Project Report No. 449

March 2009

Abstract and Summary

New fungicides for oilseed rape: defining dose-response activity

by

P Gladders[1], S J P Oxley[3], C Dyer, F Ritchie[2], J A Smith[2], S Roques[1], A Moore[4], K Maulden[1], J Torrance[3]

[1]ADAS Boxworth, Boxworth, Cambridge CB23 4NN
[2]ADAS Rosemaund, Hereford HR1 3PG
[3]SAC, West Mains Road, Edinburgh EH9 3JG
[4]ADAS Terrington, Bentinck Farm, Rhoon Road, Terrington St Clement, King's Lynn, Norfolk PE34 4HZ

This is the final report of a forty-two month project which started in August 2005. The work was funded by a contract of £154,748 from HGCA (Project No. 3200).

HGCA has provided funding for this project but has not conducted the research or written this report. While the authors have worked on the best information available to them, neither HGCA nor the authors shall in any event be liable for any loss, damage or injury howsoever suffered directly or indirectly in relation to the report or the research on which it is based.

Reference herein to trade names and proprietary products without stating that they are protected does not imply that they may be regarded as unprotected and thus free for general use. No endorsement of named products is intended nor is it any criticism implied of other alternative, but unnamed, products.

1. ABSTRACT

Fungicides are used on over 90% of winter oilseed rape crops at a total annual cost to farmers of around £12 million. Diseases cause estimated losses of up to £80 million per annum and effective management requires integration of resistant cultivars with agronomic factors and fungicides. Cultivar resistance alone has not provided adequate control of the three most important diseases: stem canker (*Leptosphaeria maculans*), light leaf spot (*Pyrenopeziza brassicae*) and sclerotinia stem rot (*Sclerotinia sclerotiorum*). The overall aim of the project was to determine the dose-response activity of new and standard fungicides against the major diseases of oilseed rape.

Replicated field experiments with disease and yield assessments were done in farm crops of susceptible cultivars in harvest years 2006 2007 and 2008 against phoma stem canker (6 sites), light leaf spot (4 sites) and sclerotinia stem rot (6 sites). The seven or eight test fungicides were applied at 0.25. 0.50, 0.75 and 1.00 (full label) doses were applied in 200 litres water/ha by OPS knapsack sprayer to plots (40-60m^2) when phoma experiments had 10-20% plants affected and 6-8 weeks later, in November and March/April for light leaf spot and at early to mid-flowering for sclerotinia stem rot control.

Disease data was obtained from all experiments and disease severity was moderate to high in 14 experiments. Yield data was obtained from 15 experiments and significant responses to the fungicide treatments were recorded at 10 sites. The response to fungicide treatments was generally related to disease severity, with largest responses (c. 2 t/ha) being obtained where sclerotinia stem rot was very severe (80-82% plants affected). When data for three years was combined, disease control and yield responses to fungicide products and dose were all highly significant for each disease**.**

Prothioconazole (Proline) performed well against light leaf spot and in mixture with tebuconazole (Prosaro) gave the highest yield at phoma stem canker sites. Filan, Compass and Proline were most effective against sclerotinia, though differences between products were most evident under high disease pressure. Whilst products can perform very well at 0.5 full label dose, higher doses are required to optimise economic performance under high disease pressure. Plant growth regulatory effects contributed to yield responses and both positive and negative effects were detected. Careful interpretation of the yield data is required when using it to guide fungicide inputs on farms.

2. SUMMARY

2.1 Introduction

Fungicides are used on over 90% of winter oilseed rape crops and total expenditure by farmers is about £12 million per annum. Diseases are estimated to cause losses of up to £80 million per annum (Fitt *et al*., 1997) and effective management requires integration of resistant cultivars with agronomic factors and fungicides. Cultivar resistance alone has not provided adequate control of stem canker (*Leptosphaeria maculans*) and light leaf spot (*Pyrenopeziza brassicae*) (Gladders *et al*., 1998a) and fungicides are required in most years to prevent significant loss of yield. In addition, cultivar resistance has not been durable on widely-grown cultivars. There is no cultivar resistance to sclerotinia stem rot (*Sclerotinia sclerotiorum*) and fungicide use against it is likely to increase in 2009 after the 2007 and 2008 epidemics in England (Gladders *et al*., 2008). Fungicides are therefore an important part of disease management and are very cost-effective if their use is optimised for product, dose and timing.

Opportunities to reduce fungicide dose will depend on careful characterisation of activity against individual diseases and the ability to define requirements from a full dose-response curve. Fungicides on oilseed rape also have physiological effects on crop growth and this can result in positive or negative effects on yield. Provision of yield data is therefore an important part of the project. It is important that farmers have up-to-date information on new and existing fungicide products. This project is the first systematic study of fungicide performance in relation to products and dose.

2.2 Objectives

The overall aim of the project was to determine the dose-response activity of new and standard fungicides against the major diseases of oilseed rape.

To determine the most appropriate fungicide dose for disease control and yield response for situations with: i) Phoma leaf spot and stem canker, ii) Light leaf spot and iii) Sclerotinia stem rot.

