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Perception of biotech trees by Slovak university students – a comparative survey

Jana Moravčíková[a, ✉], Ildikó Matušíková[b], Peter Nemeček[c], Alžbeta Blehová[d], Želmíra Balážová[e], Zdenka Gálová[e], Patrik Mészáros[f] and Ján Kraic[g,h]

[a] *Institute of Plant Genetics and Biotechnology, Centre of Biology and Biodiversity SAS, Akademická 2, P.O. Box 39A, Nitra, SK-950 07, Slovak Republic*

[b] *Department of Ecochemistry and Radioecology, Faculty of Natural Sciences, University of SS. Cyril and Methodius in Trnava, Nám. J. Herdu 2, Trnava, SK-917 01, Slovak Republic*

[c] *Department of Chemistry, Faculty of Natural Sciences, University of SS. Cyril and Methodius in Trnava, Nám. J. Herdu 2, Trnava, SK-917 01, Slovak Republic*

[d] *Department of Plant Physiology, Faculty of Natural Sciences, Comenius University, Mlynská dolina B2, Bratislava, SK-842 15, Slovak Republic*

[e] *Faculty of Biotechnology and Food Science, Slovak University of Agriculture, Tr. A. Hlinku 2, Nitra, SK-949 76, Slovak Republic*

[f] *Department of Botany and Genetics, Faculty of Natural Sciences, Constantine the Philosopher University, Nábrežie mládeže 91, Nitra, SK-949 74, Slovak Republic*

[g] *Department of Biotechnology, Faculty of Natural Sciences, University of SS. Cyril and Methodius in Trnava, Nám. J. Herdu 2, Trnava, SK-917 01, Slovak Republic*

[h] *Research Institute of Plant Production, National Agricultural and Food Center, Piešťany SK-921 68, Slovak Republic*

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Abstract

Acceptance of genetically modified plants is restricted in EU by legislation, while the attitude of public is not favourable as well. Surveys show that knowledge about GM plants is getting increased. Newly developed strategies on GM safety for environment can be a crucial aspect for the (partial) acceptance in future. GM trees as non-edible plants might appear as more admissible, however, are relatively rarely discussed. We performed a comparative survey on knowledge and perception of GM forest trees among students at four Slovak universities. We also compared their responses between as well as with the outcome of similar cross-country survey in frames of the COST Action FP0905. The results point to very similar attitude of Slovak students when compared with students from other countries, no significant difference between responses of males and females, but also influence of age as well as orientation of their study (natural sciences vs. economy) on view of GM tree safety and placing on the market.

Introduction

It is some 20 years since Biotech or genetically modified (GM) crops were commercialised and largely adopted by farmers mainly in USA, Brazil, Argentina or Canada. In 2015, Biotech crops were planted on 179.7 hectares in 28 countries (Clive 2015), while the total area of Biotech plants has increased more than one hundred fold since 1996. Hitherto, the International Service for the

✉ *Corresponding author:* jana.moravcikova@savba.sk

Table 1. Overview of GM woody plants with the regulatory approval according to the ISAAA GM approval database (January 2017).

				Authorisation	
Crop	**Trade name**	**Event name**	**Trait**	**Country**	**Type of approval** [a]
Malus x Domestica	Arctic™ "Golden Delicious" Apple	GD743	Non-browning phenotype	Canada USA	A (2015), B (2015), C (2015) A (2015), B (2015), C (2015)
Malus x Domestica	Arctic™	GS784	Non-browning phenotype	Canada USA	A (2015), B (2015), C (2015) A (2015), B (2015), C (2015)
Malus x Domestica	Arctic™ Fuji Apple	NF872	Non-browning phenotype	USA	A (2016), B (2016), C (2016)
Carica papaya	Rainbow, SunUp	55-1	Viral disease resistance	Canada Japan USA	A (2003) A (2011), C (2011) A (1997), B (1997), C (1996)
Carica papaya	not available	63-1	Viral disease resistance	USA	C (1996)
Carica papaya	Huanong No. 1	Huanong No. 1	Viral disease resistance	China	C (2006)
Carica papaya	not available	X17-2	Viral disease resistance	USA	A (2008), B (2008), C (2009)
Eucalyptus sp.	GM eucalyptus	H421	Volumetric wood increase	Brazil	A (2015), B (2015), C (2015)
Prunus domestica	not available	C-5	Viral disease resistance	USA	A (2009), B (2009), C (2008)
Populus sp.	Bt poplar, poplar 12 (*Populus nigra*)	not available	Lepidopteran insect resistance	China	C (1998)
Popupus sp.	Hybrid poplar clone 741	not available	Lepidopteran insect resistance	China	C (2001)

