REVIEW ON AGRICULTURE AND RURAL DEVELOPMENT

SCIENTIFIC JOURNAL OF THE UNIVERSITY OF SZEGED, FACULTY OF AGRICULTURE
2014. Vol. 3 (2)

FROM THE CONTENTS:

2014/2

Review on Agriculture and Rural Development 2014. vol. 3 (2) ISSN 2063-4803

THE ORIGIN AND WORLDWIDE DISTRIBUTION OF RAGWEED – A REVIEW

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ABSTRACT
The aim of the study is to provide a survey on the history of ragweed worldwide. Its climate dependence, impacts in agriculture, health effects and social costs are also presented. In Europe common ragweed *(Ambrosia artemisiifolia)* is predominant of all *Ambrosia* species that is supported by population genetic data. The most important habitat areas of ragweed and the highest pollen concentrations occur, in decreasing order of the pollen levels (1) in the south-western part of the European Russia, (2) in the southern and eastern parts of Ukraine, (3) in the Pannonian Plain in Central Europe, (4) in the Rhône-Alpes region in France, furthermore (5) in the Po River valley in Italy. Besides Europe, ragweed occurs in China, India, Japan and in other Asian countries, furthermore in Australia and the Unites States of America. However, beyond the USA little information is available. Warming trends due to the climate change favours the expansion of ragweed, producing higher pollen levels worldwide. In association with the warming, increasing ambient CO_2 levels generate greater biomass and increased pollen production. Hence, ragweed pollen production can be expected to increase significantly under predicted future climate conditions, bringing severe impacts to areas that have yet been suffering slightly.

Keywords: origin of ragweed, social costs of ragweed, distribution of ragweed, climate change, respiratory allergy

INTRODUCTION

Origin of ragweed

Common ragweed *(Ambrosia artemisiifolia)* (Asteraceae family) is an annual species, native to North America, which has been introduced and subsequently naturalized in many countries including a large part of Europe (JÄGER, 1998; JUHÁSZ, 1998; RYBNÍČEK and JÄGER, 2001; BULLOCK ET AL., 2010), Asia and Australia (LAWALRÉE, 1953; PRISZTER, 1960) following its introduction to many places in the world. The name *Ambrosia* is the same as that of the delicious food eaten by the mythical Greek gods that conferred them immortality (MAKRA ET AL., 2004). The term might refer to the tenacity of the plants, which makes it hard to rid an area of them if they occur as invasive weeds. The genus is best known for the severe and widespread allergies caused by its pollen (BÉRES, 2003).

Ambrosia artemisiifolia belongs to the phylum of angiosperms (Angiospermatophyta), to the class of Dicotyledonouses (Dicotyledonopsida), to the ordo of Composites (Asterales), to the family of Daisies (Asteraceae), to the subfamily of disc-florets (Tubuliflorae) and to the genus of ragweeds (*Ambrosia spp.*). This genus comprises 42 species. The most species occur in the Unites States, some of them in Central- and South America, while *Ambrosia senegalensis Dc.* is native in Africa (BÉRES ET AL., 2005).

The Sonora desert in Arizona (USA), north and west of the Bay of California, is considered the gene centre of *Ambrosia* species (BOHÁR, 1996), where about 10 species occur (BOHÁR, 1996). *Ambrosia artemisiifolia* was discovered in the USA before 1838 (WAGNER and BEALS, 1958), while in Canada in 1860 (BASSETT and CROMPTON, 1975). There are 41 species worldwide. In Europe, introductions of *A. artemisiifolia* stems from two different regions of their native area. Namely, populations established in Central Europe appear to have originated from eastern North America and Eastern European populations from more western North America. This may result from differential commercial exchanges between these geographic regions (GAUDEUL ET AL., 2011).
Ambrosia pollen has been found in deposits of over sixty thousand years in Canada. Nevertheless, its amount in peat deposits, except for the last 250 years, is small. However, due to deforestation and land use changes associated with the incursion of the western civiliziation, this amount increased over 100-fold. Recently, ragweed has extended areas in North-America unitl the southern part of Canada (SZIGETVÁRI AND BENKŐ, 2004).

Climatic associations
Ambrosia species are adapted to the arid climates of the desert. Ragweed favours temperate climate and prefers dry, sunny and grassy plains, sandy soils, river banks, roadsides, and ruderal sites (disturbed soils) such as vacant lots and abandoned fields (ZISKA ET AL., 2006; KAZINCZI ET AL., 2008a, 2008b).
Ragweed can take hold up and prosper if the temperature sum exceeds the threshold of 1400 °C, necessary for its floral and seed development (CUNZE ET AL., 2013). Below this threshold, under maritime climate (north-eastern Spain, Netherlands), ragweed populations seem only survive. At the same time, if the temperature sum is too high, for example in the Mediterranean, summers are hot and dry that involves a substantial decline of pollen release. However, the species is widely distributed in countries that are largely unsuitable for ragweed but import lots of seed, such as Netherlands or Belgium. In these countries, the distribution overstates the very low impact of the casual introductions (BULLOCK ET AL., 2010).
The northern and high-elevation range margin of ragweed is regulated by thermal and photoperiod constraints. Beyond their habitat areas, ragweed occurs casually and is unable to set seeds (DAHL ET AL., 1999; SAAR ET AL., 2000). In the northern range of its habitat area, even though the populations can produce seed, low temperatures or the cold climate promotes extinction. In general, over these areas ragweed grows to adulthood but fails to reproduce properly because it is too cold. At the same time, in the southern edge of its habitat, drought is considered a major factor limiting the invasion. This is the main aspect explaining a lack of ragweed pollen records from Spain and Portugal, where seed import rates should cause many introductions to occur (BULLOCK ET AL., 2010).
Long-range transport of ragweed pollen (traveling more than 100 km distance between the source area and the arrival point) can deliver pollen over less polluted areas, e.g. from the Pannonian Plain in Central Europe over the Basin of Vienna, northern Slovakia, Poland, Balkans or northern Greece and in the same way, from Ukraine over Poland (ŠIKOPARIJA ET AL., 2009; MAKRA ET AL., 2010; KASPRZYK ET AL., 2011; ŠIKOPARIJA ET AL., 2013).

Impacts on agricultural activity
The extensive spread of *A. artemisiifolia* can be associated to the political transitions in 1990s that led to the formation of young democracies in Eastern Europe. During these processes, the structure and the size of the cultivated areas, as well as land use changed. Namely, co-operatives were cut into smaller parcels due to privatization. Thus large,

formerly well-kept agricultural fields were abandoned and quickly colonised by *A. artemisiifolia* (KISS and BÉRES, 2006).
Ambrosia is a noxious agricultural weed. It grows frequently on roadsides, railway embankments, waste places and in cultivated lands. It can overgrow alfalfa and purple clover entirely, cause severe damages in potato fields and occurs often in sunflower and corn fields, as well. *Ambrosia* appears in large quantities in stubbles, effectively utilizes large amounts of fertilizer, has high productivity, and regenerates well in dry and infertile soils. Their ability to block sunlight causes reduced crop productivity (XIE ET AL., 2001). Furthermore, it does not have any natural competitors. *Ambrosia* has less sensitivity to herbicides than other weeds (VOEVODIN, 1982; BALLARD ET AL., 1995; PATZOLDT ET AL., 2001; MAKRA ET AL., 2014).

Health effects
Climate change in association with an extended urbanization, with high levels of vehicle emissions in urban areas, living in artificial environment with little movement may contribute to increasing frequency of respiratory allergy and asthma (D'AMATO, 2011). Pollen is an important trigger of respiratory diseases. Greater concentrations of carbon dioxide and, consequently, higher temperatures may increase pollen quantity and induce longer pollen seasons (ZISKA ET AL., 2003; Clot, 2008). Pollen allergenicity can also increase as a result of these changes in climate. Furthermore, there is evidence that high levels of traffic-derived air pollutants may interact with pollen and bring about more intense respiratory allergy symptoms (HJELMROOS ET AL., 1999; ANDERSEN ET AL., 2007; DÍAZ ET AL., 2007; ALVES ET AL., 2010). Accordingly, global warming may induce a wide pollen-related public health problem, for which the societies should be prepared in time.
Symptoms due to common ragweed include a runny nose, sneezing, puffy or irritated eyes, and a stuffy or itchy nose and throat, as well as hay-fever allergies (MATYASOVSZKY ET AL., 2011). Furthermore, *A. artemisiifolia* has a wide ecological tolerance and can colonize a large range of disturbed habitats (KAZINCZI ET AL., 2008a; PINKE ET AL., 2011; MAKRA ET AL., 2014). Its invasion is also facilitated by its resistance to certain herbicides (KAZINCZI ET AL., 2008b), the lack of natural enemies (MACKAY and KOTANEN, 2008) and the high genetic variability of invasive populations (GENTON ET AL., 2005; CHUN ET AL., 2010). These harmful effects, with its potential for rapid spread has made ragweed one of the most dangerous invasive non-native species in Europe. The European Commission has identified the species as a significant problem for many Member States of the EU and a very serious threat for others.

Social costs
Common ragweed and its pollen cause serious losses in the economy and several fields of the everyday life.
Common ragweed and its pollen cause serious losses in the economy and several fields of the everyday life. The current costs of *A. artemisiifolia* in terms of human health and agriculture were estimated by BULLOCK ET AL. (2010) for 40 European countries. All the costs are given in Euros at 2011 prices. The human health impacts were estimated to affect around 4 million people with total estimated medical costs of €2,136 million per year. Furthermore, total estimated workforce productivity losses and agricultural costs due to *A. artemisiifolia* as high estimates were €529 million and €3,559 million, respectively. The estimated total costs are valued at €6.224 billion per year. Over 80% of these impacts are lost crop yields. Estimated agricultural, human health, workforce and total costs are the highest in Ukraine, Romania and Hungary with €995, €770 and €605 million, respectively (BULLOCK ET AL., 2010). At the same time, in the USA, allergic disorders represent an

important group of chronic diseases with estimated costs at approximately $21 billion per year. Among twenty-five of the most harmful invasive species of China, economic losses due to ragweed, found in most of the provinces, amount to 397.9 million USD, taking ragweed the 2nd most harmful species in the country (DING ET AL., 2004; LI ET AL., 2014). Realizing the danger, those countries polluted with ragweed, have introduced anti-*Ambrosia* campaigns under the control of the National Ministries of either Health Affairs or Agriculture.

DISTRIBUTION OF RAGWEED IN EUROPE

A limitation of ragweed pollen observations is that the pollen of *A. artemisiifolia* cannot be distinguished from other species of the *Ambrosia* genus. In Western Europe, the first temporary colonization of *Ambrosia* was reported from Brandenburg and Pfaffendorf (Germany) in 1863 (HEGI, 1906; PRISZTER, 1960; HODIŞAN and MORAR, 2007). In Western Europe, four American species have established: *A. artemisiifolia, A. psilostachya, A. tenuifolia* and *A. trifida* (JÁRAI-KOMLÓDI and JUHÁSZ, 1993; MAKRA ET AL., 2004). However, in Europe, common ragweed *(A. artemisiifolia)* is predominant of all *Ambrosia* species (MAKRA ET AL., 2005; BULLOCK ET AL., 2010; VINOGRADOVA ET AL., 2010) that is supported by the population genetic data of MÁTYÁS and VIGNESH (2012).
The only two native species of ragweed in Europe can only be found in some maritime locations around the Mediterranean coastal area. The earliest described colonization of seaside *Ambrosia* (*Ambrosia maritima*) occurred in Dalmatia (Croatia) in 1842 near Dubrovnik (Croatia) and Budva (Montenegro) areas and on the neighbouring islands (DE VISIANI, 1842). While, in the western basin of the Mediterranean, *A. maritima* (Balearic Islands) and *A. tenuifolia* (Minorca Island) are autochton species (FRAGA AND GARCÍA, 2004). According to some botanists they are native, while others consider them as an annual variant of *A. psilostachya* or a variant of *A. artemisiifolia*. *A. psilostachya* occurs only sporadically in Europe (SZIGETVÁRI AND BENKŐ, 2004).
The distribution of *A. artemisiifolia* in Europe started after the First World War (MAKRA ET AL., 2014). Seeds of different *Ambrosia* species were transported to Europe from America by purple clover seed shipments, and grain imports. Major nodes of its distribution pathways are European ports, namely Rijeka (Croatia) towards Croatia and the western part of Hungary (JÁRAI-KOMLÓDI AND JUHÁSZ, 1993; MAKRA ET AL., 2005), Trieste and Genoa (Italy) towards Northern Italy (JÁRAI-KOMLÓDI and JUHÁSZ, 1993; MAKRA ET AL., 2005), Marseille (France) towards the Rhône valley in France (JÁRAI-KOMLÓDI AND JUHÁSZ, 1993; COMTOIS, 1998; MAKRA ET AL., 2005) and Odessa (Ukraine) towards southern and eastern Ukraine (RODINKOVA ET AL., 2012).
The most important habitat areas of ragweed and the highest pollen concentrations occur, in decreasing order of the pollen levels, (1) in the southern, eastern and the northern-eastern parts of Ukraine (RODINKOVA ET AL., 2012), (2) in the Pannonian Plain in Central Europe including Hungary and some parts of Serbia, Croatia, Slovenia, Slovakia and Romania (MAKRA ET AL., 2005; 2014), (3) in the Rhône valley in France (DÉCHAMP AND COUR, 1987; LAAIDI AND LAAIDI, 1999; CHAUVEL ET AL., 2006; GLADIEUX ET AL., 2011), (4) in the south-western part of the European Russia (REZNIK, 2009), furthermore (5) in north-western Milan and south Varese (Lombardy, Po valley) in Italy (CAROSSO and GALLESIO, 2000; BONINI ET AL., 2012). Less extended habitat areas with smaller pollen levels occur in the Balkan Peninsula (YANKOVA ET AL., 2000; DIMITROV AND TZONEV, 2002; ŠIKOPARIJA ET AL., 2009), in the remaining part of the European Russia (REZNIK, 2009), Switzerland (CLOT ET AL., 2002), Germany (ZINK ET AL., 2012), Czech Republic

(RYBNÍČEK ET AL., 2000), Poland (KASPRZYK ET AL., 2011), Bulgaria (YANKOVA ET AL., 2000), the Baltic States (SAAR ET AL., 2000), Spain (FERNANDEZ-LLAMAZARES ET AL., 2012) and they even occur casually in Sweden (DAHL ET AL., 1999). At the same time, the northern border of its permanent occurrence is the 55°N latitude in Europe, namely the southern parts of Poland and Germany (SZIGETVÁRI and BENKŐ, 2004). Historic spread of *A. artemisiifolia* for the European countries is reported by BUTTENSCHØN ET AL. (2009) and BULLOCK ET AL. (2010) in detail.

