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HUNGARIAN AGRICULTURAL RESEARCH

September 2017

Environmental management, land use, biodiversity

FROM CONTENTS

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CAMARO-D

Cooperating towards **A**dvanced **MA**nagement **Ro**utines for land use impacts on the water regime in the **D**anube river basin

The project

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Project budget: 2,588,138 €

3 pilot action clusters
Series of stakeholder workshops
GUIDR (Guidance for sustainable land use planning), LUDP

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Project co-funded by the European Union funds (ERDF and IPA)

HUNGARIAN AGRICULTURAL RESEARCH

Environmental management, land use, biodiversity

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COMPETITIVENESS AND SUSTAINABILITY IN AGRICULTURE

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INTRODUCTION

Agricultural activity along with the historical times of humanity have changed and evolved over millions of years. The hunting-gathering lifestyle, the production of wild plants, the domestication of wild animals refined human manners, constantly developed their abilities and contributed to the development of the human culture. The Greek word 'agriculture' expresses the role of agriculture in everyday life: it encompasses the cultivating power of the farmers with the same rank as classical arts, fine arts, theatre art and many other areas of culture.

THE DEVELOPMENT OF AGRICULTURE AND FOOD PRODUCTION – SHORT HISTORICAL OVERVIEW

The greatest impact on the development of agriculture and food production was the simultaneously increasing number of technical achievements and growth in population. The first primitive tools were made from wood and stone by our ancestors to prepare the soil for the seeds to be discarded, which also helped to keep animals, or even to grind the produced seed, and to further process the crop. The process which took place at the time of the Hungarian Conquest resulted in revolutionary changes throughout Europe. The first seeders appeared and spread, the elements of tillage cultivating tools were replaced by iron and steel. It is not accidental that posterity calls this period the First Revolution of Agriculture, because basic changes took place in the conditions of production. Hundreds of years passed until similar scale of change took place when the achievements of the Industrial Revolution broke into agriculture as well. In addition to manual and animal traction, the steam engine appeared, which simultaneously transformed the everyday practice of farming, and changed the demand of workforce in agriculture. The Industrial Revolution triggered explosive changes in agriculture (the Second Revolution of Agriculture), which directed the agro-technical development of the following centuries. Because of the technical innovations, the tools of crop production were modernized and new machines (disc, cultivators, and soil mills) emerged, which enabled farmers to produce food and raw material at a suitable level of the time. By the end of 19th century, every achievement was available to bring progress in agriculture - that had not been experienced before.

Technological revolutions also led to population growth, and rising numbers of population demanded more and more food. In Europe, the average yield of wheat tripled from 0.8 t/ha to 2.5 t/ha in four hundred years by the 1900s. In the following period, less than a hundred years was needed to produce yield growth of similar proportion. Widespread use of fertilizers, pesticides, and advanced breeding methods emerged, and the development of biotechnology was intensified both in animal breeding and crop production (Figure 1).

Thus, the 20th century brought the rapid development of agriculture, while at the same time the world's population grew at an unprecedented pace. Between 1800 and 1930 there was a need for 130 years to double the population (from 1 billion to 2 billion), and after that period only 29 years was enough to grow at a similar rate. Because of the rapid growth, the population had reached 7 billion by 2011. Although the pace of population growth has slowed down, the Earth's population is expected to reach 8 billion by 2024, which requires new solutions in water, food and energy supply.

Today, agriculture is undergoing huge changes in a global scale and its development is extremely fast. At the same

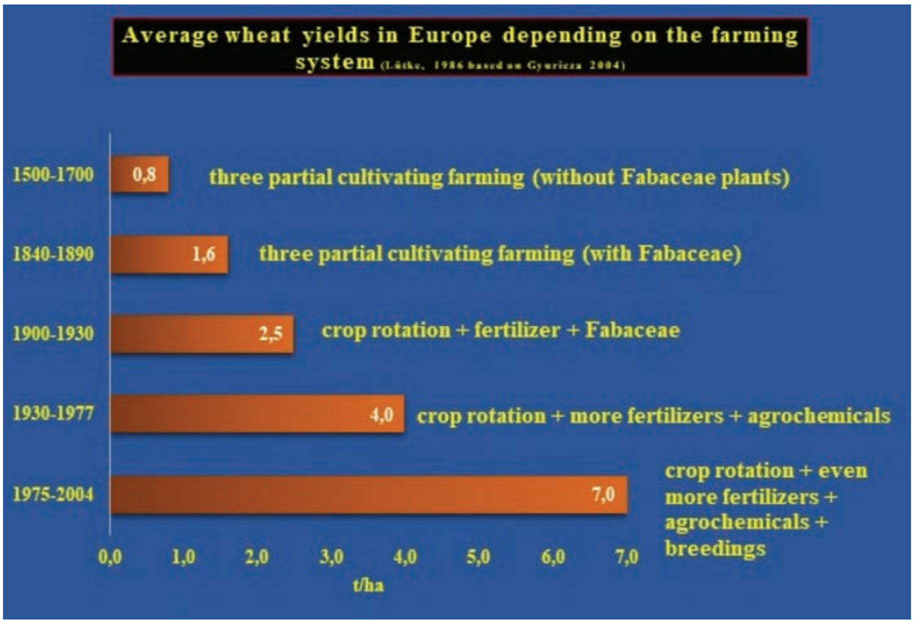

Figure 1: Average wheat yields in Europe depending on the farming system

time, the world's agricultural development has two major typical trends. The expansion of robotic technology and digitalization results made agriculture a high technology sector. The technological centers are Europe and America and it is increasingly shifting to Asia (China, Singapore, Malaysia, and India). The other direction of development is the demand of going back to traditions; the less intensive technologies are primarily strengthening in small farms' level. This includes organic farming, local food production, keeping native animals, rural tourism, etc. This duality can be well traced in the development of Hungarian agriculture as well as worldwide on all continents, although undoubtedly in different extent. Agriculture is a sector of the national economy, which can be viable if it allows farming families to be able to maintain a good quality of life. We must strive to evolve the creation of a farm that is competitive and at the same time, it is environmentally and naturally sustainable. There are many debates amongst professionals and policy makers on what are the main points in terms of structural and development in Hungarian agriculture that can improve its position in the long run.

After the change of the regime the output of the Hungarian agriculture declined significantly, the use of input materials decreased, the privatization redefined the ownership, and the food industry's output lagged behind the sector's possibilities. Since 2010, our agriculture has been growing steadily, the aspirations of the economic branch are showing encouraging results, reaching over 2600 billion HUF in 2016, showing an increase of 50-55% over the last 6-7 years. However, there are several reasons why we cannot be satisfied.

Around 40% of the budget of the European Union is devoted to support agriculture. In Hungary, it means the flow of about 400-420 billion HUF support based on the size of agricultural territory and the amount of animals from year to year. In addition, the support for investments by various operational programs (mainly rural development and economic development), generates an additional 200-250 billion HUF development funding on average. Therefore, the agricultural activity is support-oriented throughout Europe, while in Hungary about 25-28% of the output comes from subsidies, it is far exceeding the expected profitability of this sector. All of this warns the experts who are responsible for the agricultural economy that the Hungarian agriculture is maintained by the subsidies at present. The current agricultural structure's competitiveness would become questionable alongside the changing support policy.

Hungary as the European Union's member state is struck by the problem outlined above because the output of our agriculture is just about 60-65% of the developed Western European countries'. Even more thought provoking is the comparison of the Hungarian agriculture with the United States', which can work at least twice as effectively. However, we have no reason to complain about our ecological features and available agricultural land. In Hungary, there are about 20 hectares more production area per capita than in other EU countries. Compared to that, we do not reach 2% of the Union's total emissions, while based on our capacity and the size of the agricultural area 3.5-4% should be met. The agricultural performance development in the world and in Hungary is well illustrated by the fact that since 1989, the world's agricultural productivity grew by around 70%, but in Hungary, opposite to the positive tendencies of recent years, it has decreased by 30-35%.

Based on some of the facts outlined above, it can be clearly stated that in the coming period it is the vital question for the Hungarian agriculture to increase production by at least 30-40% in order to ensure that the Hungarian countryside, instead of being dependent, it should be the supporter of favorable economic, social and demographic effects.

In the first decades of the 21st century, it is considered that radical changes are needed in the four broad areas of the agricultural sector to improve competitiveness, production security, rural lifestyle and the conditions for maintaining the population.

AGRICULTURAL RESEARCH AND HIGHER EDUCATION

In Hungary, the research on agricultural science has four distinct scenarios. There are scientific activities at different levels in the 24 agro academic faculties in 13 cities. In the Agricultural Research Center of the Hungarian Academy of Sciences, which operates with the Center in Martonvásár, basic research is being carried out. The practice-oriented applied research is mainly carried out at the National Agricultural and Innovational Research Center within the Ministry of Agriculture. This institution with its 12 institutes and 4 companies covers almost every area of the Hungarian agriculture sector, and provides direct support for the development and implementation of agricultural policy (Figure 2).

The fourth field of agricultural research can be regarded as financially strong companies (primarily internationally owned enterprises, but also domestic-owned companies) who fulfill the innovation tasks for the fulfillment of business policy goals and the increase of profit. Usually research is not carried out separately, research projects with support from domestic or international sources are implemented in co-operation with the participants outlined.

Hungarian higher education has undergone a continuous transformation over the last decades. Unfortunately, the created structure cannot be considered definitive yet, and the 24 Hungarian agricultural sciences faculties are not competitive at the international field of higher education. In organizational or content aspect, the domestic higher agricultural education is not prepared to provide future engineers with a practical knowledge of competitive agriculture and up-to-date knowledge about the different branches of manufacturing industry that are based on agriculture. The currently fragmented organizational and management system is not able to utilize the resources with maximum efficiency. Therefore, one of the basic tasks of the coming period is to build a more focused agrarian higher education. An educational system capable of realizing the real needs of labor market and the national economy through a thoughtful organizational and content transformation, a system that can concentrate economic and human capital by the education of future professionals with the knowledge that can be directly utilized.

An effective and competitive agricultural sector is based on innovation and human capital throughout the world. Hungary is a small country, thus it must use its own resources for research in a thoroughly planned way. It is the waste of resources if we carry out scientific researches in

Figure 2: The Gödöllő Building of the National Agricultural and Innovational Research Center

which we have a competitive disadvantage compared to the world's major institutions or multinational companies. We must bravely admit that we will be the users of results and we will work on the adaptation of these results (e.g. agricultural information, plant protection, and research on certain aspects of breeding).

The answer of the complex question „What should be the subject of research?" can be that all research can be justified in the field of agricultural science that takes into account the agro-ecological features of the Carpathian Basin, aims to develop technologies adapted to changing climate conditions in the fields of animal husbandry, plant cultivation, horticulture and forestry as well.

USE OF TECHNOLOGIES THAT ADAPT TO CHANGING CLIMATE CONDITIONS

The weather conditions in Hungary have changed over the last decades challenging all agricultural players. The previously used plant species can be cultivated by less efficiency now. Animal breeding technology is constantly changing due to the increasing frequency of extreme weather phenomena, new plant diseases and pests appear, the weed flora changes, the cultivation of arable and horticultural plant species that were previously unsuccessful will become commonplace, forestry belts are being transformed, species structure is changing. These are just a few of the many changes that directly affect agriculture.
Using the most advanced methods of agriculture, the methods of combating climate change are diverse but the most effective results can be achieved by the rational use of agricultural water. Instead of irrigation, it is first necessary to talk about agricultural water utilization, which means rainwater management, e.g. the management of water surplus and water scarcity. We still do not put enough emphasis on moisture-saving technology during plant cultivation, which includes soil cultivation, biological foundations, crop rotation and the irrigation only as the last ultimate solution. The largest water reservoir in

Hungary is the soil, we all have a professional duty to keep as much moisture as possible and make it accessible for farming. The water absorbing capacity of the soil can be as high as 300 mm, which means even the amount of a half-year precipitation. The agrotechnical goal is therefore to receive and retain as much water as possible through the reasonable cultivation of soil by eliminating or avoiding physical degradation damages (Figure 3).
However, over the last decades, the extreme weather phenomena warns us that water-saving technologies alone do not represent a complete solution and safety in crop production, and therefore the extension of irrigation is inevitable.
However, in Hungary today, only fewer than 100,000 hectares is irrigated, which has been continually reducing from 366,000 hectares irrigated land regardless of whether events, until it has reached today's amount. It is not the weather that causes the irrigation decline. Cause of it on the one hand is the ignorance of the minimum law, on the other hand is that the costs of irrigation cannot be enforced in the price of produced crops. In addition, irrigation systems adapted to previous large-scale farming did not meet the needs of small farms. The economically irrigable estate sizes did not remain in one hand, and in domestic agricultural primary reason for irrigation is to avoid drought damage, –that is not in accordance with the conditions of intensive irrigation management (Figure 4.) The irrigation-relevant plants (arable vegetables, sugar beet) fell out of the irrigation culture due to the cessation of processing capacity, which reduced the irrigated area. The development of irrigation, the irrigated crops, the introduction of a modern irrigation culture and the processing capacity are therefore strongly related. It is estimated that the size of the irrigable area could be increased to 600 000 hectares in Hungary.

