The use of sulphur to enhance natural disease resistance in oilseed rape

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ABSTRACT

Identical factorial trials were set up in Inverness and Aberdeen, Scotland and Braunschweig, Germany to investigate the influence of sulphur nutrition on the incidence of light leaf spot on oilseed rape. The sites were very low, high and low respectively for sulphur availability. Two varieties of differing disease resistance were grown both fungicide treated and untreated at different nitrogen levels. Results over two years showed that application of sulphur to the soil increased the sulphur content of the leaves. The glucosinolate patterns and contents indicated that the sulphur metabolism of the resistant and susceptible varieties of oilseed rape were different. Application of sulphur increased glucosinolate levels but did not reduce or delay the onset of light leaf spot development.

Key Words: Sulphur-natural disease resistance-oilseed rape

INTRODUCTION

Light leaf spot (*Pyrenopeziza brassicae*) is one of the most important diseases of winter oilseed rape in the UK and northern Europe. Each year approximately £10 million are spent on fungicides in the UK to control this disease, but despite this losses in excess of £48 million are attributed to light leaf spot (Fitt *et al*., 1997). Growers in Scotland routinely apply fungicides in the autumn and spring for control of light leaf spot and yield benefits of up to 1 t/ha are possible (Sutherland, 1999). Sulphur has been used as a foliar fungicide for over 50 years but has been superseded by more effective synthetic fungicides. Adjusting the sulphur nutrition of the crop and stimulation of the plants sulphur metabolism has been shown to reduce or slow down light leaf spot infection (Booth & Walker, 1997). Work at FAL, Braunschweig, Germany suggests that disease resistance in oilseed rape is related to breakdown of the sulphur containing amino acid cysteine within the plant. Breakdown of cysteine releases H_2S, a known anti-fungal agent (Manners, 1982), which may induce resistance within the plant. It has also been shown that different varieties of oilseed rape contain different levels of L-cysteine desulfhydrase, the enzyme responsible for hydrolysis of cysteine. It has been suggested that levels of this enzyme may act as an indicator of disease resistance within the oilseed rape plant.

This paper reports on the effects of application of sulphur as a fertiliser on resistance to light leaf spot within winter oilseed rape.

MATERIALS AND METHODS

Field trials were carried out at Inverness and Aberdeen, Scotland and Braunschweig, Germany. The sites were very low, high and low respectively in terms of sulphur availability. Two varieties of winter oilseed rape were grown, Bristol (low resistance to light leaf spot) and Lipton (good resistance to light leaf spot). Treatments were two sulphur levels (0 and 100 kg S ha^{-1}), two

nitrogen levels (100 and 200 kg N ha^{-1}) and two fungicide levels (nil and 0.4 l ha^{-1} carbendazim + flusilazole in autumn and at stem extension (GS 3.5)). Sulphur was applied as K_2SO_4 to the soil and potassium balanced in other plots with KCl. Sulphur was applied in the spring in year 1 and in the autumn (50 kg S ha^{-1}) and spring (50 kg S ha^{-1}) in year 2. The trials were of a randomised split plot design, fungicide as main plot and variety x sulphur x nitrogen as sub-plots. Plots were approximately 40m^2 in size.

Disease assessments were carried out at regular intervals by sampling 10 plants per plot, incubating in a damp chamber overnight and assessing % plants and % leaf area infected with light leaf spot. In autumn and spring (pre-flowering) upper leaves were removed from 10 plants, wrapped in aluminium foil and placed in liquid nitrogen to freeze. Samples were stored at –80^oC prior to sending to Braunschweig for sulphur and glucosinolate analyses. Plots were harvested using plot combines and yields determined to 91% dry matter.