2.3 Materials & Methods

Field experiments were done in farm crops of susceptible cultivars against phoma stem canker, light leaf spot and sclerotinia stem rot in three harvest years 2006 2007 and 2008 (Tables 2.1 and 2.2). The test fungicides were applied at 0.25. 0.50, 0.75 and 1.00 (full label). Doses were applied in 200 litres water/ha by OPS knapsack sprayer to plots (40-60m^2) when phoma experiments had 10-20% plants affected and 6-8 weeks later, in November and March/April for light leaf spot and at early to mid-flowering for sclerotinia stem rot control. There was three-fold replication of seven different fungicides (eight products were tested at light leaf spot sites) and a double untreated control. Unregistered fungicides in these experiments have been included under an HGCA code, though details will be disclosed in future when products are registered for use on oilseed rape.

Foliar diseases were assessed on 10 plants per plot 6-8 weeks after treatments and pre-harvest on 25 plants/plot (phoma sites), 100 plants/plot (stem rot sites) or using whole plot methods (light leaf spot site). At least three assessments were made on light leaf spot experiments. Disease control was evaluated using incidence (% of plants affected), % leaf area affected and stem disease index (0-100 where individual plants are scored on a 0-4 index: 0 = no disease and 4 = dead) data. Plots were combine harvested and yields adjusted to 91% dry matter.

Statistical analyses were done using Genstat with curve fitting using a negative exponential function (Paveley *et al.,* 2003). Curves for individual products show the unfitted data points and the fitted line. On occasion, a satisfactory line could not be fitted and only unfitted values are shown. Significant differences between treatments in statistical analyses are indicated by asterisks (*) using the following notation: $P<0.001$ =***, $P<0.01$ = **, $P<0.05$ = *. ns = not significant.

2.4 Results

A total of 16 experiments were completed in this project during harvest years 2006 to 2008. Disease data was obtained from all experiments and disease severity was moderate to high in 14 experiments. Yield data was obtained from all experiments except the light leaf spot experiment in Aberdeen in 2008, and significant yield responses to the fungicide treatments were recorded at 10 sites. The response to

fungicide treatments was generally related to disease severity, with the largest responses (c. 2 t/ha) being obtained where sclerotinia stem rot was very severe. When data for three years was combined, disease control and yield responses to fungicide treatment were all highly significant for each disease (Table 2.3).

Product differences were evident in all experiments except for the sclerotinia experiment in Kent in 2006 and the phoma experiments at Boxworth and Terrington in 2008. Dose effects were significant in all experiments except for the light leaf spot sites at Aberdeen in 2007 and High Mowthorpe in 2008. The interaction of product x dose was only significant for yield in the light leaf spot experiment in 2006 and sclerotinia experiments in Hereford in 2006 and 2008 and disease control in Kent in 2008.

Table 2.1: Fungicide products, full doses and active ingredients used in experiments for phoma and light leaf spot 2006-2008 (P =phoma sites, L = light leaf spot sites).

Fungicide product	Full dose	Active ingredient	Experiments (2006-2008 unless indicated otherwise)
Caramba	1.2 l/ha	Metconazole (60g L^{-1})	P+L
Charisma	1.5 l/ha	Famoxadone+ flusilazole (100+106.7g L^{-1})	P+L
Folicur	1.0 l/ha	Tebuconazole (250g L^{-1})	L
Plover	0.5 l/ha	Difenoconazole (250g L^{-1})	P
Proline	0.7 l/ha	Prothioconazole (250g L^{-1})	P+L
Prosaro	1.0 l/ha	Prothioconazole+ tebuconazole (125+125g L^{-1})	P+L
Punch C (or Contrast)	0.8 l/ha	Carbendazim + flusilazole (125+250g L^{-1})	P+L

Table 2.2: Fungicide products, full doses and active ingredients used in experiments for sclerotinia 2006-2008.

Fungicide product	Full dose	Active ingredient
Amistar	1.0 l/ha	Azoxystrobin (250g L^{-1})
Compass	3.0 l/ha	Iprodione + thiophanate methyl (167+167g L^{-1})
Filan	0.5 kg/ha	Boscalid (500g kg^{-1})
Folicur	1.0 l/ha	Tebuconazole (250g L^{-1})
Proline	0.7 l/ha	Prothioconazole (250g L^{-1})
Priori Xtra	1.0 l/ha	Azoxystrobin + cyproconazole (200+80g L^{-1})
HGCAOSR2	0.5 l/ha	Not disclosed

Table 2.3: Disease severity and yield for untreated controls and mean of all fungicide treatments for cross site and year analyses in 2006-2008.

Year	Target disease	Location	Disease Severity[1]		Yield (t/ha)	
			Untreated	Treated	Untreated	Treated
2006-2008 6 sites	Phoma stem canker	Boxworth, Cambs and Terrington, Norfolk	44.03	19.98***	3.49	3.84***
2006-2008 3 sites (no yield in 2008)	Light leaf spot	Aberdeen	11.20	5.33***	3.45	3.67***
2006-2008 6 sites	Sclerotinia stem rot	Herefordshire and Kent	33.97	13.16***	3.69	4.34***
2006-2008 3 sites	Sclerotinia stem rot	Herefordshire	46.68	18.41***	2.56	4.07***
2006-2008 3 sites	Sclerotinia stem rot	Romney Marsh, Kent	19.26	7.92***	3.32	3.71***

