EFFECTS OF FUNGICIDES AND DISEASE ON GROWTH PARAMETERS AND SEED GLUCOSINOLATE CONCENTRATION OF OILSEED RAPE.

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INTRODUCTION

A series of field trials at Rothamsted in consecutive seasons (1987-88 to 1989-90) investigated the susceptibility to disease and the crop protection requirements of new double-low oilseed rape cultivars. In some seasons, fungicide applications significantly decreased the concentration of glucosinolates in seed but whether this was because of a direct effect of fungicides on the crop or to the control of disease was uncertain. Therefore, in a separate experiment in 1989-90, either fungicides or inoculum of the common pathogen Alternaria brassicae were applied to pot-grown plants of cv. Ariana at various times, and their independent effects on plant growth and seed glucosinolate concentration were measured. The effects of the timing and number of fungicide applications on growth and seed glucosinolates was tested in an associated field experiment in 1989-90.

MATERIALS AND METHODS

Seed glucosinolate concentrations were analysed in each of five experiments at Rothamsted between 1987 and 1990. In Expts. I and II, done in 1987-88 and 1988-89, respectively, various combinations of standard fungicides and insecticides were applied to six cultivars of oilseed rape. These field experiments have been described previously by Rawlinson et al. (1989). Brief details of the 1989-90 field experiments (Expts. III and IV) are given in Table 1. Full details of all four field experiments are given elsewhere (Rothamsted Experimental Station 1988; 1989; 1990a; 1990b).

In the 1989-90 pot-grown plant experiment (Expt. V, Table 1) seeds of cv. Ariana were germinated in John Innes compost in seed trays and four seedlings later transplanted to each of eighty-four 23-litre plastic pots containing a 50:50 mixture of peat-based compost and Kettering loam. All measurements were made on 12 replicate pots placed outside in a glass-roofed wire-mesh cage. Plants were either left untreated, sprayed with fungicide at rates equivalent to those used in the field or inoculated with a mycelial suspension of Alternaria brassicae in Oxoid malt extract broth in autumn, spring and summer (Table 1), at times corresponding to treatments to field crops.

In Expts. I to III, seed glucosinolates were analysed by the Food Research Institute glucose-release method (Heaney, Spinks, Hanley and Fenwick 1986) and in Expts. IV and V by X-Ray fluorescence (Schnug and Haneklaus 1988).

Table 1 Field and pot-plant experiments (III - V) 1989-90

III. Field experiment

Cultivars: Capricorn, Cobra, Lictor, Libravo, Score and Tapidor.

Treatments: fungicide treated (+F = prochloraz in autumn and spring and iprodione in summer), or no fungicide (-F).

Basal sprays of insecticide ('Decis') and herbicide ('Fusilade' and 'Butisan') were applied in autumn. Plots were not irrigated.

Design: 6 x 2 x 4 replicates

IV. Field experiment

Cultivars: Ariana, Bienvenu and Tapidor.

Treatments:

---	no fungicides
--Su	summer (iprodione)
-SpSu	spring (prochloraz) and summer (iprodione)
Au--	autumn (prochloraz)
AuSp-	autumn and spring (prochloraz)
AuSpSu	autumn, spring (prochloraz) and summer (iprodione).

Basal sprays of insecticide ('Decis') and herbicide ('Fusilade' and 'Butisan') were applied in autumn. Plots were irrigated.

Design: 3 x 6 x 3 replicates

V. Pot-plant experiment

Cultivar: Ariana

Treatments:

	Fungicide applications	Inoculations with Alternaria brassicae
---	untreated	
Au --.	autumn (prochloraz)	autumn
AuSp-	autumn and spring (prochloraz)	autumn and spring
AuSpSu	autumn, spring (prochloraz) and summer (iprodione).	autumn, spring and summer

Basal insecticide (pirimicarb) was applied in spring.

Design: 7 x 12 replicates

RESULTS

The principal diseases on plants in Expts. I - IV were light leaf and pod spot (*Pyrenopeziza brassicae*), dark leaf and pod spot (*Alternaria brassicae*), downy mildew (*Peronospora parasitica*) and leaf spot and stem canker (*Phoma lingam*, perfect state = Leptosphaeria maculans). Disease incidence was high in Expts. I and IV, but low in Expts. II and III, probably because the latter experiments were not irrigated and the seasons were dry. In Expt. V, all plants had superficial colonies of powdery mildew (Erysiphe cruciferarum), but remained free from other diseases except where inoculated with A.brassicae.

Seed glucosinolate concentrations were significantly decreased by fungicide treatment in Expt. I, and by the full combination of autumn, spring and summer treatments in Expt. IV, but in Expts. II and III concentrations were high in seed from all plots and there were no treatment effects (Tables 2 and 3). In Expt. V, seed glucosinolate concentrations were very variable and there were no significant differences between treatments (Table 4).

Table 2 Seed glucosinolate concentration (μmol g^{-1} at 9% moisture) of oilseed rape cultivars with (+F) and without (-F) fungicide treatment, in field Expts. I - III, 1988-90.

