INFLUENCE OF SULPHUR SUPPLY ONTO GLUCOSINOLATE CONTENT OF RAPESEED

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INTRODUCTION

The sulphur supply of rapeseed has lately become a more frequent point of discussion here in Germany, because due to a considerable reduction of sulphur in the atmosphere in some places, particularly in Schleswig-Holstein, a lack in the sulphur supply of rapeseed could be stated (Schnug 1986, 1987, 1988, 1989)

Please note the following pot test; the sulphur application was increased, the glucosinolates (GSL) in the green matter and in the seed were analysed in order to answer the following questions:

a) What kind of effect has the S-application on the GSL-content in green matter during the various vegetative stages ?
b) In which vegetative stage is the GSL- or rather the S-content an indicator for the seed yield ?
c) Which sulphur concentration is likely to bring about a quality reduction due to an increase of the GSL content in the seeds ?

MATERIAL AND METHODS

Four common German varieties of winter rapeseed, i.e. 'Belinda' (0), 'Arabella' (00), 'Ceres' (00) and 'Lirabon' (00), were cultivated in a pot experiment (6 replications). The pots contained a 1:1 sand:soil (loam) mixture. The pots received a basic fertilization common for rape seed. The S-fertilization was given in four different variations:

Var.	mg S/pot	kg S/ha*
1	0	0
2	100	45
3	200	90
4	400	180

* table of conversion
1 mg S/100g =
30 kg S/ha

During winter time the pots were kept in the ground. For the GSL analysis, plants were taken on four different occasions in spring(8-leaf stage until sprouts). These plants were then analysed by HPLC, a method routinely practized at the Giessen institute (Demes et al. 1988).

RESULTS

The glucosinate content is made up by alkenyle and indole glucosinolates which are summarized in fig. 1.

