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Glucobrassicin a Potential Inhibitor of Unusual Type Affecting the Germination and Growth of Plants; Mechanism of its Action

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Abstract. A water-soluble germination- and growth-inhibitor present in plants of Brassica genus was studied. Aqueous eluates from chromatograms of methanolic extracts of Savoy cabbage, cabbage and Brussels' sprouts leaves, and of Brussels' sprouts roots, inhibited the growth of wheat; the chromatographic behaviour of this inhibitor was similar to that of the thioglycoside glucobrassicin (GLUBR). GLUBRat 10^{-3}M, and the supposed product of its enzymatic degradation,3-indolylacetonitrile (IAN) at 10^{-4}M, inhibited the growth of wheat and clover in a similar manner. At lower concentrations, both substances gradually enhanced growth. In contrast to IAN, GLUBR did not appreciably influence the growth of Savoy cabbage. Other products of GLUBR degradation, such as thiocyanate ion and ascorbigen, influenced the growth to a lesser extent and in a different way. At higher concentrations GLUBR and IAN also inhibited the germination of clover seeds. The biological effect of GLUBR is dependent on the presence of the indole nucleus in its molecule; the thioglycoside glucoiberin, which is not of indolic character, does not influence growth. The presence of free myrosinase was shown in intact wheat seedlings. Hence, GLUBR taken in by the germinating plants must undergo enzymatic cleavage. The in vitro activity of myrosinase in wheat and clover was lower than in Savoy cabbage, but the quantity of IAN formed at a pH corresponding to the natural pH was higher in wheat and clover than in Savoy cabbage, where the formation of the growth-inactive ascorbigen prevailed. On the basis of these results the hypothesis was formulated that GLUBR, the indolic complex from the genera *Brassica*, *Raphanus*, *Cochleria*, *Nasturtium*, *Barbarea* and *Sisymbrium*, is a representative of a class of potential inhibitors of growth and germination, whose activity can be explained by the liberation of large amounts of growth-affecting substances during their specific enzymatic cleavage.

Recently Campbell (1959) described the inhibitory influence of aqueous extracts from parts of *Brassica oleracea* plants, on the germination and growth of clover (*Trifolium repens*) and on growth of rye-grass roots (*Lollium perenne* L. and *Lollium multiflorum* Lam.). The stimulus for this work came from the observation that the yields of mixtures of grass and clover, grown on fields where fodder plants of the *Brassica* genus had previously been cultivated, were low;

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clover especially suffered in such a case. Campbell postulated the presence of an unknown inhibitor in plants of *Brassica* which could pass into water from the plant organs. Prior to Campbell, this problem was studied by STEWART (1959), BENTLEY and BICKLE (1952) (see the review of HEMBERG, 1961). Recently TURETSKAYA and KEFELI (1963) published their results, according to which the inhibition of growth is caused by polyphenols. In our experiments we tried further to elucidate the chemical character of Campbell's inhibitor. It is well known that *Brassica* plants contain an appreciable amount of sulphur compounds, especially isothiocyanates and their glycosides (for review see KJAER, 1958). Recently the thioglycoside glucobrassicin (GLUBR)* (GMELIN and VIRTANEN, 1961) was isolated from plants of *Brassica* genus. The precursor of its indolic moiety is tryptophan (KUTÁČEK, PROCHÁZKA and VEREŠ, 1962). Later, the same authors (GMELIN and VIRTANEN, 1962) isolated from Brassica another thioglycoside, neoglucobrassicin (NEOGLUBR), which is the N_1-methoxy-derivative of GLUBR. From the physiological point of view, it is well known that isothiocyanates can inhibit the germination and growth of plants, as described for allylisothiocyanate by JIRÁČEK and KOŠTÍŘ (1960) and LÉBLOVÁ and KOŠTÍŘ (1962). According to VIRTANEN (1962) isothiocyanates possess both fungicidal and bactericidal properties. Although the explanation that Campbell's inhibitor was probably an isothiocyanate present in plants of *Brassica* genus was attractive, it was not unequivocal in view of the low solubility of isothiocyanates in water and hence their low rate of diffusion into aqueous medium. Therefore, as well as systematically testing substances present in the methanolic extract of plants of the *Brassica* genus, we concentrated out attention on the highly soluble thioglycoside GLUBR, present in these plants in high concentration. GLUBR, which belongs to the group of physiologically active "isothiocyanates", is also a representative of a little-known group of so-called indole complexes (BONNER, 1950). In this paper we describe the activity of GLUBR as a potential growth inhibitor of plants, and elucidate the biochemical causes of this activity.

