CHANGES IN THE INDIVIDUAL GLUCOSINOLATE PROFILE OF DOUBLE LOW OILSEED RAPE AS INFLUENCED BY SPRING NITROGEN APPLICATION.

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ABSTRACT

Application of spring nitrogen fertiliser significantly increased total seed glucosinolate content. Progoitrin was the major glucosinolate present and accounted for 50% of the total.Increases in progoitrin occured at the expense of glucobrassicanapin which declined from 16.3 to 10.7% of the total in response to 250 kg N/ha. The increases in total glucosinolate content and progoitrin are viewed in terms of the balance between primary and secondary metabolism and the favoured hydroxylation to form progoitrin in the alkenyl glucosinolate biosynthetic pathway.

INTRODUCTION

A reduction in total seed glucosinolate content is desirable because the presence of the S-containing secondary plant metabolites restricts the use of rape meal in animal feed due to reduced palatability, goitrogenic and other toxic effects. Variation in the profile can also alter the quality of the meal as the hydrolysed products derived from the different glucosinolates differ in their deleterious effects on animal growth and performance. Evidence suggests that 2-hydroxybut-3-enyl (progoitrin), producing vinyloxazolidine-2-thione upon hydrolysis, is one of the most harmful glucosinolates giving rise to severe goitrogenic effects (Vermorel *et al* 1986). Application of sulphur fertiliser has previously been shown to increase total seed glucosinolate content (Zhao *et al* 1994) and in particular the alkenyl glucosinolates. However, experiments examining the influence of N on total seed glucosinolate content have produced inconsistent results (Josefsson 1970, Forster 1978 and Chalmers 1989). The aims of this experiment are to examine the effects of application of spring N on total content and the profile of individual glucosinolates of low glucosinolate rapeseed.

EXPERIMENTAL

In the 1989-90 season an experiment was established to examine the effect of six rates of spring N (0, 50, 100, 150, 200, and 250 kg/ha as ammonium nitrate) applied to the double low cultivar Cobra at the University of Newcastle-upon-Tyne Experimental Farm, Cockle Park, Northumberland. The trial was a randomised block design replicated four times. Nitrogen application was split with 50 kg/ha applied on 16 March and the remainder on 27 March. The concentrations of individual glucosinolates were determined by high-performance liquid chromatography. Total glucosinolate concentrations were attained by summation of the seven major individual glucosinolates; but-3-enyl (gluconapin), 2-hydroxybut-3-enyl (progoitrin), pent-4-enyl (glucobrassicanapin), 2-hydroxypent-4-enyl (gluconapoleiferin), indol-3-ylmethyl (glucobrassicin), 4-hydroxyindol-3-ylmethyl (4-hydroxy-glucobrassicin) and 2-phenylethyl (gluconasturtiin).

RESULTS and DISCUSSION

Application of spring nitrogen increased seed glucosinolate concentration by an average of 2 μmoles per 50 kg N/ha applied between the range of 0 and 250 kg/ha (Fig 1). Progoitrin accounted for 50-55% of the total glucosinolate content (Table 1), and its increase in response to nitrogen application accounted for two-thirds of the increase in total seed glucosinolate content. There were small increases in the concentrations of gloconapin, gluconapoleiferin and 4-hydroxy-glucobrassicin in response to increasing N, but the concentration of glucobrassicanapin remained unaltered.

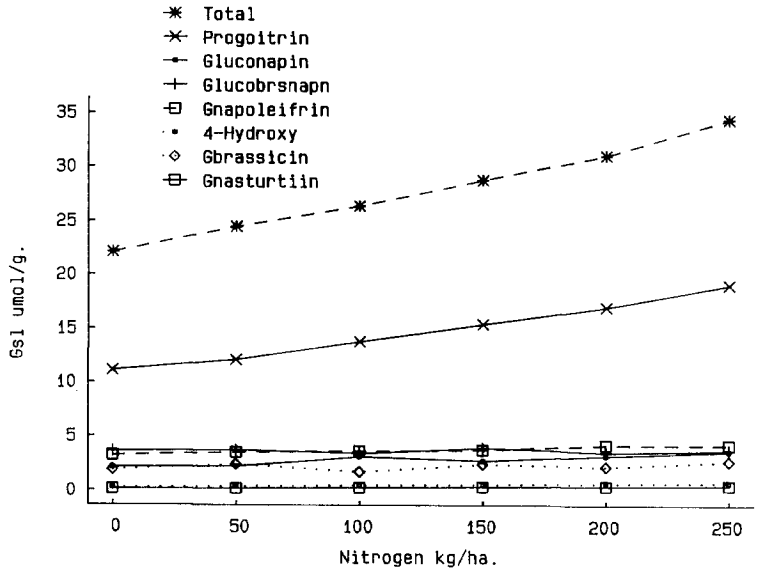

Fig 1 The influence of N on concentrations of individual glucosinolates.

