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Association between glucosinolate concentration and injuries caused by cabbage stink bugs *Eurydema* spp. (Heteroptera: Pentatomidae) on different Brassicas

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ABSTRACT. In 2010, we were determining the contents of glucosinolates in different Brassicas in order to study their influence on feeding of cabbage stink bugs (*Eurydema* spp.) and the consequent extent of damage. We confirmed that glucosinolates content depends on plant species, plant organs and the time of sampling. In the samples aliphatic glucosinolates (glucoiberin, progoitrin, epiprogoitrin, epiprogoitrin, sinigrin, gluconapin, glucoraphenin, sinalbin) prevailed. Glucobrassicin, an important indolic glucosinolate compound, was detected in all tested Brassicas. Its concentration in the oil radish samples was highest during the first assessment (30 DAS), 8.84 ± 0.65 μmol g^{-1} ds, while the oilseed rape samples displayed lowest concentration during the last assessment (134 DAS), 4.30 ± 0.80 μmol g^{-1} ds. The stimulative activity of individual glucosinolates or their negative influence on feeding of cabbage stink bugs in the Brassicas used in our experiment was not uniformly manifested. Based on a two-year field experiment we concluded that oil rape was the most adequate trap crop used to allure cabbage stink bugs. In future, glucosinolates should be employed to a greater extent in environmentally acceptable ways of food production, one of which is also the use of trap crops in order to reduce harmful effects of cabbage stink bugs.

Keywords: Phytochemicals, cabbage stink bugs, cabbage, white mustard.

Associação entre a concentração glucosinolada e danos causados pelo percevejo *Eurydema* spp. (Heteroptera: Pentatomidae) em diferentes gramíneas

RESUMO. Em 2010 o conteúdo de glucosinolatos em diferentes plantas brássicas foi determinado para estudar a influência sobre a alimentação de percevejos de repolho (*Eurydema* spp.) e a extensão do dano causado. Através do método do cultivo armadilha, durante o período de crescimento foram amostradas as partes aéreas de óleo de colza, mostarda branca, nabo forrageiro e dois híbridos de repolho branco. O conteúdo de glucosinolatos depende das espécies de plantas, órgãos de plantas e período da amostragem. Predominaram nas amostras os glucosinolatos alifáticos (glucoiberina, progoitrina, epiprogoitrina, sinigrina, gluconapina, glucoraphenina, sinalbina). A glucobrassicina foi detectada em todas as brássicas testadas. Sua concentração no nabo forrageiro foi mais alta na primeira avaliação (30 DAS), 8.84 ± 0.65 μmol g^{-1} ds, enquanto houve a menor concentração no óleo de colza durante a última avaliação (134 DAS), 4.30 ± 0.80 μmol g^{-1} ds. Considerando o experimento de dois anos, conclui-se que o óleo de colza foi o mais adequado como cultivo armadilha para atrair o percevejo do repolho. Glucosinolatos podem ser usados no futuro mais extensivamente em várias modalidades de produção de alimentos, entre as quais o emprego de cultivo armadilha para diminuir os danos do percevejo do repolho.

Palavras-chave: fitoquímicos, percevejo do repolho, repolho, nabo forrageiro, mostarda branca.

Introduction

Secondary metabolites (KLIEBENSTEIN et al., 2001) are often said to be important factors of plants' resistance to biotic (WINDE; WITTSTOCK, 2011) and abiotic stress (Björkman et al., 2011). Glucosinolates are classified as the secondary metabolites (KLIEBENSTEIN et al., 2005; SILVA CARVALHO et al., 2010), characteristic for the Caparales order (AL-GENDY et al., 2010; BJÖRKMAN et al., 2011), present particularly in the Brassicaceae family (GRIFFITHS et al. 2001; JOHNSON, 2002; DE VILLENA et al., 2007; CARTEA et al., 2008 BLAŽEVIĆ; MASTELIĆ, 2009; AL-GENDY et al., 2010; MÜLLER, et al., 2010; YANG et al., 2010; BJÖRKMAN et al., 2011; WINDE; WITTSTOCK, 2011).

