five years in which high levels of disease were recorded. Results are also included in the overall summary and conclusions.

The trial comprised 6 treatments (as shown in the Results table) plus an Untreated control laid out in 5 randomized complete blocks and was marked out in late July in an area of sugar beet cv. Zulu at Broom's Barn prior to application of treatments. The standard plot size was 6 rows x 12m of which 4 rows x 8m were machine harvested on 4 Nov. Operations in the trial were carried out according to standard farm practice (including virus yellows control but excluding routine fungicide application). Irrigation was applied when necessary. A single spray of each treatment was applied on 2 Aug, soon after the disease was first seen in the plots and disease assessments made approx. 4 and 7 weeks after this. On each occasion the leaf area infected with mildew was visually assessed on 20 plants per plot. No other diseases were recorded in the trial.

Mildew progressed rapidly in the untreated plots throughout August to give exceptionally high disease levels in early September (Table 1). However, all fungicide treatments were fully effective in preventing infection during this period. By the second assessment date however, 3 weeks later, most fungicides had lost effectiveness. In particular, plots sprayed with Alto and mixtures with Alto had become completely recolonized by mildew. Punch, Thiovit (sulphur) and mixtures of the two were still exercising some control.

These differences were reflected in yields at harvest. As with previous experience most of the effect of powdery mildew on yield was through restrictions on root growth, though small differences in sugar content were detectable. No effect on the level of any impurity was apparent (Table 2). Punch C alone, or in mixtures with full or half rate Thiovit, gave yield increases of 15-20% whereas Alto alone or with half rate Thiovit gave only 7-8%. Thiovit alone also gave only 7% despite exhibiting disease control equivalent to that of Punch. The additional benefits from Punch were clearly not due to its superior ability to control powdery mildew.

Table 1. Brooms Barn Powdery Mildew Trial : 1999

	Mildew : % Leaf Area Affected	**Yield at harvest (4.11)**	
			Adjusted

	1/9	20/9	Root weight (t/ha)	Sugar content (%)	Root yield (adj. t/ha)
Punch C (0.625)*	0.0	25.6	59.8	18.79	74.8 (14.9)†
Punch C (0.625) + Thiovit (5.0)	0.0	23.7	62.9	18.65	77.9 (19.7)
Punch C (0.625) + Thiovit (10.0)	0.0	16.9	62.2	18.62	76.8 (18.0)
Alto (0.25)	1.1	54.2	57.4	18.40	69.8 (7.2)
Alto (0.20) + Thiovit (5.0)	0.2	52.3	56.9	18.57	70.1 (7.7)
Thiovit (10.0)	0.6	28.0	57.7	18.28	69.5 (6.8)
Untreated	56.7	51.3	55.2	17.99	65.1
5% LSD	2.5	10.4	5.1	0.26	6.4

*( ) rates in l/ha or (Thiovit) kg/ha

† ( ) = % increase over Untreated control

Table 2. Brooms Barn Powdery Mildew Trial : 1999

Level of impurities

α-amino N (m. eq/100g beet)	(mg/100g sugar)	**Na** (m.eq/100g beet)	**K** (m.eq/100g beet)

Punch C (0.625)	0.63	47.4	0.41	4.26
Punch C (0.625) + Thiovit (5.0)	0.56	41.8	0.44	4.50
Punch C (0.625) + Thiovit (10.0)	0.67	50.5	0.43	4.34
Alto (0.25)	0.75	57.2	0.47	4.44
Alto (0.20) + Thiovit (5.0)	0.73	55.0	0.48	4.34
Thiovit (10.0)	0.73	55.8	0.46	4.46
Untreated	0.82	63.5	0.50	4.40
5% LSD	NS	NS	NS	NS

2000 Trial

A trial to compare the performance of sulphur and the newly approved Punch C, applied either according to recommendations or 4 weeks later than this, was carried out at Broom's Barn on the variety, Roberta. The trial was laid out as 5 completely randomized blocks with a standard plot size of 6 rows x 12m of which 4 rows x 8m was harvested by hand on either

27 Sept, 25 Oct or 27 Nov. Fungicides were applied at the full rate on 7 Aug when the disease was first seen in the plots, or 4 weeks later on 7 Sept.