In recent years there have been several times when the damage of crop production could have been significantly

Figure 3: Climate damages can be reduced by smart soil cultivation

Figure 4: Increasing the irrigated area is one of the major tasks of domestic agriculture

reduced if we had been able to irrigate at larger areas. In 2012, the volume of maize production did not reach 4 million tons, and in 2013, about 200 thousand hectares could not be harvested, which caused at least one billion tons of damage to this single crop in the agricultural sector. The above examples also support the fact that the planned cost of setting up irrigation systems is not significant compared to the loss that the country suffers by lost revenue each year.

PRECISION FARMING

Informatics is one of the fastest growing industries in the world; its technological effects also appear in agriculture and generate revolutionary changes. Precision farming is an emerging new trend because of IT and agricultural knowledge. Although its spreading is still at an early stage in Hungary, it is regarded as one of the most important tools for enhancing agri-food competitiveness.

Precise farming is focusing on technology, and aims at optimizing agricultural production. It is the introduction and application of procedures that can produce the highest results by the lowest expenditure in crop production, livestock breeding and horticultural production. The most important goal is to increase production efficiency and minimize adverse environmental impacts. Worldwide agriculture in the future will be about competitive production using precise technology. At the same time, it is also the most effective way of getting ready for the transformations or farming without subsidies (Figure 5).
According to European Union reports, "making the machines smart" means saving about 1000 HUF / hectare. If the entire production line is intelligent, and in the given parcel we collect the dispersed seed, the fertilizer, the plant protection product and the data of harvest into a database by exact square meters, the savings after the third year can reach 15 000 HUF / hectare. And if we collect the

Figure 5: Drones are an indispensable tool for precision farming

data at plant level and get the weather information and plant protection data, the savings could reach 25 000 Ft / hectare. By the use of precision technologies, the annual output of domestic agriculture is estimated to increase by 350-400 billion HUF, which corresponds roughly to the amount of direct area and livestock subsidies paid to farmers annually.

The widespread use of precision technologies has led to more difficulties. Taking into account the number of farms, it assumes the presence of thousands of IT professionals and users familiar with agricultural processes, who are designing and operating applications and can educate and give advice to the users. It is partly legitimate to fear that technological changes can cut jobs, but at the same time, they create new employment opportunities, but it is necessary to be prepared for them.

Hungary cannot make the mistake of investing significant resources into development of state-of-the-art technologies, because our primary job is to adapt and to conduct adaptation related research, which can lead to acceleration of efficient application of precision technologies in Hungary over the coming years.

VERTICAL INTEGRATION (FROM RAW MATERIAL TO PROCESSED PRODUCT; FOOD AND ENERGY PRODUCTION ORGANIZATION AND INTEGRATION)

The profitability of agricultural activity is fundamentally influenced by how it can build a processing industry based on raw material production around itself.
In agro-industrialized countries (agro-food, food-processing, pick-up), agriculture can reach 1.5 to 2.0 times the gross added value of agriculture, but in Hungary this value varies from 0.5 to 0.6.

This situation also marks the direction that the Hungarian agriculture needs to follow in order to bring raw material production and the manufacturing industry on the rise with increasing importance in the gross national product.
Hungary's Food Program 2016-2050 sets the target for the country to achieve 25% of the added value of agribusiness within the national economy by 2050.

To achieve this the aims are the following:
- the gross added value of food industry should be 2.5 times the gross added value of agriculture
- the magnitude of the export of agro-food products should reach € 20 billion
- the number of full-time employees in the agribusiness sector should be about 750,000.

Establishing jobs in agriculture and in related sectors is mostly possible in the manufacturing industry. Increasing population retention in the rural areas can be primarily achieved by increased employment capabilities. The structure and characteristics of Hungarian agriculture makes it possible to realize the entire product path (by more and more widespread foreign expression: the vertical integration) at large and small-scale plants. The preservation and strengthening of the diversity of the domestic agriculture should be present not only in production but also in processing.
Agricultural activity can be a strong pillar in the ever-changing global field where production and processing can function in organized, integrated systems and in partnerships. In Hungary, the willingness to cooperate is the weakest amongst in the whole European Union, which is the result of the bad reintegration experiences in the decades before the change of regime. One of the major challenges of the coming years is to strengthen the bargaining power, because it will be one of the key issues of Hungarian agriculture, how we can integrate, by combining and using the means of production together to improve our competitiveness.

AGRICULTURE IN DISADVANTAGED PRODUCTION SITES

It is well known that Hungary's characteristics for agricultural production are extremely good. Approximately 50% of the country's territory are arable lands and the areas utilized for agricultural use reach the 66% of it. There is hardly any country in Europe where the proportion of high-quality agricultural land can be measured to our country. Even though our ecological features are among the best ones on the old continent Climate changing conditions are challenging to farm society. At the same time, there are many areas in the country where the conditions of traditional intensive farming are not given, due to unfavorable conditions; soil conditions require a different cultivation method. From a social point of view, it is also challenging

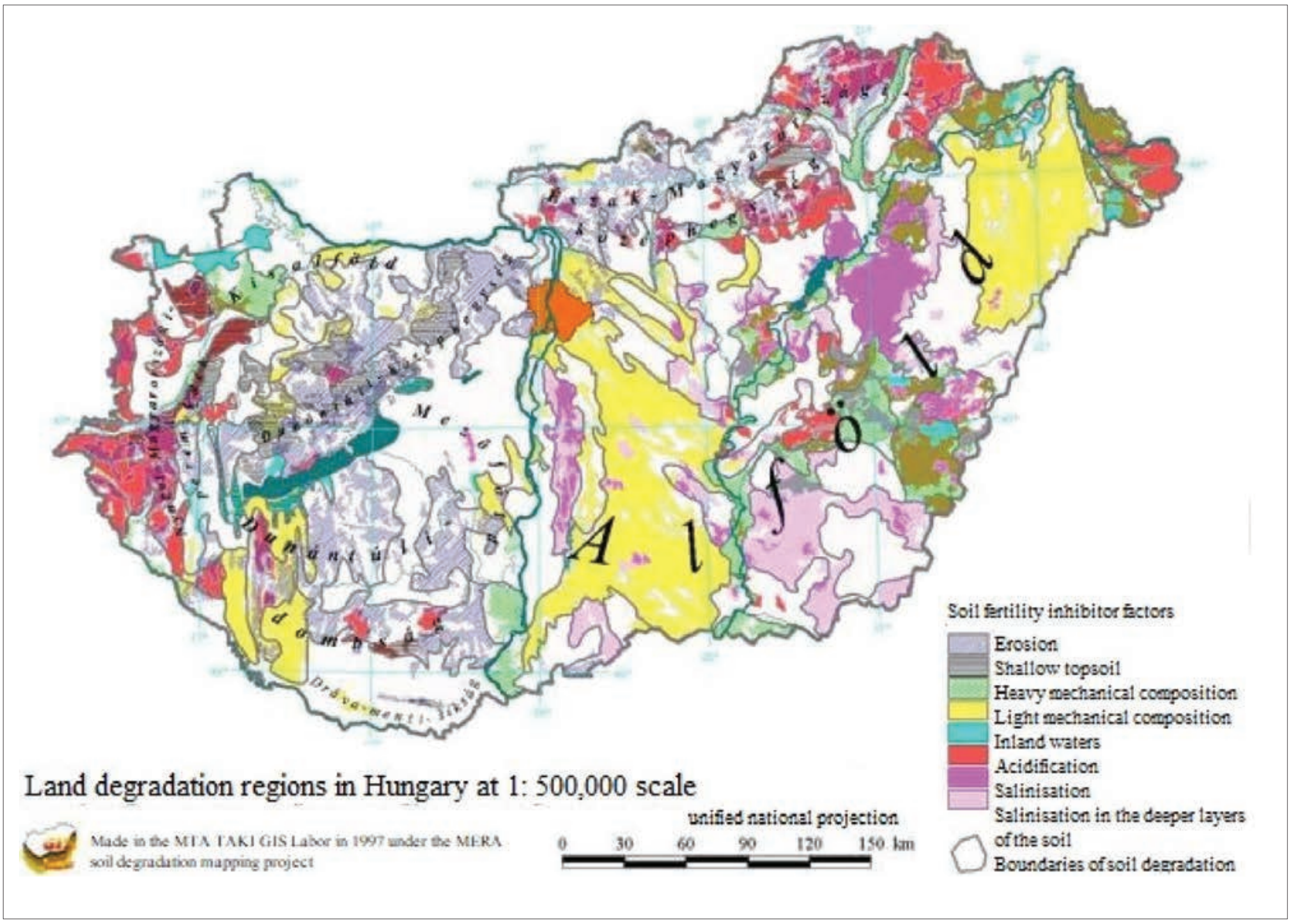

Figure 6: Soil degradation regions in Hungary (MTA TAKI, 1997)

to address this problem, because these areas are mostly in disadvantaged or multiply disadvantaged areas, where agriculture is the only employing sector for the population. In these production sites, it was never possible to carry out an effective job by following the rules of traditional farming, so in the coming years it will be decisive how new alternative methods can help to improve the living conditions of farmers in these areas.

In Hungary, the size of agricultural utilized areas are between 800 000 and 900 000 ha where the conditions of competitive farming cannot be achieved by traditional methods. The adverse soil condition may be due to the shallow topsoil, the erosion sensitivity, the heavy mechanical composition, the inland water-water sensitivity, and the acidification or the various forms of salinization (Figure 6). Agro-forestry systems can be an alternative solution for less-favored farming sites to increase the competitiveness of agriculture and increase its sustainability. Agricultural forestry means the utilization of forestry and arable hor-

Figure 7: Agriculture in practice: black nut and grainy cereals

ticultural crops in the same area and time. There are also known methods that link forestry technologies to livestock. These methods can primarily be justified if they can be used to increase the income per unit area by at least 20-25% (Figure 7).

FARMER'S OPINION FROM THE CONSERVATION OF THE KURGANS

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ABSTRACT

Our research aims at overviewing the present and the past of kurgans, who are our national values, furthemore it also aims at throwing light on their future under the new agricultural system of the EU in connection with cross-compliance. We will present both the historical background of the formation of Cumaninan mounds, and their relationship with human society in the past centuries. There were remarkable changes in the agricultural regulation concerning Cumanian mounds in the EU – and in Hungary too – in 2010. They were declared protected landscape elements therefore they became part of cross-compliance. The new regulation has created conflicts in the triangle formed by small-holders, kurgans and regulations. For the detection of this tension and for the possibilities of a solution we conducted an empirical study, a sociological survey with a deep-interview method among Békés-County small-holders as well as the experts of the subject. From the results it is evident, that the cultivation and destruction of the mounds is not the consequence of conscious activity, it can rather be attributed to the lack of knowledge and to ignorance. Having considered our results, we would recommend the rethinking of the range of mounds taken under the effect of the regulation, as well as the allocation of a minimal amount of extra subsidies, and to the authorities the establishment of contact with small-holders and their close cooperation in the interest of rescuing the mounds.

keywords: kurgan, Common Agricultural Policy (CAP), rural sociology

INTODUCTION

Two research studies in the June 2015 edition of the scientific journal Nature deal with the late Copper Age, early Bronze Age periods of Eurasian regions. Allentoft et al. (2015) (researchers from various parts of the world), in the other research study Callaway (2015) it was pointed out that in the period between 3,000 BC and 1,000 BC a significant wave of migration was characteristic in the Eurasian region. As a result of their migration and spreading these populations had a fundamental impact on the development of the cultural and ethnic image of modern age Europe. In the course of the research studies DNA analyses of bones taken from Cumanian mounds were performed and conclusions were drawn from these. Because of the characteristic shape of the mounds they are of outstanding significance from the aspects of geology, zoology and botany, as well as scenery protection and scenery history (Tóth A. 2002). Cumanian mounds are part of the cultural history of Carpatian Basin. So there are many and interesting informations in their mound body. By examinating them, not only the science of archeology can be richer but we can have a better knowledge of botany, palaeo ecology, landscape ecology and soil science as well.

