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Determining GMO awareness among students of agricultural engineering in Turkiye

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Courses on GMOs in Agricultural Faculties are included in the curriculum of the departments under different names. It was aimed to determine the knowledge level of 273 agricultural engineering students from Faculty of Agriculture studying at Kırsehir Ahi Evran University, Turkiye in this study. The questionnaire consisted of a test on Personal Information Scale to measure their knowledge about GMO Foods. The data obtained showed that the students in the Department of Agricultural Biotechnology had the highest level of awareness about GMOs and GMO based foods. It was concluded that awareness and knowledge of the students was related to their subject of the study, grade and gender. It was understood that male students had a higher GMO awareness compared to the female students. The results of the study revealed that it was appropriate and necessary to include more detailed courses about GMOs in the curricula of the departments in faculties of agriculture. The findings obtained from this study can be used as a source to prepare or rearrange curricula of the departments in agricultural faculties.

Keywords: Agricultural faculties, knowledge, transgenic organisms, GMOs, Turkiye.

INTRODUCTION

The term Genetically Modified Organisms (GMOs) is used for products that have been improved or modified by using modern biotechnological tools (Phillips, 2008). It is understood that with each increase in the level of knowledge, the level of adopting and benefiting from emerging new technologies must also increase. Organisms that have gained new features that cannot be acquired by natural processes of hybridization and are acquired by using gene technology are called transgenic or genetically modified organisms. The most commonly used method of gene transfer to plants include biolistic, electroporation, microinjection, macroinjection, sonication, desiccation, DNA transfer through fibers, pollen transformation, DNA impregnation to the zygotic embryos, agrolistic techniques and transformation through *Agrobacterium* (Taylor and Fauquet, 2002; Özkan, 2006; Yang *et al.,* 2017; Kalefetoğlu *et al.,* 2017; Lacroix *et al.,* 2020). GMOs are used in agriculture, environment, health, food, energy, protection, nanotechnology and defence sectors (Phillips, 2008). The first transgenic human food was long shelf-life tomato (Elpe, 2021). Thereafter GM plants with resistance to various diseases and pests were produced through gene transformation methods (Aktaş, 2020). In addition, edible medicines have also been developed through plants with increased oil quality, aroma, and vitamin contents (Bawa and Anilakumar 2013).

Every new technological development has pros and cons with introduction of possible risks to human life. Potential risks should not be ignored when making use of these technologies. Legal arrangements made due to these concerns have introduced the concept of biosecurity. The concept of biosecurity covers determination of modern biotechnology application techniques and the negative effects that modern biotechnology products may have on environment, human and animal health. Precautions should be taken for the elimination of the possibility of risks and the measures should be taken to control the damages that will occur in case of risks (Prakash, et al. 2011). The United Nations Convention on Biological Diversity and the Cartagena Biosafety Protocol form the basis of biosafety laws for GMOs around the world (Kumar *et al.,* 2022). Turkiye adopted the "Biosafety Law No. 5977" on 18 March 2010, which was established by adhering to the principles in this protocol. In accordance with Article 5 of the Biosafety Law, placing GMOs and their products including baby foods, infant formulas and their products etc. in the market, using or making them available without approval, production of genetically modified plants and

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animals, and use of GMOs, or GMOs based products, follow-on formulas and in infant and small child supplementary foods outside the scope of the protocol, is prohibited (Anonymous, 2021).