[1] Disease index (0-100) for stem canker and sclerotinia stem rot pre-harvest; % leaf area affected for light leaf spot (mean of three assessments per year in Scotland) $P<0.001$ =***

2.4.1 Phoma (Figures 2.1, 2.2)

The severity of phoma A leaf spotting about 6 weeks after the first fungicide treatments showed significant differences between years, sites, fungicides, dose and year x dose, but no treatment x dose interaction. Disease severity was greatest in 2007. Proline and Prosaro had less severe spotting than Charisma and Punch C, whilst Plover and Caramba did not differ from other products. Stem canker severity showed significant differences between years, sites, fungicides treatments dose and year x dose but no treatment x dose interaction. The annual mean canker indices for 2006, 2007 and 2008 were 24.1, 31.3 and 10.2 respectively. Proline, Plover and Prosaro were the most effective products. Caramba had more severe canker (index 24.0) than all the other products (index range 17.5-21.4; untreated index 44.0) but still gave acceptable stem canker control. The differences between each dose were significant and canker index decreased from 24.5 at 0.25 dose to 16.3 at full dose.

Yields showed significant differences between fungicide treatments, dose and year x dose, but not for sites or treatment x dose interactions. The annual mean yields for

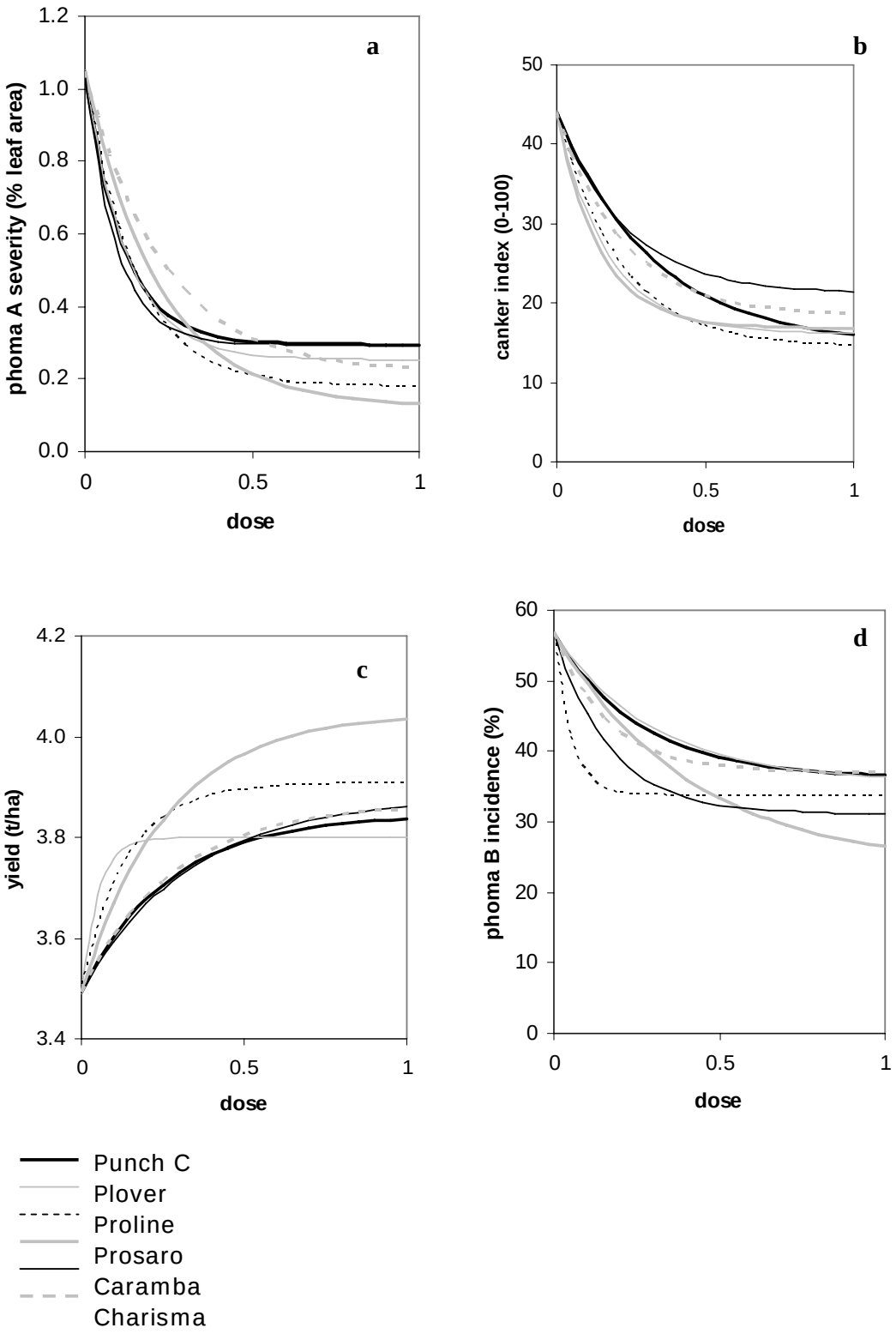

Figure 2.1: Mean data from phoma trials across three years (2006-2008) and two sites (ADAS Boxworth and ADAS Terrington): (a) phoma A leaf spot severity at first assessment; (b) canker index at final assessment; (c) yield; (d) phoma B incidence at first assessment**.**

2006, 2007 and 2008 were 4.03, 3.34 and 4.08 t/ha respectively. Boxworth and Terrington had similar yields at 3.78 and 3.85 t/ha respectively. All the products increased yields, with Prosaro giving a greater yield (3.97 t/ha) than all the other products (range 3.79-3.80 t/ha) except Proline (3.89 t/ha). All doses increased yield but there was no significant increase above 0.50 dose. The greatest yield was 3.90 t/ha at 0.75 dose.