Glucobrassicin and gluconastuurtin were present in very small concentrations and accounted for less than 2% of total seed glucosinolate content. The increase in progoitrin as a proportion of total seed glucosinolate content was at the expense of glucobrassicanapin which was reduced from 16.3 to 10.7% of the total in response to increasing N.

Table 1 Influence of spring nitrogen application on the relative proportions of individual glucosinolates in the seed of double low oilseed rape.

	---------- N rate kg/ha --------						
	0	50	100	150	200	250	SE
Progoitrin	50.2	49.4	52.3	53.5	54.7	55.4	0.64
Gluconapin	9.5	9.0	11.7	9.4	10.3	10.4	0.69
Glucobrassicanapin	16.3	15.1	12.9	13.5	11.3	10.7	0.98
Gluconapoleiferin	8.6	9.8	6.4	8.3	7.1	7.8	0.59
Glucobrassicin	1.1	1.5	1.8	1.8	2.1	2.1	0.11
4-OHGlucobrassicin	14.5	14.3	13.6	12.8	13.5	12.2	0.75
Gluconasturtiin	0.5	0.7	0.9	1.0	1.2	1.4	0.15

The effects of nitrogen on seed glucosinolate content observed in the literature are inconsistent. A reduction in seed glucosinolate content in response to N can partly be explained by a dilution effect whereby N increases seed yield and therefore reduces seed glucosinolate concentration (Holmes 1980). Increasing N may also reduce the amount of glucose available for glucosinolate biosynthesis as was postulated by Josefsson (1970). In contrast a strong positive influence of N was found in this study and as amino acids are precursors for glucosinolate biosynthesis (Josefsson 1970) the data presented here suggests that increasing N increases the amount of N available for amino acid and glucosinolate biosynthesis. However when S is deficient then increasing N may lead to a greater part of the N being utilised for primary metabolism (i.e. protein synthesis) and a suppression of glucosinolate biosynthesis would occur.

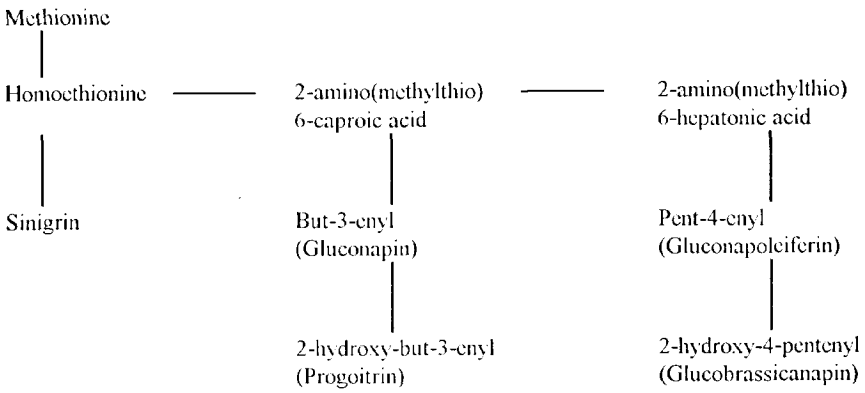

Fig 2 Pathway for alkenyl glucosinolate biosynthesis.

Application of N favoured the formation of progoitrin, which was increased in absolute terms and also relative to glucobrassicanapin. This can be explained with reference to the schematic pathway for alkenyl glucosinolate biosynthesis (Fig 2). Increasing N favours formation of the but-3-enyl compounds and in particular the hydroxylation of gluconapin to progoitrin. It is generally regarded that the level of progoitrin and to a lesser extent gluconapin in rapessed is the major limitation to the increased utilisation of the meal as a source of protein in animal diets.

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