In the curricula of agriculture faculties, there is not enough content and number of courses on biosafety and GMO-related issues. The department with the most courses about GMOs in their curriculum is the Department of Agricultural Biotechnology (11 courses), and the department with the fewest courses is the Department of Horticulture (1 course). There are no courses related to GMO in the curriculum of Plant Protection and Agricultural Economics departments. The curriculum of the Agricultural Biotechnology Department included 11 courses namely teach "Introduction to Biotechnology", "Basic Genetics", "Molecular Genetics", "Animal Tissue Culture", "Food Biotechnology", "Transgenic Plant Technology", "Animal Biotechnology", "Plant Tissue Culture", "Plant Tissue Culture" Biotechnology", "Stress Resilience and Biotechnology" and "Molecular Markers and Analysis Techniques" courses. The courses in the curriculum of the department of Field Crops included "Genetics" and "Plant Biotechnology" courses; Department of Animal Science: "Genetics" and "Animal Biotechnology" courses. The Department of Horticulture, has single course of the "Plant Biotechnology" as compulsory courses in their curriculum (Anonymous, 2022).

The knowledges and awareness of agricultural engineering students about genetically modified (GM) organisms are extremely important in terms of directing the society towards this issue. The aim of this study is to determine how the knowledge of agricultural engineering students, along with demographic characteristics such as gender and class, vary according to the departments they study. Within the framework of this purpose; Agricultural engineering students' information on GMOs was examined and compared using their levels, department, and gender as variables.

MATERIALS AND METHODS

This research was carried out to determine the GMO awareness levels of agricultural engineering students in Turkiye. The study was carried out as a Master's thesis at Kirsehir Ahi Evran University, Institute of Science and Technology, Department of Agricultural Biotechnology.

***Model of the Research*:** The study was a quantitative descriptive study as it aimed to determine the knowledge of agricultural engineering students about GMOs, to analyze the current situation and to reveal their relations with previous studies. This model is a type of research in which numerical interpretation and generalization can be made by adhering to a pre-prepared questionnaire (Koçyiğit, 2015).

***Population and Sample of the Research*:** The sample size and universe of this study consisted of a total of 273/430 (64%) students studying at the Faculty of Agriculture in Kırşehir, a city located in the Central Anatolian Region of Turkiye, during 2018-2019 who participated in the survey on a voluntary basis.

***Data Collection Tools and Implementation Process*:** Personal knowledge scale, GMO knowledge test scale, about GMO foods were used as data collection tools in the study (Bici, 2010; Sönmez, 2011; Kılınç *et al.,* 2013; Çelik, 2015; Demiral and Türkmenoğlu, 2018). Personal knowledge scale was prepared by the researchers to collect the demographic information of the students regarding their department, class, and gender. GMO foods knowledge test refers to the test consisting of ten opinions to test the knowledge that the students have learned about GMO foods in the past and that they had acquired during their education and training process. Each question included 'Correct', ' Incorrect' and 'Do not know' options.

***Implementation Process*:** Each test was applied to 25, 108, 50, 25, 61, 4 students of the Horticulture, Plant Protection, Agricultural Economics, the Agricultural Biotechnology, Field Cropsand and the Animal Science Department in the same order. The data collection tools were applied to the students face to face, under the control of the researchers, in about half an hour. The reasons for the face-to-face application of the scales were to ask the researchers about the incomprehensible parts of the scales and thus to increase the reliability of the opinions to be taken to the questions.

***Data Analysis*:** knowledge scales related to GMOs were analyzed with IBM SPSS Statistics v.16 Windows package program (IBM SPSS, 2008) in the study. The level of significance was determined as $p<0.01$ and $p<0.05$ in statistical analysis. Chi-square test was used in the analysis of proportional data.

RESULTS

Demographic characteristics of agricultural engineering students were examined at the level of departments, classes and genders. Students' knowledge levels about GMOs were discussed within the scope of the same variables.

Demographic Characteristics of Students: A total of 273 agricultural engineering students participated in the research. Their departments, classes and gender variables are given in Table 1 as number (n) and proportion (%).

According to Table 1, 108 (39.6%), 25 (9.2%), 50 (18.3%), 61 (22.3%), 25 (9.2%), 4 (1.5%) of the students belonged to Plant Protection, Horticulture, Agricultural Economics, Field Crops, Agricultural Biotechnology, and Animal Sciences. Similarly, 58 (21.2%) of the students are in the 1st grade, 95 (34.8%) in the 2nd grade, 50 (18.3%) in the 3rd grade, and 70 (25.6%) in the 4th grade. 173 (63.4%) of the students are male and 100 of them (36.6%) are female students.