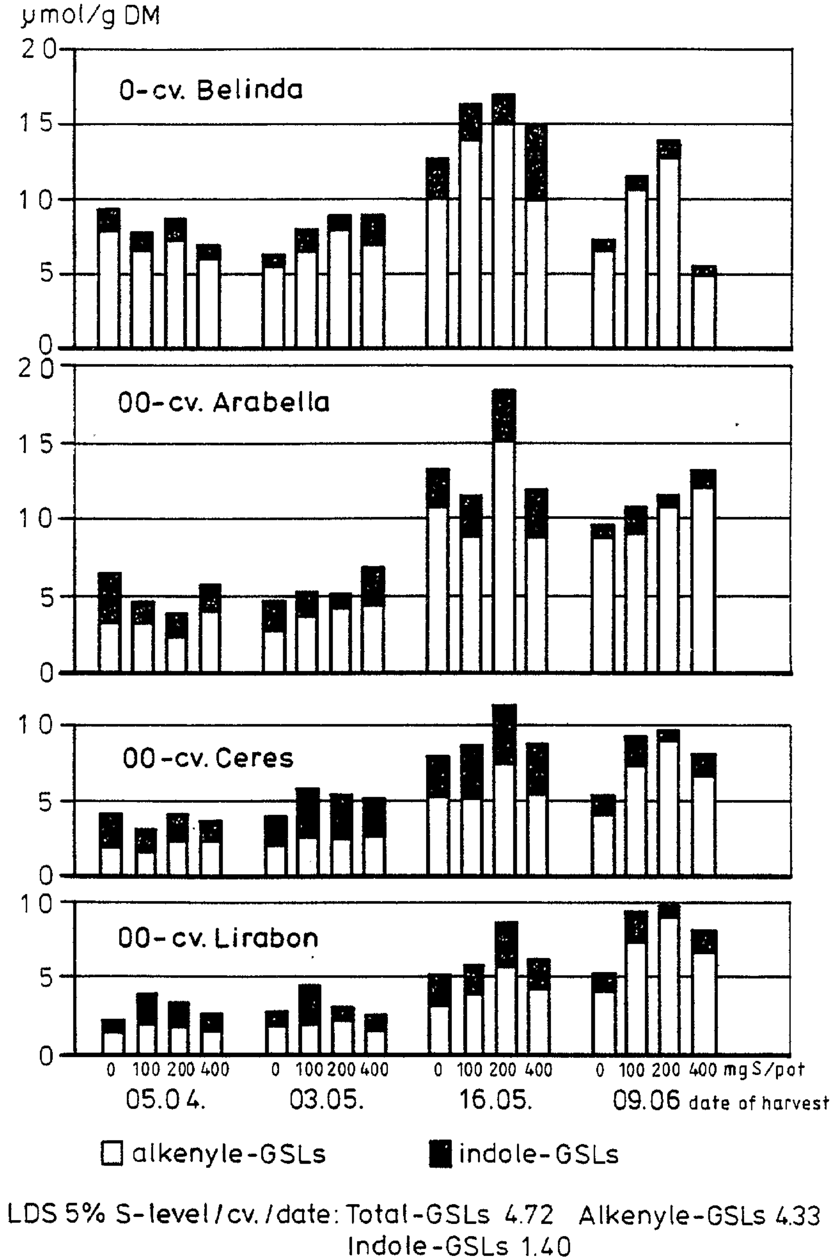

Fig. 1: The influence of sulphur fertilization on GSL-content in green matter of oilseed rape

The statistical evaluation of the results show, that variety and the time of harvest or rather the vegetative state of the plants are the main reasons for variance of the glucosinolates in the green matter.
The different S-applications influence the alkenyle fraction significantly which also effects the total glucosinolate content.

Tab. 1: Sources of variation of the GSL-content in the green matter of rape with different S-application

Source of variation	FG	Total-GSL MQ/F-Test	alkenyle-GSL MQ/F-Test	indole-GSL MQ/F-Test
S-application	3	7.34	6.96	0.01
variety	3	34.11 **	31.60 **	0.72
time of harvest	3	210.97 **	210.22 **	4.18**
S-appl./variety	9	4.99	5.55	0.75
S-appl./time of harv.	9	13.49 *	10.67 *	0.98
variety/time of harv.	9	20.44 **	19.95 **	0.86
S-appl/var/t.of harv.	27	3.53	2.93	0.65
residual	63	5.75	4.68	0.49
Σ	127			

* p= 5%; ** p= 1%

At the time of the last harvest of green matter, sulphate, sulphur and nitrate were determined in order to find out how the plants have been provided with these nutritive substances:

Tab. 2: Total-S, sulphate-S and nitrate in the green matter of rapeseed in dependence upon sulphur supply (in % dm)

	total-S-concentration				nitrate-concentration			
variety	0	100	200	400	0	100	200	400
1 *)	0,43	0,65	0,70	0,75	8,8	7,3	5,3	2,9
2	0,50	0,65	0,70	0,83	6,7	6,1	6,0	5,6
3	0,53	0,64	0,71	0,70	6,4	6,7	5,4	5,6
4	0,57	0,63	0,68	0,66	7,0	6,1	6,3	5,0
	sulphur-S-concentration							
1	0,01	0,23	0,35	0,26	*) 1 = Belinda			
2	0,01	0,17	0,21	0,32	2 = Arabella			
3	0,03	0,14	0,21	0,47	3 = Ceres			
4	0,09	0,13	0,19	0,32	4 = Lirabon			

At harvest of the seeds only two pots were used to determine the seed-quantity, so that results in tab. 3 can only be contidered trends.
All of the variants without S-application show a dramatically reduced yield, due to lack of sulphur. With an application of 100 mg S the maximum yield potential is obviously reached. Further amounts of sulphur have no further effect on yield, so that a higher S supply goes beyond the biological need.