In Hungary, the different types and ages of prehistoric mounds are called Cumanian mounds. This name (which is a bit inexact) suggests that it is only about the man-made mounds that were built by the Cumanian ethnic group in the 13th century. On the contrary, archeological excavations and datings have proved that most of them are a lot older than the tumulus that the Cumanians built. These man-made formations kurgans have main importance in nature conservation, landscape, archeological, botanical, zoological, cultural history viewpoints (Tóth A. 1999).

The archeological excavations disclosed that most mounds originate from the Copper Age, and they are tombs from the early Bronze Age, settlements from the Bronze Age, Sarmatan, German and Hungarian Conquest-Aged cemeteries, churches and tombs from the Árpád Age and some of them still have their burial traces. The outstanding botanical value of the Cumanian mounds is that it is the last shelter for the non-cultivated, natural habitat and for the rarefying plants of the steppe. The mounds that detach as islands, are the places that keep the biological diverseness (Sudnik-Wójcikowska et al. 2011). Beside their botanical and archeological values these also have landscape, soil science and palaeo ecological values (Hejcman et. al. 2013). The mounds are also valuable considering soil science. The detailed examination of the once buried and the soils that have been formed in the past millenia can broaden – moreover it can augment new results – the body of knowledge of the holocene environmental changes, like climate changes (Alexandrovskiy, Chichagova 1998, Barczi, Golyeva, Pet 2009), it also helps evaluate the man-made, antropogen soil formations (Puskás, Farsang 2008).

Based on map sources there were approximately ten thousand mounds in Hungary but by the mid-20th century they significantly decreased in number and their condition drastically deteriorated. During the 19th and 20th century hundreds of mounds were eroded and ploughed mainly by the river control and then by the developing commercial agriculture, the names of those remained have been forgotten by today. Although the I. Josephian military map-sheets show a large number of Cumanian mounds in the Carphatian Basin and by gleaning the old maps we can see almost fourty thousand mounds, today we can hardly ever see an untouched, undamaged mound in the Great Hungarian Plain that we could be proud of.

According to the database assembled in 2002, after the countrywide cadastring, the mounds have been in very bad condition. Almost half of the mounds are under intensive plough cultivation, 40 % of them are damaged and a fifth of them have no landscape value, they are forested and weedy mounds (Tóth Cs., Tóth A. 2011). Although making the cadastre – which is maintained by the assesment and data supply of National Parks – was successful, the assessment itself did not protect the mounds efficiently.

There was a remarkable step in the common agricultural policy (CAP) of reform of 2009. The basis of today's work are the communal order that came into force by the reform, the relating local laws and their impact on the growers and the country land. The new regulation has two basic elements: Statutory Management Requirements (SMR) which are governed by the law, and the required standards in the agricultural and environmental conditions (GAEC). Cross-compliance was introduced by Council Regulation (EC) No. 73/2009 owing to the reform in Common Agricultural Policy in 2003. The aim of our survey is to observe the effects and results of the kurgans in Békés county concerning the landscape changes. Our observations include the morphological changes on the kurgans as well as the demodulation of the farmers' attitudes which is important and significant as it can be a source of conflicts due to the new laws and regulations. At the same time, these conflicts need to be cleared and handled as farmers form the landscape and are also integral part of it. The kurgans are also protected by them for the next generations.

MATERIAL AND METHODS

In the course of my scientific research I would like to explore the emotions, motivations and suggestions of the people who live and farm in the scenery, regarding the mounds and their preservation. Taking the situation, protection of the mounds and solution possibilities into consideration we specified a range of issues comprised of four points. For the exploration of the range of issues, the detection of cause and effect correlations, the understanding of processes and for solution options I used a methodology of social sciences, the so-called structured interview. I conducted a total of 20 structured interviews in the territory of Békés County. In the course of the work I conducted 5 expert interviews among the experts of the subject. The discussions I had with them also contributed to the expansion of my own knowledge, at the same time, in the course of processing I compared their viewpoints with the opinions of the affected people. I conducted 15 interviews. For the purpose of easier processing, audio recordings were also made of the interviews, by means of a Dictaphone. The length of these was 2.5 hours in the case of experts, and over 6 hours in the case of the affected people. A verbatim transcript was not made of the interviews. During the interviews I also used a pre-printed datasheet containing a series of questions.

I subjected the conducted interviews to quantitative evaluation and content analysis based on the methodological recommendations of Babbie (2003) and Newing (2011). In the course of this I also reflected on the opinions of the experts. I tried to increase the reliability of the results of the qualitative research by several methods in the course of my work. During the discussions I devoted special attention to not stepping out of the role of researcher, and to avoid influencing the respondent's answers. In the course of the work I tried to record my observations accurately and in detail, and during the processing I tried to support my conclusions with quotes originating from the respondents.

RESULTS AND DISCUSSION

The majority of interview subjects did not detail their past in any particular depth, very few referred to their ancestors. This is perhaps more expectable from the members of older age groups. At the same time, Dóra who represents the younger age group (25 years old) mentioned family traditions in the field of farming.

„Even my great-great grandparents were farmers, this is the reason why I chose agriculture as well." /Dóra, 25 years old/

Every respondent spoke about their farming history in detail, the development of their own farm. We separately discussed the factors that can be considered critical from the aspect of farming. In the course of the conversations

they mentioned weather factors, marketing difficulties, administrative and agricultural subsidy regulations.
According to the content of the interviews, it can be established that the majority of farmers have rather little knowledge regarding Cumanian mounds.
„They were formed about 150-200 years ago, in my opinion they were built." /Tamás, 41 years old/
There were only a few who demonstrated deeper knowledge in the course of the discussions.
The conversations revealed that the Act on Environmental Protection previously providing protection to the Cumanian mounds was not integrated into common knowledge. Few of the respondents made a reference to the Act.
„I think it was around '91, because at the time I read that even livestock may be harmful to them…". /Valéria, 44 years old/
Most farmers made a reference to the GAEC decree.
„They have been protected since 2010. Cultivating them isn't allowed, only reaping grass on them and replanting grass…". /István, 64 years old/
It was revealed by the interviews that most of the affected people learned about the changed rules from the town agronomist.
„I learned it from the town agronomist …". /Tamás, 41 years old/
From the conversations it was revealed that the circle of farmers who were not disadvantageously affected by the regulation is small. Even so, from the interviews it was evident that most of them abandoned the cultivation of the mounds because of possible legal consequences. Mária (29 years old) said the same thing: „We are afraid of the sanctions, we are trying even more to preserve these Cumanian mounds."
Among the respondents there were a few who did not know about the processes damaging the mounds. It is evident that the affected people assess the damaging processes incorrectly. Attila (37 years old) opines: „I think that cultivation was a very-very slow erosion…". In contrast, according to an expert, János Greksza: „Ploughing is one of the most damaging processes…".
In the course of the interviews the affected people were divided in connection with the problem of possible production shortfall arising from abandoning the mounds. There were some who complained that production shortfall had occurred, but there were also some who disagreed.
„Even a grazing ground is not favorable on it, because it dries and burns out too fast." /Sándor, 64 years old/
„The tractor has a harder time going up on it, that is all." /György, 46 years old/
In the course of analyzing the interviews I reached the conclusion that the new regulation had a considerable reaction among the farmers in the region.
During the discussions I wished to find out what kind of suggestions the affected people would have in relation to the possible amendment of the GAEC decree. In the course of the evaluation of this I compared the opinions of the affected people with those of the experts regarding the issue.
A smaller circle of affected people accept the regulation. According to Demeter (66 years old) „If the law says that I shouldn't cultivate it then I will not." At the same time making the regulation stricter also arose from the part of Valéria (44 years old): „I would make the regulation stricter." The experts were cautious regarding this issue.
It was evident that the land registry settlement of the areas of the mounds could be important. This subject arose from the part of both the farmers and the experts.
„The land registry settlement of this issue should be solved." /Sándor, 64 years old/
„The land registry settlement of this issue would have great significance…". /Veronika Tóth, ARDA)/
The need for expanding knowledge related to the mounds arose from both sides.
„We were able to convince them in the framework of lectures, friendly conversations, addressing their hearts and minds." /István, 64 years old/
In the case of both the affected people and the experts the subject of reconsidering the range of mounds included in the decree arose, their classification, the deletion of smaller size mounds from the regulation.
„I recommend additional research and the establishment of more categories, because low elevation mounds and those with a small area need not be protected in my opinion." /Tóth János, ARDA/
The need for granting extra resources was voiced by a large circle of affected people. According to László (39 years old): „We must weigh its financial side…". The experts carefully considered the issue of subsidies.
From the expressions during the interviews it was also palpable that beyond financial support the farmers also desire moral recognition. „I should stop cultivating them, start managing them, mark their location with a sign, I would do that even with no compensation at all" – stated György (26 years old).
I also experienced a division regarding the management of the areas of the mounds. A portion of the respondents regard it to be a state responsibility, the experts characteristically would rather entrust this on the farmers. A rather large number of people would also support marking the mounds with a sign onsite. The experts mentioned this as well. This is also supported by the opinion of István (64 years old): „It's important that they should be marked with some kind of a sign." „The mounds should be designated onsite in the presence of the affected parties" – opines expert János Tóth.
At the end of the interview discussions I definitely wanted to bring up what the affected people think about the future of the mounds. By their responses I also received an answer to the significance, justification and support for my own research. I think that in the case of this subject their statements are the most genuine.

„There are so few things – including castles, or anything else –, that we can show to future generations. They should be preserved! Without any grand words, but I seriously think that" /Ferenc, 46 years old/

CONCLUSIONS

Farmers are fundamentally accepting of our scenery elements located in their region, even if their preservation entails the restriction of their own farming activities. It was also discovered that with the expansion of knowledge related to protected scenery elements – besides the introduction of other compensation methods –, respect and acceptance toward them increases.

Taking the results of previous studies into consideration, my research confirmed that the significant damage to Cumanian mounds ongoing for several centuries – aside from a few exceptions – was not the result of conscious human activity. It is rather attributable to the lack of related knowledge. From the results of my interviews it was also revealed that man shaping the scenery possesses general knowledge of the mounds, at the same time – with a few exceptions – knowledge connected to their characteristics, the processes causing or facilitating their destruction is rather superficial.

As a closing though to my recommendations I quote László Szelekovszky (1999): „One thing that makes the mounds special is that they are manmade, millennia old cultural history monuments, in the past they were residences and graves – and graves must be taken care of, BECAUSE GRAVES CONSECRATE A NATION INTO HOMELAND."