BULLOCK ET AL. (2010) synthesised and reviewed (1) the information on the current extent of ragweed infestation in Europe; (2) the measures controlling ragweed spread and (3) the economic, social and environmental aspects of harmful effects in all economic sectors.

RAGWEED IN INDIVIDUAL COUNTRIES, WORLDWIDE

Ragweed in Hungary may have originated in Canada, rather than the United States (CSEH ET AL., 2008). Here, *A. artemisiifolia* was firstly described in Budapest in 1888 (THAISZ, 1910) then in Orsova (Lower-Danube region) in 1908 (JÁVORKA, 1910). As an arable weed, its first appearance in the South-Transdanubian part of Hungary (i.e. on the south-western part of the Pannonian Plain) was proved near Somogyvár (Somogy county) in 1922 in the south-western part of Hungary (LENGYEL, 1923). Since then, it has been spread rapidly towards the north-east parts of the country. Between the Danube and Tisza rivers *A. artemisiifolia* was spread from Szeged city, in the middle of the Pannonian Plain, towards North-Hungary (TÍMÁR, 1955). Recently the annual ragweed pollen level is 36-45% of the total annual pollen release in Szeged (JUHÁSZ, 1998). East from the Danube, the northern part of Pannonian Plain was infected from Szeged city (KAZINCZI ET AL., 2008a). By the end of the last century, Hungary was fully occupied by ragweed excluding the mountainous areas. In the 1950s, based on the Hungarian National Weed Survey, the species was ranked 21st in the weed list and has since risen to: 8th in the 1970s and to 4th by the 1980s (JÁRAI-KOMLÓDI, 1998; NOVÁK ET AL., 2009; BULLOCK ET AL., 2010). The phases of its distribution in Hungary have been mapped by PRISZTER (1957; 1960) and BÉRES and HUNYADI (1991). SONG and PROTS (1998) reconstructed the invasion of *Ambrosia artemisiifolia* in the Pannonian Plain in Central Europe and the Ukrainian Carpathians Mountains on the basis of floristic records. They found that the spreading speed of the species was around 70 km/year (on the average) since the middle of the 20^{th} century.

The species was first recorded in Serbia around 1935 in the village of Osojci, near Derventa (MALY, 1940). The species was then recorded in 1953 around Sremski Karlovci, Petrovaradin and Novi Sad. It is believed that the species arrived from Romania on ships that sailed on the Danube (SLAVNIĆ, 1953). From the 1970s to the present, *A. artemisiifolia* has spread across a wide area of Serbia and recently it is considered to be a widespread ruderal weed species in Vojvodina often forming large, compact communities in sandy and ruderal habitats (KONSTANTINOVIĆ ET AL., 2004; BULLOCK ET AL., 2010).

In Croatia, the first records of *A. artemisiifolia* were collected in the 1940s around Pitomaca in Central Croatia. Inland parts of the country are highly infested with *A. artemisiifolia*, while in the coastal areas it is mainly concentrated in some districts (PETERNEL ET AL., 2006; GALZINA ET AL., 2010). *A. artemisiifolia* is expanding towards west, at a rate of between 6 and 20 km per year (GALZINA ET AL., 2010).

In Slovenia, *A. artemisiifolia* was introduced at the end of the Second World War. It is now well established and spreads widely and fast in the lowlands of the country (KOFOL SELIGER, 1998). Spreading of *A. artemisiifolia* towards both Serbia (ŠIKOPARIJA ET AL.,

2009) and Bosnia and Herzegovina (SOLJAN AND MURATOVIĆ, 2004) occurred from north, i.e. from the Pannonian Plain.
Until 1995, no data were available on the distribution of *Ambrosia* species in Bulgaria. YANKOVA ET AL. (1996; 1998) published the first results on *Ambrosia* pollen measurements in the air of Sofia, Bulgaria, that started in 1981. Here, ragweed colonization is extended in the Danubian Plain and Sofia region only (DIMITROV and TZONEV, 2002) and peak annual pollen concentrations here are very high, exceeding 10,000 pollen grains·m^{-3} of air in several years (YANKOVA ET AL., 1996).
The source region of *A. artemisiifolia* in Slovakia is Csallóköz and eastern Slovakia. The first description of its presence (Komarno, Southwest Slovakia) dated back to 1949. *A. artemisiifolia* is partly native and partly transported either by southerly winds from Hungary or arrived via cereal transports from the former Soviet Union (MAKOVCOVÁ ET AL., 1998).
The first record for Austria is a herbarium specimen collected in 1883, while the first naturalized population was recorded in Lower Austria, Burgenland and Linz in 1952 (ESSL ET AL., 2009). Furthermore, fields have been colonized by the 1970s (ESSL ET AL., 2009). *Ambrosia* pollen can be transported from the Pannonian Plain to eastern Austria and Vienna during August and September, when south-eastern winds are predominant in the region (ESSL ET AL., 2009; KARRER, 2010). JÄGER and LITSCHAUER (1998) detected pollen of *Ambrosia* coming from western Hungary in the air of Vienna. Native *Ambrosia* is also found in the Austrian countryside (JÄGER and BERGER, 2000). The migration velocity of new plant occurrences from east to west is 6-20 km per year (JÄGER and LITSCHAUER, 1998).
In the Czech Republic, the species was first recorded in 1883 in clover fields near Třeboň and a field near Doudlevice u Plzně (SLAVÍK and ŠTĚPÁNKOVÁ, 2004). Over the past 30 years *A. artemisiifolia* has spread from harbours, grain houses, silos, mills and transport links to lowland areas of south and north east Moravia, as well as along the Elbe valley (SLAVÍK and ŠTĚPÁNKOVÁ, 2004).
Ambrosia pollen came to Switzerland by the southerly winds from Northern Italy and the Rhône valley (PEETERS, 1998). However, it was recently shown that there is native *Ambrosia* in Geneva, Switzerland, as well (CLOT ET AL., 2002). In the country, *Ambrosia* pollen was firstly observed in Basel in 1970 by LEUSCHNER (1974).
In France, *A. artemisiifolia* occurred in at least three botanical gardens in the 18th century (Lyon, 1763; Paris, 1775; and Poitier, 1791) and during the first half of the 19th century in at least five gardens, namely in: Alençon, Angers, Avignon, Montpellier and Strasbourg. The earliest herbarium record in Europe also comes from France in 1863 (CHAUVEL ET AL., 2006; BULLOCK ET AL., 2010). The species showed a gradual but continuous spread in this region, demonstrating its continuous presence in the area of Lyon, which seems to be the focus of its current French distribution (THIBAUDON, 1998; CHAUVEL ET AL., 2006; GLADIEUX ET AL., 2011). The agricultural trade between America and Europe in the 19th century and the First World War facilitated the introduction and spread of *A. artemisiifolia* in France. The plant is spreading from north to south in the mid-Rhone valley area and it is more dominant in rural than in urban areas (DÉCHAMP AND PENEL, 2002). The temporal and spatial spread of the species in France has speeded up in the last 30 years with a number of sub-regions being free of *A. artemisiifolia* declining dramatically from 54 in 1982; to 38 in 2004; and 9 in 2011 (CHAUVEL ET AL., 2006; BULLOCK ET AL., 2010; PETERMANN, 2011).
In Italy, the species was first recorded in 1901-1902 from Piedmont. *A. artemisiifolia* has been naturalized in the province of Milan (Lombardy) since the 1940s (STUCCHI, 1942; ZANON ET AL., 1998); however, it has been spreading rapidly since the 1980s. Currently,

the north-western Milan and south Varese (Lombardy, Po valley) are the most polluted areas with ragweed pollen in Italy (BONINI ET AL., 2012).
In Spain, *Ambrosia* species occur only over some areas, namely northern Spain (LAÍNZ and LORIENTE, 1983), the Basque Country, the Cantabric coasts and Galice (Fernández-LLAMAZARES ET AL., 2012), as well as central Spain (AMOR ET AL., 2006). The first record of the genus *Ambrosia* here dates back to the 19th century and corresponds to *A. maritima*, the only native species in the Peninsula (PÉREZ, 1887). The major ragweed colonies in Spain and Portugal are closely associated with some of the most important harbours, such as Barcelona, Bilbao, Lisbon, Porto, Santander or Valencia (FERNÁNDEZ-LLAMAZARES ET AL., 2012).
In the United Kingdom, the species was first recorded as a casual species in 1836. It is considered to be increasing in range and abundance, but most records are still classed as casual (CASARINI, 2002; BULLOCK ET AL., 2010).
In Germany, *A. artemisiifolia* was first recorded in 1860, in Hamburg. It is believed that *A. artemisiifolia* was introduced with grain and seed shipments from the USA. Up until the 1970s, *A. artemisiifolia* was found in only a few areas but since the 1990s it has spread eastward. The species is mostly found in the south and east of the country (ALBERTERNST ET AL., 2006) in areas where anthropogenic activity is the highest (BULLOCK ET AL., 2010). ZINK ET AL. (2012) found that in north-eastern Germany the majority of the pollen originated in local areas; however, up to 20% of the total pollen load came via long-range transport from Hungary. Furthermore, according to BOEHME ET AL. (2009) a substantial ratio of children was sensitized by ragweed pollen in Baden Wurttemberg.
In Belgium the species was first recorded in 1883 and has since become widely spread with most records from the north of the Samber-Meuse river corridor. The majority of the records are found in the more urbanised regions (MARTIN AND LAMBINON, 2008; BULLOCK ET AL., 2010).
For Denmark, the earliest record of *A. artemisiifolia* dates from 1865 but today it has only a limited distribution in the country. However, the species has been noted as spreading from the established areas (BULLOCK ET AL., 2010).
In Poland, *A. artemisiifolia* was first introduced into Szczepanowice (Silesian Lowland - south-western Poland) in 1873. It is also possible that the species may have been introduced as early as 1613 (TOKARSKA-GUZIK, 2005). The species has since spread to southern and central-eastern Poland (CHLOPEK ET AL., 2011). The spreading rate is poorly understood since both the species and incidence of biological recording in the country are increasing. However, in southern Poland *A. artemisiifolia* is supposed to have spread 30 km in the period 2007-2010 (BULLOCK ET AL., 2010; CHLOPEK ET AL., 2011). Ragweed pollen arrives in Poland from Slovakia, the Czech Republic and Austria (KASPRZYK ET AL., 2011). However, its most important source areas are the Pannonian Plain (MAKRA ET AL., 2010; ŠIKOPARIJA ET AL., 2009; 2013) and the Ukraine (RODINKOVA ET AL., 2012) not only for Poland but for all Central European countries. Their distribution here is limited to ruderal places, waste lands, lawns, sea ports, places near roads and railway tracks (KASPRZYK ET AL., 2011).
Concerning the Baltic area, ragweed is considered a casual species and the spreading rate is considered to be very low. *A. artemisiifolia* was first found in Lithuania in 1884, in Latvia in 1936 and in Estonia in 1954 (TABAKA ET AL., 1988; GUDŽINSKAS, 1993; SAAR ET AL., 2000). *A. artemisiifolia* is mostly recorded along railways and close to major cities (Herbarium of Institute of Biology of the University of Latvia) (BULLOCK ET AL., 2010; ŠAULIENĖ AND VERIANKAITĖ, 2012).
On the territory of Romania the species was first recorded in 1908 in Orsova (south-western Romania), the area belonged to the Austro-Hungarian Empire at the time

(JÁVORKA, 1910). Recently common ragweed has extended its range across the entire country with the exception of the mountainous regions (HODIŞAN AND MORAR, 2008; BULLOCK ET AL., 2010). The agricultural areas have been greatly infested. *Ambrosia* has extended from the west and north-west towards the central and southern part of Romania and continues to extend to the east and north-east (IANOVICI AND SIRBU, 2007; SKJØTH ET AL., 2010; IANOVICI ET AL., 2013).