***GMO Knowledge Levels of the Students*:** GMO knowledge levels of agricultural engineering students was examined with a knowledge level test consisting of ten opinions. The

numbers and percentages of the answers given to the opinions in each item of the scale are given in Table 2. The students selected one answer among the multiple choice as "Correct", "Incorrect" or "Do not know" against each question.

Table 1. Analysis of agricultural engineering students participating in the study according to their gender, department and class variables.

Demographic Characteristics		Number (n)	Percentage (%)
Scientific Programmes	Plant Protection	108.00	39.60
	Horticulture	25.00	9.20
	Agricultural Economy	50.00	18.30
	Field Crops	61.00	22.30
	Agricultural Biotechnology	25.00	9.20
	Animal Sciences	4.00	1.50
Total		273.00	100.00
Classes	1	58.00	21.20
	2	95.00	34.80
	3	50.00	18.30
	4	70.00	25.60
Total		273.00	100.00
Gender	Male	173.00	63.40
	Female	100.00	36.60
Total		273.00	100.00

The correct answers given by the students to four out of 10 questions (as shown in Table 2) was 53.5%-66.7%, incorrect to one (48.7%), and do not know (34.4%-86.8%) to five questions. The only question with incorrect reply was "Genetically modified products are products with hormones." To this question, 48.7% of the students answered yes (correct), 38.8% said no (incorrect) and 12.5% said they do not know. The reply is in agreement with Tahmaz and Özkaya (2017), who noted that consumers most often confuse the concepts of GMO and hormone due to the fact that lack basic information's about two different subjects. The replies are based on knowledge based on social media, rather than actual knowledge obtained through subject teachers in the universities. The data obtained regarding the opinions of the Knowledge Test were analyzed at the level of departments in Table 3, and at the level of class and gender in Table 4.

According to Table 3., the students gave correct answers to only three out of ten questions across all departments ($p<0.01$). The correct answers to the other questions varied between 9.9% and 48.7%. The question that the students know correctly was "The nutritional value of the products can be increased with GMOs (53.5%)", "The country with the highest GMO production is the USA (53.5%)" and "The most produced genetically modified plants in the world are corn and soybean. (60.8%)". The results are consistent with the results of previous studies (Koçak *et al.*, 2010; Alkara, 2013; Öztürk *et al.*, 2014; Adana *et al.*, 2014; Ergin *et al.*, 2015; Çelik, 2015; Sağlam, 2015; Tiryaki and Vatan 2016; Kaya and Akar, 2016; Bahadır, 2017; Oğur and Aksoy, 2017). The reasons underlying the fact that the students' level of knowledge about GMOs is low is the insufficient number and content of the courses related to GMOs (biotechnology, genetics, etc.) in the curriculum of the respective departments they study. Students say "I know enough about GMOs." The answers given to the question also support this fact (Table 5). According to Table 4, at least more than half of all classes knew that GMO foods cannot be digested ($p<0.05$) and that the most produced genetically modified plants in the world are corn and soybean ($p<0.01$). The classes that gave the most correct answers to the questions were the fourth, the third, the second and the first graders, in descending order. As the grade level decreased, the level of knowledge also decreased. The results are consistent with the results of previous studies (Demir and Pala 2007; Turan and Koç 2012). The reasons for the improvement in the level of knowledge is based on the fact the increase in the number of courses they take about GMOs also improve background knowledge of the students. Only "The nutritional value of the products can be increased with GMOs." there was a statistically significant difference at

Table 2. GMO knowledge levels of agricultural engineering students.