[a] A – food, direct use or processing; B – feed direct use or processing; C – cultivation domestic or non-domestic use. In the brackets the years of approval are given.

of Agri-biotech Applications (ISAAA) GM approval database contains more than four hundred entries concerning Biotech/GM events with regulatory evaluations and approvals (ISAAA 2017). The most common genetically engineered crops are soybean, maize, canola and cotton with traits ensuring tolerance to herbicides and/or insect resistance.

In European Union, deliberate release of GM plants for research purpose and placing on the market are directed by EU Directive 2001/18/EC (EC 2001) that was implemented into national legislations. The Directive was amended by EU 2015/412 (EC 2015) as regards the possibility for the Member States to restrict and prohibit GM organisms in their territory after they have been authorised to be placed on the Union market. The EU legislation requires upfront evaluation of direct, indirect, immediate and delayed effects as well as the cumulative long term effects on human health and the environment. Comprehensive and strict legal regulations allow using Biotech plants with EU authorisation only for food/feed purposes (ISAAA 2017; EU register of authorised GMOs 2017).

The first GM (poplar) tree was reported by Filatti *et al.* (1987) five years later as the first ever GM (tobacco) plant was generated. GM trees were developed and studied in greenhouse or field conditions for improved woody quality, faster growth, herbicide tolerance, insect and disease resistance or abiotic stress tolerance. Of nearly 800 GM field trials approved worldwide, however, fewer than 50 were in Europe, mainly for research purposes (Haggman *et al.* 2013) at strictly controlled dissemination and sexual maturity (Pilate *et al.* 2016). Technical limitation, biosafety concerns and existing legislation hinder research progress and commercial application of GM tree technology in Europe. So far, only small number of GM woody plants has been successfully commercialised (Table 1) and include woody plants such as papaya, eucalyptus, apple and plum trees with authorisation in Canada, USA, Japan, Brazil

or China. Among forest trees, only GM poplar is commercialised in China (Table 1).
In spite of obvious economical benefits from commercial plantation of GM trees, the majority of public discussion is focused on their unintended effect on environment. However, the key arguments are associated with ethical consideration and moral imperatives. Most of studies on public attitude of GMOs are referred to GM crops (Lucht *et al.* 2015) but only few GM trees (Nonić *et al.* 2015; Kazana *et al.* 2016). Here, students of four Slovak universities with different field of study were asked to give anonymously their opinion on GM tree plantation. We deliberately focused on students aged from 18 to 25, future experts that should not be blinkered from GMOs. We aimed to estimate their i) knowledge concerning GM forest trees, ii) agreement with GM trees commercialisation and iii) perception of GM trees (adoption) safety. The survey extends the screening carried out within the frame of European COST action FP0905 "Biosafety of forest transgenic trees and EU police directives" (Vettori *et al.* 2016).

Table 2. Socio-demographic profile of respondents.