Tab. 3: Effects of S-application on the seed yield (g per pot)

cultivar	S-application in mg per pot 0	100	200	400
Belinda	8,7	33,6	34,9	35,1
Arabella	3,7	31,9	35,4	36,2
Ceres	3,8	32,6	32,2	32,0
Lirabon	3,1	34,2	33,6	36,3
average	4,8	33,1	34,0	34,9

A lack of S, however, causes not only a reduction in weight but also a reduced oil content of the seeds (fig. 2). Again 100 mg S bring the ssed weight and the oil content up to a level where additional S applications have no further effect.

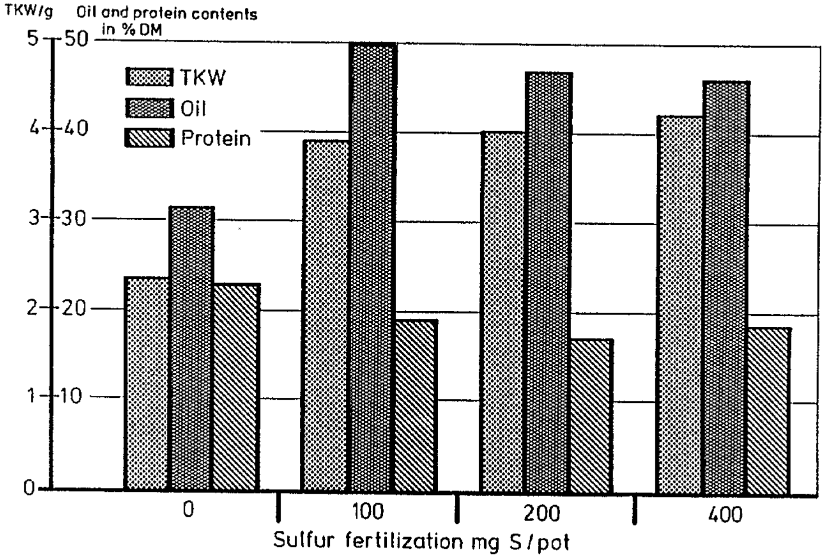

Fig. 2: Sulphur-effects on the weight, oil and protein content in rapeseed (average of 4 varieties)

Among the S variants no significant difference in weight and oil content can be seen, so that in analogy to the yield it can be estimated, that above a certain amount of S no further effect on the above criteria is to be expected. In this respect, all variants react similarly, so that only averages are shown in figure 2.

The most important quality criterion nowadays - the glucosinolate content in the seeds is shown in fig. 3. Here, the 0-cv. 'Belinda' and the variants without S are not of any practical relevance, they are only used as a reference. Within the variants with S application the influence of sulphur on the GSL-content is well documented.