Different Brassicaceae species are important from the agronomical (FONT et al., 2005; VAUGHN; BERHOW, 2005; CARTEA et al., 2008; BLAŽEVIĆ; MASTELIĆ, 2009; HASAN; ANSARI, 2011) and the economic point of view (RAYBOULD; MOYES, 2001; VAUGHN; BERHOW, 2005). Glucosinolates are composed of the β-D-glucan group, the functional group of sulphated oxime and a variable side-chain (BEEKWILDER et al., 2008; VIG et al., 2009; AL-GENDY et al., 2010). Glucosinolates are according to their side-chain categorised as aliphatic, indole and aromatic (CARTEA; VELASCO, 2008; VAN EYLEN et al., 2009) and the concentration of these varies between individual plant organs (FAHEY et al., 2001; WINDE; WITTSTOCK, 2011), plant species (MOYES et al., 2000; CHAPLIN-KRAMER et al., 2011), developmental stages of the same plant species (DE VILLENA et al., 2007; CARTEA et al., 2008; SARIKAMIŞ; YANMAZ, 2011), and it depends also on weather conditions (VELASCO et al., 2007; WINDE; WITTSTOCK, 2011).

The hydrolysis of glucosinolates creates several physiologically active components, including isothyocianates, nitriles, thyocianates and oxazolidinones (BROWN; MORRA, 1996; BEEKWILDER et al., 2008; VIG et al., 2009; BLAŽEVIĆ; MASTELIĆ, 2009). These components and also glucosinolates as a whole can protect plants from infections by pathogens (HOPKINS et al., 1998; BLAŽEVIĆ; MASTELIĆ, 2009) and attacks of generalists (HOPKINS et al., 1998; MOYES et al., 2000; HOOKS; JOHNSON, 2003), while their influence on specialists is often stimulative (HOPKINS et al., 1998; MOYES, et al., 2000; HOOKS; JOHNSON, 2003; MÜLLER, 2009); MÜLLER et al., 2010; CHAPLIN- KRAMER et al., 2011).

Among the pests that can infest Brassicas, cabbage stink bugs *Eurydema* spp. (Heteroptera: Pentatomidae) feed on outer leaves of older plants developing bronze discolorations, and when they suck on young plants, bright specks are the symtoms caused by their feeding (TRDAN et al., 2006; DEMIREL, 2009; ELTEZ; KARSAVURAN, 2010; BARIĆ; PAJAĆ, 2011). Trdan et al. (2006) in one of the previous studies confirmed their detrimental effects on cabbage crops. Our study was spurred by the fact that cabbage stink bugs in the South-East Europe (BARIĆ; PAJAĆ, 2011) and Asia Minor (DEMIREL, 2009) significantly harm the family Brassicaceae, and it seems that their population density and thus harmfulness are increasing, and also by the fact that some countries either lack registered insecticides for their suppression or they have been drastically reduced. The study deals with the trap crop method which takes advantage of characteristics of those plants which are susceptible to harmful pests. This method belongs to the group of environmentally acceptable methods for reducing the economic impact of harmful pests on plants (TRDAN et al., 2005; COOK et al., 2006).

The purpose of our study was to establish glucosinolate content in different species of Brassicas so as to determine practical applications in protection of cabbage against cabbage stink bugs. The connection between the extent of damage caused by these pests on cabbage and the concentration of glucosinolates in this Brassica has so far not been studied, the same holds true for the significance of glucosinolate concentration in oilseed rape, white mustard and oil radish, which have been used in this study to trap cabbage stink bugs and thus deter them from feeding on cabbage.