University	Faculty	Field of study	No. students	Gender Male/female	Average age
Comenius University in Bratislava (CU)	Faculty of Natural Sciences (FNS)	Plant physiology, Genetics	24	7/17	22
University of SS. Cyril and Methodius in Trnava (UCM)	Faculty of Natural Sciences (FNS)	Biology	22	7/15	22
Slovak University of Agriculture in Nitra (SUA)	Faculty of Biotechnology and Food Sciences (FBFS)	Biotechnology	20	6/14	24
	Faculty of Economics and Managements (FEM)	Accounting	23	9/14	22
	Horticulture and Landscape Engineering Faculty (HLEF)	Horticulture	20	10/10	21
Constantine the Philosopher University in Nitra (UKF)	Faculty of Natural Sciences (FNS)	Biology	21	5/16	20
Total			130	44/86	$\bar{x}$ = 22

Experimental

A survey was conducted among students of Comenius University in Bratislava, University of SS. Cyril and Methodius in Trnava, Slovak University of Agriculture in Nitra and Constantine the Philosopher University in Nitra. Target groups were students of disciplines related to natural sciences and economics. Socio-demographic profile of respondents is given in Table 2. The questionnaire contained nine questions (Q1–Q9) and was organised into four sections: i) socio-demographic information, ii) knowledge about GM forest trees (Q1–Q3), iii) acceptance of cultivation of GM forest trees (Q4–Q7) and iv) perception of GM trees (adoption) safety (Q8–Q9). The questions were as follows:

Q1 – Do you know what a genetically modified forest tree (transgenic forest tree) is?

Q2 – Do you know if transgenic forest plantations are grown commercially?

Q3 – Do you know if final products of transgenic forest plantations (wood, biofuel, pulp, paper) are being sold in the market (stores, supermarkets etc.)?

Q4 – Would you agree with forest transgenic crops to be approved for commercial planting?
Q5 – Would you purchase the final products (wood products, pulp, paper etc.) produced from transgenic forest plantations?
Q6 – Would you agree with the final products produced from transgenic forest plantations to be labelled to indicate that they originate from genetically modified trees? If yes, would you agree with the labelling of such products to be legally mandatory? (Q6.a)
Q7 – Which of the following benefits resulting through adoption of transgenic forest crops do you think may be important in your country?: Use of less chemicals and energy to process cellulose (Q7.a), Harvesting of a smaller number of trees for consumption (Q7.b) Use of less pesticides in forest plantations (Q7.c), Less herbicide treatments of forest plantations (Q7.d), Restoration of contaminated soils (Q7.e), Less old growth logging (Q7.f), Better timber quality/higher value product (Q7.g), Higher pulping efficiency (Q7.h), More efficient biofuel production from GM forest trees (Q7.i), Stronger timber construction materials (Q7.j), Higher tree productivity (Q7.k).
Q8 – Which of the following issues concerns you the most regarding adoption of transgenic forest crops? Which of the following do you think if it occurs when adopting a transgenic forest crop may constitute a hazard?: Forest trees less fit (Q8.a), Forest trees more vulnerable to viral diseases (Q8.b), Higher rates of soil decomposition (Q8.c), More pesticide resistant forest species (Q8.d), More use of broad spectrum herbicides (Q8.e), Loss of biodiversity (Q8.f), Adverse effects on bio-trophic processes of host ecosystems (Q8.g), Increased cost of controlling pest outbreaks. (Q8.h), Cultural adaptation to changing biodiversity (Q8.i), Transgene genes become inactive (Q8.j).

Table 3. Comparison of responses to selected questions (Q) among individual groups of respondents using Fisher's LSD test.

Score[a]	**Dependent**	**Variable**[b]	**Mean Difference (I-J)**	**Std. Error**	**Significance**	**95 % Confidence Interval**	
						Lower Bound	**Upper Bound**
QA	SUA	CU	0.1859*	0.0808	**0.023**	0.026	0.346
	FNS	FEM	-0.2501*	0.0806	**0.002**	-0.410	-0.091
QB	UKF	UCM	-0.2123*	0.1024	**0.040**	-0.415	-0.010
	SUA	UCM	-0.1830*	0.0831	**0.029**	-0.347	-0.019
	UKF	UCM	-0.2576*	0.0990	**0.010**	-0.454	-0.062
	FBFS	FEM	-0.2782*	0.0923	**0.003**	-0.461	-0.096
Q8	FNS	HLEF	-1.549*	0.669	**0.022**	-2.87	-0.23

[a] Group QA includes questions Q1, Q2 and Q3; group QB includes questions Q4, Q5, Q6 and Q6a.
[b] comparisons between universities and between faculties.
* The mean difference is significant at the 0.05 level.

