ACTA AGROBOTANICA
vol. 35, z. 1 – 1982
25-29

The occurrence of glucosinolates during the flowering and maturation of oilseed rape (Brassica napus L.)

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(Received: April 21, 1980)

Abstract

It was found that in the vegetative organs of rape, glucosinolates are present in insignificant amounts and their content decreases toward development. Higher amounts were found in flower buds; in the course of seed formation, continuous accumulation of glucosinolates proceeds up to the stage of technical maturity. Among the glucosinolates, progoitrin predominated during all developmental stages.

INTRODUCTION

Glucosinolate content in rape seeds has been the subject of several recent studies but information on the glucosinolate content in the vegetative organs is lacking. This paper reports the content of glucosinolates in the vegetative and generative organs of rape in the course of flowering and maturation.

MATERIAL AND METHODS

The experiments were conducted on winter rape (*Brassica napus* L. var. *oleifera*, cv. 'Skrzeszowicki') which is characterized by a high glucosinolate content. The following isothiocyanates were determined: 3-butenyl (ITC-B) and 4-pentenyl (ITC-P) isothiocyanates and L-5-vinyl-2-oxazolidinethione (VOT). These are the breakdown products of three glucosinolates, commonly present in rape: gluconapin, glucobrassicanapin and progoitrin (K j a e r, 1960; J o s e f s s o n, 1967; K r z y m a ń s k i, 1970). The hydrolysis is accomplished by the enzyme myrosinase, yielding sulphate, glucose and isothiocyanates or nitriles (J o s e f s s o n, 1970b). The volatile isothiocyanates were estimated by gas chromatography and the nonvolatile VOT spectrophotometrically. The methods of Youngs and Wetter as well as of Josefsson and Appelqvist in the modification of B y c z y ń s k a (1971) were used.

RESULTS AND DISCUSSION

The glucosinolate content of rape is related to the developmental stages and is affected by variety as well as environment, such as fertilizers, temperature, light (J o s e f s s o n, 1970a; D r o z d o w s k a and R o g o z i ń s k a, 1981.). Isothiocyanates, products of glucosinolate hydrolysis, as well as isothiocyanate secondary products, may be toxic to animals.

The results shown in Table 1 illustrate the glucosinolate content in the vegetative organs of rape in the course of flowering up to the stage of technical maturation. In the leaves, stems and roots those compounds are present in insignificant amounts. Among the glucosinolates analysed, VOT, a product of progoitrin hydrolysis is predominant. The largest amounts of this compound were detected in the leaves at the time preceding flowering and after the period of flowering in the stems and roots. Glucobrassicanapin, determined after its hydrolysis to ITC-P, was detected in lesser amounts. In the course of plant maturation, the amount of glucosinolates in the leaves and stems decreased. In the roots, the largest quantities were detected after flowering. ITC-B, derived from the breakdown of gluconapin, was present only in trace amounts and sometimes was absent. This concerns both the period preceding flowering as well as the period of flowering and technical maturity.

Thus, among the organs analysed, the largest content of VOT and isothiocyanates was found in the leaves in the time preceding flowering as well as in the course of flowering. On the other hand, after flowering, the largest amounts of glucosinolates were present in the roots. Thus, the glucosinolate content in the vegetative organs is variable, depending on the developmental stage of the plant. There is a continuous oecrease of these compounds, and in the stage of technical maturity only trace amounts of glucosinolates were detected in the roots. This may indicate that the vegetative organs are depleted of the glucosinolates due to the transport of the latter to the developing seeds.

Somewhat differently runs the glucosinolate metabolism in the developing generative organs. Table 2 shows that in the flower buds ITC-P was present in the largest amounts followed by VOT and ITC-B. The contents of these glucosinolates gradually increased and the quantitative proportions between them changed. In the time preceding flowering VOT predominated and ITC-B was present in the smallest quantities.

Detailed estimates performed during flowering indicate that, in the pistils, the glucosinolates are present in the largest quantities, followed by the stamens. In smaller amounts some of them were detected in the petals and sepals (Table 3).