REFERENCES

1. Alexandrovsky, A. L.–Chichagova, O. A. 1998. Radiocarbon age of Holocene paleosols of the East European forest – steppe zone. In: Catena 34: 197–207.
2. Allentoft, M.E.–Sikora, M.–Sjögren, K.G.–Rasmussen, S.– Rasmussen, M.–Stenderup, J.–Damgaard, P.B.–Schroeder, H.–Ahlström, T.–Vinner, L.–Malaspinas, A.S.–Margaryan, A.–Higham, T.–Chivall, D.–Lynnerup, N.–Harvig, L.–Baron, J.–Della Casa, P.–D browski, P.– Duffy, P.R.–Ebel, A.V.–Epimakhov, A.–Frei, K.–Furmanek, M.– ralak, T.–Gromov, A.–Gronkiewicz, S.–Grupe, G.–Hajdu, T.–Jarysz, R.–Khartanovich, V.–Khokhlov, A.–Kiss, V.–Kolá , J.–Kriiska, A.– asak, I.–Longhi, C.–McGlynn, G.–Merkevicius, A.–Merkyte, I.–Metspalu, M.–Mkrtchyan, R.–Moiseyev, V.–Paja, L.–Pálfi, G.–Pokutta, D.–Pospieszny, Ł.–Price, T.D.–Saag, L.–Sablin, M.– Shishlina, N.–Smr ka, V.–Soenov, V.I.–Szeverényi, V.–Tóth, G.– rifanova, S.V.–Varul, L.–Vicze, M.–Yepiskoposyan, L.–Zhitenev, V.– Orlando, L.–Sicheritz-Pontén, T.–Brunak, S.–Nielsen, R.–Kristiansen, K.–Willerslev, E. 2015. Population genomics of Bronze Age Eurasia. In: Nature 522 (7555): 167–172.
3. Babbie, E. 2003. A társadalomtudományi kutatás gyakorlata. Budapest: Balassi Kiadó. 690.
4. Newing, H. 2011. Conducting research in conservation – A social science perspective. Abingdon: Taylor & Francis. 367.
5. Barczi, A.–Golyeva, A. A.–Pet , Á. 2009. Palaeoenvironmental reconstruction of Hungarian kurgans on the basis of the examination of palaeosoils and phytolith analysis. In: Quaternary International 193: 49–60.
6. Callaway, E. 2015. DNA data explosion lights up the Bronze Age. Population-scale studies suggest that migrants spread steppe language and technology. In: Nature 522 (7555): 140–141.
7. I. Puskás - A. Farsang 2008. Diagnostic indicators for characterising urban soil of Szeged, Hungary. Geoderma, Vol. 148 (3-4) p. 267-281.
8. M. Hejcman - K. Sou ková - P. Krištuf - J. Peška 2013. What questions can be answered by chemical analysis of recent and paleosols from the Bell Beaker barrow (2500-2200 BC), Central Moravia, Czech Republic? Quaternary International, 01/2013, Vol. 316, p. 179-189.
9. Sudnik-Wójcikowska, B. 2012. Kurhany na „Dzikich Polach" – dziedzictwo kultury i ostoja ukrai skiego stepu. – Kurgans in the „Wild Field" – a cultural heritage and refugium of the Ukrainian steppe. Warszawa: Wydawnictwa Uniwersytetu Warszawskiego (ISBN: 978-83-235-0965-3). 194.
10. Szelekovszky L. (Szerk.) 1999. Békés megye kunhalmai. Békéscsaba: Körös–Maros Nemzeti Parkért Egyesület, 88.
11. Tóth A. (Szerk.) 1999. Kunhalmok. „Ti vagytok a mi katedrálisaink". Kisújszállás: Alföldkutatásért Alapítvány, 77.
12. Tóth A. (Szerk.) 2002. Az Alföld piramisai. Kisújszállás: Alföldkutatásért Alapítvány, 96.
13. Tóth, Cs.– Tóth, A. 2011. The complex condition assessment survey of kurgans in Hungary. 9-17. p. In: PET , Á.–BARCZI, A. (Szerk.): Kurgan Studies. An environmental and archaeological multiproxy study of burial mounds in the Eurasian steppe zone. Oxford: British Archaeological Reports International Series 2238. Archaeopress, 350.

PANNON PIKEPERCH: PIKEPERCH HYBRID *SANDER LUCIOPERCA × SANDER VOLGENSIS*

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Due to the geographical and climatic conditions of the Carpathian basin, the dominant fish species of standard fish farms is the common carp. According to last year's statistical summary of fish production of pond culture, 75% of the total harvested market-size fish (14,282 tons) is common carp and 1,26% is the rate of carnivorous species (catfish, pikeperch, pike). The amount of pikeperch (*Sander lucioperca*) was only 27,1 tons (0,19%!) (Statisztikai Jelentések, lehalászás Jelentés, 2015, in Hungarian). Because of a market demand for better meat quality and less fattening products the production rate of Hungarian carnivorous fish should be increased. A significant increase of pikeperch production can be achieved only by developing new technologies, similar to intensive trout rearing with pellet feeding. Originally, pikeperch consumes live food, thus, this species require a specific diet.

The lack of knowledge on (pond) culture conditions inhibited evaluation of intensive rearing methods so far. In the last 15 years, research on percids has accelerated. Pikeperch rearing on formulated feeds is a new alternative way for the intensification of its production (Bódis et al. 2007, Kestemont et al. 2007). However, there is another possible way to increase the production of percids. Instead of technology improvement, a new product shall be created which can be implemented and used in a production of pond culture. This way, there is no need for an expensive farm construction. Another species of the European *Sander* genus is the Volga pikeperch (*S. volgensis*) which has perfect meat quality, as well. Although its growth is slower

Table 1. Some differences between the *S. lucioperca* and *S. volgensis* (summarised data from Balon et al., 1977; Specziár & Bíró, 2002; Specziár & Bíró, 2003; Specziár, 2005).

	S. lucioperca	S. volgensis
Duration of the reproductive season in Lake Balaton	first half of April	from mid-April to the end of May, in some years to mid June
Spawning	synchronised, one spawning within a two weeks period (see fig 1.)	non-synchronised, multiple spawnings (see fig 1.)
Reproductive guild	guarders, nesters, fitophyl	nonguarders, open substratum egg scatterers, lito-fitophyl
Distribution	large area in Europe (also occurs outside the distribution range of S. volgensis)	restricted to some river basins of the Black Sea and Caspian Sea (always sympatric with S. lucioperca)
Habitat	rivers, lakes and brackish waters (also occurs outside the distribution range of S. volgensis)	rivers and only some large lakes (always sympatric with S. lucioperca)
Ontogenetic shifting to piscivory	generally it is crucial during the first season, but at latest in the second spring	may be delayed even to third or fourth year of life
Maximum prey size during the first year	often feeds on preys close to the mouth gape width	maximum prey size is less than half of the mouth gape width
Cannibalism	occurs from 14 mm S_L	occurs only from the second year of life

Figure 1. Pikeperch (left) and Volga pikeperch (right) egg stripping

than that of the pikeperch (*Sander lucioperca)*, the Volga pikeperch starts its predatory activity later.

Due to its feeding characteristics, compared to *S. lucioperca* Volga pikeperch can be weaned to accept inanimate feed much more easily, and more efficiently even at older ages and at larger body size (own observation). This transition period was found to be at least two weeks for the pikeperch fry. Weaning of Volga perch fry from zooplankton to pellet demands only 8 to 10 days.

Survival of pellet fed pikeperch is between 44% and 49%, in which cannibalism plays a significant role, while "natural" causes of losses have a ratio of 3% to 14%. No cannibalism was observed in case of *S. volgensis* (Molnár et al., 2006). It is a very important fact that the western limit of the distribution area of Volga pikeperch is Hungary. For this reason, Western European researchers had no interest in this species, so far.

One possible solution for increasing pikeperch production is to produce a less demanding hybrid of Volga pikeperch and a pikeperch that has a late food training. But the first objective is to assess the characteristics of hybrids.

Inter-specific hybrids have been produced for aquaculture to increase growth rate, combine desirable traits of the two species, to reduce unwanted reproduction through production of sterile or monosex stocks, to take advantage of sexual dimorphism, to increase harvest survival and to increase environmental tolerance (Bartley et al. 2000). Hybridization among species of the genus Sander has been described. The saugeye (*S. vitreus* × *S. canadensis*) has been widely used in North-American aquaculture and stocked for angling purposes to natural waters due to its better growth ability and lower sensitivity to environmental conditions (Tew et al., 2006). Its biological function as a predator was to reduce recruitment and improve growth and size structure of overabundant crappie (*Pomoxis* spp.) populations (Galinat et al., 2002). Growth of Volga pikeperch (*S. volgensis)* is slower than that of the *S. lucioperca* in nature, but the first attempts on feeding Volga pikeperch with dry feed showed that its intensive culture is easier than pikeperch (Bercsényi et al., 2001). The natural hybridization of *S. lucioperca* and *S. volgensis* is rare (Müller et al., 2010), probably because of the differences in their reproductive ethology. Cross-breeding of the two species (*S. lucioperca* female × *S. volgensis* male) could

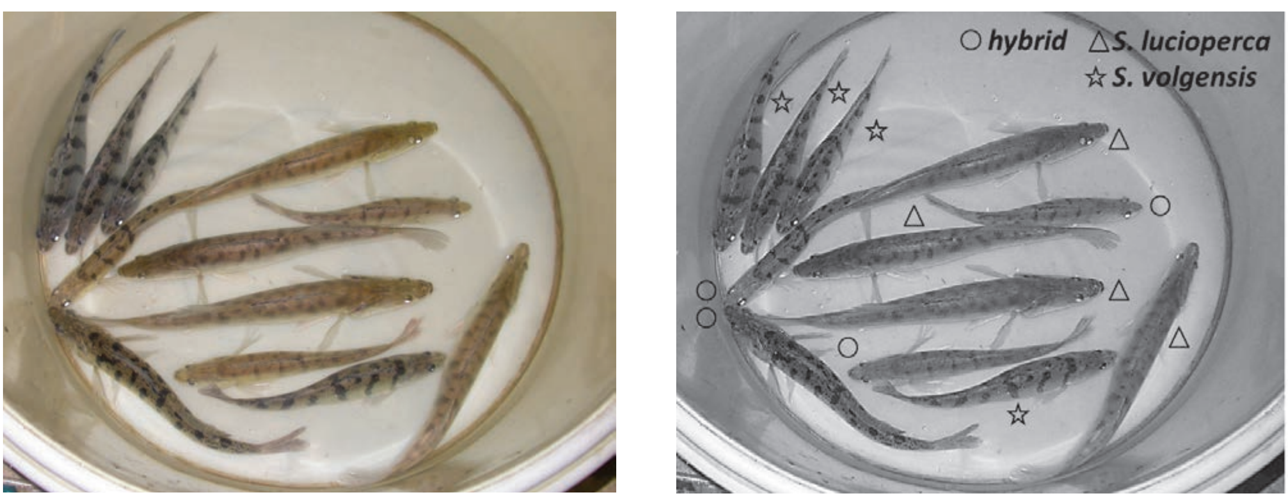

Figure 3. ***S. lucioperca, S. volgensis*** **and its hybrid**

be induced in a laboratory with a common propagation technique (Müller et al., 2004; Müller et al., 2006; Müller et al., 2009a).

The newly hatched larvae of *S. volgensis* are smaller (3.25 ± 0.17 mm, Müller et al., 2009b) than those of *S. lucioperca* (5.04 ± 0.05 mm, Ostaszewska, 2005). The growth rate and final size of pikeperch also exceeds those of the Volga pikeperch in natural waters. *S. lucioperca* grows to 145-213 mm at age 1+ (Bíró, 1970; Bíró, 1985; Bíró et al., 1998), while this same size was reached by *S. volgensis* (196 mm) at age 3+ (Specziár and Bíró 2003) in Lake Balaton, Hungary. The potentially more valuable hybrid, (*S. lucioperca* female × *S. volgensis* male) was chosen due to the considerations mentioned above in our studies.