Material and Methods

The GLUBR used in this study was isolated according to GMELIN and VIRTANEN (1961) from a methanolic extract of Brussels' sprouts (*Brassica oleracea* L., var. *gemmifera* (DC.) THELL). The purity of the isolated GLUBR was checked chromatographically and oscillopolarographically (KUTÁČEK and POSPÍŠIL, 1964). GLUIB, the glycoside producing 3-methylsulphoxypropyl isothiocyanate, was kindly put at our disposal by Dr. R. GMELIN. Synthetic ASCBG was prepared by Ž. PROCHÁZKA (1963). In the experiments in which we investigated the activity of single compounds on germination and growth, seeds of wheat (*Triticum aestivum* L., var. *erythrospermum* (KÖRN.) MFF. "Kaštická osinatka", later "Chlumecká"), of clover (*Trifolium pratense* L., "red Chlumecký"), and of Savoy cabbage (*Brassica oleracea* L., var. *sabauda* L., "Dětěnická late") were used. The seeds were sterilized with 70% ethanol and seeded on a filter paper disc of 9 cm. in diameter in Petri dishes, 50 seeds per paper. Each experimental series with one substance was repeated 2 to 3 times, and each concentration of inhibitor was tested three times. At the beginning of the experiment 3 ml. of a solution of the experimental substance were added

* In this paper the following abbreviations will be used: glucobrassincin—GLUBR, neoglucobrassicin — NEOGLUBR, glucoiberin — GLUIB, ascorbigen — ASCBG, 3-indolylacetonitrile — IAN, 3-indolylacetic acid — IAA, indole-3-carboxylic acid — ICOOH, 3-indolylacetamide — IAAmide, thiocyanate — CNS, tryptophan — TRY.

to the seeds, usually in concentrations from 10^{-5} to 10^{-2}M. Controls were supplied with water only Petri dishes were put into a thermostat at 25° C. After two days the germinated seeds were counted and measurements were made of the length of the seedlings. These measurements were repeated each day up to the sixth from the beginning of the experiment. During the experiment distilled water was added to the Petri dishes if necessary. The fate of experimental substances was investigated during the course of the experiment by chromatography on Whatman No. 1 paper in three solvents. n-Butanol-acetic acid-water 4 : 1 : 3 (S_1) was used to identify GLUBR and TRY (GMELIN and VIRTANEN, 1961); butyl acetate saturated with water (S_2) for the identification of ASCBG (PROCHÁZKA, ŠANDA and MACEK, 1959; KUTÁČEK, NOVÁKOVÁ and VALENTA, 1963); trichlorethylene-acetic acid (100 : 2) (S_3) for the identification of ICOOH, IAA and IAN (KUTÁČEK, NOVÁKOVÁ and VALENTA, 1963). Detection was carried out with formaldehyde reagent (PROCHÁZKA, ŠANDA and MACEK, 1959). For biological testing, the chromatograms were cut into 10 zones (according to R_F values). Individual zones were cut into small pieces and extracted with water (6 ml.) overnight. The influence of aqueous eluates (3 ml.) on the germination and growth of wheat ("Chlumecká") was followed as described in the paragraph on biological testing. Methanolic extracts of young leaves of cabbage, Brussels' sprouts and Savoy cabbage, and of roots of Brussels' sprouts were chromatographed on paper, and eluates of the chromatograms were tested in the same way. Extraction was preceded by inactivation of tissue enzymes: whole, intact organs were immersed in boiling methanol for 1—2 minutes (KUTÁČEK, PROCHÁZKA and VEREŠ, 1962). In control experiments (K) the wheat seeds were allowed to germinate in aqueous eluates of pure chromatographic paper (Whatman No. 1), through which the chromatographic solvent (S_1) had passed before elution.