Q9 – Which of the following items do you think may constitute a hazard when adopting a transgenic forest crop?: Forest trees less fit (Q9.a), Forest trees more vulnerable to viral diseases (Q9.b), Higher rates of soil decomposition (Q9.c), More pesticide resistant forest species (Q9.d), More use of broad spectrum herbicides (Q9.e), Loss of biodiversity (Q9.f), Adverse effects on bio-trophic processes of host ecosystems (Q9.g), Increased cost of controlling pest outbreaks. (Q9.h), Cultural adaptation to changing biodiversity conditions (Q9.i).
The questions Q1–Q6 were type of yes/no, while the question Q7 was evaluated using four-level rating scale: very important (4), slightly important (3), not important (2) and I do not know (1). In the question Q8, students had to select only one safety issue. The question Q9 was evaluated using scale: serious hazard (4), slight hazard (3), no hazard (2) and I do not know (1).

For data processing, Fisher's LSD test was applied to compute the pooled standard deviation from groups QA (Q1, Q2, Q3), QB (Q4, Q5, Q6) and Q8 using the statistical program IBM SPSS 22.

Results and Discussion

The questionnaire was submitted to a total of 130 students of four Slovak universities (Table 2). Respondents were aged from 18 to 25 with average age of 22. A total of 66 % students were women (Table 2).

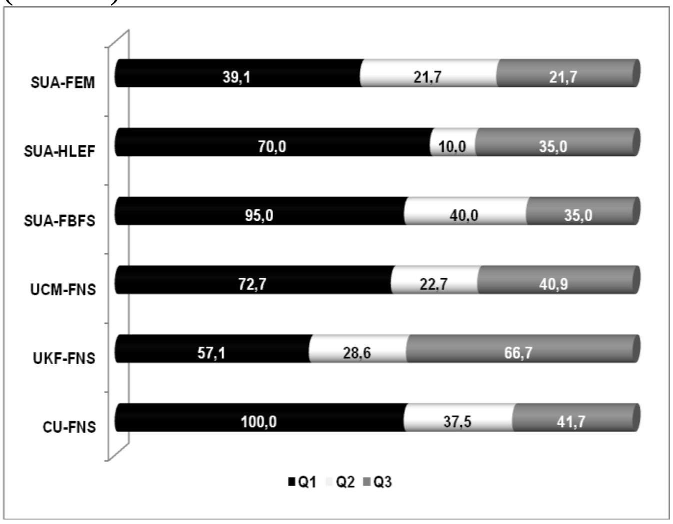

Fig. 1. Respondents' positive attitude in percentage concerning knowledge on GM forest trees (Q1), their commercialisation (Q2) and placing on the market (Q3).

The first section of the questionnaire QA (Q1–Q3) was focused on knowledge of respondents about GM trees. Data are summarised in Fig. 1. In average, more than 57 % students of environmental disciplines indicated that they knew meaning of forest GM trees (Q1). The highest percentage was recorded in students of CU-FNS (100 %) and SUA-FBFS (95 %). The lowest number of positive responses (39 %) was recorded in students of disciplines related to economics. Despite that high number of respondents indicated a positive answer on the question Q1, abundance of positive responses on remaining two questions (Q2 and Q3) was significantly lower. Less than 40 % respondents knew if GM forest trees are grown commercially (Q2) and less than 41 % knew if final products of GM trees are placed on the market (Q3). Similar non-uniform pattern was observed in the cross-country survey focused on public attitude towards the use of GM trees performed by Kazana *et al.* (2016) or in the survey conducted in Serbia by Nonić *et al.* (2015). For example, 82.5 % of students of University of Belgrade declared that they know meaning of GM tree; however, only 51.5 % knew if GM trees are grown commercially. It may coincide with the fact that until now only few GM trees were authorised, moreover outside of the EU (Table 1).