RESULTS

In 2000/2001 there was very little disease at Inverness, <1% leaf area infected with light leaf spot at stem extension (GS 3.5), and no disease at Braunschweig. At Aberdeen, on average 94.69% of plants were infected with light leaf spot at GS 3.5, with 4.53% leaf area infected. Application of sulphur had no effects on disease levels and there were no interactions between variety and sulphur. Application of sulphur in the spring increased the sulphur content of leaves (Table 1). At the low sulphur status site in Inverness, the main glucosinolates found in leaf tissues were progoitrin and glucobrassicanapin. Application of sulphur significantly increased the total amounts of glucosinolates within leaves, particularly in the susceptible variety Bristol (Table 2). Application of fungicide reduced levels of glucosinolates within leaf tissue in the resistant variety Lipton but had little effect on levels of glucosinolates within the susceptible variety Bristol.

Table 1. Sulphur content of leaves at stem extension in relationship to S supply.

		S content (mg g^{-1})			
		2000/2001		2001/2002	
		0 kg S ha^{-1}	100 kg S ha^{-1}	0 Kg S ha^{-1}	100 kg S ha^{-1}
Aberdeen	Lipton	6.2	6.8	4.16	7.68
	Bristol	6.2	9.0	4.21	7.81
Inverness	Lipton	3.6	6.8	3.48	7.57
	Bristol	3.4	7.0	3.44	7.78
Braunschweig	Lipton	4.0	8.8	-	-
	Bristol	4.2	11.5	-	-

Table 2. Relationship between S nutrition and fungicide application on glucosinolate content of younger leaves of oilseed rape, Inverness 2001.

	GSL content µmol g^{-1}	
	Lipton	Bristol
0 kg S ha^{-1}	6.09	5.61
100 kg S ha^{-1}	7.37	8.43
No fungicide	7.99	7.28
With fungicide	5.47	6.77
LSD ($p \leq 0.05$)	1.00	1.21

In 2001/2002, application of sulphur in the autumn did not delay the onset of light leaf spot and encouraged the onset of disease in the susceptible variety Bristol (Figure 1). Spring application

of sulphur had no effects on light leaf spot levels and there were no interactions between variety and sulphur. Fungicide still provided significant benefit for disease control.

In both seasons, yield responsiveness to sulphur varied according to the deficiency of the site, with the very low site giving a response of more than 0.8 t/ha (Table 3). There was a significant nitrogen sulphur interaction where responsiveness to nitrogen depended on adequate sulphur supply.