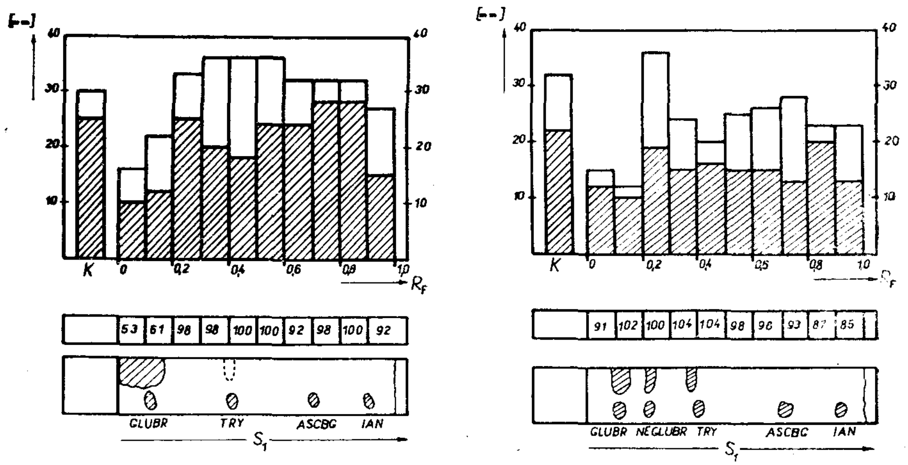
Enzymatic cleavage of GLUBR was followed in intact plants or organs as well as in tissue breis. Intact wheat seedlings (height of plumula 3 mm.) or extirpated germs were washed with 70% alcohol and put into a 1 mg% solution of GLUBR with the addition of several drops of toluene. GLUBR was introduced into intact wheat leaves (10 cm.) by the transpiration current. Tissue breis were prepared by grinding of the extirpated plants of wheat or seedlings of clover and Savoy cabbage and diluting with water (4 ml. of water for 0·5 g. of the tissue). The pH of the breis was about 5·1—5·4. The experimental material was then incubated in a thermostat for 20 hours at 25° C. Extracts or aliquots or samples were analysed chromatographically.

The quantity of thiocyanante ions set free from GLUBR was determined colorimetically at 470 mμ with Bakers's reagent (MICHAJLOVSKIJ and LANGER, 1958).

Results

From the graphs 1-a-b it is evident that marked inhibition of the growth of roots as well as coleoptiles of wheat (after 3 day's germination, see upper part of the graph) corresponds to the position of GLUBR on the chromatograms. Extracts of Brussels' sprouts leaves also diminished the number of wheat seeds that germinated (data in the middle). Similar results were obtained with leaves of Savoy cabbage (*Brassica oleracea* L., var. *sabauda* L.). Brussels' sprouts and Savoy cabbage have a relatively high content of GLUBR (see the stained part of the chromatograms). The presence of GLUBR in extracts from single zones of the chromatograms was demonstrated by repeated chromatography of aliquots of aqueous extracts. The position of NEOGLUBR, which was readily visible on chromatograms of extracts from roots of Brussels' sprouts and less so on those of Savoy cabbage leaves, corresponds to a stimulation of root growth of wheat (see graphs).

In other experiments the influence of GLUBR and possible products of its degradation, i.e. IAN, CNS and ASCBB, on the germination and growth of wheat, clover and Savoy cabbage was determined (Fig. 2). The growth of wheat coleoptiles in the presence of GLUBR was indeed inhibited (hatched area), when compared with the controls in water (1st column), but not nearly so strongly as was the growth of roots (white area). The roots of wheat grew very slowly and were very short, their number was greater in comparison with the control and they formed bunches especially at higher concentrations of GLUBR. The growth of clover was also inhibited. In both instances the 10^{-2} and 10^{-3} M concentrations of GLUBR were strongly inhibitory (2nd and 3rd column of the daily record), at the 10^{-4} M concentration the inhibitory influence



a) b)

Fig. 1. Biological evaluation of chromatograms of methanolic extracts of
a) leaves of Brussels' sprouts (*Brassica oleracea* L. var. *gemmifera*)
b) roots of Brussels' sprouts.
Chromatography was carried out in solvent system S_1; for detection wheat seedlings (var. "Chlumecká") were used. The measurement of lengths of roots (white areas) and coleoptiles (hatched area) in mm. was carried out after 3 days.

of GLUBR decreased somewhat, and at 10^{-5} M concentration the influence sometimes became a stimulatory one (especially with clover). The inhibition of cabbage was less obvious than that of wheat and clover, and the change of inhibition to stimulation occurred at higher concentrations. A 10^{-2} M solution of IAN could not be prepared because of its low solubility. However, relatively high concentrations (10^{-3} M and 10^{-4} M) of IAN were clearly inhibitory. The influence of IAN on the growth of wheat and clover was similar to that of GLUBR; both substances inhibited predominantly the growth of roots. Particularly striking was the change in activity of IAN and GLUBR with changes in their molar concentration. With wheat the effect of a given concentration of GLUBR always corresponded to the effect of a ten times lower concentration of IAN. IAN, in contrast to GLUBR, noticeably inhibited the growth of Savoy cabbage, especially of its roots. The influence of thiocyanate ions (CNS) was less pronounced. CNS did not display, for example, such a definite influence on the growth of roots. The effect of ASCBG on the growth of wheat was rather indistinct; a definite inhibition was found only in clover (see Fig.2).