Mildew developed slowly following its first appearance and levels were still low in the untreated plots on both assessment dates in Sept (Table 3).

Despite this, substantial yield increases were recorded in the timely Punch C (20%) and sulphur (11%) treatments in the early harvested (late Sept) plots. These yield benefits declined with later harvests so that by the end of Nov only the timely Punch C treatment gave a statistically significant yield increase (17%). Late applications of fungicides in general give no significant yield response.

Over the two month harvesting period (end Sept – end Nov), adjusted root yields increased by 19.2 (26%) in the Punch C treatment, 9.9 (15%) with sulphur and 18.2 (30%) in the untreated plots.

Table 3. Brooms Barn Fungicide Trial : 2000

Mildew : % Leaf Area Affected		Adjusted root yields (t/ha)		
4/9	25/9	End Sept	End Oct	End Nov

Sulphur (normal)†	0	0	67.0 (10.6)	79.2 (3.3)	76.9 (-2.4)
Punch C (normal)	0	0	73.0 (20.5)	85.8 (11.9)	92.2 (17.0)
Sulphur (late)	0	0	62.3 (2.8)	80.0 (4.4)	81.5 (3.4)
Punch C (late)	0	0	70.2 (15.8)	80.2 (4.6)	84.6 (7.4)
Untreated	0.1	0.5	60.6	76.7	78.8
5% LSD	-	-	9.7	9.7	9.7

† normal applcn = 7/8, late applcn = 7/9. ( ) = % increase over Untreated

2001 Trials

1. Broom's Barn

In this trial there were 5 treatments and 3 harvest dates (i.e. 15 treatments) completely randomized within 5 replicated blocks. The treatments comprised a full rate of Thiovit

(sulphur) or Punch C applied when the disease was first seen in the plots (10 August) or, alternatively, 4 weeks after this date (12 Sept), plus an Untreated control.

Mildew developed more rapidly than in the previous year and had reached more than 20% leaf cover on those plots that had not yet been treated at the time of the first disease assessment (Table 4). Sprays applied on 10 August were very effective in controlling disease through to the middle of September. However, subsequent to the first assessment there was very little further disease development on the newly produced leaves, even on untreated plots, due no doubt to the exceptionally wet weather. 20 days with rain were recorded at Broom's Barn in September 2001. Probably as a result of this, yield responses to control were not large, with timely applications of Punch C and sulphur giving a 7-8% and 2-4% yield increase, respectively. Late applications of these products gave no significant yield response.

The increase in yield between late Sept and late Nov was 16.6 adj. t/ha (28%) in the timely Punch C treatment, 19.1 adj. t/ha (34%) in the sulphur treatment and 17.6 adj. t/ha (32%) in the untreated plots.

2. Outside trials

For the first time in 2001 a series of trials examining the performance of approved products in the different sugar beet growing regions (2 each in the North and the West, 1 in the East) were established in growers crops, in addition to those at Broom's Barn.

Three treatments were investigated in the 5 trials established on outside sides in 2001; Punch C (carbendazim + flusilazole), Alto 250 EC (cyproconazole) and Thiovit (sulphur), all applied at full rate in late July/early August. In addition, on two sites an additional product, Lyric (flusilazole alone) was included to determine whether the carbendazim component in Punch C was required for disease control. The long (7 week) harvest interval for Punch C is stipulated because of this specific component in the mixture. 2001 was a relatively low and late year for disease development and mildew levels on the untreated plots never exceeded 12% even by mid-September (Table 5). Against this background all products were extremely effective though there was some suggestion that Alto was less persistent than the others in the later disease assessments on sites where mildew developed. Unfortunately, no disease developed on sites where Lyric was included.