Plant material

The two-year field experiment (2009-2010) was carried out in the village Zgornja Lipnica (46°19' N latitude, 14°10' E longitude, 511 m above the sea level) in Slovenia, during the growth period in the second year of the experiment we were collecting samples of selected above-the-ground parts of oilseed rape (*Brassica napus* [L.] ssp. *oleifera* f. *biennis*), cv. Daniela (supplier: Semenarna Ljubljana, d. d., Ljubljana, Slovenia), white mustard (*Sinapis alba* [L.]), cv. Zlata (supplier: Semenarna Ljubljana, d. d., Ljubljana, Slovenia), oil radish (*Raphanus sativus* [L.] var. *oleiformis*), cv. Apoll (supplier: Semenarna Ljubljana, d. d., Ljubljana, Slovenia), the early hybrid of white cabbage (*Brassica oleracea* [L.] var. *capitata* f. alba), cv. 'Tucana' (supplier: Semenarna Ljubljana, d. d., Ljubljana, Slovenia) and the medium-late cabbage hybrid (*Brassica oleracea* [L.] var. *capitata* f. alba), cv. 'Hinova' (producer: Bejo Zaden, Warmenhuizen, The Netherlands; supplier: Agroprogress, d. o. o., Ljubljana, Slovenia).

Field evaluation

The field of 528 m^2 was divided into four blocks, where the three species of trap crops were sowed within the plots in separate treatments, and the fourth treatment was the control, where no trap crop was sowed (bare surface). In each treatment we also sowed both cabbage hybrids in separate sub-plots. The treatments within blocks were arranged randomly. The trap crops which were used for chemical analysis were sowed on the April 19th 2010, while the cabbage was sowed outdoors on the April 26th 2010. The seedlings of cabbage were cultivated in the Department of Agronomy's greenhouse at the Biotechnical Faculty according to the protocol as described in Trdan et al., 2009. The injuries caused by the stink bugs on Brassicas were assessed by the 6-grade visual scale (STONER; SHELTON, 1988), which was

developed for assessing the extent of damage done on cabbage by onion thrips (*Thrips tabaci* Lindeman), while Trdan et al. (2006) had successfully used a slightly modified scale to evaluate damage done on cabbage by cabbage stink bugs.

Glucosinolate analysis

Plant material for the analysis of glucosinolates was sampled at different intervals. The material was collected by scissors. Sampling of cabbage leaves was carried out at five different intervals (30 DAT (days after transplanting), 48 DAT, 66 DAT, 92 DAT and 111 DAT). Samplings of above-the-ground parts of oilseed rape was carried out at five different intervals (30 DAS (days after sowing), 50 DAS, 78 DAS, 103 DAS, 134 DAS), while the sampling of oil radish and white mustard was performed at four intervals (the former at 30 DAS, 50 DAS, 65 DAS and 103 DAS of July; the latter at 30 DAS, 50 DAS, 65 DAS and 78 DAS).

Four samples of individual plant species were collected at individual intervals of assessment. An individual sample (the specified part of a plant species) was the representative plant sample of one block. When analysing glucosinolates, the analysis of individual samples was repeated twice. The material was then freeze-dried (tip: LIO-10P; producer: Kambič Laboratorijska oprema, Semič, Slovenia) and homogenized before extraction of glucosinolates. The lyophilised samples were stored in 50 ml bottles in a freezer (type: U3286S; producer: Sanyo) at -80°C.

The glucosinolate extraction and analysis were performed according to ISO 9167:1-1992. As internal standards sinigrin or glucotropaeolin (C_2 Bioengineering ApS, Denmark) were added. The extracted glucosinolates were purified on a 1.5 cm DEAE Sephadex A-25 anion exchange column. The column was washed twice with 1 mL distilled water loaded with 2ml of the glucosinolates extract and then washed twice with 1 mL 20 mM NaAc-solution and treated with sulphatase (75 μL and 25 mg mL^{-1}). After an overnight reaction at room temperature the desulfoglucosinolates were eluted with distilled water (2*1mL). The eluate was filtered over 0.45 μm filter and then sample was ready for HPLC analysis.

For GLS quantification, twenty microlitres of desulfoglucosinolates solution were run on an Agilent 1200 Series HPLC system (Palo Alto, CA, USA) at 2 Ml min^{-1}. The column was a Discovery C18, 25 cm x 4.6 mm, 5 μm (Supelco). The mobile phases were water and methanol, running time: 28 min. The gradient changed as follows: 100% A for 1 min., then in 20 min. to 20% B, followed by 100% B for 5 min. Afterwards the column was equilibrated at 100 % A for 3 min. The desulfoglucosinolates were detected with DAD detector at 229 nm. The desulfoglucosinolates were identified with external standards (C2 Bioengineering ApS, Denmark). The certified reference material used was BCR-367R. The content of each GLS was back calculated and expressed in micromoles per gram (μmol g^{-1}) of dry seed.