In Moldova, *A. artemisiifolia* was first reported at Ungheni (BORZA AND ARVAT, 1935), downstream of the Nistru River (MARZA, 2010). Since its introduction, the species has spread in the south-eastern part of the country (BULLOCK ET AL., 2010; MARZA, 2010).

Ambrosia was introduced to Ukraine through a few trade routes in different years. A German pharmacist Krikker grew ragweed in the Dnipropetrovsk region as a medicinal plant (substitute for quinine and as an anthelmintic remedy) in 1914 (MAR'YUSHKINA, 1986). Ragweed was first described in the Kyiv region in 1925. The army of General Denikin brought *Ambrosia* with seeds of alfalfa to Eastern Ukraine, so this weed was spread in Zaporozhye, Donetsk and Lugansk regions (RODINKOVA ET AL., 2012). The next ragweed intervention to Ukraine was registered in 1946 when the first wheat consignment was shipped to USSR from USA.

This allergenic weed is currently found in all over the country. Ragweed is usually spread from southern and eastern parts of Ukraine toward north-west by transportation, with sunflower seeds contaminated by seeds of ragweed while they are transported from steppe to forest-steppe zone of Ukraine. Sensitivity of compromised children to *Ambrosia* pollen in 2000 was 3%, and in 2009 it was already 10% in the western part of Ukraine (BESH ET AL., 2011), which is consistent with a significant increase in *Ambrosia* pollen abundance (PALAMARCHUK ET AL., 2012).

In Russia, *Ambrosia artemisiifolia* was first recorded in the southern European part of the country in 1918 (KOVALEV, 1989). The first occasional introductions were possibly connected with the increasing international trade via the Black Sea ports (KOVALEV, 1989) and rail roads (MAR'YUSHKINA, 1986). However, until the mid-sixties, there was no information on allergic properties of ragweed pollen in the USSR (OSTROUMOV, 1964). Recently, almost 80% of the total square infested by common ragweed in Russia falls in Krasnodar territory (MOSKALENKO, 2002). Also Stavropol' territory, Rostov province and the Russian North Caucasus are highly infested extending southwards to Georgia. Furthermore, Primorsk and Khabarovsk territories (Russian Far East) are another, relatively small, isolated areas of common ragweed invasion (REZNIK, 2009).

Israel is also infected with *Ambrosia*. The invasion of new species of *Ambrosia* into Israel is still in progress, mainly in the eastern Galilee and in the Sharon plain (WAISEL ET AL., 2008).

A. artemisiifolia is extensively distributed in Asia, North and South America and Australia (LAWALRÉE, 1953; PRISZTER, 1960). The dynamic spread of *A. artemisiifolia* in Turkey is a serious environmental issue (KAPLAN ET AL., 2003; ZEMMER ET AL., 2012). *Ambrosia* species extensively occur in large areas of India (SINGH ET AL., 2004; SAHA and MISHRA, 2009), while BALLARD ET AL. (1995) reported that *A. artemisiifolia* and *A. trifida* are important weeds of soybean plantations here. Ragweed invaded South Korea from Europe and North America (KIL ET AL., 2004), while Japan from North America (FUKANO and YAHARA, 2012). In Japan, pollen allergy due to *A. artemisiifolia* is the 2nd most important following Cryptomeria (KAZINCZI AND NOVÁK, 2012). In China, common ragweed was first documented in 1935 both in the north-eastern part of the country (CHEN ET AL., 2007a; 2007b) and in Eastern China (Hangzhou, Jiangsu Province). Since that time on, ragweed has rapidly spread to northern, central and eastern China including over 15 provinces. Giant ragweed reportedly invaded Northeast China in the 1950s. By 1989, ragweed had expanded from centres in Shenyang, Nanjing, Nanchang and Wuhan to include 12 provinces (WAN ET AL., 1993; LI, 1997; XIE ET AL., 2001). The suitable areas for ragweed include almost exclusively the eastern, most populated part of the country with the Sichuan basin, supplemented with parts of Xinjiang Uygur Autonomous Region. This suggests that ragweed may be able to invade these areas in the future (CHEN ET AL., 2007b). *A. artemisiifolia* is in abundance in the reaches of the Changjiang (Yangtze) River and along roadsides, while *A. trifida* along village paths and riverbanks in northeastern China (WANG ET AL., 1985). The species continue their southward spread into the subtropical regions of the country (QIN ET AL., 2012). The reason of the large-scale invasion of *A. artemisiifolia* in China is its great germination success over the highly variable climatic conditions (SANG ET AL., 2011). LI ET AL. (2012) found that high levels of genetic variation in China indicate that there has been no erosion of genetic variance due to a bottleneck during the introduction process. They also suggest that the successful invasion of *A. artemisiifolia* into Asia was facilitated by repeated introductions from multiple source populations in the native range creating a diverse gene pool within Chinese populations.

In the United States, the suitable region for ragweed involves almost exactly the eastern half of the country, including the Pacific coastal areas (CHEN ET AL., 2007b). Here, in the home of *Ambrosia spp.*, duration of the ragweed pollen season has been increasing in recent decades as a function of latitude, in association with an enhanced warming (ZISKA ET AL., 2011). In southern Québec (Canada), *A. artemisiifolia* has been present since at least 200 years but the species was probably restricted to the Montréal area during the 19th century (LAVOIE ET AL., 2007). It is unclear whether common ragweed is native here or has been introduced from the Canadian Prairies (ROUSSEAU, 1974; BASSETT AND CROMPTON, 1975). However, this species is clearly more widespread here today than at the beginning of the 20th century (ROUSSEAU, 1974).

In South America, *Ambrosia* species are widely prevalent weeds (SULSEN ET AL., 2011; MASCIADRI ET AL., 2013).

In Australia, ragweed pollen is in the air in abundance for a sufficient length of time and its concentration to sensitize and provoke fall hay fever and asthma exacerbations (BASS ET AL., 2000).

PERSPECTIVES

At high CO_2 levels, *A. artemisiifolia* showed substantially greater biomass, as well as increased pollen production compared to those in ambient CO_2. Hence, ragweed pollen production can be expected to increase significantly under predicted future climate conditions (WAYNE ET AL., 2002; ROGERS ET AL., 2006).

Warming trends in long-term climate change involve greater exposure times to seasonal allergens that lead to higher risk potential of public health incidences (D'AMATO and CECCHI, 2008; SHEA ET AL., 2008).

In North America, duration of the ragweed pollen season has been increasing in recent decades as a function of latitude (ZISKA ET AL., 2011). For Europe, future spread of ragweed will depend on the climate and land use change. Based on different models, ragweed will spread north (e.g. Germany, Poland, northern part of the European Russia) with a warmer climate compared to its current range, bringing severe impacts to areas that have yet been suffering slightly (BULLOCK ET AL., 2010; CUNZE ET AL., 2013).

Nevertheless, there is some evidence to suppose that very high temperatures are harmful for ragweed. The highest increase in the mean temperature, especially in summer time (August), represents a limit for pollen production of *Ambrosia*. In this period, the loss of

water makes a difficulty for phyto-physiological processes, so in order to save water the plant reduces its pollen production. This effect will limit the climate change related expansion of ragweed (MAKRA ET AL., 2011).
Concerning future economic expenses of *A. artemisiifolia* for Europe, without controls the influence of climate change will increase the medical and work productivity costs, but the agricultural costs will reduce. This suggests that, due to the climate change, agricultural areas will reduce and pollen sensitivity will increase in the population (BULLOCK ET AL., 2010).

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SPATIAL SPECIALISATION OF LIVESTOCK IN HUNGARY

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ABSTRACT
The territorial location issues of livestock in the European Union and also in our country got into the focus over the past few years. There are different animal structures in the regions of our country and different animal species became dominant. The location and the development of certain animal types are affected by a number of socio-economic factors (the history of breeding, ownership, labour and capital assets, etc.). In case of the spatially differentiated species-structure, variable profitability, human-resource, technical standards, different risk factors and market opportunities must be taken into consideration in different regions. The actuality of the research topic is enhanced by the fact that nowadays the spatial structure of animal production has become an important key issue. That is why more and more research is needed in Hungary, primarily research studying and analysing the structural changes and principals of animal production in order to ensure that each region would have a rational and efficient breed-structure. In addition, it is expected in modern market economies that the various regions should specialize in animal species, for which they have the most favourable breeding conditions. In order to follow the livestock changes (spatial and structural) in the last decade, it was important to consider the spatial specialization of different species over time.

Keywords: livestock (cattle, pig, sheep, hen species), spatial specialisation

INTRODUCTION

Animal production used to have a leading role in Hungarian agriculture for a long time, which had a close correlation with the structure and the standard of plant production. (KOMAREK, 2007, 2008c)

In the era of planned economy the importance of agriculture within the whole national economy decreased considerably compared to the situation before 1938 due to the intensive industrialisation. This decrease, however, occurred beside a dynamic development and growth. Spectacular results were achieved mainly from 1961, after the large scale reorganisation of agriculture. In the mid 1980s our agriculture in many aspects got into the forefront of the world despite the fact that we had a lot to do concerning yield, production costs, production structure, the speed of adapting to the markets and the harmonisation between the elements of the food industry verticum. The mid 1980s saw a dynamic development in spite of the unequal pace, then various tensions and imbalances got into the surface in the field of agriculture (BENKŐ-KISS ET AL., 2010; BODNÁR AND HORVÁTH, 2005; KOMAREK, 2003, 2004).

After the regime change profound changes took place in all sectors of animal production and there was an entirely new situation. Animal production has serious difficulties since then. The volume of production declined, the composition became more diverse and the structure of production sometimes became irrational, difficulties arose in selling etc. Profitability decreased in the field of animal production overall and certain activities became uneconomic. The low level of profitability resulted in unreasonable production decline and also led to a never experienced decrease in the number of our livestock (HORVÁTH, 2002; KOMAREK, 2008a, 2008b, 2011).

MATERIAL AND METHOD

The statistical data of the Hungarian Central Statistical Office were used as a source. An index was formed from the data in order to facilitate the comparison of special distribution within the animal production sectors. The investigation involved the temporal and spatial data of cattle, pig, sheep and hen stocks in the period from 2003 to 2013.

In the past few years and even nowadays the transformation of Hungarian agriculture resulted in significant changes in the sector-specific and spatial structure of animal production. These changes require examinations in order to find out if a regional specialisation can be observed in the spatial organisation of livestock. To answer these assumptions, mathematical and statistical methods used in spatial research were applied.

A widespread method for the measurement of specialization is the so called spatial specialization index. This indicator shows the national share of each unit area concerning a specific product or production branch. That's called common specialization index.

General formula:

$$S_{köz} = \frac{x_r}{x_t} \times \frac{t}{r}$$

where:
$S_{köz}$ = common specialization index
x_r = unit area value
x_t = national value
t = territory of the country
r = territory of the unit area

The common specialization index shows the share of a unit area from the national production of a specific product or production branch. The higher the specialisation index is, the higher the level of specialisation will be.

RESULTS

When investigating the spatial specialisation of Hungarian livestock overall we can conclude from the calculated data that there were changes in the rate of the specialisation concerning certain types of animals. In some regions the rate of specialisation strengthened with regard to the given species and in others they lost their role and significance during the past decade.

In the past years the cattle stock of Hungary was changing. There were 739 000 cattle in 2003 and this number was decreasing during the years until it reached its lowest point of 682 000 in 2010.

From 2011 until today there was a dynamic increase in the cattle stock, and by 2013 the number of animals reached and even exceeded the 783 000 value of 2003. The considerable increase of the purchase price of cattle in recent years had a part in that. In addition to the number of the animal stock, another important factor is its spatial specialisation. In case of cattle Győr-Moson-Sopron and Hajdú-Bihar Counties represented the highest specialisation value in the base year (2003). Then Fejér, Békés and Tolna Counties followed. During the period up to 2013 Hajdú-Bihar and Győr-Moson-Sopron Counties retained their prominent position in the field, however, while the rate of specialisation in Győr-Moson-Sopron County deceased, it was growing in Hajdú-Bihar County. Similarly, the rate of specialisation was growing in Békés County in the period between 2003 and 2013. In contrast, Fejér and Tolna Counties lost their importance in the field of cattle production.

