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Agronomic factors influencing the glucosinolate content of double-low winter-sown oilseed rape in the United Kingdom

E.J. EVANS and P.E. BILSBORROW
Agriculture Department, University of Newcastle-upon-Tyne
and
G.F.J. MILFORD, J.E. FIELDSEND, A.J.R. PORTER and C.J. RAWLINSON
AFRC Institute of Arable Crops Research, Rothamsted Experimental Station

Summary

Material from well-established programmes of agronomic experiments on winter-sown oilseed rape at two sites in the UK has been used to examine the influence of agronomic and husbandry practices on the concentrations of glucosinolates in the harvested seed. The major conclusion is that most agronomic practices have relatively little effect and that practices used by growers to maximise productivity in terms of yield are unlikely to be deleterious in terms of glucosinolates in double-low cultivars.

Introduction

Commercial production of double-low winter-sown oilseed rape in the United Kingdom commenced in 1987 with the introduction of the German bred variety, Ariana. This accounted for approximately 15% of the total rapeseed area in the first year, but further introductions of the varieties Cobra and Libravo has resulted in a rapid increase in the sowing of double-low rapeseed which now occupies 95% of the UK winter-sown area. There is limited commercial experience of the growing of double-low material, but the considerable body of data obtained from the trials of the National Institute of Agricultural Botany shows that significant site and seasonal variations occur in the levels of glucosinolates in seed (Kimber, 1988). However, part of this variation could result from changes in agronomic inputs from one trial site to another.

To establish the importance of different agronomic practices on seed glucosinolates, a programme of research was initiated and funded by the Ministry of Agriculture, Fisheries and Food at the University of Newcastle-upon-Tyne and the AFRC Institute of Arable Crops Research, Rothamsted. This paper presents the results from the first year of this programme (1987/88), but data from 1986/87 are included where appropriate.

Multifactorial Experiments

The variety Ariana was introduced into Rothamsted's ongoing series of multifactorial oilseed-rape experiments previously described by Rawlinson (1985). These experiments are designed to test a wide range of agronomic inputs on yield and glucosinolate content, but only data on glucosinolates are presented in Table 1 and, since there were no interactions between factors, only the effects of main factors are given.

As expected the glucosinolate conentrations in the seed of the single-low (Bienvenu) and double-low (Ariana) varieties differed, but they were not significantly altered by any of the factors, at the levels tested, in this experiment. The mean glucosinolate concentrations, averaged over all factors, were 28.2 μmol g^{-1} at 9% moisture for Ariana and 66.1 μmol g^{-1} for Bienvenu.

Table 1. Effects of husbandry practices on total glucosinolate (GLS) concentrations (μmol g^{-1} at 9% moisture) in seed of the cvs Ariana and Bienvenu at Rothamsted in 1987/88.

Treatment		Bienvenu GLS	Ariana GLS	SED
Sowdate:	Mid August	66.2	30.8	
	Early September	65.9	25.6	3.97
N appl^{n}:	Single	70.9	28.0	
	Divided	61.2	28.3	3.97
PGR:	None	62.4	27.1	
	Triapenthenol	69.7	29.2	3.97
Fungicide:	None	64.3	29.0	
	PR+IP*	67.8	27.4	3.97

*Prochloraz in autumn and spring and iprodione in summer

A comparable trial at Newcastle examined the effects of the plant growth regulator, Triapenthenol, and a pest and disease control programme on seed glucosinolate concentrations in four varieties (Table 2). Here again, although glucosinolate concentrations differed between varieties, neither the PGR treatment nor the control of pests and diseases significantly influenced glucosinolate concentrations.

Table 2. Glucosinolate concentrations (μmol g^{-1} at 9% moisture) in seed of different cultivars given different PGR and pest and disease control treatments at Newcastle in 1988.