Yield responses to treatment, in the absence of significant disease, were rarely statistically significant in any one trial (Table 6). However, consistent trends were apparent and, when averaged over all trials, significant yield increases of 3-4 adjusted tonnes over the untreated control were achieved with all products.

Table 4. Brooms Barn Fungicide Trial : 2001

	Mildew : % Leaf Area Affected		**Adjusted root yields (t/ha)**		
	5/9	**26/9**	**End Sept**	**End Oct**	**End Nov**
Sulphur (normal)†	1.0	6.5	57.0 (2.5)	67.8 (0.6)	76.1 (4.0)

Punch C (normal)	0.4	7.0	59.9 (7.7)	73.1 (8.5)	76.5 (4.5)
Sulphur (late)	23.1	8.3	56.0 (0.7)	69.0 (2.4)	72.4 (-1.1)
Punch C (late)	24.0	9.0	55.6 (0)	63.8 (-5.3)	70.2 (-4.1)
Untreated	22.3	20.4	55.6	67.4	73.2
5% LSD	7.3	4.3	6.7	6.7	6.7

† normal applcn = 10/8, late applcn = 12/9 ( ) = % increase over Untreated

Table 5. Outside Fungicide trials : 2001

Powdery Mildew (1) : % Leaf Area Affected (21-29 Aug)

	Untreated	**Punch C**	**Alto**	**Lyric**	**Thiovit**	**5% LSD**
Chillesford (Suffolk)	2.3	0	0	-	0	-

Duncote (Shrops)	0	0	0	0	0	-
Tibberton (Shrops)	0.2	0	0	-	0	-
Hibalstow (Lincs)	1.8	0	0	-	0	-
Harswell (Yorks)	1.5	0	0	0	0	-

Powdery Mildew (2) : % Leaf area Affected (13-24 Sept)

	Untreated	**Punch C**	**Alto**	**Lyric**	**Thiovit**	**5% LSD**
Chillesford (Suffolk)	6.8	0.3	3.0	-	0	4.1
Duncote (Shrops)	0	0	0	0	0	-
Tibberton (Shrops)	11.6	7.3	10.4	-	7.4	3.4
Hibalstow (Lincs)	1.1	0	0	-	0	-
Harswell (Yorks)	11.6	0	2.5	0	1.8	4.0

Table 6. Outside Fungicide trials : 2001

Adjusted Root Yield (t/ha)

	Untreated	**Punch C**	**Alto**	**Lyric**	**Thiovit**	**5% LSD**

Chillesford (Suffolk)	72.3	77.4	76.4	-	78.0	NS
Duncote (Shrops)	63.7	67.6	66.5	66.5	64.1	NS
Tibberton (Shrops)	59.8	64.9	68.7	-	65.9	4.2
Hibalstow (Lincs)	80.1	81.7	78.8	-	80.6	NS
Harswell (Yorks)	62.7	66.1	66.9	65.1	65.6	NS
Mean over sites:	67.3	71.3	70.6	-	70.2	2.3
Increase over Untreated:	-	4.0	3.3	-	2.9	(2.3)

Trial Calendar

	Sprayed	**Disease Assessment**		**Harvested**
		1	**2**	
Tibberton (Shrops)	24 July	21 August	17 Sept	29 Nov
Hibalstow (Lincs)	31 July	29 August	24 Sept	27 Nov
Chillesford (Suffolk)	26 July	23 August	13 Sept	3 Dec
Duncote (Shrops)	24 July	21 August	17 Sept	28 Nov
Harswell (Yorks)	1 Aug	29 August	24 Sept	26 Nov

2002 Trials

1. Broom's Barn

The trial established in 2002 compared single applications of Punch C and Sulphur (Thiovit), applied when disease was first seen, with two applications of these chemicals, the second spray applied 5 weeks after the first. The overall objective was to determine whether two sprays could give cost effective yield benefits over single applications and whether this was affected by harvest date. The 4 treatments plus untreated control were randomized in 5

replicate blocks as before and applied on 16 July (1st spray) and 21 Aug (2nd spray) to the variety Roberta. Standard plots were harvested by hand on 26 Sept, 29 Oct and 26 Nov.