Table 1

Glucosinolate content (mg/g fr. wt) in vegetative organs of rape depending on developmental stages

Time at which the material was taken for analysis	Leaves			Stems			Roots		
	ITC-B	ITC-P	VOT	ITC-B	ITC-P	VOT	ITC-B	ITC-P	VOT
Ca 1 week before flowering	0.006	0.028	0.148	0.0	0.009	0.013	0.0	0.004	0.0
Flowering	0.006	0.017	0.016	0.0	0.010	0.012	0.0	0.013	0.016
Ca 1 week after flowering	0.006	0.016	0.007	0.001	0.004	0.028	0.006	0.030	0.102
Technical maturity	0.0	0.0	0.0	0.001	0.0	0.0	0.01	0.002	0.016

Table 2

Glucosinolate content in developing flower buds

Time at which the material was taken for analysis	Date	mg/g fresh weight		
		ITC-B	ITC-P	VOT
The appearance of flower buds	4.05.1976	0.016	0.104	0.077
Ca 1 week after the appearance of flower buds	11.05.1976	0.020	0.090	0.072
	2.05.1977	0.036	0.156	0.160
Ca 2 weeks after the appearance of flower buds	18.05.1976	0.030	0.114	0.067
	9.05.1977	0.030	0.156	0.142
Ca 1 week before flowering	25.05.1976	0.060	0.126	0.254
	16.05.1977	0.060	0.148	0.331
Full blossom	1.06.1976	0.055	0.099	0.211
	23.05.1977	0.036	0.096	0.156

Table 3

Glucosinolate content in flower elements

Flower parts	mg/g fresh weight		
	ITC-B	ITC-P	VOT
Pistils	0.060	0.140	0.160
Stamens	0.030	0.100	0.120
Petals	0.012	0.024	0.0
Sepals	0.0	0.0	0.106

Seed maturation and reserve material accumulation is accompanied also by the accumulation of the secondary metabolites investigated by Byczyńska et al. (1970). As shown in Table 4, there is a continuous increase in glucosinolates, the accumulation of which proceeds progressively during seed development and ripening. In immature seeds (ca 6 days old) only VOT was detected among the glucosinolates tested. Isothiocyanate 3-butenyl and 4-pentenyl appeared in the seeds in the course of their ripening and were detected in 13-day-old seeds. The continuous accumulation of ITC-P and VOT lasted until technical maturity and that of ITC-B up to the time of half-technical maturity (Table 4). In the seeds, similarly as in the case of the vegetative organs, VOT

Table 4

Glucosinolate content during seed ripening

Days after the end of flowering	Maturity stages	mg/g fresh weight		
		ITC-B	ITC-P	VOT
6	green	0.0	0.0	0.760
13	green	0.130	0.040	0.220
20	green	0.724	0.220	1.128
26	half-technical	0.732	0.232	1.488
31	half-technical	0.600	0.240	1.752
41	technical	0.648	0.300	1.780

predominated among the glucosinolates during all stages of seed development. The results are in agreement with earlier investigations reported by Kondra and Downey (1969) and Byczyńska et al. (1970) using summer rape and an other variety of winter rape.

As demonstrated by the experiments, the occurrence of glucosinolates depends both on the developmental stage of the plant as well as on the organ. In the vegetative stage of the plant, these compounds occur only in insignificant amounts. The transition of the plants from the vegetative to the generative stage is accompanied by a temporarily increased glucosinolate content, may be due to enhanced synthesis and transport to the developing generative organs. This is supported by Byczyńska et al. (1970) who have shown that seeds threshed from the plants and dried in shed have a higher glucosinolate content than seeds threshed just after harvest.

Acknowledgements

We are indebted to Professor J. Krzymański and Dr B. Byczyńska for the glucosinolate analyses performed in their laboratory at the Institute of Plant Breeding and Acclimatization, Poznań.

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Występowanie glikozynolanów w czasie kwitnienia i dojrzewania rzepaku (*Brassica napus* L.)

Streszczenie

Stwierdzono, że w organach wegetatywnych rzepaku glikozynolany występują w nieznacznych ilościach i zawartość ich obniża się wraz z rozwojem roślin. Większe ilości obecne są w pąkach kwiatowych; w czasie tworzenia nasion następuje nagromadzenie glikozynolanów trwające do stanu dojrzałości technicznej. Wśród glikozynolanów, we wszystkich stadiach rozwojowych przeważała progoitryna.