Phoma B leaf spot incidence (Fig. 2.1d) at the first assessment in late November or early December showed significant effects for control, year, fungicide, dose, but no fungicide x dose interactions. Its incidence was greater in harvest year 2007 (75% plant affected) than in 2006 (34% plants affected) and 2008 (4% plants affected). Treatments decreased incidence from 57% plants affected to 36%. Prosaro, Proline and Caramba gave better control than Charisma, Punch C and Plover, though differences were small (range of incidence 33% to39% plants affected). Control improved as dose increased, with incidence decreased from 39% plants affected at 0.25 dose to 31% at full dose. Full dose was more effective than all the other doses. Phoma B severity was very low (0.01% leaf area affected) and no product differences were found.

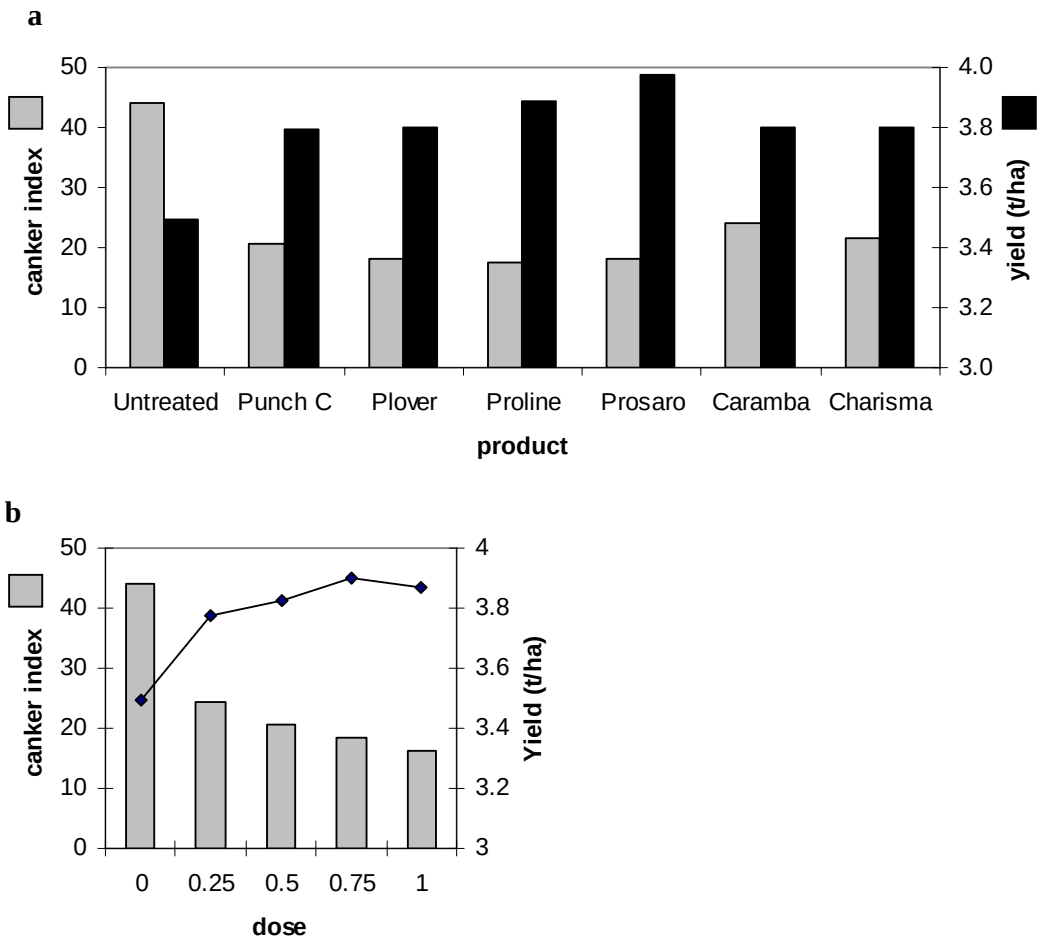

Figure 2.2: Mean data from phoma trials across three years (2006-2008) and two sites (ADAS Boxworth and ADAS Terrington), showing canker index (0-100) and yield (t/ha): (a) data averaged across doses for each product; (b) data averaged across products for each dose.