Despite arriving early in the trial (15 July) the disease progressed slowly, reaching only 19% leaf area infected on untreated plots by 12 Aug and declining thereafter as the new leaves that were produced failed to become infected (Table 7). No discrimination of the different treatments in terms of disease control was possible. However, it was evident from the yield data (in this very high yielding year) that (a) Punch C was giving, on average, twice the yield response of Thiovit and (b) two applications were giving slightly greater yields than one, largely regardless of harvest date. The yield increases over the two month harvesting period ranged from 13% in the untreated to 15% with the single applications of Punch and Thiovit, to 17% with the two applications of Punch; this latter was an experimental treatment not approved for general use.

2. Outside Trials : 2002

Six trials were set up in the beet growing regions to examine standard (Punch, Alto, Thiovit) and newly approved (Fortress : a.i. quinoxyfen) fungicides as well as an experimental strobilurin (Comet : a.i. pyraclostrobin). Fungicides were applied in late July/early August except at Woodbridge, Suffolk where a trial was deliberately established late in response to the presence of a developing rust attack. The absence of significant powdery mildew on the leaves at all sites (Table 8) allowed the development of both rust and ramularia and these diseases were assessed when they became most prominent (Table 9). However, rust remained at low levels even at the Woodbridge site and it was possible only to demonstrate the relative effectiveness of the triazoles and strobilurin, and the ineffectiveness of Thiovit and Fortress at controlling this disease approx. 2 months after applying the treatments. Ramularia developed in some trials even later than rust, during Oct/Nov, but it was nevertheless possible to demonstrate some suppression of these diseases by Punch, Alto and Comet from the single sprays applied in early August.

It seems unlikely that the low levels of mildew and rust recorded in the trials and the significant but extremely late ramularia development would have been sufficient to cause significant yield losses, but this cannot be entirely ruled out. Over all trials Punch and Alto gave average yield increases of 4.4–4.9 adj. t. per ha (5–6 %) whereas Thiovit did not increase yields (Table 10). In the two trials where it was included Fortress gave the highest yield in one and the lowest in the other. Comet on the other hand consistently gave the highest yield in the two trials in which it was included.

Table 7. Brooms Barn Fungicide Trial : 2002

	Mildew : % Leaf Area Affected		**Adjusted root yields (t/ha)**		
	12/8	**11/9**	**End Sept**	**End Oct**	**End Nov**
Sulphur	0.1	0.2	83.3 (3.7)	95.7 (5.3)	96.1 (5.6)
Punch C	0	0.3	86.4 (7.6)	102.1 (12.3)	99.4 (9.2)

Sulphur x 2	0.1	0	84.3 (5.0)	98.5 (8.4)	97.2 (6.8)
Punch C x 2	0	0	88.4 (10.1)	102.6 (12.9)	103.6 (13.8)
Untreated	18.6	1.5	80.3	90.9	91.0
5% LSD	-	-	3.9	3.9	3.9

( ) = % increase over Untreated

Table 8. Outside Fungicide trials : 2002

Mildew (1) : % Leaf Area Affected (28 Aug – 2 Sept)

	Untreated	**Thiovit**	**Alto**	**Punch**	**Fortress**	**Comet**	**5% LSD**
Claverley (Shrops)	4.9	0	0	0	0	-	-
Newton (Yorks)	0	0	0	0	0	-	-
Watton (Norfolk)	0	0	0	0	-	-	-

Shrewsbury (Shrops)	3.3	0	0	0	-	0	-
Wainfleet (Lincs)	0	0	0	0	-	0	-
Woodbridge (Suffolk)	0	-	0	0	0	0	-