	Bienvenu	Cobra	Libravo	Ariana
No control measures	59.5	17.5	21.9	27.0
Fungicide + insecticide*	57.6	18.7	18.1	30.5
No PGR	59.9	18.1	20.6	30.5
Triapenthenol	57.1	18.1	20.1	26.9

SED: Cv x F+I = 2.09; Cv x PGR = 2.09
*Prochloraz + deltamethrin

Plant Population

The effect of altering plant population was tested using seed harvested from a seed rate x row width experiment at Rothamsted in 1986/87. Large differences in plant structure and evenness of pod maturity were observed, but these changes did not result in differences in glucosinolate concentrations in the seed at harvest (Table 3). Similar results were obtained from a trial with Ariana at Newcastle, where a range of plant populations was examined for a standard 18 cm row width (Table 4). Seed yield also was not significantly influenced by plant population. There was no evidence of contamination by single-low volunteers in either of these trials.

Table 3. Glucosinolate concentrations (μmol g^{-1} at 9% moisture) in seed from crops of the cv. Ariana grown at varying seed rate and row spacings at Rothamsted in 1987.

		Rowspace (cm)			
		17.5	35.0	52.5	Mean
Seed rate kg ha^{-1}	4	30.6	31.1	31.9	31.2
	6	31.3	30.7	29.8	30.6
	8	31.5	30.8	29.4	30.6
Mean		31.2	30.9	30.4	

SEDs: Rowspace = 1.56; Seedrate = 1.56; R x S = 2.09

Table 4. Effects of plant population on yield (t ha^{-1} at 9% moisture) and on glucosinolate concentrations in seed (μmol g^{-1} at 9% moisture) at Newcastle in 1988.

Number of plants m^{-2}	Seed yield	Glucosinolate concentration
23	3.9	25.6
45	3.8	28.7
76	3.7	28.9
SE	0.16	3.22
	NS	NS

Amount of Nitrogen

Two experiments, one at each site, which examined the effect of nitrogen on the cv. Ariana showed that applications of nitrogen within the range 0 to 150 kg N ha^{-1} increased the concentration of glucosinolates in seed by 5 to 6 μmol g^{-1} (Figure 1). At Rothamsted, the form of the response was modified by the seed rate used. When a high seed rate of 16 kg ha^{-1} was used there was no change in seed glucosinolate concentrations with increments of nitrogen above 150 kg ha^{-1} and the response curve was similar to that observed at Newcastle. A smaller seed rate of 8 kg ha^{-1}, on the other hand, resulted in a pattern in which seed glucosinolate concentrations increased with each increment of nitrogen up to the highest rate applied. This suggests that seed glucosinolate concentrations are probably influenced more by the amounts of nitrogen taken up by individual plants than by the total amount applied to the crop. Clearly, the physiological basis for this varying response to nitrogen requires further study.

Time of Nitrogen Application

Spring applications of nitrogen to winter-sown oilseed rape are normally made in the UK as split dressings with 50 to 80 kg N ha^{-1} being applied between late February and early March and the main top dressing of 150 to 180 kg N ha^{-1} being applied in late March. A trial at Newcastle investigated, in four varieties, the effects on the levels of glucosinolates in seed of delaying the main top dressing (Table 5). As expected there were significant differences between the glucosinolate concentrations of the four varieties, but the concentrations were not affected by varying the time at which the main top dressing was applied.

Table 5. Effect of nitrogen timing on the glucosinolate concentrations (μmol g^{-1} at 9% moisture) in the seed of different varieties at Newcastle in 1988.

Date and amount of N		Cultivar Ariana	Bienvenu	Cobra	Libravo	N Time means
3 March	80					
30 March	160	36.5	71.3	19.8	20.3	37.0
3 March	80					
21 April	160	37.7	72.6	22.0	24.3	39.2
3 March	80					
5 May	160	37.9	70.9	22.4	19.6	37.7
Cultivar means		37.4	71.6	21.4	21.4	

SEDs: Cultivars = 3.16; N Time = 2.74

Sulphur Application

Schnug (1988) has demonstrated that the sulphur metabolism of double-low varieties of oilseed rape differs significantly from that of single-low types. The majority of sulphur trials in the UK on winter-sown oilseed rape have been done with single-low varieties and few have examined the effects of applications of sulphur in spring on the levels of glucosinolates in seed.