Overall, 26 out of 130 (20 %) Slovak respondents answered positively on all three questions (Q1, Q2 and Q3). These respondents can be considered as well informed.

To compare answers between universities and faculties, all responses were statistically analysed. At university level the differences among answers to questions Q1, Q2 and Q3 (score QA) of respondents were in general at the border of significance (P=0.057), while respondents from CU and SUA differed in their knowledge on GM trees most obviously (at $P \leq 0.05$) (Table 3). However, significant differences (at $P \leq 0.05$) were observed between individual faculties oriented towards natural sciences (FNS) or biotechnologies (FBFS) exerted significantly different knowledge comparing to those studying economy (FEM) (at $P \leq 0.05$).

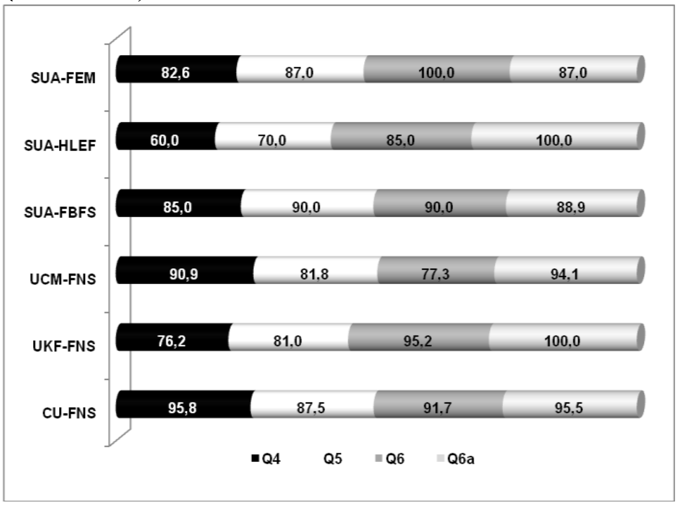

Fig. 2. Respondents' positive attitude in percentage concerning acceptance of GM trees for commercial use (Q4), purchase of the final product from GM trees (Q5) and labelling of such products (Q6, Q6a).

Respondents´ attitudes towards benefits resulting from adoption of GM trees (Q7) were evaluated using four-step scale: very important (4), slightly