Data analysis

The experiment's results were statistically evaluated by the program Statgraphics Centurion XVI (STATGRAPHICS CENTURION XVI, 2009). The differences between values of glucosinolates during the growth period and between individual plant species were calculated by the analysis of variance (ANOVA) and Duncan's test of multiple comparisons ($p < 0.05$). We calculated correlations between the concentration of an individual glucosinolate and the average injury index of the plant species.

Results and discussion

Glucosinolate content in trap crops

The samples of oil radish had six different glucosinolates, which can be divided into three different groups (Table 1). The time of assessment of the developmental stage of the studied plants had significant influence on the concentration of glucobrassicin in the samples ($p = 0.0005$; $F = 8.68$; $Df = 3$). The average value of glucobrassicin content was significantly highest during the first assessment (8.84 ± 0.65 μmol g^{-1} of dry seed (ds)), while during the last assessment the concentration was 0.84 ± 0.18 μmol g^{-1} ds. On average the concentration of glucoraphenin in the oil radish samples was 8.66 ± 1.81 μmol g^{-1} ds.

The concentration of the said glucosinolate is not conditioned by the time of assessment ($p = 0.3755$; $F = 1.10$; $Df = 3$). The established average value of sinalbin in the samples was 0.36 ± 0.12 μmol g^{-1} ds, while the said concentration was not significantly conditioned by the time of sampling ($p = 0.7193$; $F = 0.37$; $Df = 2$). Glucoiberin and progoitrin were present in traces only.

The analysis of oilseed rape samples found out eight different glucosinolates (Table 1). The most frequent among aromatic glucosinolates was gluconasturtiin (0.13 ± 0.04 μmol g^{-1} ds), which was not significantly influenced by different times of assessment ($p = 0.0646$; $F = 96.33$; $Df = 1$). We also found out that the concentration of glucobrassicin was significantly influenced by the times of assessment or developmental stages ($p = 0.0044$; $F = 6.19$; $Df = 4$).

Table 1. Average values of glucosinolates in individual plant species (in μmol g^{-1} ds). Zgornja Lipnica, Slovenia, 2009/2010.

Systematic name	Trivial name	Oil radish	Oil rape	White mustard	'Hinova'	'Tucana'
Aliphatic						
3-Methlysufinylpropyl	Glucoiberin	< 0.1	< 0.1	< 0.1	0.33 ± 0.08	0.38 ± 0.09
2 (R)-2-Hydroxy-3-butenyl	Progoitrin	< 0.1	1.55 ± 0.51	< 0.1	1.13 ± 0.02	0.27 ± 0.03
2 (S)-2-Hydroxy-3-butenyl	Epiprogoitrin	x	0.19 ± 0.06	2.45 ± 0.38	y	Y
2-Propenyl	Sinigrin	x	X	x	0.30 ± 0.03	0.35 ± 0.06
3-Butenyl	Gluconapin	x	0.38 ± 0.05	x	0.17 ± 0.03	0.24 ± 0.10
4-Methylsulfinyl-3-butenyl	Glucoraphenin	8.66 ± 1.81	0.99 ± 0.87	0.51 ± 0.19	< 0.1	< 0.1
Indole						
3-Indolmethyl	Glucobrassicin	3.24 ± 0.86	1.39 ± 0.49	1.71 ± 0.88	0.40 ± 0.15	0.79 ± 0.27
Aromatic						
2-Phenylethyl	Gluconasturtiin	< 0.1	0.13 ± 0.04	x	y	Y
4-Hydroxybenzyl	Sinalbin	0.36 ± 0.12	11.16 ± 6.50	30.12 ± 5.52	y	Y

x - type of glucosinolate not present in the plant species ; y – detection was made, but there was no glucosinolate.

While the concentration of glucobrassicin in the oil radish samples was significantly highest during the first assessment, the concentration of glucobrassicin in the oilseed rape samples was significantly lowest during the last assessment (4.30 ± 0.80 μmol g^{-1} ds). We found out that the concentration of gluconapin in the samples was conditioned by the times of assessment ($p = 0.0365$; $F = 3.76$; $Df = 4$).