The thioglycoside GLUIB, which does not contain an indole nucleus in the molecule, did not inhibit the growth of experimental plants. It produced only a feeble stimulation (Fig. 3).

In the above experiments we also determined the percentage of seeds that germinated. Seeds of clover and wheat were strongly affected (Table 1); at the highest concentrations tested GLUBR and IAN inhibited their germination, ASCBG had a small effect, and GLUIB was without influence. CNS stimulates

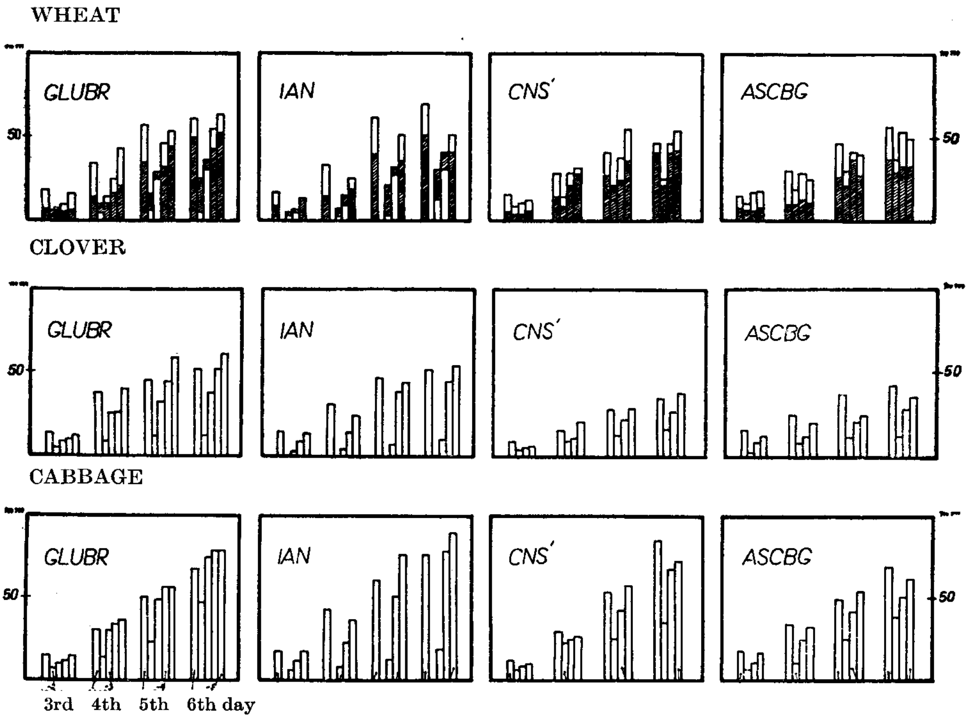


Fig. 2. Effect of glucobrassicin (GLUBR), 3-indolylacetonitrile (IAN), ammonium thiocyanate (CNS) and ascorbigen (ASCBG) on the growth of wheat, clover and Savoy cabbage. For wheat average lengths of roots (white areas) and coleoptiles (hatched areas) are given; for clover and Savoy cabbage only lengths of whole plants were measured. The plants were measured during the 3rd to 6th day period. In daily records the first column represents control plants, grown in water, the following columns correspond to experiments with 10^{-2} and 10^{-3}M, 10^{-4} and 10^{-5}M concentrations of tested substances.

the germination slightly (GEMEINHARDT, 1938). The germination of Savoy cabbage seeds was not influenced by any of these substances.