2.4.2 Light leaf spot (Figures 2.3, 2.4)

Only the data from the Aberdeen sites was included in the three year analyses and yield data were only available for 2006 and 2007. The severity of light leaf spot averaged over three assessments in spring each year showed significant differences between years, fungicides, dose and year x fungicide, but no treatment x dose interaction. Mean severity was 6.8% leaf area affected in 2006, 6.6% in 2007 and 5.2% in 2008, whilst untreated means were 12.3%, 13.0% and 8.3% respectively. Proline gave better control of light leaf spot than all the other treatments and Prosaro was better than all the remaining products except Folicur. Overall, untreated levels were 11.2% leaf area affected and treated severity 5.3%. Disease severity was decreased progressively as dose increased from 6.1% area affected at 0.25 dose to 4.6% at full dose. Full dose was significantly more effective than half dose. Yields

showed significant differences between control in the two years, fungicide treatments, and for control x treatment x dose interactions, but not for dose. Mean yields were 3.49 t/ha in 2006 and 3.79 t/ha in 2007. Untreated yield averaged 3.45 t/ha compared with 3.67 t/ha for all treatments. Dose trends between 0.25 and full dose were from 3.64 to 3.71 t/ha. Proline (3.92 t/ha, a response of 0.47 t/ha) gave a significantly higher yield than all the other products except Prosaro (3.82 t/ha). At High Mowthorpe in 2008, light leaf spot severity was low and there were no significant differences between products or doses for disease control. Fungicides increased plant height in spring. Folicur, Caramba and Prosaro gave the highest yields, though these were not significantly different from Proline.

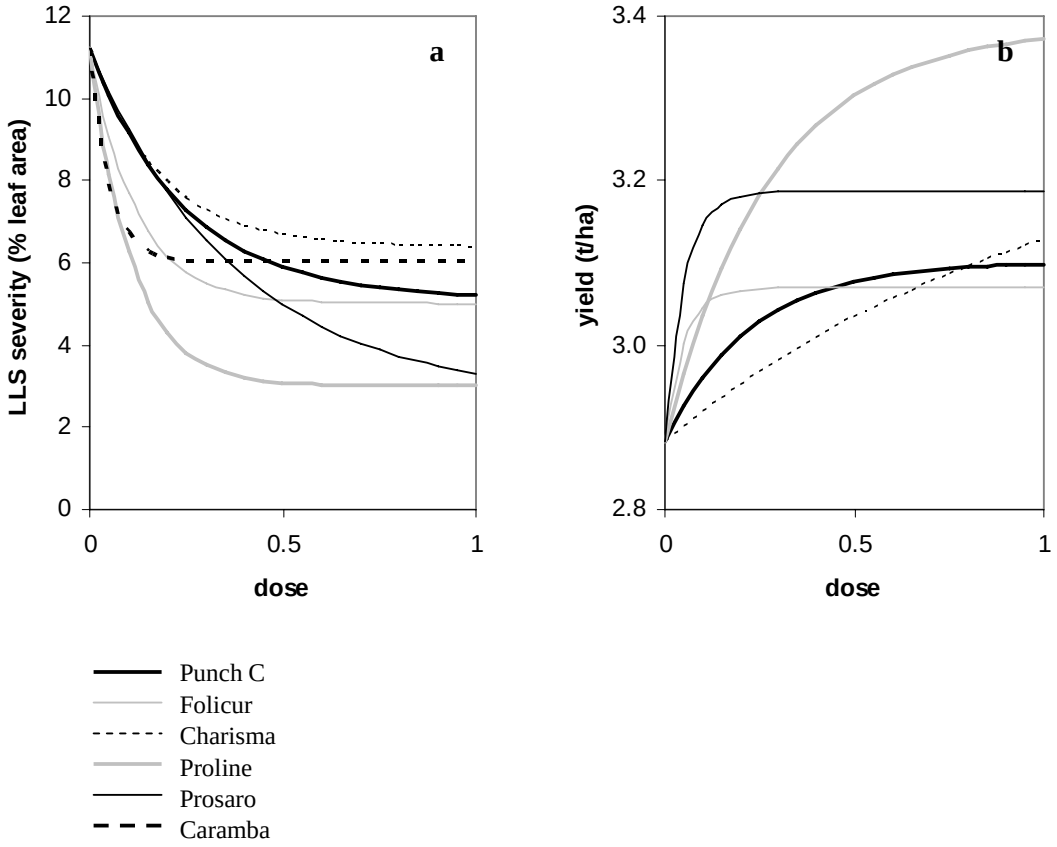

Figure 2.3: Mean data from light leaf spot trials across three years (2006-2008) at SAC, Aberdeenshire: (a) light leaf spot severity; (b) yield [curve fitting was not possible for Caramba yield].

2.4.3 Sclerotinia (Figures 2.5, 2.6)

The combined data on sclerotinia incidence from all six experiments showed highly significant effects from year, site, fungicide, dose and their interactions except for fungicide x dose interactions. Overall fungicides decreased incidence from 44% to 22%. Products were ranked in order of efficacy: Filan, Proline>Compass>Amistar, Folicur, Priori Xtra. Each increase in dose gave a significant improvement in control with incidence decreasing from 27% at 0.25 dose to 17% at full dose.