The concentration of gluconapin was significantly lowest in the second (0.20 ± 0.04 μmol g^{-1} ds) and the first assessment (0.22 ± 0.01 μmol g^{-1} ds), the highest was during the last assessment (0.60 ± 0.07 μmol g^{-1} ds). The concentration of sinalbin in the oilseed rape samples was not conditioned with the times of assessment ($p = 0.2035$; $F = 2.63$; $Df = 1$). No significant influence of the times of sampling on the concentration of glucoraphenin in the oilseed rape samples was found ($p = 0.5729$; $F = 0.76$; $Df = 4$). We found out that the concentration of epiprogoitrin in the plant samples varied with the times of sampling ($p = 0.0013$; $F = 782.29$; $Df = 1$). The significantly highest concentration of epiprogoitrin was found in the samples which were collected at 30 DAS or during the first assessment (0.37 ± 0.01 μmol g^{-1} ds), while the value of the said glucosinolate during the last assessment was the significantly lowest (0.13 ± 0.03 μmol g^{-1} ds). The analysis of the oilseed rape sample revealed significant influence of the time of sampling on the concentration of progoitrin in the plant tissue of oilseed rape ($p < 0.001$; $F = 219.78$; $Df = 4$). Despite the fact that the concentration of the said glucosinolate in the plant varies, it was significantly the highest during the last assessment (3.64 ± 0.12 μmol g^{-1} ds). Glucoiberin was present in traces only (< 0.1 μmol g^{-1} ds).

In the white mustard samples we found the presence of six glucosinolates. The most distinctive among aliphatic glucosinolates was the presence of sinalbin and it was conditioned by the times of assessment ($p = 0.0168$, $F = 4.43$; $Df = 3$). The times of sampling also significantly influenced the concentration of glucobrassicin ($p = 0.0096$; $F = 5.23$; $Df = 3$;) and epiprogoitrin ($p = 0.0008$; $F = 13.30$, $Df = 3$). Its concentration was significantly the highest during the first assessment (6.59 ± 2.91 μmol g^{-1} ds), while the concentration of epiprogoitrin was the significantly lowest in the first sampling (0.25 ± 0.12 μmol g^{-1} ds).

Glucosinolate content in cabbage hybrids

In the samples of the early cabbage hybrid six different glucosinolates were discovered. The concentration of glucobrassicin varies with the times of assessment ($p = 0.0056$; $F = 5.82$; $Df = 4$). The average value was the significantly highest in the samples which were collected in the first sampling (2.34 ± 0.37 μmol g^{-1} ds). The concentration of the said glucosinolate varies throughout the growth period, at the end of it the average value was 0.15 ± 0.02 μmol g^{-1} ds. The average value during the entire growth period was 0.79 ± 0.27 μmol g^{-1} ds). The times of assessment also did not significantly influence the concentration of sinigrin ($p = 0.4628$; $F = 0.61$; $Df = 1$) and glucoiberin ($p = 0.6575$; $F = 0.45$; $Df = 2$) in the cabbage samples. The concentration of sinigrin varied from 0.41±0.06 μmol g^{-1} ds during the first assessment to 0.30 ± 0.12 μmol g^{-1} ds during the assessment in the second decade of August (0.30 ± 0.12 μmol g^{-1} ds). The concentration of glucoiberin, on the other hand, varied from 0.35 ± 0.09 μmol g^{-1} ds during the first assessment to 0.33 ± 0.11 μmol g^{-1} ds during the last but one assessment. The limit of detection for glucoraphenin is < 0.1 μmol g^{-1} ds.

The samples of the medium-late hybrid were tested on nine glucosinolates. We found out that the concentration of glucoiberin depended on the times of assessment – the concentration varies during the growth period ($p = 0.0016$; $F = 12.13$; $Df = 3$). Sinigrin, whose concentration was not conditioned by the times of sampling ($p = 0.1054$; $F = 3.63$; $Df = 1$), was present in the hybrid from 0.25 ± 0.03

during the first sampling to 0.36 ± 0.05 μmol g^{-1} dt during the assessment in mid-August. No significant influence of the times of sampling on the concentration of gluconapin was found (p = 0.1648; F = 2.88; Df = 1). The concentration of glucobrassicin in the samples of the hybrid 'Hinova' was also conditioned by time (p = 0.0000; F = 28.83; Df = 4) and was significantly the highest during the first assessment.