Table 1. Spatial specialisation of cattle stock in Hungary

Spatial Unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Budapest	0.63	0.65	0.58	0.58	0.83	0.42	0.42	0.37	0.36	0.49	0.40
Pest	0.97	1.08	1.10	1.20	1.18	1.14	1.18	1.30	1.20	1.16	1.27
Central Hungary	**0.91**	**1.00**	**0.99**	**1.05**	**1.10**	**0.98**	**1.02**	**1.12**	**1.03**	**1.03**	**1.09**
Fejér	1.46	1.38	1.33	1.26	1.17	1.23	1.20	1.19	1.17	1.13	1.15
Komárom-Esztergom	0.86	0.88	0.82	0.83	0.71	0.71	0.71	0.64	0.70	0.64	0.62
Veszprém	1.12	1.11	0.98	1.02	1.14	1.09	0.99	0.99	1.08	1.05	1.10
Central Transdanubia	**1.23**	**1.18**	**1.10**	**1.08**	**1.08**	**1.08**	**1.02**	**1.00**	**1.04**	**1.01**	**1.02**
Győr-Moson-Sopron	1.75	1.91	1.74	1.75	1.80	1.82	1.76	1.63	1.68	1.68	1.52
Vas	1.15	0.98	0.97	1.06	1.06	1.10	1.11	1.12	1.03	1.13	1.02
Zala	0.68	0.75	0.84	0.95	0.84	0.81	0.74	0.82	0.73	0.74	0.75
West Transdanubia	**1.19**	**1.21**	**1.22**	**1.29**	**1.27**	**1.28**	**1.23**	**1.20**	**1.19**	**1.21**	**1.12**
Baranya	0.94	0.87	0.87	0.84	0.81	0.79	0.79	0.84	0.82	0.75	0.81
Somogy	0.64	0.70	0.72	0.66	0.70	0.66	0.56	0.57	0.63	0.62	0.56
Tolna	1.21	1.05	1.04	1.01	0.96	0.93	0.97	0.84	0.90	0.82	0.83
South Transdanubia	0.89	0.85	0.85	0.81	0.80	0.77	0.74	0.72	0.76	0.72	0.71
Borsod-Abaúj-Zemplén	**0.67**	**0.70**	**0.77**	**0.74**	**0.69**	**0.77**	**0.78**	**0.76**	**0.71**	**0.68**	**0.79**
Heves	0.36	0.37	0.38	0.38	0.38	0.38	0.42	0.32	0.38	0.35	0.34
Nógrád	0.54	0.66	0.67	0.63	0.68	0.79	0.79	0.64	0.63	0.58	0.66
North Hungary	**0.56**	**0.60**	**0.63**	**0.60**	**0.61**	**0.66**	**0.68**	**0.61**	**0.60**	**0.58**	**0.63**
Hajdú-Bihar	1.70	1.73	1.83	1.78	1.82	1.80	1.96	1.87	1.87	1.81	1.83
Jász-Nagykun-Szolnok	1.09	1.10	1.15	1.07	1.04	1.07	1.02	1.02	1.09	1.10	1.15
Szabolcs-Szatmár-Bereg	0.77	0.76	0.69	0.76	0.76	0.78	0.76	0.74	0.66	0.71	0.71
North Great Plain	**1.18**	**1.19**	**1.21**	**1.20**	**1.19**	**1.20**	**1.24**	**1.20**	**1.20**	**1.20**	**1.23**
Bács-Kiskun	0.82	0.76	0.73	0.78	0.82	0.83	0.84	0.89	0.95	1.02	0.93
Békés	1.26	1.24	1.19	1.20	1.20	1.20	1.28	1.56	1.42	1.47	1.58
Csongrád	1.08	1.08	1.25	1.11	1.04	1.08	1.08	1.03	1.10	1.09	0.95
South Great Plain	**1.01**	**0.97**	**0.98**	**0.98**	**0.99**	**1.00**	**1.02**	**1.12**	**1.12**	**1.17**	**1.13**

Source: Author's calculations based on KSH data

There were negative changes in the pig stock during the observation period. The number of pigs in 2003 was 4913 thousand, which fell back to 3013 within a decade meaning a 38.7% decrease from the base year to the reference year. Despite the fallback in pig numbers there are regions specialised on pig production. In the base year (2003) particularly Komárom-Esztergom, Hajdú-Bihar, Csongrád and Békés Counties were specialised in pig production. By the reference year (2013) the specialisation of the above counties in pig production decreased except Hajdú-Bihar County. In case of Hajdú-Bihar County there was even an intensive specialisation compared to the base year. In addition, in case of Baranya County we can observe growth in this field although it used to have lower specialisation previously.

Table 2. Spatial specialisation of pig stock in Hungary

Spatial Unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Budapest	0.11	0.15	0.18	0.13	0.18	0.36	0.16	0.32	0.19	0.33	0.29
Pest	0.67	0.64	0.71	0.70	0.73	0.73	0.74	0.73	0.63	0.43	0.48
Central Hungary	**0.57**	**0.55**	**0.59**	**0.57**	**0.61**	**0.65**	**0.61**	**0.65**	**0.54**	**0.41**	**0.44**
Fejér	0.90	0.77	0.79	0.65	0.56	0.54	0.46	0.52	0.60	0.62	0.58
Komárom-Esztergom	2.09	1.73	1.82	1.63	1.61	1.97	1.78	1.92	1.39	1.28	1.34
Veszprém	0.87	0.90	0.80	0.83	0.78	0.83	0.83	0.81	0.71	0.77	0.58
Central Transdanubia	**1.14**	**1.02**	**1.00**	**0.92**	**0.86**	**0.94**	**0.86**	**0.92**	**0.81**	**0.81**	**0.73**
Győr-Moson-Sopron	1.00	1.30	1.11	1.04	1.04	1.01	1.09	1.11	1.30	1.47	1.38
Vas	0.43	0.48	0.46	0.46	0.36	0.39	0.34	0.31	0.33	0.33	0.31
Zala	0.46	0.49	0.57	0.44	0.39	0.43	0.44	0.47	0.47	0.51	0.40
West Transdanubia	**0.64**	**0.77**	**0.74**	**0.67**	**0.62**	**0.63**	**0.66**	**0.66**	**0.74**	**0.82**	**0.75**
Baranya	1.53	1.77	1.95	1.76	2.07	1.54	1.76	1.76	1.85	1.90	1.99
Somogy	0.66	0.67	0.71	0.71	0.71	0.80	0.59	0.67	0.65	0.66	0.72
Tolna	1.52	1.47	1.40	1.40	1.20	1.43	1.23	1.23	1.34	1.40	1.25
South Transdanubia	**1.16**	**1.23**	**1.29**	**1.23**	**1.28**	**1.20**	**1.14**	**1.16**	**1.21**	**1.25**	**1.27**
Borsod-Abaúj-Zemplén	0.44	0.35	0.38	0.35	0.39	0.39	0.42	0.37	0.39	0.40	0.41
Heves	0.39	0.36	0.36	0.32	0.37	0.37	0.47	0.34	0.30	0.30	0.33
Nógrád	0.36	0.30	0.35	0.30	0.31	0.26	0.29	0.25	0.29	0.11	0.11
North Hungary	**0.41**	**0.34**	**0.37**	**0.33**	**0.37**	**0.36**	**0.41**	**0.34**	**0.34**	**0.31**	**0.33**
Hajdú-Bihar	1.81	1.75	1.80	1.94	2.03	2.21	2.39	2.25	2.61	2.60	2.53
Jász-Nagykun-Szolnok	0.99	0.92	1.05	1.02	1.04	1.07	1.07	1.00	1.06	1.14	1.19
Szabolcs-Szatmár-Bereg	0.94	0.93	0.85	0.87	0.89	0.77	0.78	0.93	0.62	0.64	0.75
North Great Plain	**1.24**	**1.20**	**1.22**	**1.27**	**1.31**	**1.34**	**1.40**	**1.39**	**1.42**	**1.45**	**1.49**
Bács-Kiskun	1.07	1.04	1.10	1.12	1.26	1.14	1.09	1.17	1.12	1.13	1.21
Békés	1.65	1.48	1.54	1.66	1.61	1.54	1.60	1.82	1.76	1.56	1.59
Csongrád	1.69	2.09	1.55	1.91	1.47	1.61	1.63	1.18	1.34	1.40	1.27
South Great Plain	**1.39**	**1.42**	**1.34**	**1.47**	**1.41**	**1.37**	**1.37**	**1.36**	**1.36**	**1.32**	**1.34**

Source: Author's calculations based on KSH data

The Hungarian sheep stock mostly stagnated or somewhat decreased in the examination period. In 2003 the number of the animals reached 1296 thousand, which fell down to 1271 thousand by 2013. The stock peaked in 2005 (1405 thousand), while in 2011 the lowest ever number was observed (1120 thousand). Compared to the previous years, there were no significant changes regarding spatial specialisation. In the base year (2003) Hajdú-Bihar, Szabolcs-Szatmár-Bereg and Bács-Kiskun Counties were specialised in sheep production the most intensely. Out of these three counties the specialisation of Hajdú-Bihar and Bács-Kiskun Counties increased by the reference year (2013) while in case of Szabolcs-Szatmár-Bereg County we could witness a decreasing specialisation. However, this county is still in the national forefront concerning sheep production in Hungary.

The examinations prove that there have been no considerable spatial changes in sheep production recently.

Table 3. Spatial specialisation of sheep stock in Hungary

Spatial Unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Budapest	0.62	1.10	0.67	0.68	0.71	0.80	0.72	0.80	0.34	0.84	0.78
Pest	0.71	1.14	1.29	0.80	0.75	0.54	0.53	0.82	0.66	0.72	0.76
Central Hungary	**0.69**	**1.12**	**1.16**	**0.77**	**0.73**	**0.60**	**0.57**	**0.81**	**0.60**	**0.74**	**0.76**
Fejér	0.83	0.72	0.70	0.82	0.80	0.68	0.62	0.56	0.58	0.55	0.56
Komárom-Esztergom	0.72	0.61	0.56	0.58	0.57	0.44	0.41	0.27	0.36	0.44	0.41
Veszprém	0.99	1.03	0.91	0.95	0.76	0.63	0.59	0.94	1.34	0.85	0.88
Central Transdanubia	**0.86**	**0.81**	**0.75**	**0.82**	**0.73**	**0.61**	**0.57**	**0.65**	**0.83**	**0.65**	**0.65**
Győr-Moson-Sopron	0.14	0.11	0.11	0.12	0.12	0.14	0.13	0.15	0.16	0.17	0.12
Vas	0.09	0.20	0.12	0.09	0.09	0.07	0.07	0.10	0.10	0.10	0.09
Zala	0.22	0.11	0.14	0.29	0.38	0.32	0.22	0.34	0.32	0.26	0.30
West Transdanubia	**0.15**	**0.13**	**0.14**	**0.17**	**0.19**	**0.18**	**0.14**	**0.20**	**0.19**	**0.18**	**0.16**
Baranya	0.47	0.39	0.41	0.47	0.46	0.48	0.47	0.48	0.38	0.38	0.43
Somogy	0.27	0.32	0.30	0.28	0.28	0.25	0.27	0.37	0.38	0.34	0.40
Tolna	1.21	1.24	1.37	1.30	1.21	0.90	0.84	0.90	0.85	0.92	1.01
South Transdanubia	**0.57**	**0.58**	**0.61**	**0.60**	**0.58**	**0.49**	**0.48**	**0.55**	**0.50**	**0.49**	**0.56**
Borsod-Abaúj-Zemplén	0.72	0.61	0.62	0.63	0.63	0.73	0.64	0.65	0.76	0.78	0.48
Heves	0.47	0.49	0.52	0.43	0.36	0.38	0.58	0.33	0.46	0.39	0.50
Nógrád	0.42	0.24	0.37	0.45	0.42	0.42	0.51	0.50	0.33	0.47	0.41
North Hungary	**0.59**	**0.51**	**0.54**	**0.54**	**0.51**	**0.57**	**0.59**	**0.53**	**0.59**	**0.60**	**0.48**
Hajdú-Bihar	2.78	2.97	3.11	3.15	3.31	3.34	3.28	2.93	2.56	2.90	3.03
Jász-Nagykun-Szolnok	0.73	0.76	0.87	0.72	0.73	0.69	0.84	0.95	1.03	1.04	1.18
Szabolcs-Szatmár-Bereg	2.67	2.05	1.83	2.58	2.73	2.36	2.36	2.07	2.12	2.06	1.95
North Great Plain	**2.07**	**1.93**	**1.93**	**2.16**	**2.27**	**2.13**	**2.17**	**1.98**	**1.91**	**2.01**	**2.06**
Bács-Kiskun	1.81	2.10	1.84	1.73	1.58	2.06	2.00	1.80	1.93	1.79	1.84
Békés	0.82	0.47	0.67	0.56	0.68	0.86	0.96	1.30	1.23	1.24	1.18
Csongrád	0.88	1.02	1.05	0.87	0.95	0.99	1.06	1.05	1.11	1.19	1.06
South Great Plain	**1.30**	**1.36**	**1.31**	**1.18**	**1.17**	**1.45**	**1.47**	**1.47**	**1.52**	**1.48**	**1.45**

Source: Author's calculations based on KSH data

The stock of hen species showed a somewhat hectic pattern in the past ten years. There were both ups and downs characterizing the changes of this period. In 2003 there were 37502 thousand hens in the stock, which decreased to 29474 thousand by 2013, meaning the lowest number of birds in the examination decade. In the base year (2003) the highest specialisation in case of hens was represented by Komárom-Esztergom County. Nationally, it was the county with the highest degree of specialization for breeding hens. Hajdú-Bihar and Baranya Counties can also be mentioned, however, the specialisation index of these counties is considerably lower than that of Komárom-Esztergom County. By the reference year (2013) Komárom-Esztergom County lost some of its strong specialisation, however it remained a dominant county in the field of hen breeding. The value and through that the

rate of specialisation increased in Hajdú-Bihar County, while it fell back in Baranya County from the base year to the reference year.
The specialization increase in Budapest and in Szabolcs-Szatmár-Bereg County is also worth mentioning, which means that the spatial structure of hen farming is under constant change.