Mildew (2) : % Leaf Area Affected (24 Sept – 8 Oct)

	Untreated	**Thiovit**	**Alto**	**Punch**	**Fortress**	**Comet**	**5% LSD**
Claverley (Shrops)	12.0	0.1	1.7	0	0	-	3.4
Newton (Yorks)	0	0	0	0	0	-	-
Watton (Norfolk)	0	0	0	0	-	-	-
Shrewsbury (Shrops)	3.4	0	0	0	-	0.1	-
Wainfleet (Lincs)	0	0	0	0	-	0	-
Woodbridge (Suffolk)	0	-	0	0	0	0	-

Table 9. Outside Fungicide trials : 2002

Rust : % Leaf Area Affected (24 Sept – 8 Oct)

	Untreated	**Thiovit**	**Alto**	**Punch**	**Fortress**	**Comet**	**5% LSD**
Claverley (Shrops)	3.9	6.3	0	0.4	2.3	-	2.4
Newton (Yorks)	1.5	1.5	0	0	0.6	-	1.0

Watton (Norfolk)	5.3	6.1	0.9	6.9	-	-	2.1
Shrewsbury (Shrops)	5.3	3.6	0.1	0.4	-	0.8	1.8
Wainfleet (Lincs)	2.2	2.3	0	0.2	-	0.2	0.8
Woodbridge (Suffolk)	7.2	-	2.5	4.1	5.5	4.3	2.3

Ramularia : % Leaf Area Affected (7 – 22 Nov)

	Untreated	**Thiovit**	**Alto**	**Punch**	**Fortress**	**Comet**	**5% LSD**
Claverley (Shrops)	28	22	13	12	18	-	5.4
Newton (Yorks)	22	23	11	17	25	-	8.7
Watton (Norfolk)	0	0	0	0	-	-	-
Shrewsbury (Shrops)	0	0	0	0	-	0	-
Wainfleet (Lincs)	42	23	13	14	-	11	9.7
Woodbridge (Suffolk)	22	-	14	15	21	15	5.1

Table 10. Outside Fungicide trials : 2002

Adjusted Root Yield (t/ha)

	Untreated	**Thiovit**	**Alto**	**Punch**	**Fortress**	**Comet**	**LSD**
Claverley (Shrops)	98.8	95.9	103.4	101.3	103.7	-	5.4
Newton (Yorks)	86.0	85.1	89.2	87.7	84.5	-	NS

Watton (Norfolk)	75.9	74.7	79.7	79.2	-	-	NS
Shrewsbury (Shrops)	80.4	83.9	88.5	87.2	-	89.4	3.3
Wainfleet (Lincs)	87.4	87.5	92.1	94.9	-	96.5	5.4
Mean over sites:	85.7	85.4	90.6	90.1	-	-	2.0
Increase over Untreated	-	-0.3	4.9	4.4	-	-	(2.0)

Trial Calendar

		Disease Assessments			Harvested
	Sprayed	**1**	**2**	**3**	
Claverley (Shrops)	6 Aug	2 Sept	24 Sept	20 Nov	20 Nov
Newton (Yorks)	7 Aug	3 Sept	25 Sept	13 Nov	13 Nov
Watton (Norfolk)	30 July	28 Aug	8 Oct	-	4 Nov
Shrewsbury (Shrops)	6 Aug	2 Sept	24 Sept	-	28 Nov
Wainfleet (Lincs)	7 Aug	3 Sept	27 Sept	7 Nov	7 Nov
Woodbridge (Suffolk)	11 Sept	24 Sept	22 Nov	-	22 Nov

2003 Trials

1. Broom's Barn

This trial was largely a repeat of the treatments examined in 2002 with comparisons of single vs. double applications of Punch C and sulphur (Thiovit). However, Fort (cyproconazole) was included as an alternative triazole widely used on the crop and, to make room for this treatment, early (end Sept) harvests of the double application treatments were omitted. The disease arrived very early, being first detected in the plots on 17 July, but because of a period of wet and/or windy weather the first sprays could not be applied until 23 July. The trial was laid out as usual in 5 randomized blocks of the variety Roberta. Disease assessments were

carried out at 4 and 7 weeks from the first sprays and, where required, second sprays were applied on 21 Aug. Plots were hand harvested on 30 Sept, 28 Oct and 27 Nov.