Very significant results were obtained by the study of enzymatic cleavage of GLUBR. In the first series of experiments, where intact plants or organs of wheat were used, we proved that free myrosinase is present only in seedlings. The presence of IAN and also IAA (formed under the influence of indolylacetonitrilase, THIMANN, 1953) was demonstrated chromatographically in methanolic extracts of seedlings, after 1—2 minute's inactivation by boiling. In fully grown leaves we were unable to show any activity of free myrosinase. In the second series of experiments with tissue breis, we studied the specificity of degradation of GLUBR by myrosinase of different plants. Chromatographic analysis of degradation products in the S_1 system showed that the myrosinase from Savoy cabbage was most active. No GLUBR was present in the brei after incubation. In the breis prepared from wheat and clover some of the GLUBR (R_F 0·1) remained unchanged. The most important result of these experiments

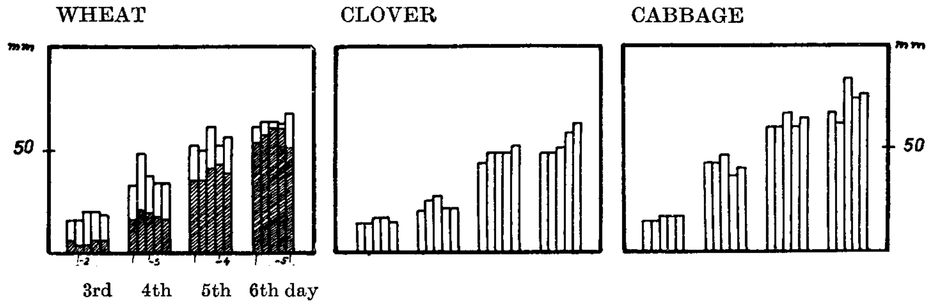


Fig. 3. Effect of glucoiberin (GLUIB) on the growth of wheat, clover and Savoy cabbage. Experimental arrangement as in Fig. 2.

(chromatogram in S_3) is the detection of different amounts of IAN (R_F 0·6) from different plants. In the experiments with wheat approx. 3 μg. of IAN were formed from 100 μg. of GLUBR, with clover the amount was 1·5 μg. of IAN from 100 μg. of GLUBR, and with wheat the amount of IAN formed was negligible (less than 0·25 μg.).

Chromatography in S_2 showed that in Savoy cabbage and clover, ASCBG was formed. With Savoy cabbage a part of it was transformed to other degradation products, substances T, S and C (Kutáček, Nováková and Valenta, 1961; Šanda, Constantzas and Procházka, 1962). With wheat another indole derivative (R_F 0·8) was formed, similar in some respects to IAAmide (Kutáček, Rokosová and Řetovský, 1959; see also Zenk, 1962).

Tab. 1. Effect of glucobrassicin (GLUBR), 3-indolylacetonitrile (IAN), ammonium thiocyanate (CNS), ascorbigen (ASCBG) and glucoiberin (GLUIB) on germination of clover in % of control plants grown in water (counted the 3rd day of the experiment)

Molar concentration of inhibitor	GLUBR	IAN	CNS	ASCBG	GLUIB
10^{-2}	73	—	107	87	100
10^{-3}	96	48	127	105	102
10^{-4}	101	99	116	102	102
10^{-5}	95	96	—	—	102

In addition to a spot corresponding to ICOOH, another less distinct spot, corresponding to IAA, was observed with wheat. The amount of CNS formed by degradation of GLUBR was also determined. It was very high with Savoy cabbage. With wheat the amount of CNS formed was only 19·1%, and with clover only 21·3% of that with Savoy cabbage.

Summarizing the results of the chromatographic analysis of degradation products of GLUBR, we can conclude that under the influence of myrosinase at pH 5·1—5·4, the following indoles are formed in appreciable amounts with various plants: a) with wheat — "IAAmide?", IAN, b) with clover — ASCBG, ICOOH, IAN, and c) with Savoy cabbage — ASCBG, substances T, S, C, and ICOOH.

Discussion

Our work concerns the study of the physiological activity of GLUBR. The present results demonstrate mainly the influence of GLUBR on plants of genera other than *Brassica*, where GLUBR is a naturally occurring plant component.

In animals GLUBR produces thiocyanate ions, which are goitrogenic (Gmelin and Virtanen, 1960; Virtanen, 1961). It seems that the physiological activity of GLUBR in plants is primarily due to its indolic moiety. This idea is borne out by the experiment with the thioglycoside GLUIB, which does not contain the indole nucleus in the molecule, and which was not, in contrast to GLUBR, markedly physiologically active. We believe that the biological activity of GLUBR results from its breakdown in the plant, into which it is introduced, i.e. from the enzymatic release of the active indole IAN from its molecule. For this reason we investigated the enzymatic cleavage of GLUBR. In testing for free myrosinase we chose wheat, because the inhibitory effect of GLUBR was rather pronounced with it. We found that free myrosinase is indeed formed in intact experimental plants during their germination.