	1987-88		1988-89		1989-90	
	+F	-F	+F	-F	+F	-F
Bienvenu[1]	54.1	41.5	43.2	51.5	-	-
Ariana	30.3	21.0	43.1	32.0	-	-
Capricorn	16.8	13.6	18.8	18.8	23.2	21.9
Cobra	20.8	17.5	25.4	27.6	29.3	25.1
Corvette	16.8	18.6	-	-	-	-
Cosmic	14.0	15.2	-	-	-	-
Librav o	-	-	25.9	23.7	31.4	28.8
Lictor	-	-	-	-	30.2	31.8
Score	-	-	-	-	28.9	30.3
Tapidor	-	-	16.4	17.6	24.5	28.3
S.E.D.	2.32		7.32		3.04	
Mean	25.5	21.2	28.8	28.5	27.9	27.7
S.E.D.	0.85		2.98		1.24	

[1] single-low cultivar

Table 3 Effect of timing and number of applications of fungicide on the glucosinolate concentration (μmol g^{-1} at 9% moisture) in the seed of oilseed rape cultivars, Expt. IV.

Cultivar	Timing of treatments					
	---	--Su	-SpSu	Au--	AuSp-	AuSpSu
Bienvenu[1]	66.87	64.90	63.23	63.43	65.53	58.93
Ariana	24.50	21.50	24.37	21.87	21.60	19.27
Tapidor	5.33	4.67	3.43	2.87	2.63	4.93
SED	3.56					
Mean	32.23	30.36	30.34	29.39	29.92	27.71
SED	1.58					

[1] single-low cultivar

Table 4 Glucosinolate concentration (μmol g^{-1} at 9% moisture) in the seed of pot-grown cv. Ariana after fungicides applied at different times and frequencies or inoculations with Alternaria brassicae, Expt. V.

Timing of Treatment	Control	Fungicide treated	Inoculated
---	25.43	-	-
--Su	-	28.11	28.49
-SpSu	-	25.38	27.23
AuSpSu	-	27.21	27.57

SED = 2.398.

Fungicides affected some aspects of crop growth, both in the field and when applied alone to pot-grown plants. Autumn and spring applications in Expts. IV and V increased the number of leaves retained by plants and plant height on 10-11 May (Table 5), at growth stage 6.1 - 6.2 (Sylvester-Bradley 1985) although height at harvest was unaffected by treatment. Pod maturation was delayed by fungicides in both experiments.

Table 5 Effect of fungicide applications on leaf number and plant height in field- and pot-grown plants, Growth stage 6.1 - 6.2 (experiments IV and V).

Timing of Treatment[1]	Plant height (cm)		Leaves per plant	
	Field	Pot-grown	Field	Pot-grown
---	109.7	159.3	4.67	11.80
--Sp	107.0	160.1	4.94	14.58
AuSp	111.4	166.8	5.71	15.40
SED	2.61	3.32	0.43	0.58

[1]Measurements were taken before the summer fungicide application

DISCUSSION

The effects of fungicides on seed glucosinolate concentration in field-grown crops varied between seasons and experiments. When disease incidence was high, as in Expts. I and IV, fungicides significantly reduced glucosinolate concentrations. This is compatible with observations that pathogen infection and pest damage cause glucosinolates to accumulate in oilseed rape leaves (Doughty et al 1991) and seed (Lammerink et al. 1984). However, disease incidence was low in Expts. II and III and the main stress experienced by plants was drought. Seed glucosinolate concentrations are increased by pre- and post-flowering periods of water stress (Mailer and Cornish 1987), so the effects of drought may have masked the effects of pests, diseases and crop protection.

The absence of treatment-effects in Expt. V contrasts with the response to fungicide applications in Expts. I and IV and with the accumulation of glucosinolates in infested and infected plants in other studies. However, Stovold, Mailer and Francis (1987) found no relationship between the level of Alternaria-contamination in seed and glucosinolate content. The large variation in concentrations within similarly-treated groups of pot-grown plants (Expt. V) may indicate that plants grown under these conditions are not suitable for this type of study. However, fungicides did accelerate stem extension and delay the onset of senescence in leaves and pods, indicating that the observed effects of applications on the growth of oilseed rape in the field (Rawlinson et al. 1988; Ballinger et al. 1988) may be due in part to properties of the chemicals themselves, rather than entirely to the control of disease.

The effects of fungicides on crop growth are likely to be attributable to prochloraz, which is structurally related to growth regulating chemicals which are applied to oilseed rape to shorten stems and lateral racemes. One of these growth regulators, triapenthenol, also reduces the incidence of Alternaria in field plots, apparently through fungicidal activity because it changes canopy structure in a way that would otherwise encourage infection (Child et al. 1988). It appears that possession of both growth-regulatory and fungicidal activities may be a common feature of triazole-related compounds, although the effect on crop growth varies. Prochloraz, like flutriafol, another azole fungicide (Ballinger et al. 1988), temporarily increases height, rather than shortening the stem.

Our results have shown that fungicides, as well as improving yield (Williams, Doughty, Bock and Rawlinson 1991), can also improve seed quality by decreasing glucosinolate concentrations in seasons when disease is prevalent.

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