The results of our study show that glucosinolates content in individual parts of Brassicas varies, what was already confirmed by Fahey et al., (2001) and Winde and Wittstock (2011). Data obtained from our survey can confirm that glucosinolate content also differs between individual species of Brassicas (MOYES et al., 2000; CHAPLIN-KRAMER et al., 2011); and that their concentration varies during the growth period (DE VILENA et al., 2007; CARTEA et al., 2008; SARIKAMIŞ; YANMAZ, 2011).

High concentrations of aliphatic glucosinolates (BEEKWILDER et al., 2008) (in our case progoitrin,epiprogoitrin,gluconapin, glucoraphenin) are evaluated as an important factor determining resistance of these plants. The presence of progoitrin in the plants of oil radish and white mustard was below the limit of detection, which enables a wider spectrum of their use since the said aliphatic glucosinolate can cause negative effects in feeding of animals (VAN DOORN et al., 1998; PADILLA et al., 2007). Data obtained from our survey confirm the highest concentration of progoitrin in oil rape during the last assessment. Although stimulative effects of progoitrin is present.

The harmful pests' distinct preference for oil rape, in our case this holds true for both years of the field experiment (BOHINC; TRDAN, 2012), often deters farmers from planting the said species (VALANTIN-MORISON et al., 2007). We can relate the extent of damage to the concentration of gluconapin.

From the results of our study we can conclude that the concentration of progoitrin in cabbage hybrids is an important factor of selecting cabbage hybrids to be cultivated, since the concentration of the said glucosinolate in the two cabbage hybrids differed and caused different extent of injuries done by the studied harmful pests. The data obtained by our study show that higher values of glucobrassicin in above-the-ground parts of white mustard, oil radish, the early and the mid-late cabbage hybrid reduce the extent of injuries done by cabbage stink bugs. Stimulative effects of glucosinolates on these insects were found only in oilseed rape. We suggest oil rape as one of the plant species that can be used as a trap crop to allure cabbage stink bugs.

Correlations between glucosinolate contents in different Brassicas and damage caused by cabbage stink bugs

Stimulative influence of epiprogoitrin on feeding of cabbage stink bugs was found in the white mustard samples (r = 0.69), while the concentration of epiprogoitrin in oilseed rape plants negatively influenced feeding of cabbage stink bugs (r = -0.99) (Table 2). The concentration of glucobrassicin negatively influenced feeding of cabbage stink bugs on the plants of white mustard (r = -0.54), oil radish (r =-0.30), the early cabbage hybrid (r = -0.29), the medium-late cabbage (r = -0.59), while they stimulated feeding of bugs on oilseed rape (r = 0.24). Stimulative influence of progoitrin on feeding of cabbage stink bugs was found in the medium-late cabbage samples (r = 0.76) and in the oilseed rape samples (r = 0.51), while its concentration negatively influenced feeding on the early cabbage hybrid (r = -1.0). We established positive correlation between the concentration of gluconapin in the samples of the early hybrid (r = 0.31), the samples of oilseed rape (r = 0.64), and the extent of injuries, while negative influence of the said glucosinolate was established in the samples of the medium-late hybrid (r= -0.62).

The results of our study show the potential of trap crops to be used in ecological or integrated production of cabbage, which could be particularly important due to the increasing limitations in the use of synthetic insecticides (BJÖRKMAN et al., 2011), which are ever more frequently reflected even by complete absence of registered preparations (THE LIST OF REGISTERED…, 2011). Among such insects in the country where our study took place are cabbage gall midges *Contarinia nasturtii* (Kieffer), cabbage flies *Delia radicum* (L.) and also cabbage stink bugs *Eurydema* spp. Since the concentration of chemical substances in plant tissue of Brassicas is one of the main factors of susceptibility to injuries by herbivores (HOOKS; JOHNSON, 2003), which differs also between plant species.