In a trial at Newcastle in 1988, two equal dressings of nitrogen, each of 120 kg ha^{-1}, were applied in late February and late March as either ammonium nitrate (containing no S) or ammonium sulphate (containing 24% S). Each application of ammonium sulphate supplied 127 kg S ha^{-1}. Glucosinolate concentrations in the seed ranged from 20 to 30 μmol g^{-1} and were increased, on average, by 1.5 μmol g^{-1} by each 50 kg S ha^{-1} applied (Figure 2).

Seasonal Variation

The glucosinolate concentrations of seed from crops grown from a common seed stock and with identical husbandry over a three year period at Newcastle showed considerable variation from one season to another (Table 6). As the glucosinolate concentrations of the seed that was sown did not vary from one year to the next, the variation in concentrations in the harvested seed is wholly attributable to the seasonal differences in the growing environment. The basis of this seasonal variation is the subject of more intensive investigation.

Table 6. Variation in the glucosinolate concentrations (μmol g^{-1} at 9% moisture) of seed harvested from crops of different varieties grown in successive years from a common stock of seed.

Variety	Seed sown	Seed harvested 1986	1987	1988
Liradonna	-	27.2	20.3	25.4
Darmor	34.0	26.2	16.7	31.9
Ariana	-	-	27.9	29.9
Santana	22.0	-	19.3	26.5

Fig. 1. Effects of increasing applications of fertiliser N on glucosinolate concentrations (μmol g^{-1} seed at 9% moisture) in crops of the cv. Ariana grown in 1988 at Newcastle at the standard seed rate (●) and at Rothamsted using seed rates of 8 (○) and 16 (□) kg ha^{-1}. The dashed vertical bar represents the SED for the seed rate x N rate interaction at Rothamsted.

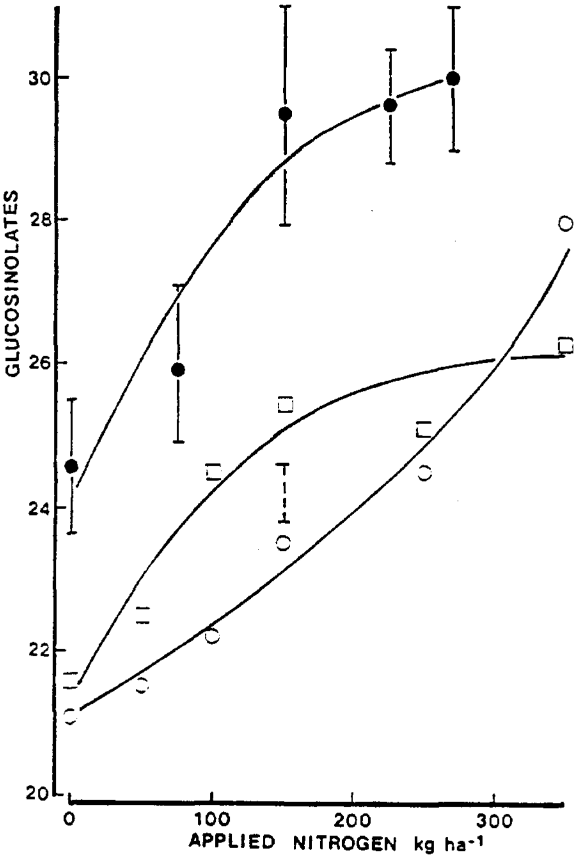

Fig. 2. Effects of the time and rate of sulphur application on glucosinolate concentrations (μmol g^{-1} seed at 9% moisture) of a crop of the cv. Ariana grown at Newcastle in 1988.