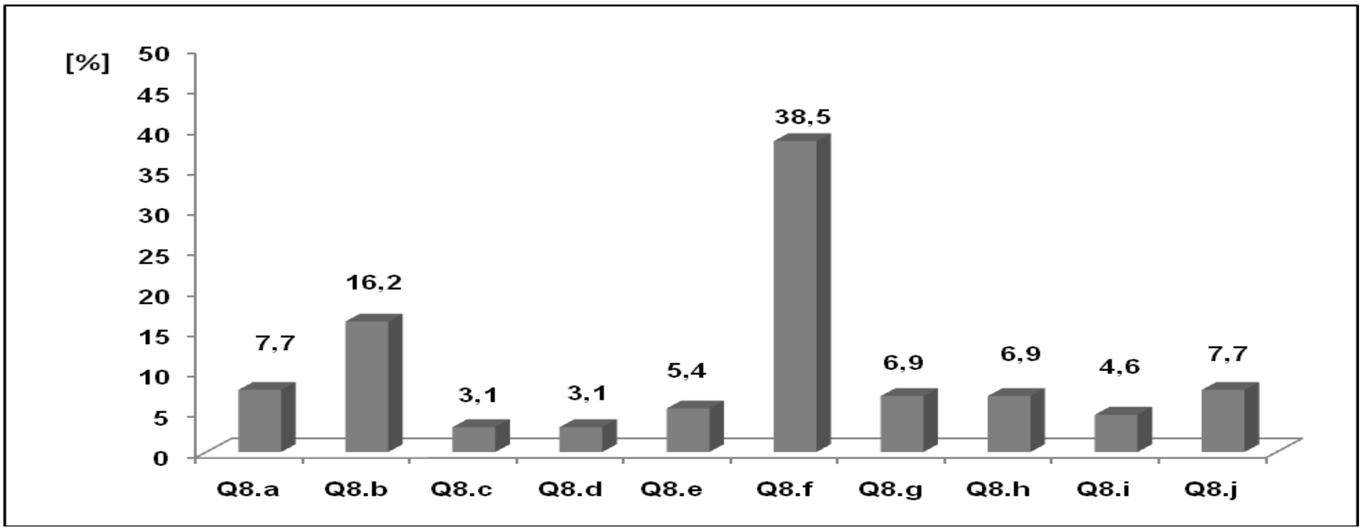

Fig. 3. The most important safety issues of GM trees (Q8) evaluated according to the respondents.

Table 4. Opinions of students about potential benefits from GM forest tree adoption (questions Q7). Individual sub questions Q7a-k are described in Experimental.

	CU-FNS [%]*				**UKF-FNS [%]***				**UCM-FNS [%]***			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Q7.a	0	4.2	29.2	70.8	9.5	0.0	19.0	71.4	0	0	40.9	59.1
Q7.b	0	4.2	12.5	83.3	0.0	0.0	9.5	90.5	0	0	4.5	95.5
Q7.c	0	8.3	33.3	50.0	4.8	14.3	19.0	61.9	4.5	0	31.8	63.6
Q7.d	0	12.5	37.5	50.0	4.8	9.5	42.9	42.9	9.1	18.2	27.3	45.5
Q7.e	4.2	0	45.8	50.0	0	19.0	19.0	61.9	4.5	0	4.5	90.9
Q7.f	0	8.7	21.7	69.6	4.8	9.5	19.0	66.7	0	4.5	27.3	68.2
Q7.g	8.7	17.4	65.2	8.7	19.0	9.5	42.9	28.6	22.7	9.1	54.5	13.6
Q7.h	0	0	56.2	43.5	4.8	4.8	23.8	66.7	0	4.5	50.0	45.5
Q7.i	8.7	21.7	43.5	26.1	14.3	4.8	14.3	66.7	9.1	9.1	13.6	68.2
Q7.j	4.3	13.0	65.2	17.4	9.5	9.5	38.1	38.1	0.0	22.7	45.5	31.8
Q7.k	0	0	43.5	56.5	14.3	4.8	28.6	52.4	4.5	13.6	40.9	40.9
	SUA-FBFS [%]*				**SUA-HLEF [%]***				**SUA-FEM [%]***			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Q7.a	0	5.0	45.0	50.0	0	5.3	42.1	52.6	0.0	4.3	34.8	60.9
Q7.b	0	0	25.0	75.0	0	0	5.3	94.7	4.3	0.0	17.4	78.3
Q7.c	5	5.0	30.0	60.0	0	5.3	42.1	52.6	4.3	8.7	30.4	34.8
Q7.d	0	10.0	30.0	60.0	5.3	0.0	26.3	68.4	17.4	13.0	65.2	30.4
Q7.e	5	10.0	20.0	65.0	21.1	5.3	10.5	63.2	4.3	8.7	26.1	60.9
Q7.f	0	10.0	35.0	60.0	5.3	0	21.1	73.7	8.7	8.7	26.1	56.5
Q7.g	10.0	10.0	70.0	10.0	47.4	15.8	26.3	10.5	26.1	8.7	52.2	13.0
Q7.h	0	10.0	40.0	50.0	26.3	0	21.1	52.6	4.3	4.3	60.9	30.4
Q7.i	0	25.0	25.0	50.0	21.1	10.5	15.8	52.6	13.0	8.7	47.8	30.4
Q7.j	5.0	20.0	30.0	45.0	0	26.3	26.3	47.4	8.7	17.4	56.5	17.4
Q7.k	5.0	5.0	45.0	45.0	0	5.3	31.6	63.2	8.7	4.3	43.5	43.5

* Percentage of students considering the given benefit as (4) Very important, (3) Slightly important, (2) Not important, (1) I do not know.

important (3), not important (2) and I do not know (1). Majority of students indicated as very important the use of less chemicals (Q7.a), harvesting of smaller number of trees (Q7.b), restoration of poison contaminated soil (Q7.e) and less old growth logging (Q7.f). Slightly lower importance was attributed by students to the use of less insecticides/pesticides/herbicides (Q7.c/Q7.d), higher pulping efficiency (Q7.g), better timber quality Q7.h), more efficient biofuel production (Q7.i), stronger timber construction (Q7.j) or higher tree productivity (Q7.k). Data are summarised in Table 4.