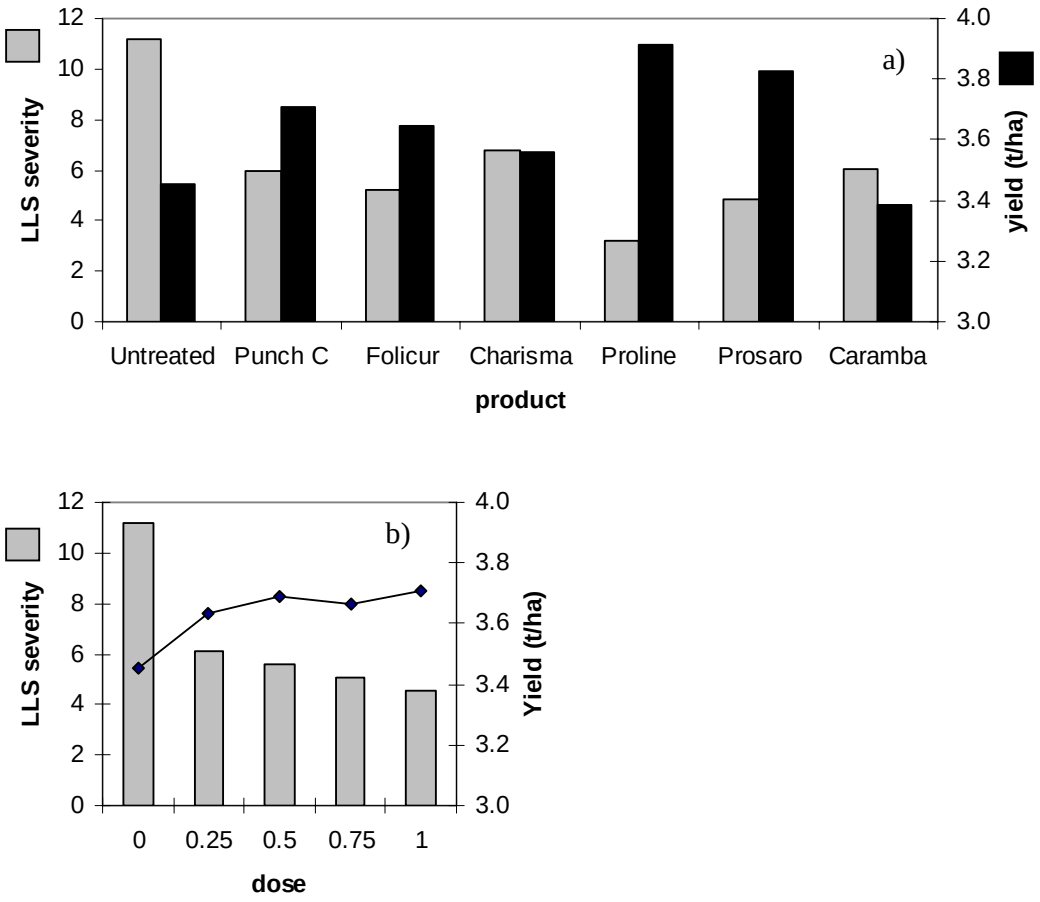

Figure 2.4: Mean data from light leaf spot trials across three years (2006-2008) at SAC, Aberdeenshire, showing light leaf spot severity (% leaf area) and yield (t/ha) (yield for 2006 and 2007 only: (a) data averaged across doses for each product; (b) data averaged across products for each dose.

The combined data on sclerotinia severity index from all six experiments showed highly significant effects from year, site, fungicide, dose and their interactions except for fungicide x dose interactions. The Hereford sites averaged 20.4 sclerotinia compared with 8.3 in Kent. Overall fungicides decreased incidence from 33.7 to 13.0.