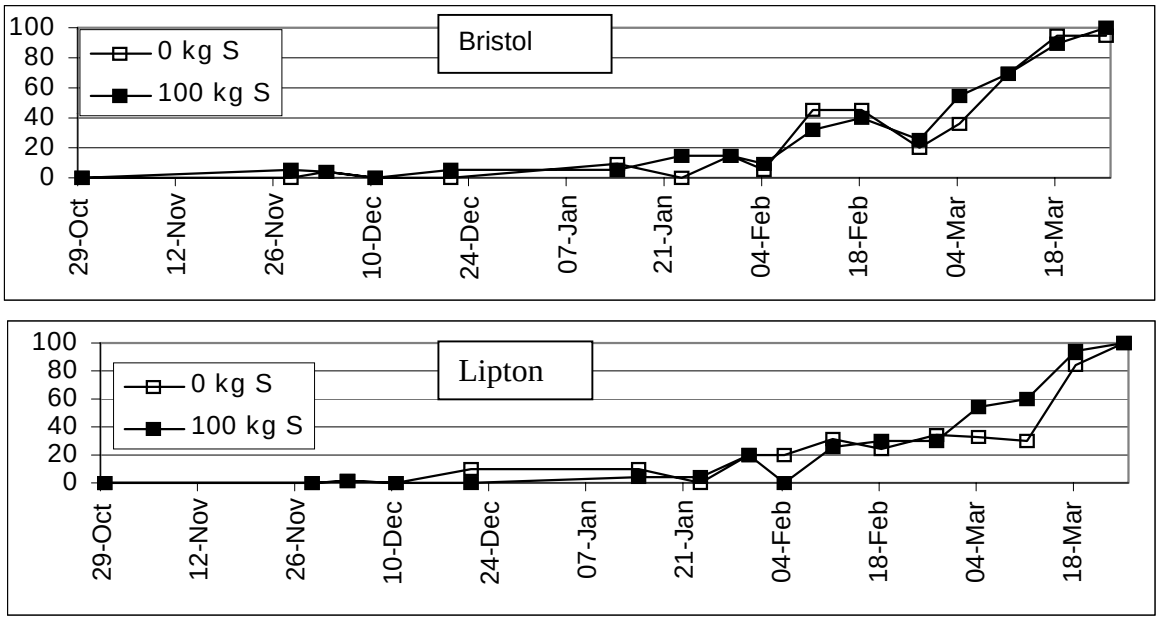

Fig. 1. Effect of sulphur on the progress of light leaf spot development

Table 3. Yield of winter oilseed rape in response to sulphur application

			Yield t/ha					
	Kg S ha-1	Kg N ha-1	Ab 01	Inv 01	Br 01	Ab 02	Inv 02	Mean
Bristol	0	100	2.658	2.209	3.150	2.606	2.154	2.555
	0	200	3.609	2.530	3.320	2.891	2.373	2.945
	100	100	2.941	2.517	3.416	2.689	2.074	2.727
	100	200	3.666	3.377	3.586	3.234	2.409	3.254
Lipton	0	100	3.380	2.246	3.230	2.833	2.053	2.748
	0	200	4.292	2.674	3.648	3.949	2.634	3.439
	100	100	3.304	2.367	3.530	3.110	2.334	2.929
	100	200	4.539	3.196	3.816	3.641	2.666	3.572
LSD ($p \leq 0.05$)			0.454	0.220	0.312	0.361	0.265	-

DISCUSSION

Application of sulphur to the soil increased the sulphur content of leaf tissue of oilseed rape but did not delay or reduce infection with light leaf spot. Foliar applied sulphur has been used as a fungicide for over fifty years against diseases such as *Erysiphe graminis* in barley, the sulphur having a direct effect on the fungus (Carlile, 1995). Application of sulphur to the soil as a fertiliser did not reduce disease in oilseed rape in these trials, indicating that soil applied sulphur did not have a direct effect on the light leaf spot fungus. Schnug (1997) suggested that soil applied sulphur

is used by the plant to manufacture sulphur containing amino acids such as cysteine. Hydrolysis of cysteine by the enzyme L-cysteine desulfhydrase releases H_2S, a natural anti-fungal compound within plants. Schnug (1997) suggested that release of H_2S could induce resistance to light leaf spot within oilseed rape. If the soil applied sulphur was incorporated into cysteine within this study then any subsequent release of H_2S did not induce resistance to light leaf spot within the two varieties used.

The seeds and leaves of oilseed rape crops contain bioactive molecules, the glucosinolates, and the enzyme myrosinase. In the presence of myrosinase, glucosinolates are degraded into various derivatives, some of which have anti-fungal and insecticidal activity (Bagger *et al*, 1999). In this present study the glucosinolate patterns and contents of leaves indicated that the sulphur metabolism of the resistant and susceptible varieties of oilseed rape were different. Application of sulphur to the soil increased glucosinolate levels within the leaves of oilseed rape plants but did not induce resistance to the light leaf spot fungus.

It is suggested that at the low sulphur site, where sulphur induced resistance and differences in disease levels may have been expected, any effects of increased levels of sulphur and glucosinolates were not apparent due to the very low disease levels. At the high sulphur site, where disease was present, sulphur application would not induce the same differences in resistance to disease within the plant as sulphur levels in the non-S treatment were sufficiently high.

CONCLUSION

Application of sulphur to the soil increased the sulphur and glucosinolate content of oilseed rape leaves but did not reduce light leaf spot infection. Results from these trials suggest soil applied sulphur did not induce resistance to light leaf spot within the oilseed rape crop, but this may be due to very low disease levels at the low sulphur site preventing effects from being apparent.

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