Table 5. Respondents' attitudes about potential hazards related to the GM tree plantations (Q9). Individual sub questions (Q9a-i are described in Experimental.

	CU-FNS [%]*				UKF-FNS [%]*				UCM-FNS [%]*			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Q9.a	8.3	12.5	54.2	25	4.8	19.0	57.1	19.0	18.2	4.5	50.0	27.3
Q9.b	4.2	4.2	41.7	50	14.3	14.3	23.8	47.6	22.7	4.5	40.9	31.8
Q9.c	25	4.2	54.2	16.7	19.0	9.5	19.0	52.4	13.6	9.1	40.9	36.4
Q9.d	8.3	4.2	45.8	41.7	4.8	14.3	52.4	28.6	9.1	27.3	45.5	18.2
Q9.e	4.2	4.2	29.2	62.5	4.8	4.8	38.1	52.4	18.2	13.6	18.2	50.0
Q9.f	0	0	25.0	75.0	0	0	28.6	71.4	13.6	9.1	18.2	59.1
Q9.g	4.2	12.5	29.2	54.2	9.5	9.5	42.9	38.1	9.1	9.1	36.4	45.5
Q9.h	4.2	16.7	16.7	62.5	4.8	9.5	42.9	42.9	13.6	13.6	27.3	45.5
Q9.i	4.2	16.7	33.3	45.8	14.3	9.5	52.4	23.8	13.6	18.2	45.5	22.7
	SUA-FBFS [%]*				**SUA-HLEF [%]***				**SUA-FEM [%]***			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Q9.a	0	26.3	52.6	21.1	15.8	5.3	47.4	31.6	4.3	8.7	56.5	30.4
Q9.b	5.3	10.5	36.8	47.4	5.0	10.0	35.0	50.0	13.0	4.3	56.5	26.1
Q9.c	21.1	10.5	52.6	15.8	20.0	15.0	35.0	30.0	0	26.1	43.5	30.4
Q9.d	0	10.0	35.0	55.0	5.0	5.0	50.0	40.0	34.8	13.0	43.5	8.7
Q9.e	0	0	63.2	36.8	15.0	20.0	15.0	50.0	30.4	26.1	30.4	13.0
Q9.f	0	15.0	20.0	65.0	10.0	5.0	20.0	65.0	13.0	0	30.4	56.5
Q9.g	5.3	10.5	63.2	21.1	15.0	5.0	20.0	60.0	8.7	4.3	30.4	56.5
Q9.h	5.3	15.8	57.9	21.1	0	15.0	50.0	35.0	0	17.4	69.6	13.0
Q9.i	10.5	21.1	36.8	31.6	5.0	15.0	35.0	45.0	8.7	4.3	30.4	56.5

* Percentage of students considering the potential hazard of GM trees as (4) Serious hazard, (3) Slight hazard, (2) No hazard (1) I do not know.

Conclusions

Our survey shows that in a relatively small country like Slovakia the students of four selected Universities share similar opinion on GM trees, though differences related to study orientation (economy vs. science-related) were identified. Remarkable coincidence can be found between responses of males and females, in contrast different age categories face the issue of GM tree differently. Nevertheless, the attitude of Slovak students coincides with those described in other European countries. Based on our survey we suggest that knowledge of students about GMs should be extended since was lower compared to other published European surveys. Moreover, better knowledge on GMs is a prerequisite towards acceptance of this potentially powerful tool to solve several serious issues of humankind, despite of current restriction in EU countries.

Acknowledgements

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