Our recent knowledge on the important features of the hybrid are summarised as follows (Müller et al., 2004; 2006; 2009; 2010; 2011; 2012):

- The first feeding fry of the hybrid can be reared easier and more effectively than the larvae of pikeperch in laboratory conditions. There was a non-experimental observation that the hybrid larvae were not as sensitive to *Costia* infections as pikeperch larvae.
- Weaning of the hybrid juveniles to artificial food was much easier than that of the pikeperch. Volga pikeperch could be weaned to dry feed at a survival rate of 100%. In our case the survival rate of the hybrid was about 90-95%, while in the case of pikeperch the weaning losses varied between 31-88 %.
- The growth rate of hybrid was lower than the growth of the pikeperch but higher than the growth of the perch (*Perca fluviatilis*).
- Hybrids found it difficult to tolerate disturbances during the experimental period. In the mixed group interactions were observed. Hybrids in mixed groups were not as stressed as those in hybrids-only groups.
- According to laboratory experiments, F1 hybrids are fertile. The following fertilisation tests were performed: pikeperch × pikeperch (P), pikeperch × Volga pikeperch (PV) as well as pikeperch × hybrid (PH). There was no significant difference in fertilisation rates: P-86%, PV-85.6%, PH-73.6%.
- According to the three experiments done on the comparative oxygen tolerance of pikeperch and hybrid juveniles, the hybrid performed better than pikeperch in two events. In these experiments, significantly higher oxygen tolerance has been shown in the PH and PV than in purebred pikeperch. In a previous report, hybrid oxygen tolerance was closer to that of the pikeperch, not differing in the value expressed in mg/L, however, the pikeperch tolerated low oxygen concentrations for a longer period of time (Müller et al., 2006). In this experiment, hybrid and PH and PV showed longer oxygen tolerance than the pikeperch.
- Morphological keys for *S. lucioperca* ♀ × *S. volgensis* ♂ hybrid were described. Results of the genetical analyses definitely proved the hybrid status of the investigated fish.
- The natural hybridization of *S. lucioperca* and *S. volgensis* is rare, probably because of the differences in their reproductive ethology. In November 2008 a presumed hybrid was caught from Lake Balaton by fishermen. Results of the morphological and genetic analysis definitely proved the hybrid status of that fish, and mitochondrial sequence analyses showed that the female parent was a *S. lucioperca*. The captured hybrid is definitely a wild born hybrid. Based on scale readings the captured hybrid was aged to 6+ old, therefore it was born one year before the first artificial hybridization attempt (Müller et al., 2004). *S. lucioperca,S. volgensis* and their F1 hybrids can clearly be separated based on multivariate analysis of meristic and morphometric characters. Lateral line, which proved to be the most decisive character in juveniles, supported the hybrid status of the investigated putative natural hybrid.

Further investigations are needed to reveal the quantity traits of hybrids and to compare the hybrid to Volga pikeperch as well as to investigate the possibility of cross hybridization.

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LITERATURE

1. Balon, E. K.; Momot, W. T.; Regier, H. A., 1977: Reproductive guilds of percids: results of the paleogeographical history and ecological succession. J. Fish. Res. Board Can. 34, 1910–1921.
2. Bartley D. M., Rana K., Immink. A. J. (2000): The use of inter-specific hybrids in aquaculture and fisheries. Reviews in Fish Biology and Fishereis, 10, 325-337.
3. Bercsényi M., Merth J., Födelmesi Z., Müller T. (2001): Rearing of pikeperch, perch and Volga pikeperch on pellet. In: Abstract book of 25th Scientific Conference on Fisheries & Aquaculture, p. 41. Research Institute for Fisheries, Aquaculture & Irrigation, Szarvas, Hungary, (in Hungarian).
4. Bíró P. (1970): Investigation of growth of pike-perch (*Stizostedion lucioperca* L.) in Lake Balaton. Annales Instituti Biologici (Tihany) Hungaricae Academiae Scientiarium, 37, 145-164.
5. Bíró P. (1985): Dynamics of pike-perch, *Stizostedion lucioperca* (L.) in Lake Balaton. Internationale Revue der gesamten Hydrobiologie, 70, 471-490.
6. Bíró P., Specziár A., Tölg L. (1998): A Balaton halállományának minőségi-mennyiségi felmérése (1995-98). In: Salánki J. and Padisák J. Eds: A Balaton kutatásának 1997-es eredményei. VEAB and MEH BT, Veszprém, pp. 134-137. (in Hungarian).
7. Bódis M., Kucska B., Bercsényi M. (2007): The effect of

different diets on the growth and mortality of juvenile pikeperch (Sander lucioperca) in the transition from live food to formulated feed. Aquaculture International, 15, 83-90.

8. Galinat G. F., Willis D. W., Blackwell B. G., Hubers M. J. (2002): Influence of a saugeye (Sauger × Walleye) introduction program on the black crappie population in Richmond Lake, South Dakota. North-American Journal of Fisheries Management, 22, 1416-1424.
9. Kestemont P., Xu X. L., Hamza N., Maboudou J., Toko. I. I. (2007): Effect of weaning age and diet on pikeperch larviculture. Aquaculture, 264, 197-204.
10. Molnár, T., Müller, T., Szabó, G., Hancz, C. (2006). Growth and feed conversion of intensively reared Volga perch (*Stizostedion volgensis*). Acta Agraria Kaposváriensis 10 (2), 315-319.
11. Müller, T., Bódis, M., Bercsényi, M (2006). Comparative oxygen tolerance of pikeperch *Sander lucioperca*, Volga pikeperch *S. volgensis* and their hybrids *S. lucioperca* × *S. volgensis*. Aquaculture Research 37(12), 1262-1264.
12. Müller, T., Bódis, M., Urbányi, B., Bercsényi, M. (2011). Comparison of the growth of pikeperch *Sander lucioperca* (L.) and hybrids of pikeperch and Volga pikeperch *S. lucioperca* × *S. volgensis* (Gmelin, 1789) juveniles reared under controlled conditions. Israeli Journal of Aquaculture- Bamidgeh [IIC:63.2011.545]
13. Müller, T., Pál, L., Bódis, M., Kucska, B., Wágner, L., Bercsényi, M., Husvéth, F., Szabó, G., Molnár, T. (2012). Effect of different dietary fat replacement on the body composition of intensively reared pikeperch and Volga pikeperch hybrid. *The Israeli Journal of Aquaculture - Bamidgeh*, [IJA:64.2012.694]
14. Müller, T., Taller, J., Kolics, B., Kovács, B., Urbányi, B., Specziár, A. (2010). First record of natural hybridization between pikeperch *Sander lucioperca* and Volga pikeperch *S. volgensis.* Journal of Applied Ichthyology 26:481-484
15. Müller, T., Taller, J., Nyitrai, G., Kucska, B., Cernák, I., Bercsényi, M. (2004). Hybrid of pikeperch (*Sander lucioperca*) and Volga perch (*S. Volgense* GMELIN). Aquaculture Research 35 (9): 915-916.
16. Müller, T., Budaházy, A., Trenovszki, M., Hegyi, Á,, Boczonádi, Zs., Urbányi, B. (2009a). Observations on comparison of larvae survival and juvenile oxygen tolerance of pikeperch (*S. lucioperca*), pikeperch and volga pikeperch hybrids (*S. lucioperca* × *s. volgensis*) and (*S. lucioperca* × [*S. lucioperca* × *S. volgensis*]). EAS Aqua2009 Aug 14.-17., Trondheim. (abstract book, pp. 434-435).
17. Müller, T., Nyitrai, G., Trenovszki, M., Bercsényi, M., Urbányi, B. (2009b). Artificial propagation of Volga pikeperch (Sander volgensis). EAS Aqua2009 Aug 14.-17., Trondheim. (abstract book, pp. 436-437).
18. Müller, T., Bódis, M., Bercsényi, M (2006). A süllő (*Sander lucioperca*), kősüllő (*S. volgensis*) és a fehérköves (*S. lucioperca* × *S. volgensis*) összehasonlítása intenzív körülmények között. XXX. Halászati Tudományos Tanácskozás, Szarvas, május 24-25 (abstract book, p. 56-57).
19. Ostaszewska T. (2005): Develeopmental stages of digestive system structures in Pike-perch (Sander lucioperca). Electronic Journal Ichthyology, 2, 65-78.
20. Specziár, A., Bercsényi, M., Müller, T. (2009). Morphological characteristics of hybrid pikeperch (*Sander lucioperca* ♀ × *Sander volgensis* ♂) (Osteichthyes, Percidae). Acta Zoologica Academiae Scientiarum Hungaricae 55(1) 37-52.
21. Specziár A., Bíró P. (2003): Population structure and feeding-characteristics of Volga Pikeperch, *Sander volgensis* (Pisces, Percidae), in Lake Balaton. Hydrobiologia, 506, 503-510.
22. Statisztikai Jelentések, lehalászás Jelentés (2015). https://www.aki.gov.hu/publikaciok/publikacio/a:116/Jelent%C3%A9s+a++hal%C3%A1szatr%C3%B3l, in Hungarian
23. Tew S. K., Conroy J. D., Culver D. A. (2006): Effects of lowered inorganic phosphorus fertilization rates on pond production of percid fingerlings. Aquaculture, 255, 436-446.

TEA BAG METHOD: A NEW POSSIBILITY TO ASSESS IMPACTS OF AGRI-ENVIRONMENTAL MEASURES ON SOIL FUNCTIONING

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ABSTRACT

The agri-environmental schemes (AES) were introduced in the late 1980s in European Union countries to counteract negative impacts on environment resulting from agricultural intensification. Simply applicable, universal and globally accepted indicators are needed to assess the effectiveness of agri-environmental measures (e.g. integrated and organic farming systems) on soil biological quality and functioning. A national soil survey was conducted in 2014, as part of the Hungarian Agri-Environmental Monitoring Programme. Soil samples were collected from 149 arable sites throughout Hungary, incorporating a wide range of soil pH, soil organic matter (SOM%) and texture. Soil quality was estimated by means of a biological index based on soil microarthropod (QBS index). Tea Bag method was applied to assess organic matter decomposing activity of arable soils. Soil biological quality decreased in order of conventional > organic > integrated management practice and there was significant difference between conventional and integrated farming systems ($p = 0.019$). Our results showed that SOM% had a significant positive correlation with QBS index (z value = 2.658; $p = 0.008$). Plant tissue decomposition was significantly influenced by soil pH (t value = -2.942; p value = 0.004) only. However, we experienced no significant effect of agricultural management. We found organic matter decay rate was positively correlated with QBS index (Spearman's rho = 0.17, $p = 0.037$). The present study highlights that at least in the short-term, microbial decomposition of organic matter in arable fields was not predominantly controlled by agri-environmental measures in Hungary. Furthermore, we highlight the importance of regular evaluations of agri-environmental schemes. This is the first study to apply Tea Bag technique for the assessment of impacts of AES and we recommend its usage as an ecological indicator within a national or/and European soil monitoring scheme.

keywords: agri-environmental schemes, ecological indicator, plant tissue decomposition, QBS index

INTRODUCTION

Soil serves as habitat for over one fourth of all living species on Earth, contains huge amount of carbon stock and provides several ecosystem services that contribute to human well-being[1]. These soil related ecosystem services such as primary production, nutrient cycling, including carbon storage and mineralisation, and bioremediation of toxic compounds depend on soil health. Soil biodiversity is the driving force behind their regulation[2].

Soil biota plays vital role in agroecosystem functioning maintaining soil fertility and sustaining soil health. Soil microorganisms mediate the decomposition of plant residues and soil organic matter (SOM). Bacteria and fungi are responsible for 90% of the total organic matter decomposition occurring in soils[3]. Soil arthropods participate in e.g. decomposition of organic residues, biogeochemical cycling, organic carbon sequestration and maintenance of soil structure. They are key regulators of decomposition processes due to their roles in fragmentation, ingestion and inoculation of detritus[3-5].

Organic matter (OM) decomposition, as essential part of nutrient cycling, is a main process in carbon cycle. Therefore, minor changes in OM dynamics might lead to increase in atmospheric concentration of greenhouse gases such as CO_2, provoking positive feedbacks and enhancing global warming[2]. Concerns about rising atmospheric CO_2 have raised the public interest in managing agricultural soils as carbon (C) sinks[6]. Consequently, agricultural lands could have great potential to sequester C by improving agricultural management practices[7].