Table 4. Spatial specialisation of hen stock in Hungary

Spatial Unit	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Budapest	0.62	0.67	0.63	1.13	1.23	1.30	0.86	1.18	1.41	0.84	2.16
Pest	0.77	0.95	1.07	0.89	0.77	1.06	0.78	0.67	0.82	0.87	1.03
Central Hungary	**0.74**	**0.90**	**0.97**	**0.95**	**0.87**	**1.11**	**0.79**	**0.77**	**0.94**	**0.87**	**1.26**
Fejér	0.89	0.83	0.80	0.74	0.61	0.53	0.83	0.77	0.67	0.67	0.69
Komárom-Esztergom	4.96	5.00	5.58	5.38	4.54	4.01	5.06	6.25	6.55	3.32	3.47
Veszprém	0.71	0.70	0.59	0.61	0.68	0.85	0.72	0.68	0.58	0.71	0.76
Central Transdanubia	**1.67**	**1.66**	**1.69**	**1.63**	**1.43**	**1.36**	**1.65**	**1.88**	**1.85**	**1.23**	**1.29**
Győr-Moson-Sopron	0.83	0.99	0.71	0.91	0.96	0.69	0.85	0.83	0.84	0.92	0.96
Vas	1.10	0.87	0.79	0.81	0.60	0.95	1.18	0.93	0.87	0.87	0.94
Zala	0.85	0.93	1.10	1.07	0.91	1.37	1.18	0.76	0.87	1.25	1.21
West Transdanubia	**0.91**	**0.93**	**0.86**	**0.93**	**0.84**	**0.99**	**1.05**	**0.84**	**0.86**	**1.01**	**1.04**
Baranya	1.52	1.37	1.45	1.26	1.37	1.35	1.17	1.32	1.18	1.10	1.03
Somogy	0.45	0.37	0.42	0.47	0.46	0.34	0.30	0.33	0.23	0.25	0.29
Tolna	0.55	0.52	0.66	0.57	0.56	0.56	0.45	0.47	0.46	0.42	0.45
South Transdanubia	**0.82**	**0.73**	**0.82**	**0.75**	**0.78**	**0.72**	**0.62**	**0.69**	**0.60**	**0.57**	**0.57**
Borsod-Abaúj-Zemplén	0.78	0.85	0.77	0.89	1.04	1.02	0.99	0.82	0.71	0.70	0.78
Heves	0.37	0.32	0.29	0.38	0.27	0.29	0.28	0.38	0.28	0.28	0.41
Nógrád	0.95	0.36	0.41	0.36	0.39	0.31	0.36	0.30	0.31	0.25	0.35
North Hungary	**0.70**	**0.61**	**0.56**	**0.64**	**0.69**	**0.67**	**0.66**	**0.59**	**0.51**	**0.49**	**0.59**
Hajdú-Bihar	1.70	1.51	1.74	1.75	2.09	1.75	1.72	2.07	1.66	2.29	1.94
Jász-Nagykun-Szolnok	0.53	0.71	0.69	0.56	0.61	0.65	0.45	0.40	0.39	0.42	0.44
Szabolcs-Szatmár-Bereg	0.89	0.98	1.20	1.32	1.57	1.29	1.62	1.69	2.04	1.95	1.87
North Great Plain	**1.03**	**1.06**	**1.21**	**1.21**	**1.42**	**1.23**	**1.27**	**1.39**	**1.38**	**1.56**	**1.43**
Bács-Kiskun	1.18	1.26	1.08	1.16	1.03	1.24	1.13	0.91	0.96	1.33	0.99
Békés	0.72	0.81	0.82	0.68	0.62	0.77	0.62	0.51	0.61	0.58	0.70
Csongrád	1.34	1.26	0.74	0.71	0.80	0.64	0.86	0.92	1.02	1.00	0.88
South Great Plain	**1.09**	**1.13**	**0.92**	**0.91**	**0.86**	**0.96**	**0.92**	**0.79**	**0.87**	**1.03**	**0.88**

Source: Author's calculations based on KSH data

CONCLUSIONS

When examining the spatial specialisation of Hungarian livestock we can conclude that the values of the specialisation index show a diverse picture. Concerning the animal species, both increase and decrease can be observed in spatial specialisation in all cases, however if we examine the tendencies, special specialisation has bigger changes in hen production, while there is no change in sheep production. With regard to regional aspects, the winners of specialisation in case of animal production are the plain territories situated east from the River Danube. This means that on these lowland areas it is the animal production sector with the highest value of specialization that gives the significant part of the livestock in the given area (eg. county, region). This animal production sector forms the "skeleton" of the livestock in the region, around which the production complex is formed, and which determines the direction of development and significantly affects the other animal production sectors. In addition, it has the potential to shape the region and using the available favourable natural-socio-economic conditions it provides maximum economic yield enforcement effort at minimal expense. Beside the livestock industry that represents specialization, the development of the service sector, as well as the sectors supplying local needs, so most of the sectors of local importance, also have a significant role.

In my opinion, the processes and trends in animal production over the past decade are well reflected in the final study . In several cases, the available data show that in recent years there was a decrease in the livestock, except for cattle, which can be explained in many cases with the high feed prices (especially in the situation created by the fall of 2007), and sometimes with the low purchase price, the more difficult sales opportunities explained by the continuous inflow of cheap, low-quality products imported from abroad. Thus, animal production in our country is currently unprofitable in many cases, an activity likely to be degraded. The negative trends were further deteriorated, hopefully only temporarily, by the very high feed prices of 2007.

In the field of animal production, sometimes after a major setback of the stock, it may have a more favourable position in the future only with appropriate caution, with a well thought out agricultural policy taking into account the conditions of the European Union, and with a professional quality control. Long and medium term, it is very important that livestock would have an increasing role in Hungarian agriculture, in rural development, thereby with a further multiplicative effect.

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Review on Agriculture and Rural Development 2014. vol. 3 (2) ISSN 2063-4803

MAJOR TENDENCIES IN LIVESTOCK CHANGES AFTER THE EU ACCESSION

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ABSTRACT
In the mid 80s Hungarian agriculture belonged to the forefront of the world in many respects, despite the fact that there was a lot to do regarding yields, production costs, production structure, and the fastness of adaptability to markets and establishing accordance between the elements of the food industry chain. The mid 1980s witnessed an energetic improvement despite the unequal pace, and then followed an era of different tensions and imbalances in Hungarian agriculture. At the time of the regime change the agricultural sector, and particularly animal production within that, suffered from the signs of crisis and it was getting into an increasingly difficult position. The vast majority of the agricultural large scale farms ceased to exist, and most of the arable land was privatised. Production fell back, its composition became more heterogeneous, sometimes with an irrational production structure and selling difficulties arouse. Profitability decreased in the field of animal production generally, and some activities even had losses. The domestic consumption fall-back, which was caused by the farmers' lack of capital, the unorganised production, and the decrease in living standards, produced an amount of unsellable goods and it made the otherwise low profitability even worse. The low level of profitability resealed in unjustified production decline and led to the fact that the number of domestic animals in Hungary decreased to a never experienced depth. Today there are positive changes in the field of animal production, which might result in the long-term growth of our livestock. This study was designed to present the major tendencies and spatial characteristics of Hungarian livestock.

Keywords: livestock (cattle, pig, sheep, hen species), temporal and spatial changes, purchase price

INTRODUCTION

The regime change and the transition to a market economy induced significant changes in Hungarian agriculture and within that in all sectors of animal production. (KOMAREK, 2003, 2008a)
In 2004 the EU accession meant another challenge for the agriculture, which had considerable changes and was somewhat recovering. The balance between the two sectors of agriculture gradually changed. The decrease of animal production, which exceeded that of plant production, resulted in the dominance of the plant sector in 2007.
Today the relative ratio of the two sectors did not change significantly since plant production is still dominant with a two third proportion (GOCKLER, 2014; KOMAREK, 2004, 2008b, 2011).
The transformation of agriculture did not influence the regions evenly. Although agricultural production fell back everywhere and so did their contribution to the GDP, the agricultural regions kept their leading position, among others, in the field of animal production (KOMAREK, 2007, 2008c; NOVÁK AND PÁLFALVI, 2008).

MATERIAL AND METHOD

The statistical data provided by the Hungarian Statistical Office (KSH) were used for the analysis. Indices were formed from the data in order to present the temporal and spatial comparative analysis of the animal production sectors and also the main tendencies of the changes. The data of the following livestock were used with regard to the period between 2004 and 2013: cattle, pig, sheep, and hen species.

In the past few years and even today the transformation of Hungarian agriculture resulted in considerable changes in the sector and spatial structure of animal production. Due to these changes it is necessary to perform examinations that could find the answers if there were positive or negative proportion changes in the sector structure of animal production as well as the role and importance of which animal production sectors increased or decreased in the past few years. To answer these assumptions I used mathematical-statistical methods for my analysis.

RESULTS

Hen (poultry) and pig production are dominant in Hungarian animal production. Nonetheless there was a significant change in case of these two animal species during the investigation period (*Table 1*). The number of pigs was 4.059 million in 2004, which fell back to 3.013 million by 2013. It means approximately a 26 percent decrease. Hen production showed a variable trend between 2004 and 2012, while it has been decreasing since 2012 until these days. The decrease in case of the hens was somewhat smaller in the investigation period (10 percent).

Cattle production has a more favourable position, as the number of animals is constantly increasing. In 2004 there were 723 thousand cattle in the country, which increased to 783 thousand by 2013. It means an 8 percent increase compared to the data of the base year (*Table 1*).

Table 1. Temporal changes in Hungarian livestock (2004-2013)

Year	Cattle		Pig		Sheep		Hen species	
	Thousand animals	Basis relative number	Thousand animals	Basis relative number	Thousand animals	Basis relative number	Thousand animals	Basis relative number
2004	723	1.00	4059	1.00	1397	1.00	32814	1.00
2005	708	0.98	3853	0.95	1405	1.01	31902	0.97
2006	702	097	3987	0.98	1298	0.93	30303	0.92
2007	705	0.98	3871	0.95	1232	0.88	29866	0.91
2008	701	0.97	3383	0.83	1236	0.89	31165	0.95
2009	700	0.97	3247	0.80	1223	0.88	32128	0.98
2010	682	0.94	3169	0.78	1181	0.85	31848	0.97
2011	697	0.96	3044	0.75	1120	0.80	32860	1.00
2012	760	1.05	2989	0.74	1185	0.85	30075	0.92
2013	783	1.08	3013	0.74	1271	0.91	29474	0.90

Source: Author's calculations, based on KSH data

Sheep production in Hungary is of less importance, but the tendency of change in the number of animals is variable here as well. During the investigation period there was an increase from 2004 to 2005 followed by a decrease until 2005-2007, and then another slight increase came and again a decrease followed from 2008 to 2011 (*Table 1*).

From 2011 until today the signs of increase can be seen in the field of sheep production. Nonetheless there was a 9 percent decrease from the base year to the reference year.

The sometimes unfavourable tendencies in our livestock changes may be explained in many cases with high feedstuff prices, low selling prices, the ever harder selling possibilities, and the cheap, poor quality import products that keep pouring in. Therefore today in Hungary animal production is in many cases means an unprofitable activity sometimes planned to be terminated.

The cattle stock in Hungary was 783 thousand in 2013. 46.3% of the animals can be found in the Northern Great Plain and in the Southern Great Plain region. On regional level the upper extreme value was represented by the Northern Great Plain region with 188 thousand animals, that is 24%, while the lower extreme value by the Central Hungary region with 69 thousand animals, that is 8.8%.

The pig stock in Hungary was 3.013 million animals in 2013, the highest values found on the Plain regions. 55.6% of the pig stock of Hungary is given by the Plain territories. When considering the upper and lower extreme values we found that the situation is similar to that of the cattle stock. In case of pigs, the Northern Great Plain region had the upper extreme value (880 thousand animals – 29.2%), while the Central Hungary region had the lower extreme value (108 thousand animals – 3.6%).

The role of the Plain regions is quite significant in case of the sheep stock as well. In 2013 there were 1.271 million sheep in Hungary, 69.1% of which is shared between the Northern Great Plain and the Southern Great Plain regions. It means a considerable spatial concentration. In case of sheep the upper extreme value was represented by the Northern Great Plain region with 514 thousand animals, that is 40.4%, while the lower extreme value by the Western Transdanubian region with 25 thousand animals, that is 2.0%.

In case of hen species, it is the Central Transdanubian region that has a considerable stock besides the Plain regions (Northern and Southern Great Plain). In 2013 there were 29.474 million hens in Hungary. This number does not give a real picture as it does not include the number of geese, ducks, turkeys etc. However, in the Southern Great Plain region for instance, the above mentioned poultry species also have importance. Considering the hen species, the Northern Great Plain region had the upper extreme value (8.275 million animals – 28.1%), while the Southern Transdanubian region had the lower extreme value (2.426 million animals – 8.2%).

Regarding the livestock of Hungary, we can say that despite the difficulties, the Plain regions (Northern and Southern Great Plain region) have an essential role in animal production these days, since their share from the national livestock exceeds 50%, cattle and hen species not considered here.

In case of cattle stock per a hundred hectares of agricultural land, there are four regions exceeding the national average (Western Transdanubia, Central Hungary, Central Transdanubia and the Northern Great Plain). In 2013 the national average was 14.7 animals. The Western Transdanubian region is outstanding with 18.4 animals and the last one is the Southern Transdanubian region with 10.3 animals (*Figure 1*).