Because mildew had already become established in the plots at the time the first treatments were applied disease control with the protectant triazoles was not as good as in previous years. Compared with sulphur there was significant infection in plots of Punch and Fort 4 weeks after spraying and by 7 weeks no disease control was apparent in these treatments (Table 11). Only the two spray programmes of Punch and Thiovit continued to suppress disease effectively at 7 weeks. Yields were again high generally with the largest responses to treatment being achieved with sulphur at the end of Nov, whether with one application (14.7 adj. t. or 16%) or two (17.8 adj. t. or 20%). Single applications of Punch or Fort gave similar, but substantially lower yield increases (9%). Clearly, the greater persistence and disease control of sulphur outweighed any growth promoting effects of triazoles in this early and severely infected trial. No effect of treatments on sugar % or impurity levels was detected. Yield increases over the two month harvesting period ranged from 10-13% for the fungicide treatments compared with 7% for the untreated plots.

2. Outside trials : 2003

Trials in 2003 were carried out as before in the West Midlands (2) the Northern Region (2) and one in Suffolk, along with the trial at Broom's Barn separately reported. Treatments in this year were restricted to the main products approved for use on the crop, Punch, Fort (Formerly Alto), Fortress and Thiovit (sulphur). However, it was again a year in which low levels of mildew generally were forecast and where the disease failed to develop in the trials (Table 12). Rust was assessed when it appeared in a trial but, again, failed to develop to significant levels.

Against this low disease background there was little significant difference in yield between fungicide treatments within any one trial (Table 13). However, overall, results from previous low/no disease years were confirmed with Punch and Fort giving 3.5 – 4.4 adj. t./ha (4-5%) increase and Thiovit no yield response over the untreated plots. Fortress gave a small but not statistically significant increase.

Table 11. Brooms Barn Fungicide Trial : 2003

	Mildew : % Leaf Area Affected		**Adjusted root yields (t/ha)**		
	20/8	**9/9**	**End Sept**	**End Oct**	**End Nov**
Sulphur	1.5	39.1	92.3 (9.5)	98.5 (10.1)	104.9 (16.3)
Punch C	10.4	54.3	89.5 (6.2)	93.8 (4.8)	98.4 (9.1)
Fort	18.6	60.0	87.1 (3.3)	92.8 (3.7)	98.5 (9.2)

Sulphur x 2	1.3	4.5	-	105.5 (17.9)	108.0 (19.7)
Punch C x 2	8.2	6.5	-	103.2 (15.3)	104.7 (16.1)
Untreated	32.5	53.3	84.3	89.5	90.2
5% LSD	4.8	5.6	4.9	4.9	4.9

( ) = % increase over Untreated

Table 12. Outside Fungicide trials : 2003

Powdery Mildew : % Leaf Area Affected (28 Aug – 17 Sept)

	Untreated	**Punch C**	**Fort**	**Fortress**	**Thiovit**
Shipton (Yorks)	0	0	0	0	0
Wainfleet (Lincs)	2.2	0	0	0	0
Claverley (Shrops)	2.2	0	0	0	0

Shrewsbury (Shrops)	0	0	0	0	0
Falkenham (Suffolk)	3.4	0.1	3.1	0.1	0.8

Rust : % Leaf Area Affected (10 – 18 Sept)