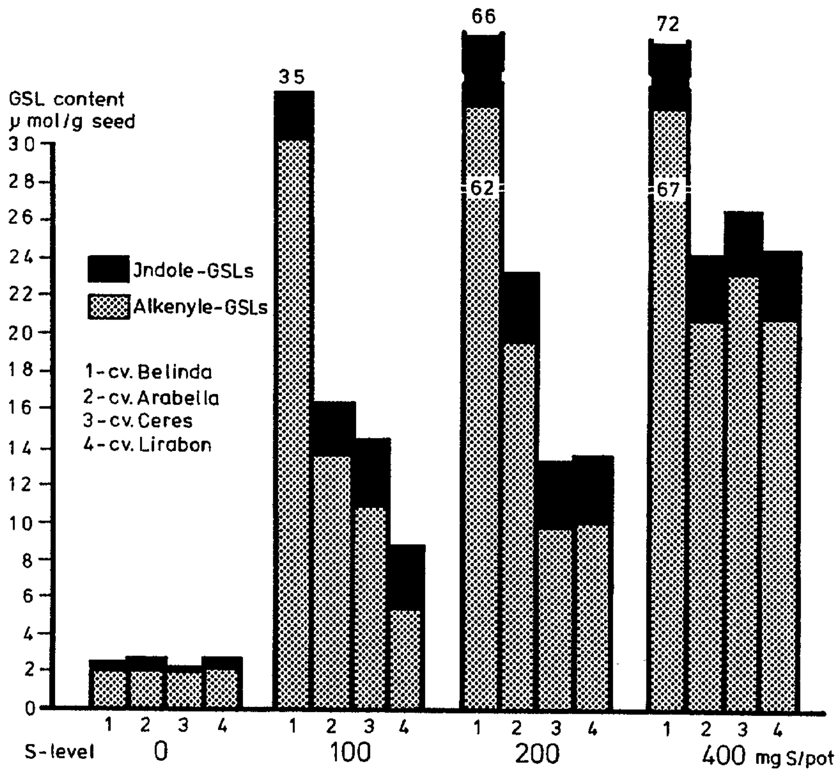

Fig. 3: Influence of S-application on the GSL-content in rapeseed (in μmol/g seed)

Applications of 200 and even 400 mg S still enhanced the GSL-content while these amounts had no more effects, neither on the yield nor on the oil content.
Concerning the glucosinolates, different reactions of cultivars caused by the S application are obvious. 'Arabella' already reaches it's glucosinolate peak with 200 mg S, whereas 'Lirabon' is caracterized by steadily (nearly linear) increasing GSL-content with increasing amounts of sulphur. The glucosinolate content of this variety increases from 8,4 μmol (100 mg S) to 24,8 μmol with 400 mg S. 'Ceres' reacts differently, the application of 200 mg S does not enhance the GSL-content, but with 400 mg S it is increased suddenly to the same level as that of 'Lirabon' and 'Arabella'. In other words, 'Ceres' reacts to an S-application less elastically than the other varieties. The increase in the glucosinolate content is caused only a strong enhancement of the alkenyle fraction exclusively.
The relation between the GSL-content in the green matter and that in the seeds is shown in table 4. This table also shows correlations between sulphur, sulphate and nitrate in the green matter with the glucosinolate content in the seeds.

Tab. 4: Correlations of sulphur and nitrate in the green matter of rape with yield and GSLs in the seeds

GREEN MATTER		SEEDS yield	total GSLs	alkenyle-GSLs
1. harvest	total GSL	-.575	-.550	-.498
	alkenyle-GSL	-.432	-.499	-.459
2. harvest	total GSL	-.317	-.145	-.049
	alkenyle-GSL	-.395	-.262	-.200
3. harvest	total GSL	-.616*	-.617	-.575
	alkenyel-GSL	-.777**	-.645	-.584
	total S	.831**	.908**	.880**
	sulphate	.822**	.920**	.895**
	nitrate	-.647*	-.752**	-.743**

* significant at 5% level ** significant at 1% level

The negative correlation between glucosinolates in the green matter and those in the seeds can be interpreted in this way that the S-supply has a stronger influence on the glucosinolates in the seed than on those in the green matter.

The total sulphur and sulphate content in green matter is positively correlated with the GSL-content in the seeds and with seed yield. Therefore, sulphur and the sulphate in the green matter can be used as indicators regarding the yield, but the positive correlation also shows the negative effect of an unbalanced S-application on the glucosinolate content in the seeds.

CONCLUSION

It can generally be stated that a shortage of sulphur in rapeseed production goes along with a decline in yield. This could also be shown in the work by Schnug (1988 and 1989).
As a consequence, sulphur application has to be well adapted to the biological need. Excexsive amounts of S would cause increasing amounts of glucosinolates in the seeds, so that the quality is negatively affected.
The amount of sulphur or sulphate in the green matter is obviously a good indicator to determine the genetical need in order to get a maximum yield with low glucosinolates in the seeds. In this study, concentrations of 0,65% S and 0,20% sulphate in the green matter seemed to be the optimum, in order to guarantee high yield with still low glucosinolate content.

LITERATURE

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