Knowledge Test Scale	Correct answer	Correct		Incorrect		Do not know	
		f	%	f	%	f	%
Nutritional value of products can be increased with GMOs	D	146	53.5	81	29.7	46	16.8
GMO foods can't be digested	Y	27	9.9	182	66.7	64	23.4
Genetically modified products are hormonal products	Y	133	48.7	106	38.8	34	12.5
The cultivation area of GM plants is in the world approximately 190 million hectares	D	44	16.1	5	1.8	224	82.1
The most GMO producing country is USA	D	146	53.5	11	4.0	116	42.5
Production of GMOs is free in Turkiye	Y	87	31.9	92	33.7	94	34.4
The most widely produced GM plants in the world are corn and soybeans	D	166	60.8	12	4.4	95	34.8
The first GM human food is an extended shelf life of tomatoes	D	98	35.9	14	5.1	161	59.0
GMOs are free in 26 countries in the world	D	30	11.0	6	2.2	237	86.8
GMOs are free only in animal feed in Turkiye	D	53	19.4	82	30.0	138	50.5

Table 3. Distribution of the "Correct" answers given by the students to the opinions in the knowledge test scale at the level of the departments.

Knowledge Test Scale		All Departments	Plant Protection	Horticulture	Agricultural Economics	Field Crops	Agricultural Biotechnology	Animal Science	Sig.
Nutritional value of products can be increased with GMOs.	f	146	58	13	14	37	22	2	**
	%	53.5	53.7	52.0	28.0	60.7	88.0	50.0	
GMO foods can't be digested.	f	27	10	2	6	7	2	0	**
	%	9.9	9.3	8.0	12.0	11.5	8.0	0	
Genetically modified products are hormonal products.	f	133	54	4	40	29	3	3	**
	%	48.7	50.0	16.0	80.0	47.5	12.0	75.0	
The cultivation area of GM plants is in the world approximately 190 million hectares.	f	44	9	3	2	12	15	3	**
	%	16.1	8.3	12.0	4.0	19.7	60.0	75.0	
The most GMO producing country is USA.	f	146	52	15	19	37	20	3	-
	%	53.5	48.1	60.0	38.0	60.7	80.0	75.0	
Production of GMOs is free in Turkiye.	f	87	39	4	15	23	4	2	**
	%	31.9	36.1	16.0	30.0	37.7	16.0	50.0	
The most widely produced GM plants in the world are corn and soybeans.	f	166	62	13	21	48	19	3	**
	%	60.8	57.4	52.0	42.0	78.7	6.0	75.0	
The first GM human food is an extended shelf life of tomatoes.	f	98	24	13	11	33	14	3	**
	%	35.9	22.2	52.0	22.0	54.1	56.0	75.0	
GMOs are free in 26 countries in the world.	f	30	9	1	4	8	5	3	**
	%	11.0	8.3	4.0	8.0	13.1	20.0	75.0	
GMOs are free only in animal feed in Turkiye.	f	53	14	3	5	18	12	1	**
	%	19.4	13.0	12.0	10.0	29.5	48.0	25.0	

**: $p \leq 0.01$; *: $p \leq 0.05$; -: nonsignificant effects

Table 4. Distribution of the "correct" answers given by the students to the opinions in the knowledge test scale at the level of class and gender.