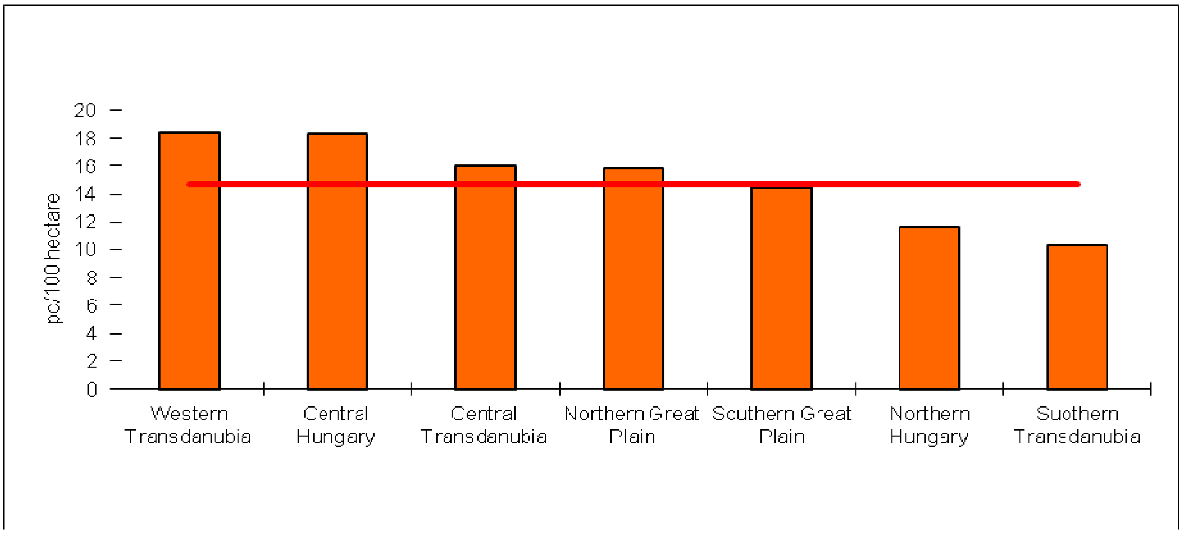

Figure 1. Cattle stock on100 ha of agricultural land (2013)
Source: own calculation

Considering the pig stock on 100 hectares of agricultural land, the national average was 56.4 animals. The national average was exceeded by three regions: the Northern Great Plain (74.0 animals), Southern Transdanubia (70.5 animals) and the Southern Great Plain (65.9 animals). Consequently in this case the upper extreme value is represented by the Northern Great Plain, while the lower extreme value by Northern Hungary (*Figure 2*).

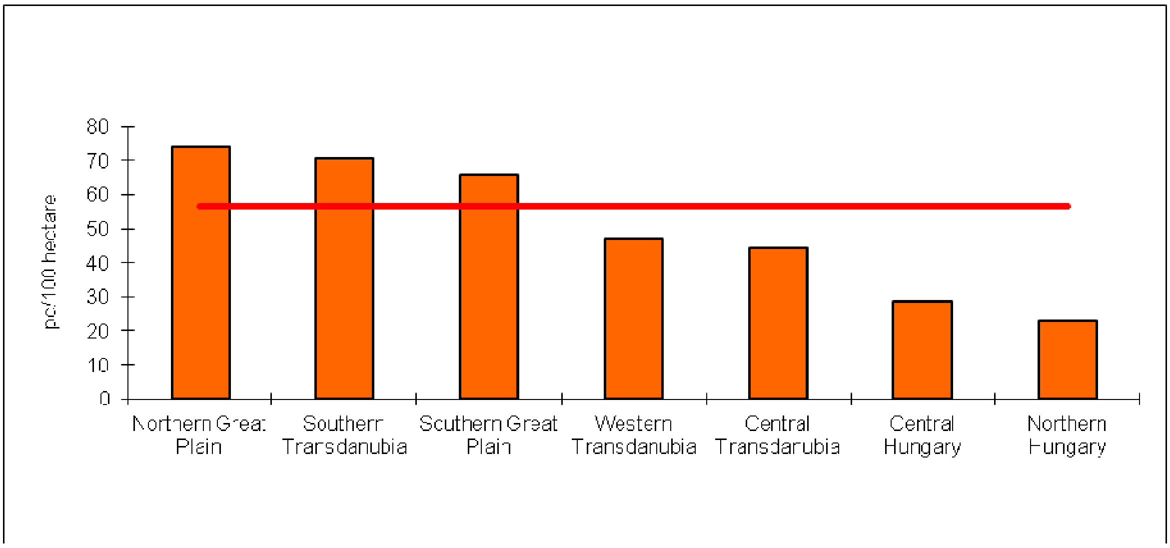

Figure 2. Pig stock on100 ha of agricultural land (2013)
Source: own calculation

In case of the sheep stock on 100 hectares of agricultural land is more subtle. There are only two regions exceeding the national average, they are the Northern Great Plain and the Southern Great Plain. The national average in the time of the investigation was 23.8 animals. The upper extreme value is represented by the Northern Great Plain with 43.3 animals), while the lower extreme value by Western Transdanubia with 4.4 animals. *Figure 3* reflects well that the sheep industry is rather concentrated.

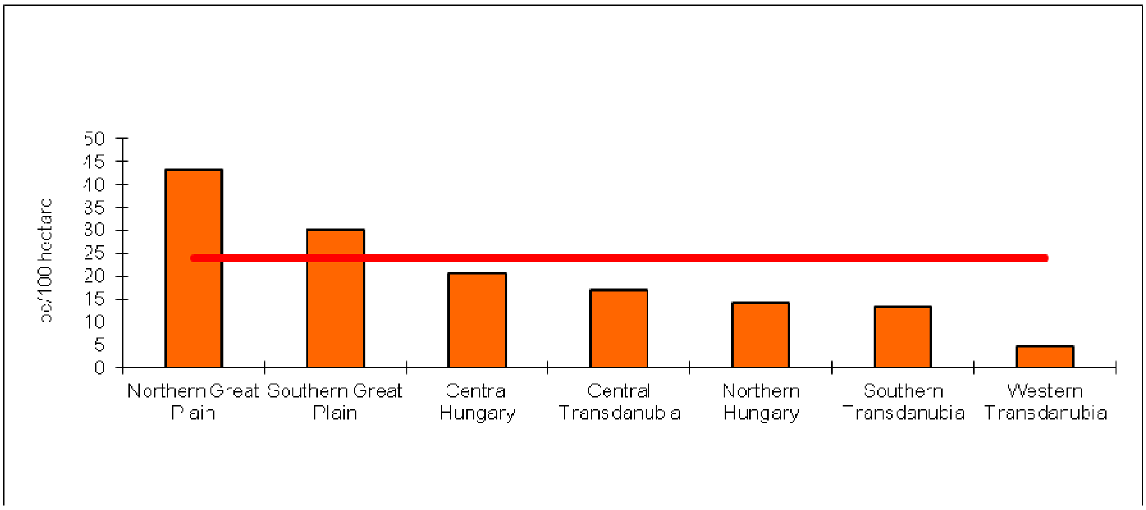

Figure 3. Sheep stock on100 ha of agricultural land (2013)
Source: own calculation

A similarly subtle picture is given when regarding the stock of hen species on 100 hectares of agricultural land. There are only four regions (Central Hungary, Central Transdanubia, the Northern Great Plain and Western Transdanubia) reaching and exceeding the national average, which was 521.7 animals in 2013. The upper extreme value was held by Central Hungary with 790.9 animals, while the lower extreme value by the Southern Transdanubia region with 308.7 animals (*Figure 4*).

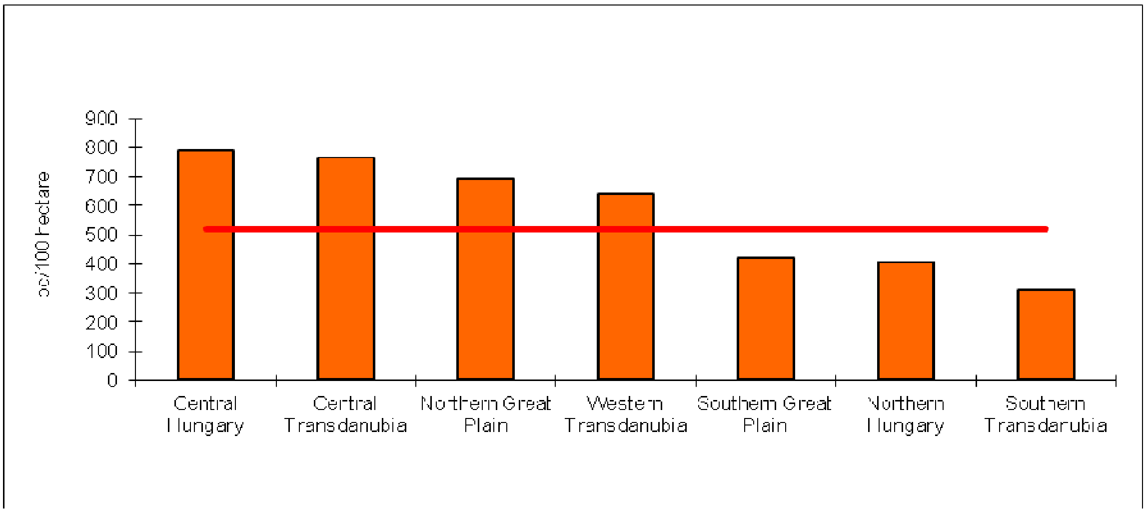

Figure 4. Hen stock on100 ha of agricultural land (2013)
Source: own calculation

The average selling price of some important animal species varied in the investigation period; however it had an increasing tendency. From the base year of 2004 to 2013 the average price of the slaughter cattle increased by 91.6%, the slaughter chicken by 59.6%; the slaughter pig by 52.7%; the slaughter poultry by 50.2%; the slaughter hen by 38.5%; and the price of the slaughter sheep by 31.3% (*Table 2*).

Table 2. The average prices of some important animals (HUF/kg)

Year	Slaughter cattle	Slaughter sheep	Slaughter pig	Slaughter poultry	Slaughter chicken	Slaughter hen
2004	225	576	262	225	183	91
2005	267	626	275	210	170	89
2006	297	637	292	215	170	109
2007	287	591	260	247	198	96
2008	303	594	306	286	232	90
2009	327	653	315	263	215	111
2010	356	666	296	262	214	99
2011	507	771	330	301	250	110
2012	520	784	388	322	271	123
2013	431	756	400	338	292	126

Source: KSH data

The average price of the most important live animals on animal markets and fairs shows a different picture. Compared to the base year (2004) there is an increase in case of all animal species in the investigation. In the investigation period the average price of live animals increased compared to the base year as follows: in case of the live chicken by 74.8%; the young pig by 59.0%, the piglet by 57.8%, the live hen by 52.7% and the slaughter pig by 51.4%

Table 3. The average prices of some live animals on markets and fairs (HUF/kg)

Year	Piglet HUF/pc	Young pig	Slaughter pig	Live chicken	Live hen
2004	7 755	390	311	429	425
2005	10 262	481	348	483	461
2006	9 667	479	351	503	460
2007	7 921	404	338	582	521
2008	8 773	443	355	622	558
2009	13 537	629	422	675	607
2010	11 060	520	396	652	642
2011	9 383	469	382	691	640
2012	12 649	604	497	781	734
2013	12 237	620	471	750	649

Source: KSH data

As the data of *Table 3* indicate, sometimes there is significant difference between the average selling price and the average prices on animal markets and fairs.

Those producers who have small animal stock can sell their products on animal markets and fairs. Producers having larger number of animals must sell their products at the average purchase prices and therefore reckon with considerable losses, since it is sometimes considerably lower than the average prices on animal markets and fairs. No wonder that the number of animals in Hungary has fallen back recently, as the price do not cover the maintenance and feedstuff cost, which means that the average profitability of animal production is decreasing.

CONCLUSIONS

Overall it can be concluded that the position of animal production today is not quite favourable. As a result of the regime change the whole agriculture suffered considerable loss, within that animal production is significantly higher than plant production. After the EU accession the fallback in case of livestock kept going on, except the last two years, the yields however, improved only very little. There are many reasons for that, but perhaps the most important is the lack of the up-to-date machines and equipment as well as that of the buildings to support their function and also that the farms with smaller numbers of animals did not have a possibility to purchase and operate such equipment. Another problem was the lack of own forage-production areas and the unfavourable, sometimes the unpredictable price fluctuation, in addition the professional deficiencies, the lack of large-scale investments, occasionally the fluctuations of the livestock purchase prices and the high costs of meeting the animal welfare and environmental requirements set by the EU. It would be an important task in the future to stop the decline of the livestock and also to increase the number of animals and improve the yields especially in the regions where animal production has a long history and traditions. It is all the more important since the western European countries having more developed agriculture are ahead of us in this respect as well.

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INFLUENCE OF COLOUR NET SHADING ON QUANTITY AND QUALITY OF SWEET PEPPER YIELD

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ABSTRACT
Sweet pepper (*Capsicum annuum* L.) is one of the main cultivated vegetable species in Hungary mostly produced under plastic tunnel by unheated technology. Sweet pepper plants could suffer high temperature and radiation during summer season. However, photoselective-shading nets can provide a new tool for light quality manipulation and support the plant development and fruit quality. The effect of shading colour nets depends on natural light conditions and other environment factors; therefore it is necessary to evaluate the shading technology. Hungarian sweet pepper variety was grown in South-East part of Hungary under plastic tunnels using different colour nets, as white, yellow, green and red, for shading in 2013. Results of trial proved that green colour shading net usually decrease the yield, while yellow and red nets can increase the yield and the fruit quality of Hungarian type sweet pepper. Growers have to care the shading intensity of the net, which should not be higher than 35-40%. Colour shading nets can be placed onto the plastic tunnels just after the planting.