The European Union (EU) is one of the most intensive agricultural regions per unit of surface area[8]. Agriculture is a dominant form of land management in Europe, with 40% of the total land area of the EU 28 used for crop production and for grassland[9]. Numerous studies have shown that agricultural intensification represents a major threat to soil biodiversity and to the provision of ecosystem services and alters the structure of soil biological communities[10-12]. European agricultural policy has long relied on agri-environmental schemes (AES) through a policy of payments to farmers for voluntary implementing of environmental farming practices. AES were introduced in a few EU member states in the late 1980s as voluntary measure to alleviate the negative environmental impacts of agricultural intensification. Since 1992 AES became mandatory for all member states, including those that joined the EU in 2004, such as Hungary[13]. However, the effectiveness of such measures has been questioned across the whole EU [14-16]. Furthermore, most evidence on the performance of various types of AES comes from Western European countries while studies from the East (i.e. new member states) are largely lacking[17].

In this context, there is a need for assessment tools capturing the trends in soil functioning and in soil quality changes. Unfortunately, direct measurements are often impossible to perform, due to methodological problems or practical reasons of cost and time. Essentially, ecological indicators have two main functions: 1) to inform and 2) to aid communication between decision makers and scientists. Much work has already been done in Europe on indicators of soil biodiversity and quality which showed the usefulness of most soil organisms as indicators of soil health and/or described their responses to different effects[18].

Soil microarthropods (principally mites and springtails) have been shown to respond sensitively to a variety of ecological and environmental factors[19], like changes in soil chemistry[20,21], micro-habitat configuration, landscape composition[22,23], farming practices[24,25] and to be correlated with beneficial soil functions. However, they have high species diversity, thus species identification is time-consuming and requires expert knowledge. Trait-based approaches are less time consuming and can be considered a cost-effective way to assess soil quality. One of these indices is the well-known QBS (''Qualità Biologica del Suolo'', meaning ''Biological Quality of Soil'') that is an integrated soil biological quality index based on eco-morphological types of edaphic microarthropods[26]. The QBS index is the sum of eco-morphological index (EMI) scores that increases with degree of microarthropods' adaptation to soil environment. Its concept is that high soil quality is associated to the number of microarthropod groups well-adapted to soil habitat. The strength of this indicator is that it is sensitive to land use change and to short term variations in management practices. However, it is less sensitive to large variations in some soil parameters, such as SOM[26,27]. In spite of its versatility and relative ease of use (no need for species' identification or abundance estimations), it requires a special degree of expertise.

The importance of the measurements of biological activity in soils is rather neglected. OM decomposition can be considered as a function of soil biological activity (decomposition rate) and serves as a good indicator of soil functioning. Tea Bag technique is a quasi litterbag method that is standardized, time and cost effective and enables global comparison of decomposition efficiency in different soils. The mesh size of tea bags (280-300 μm) excludes the majority of soil fauna so decay of plant material reflects primarily to microbial decomposition. For further information regarding tea material and chemical descriptions see Keuskamp et al. (2013)[28]. Therefore, tea bags can be also used as an ecological indicator to assess impacts of agri-environmental schemes on soil biological activity. This simple and inexpensive method has been increasingly used in ecological studies (GLUSEEN-http://www.gluseen.org/; ILTER-https://www.ilternet.edu/content/litter-decomposition; TeaBag Index-http://www.teatime4science.org/) to compile global databases with participation of volunteers in soil science.

In the present study we employed Tea Bag method to assess the potential organic matter decomposing activity of arable lands (149 sites) of varying physicochemical soil parameters, located across a range of contrasting geographical regions and farming practices across Hungary. The objective of this study was twofold: firstly, to determine the range of organic matter decomposing activity for Hungarian agricultural soils, how this varied according to key soil properties (pH, clay and SOM content), and was influenced by agri-environmental measures from 2009 to 2014. In Hungary, agricultural areas represent about 57% of the total land area[29]. Therefore, it is particularly important to investigate the effectiveness of Hungarian AES in benefitting soil biological quality and OM decomposition. Secondly, to recommend the Tea Bag method as an indicator of soil biological activity in a Hungarian (or European)-wide monitoring network.

MATERIAL AND METHODS

Study sites and design

Arable fields were selected to allow direct comparison of different management systems at various geographical locations throughout Hungary as part of the Hungarian Agri-Environmental Monitoring Programme in 2014 (Figure 1). The national soil survey was conducted on 1043 parcels according to the Hungarian Agri-Environmental Scheme. We used 149 parcels' samples out of the total in this study.

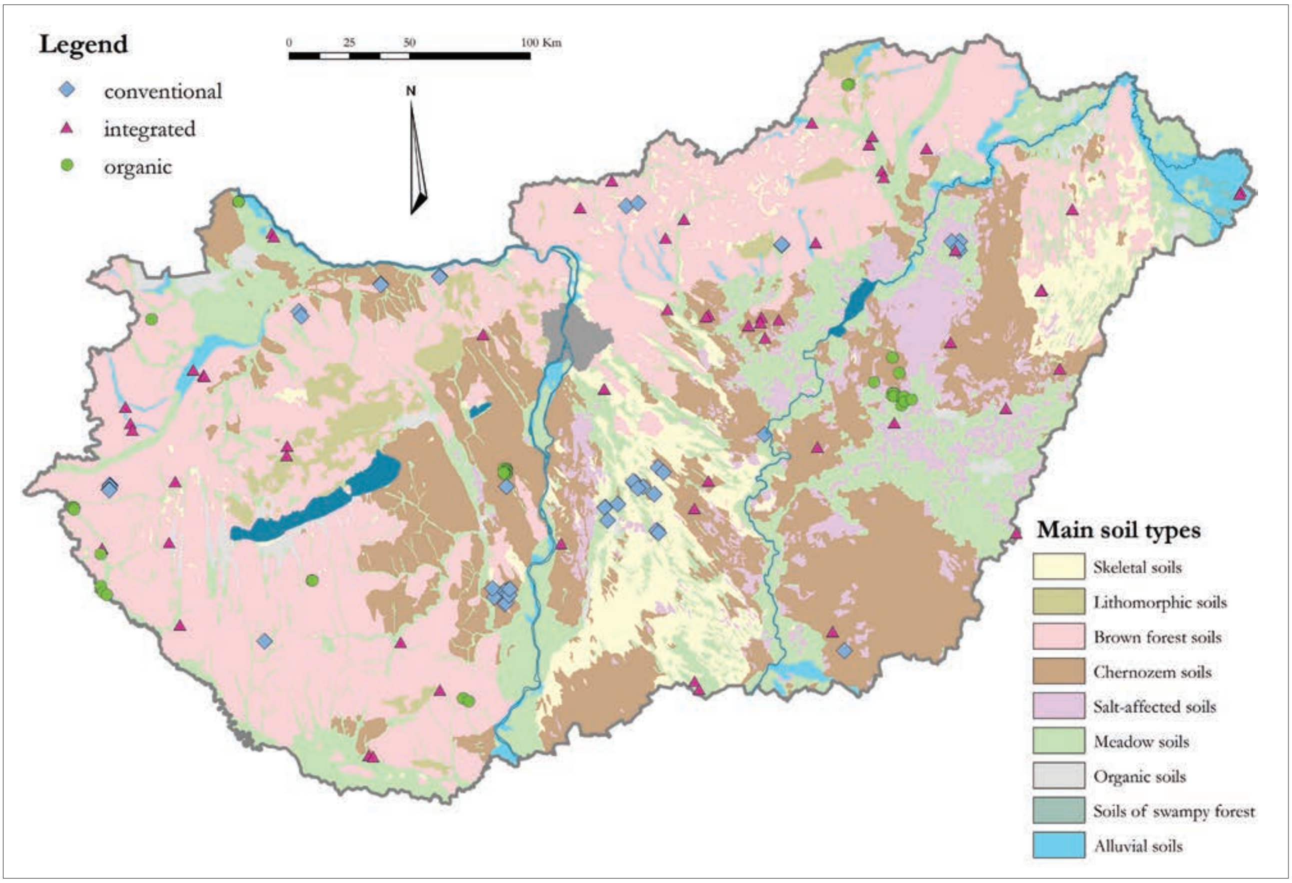

Figure 1: Map of Hungary showing the soil sampling locations used in the study.

We investigated only arable lands since AES is particularly related to cereal production. Sample sites, represented a wide range of soil properties [organic matter, texture (% clay content), pH], were selected in different geographical locations of Hungary (Table 1).

Three types of farming systems were compared: farms with organic AES contracts; farms with integrated (environmentally friendly) management AES contracts; farms without AES contracts (control group, conventional farming) (Table 2). The treatments represent a gradient of cultivation intensity: conventional > integrated > organic. All the sites were characterised by a temperate climate with a mean annual temperature range of 10-11 °C and mean annual rainfall range from 500 to 750 mm.

Soil sampling and analyses

Soil was sampled by taking six undisturbed soil cores (0–8 cm depth, 8 cm in diameter, 402 cm^3) from each of the 149 sites during April-June, 2014. Sampling plots of 5 ha were spatially allocated on the parcels randomly chosen from the farms. Samples were taken along a diagonal line. Soil samples preserved in partly perforated plastic sample holders were delivered to the laboratory within 3-5 days. In the laboratory four samples were halved by a big box cutter before opening the holders and used for soil physicochemical and zoological tests. The remaining two soil

Table 1: Chemical and physical parameter groupings of 149 soils sampled across Hungary.

Category	Conven-tional	Integrated	Organic	Total
pH				
< 6.5	15	17	15	47
6.5-7.5	14	24	18	56
> 7.5	21	16	9	46
SOM%				
< 1.5	23	11	5	39
1.5-2.5	9	26	10	45
> 2.5	18	20	27	65
Texture				
Coarse				
< 20% clay	24	19	3	46
Medium				
20% < clay < 35%	24	19	23	66
Fine				
> 35% clay	2	19	16	37

Table 2: Farming systems established in Hungary and their characterisation.			
	Conventional	Integrated	Organic
Fertilizers	yes	low use of mineral fertilizers and use of green fertilizers at least every five years	no mineral fertilizers and use of green fertilizers at least every five years
Chemicals	yes	low use of exclusively environment-friendly chemicals	no (mechanical weed control)
Tillage	yes	minimum tillage and a mid-deep loosening to a depth of 35-60 cm in a five year period	no-tillage and a mid-deep loosening to a depth of 35-60 cm in a five year period
Cropping system	monoculture	mixed cropping, crop rotation (combined share of winter wheat, corn and sunflower should not account for more than 60% of the cropped area of a farm, and legumes should be grown, with no less than 10%)	mixed cropping, crop rotation (combined share of winter wheat, corn and sunflower should not account for more than 50% of the cropped area of a farm, and legumes should be grown, with no less than 10%)
Parcel size	unlimited	limited (0.3-75 ha)	limited (0.3-75 ha)

cores were used in the tea bag decomposition experiment. Physical and chemical analyses of soils were conducted on air-dried samples. Crop residues, root fragments and rocks larger than 2 mm had been removed[30]. Particle size pipette method was applied to determine soil clay content[31]. Soil pH was measured in 1:2.5 soil: water suspensions for 12 h after mixing[30]. Soil organic matter content in percentage (SOM%) was determined using MSZ 21470-52 (1983)[32].

Soil biological quality (QBS index)

Soil microarthropods were extracted, using modified Berlese-Tullgren extractors. Animals were collected during an 8-10-day extraction period, and stored in vials containing 70% ethanol. All animals were counted under a stereomicroscope. After classification into taxonomic groups we calculated QBS index according to Parisi et al. (2005)[26].

Plant tissue decomposition: Tea Bag method

To determine soil biological (microbial) activity, a decomposition experiment was conducted in summer 2014, using pyramid-shaped, synthetic tea bags filled with rooibos *(Aspalathus linearis)* tea. Before application, tea bags were prepared using the protocol developed in GLUSEEN project (http://gluseen.org/protocols/preparing-teabags/) to eliminate water soluble materials (e.g. simple sugars and phenolics). This is important to exclude abiotic mass loss due to precipitation induced leaching. In each soil sample one tea bag was placed at a depth of 3-5 cm from the surface. Thus, altogether 298 tea bags were buried. After gently removing soil adhered to the bags from the outside, the bags were soaked in tap water to remove silt that had passed through the bags during incubation (see GLUSEEN protocol). All samples were air dried at room temperature then in climate cabin at 36 °C. Dried samples were used to measure changes in mass of OM through time and to estimate decomposition rate constant (k). Decay experiment was carried out in the laboratory at constant temperature (T = 20 °C) for 90 days. The experiment was established using a factorial design (Table 1): agricultural management type with three levels - conventional, integrated and organic farming, resulting in 298 experimental units (management types × sites number × 2 replicates). Each soil samples were moistened by distilled water to reach field capacity and were maintained at this humidity level throughout the experiment. The perforated ends of plastic tubes allowed gas exchange.