		Classes					Gender		
Knowledge Test Scale		1	2	3	4	Sig.	Male	Female	Sig.
Nutritional value of products can be increased with GMOs.	f	22	43	33	48	**	103	43	**
	%	37.9	45.3	66.0	75.3		59.5	43.0	
GMO foods can't be digested.	f	36	54	37	55	*	120	62	-
	%	62.1	56.8	74.0	73.2		69.4	62.0	
Genetically modified products are hormonal products	f	9	29	20	48	**	69	37	-
	%	15.5	30.5	40.0	67.8		39.9	37.0	
The cultivation area of GM plants is in the world approximately 190 million hectares.	f	5	9	16	14	**	31	13	-
	%	8.6	9.5	32.0	25.3		17.9	13.0	
The most GMO producing country is USA.	f	25	37	32	52	**	96	50	-
	%	43.1	38.9	64.0	78.4		55.5	50.0	
Production of GMOs is free in Turkiye.	f	13	15	24	40	**	66	26	-
	%	22.4	15.8	48.0	69.0		38.2	26.0	
The most widely produced GM plants in the world are corn and soybeans.	f	31	48	30	57	**	112	54	-
	%	53.4	50.5	60.0	82.3		64.7	54.0	
The first GM human food is an extended shelf life of tomatoes.	f	14	32	22	30	-	67	31	-
	%	24.1	33.7	44.0	53.7		38.7	31.0	
GMOs are free in 26 countries in the world.	f	4	6	9	11	**	24	6	-
	%	6.9	6.3	18.0	31.3		13.9	6.0	
GMOs are free only in animal feed in Turkiye.	f	5	9	14	25	**	37	16	-
	%	8.6	9.5	28.0	57.3		21.4	16.0	

**: $p \leq 0.01$; *: $p \leq 0.05$; -: nonsignificant effects

the $p<0.01$ level between the genders in the distribution of the correct answers given to the questions. Correct answers to all other views are statistically non-significant.

DISCUSSION

The answers in each category/scale were evaluated according to the department, class and gender variables of the students,

and mostly according to the answers given by at least more than half of the students. It was noted how the background of the students' their departments, classes and gender reflected their awareness about GMOs.

When the students were evaluated across all departments, only three of the ten questions were replied correctly. However, the questions with statistically significant results specific to the departments are only questions that "The nutritional value of the products can be increased with GMOs" and "The most produced genetically modified plants in the world are corn and soybean". The department that gave the most correct answers to these questions was the Department of Agricultural Biotechnology, and the department that gave the least correct answers was the Department of Agricultural Economics. For all three questions, which were answered correctly and statistically significant results were obtained, the senior classes gave more correct answers than the other classes. In terms of genders, only the answers given to the question "Nutrition values of products can be increased with GMOs" were found to be statistically significant, and it was observed that male students gave more correct answers to this question than female students. These results show that agricultural engineering students do not have sufficient level of knowledge about GMOs in terms of departments, classes and genders in Turkiye.

At least more than half of the students argue that GMOs harm human health and that GMO foods disrupt the natural balance (p<0.01). The department with the highest participation in both views was Agricultural Economics, and the department with the least participation was the Department of Agricultural Biotechnology. In terms of classes, the answers given to the opinion that only GMOs harm human health were statistically significant, and the classes that agreed with this opinion were the 1st, 2nd, 3rd and 4th graders, in the same order.

It was found that the number and content of biotechnology-related courses in the curriculum of the departments of the students influenced in shaping the knowledge of agricultural engineering students about GMOs. Adding biotechnology-related courses to the current curriculum of the relevant departments will support agricultural engineering students to graduate with better information therefore, it would be appropriate to revise the curriculum of the Departments. It has been concluded that the related courses taken by the students as the grade level increases are beneficial in the formation of correct opinion. It is seen that male agricultural engineering students have more information about GMOs than female students. The training of female agricultural engineering students can be enriched by seminars, congresses, etc., as well as enriching the courses supported with scientific activities.

***Conclusion*:** There is a serious lack of knowledge of agricultural engineering students about GMOs in Turkiye. In order to eliminate this deficiency, more courses on the subject should be added to the curriculum of agricultural faculties. The lack of knowledge of agricultural engineering students about GMOs is a major obstacle to increase awareness of Turkish society. For this reason, there is a need to raise awareness of the students who are understood to influence the society more about GMOs based on correct facts.

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***Authors contributions statement*:** Saglam Yılmaz S: Conceived the idea, designed the study, wrote the article, reviewing and editing; Kutlu S: Assisted in survey work, in data collection and writing the article.

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