The study of specificity of degradation in various plants was carried out by means of tissue breis. Gmelin and Virtanen (1961) have already described the enzymatic cleavage of GLUBR by myrosinase prepared from mustard seeds (*Brassicaceae*). According to their results the formation of appreciable amounts of IAN takes place only at low pH values, i.e. 3—4. At pH of about 6, usual in tissue brei, ASCBG is formed predominantly in the presence of ascorbic acid, and the amount of IAN formed is relatively low (Gmelin and Virtanen, 1961; Kutáček, Procházka and Grünberger, 1961). In contrast to this, we found in the experiments with wheat and clover, that even at pH of about 5·2 and with lower activities of myrosinase, the amount of IAN formed can be relatively high — higher than in Savoy cabbage.

Our hypothesis that the observed inhibitory activity of GLUBR, changing gradually to stimulation at lower concentrations is caused by IAN set free from GLUBR, is supported by morphological changes in experimental plants (the striking influence of GLUBR and IAN on the root growth), as well as by the results of enzymological experiments. The different effects of GLUBR on various plant species can be explained by the specificity of myrosinases in these plants. In wheat and clover, the strong inhibitory effect of GLUBR corresponds to the relatively high rate of formation of IAN. In Savoy cabbage, where the inhibitory effect of GLUBR is negligible, the formation of ASCBG prevails, which does not influence appreciably the growth. By contrast with other products of degradation of GLUBR (ASCBG, CNS) only IAN imitates (in a comparable manner) the physiological and morphological effects of GLUBR. The physiological effect of CNS ions is different from that of GLUBR. CNS does not influence the growth of roots, although this effect was observed with GLUBR, and in addition CNS stimulates the germination of seeds. In contrast to this, GLUBR and higher concentrations of IAN inhibited the germination of clover and, to a lesser extent, of wheat seeds. In view of the appreciable amounts of CNS ions, formed from GLUBR in Savoy cabbage, we believe that these ions may be the cause of the slight effect of GLUBR, when given in the highest concentration, on the growth of Savoy cabbage.

GLUBR, the indole complex from plants of *Brassica, Raphanus, Nasturtium, Cochlearia, Barbarea* and *Sisymbrium* genera (Kutáček, 1964) is, according to our hypothesis, a representative of a relatively unknown class of potential natural inhibitors of germination and growth, whose effect can be explained by the enzymatic release from these complexes of growth-affecting substances. It can be assumed that the plant kingdom will be found to contain more such substances, analogous to GLUBR, whose inhibitory or stimulatory activity will be a function of their concentration. In this respect we may mention the finding of Schulz and Gmelin (1954), who found growth activity in hydrolysates of glucotropaeolin (glycoside of the benzylisothiocyanate), where they demostrated the presence of phenylacetic acid.

Returning to the original purpose of our work, i.e. to the explanation of Campbell's finding of the presence of an inhibitor of growth and germination in *Brassica* plants or their organs, we may suggest the hypothesis that the most important source of the inhibitory effect in this laboratory experiment was GLUBR, which is readily soluble in water. However, under field conditions, where after cultivation and harvesting of *Brassica* plants parts of the plants remain in the soil, the pattern of inhibitors will be more complex, and the conditions for their influence more complicated (i.e. absorption in the soil, inhibition of microbial degradation of remnants by bactericidal properties of sulphur-containing substances etc.). In addition to the effect of GLUBR and NEOGLUBR, the products of their degradation could influence the germination and growth of plants sown subsequently. The CNS ions probably also have a certain effect, and maybe also less soluble isothiocyanates, such as allylisothiocyanate (Léblová, Jiráček and Koštíř, 1960; Léblová and Koštíř, 1962). It is almost certain that substances of polyphenolic character also play a certain role (Turetskaya and Kefeli, 1963). It is important to note that GLUBR did not appreciably influence the growth of Savoy cabbage, i.e. a plant of *Brassica* genus which contains already GLUBR, but had an influence on plants of other species — clover and wheat. This observation could help in our understanding of some oecological factors in cultivation, and add to the theoretical and practical importance of the GLUBR complex, a new type of potential inhibitor of germination and growth.