Data analysis

All statistical analyses were performed with R 3.2.2 software (www.r-project.org). Normality and homogeneity of variances were checked graphically and by Shapiro-Wilk tests. Outliers were identified and removed prior to data analysis. Statistical significance was determined at the level: $\alpha = 0.05$. QBS index was modelled using Generalized Linear Model (GLM) as a function of the explanatory variables (management type, pH, SOM% and clay %). GLM was constructed using identity as link function, and assuming negative binomial distribution of the response variable ('glm.nb' functions in R software).

Mass loss of OM (initial mass – remaining mass after incubation) was used to calculate decomposition rate (k), using a negative exponential decay model[33]:

$M_t / M_0 = e^{-kt}$,

where M_0 is the initial dry mass, M_t is the residual dry mass at time t (90 days), and k is the daily decay constant expressed in day^{-1}. Means of two replicates were used for all statistical analyses. After natural log transformation of decay rate to meet the assumption of normality, Multiple Linear Regression was performed to examine influence of agricultural management type, pH, SOM% and clay content on organic matter decomposition rate.

After fitting the full models for each dependent variable, we used Akaike Information Criterion (AIC) to select the most parsimonious model[34].

To determine differences for both response variables (QBS index, k) between management types multiple comparisons were computed by using 'lsmeans' function from 'lsmeans' package[35].

Since our data did not meet the assumptions of normality, Spearman correlation was used for quantifying relationships between QBS index and decay rate.

RESULTS

Soil characteristics

As part of Hungarian Agri-Environmental Monitoring Programme, 149 sites were selected in this study representing three farming practice categories (conventional – no AES, integrated with AES contract and organic management with AES contract) with a broad spectrum of soil properties; pH, soil organic matter content and clay content. Soil pH and SOM ranged from 5.38 to 8.61 and from 0.96% to 4.61%, respectively. Clay content varied from 3% to 44%. These parameters were categorised to show the number of sites representing the range of soil properties (Table 1).

Soil biological quality (QBS index)

The QBS index showed a very large variation range (0–252). The soil biological quality (QBS index) was significantly different ($p = 0.019$) among management types and followed the series: conventional > organic > integrated. On average, QBS was 47.5% higher in soils with conventional management than in the case of integrated (environmentally friendly) one (Figure 2).

Soil organic matter content had a significant positive correlation with QBS index (z value = 2.658; $p = 0.008$). One % increase in SOM content results in 24.8% increase in QBS index according to the generalized linear model.

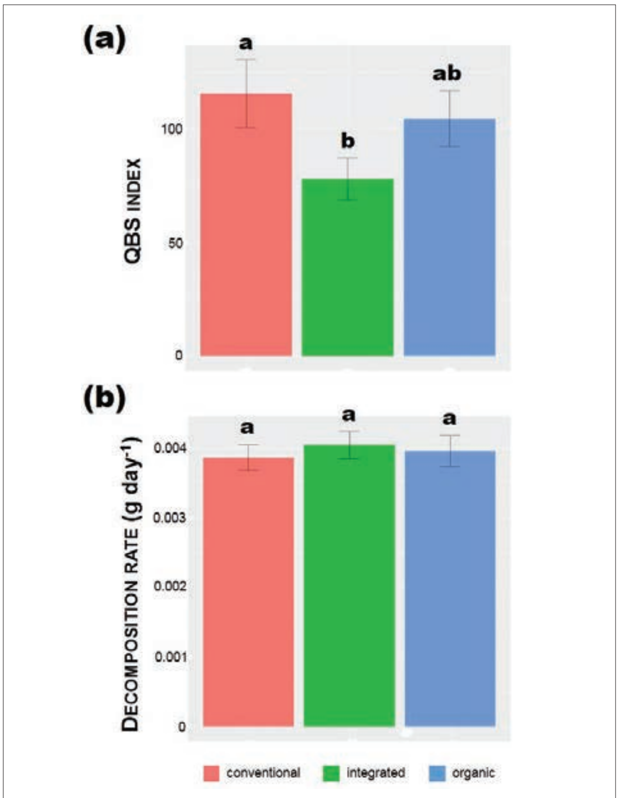

Figure 2: Comparison of soil biological quality index (QBS) (a) and organic matter decomposition rate (b) among the three different management types. Values are means ± standard error, and different letters represent significant differences at P < 0.05.

Plant tissue decomposition

On average, 29.92% of organic matter was decayed during the 90 days of the experiment. OM decomposition rate was significantly influenced by soil pH (t value = -2.942; p value = 0.004) only. Soil pH showed a significant negative correlation with intensity of mass loss, suggesting a lower substrate utilisation in more alkaline soils. On average, one-unit increase in soil pH results in 9.78% decrease in decay rate according to the general linear model. OM decomposition decreased in order of integrated > conventional > organic management (Figure 2). However, there was no significant effect of agricultural management in our study. OM decay rate was positively correlated with QBS index (Spearman's rho = 0.17, $p = 0.037$).

DISCUSSION

Our results indicate that the Hungarian agri-environmental schemes have limited impacts on soil biological quality and soil functioning in arable lands. In contrast to the results of other investigations[36,37], we found no significant positive effect of organic and integrated management on soil microarthropods, thus on QBS index. The majority of these studies indicated that organic farming usually increases species richness and abundance of soil organisms compared with conventional systems[36,37]. Several previous studies have reported microarthropod populations' increase under conservation tillage compared to conventional tillage[38-40]. Parisi et al. (2005)[26] reported higher QBS index in organic than conventional systems. The benefits of organic farming seem to be the results of limited use of agricultural chemicals, higher plant diversity and reduced levels of disturbance. On the other hand, several studies have shown no significant positive effect of organic farming on soil arthropods[24,37]. Our results showed a positive correlation between QBS index and soil organic matter content. This is consistent with some previous studies reported by Andrén and Lagerlöf (1983)[41] and Kautz et al. (2006)[42] who found that higher amount of organic material in soil increases abundance of soil microarthropods. This is important in all types of farming systems, but the incentive to use organic fertilizers, manure and ley, is higher in organic farming.

The effectiveness of AES on soil biodiversity has been questioned across the whole EU: some studies demonstrate convincing positive effects measured in terms of increased species diversity or abundance, while other studies show no effects, negative effects, or positive effects on some species and negative effects on others [37,43,44]. Reviewing the effectiveness of European agri-environmental schemes based on 17 studies, Kleijn and Sutherland (2003)[43] reported that 11 found positive effects, three both positive and negative effects, and the remaining three studies did not find any effects of schemes on arthropods. Kleijn et al. (2006)[45] pinpointed that the three examined arthropod groups (bees, orthopterans, spiders) did not respond consistently to scheme implementation. Conservation effectiveness of AES further depends on landscape characteristics, land use context and taxa of organisms studied. According to the landscape-moderated conservation hypothesis[46], conservation effectiveness of AES is lower in complex agricultural landscapes with a high proportion of semi-natural habitats (>20%) than in homogenous ones. Tuck et al. (2014)[47] found that organic farming has a greater benefit on biodiversity in landscapes with higher land use intensity. In the present study, agri-environmental measures (organic and integrated farming practices) had no effect on plant tissue decay rate. Numerous studies have reported that microbial communities are sensitive to disturbance such as agricultural management but this does always not cause changes in ecosystem process rates[48]. This may be explained by the concept of functional redundancy of microbial communities that means the ability of one microbial taxon to carry out a process at the same rate as another under the same environmental conditions[48,49]. However, soil pH significantly affected the intensity of organic matter decomposition. We found that higher soil pH resulted in lower decay rate. This might be due to the fact that fungi are primarily responsible for decomposing complex compounds with higher C/N ratios such as rooibos[50]. Pengilly et al. (2008)[51] found that the dried, fermented rooibos tea material contains 41.96 ± 0.32% cellulose and 26.88 ± 0.57% lignin. We therefore assumed that some of these compounds could be decomposed by hydrolytic enzymes produced by fungi known for the production of complex polysaccharase systems (including cellulases, hemicellulases, and accessory enzymes responsible for the hydrolysis of -glycosidic bonds and esters). It has been reported that fungi have higher pH tolerance than bacteria[52]. Rousk et al. (2009)[53] found an approximately 30-fold increase in fungal importance, as indicated by the fungal growth/bacterial growth ratio, from pH 8.3 to pH 4.5.

Our results showed a positive correlation between QBS index and OM decomposition rate. This is in agreement with previous studies finding enhanced OM decomposition in the presence of soil microarthropods. It has been shown that microarthropods are primary regulators of mass loss of plant residues[54,55]. Mesofauna are known to stimulate decomposition rate indirectly by interacting with fungi[56,57]. Mueller et al. (1990)[58] found a positive relationship between litter decay rates and mean densities of mites.

CONCLUSION

This is the first study to apply Tea Bag technique for the assessment of impacts of AES. We recommend its usage as an ecological indicator within a national or/and European soil monitoring scheme.

The present study highlights that at least in the short-term, microbial OM decomposition in arable fields in Hungary was not controlled predominantly by agri-environmental measures. Furthermore, the Hungarian AES did not achieve the expected effect or even have negative side-effects on soil biological quality (based on QBS index). Possible reasons for this are: 1) the management restrictions in AES were not sufficient to enhance species richness or/and abundance of soil microarthropods and to promote microbial activity, thus organic matter decomposition; 2) the implementation of measures by farmers being suboptimal; 3) the AES being implemented in unsuitable locations or 4) a combination of these causes. We need to account for environmental factors that are outside the control of farmers but nevertheless constrain the effects of their conservation measures. The fact that a number of studies found no change or even negative effects of agri-environmental schemes on biodiversity or/and ecosystem processes emphasises the importance of regular evaluations of agri-environmental schemes. However, there is a lack of research aiming the effects of agri-environment programmes on soil biodiversity and processes, particularly in Central-Europe.

In addition to regular evaluation and monitoring, it is essential to formulate clear and quantifiable objectives at the start of the scheme. This could make agri-environmental schemes a more effective tool for biodiversity conservation. Further experimental studies are required before an exact cause could be determined for the failure of agri-environmental schemes to enhance biodiversity and subsequently, scheme effectiveness could be improved.

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REFERENCES

1. Dominati, E. - Patterson, M. - Mackay, A. 2010. A framework for classifying and quantifying the natural capital and ecosystem services of soils. Ecological Economics 69: 1858-1868.
2. Wall, D.H. - Bardgett, R.D. - Behan-Pelletier, V. - Herrick, J.E. - Jones, T.H. - Ritz, K. - Six, J. - Strong, D.R. - Van der Putten, W.H. (Eds.) 2012. Soil ecology and ecosystem services. Oxford University Press, Oxford.
3. Swift, M.J. - Heal, O.W. - Anderson, J.M. 1979. Decomposition in terrestrial ecosystems. Blackwell Scientific Publications, Oxford.
4. Lavelle, P. - Spain, A.V. 2001. Soil Ecology. Kluwer Scientific, Amsterdam.