	Untreated	**Punch C**	**Fort**	**Fortress**	**Thiovit**
Shipton (Yorks)	5.2	1.0	0.3	2.6	4.1
Wainfleet (Lincs)	0	0	0	0	0
Claverley (Shrops)	5.0	1.2	0.6	3.8	5.0
Shrewsbury (Shrops)	0	0	0	0	0
Falkenham (Suffolk)	4.6	2.1	0.1	4.2	3.4

Table 13. Outside Fungicide trials : 2003

Adjusted Root Yield (t/ha) : (10 Oct – 18 Nov)

	Untreated	**Punch C**	**Fort**	**Fortress**	**Thiovit**	**5% LSD**
Shipton (Yorks)	103.4	105.9	106.7	101.2	102.7	NS
Wainfleck (Lincs)	85.7	92.3	94.0	91.0	91.9	3.7

Claverley (Shrops)	105.7	107.2	112.4	106.2	105.0	NS
Shrewsbury (Shrops)	92.9	93.3	91.9	90.7	92.5	NS
Falkenham (Suffolk)	79.1	85.8	84.2	83.8	74.2	NS
Mean over sites :	93.4	96.9	97.8	94.6	93.3	3.4
Increase over Untreated :	_	3.5	4.4	1.2	-0.1	(3.4)

Trial Calendar

	Sprayed	**Disease Assessments** 10	**2**	**Harvested**
Shipton (Yorks)	14 Aug	28 Aug	18 Sept	18 Nov
Wainfleet (Lincs)	31 July	28 Aug	18 Sept	13 Nov
Claverley (Shrops)	13 Aug	10 Sept	2 Oct	5 Nov
Shrewsbury (Shrops)	13 Aug	10 Sept	2 Oct	4 Nov
Falkenham (Suffolk)	28 July	26 Aug	17 Sept	10 Oct

Summary of Results and Conclusions

The overall results of the trials carried out in 1999-2003, illustrating the performance Of the three most widely used fungicides under different levels of disease pressure, are summarized in Table 14. Only two of the trials during this period could be classified as exerting high disease pressure, two had moderate disease, whereas 16 on outside sites showed very little or no disease during the first month after spraying. Because of this relatively low number of severe and moderately infected trials (which largely reflects the disease situation prevailing during the years in which the trials were conducted) less reliance should be placed on these results. In particular, the results with Thiovit were distorted by the one severely infected trial in 2003 and its average performance under high disease pressure may be exaggerated by this result.

However, several preliminary conclusions can be drawn. Most importantly, the 16 low disease trials clearly illustrate the benefits to be obtained, even in the near or complete absence of disease, by triazoles but not from sulphur products. The basis of this yield boost, resulting presumably from the enhanced leaf greening effect, has been investigated in the associated project "Physiology of beet growth during the autumn". Secondly, the slight superiority of Punch C (flusilazole + carbendazim) over Alto/Fort (cyproconazole) reflects its greater persistence against powdery mildew, which was the only significant disease in these trials during the August/September period. Although other diseases, such as rust and ramularia, were detected they normally failed to develop significantly or (in the case of ramularia) developed too late to have a significant affect on yield.

Translating these results into economic benefits for growers (Table 15) is clearly very largely dependent on whether returns are calculated on the basis of A/B quota or surplus-to-quota ('C') prices. These in turn vary from year to year. Calculations for the 2003/4 crop have been based on a conservative estimate of £30 per adjusted tonne for A/B quota beet and an arbitrary estimate if £5 per tonne for 'C' beet. Yield increases in response to treatment with the fungicides have been based on the average response under high/moderate disease pressure or low/no disease pressure, respectively, using data from Table 14. The large margins from controlling disease, and even in the absence of disease, obtainable from a single application of a triazole fungicide at the A/B price are clearly apparent. Punch C is more cost-effective than the cypronazole products (Alto/Fort/Caddy/Cabaret) when powdery mildew is the predominant disease. Interestingly, the calculations also indicate that, at a 'C' price of £5 per tonne, triazoles will give a small net margin when disease is present and even when disease is absent no loss is incurred.