Keywords: photoselective net, shading, *Capsicum annuum* L., fruit quality

INTRODUCTION

Using photoselective net in greenhouse technologies of vegetable crops have been widespread in the Mediterranean area since the early 2000s. SHAHAK and co-workers announced first, that the different coloured nets, as red, yellow, blue, grey and pearl give additional affect to horticulture indoor production (SHAHAK ET AL., 2004). Comparing traditional black shade nets with coloured nets in pepper production in Israel increased productivity and was cleared in total fruit yields. During a three-year trial under red, yellow and pearl nets pepper yield was higher by 115-135% to control thanks to mainly the more fruit number per plant. Authors found that photoselective nets can modify the shading quality both by light dispersion and spectral composition (SHAHAK ET AL. 2008). Measuring the reflectance of sunlight by spectrometer SHAHAK and co-workers (2009) found different spectral composition by each shading net. While the black net transmitted light normal way (300-850 nm), the colour nets exhibited spectral cut-off below 580 nm (red), 510 nm (yellow), or 380 nm (pearl). Similar photon flux densities of different wavelength resulted different rates of leaf photosynthesis, consequently the same amount of PAR supplied by different assimilation light might result in different biomass production (IEPEREN, 2012). Photosynthetic activity and leaf characteristics of sweet pepper grown under different colour nets were studied and cleared, so that photoselective shading can differently affect the leaf parameters and activities (KONG ET AL., 2012). During ten year collaboration between Polysack Plastic Industries Ltd. and Volcani Institute in Israel a new colour net product, ChromatiNet® was developed. Nets were evaluated in wide range of trials in several countries and climate regions. Currently the leading ChromatiNet® product is red net (GANELEVIN, 2008). SANTANA and co-workers (2012) used red and blue photoselective screens from Polysack to investigate productivity of red and yellow fruit colour sweet pepper varieties in Brazil. Screened productions showed more intensive stem growth, less number of leaves and fruits compared with field condition. The fruit losses caused by sunscald were much less (5%), than in control field (35%).

In Hungary KOVÁCS and co-workers (2011) investigated the effect of commercially used green shading net on Hungarian type sweet pepper production under plastic tunnel for the first time. They found significant losses comparing the yield with the results of uncovered plots. Photon flux density and spectral range of four colour Raschel net: white, red, yellow and green (produced by Hungarian firm) were measured on plastic tunnels in 2011-2012. In both years photon flux density was the highest under plastic tunnel covered with additional red net, compared to measures in open field during the summer season, while green shading caused significantly much more light loss (KOVÁCS, 2012). During the same trial spectral reflectance and SPAD values on 'Kapia' type red sweet pepper leaves were also measured. It was found, that the leaves at the same age and position responded to different light quality the highest values at middle of July under red net (LEDÓNÉ ET AL., 2013). Sweet pepper yield quantity and quality have been evaluated in Hungary under plastic tunnel unheated production since 2010 (LEDÓNÉ, 2011).

The aim of this study is to summarise the yield results of Hungarian type sweet pepper produced under plastic tunnels covered by photoselective shading nets in South East part of Hungary in 2013.

MATERIAL AND METHOD

Unheated greenhouse trial was carried out near Hódmezővásárhely, in South East part of Hungary in 2013. Separate plastic tunnels were covered with coloured shading nets having 100 m^2 surfaces by each. White (W), yellow1 (Y1), yellow2 (Y2), green (G), red (R) Raschel nets serving 35% shading intensity provided by the Első Magyar Kenderfonó Ltd. were investigated beside uncovered control tunnel. ChromatiNet®- red (CNR) with 40% shading intensity was additionally used too. Plastic tunnels were covered by shading nets just after the planting. Hungarian type ivory conical pepper variety, Galga (ZKI) was planted into the tunnels on the 18^{th} of April. The grower used traditional pepper growing technology applying mainly natural fertilizer (Orgevit) during the production season and some leaf fertilizers in some cases. Watering system was put over the plants and the water supply was satisfied according to the plants' demand. The average amount of water got out was 364 mm, while the uncovered control had 370 mm and CNR tunnel had 322 mm during the season. Number of hours of sunshine was 25 % more during the season in 2013 than it was the average between 1971-2010 (http1). The harvest period started the last week of July and ended the last week of October, meaning 10 fold harvests. Fruits were measured by weight and by size at harvest time. Based on the results of fruit classification and yield income was calculated using the market information served by DélKerTÉSZ in 2013. The statistical analyses were conducted by Microsoft® Excel 2007 Analysis Toolpak (Microsoft Corp., Redmond, Washington). The data are presented as mean±standard deviation (n=3).

RESULTS

Summarizing the totally harvested sweet pepper fruits there were high differences in the yield among tunnels covered by shading nets of different colour (*Figure 1*). It was clear, that production under green colour net resulted almost 3 kg/m^2 less yield than in Control plot. The highest yield was measured in CNR plot, followed by control and yellow2 tunnels.

Taking notice the share of fuits among different quality (*Figure 2*), CNR net had favourable effect on production of extra fruits of 'Galga' in 2013. Galga produced the most 1st class fruits under the green net. Regarding the amount of fruits suffered by blossom end rot (BER) was not too high, that problem was not considerable in 2013.

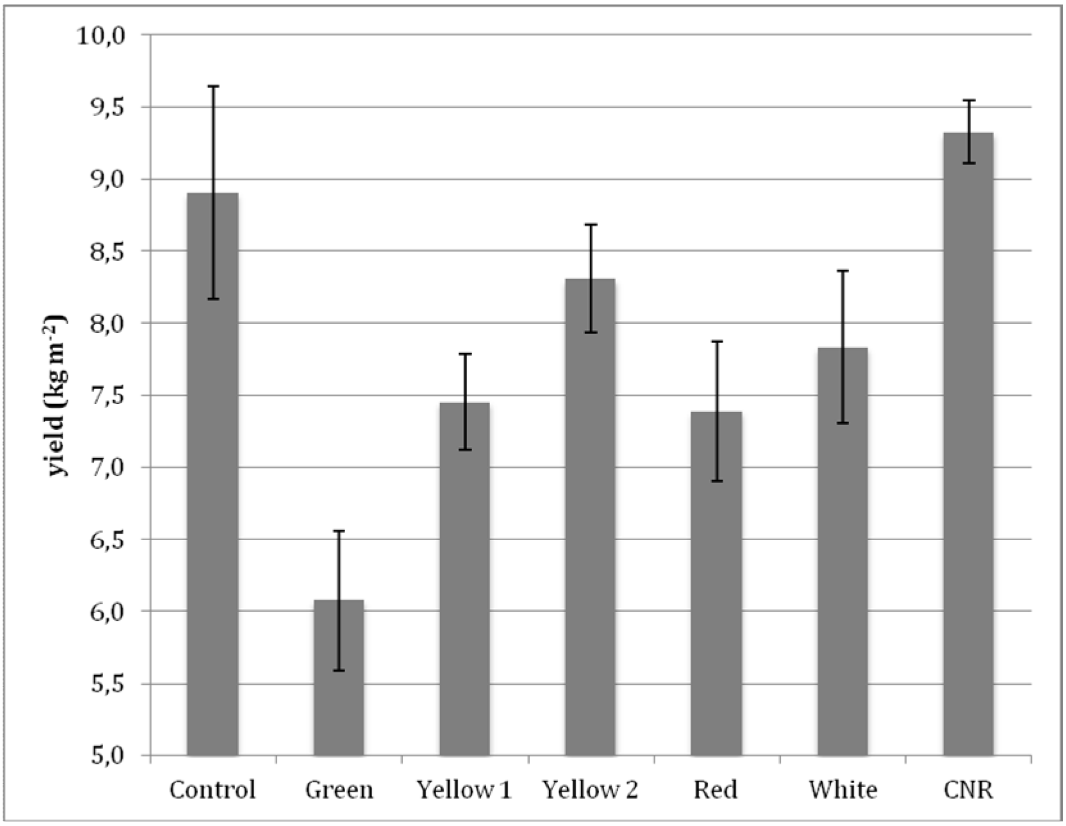

Figure 1. Total yield of sweet pepper varieties by colour shading nets in 2013

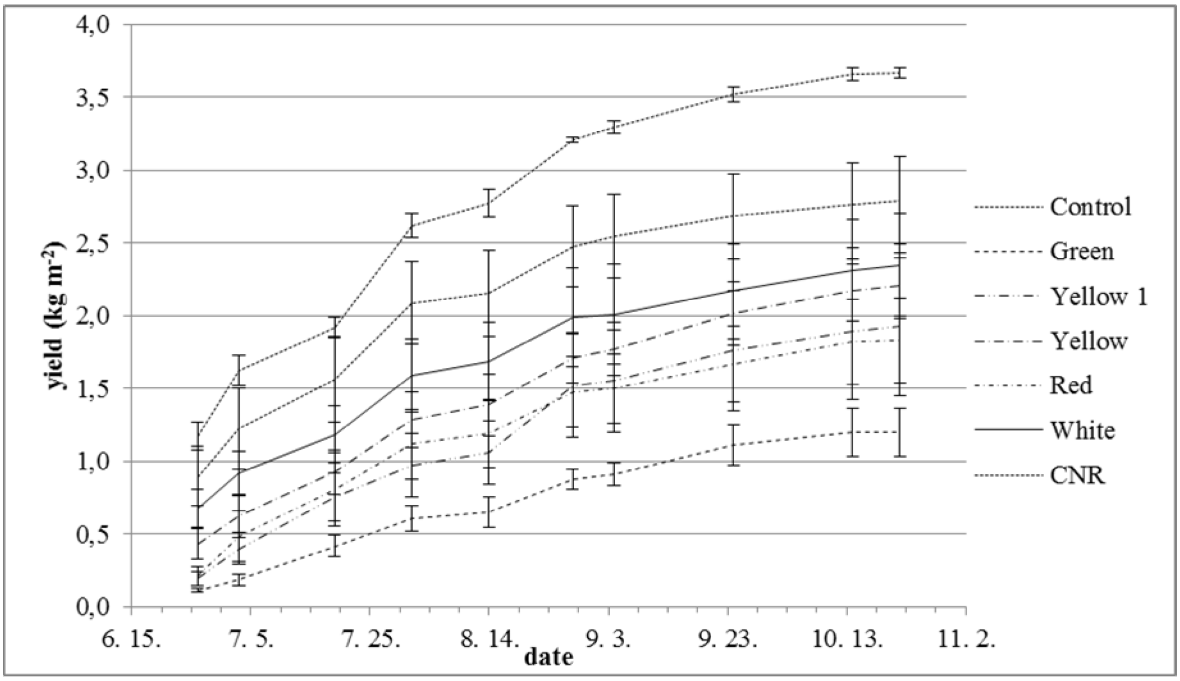

Figure 2. Total amount of extra class fruit quality of sweet pepper variety 'Galga' by colour shading nets produced in 2013

Grower's income was calculated by shading colour nets based on the average pepper price according to the fruit quality gained in each harvest time in 2013 (*Table 1*). In spite of the outstanding fruit quality of pepper grown under yellow, red and CNR nets income was slightly higher compared to of control. The production and income was the least in the case of a tunnel covered with green net (*Figure 3*).

Table 1. Average pepper price used for income calculation

Average pepper price given to grower (source DélKerTÉSZ)

HUF/kg	26 June	03 July	19 July	01 Aug.	14 Aug.	28 Aug.	04 Sept.	24 Sept.	14 Oct.	22 Oct.
Extra	176	178	210	122	90	120	150	182	252	278
1st class	166	170	200	107	81	116	146	178	245	273
2nd class	150	150	132	55	40	93	130	142	202	241

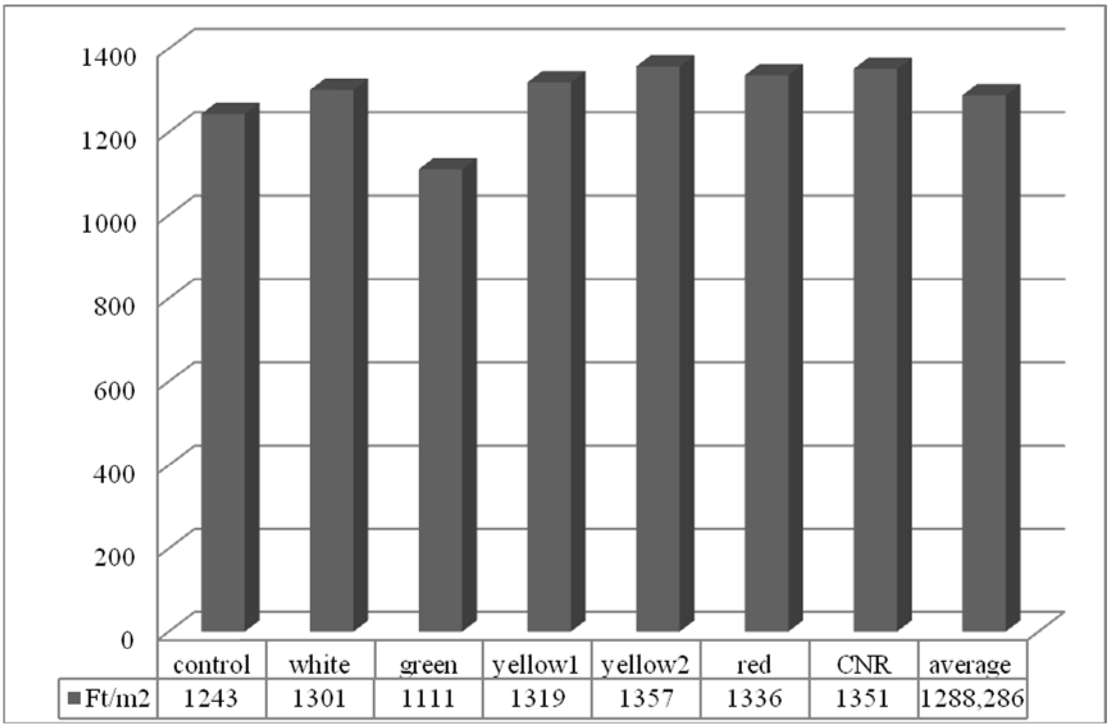

Figure 3. Average income of sweet pepper varieties by colour shading nets produced summer in 2013

CONCLUSIONS

The result of shading trial proved that using green colour shading net for ivory conical forced sweet pepper production will cause significant yield loss in homeland as it was published recently by KOVÁCS ET AL. (2011). The favourable effect of yellow1, yellow2, red and CNR colour shading nets for pepper production could not been proved in equally in this trial. ChromatiNet® Red material having the higher shading intensity caused the higher yield. Numbers of fruits of extra quality had increased under yellow and red nets, as it was published according to FERREIRA ET AL. (2012), who had found increased pepper fruit quality found in size, weight and health of sweet pepper ripening to yellow and red colour under CNR.