Among the other cabbage pests, which occur on the area, where the present research was carried out, cabbage aphid (*Brevicoryne brassicae* [L.]) is known for its explotation of glucosinolates for the purpose of defending against natural enemies (BROEKGAARDEN et al., 2008), while stimulative effect of glucosinolates on oviposition was detected for cabbage butterfly (*Pieris brassicae* [L.]) (SMALLEGANGE et al., 2007). In one study the presence of sinigrin in Brassicas was confirmed to induce defence mechanisms against diamondback moth (*Plutella xylostella* [L.]) (SILVA CARVALHO et al., 2010).

Table 2. Correlations between concentrations of different glucosinolates in individual plant species and the extent of injuries done by cabbage stink bugs ($p < 0.005$ Duncan's multiple range test). Zgornja Lipnica, Slovenia, 2009/2010.

	r	P	Ŷ
White mustard			
Epiprogoitrin	0.69	0.0057*	1.24265 + 0.433471*epiprogoitrin
Glucobrassicin	-0.54	0.0119*	2.45713 - 0.12113*glucobrassicin
Glucoraphenin	-0.26	0.4902	2.40176 - 0.462479*glucoraphenin
Sinalbin	0.36	0.0996	1.95608 + 0.0112671*sinalbin
Oil rape			
Gluconasturtiin	-0.98	0.1333	7.65868 - 30.7078*gluconasturtiin
Glucobrassicin	0.24	0.3232	3.24056 + 0.171768*glucobrassicin
Gluconapin	0.64	0.069	2.09383 + 4,3665*gluconapin
Sinalbin	-0.68	0.2035	2.37452 - 0.0514846*sinalbin
Glucoraphenin	0.09	0.7148	3.373715 + 0.0352183*glucoraphenin
Epiprogoitrin	-0.99	0.0019*	7.32541 – 16.8443*epiprogoitrin
Progoitrin	0.51	0.1123	3.26631 + 0.451754*progoitrin
Glucoiberin	-1	-	4.8250-0.208333*glucoiberin
Oil radish			
Glucobrassicin	-0.30	0.1272	2.97621 - 0.0798455*glucobrassicin
Glucoraphenin	0.15	0.5100	2.73785 + 0.021328*glucoraphenin
Sinalbin	0.40	0.3670	1.76274 + 1.28603*sinalbin
'Tucana'			
Glucobrassicin	-0.29	0.2348	1.77559 - 0.155098*glucobrassicin
Sinigrin	-0.30	0.4641	2.25673 - 1.36632*sinigrin
Gluconapin	0.31	0.3258	1.58063 + 0.55905*gluconapin
Glucoiberin	0.03	0.9915	1.83206 + 0.0105085*glucoiberin
Progoitrin	-1.0	-	2.54313 - 1.67504*progoitrin
'Hinova'			
Glucobrassicin	-0.59	0.0095*	2.30235 - 0.764395*glucobrassicin
Sinigrin	0.50	0.2124	0.297512 + 5.43967*sinigrin
Gluconapin	-0.62	0.1893	3.22748 - 5.78143*gluconapin
Glucoiberin	0.37	0.2078	1.66917 + 1.08091*glucoiberin
Progoitrin	0.76	0.2408	2.41404 + 0.218165*progoitrin

r = correlation coefficient; *= $p < 0.05$; Ŷ=linear regression model which shows dependence of injuries done by cabbage stink bugs on contents of individual glucosinolate in a plant species.

In future we will have to perform even more studies on the influence of different Brassica species on bionomics of economically important insect pests (AL-ZYOUD et al., 2005; DE ALBUQUERQUE et al., 2006). Globally, Brassicas have a very wide spectrum of use (BJÖRKMAN, et al., 2011), and they are also very important in human diet. If we suppose that negative influence of glucosinolates on human diet is ruled out (BRANCA et al., 2002; PADILLA et al., 2007), the role of safely produced food is even more important.

Conclusion

Oil rape is the most adequate trap crop used to allure cabbage stink bugs;

In future glucosinolates should be employed to a greater extent in environmentally acceptable ways of food poduction.

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