Industry Benefits

In 2003, 60% of the natural crop area received an application of a triazole fungicide. Assuming, in the absence of disease, a conservative 4 adjusted tonne/ha yield increase on the 90k ha sprayed, the total additional production from triazole use was 360K tonnes, worth £11m at the A/B price. This figure would be substantially greater in a year more favourable to disease development, as forecast for 2004.

Future research

This project has successfully established the average yield benefits and financial returns to be obtained from the use of triazoles in low/no disease situations. Fewer trials examining their performance under high/moderate disease pressure were established and this is to be examined further under the recently initiated project "Optimizing yield benefits from triazole and strobilurin fungicides", utilizing artificial inoculation methods where possible to ensure disease development. At the same time, the newly introduced strobilurin fungicides will be examined for claims of even greater disease control and growth promoting activity.

Table 14. Summary of yield responses in trials (1999-2003)

	Disease Level†		
	High	**Moderate**	**Low**
Punch C	9.7* (99)	5.7 (01)	9.1 (00)
	6.2 (03)	11.2 (02)	4.0 (01)#
	Mean: 8.0 [10.9]	**8.5 [10.4]**	4.4 (02)#
			3.5 (03)#
			5.3 [6.7]

Alto/Fort	4.7 (99)	-	3.3 (01)#
	5.8 (03)	-	4.9 (02)#
	Mean: 5.3 [6.9]	-	4.4 (0.3)#
			4.2 [5.1]
Thiovit	4.4 (99)	0.4 (01)	2.5 (00)
	11.8 (03)	4.8 (02)	2.9 (01)#
	Mean: 8.1 [10.0]	**2.6 [2.9]**	-0.3 (02)#
			-0.1 (03)#
			1.3 [1.9]

† High = 30-60%, Moderate = 18-25% and Low = <5% leaf area infected on Untreated plots (assessed at 4 weeks after treatment)

* Yield increase (adj. t./ha) over Untreated in trial
( ) Year of trial/s
Mean of 5 trials
[ ] % increase in yield

Table 15. Economics of disease control : 2003/4

	Costs per ha (£) including spraying (@£7/ha)	**Average yield response and net margin per hectare***					
		High/Moderate Disease			**Low/No Disease**		
Products		**t/ha**	**A/B** £/ha	**C** £/ha	**t/ha**	**A/B** £/ha	**C** £/ha
Punch C	25	8	215	15	5	125	0
Alto/Fort/Caddy/Cabaret	20	6	160	10	4	100	0

Thiovit	16	5	134	9	1	14	-11

***At A/B price of £30 and C price of £5 per adj. tonne**

Expenditure and scientific staff input for 2003/4

Planned expenditure :	£63,208
Actual expenditure :	£64,061.56
Planned scientific input in staff years :	1
Actual scientific input in staff years :	1

Publications

Asher, M. J. C. (2004) Foliar disease control update. *British Sugar Beet Review* **72** (2), in press

Asher, M. J. C. (2002) Diseases in 2001 and their control. *British Sugar Beet Review* **70** (2), 30-33.

Asher, M. J. C. (2001) Protecting autumn growth. *British Sugar Beet Review* **69** (2), 17-18.

Asher, M. J. C. (2000) Control of foliar diseases. *British Sugar Beet Review* **68** (2), 28-33.

Presentations at BBRO meetings

7.3.2000 Kidderminster
8.3.2000 Telford
30.1.2001 Grantham
14.2.2001 Kidderminster
27.2.2001 York
29.1.2002 Stamford
30.1.2002 Market Rasen
6.2.2002 Kings Lynn
7.2.2002 Ely
19.2.2002 Telford
20.2.2002 Ross-on-Wye
12.3.2003 Norwich

Also attendance at ‘Cereals’ and ‘Roots’ events