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Byl studován ve vodě rozpustný inhibitor klíčení a růstu přítomný v rostlinách rodu *Brassica* Vodné eluáty z chromatogramů metanolických extraktů listů kapusty, zelí, listů a kořenů růžičkové kapusty inhibovaly růst pšenice v rozmezí polohy na chromatogramech thioglykosidu Glukobrassicinu (GLUBR). Bylo shledáno, že GLUBR a předpokládaný produkt jeho enzymatického rozkladu 3-indolylacetonitril (IAN) inhibují ve vyšších koncentracích souhlasným způsobem růst pšenice a jetele, především kořenů (IAN do koncentrace 10^{-4}M, GLUBR do 10^{-3}M), v koncentracích nižších obě látky růst rostlin postupně stimulují. GLUBR na rozdíl od IAN růst kapusty zřetelně neovlivňoval. Další produkty rozkladu GLUBR, rhodanidové ionty a askorbigen, ovlivňovaly růst rostlin méně a způsobem odlišným. GLUBR a IAN brzdily ve vyšších koncentracích klíčivost především jetele. Biologický účin GLUBR je závislý na přítomnosti indolového jádra v molekule; thioglykosid Glukoiberin, který není indolové povahy, růst neovlivňuje. V intaktních klíčcích pšenice byla zjištěna přítomnost volné myrosinázy, klíčními rostlinami přijatý GLUBR musí tak být štěpen. Celková aktivita myrosinázy byla u pšenice a jetele nižší než u kapusty, avšak podíl vzniklého IAN při pH odpovídajícím přirozeným poměrům byl vyšší u pšenice a jetele než u kapusty, u které vznikal především růstově inaktivní askorbigen. Na základě těchto výsledků byla vyslovena hypotéza, že GLUBR, indolový komplex z rostlin rodů *Brassica, Raphanus, Cochlearia, Nasturtium, Barbarea* a *Sisymbrium* je představitelem potenciálních inhibitorů klíčení a růstu, jejichž účinek lze vysvětlit působením vysokých dávek růstových látek, které se uvolňují při jejich specifickém enzymatickém rozkladu.

М. КУТАЧЕК, Институт экспериментальной ботаники ЧСАН, Прага: **Глюкобрасицин, потенциальный ингибитор необычного типа, оказывающий влияние на рост и прорастание растений и механизм его действиа.** — Biol. Plant. 6 : 88—98, 1964.

Изучался в воде растворимый ингибитор прорастания и роста присутствующий в растениях рода *Brassica*. Водные эллюаты хроматограмм метанолевых экстрактов листьев савойской капусты, листьев и корней брюссельской капусты ингибировали рост пшеницы в диапазоне положения на хроматограммах тиоглюкозида глюкобрассицина (ГЛЮБР). Установлено, что ГЛЮБР и предполагаемый продукт его энзиматического разложения — 3-индолилацетонитрил (ИАН) в повышенных концентрациях сходным образом ингибируют рост пшеницы и клевера, прежде всего в отношении корней (ИАН до концентрации 10^{-4} М, ГЛЮБР до 10^{-3} М), в пониженных концентрациях оба вещества постепенно рост растений стимулируют. ГЛЮБР в отличие от ИАН не оказывал заметного действия на рост савойской капусты. Дальнейшие продукты разложения ГЛЮБР, роданиевые йоны и аскорбиген, оказывали меньшее влияние на рост растений и другим способом. ГЛЮБР и ИАН в повышенных концентрациях тормозили прорастание прежде всего клевера. Биохимическое действие ГЛЮБР зависит от присутствия ядра индола в молекуле; тиоглюкозид глюкоиберин, неиндолевой природы, влияния на рост не оказывает. В интактных проростках пшеницы обнаружено присутствие мирозиназы, следовательно, растениями принимаемый ГЛЮБР должен расщепляться. Общая активность мирозиназы у пшеницы и клевера ниже по сравнению с капустой, однако, доля возникшего ИАН при pH, соответствующем природным условиям, у пшеницы и клевера выше по сравнению с савойской капустой, у которой возникал прежде всего в отношении роста инактивный аскорбиген. На основании этих результатов высказано предположение, что ГЛЮБР, индолный комплекс из растений родов *Brassica, Raphanus, Cochlearia, Nasturtium, Barbarea* и *Sisybrium* является представителем потенциальных ингибиторов прорастания и роста, действие которых возможно объяснить действием высоких доз ростовых веществ, которые освобождаются при их специфическом энзиматическом расщеплении.