5. Brussaard, L. - de Ruiter, P.C. - Brown, G.G. 2007. Soil biodiversity for agricultural sustainability. Agriculture, Ecosystems and Environment 121: 233-244.
6. Stockmann, U. - Adams, M.A. - Crawford, J.W. - Field, D.J. - Henakaarchchi, N. - Jenkins, M. - Minasny, B. - McBratney, A.B. - Courcelles, V.D.R.D. - Singh, K. - Wheeler, I. - Abbott, L. - Angers, D.A. - Baldock, J. - Bird, M. - Brookes, P.C. - Chenu, C. - Jastrow, J.D. - Lal, R. - Lehmann, J. - O'Donnell, A.G. - Parton, W.J. - Whitehead, D. - Zimmermann, M. 2013. The knowns, known unknowns and unknowns of sequestration of soil organic carbon. Agriculture, Ecosystems and Environment 164: 80-99.
7. Bajželj, B. - Richards, K.S. - Allwood, J.M. - Smith, P. - Dennis, J. S. - Curmi, E. - Gilligan, C.A. 2014. Importance of food-demand management for climate mitigation. Nature Climate Change 4: 924-929.
8. Monfreda, C. - Ramankutty, N. - Foley, J.A. 2008. Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000. Global Biogeochemical Cycles 22: GB1022
9. Eurostat 2013. Agriculture, Forestry and Fishery Statistics Pocketbooks 2013 Edition. Publications Office of the European Union, Luxembourg.
10. Swift, M.J. - Izac, A.-M.N. - van Noordwijk, M. 2004. Biodiversity and ecosystem services in agricultural landscapes—are we asking the right questions? Agriculture, Ecosystems and Environment 104: 113-134.
11. Thiele-Bruhn, S. - Bloem, J. - de Vries, F.T. - Kalbitz, K. - Wagg, C. 2012. Linking soil biodiversity and agricultural soil management. Current Opinion in Environmental Sustainability 4 (5): 523-528.
12. Tsiafouli, M.A. - Thébault, E. - Sgardelis, S.P. - De Ruiter, P.C. - Van der Putten, W.H. - Birkhofer, K. - Hemerik, L. - De Vries, F.T. - Bardgett, R.D. - Brady, M.V. - Bjornlund, L. - Jørgensen, H.B. - Christensen, S. - D'Hertefeldt, T. - Hotes, S. - Hol, W.H.G. - Frouz, J. - Liiri, M. - Mortimer, S.R. - Setälä, H. - Tzanopoulos, J. - Uteseny, K. - Pižl, V. - Stary, J. - Wolters, V. - Hedlund, K. 2015. Intensive agriculture reduces soil biodiversity across Europe. Global Change Biology 21 (2): 973-985.
13. European Commission 2005. Agri-environment Measures Overview on General Principles, Types of Measures, and Application. Directorate General for Agriculture and Rural Development. (http://ec.europa.eu/agriculture/publi/reports/agrienv/rep_en.pdf) verified April 06, 2017
14. Marshall, E.J.P. - Moonen, A.C. 2002. Field margins in northern Europe: their functions and interactions with agriculture. Agriculture, Ecosystems and Environment 89: 5-21.
15. Berendse, F. - Chamberlain, D. - Kleijn, D. - Schekkerman, H. 2004. Declining biodiversity in agricultural landscapes and the effectiveness of agri-environment schemes. Ambio 33: 499-502.
16. Grashof-Bokdam, C.J. - Van Langevelde, F. 2005. Green veining: landscape determinants of biodiversity in European agricultural landscapes. Landscape Ecology 20: 417-439.
17. Uthes, S. - Matzdorf, B. 2013. Studies on agri-environmental measures: a survey of the literature. Environmental Management 51: 251-266.
18. Paoletti, M.G. 1999. Using bioindicators based on biodiversity to assess landscape sustainability. Agriculture, Ecosystems and Environment 74: 1-18.
19. Hopkin, S.P. 1997. Biology of the Springtails. University Press, Oxford.
20. Van Straalen, N.M. - Verhoeff, H.A. 1997. The development of a bioindicator system for soil acidity based on arthropod pH preferences. Journal of Applied Ecology 34: 217-232.
21. Van Straalen, N.M. 1998. Evaluation of bioindicator systems derived from soil arthropod communities. Applied Soil Ecology 9: 429-437.
22. Verhoef, H.A. - Van Selm, A.J. 1983. Distribution and population dynamics of Collembola in relation to soil moisture. Holarctic Ecology 6: 387-394.
23. Pflug, A. - Wolters, V. 2001. Influence of drought and litter age on Collembola communities. European Journal of Soil Biology 37: 305-308.
24. Alvarez, T. - Frampton, G.K. - Goulson, D. 2001. Epigeic Collembola in winter wheat under organic, integrated and conventional farm management regimes. Agriculture, Ecosystems and Environment 83: 95-110.
25. Gardi, C. - Menta, C. - Montanarella, L. - Cenci, R. 2008. Main threats to soil biodiversity: the case of agricultural activities impacts on soil microarthropods. In: Toth, G. - Montanarella, L. - Rusco, E. (Eds.), Threats to Soil in Europe. Office for the Official Publications of the European Communities, Luxembourg, pp. 100-110.
26. Parisi, V. - Menta, C. - Gardi, C. - Jacomini, C. - Mozzanica, E. 2005. Microarthropod communities as a tool to assess soil quality and biodiversity: a new approach in Italy. Agriculture, Ecosystems and Environment 105 (1-2): 323-333.
27. Gardi, C. - Tomaselli, M. - Parisi, V. - Petraglia, A. - Santini, C. 2002. Soil quality indicators and biodiversity in northern Italian permanent grasslands. European Journal of Soil Biology 38 (1): 103-110.
28. Keuskamp, J.A. - Dingemans, B.J.J. - Lehtinen, T. - Sarneel, J.M. - Hefting, M.M. 2013. Tea Bag Index: a novel approach to collect uniform decomposition data across ecosystems. Methods in Ecology and Evolution 4 (11): 1070-1075.
29. Hungarian Central Statistical Office 2014. Land area of Hungary by land use categories, 1853–2014. (https://www.ksh.hu/docs/eng/agrar/html/tabl1_3_1.html) verified April 06, 2017
30. MSZ (Hungarian Standard) 21470-2. 1981. Environmental protection. Preparation of soil sample. Determination of electrical conduction, humidity and pH

31. MSZ (Hungarian Standard) 08-0205. 1978. Determination of physical and hydrophysical properties of soils.
32. MSZ (Hungarian Standard) 21470-52. 1983. Environmental protection. Testing of soils. Determination of organic matter.
33. Olson, J.S. 1963. Energy storage and the balance of producers and decomposers in ecological systems. Ecology 44: 322-331.
34. Burnham, K.P. - Anderson, D.R. 2002. Model selection and multimodel inference: A practical information-theoretic approach. Springer-Verlag, New York.
35. Lenth, R.V. 2016. Least-Squares Means: The R Package lsmeans. Journal of Statistical Software 69 (1): 1-33.
36. Bengtsson, J. - Ahnström, J. - Weibull, A.C. 2005. The effects of organic agriculture on biodiversity and abundance: a meta-analysis. Journal of Applied Ecology 42: 261-269.
37. Hole, D.G. - Perkins, A.J. - Wilson, J.D. - Alexander, I.H. - Grice, P.V. - Evans, A.D. 2005. Does organic farming benefit biodiversity? Biological Conservation 122: 113-130.
38. Wardle, D.A. 1995. Impacts of disturbance on detritus food webs in agroecosystems of contrasting tillage and weed management practices. Advances in Ecological Research 26: 105-185.
39. Garrett, C.J. - Crossley, D.A. - Coleman, D.C. - Hendrix, P.F. - Kisselle, K.W. - Potter, R.L. 2001. Impacts of the rhizosphere on soil microarthropods in agroecosystems on the Georgia piedmont. Applied Soil Ecology 16: 141-148.
40. Coleman, D.C. - Fu, S. - Hendrix, P.F. - Crossley Jr., D.A. 2002. Soil foodwebs in agroecosystems: impacts of herbivory and tillage management. European Journal of Soil Biology 38: 21-28.
41. Andrén, O. - Lagerlöf, J. 1983. Soil fauna (microarthropods, enchytraeids, nematodes) in Swedish agricultural cropping systems. Acta Agriculturae Scandinavica 33: 33-52.
42. Kautz, T. - López-Fando, C. - Ellmer, F. 2006. Abundance and biodiversity of soil microarthropods as influenced by different types of organic manure in a long-term field experiment in Central Spain. Applied Soil Ecology 33 (3): 278-285.
43. Kleijn, D. - Sutherland, W.J. 2003. How effective are European agri-environment schemes in conserving and promoting biodiversity? Journal of Applied Ecology 40: 947-969.
44. Kleijn, D. - Rundlöf, M. - Scheper, J. - Smith, H.G. - Tscharntke, T. 2011. Does conservation on farmland contribute to halting the biodiversity decline? Trends in Ecology & Evolution 26: 474-481.
45. Kleijn, D. - Baquero, R.A. - Clough, Y. - Diaz, M. - De Esteban, J. - Fernández, F. - Gabriel, D. - Herzog, F. - Holzschuh, A. - Jöhl, R. - Knop, E. - Kruess, A. - Marshall, E.J.P. - Steffan-Dewenter, I. - Tscharntke, T. - Verhulst, J. - West, T.M. - Yela, J.L. 2006. Mixed biodiversity benefits of agri-environment schemes in five European countries. Ecology Letters 9: 243-254.
46. Tscharntke, T. - Klein, A.M. - Kruess, A. - Steffan-Dewenter, I. - Thies, C. 2005. Landscape perspectives on agricultural intensification and biodiversity ecosystem service management. Ecology Letters 8: 857-874.
47. Tuck, S.L. - Winqvist, C. - Mota, F. - Ahnstrom, J. - Turnbull, L.A. - Bengtsson, J. 2014. Landuse intensity and the effects of organic farming on biodiversity: a hierarchical meta-analysis. Journal of Applied Ecology 51: 746-755.
48. Allison, S.D. - Martiny, J.B.H. 2008. Colloquium paper: resistance, resilience, and redundancy in microbial communities. Proceedings of the National Academy of Sciences of the United States 105: 11512-11519.
49. Strickland, M.S. - Lauber, C. - Fierer, N. - Bradford, M.A. 2009. Testing the functional significance of microbial community composition. Ecology 90: 441-451.
50. Fierer, N. - Strickland, M.S. - Liptzin, D. - Bradford, M.A. - Cleveland, C.C. 2009. Global patterns in belowground communities. Ecology Letters 12: 1238-1249.
51. Pengilly, M. - Joubert, E. - van Zyl, W.H. - Botha, A. - Bloom, M. 2008. Enhancement of rooibos (Aspalathus linearis) aqueous extract and antioxidant yield with fungal enzymes. Journal of Agricultural and Food Chemistry 56: 4047-4053.
52. Blagodatskaya, E.V. - Anderson, T.H. 1998. Interactive effects of pH and substrate quality on the fungal-to-bacterial ratio and qCO_2 of microbial communities in forest soils. Soil Biology and Biochemistry 30: 1269-1274.
53. Rousk, J. - Brookes, P.C. - Bååt, E. 2009. Contrasting soil pH effects on fungal and bacterial growth suggest functional redundancy in carbon mineralization. Applied and Environmental Microbiology 75 (6): 1589-1596.
54. Elkins, N.Z. - Whitford, W.G. 1982. The role of microarthropods and nematodes in decomposition in a semi-arid ecosystem. Oecologia 55: 303-310.
55. Vreeken-Buijs, M.J. - Brussaard, L. 1996. Soil mesofauna dynamics, wheat residue decomposition and nitrogen mineralization in buried litterbags. Biology and Fertility of Soils 23: 374-381.
56. Rusek, J. 1998. Biodiversity of Collembola and their functional role in the ecosystem. Biodiversity and Conservation 7: 1207-1219.
57. Hooper, D.U. - Bignell, D.E. - Brown, V.K. - Brussaard, L. - Dangerfield, J.M. - Wall, D.H. - Wardle, D.A. - Coleman, D.C. - Giller, K.E. - Lavelle, P. - Van der Putten, W.H. - de Ruiter, P.C. - Rusek, J. - Silver, W.L. - Tiedje, J.M. - Wolters, V. 2000. Interactions between aboveground and belowground biodiversity in terrestrial ecosystems: patterns, mechanisms, and feedbacks. BioScience 50: 1049-1061.
58. Mueller, B.R. - Beare, M.H. - Crossley Jr., D.A. 1990. Soil mites in detrital food webs of conventional and no-tillage agroecosystems. Pedobiologia 34: 389-401.

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Project budget: 2,588,138.36 €
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A stream of cooperation

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