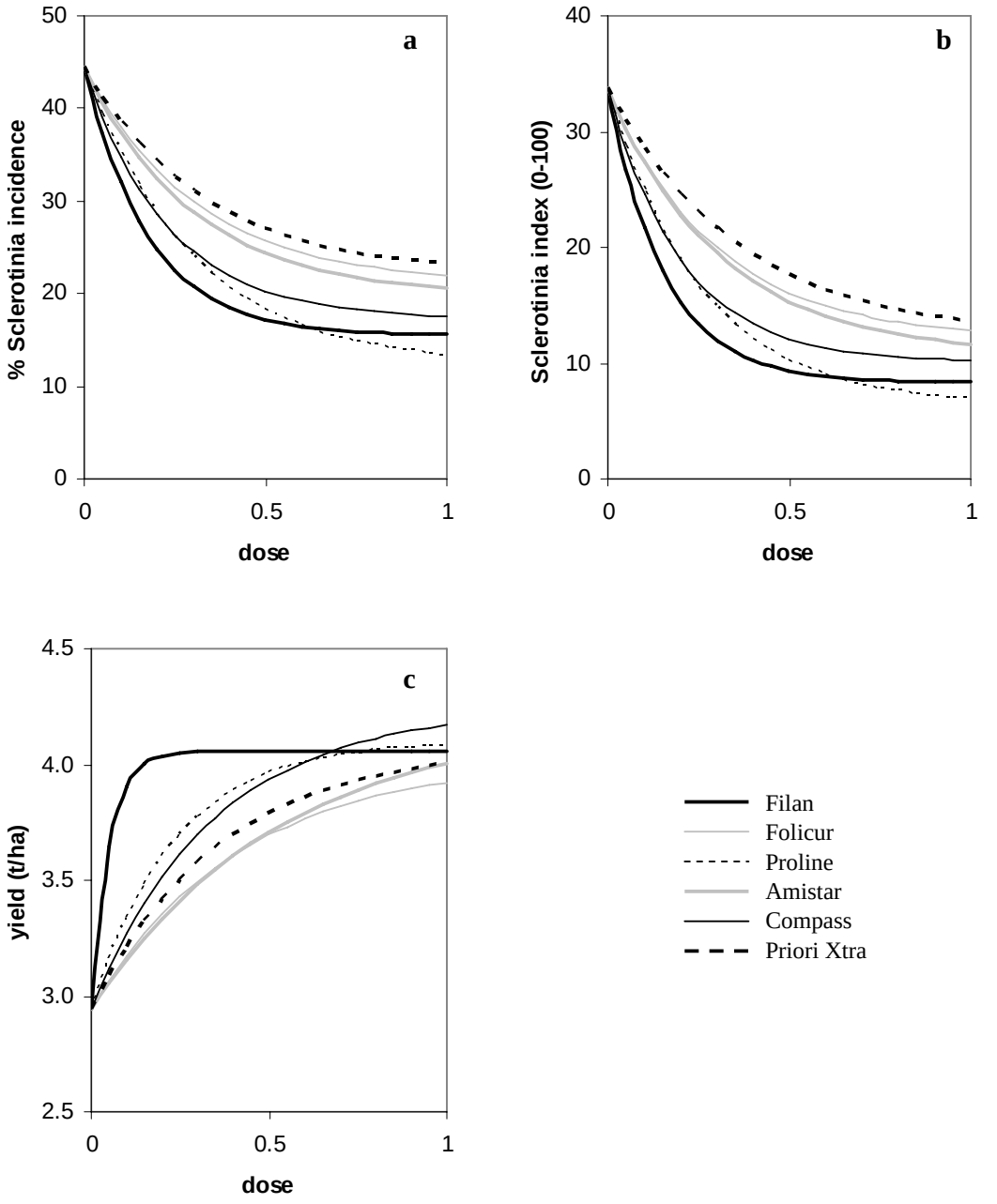

Figure 2.5: Mean data from Sclerotinia trials across three years (2006-2008) and two sites (Romney Marsh and ADAS Rosemaund): (a) Sclerotinia incidence at final assessment; (b) Sclerotinia index at final assessment; (c) yield.

Products were ranked in order of efficacy as Filan (index 9.9), Proline>Compass>Amistar, Folicur, Priori Xtra (index 17.3) – identical to the incidence data. Each increase in dose gave a significant improvement in control with index decreasing from 17.5 at 0.25 dose to 9.4 at full dose.

The yield from Hereford sites averaged 3.97 t/ha compared with 3.68 t/ha in Kent. Products were ranked in order of yield as Filan, Compass, Proline> Priori Xtra, Amistar, Folicur Each increase in dose gave a significant improvement in control up to 0.75 dose with no additional benefit at full dose. Untreated yield at the Hereford sites was 2.56 t/ha and the mean treated yield 4.07 t/ha, a response of 1.51 t/ha. Products were ranked in the order: Filan (4.36 t/ha)> Proline, Compass> Priori Xtra, Amistar> Folicur (3.69 t/ha). There were significantly increased yields with dose up to 0.75 dose and then no further increase at full dose. The responses ranged from 1.11 t/ha at 0.25 dose up to 1.74 t/ha at 0.75 dose.

There was a significant yield response overall in Kent where untreated yield averaged 3.32 t/ha and treated yield was 3.71 t/ha. There were no significant yield differences between products (range 3.64-3.76 t/ha) or doses (range 3.63-3.74 t/ha). Clearly, products performed quite differently at the Hereford site.

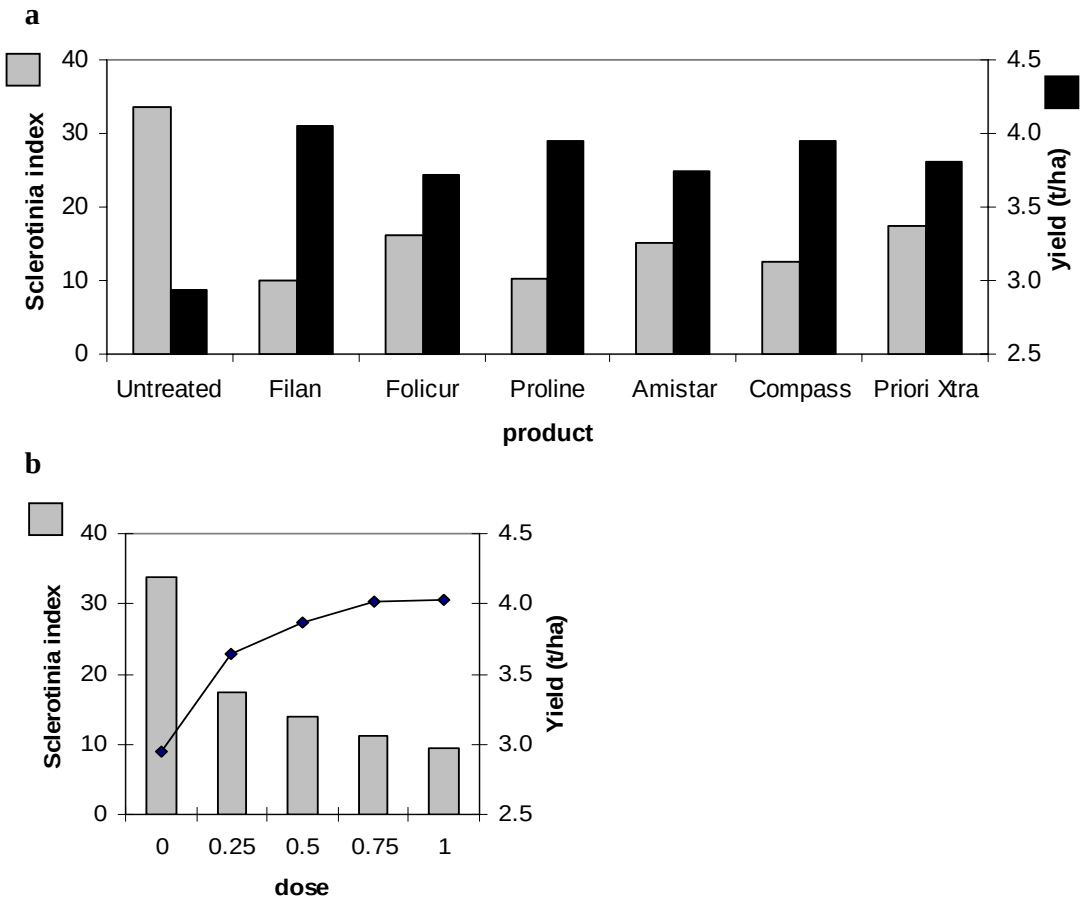

Figure 2.6: Mean data from Sclerotinia trials across three years (2006-2008) and two sites (Romney Marsh and ADAS Rosemaund), showing Sclerotinia index (0-100) and yield (t/ha): (a) data averaged across doses for each product; (b) data averaged across products for each dose.

2.5 Discussion

Products have been exposed to testing disease pressure and the project has therefore provided detailed new information on fungicide efficacy and impact on yield. There has been previous work comparing full and half doses, but no systematic study of products for a range of doses. The oilseed rape protocols with one or two fungicide applications provide valuable yield response data as other diseases are kept at low levels by site selection or oversprays. The yield effects are important as it is clear that responses relate to both disease control and physiological effects on the plant. The latter may have positive or negative effects and influence the economic benefits of treatments.

The number of experiments completed for each disease is still small and careful interpretation of yield benefits from treatments is required before selecting appropriate doses and products for use on farms. For example, the benefits from metconazole in stem canker trials were associated with stem canker control and plant growth regulatory effects on medium to large plants in autumn and these may not occur in crops where plants are small. Similarly the benefits may be larger in dry summers if treatments lead to improved rooting at depth.

Generally, a dose at 0.5 rate is robust for phoma control and this rate is widely used on farms (Garthwaite *et al.,* 2007). The data from 2006/07 provides support for use of products at 0.75 dose where crops have early infection (including cotyledons) and have disease levels well above threshold. Data for light leaf spot control are more limited, but doses of Proline should be kept about 0.5 dose for yield response. Site and variety may also be important for the economic performance of products, though the effects of these factors are often smaller than seasonal variation which is both large and difficult to predict (see PASSWORD project, Gladders *et al*., 2006).

The sclerotinia products had similar rankings for disease control under different disease pressures at the sites in Kent and Hereford. However there were differences between these sites in dose responses for yield. If products are applied under ideal conditions or low disease pressure then it may not be possible to statistically separate commercial products.

2.6 Conclusions and implications for levy payers

- Independent data are now available for disease control and yield response for the three most important diseases of winter oilseed rape: phoma stem canker, light leaf spot and sclerotinia stem rot.

- Under moderate or severe disease pressure, significant differences in product performance were evident for disease control and yield response. However, these differences were usually small. Under low disease pressure, there were no significant differences between product and no dose effects.

- The yield response data should be interpreted carefully in relation to disease development, disease severity, location, crop and environmental factors.

- Prothioconazole was identified as a significant new fungicide with strong performance against all three target diseases. It performed better than established products for light leaf spot control and yield in the Aberdeen area.

- All products gave good control of phoma leaf spot and stem canker. Caramba gave weaker control of stem canker than other products, but performed as well as established products on yield. Prosaro gave a higher yield than all other products except Proline and this was associated with pant growth regulatory effects as well as disease control.

- Whilst 0.5 dose was robust for phoma control, higher doses (0.75 dose) were beneficial against early and severe leaf spotting.

- Light leaf spot was difficult to control with autumn + late winter programmes. Yield was decreased by high doses of some products with plant growth regulatory activity in Scotland. Further data is required to define product and dose effects in England.

- Control of very severe sclerotinia stem rot gave yield responses of >2 t/ha, with 0.75-full dose being optimal for yield. Control of moderate epidemics resulted in smaller responses (c. 0.5 t/ha) and dose effects were not significant. The

economics of these treatments should also consider disease control efficacy as this affects sclerotial returns and hence future disease risk.

- Fungicides applied for sclerotinia control at early to mid-flowering did not protect crops against infection at the end of flowering. Two sprays for sclerotinia control may be required to achieve good control of sclerotinia at high risk sites.

- Up-to-date information on new products should enable strategies to protect products against the development of fungicide resistant strains to be deployed more effectively. Base-line data will enable shifts in product performance or fungicide sensitivity to be detected more readily.

- The various dose-response curves can be exploited to improve selection of fungicide treatments and improve margins over input costs.