As a conclusion, yellow and red colour shading nets can be offered for summer sweet pepper production in Hungary. Growers have to care the shading intensity of the net, which should not be higher than 35-40%. Growers have to check and ask guarantees of UV and colour stability of shading materials before using. Colour shading nets can be placed onto the plastic tunnels just after the planting.

ACKNOWLEDGEMENTS

This study was supported by TÉSZ-ÉSZ Nonprofit Ltd., and co-financed by the TAMOP-4.2.1.B-11/2/KMR-2011-0003 research project governed by Institute of Horticulture, Szent István University.

The author is thankful for the grower, Ferenc Hódi for the precise production.

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THE CO-ADSORPTION OF HYDROGEN AND CARBON DIOXIDE ON CATALYSTS

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ABSTRACT
In the elucidation of the reaction mechanism of a catalytic process it is important to establish the reaction intermediates and their possible role in the reaction. In most cases, however, this is not an easy task as a real reaction intermediate exists only transitorily and in a very low concentration on the catalysts.
The adsorption of CO_2 and the co-adsorption of H_2 + CO_2 on Re supported by Al_2O_3, TiO_2, MgO and SiO_2 have been investigated by FT-IR spectroscopy. The dissociation of CO_2 was not experienced on the Re/Al_2O_3 reduced at 673 K, it occurred, however, on the sample reduced at 1073 K. Addition of H_2 to CO_2, initiated the dissociation on all catalysts as indicated by CO bands at 2022-2053 cm^{-1}. Besides, new spectral features were developed at 1600-1550, 1395 and 1365 cm^{-1} attributed to format species. No bands due to format were detected on Re/SiO_2 and no format was detected following the co-adsorption of CO_2-containing gas mixture on the supporting oxides alone. It was assumed that the format species identified in the surface interactions is located on the support, where it is stabilized. The possible pathways of the occurrence of format complex on the oxides are described.

Keywords: catalyst, support, co-adsorption, $H_2 + CO_2$ reaction, formate

INTRODUCTION

The number of chemical products produced in the world moves about 30,000 nowadays (WEISSERMEL AND ARPE, 1997, ARPE, 2010). But despite the relatively large numbers, they are just made from a few raw materials. The applied coal is obtained almost exclusively from fossil sources - namely, mineral oil, natural gas and hard coal.
The limited resources of coal raised the problem of the exploitation of alternative carbon sources in the early 1970s. Carbon dioxide has always enjoyed great attention because of the nature of synthetic building process used successfully during photosynthesis - which can be considered as the basis of life on Earth as well. In our planet the amount of CO_2 and CO_3^{2-} forms are available several times higher than natural resources in the form of hard coal, oil or natural gas form. In addition, this source is virtually limitless, especially if we consider that since the middle of the 19th century at the beginning of industrialization – the amount of "anthropogenic" CO_2 has multiplied considerably in the atmosphere. (In 1989 the amount of CO_2 emission due to industrial activities was approximately 7×10^9 t (LEITNER, 1995).
Supported Re is a widely used catalyst in several technologically important reactions, such as the reforming of petroleum feedstock (CIAPETTA AND WALLANCE, 1971). Re also exhibits oxygen storage properties in automatic three-way catalysts (TAYLOR ET AL., 1984).

MATERIAL AND METHOD

Supported rhenium was prepared by impregnating the support in aqueous solution of $(NH_4)_2ReO_4 \cdot 4H_2O$ (Merck).The following supports were used: SiO_2 (CAB-O-SiL, and MS

Scintran BHD); Al_2O_3 (Degussa); TiO_2 (Degussa P25) and MgO (DAB). After impregnation, the suspensions were dried in air at 383 K. The dried and pulverized samples were pressed into thin self-supporting wafers (30 mm x 10 mm, ~60 mg/cm^2). Further treatment was applied in situ: it consisted of oxidation at 573 K (100 Torr of O_2 for 30 min), evacuation at 573 K for 30 min, reduction at 673 K and in certain cases at 973-1073 K (100 Torr of H_2 for 60 min), and evacuation at the temperature of reduction for 30 min. Note that the heating of the sample from 573 K to the temperature of reduction was carried out in the presence of hydrogen. As hydrogen can promote the dissociation of CO_2 (see next chapter), it was absolutely necessary to remove completely the hydrogen from the system after the reduction of Re catalyst, otherwise the appearance of CO bands cannot be avoided. The Re content was 5 wt% on all samples.

Infrared spectra were recorded with a Digilab. Div. FTS 155 by Biorad with a wave number accuracy of ±4 cm^{-1} (*Figure 1*). Typically 128 scans were collected. All of the spectra were taken without the use of a scaling factor (f = 1.0).

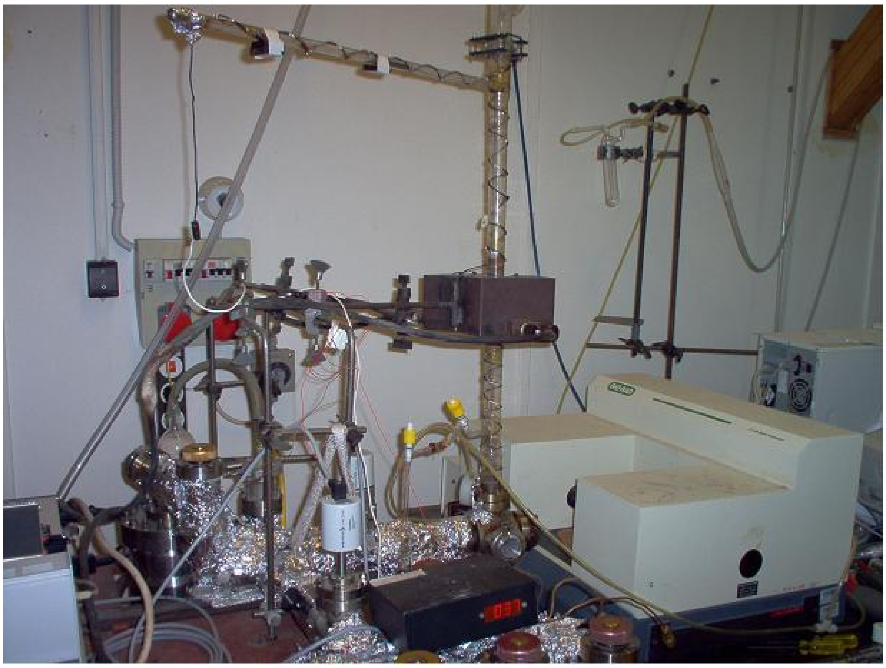

Figure 1. FTIR 155 set

RESULTS

CO_2 adsorption

The spectra obtained after adsorption of CO_2 on Re/Al_2O_3 (T_R = 673 K) are displayed in *Figure 2A*.

Strong bands appeared at 2334, 1646, 1481, 1443 and 1232 cm^{-1}. The intensity of which only slightly decreased after degassing at 300 K. There were no other spectral features following the adsorption at higher temperatures, 373-673 K. Similar experiment on the Re/Al_2O_3 reduced at 1073 K produced a weak absorption band at 2040 cm^{-1}, in addition to the previously observed peaks (*Figure 2B*). For Re/MgO, we measured absorption at ~2334, 1660-1670, 1450, 1543, 1310 and 1220 cm^{-1} at 300 K. Admission of CO_2 on

Re/TiO_2 at 300 K produced bands at 2334, 1667, 1582, 1438, 1378 and 1322 cm^{-1}. The position of which was independent of the temperature in the range of 300-573 K. In the case of Re/SiO_2, we obtained only a band at 2334 cm^{-1}. Evacuation of the cell led to the elimination of the 2334 cm^{-1} feature in all cases, but did not affect the other bands.

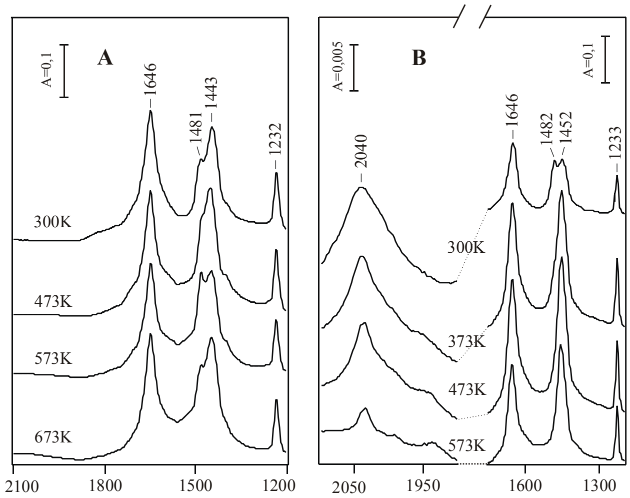

Figure 2. FTIR spectra of Re/Al_2O_3 following the adsorption of CO_2 (50 Torr) at different temperatures for 15 min (T_R = 673 K) Reduction temperature: 673 K (A) and 1073 K (B).

H_2 + CO_2 adsorption

Adding H_2 to CO_2 caused a change in the IR spectra of adsorbed CO_2 registered by Re/Al_2O_3 (T_R = 673 K) (*Figure 3A*).

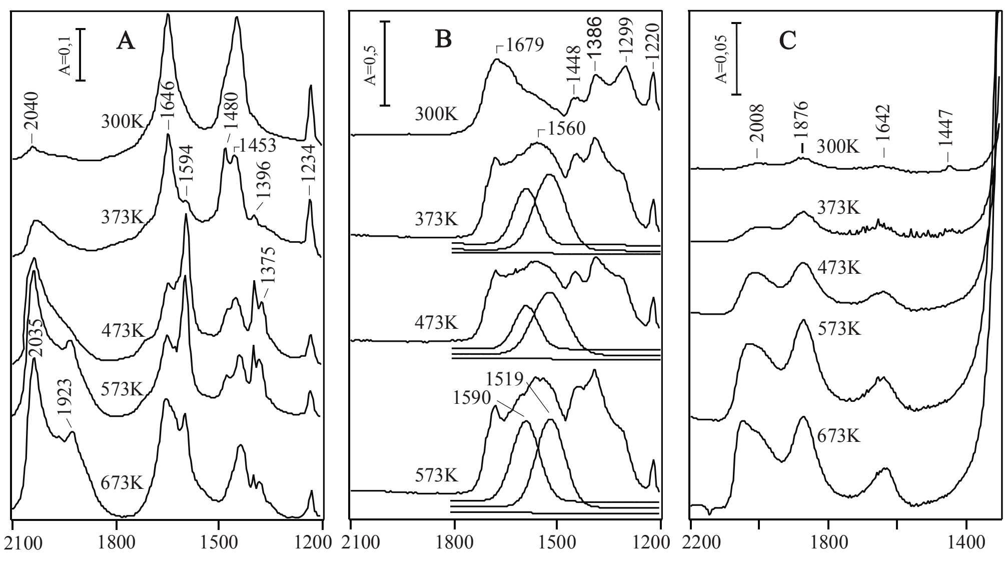

Figure 3. FTIR spectra of Re catalysts following the adsorption of H_2 + CO_2 (1:1) at different temperatures for 15 min (T_R = 673K) Supports: Re/Al_2O_3 (A); Re/MgO (B); Re/SiO_2 (C)

In consequence of the bands of various carbonates detected after CO_2 adsorption, new spectral features appeared at 2040, 1594, 1396 and 1375 cm^{-1}. These new bands were seen even after adsorption at 300 K: their intensities increased in time of the adsorption. Raising the temperature resulted in an enhancement of all new bands, and produced another peak at 1923 cm^{-1}. Note that we also obtained a very weak signal at 2873 cm^{-1}. Degassing the catalyst at 300 K after above experiments caused a slight reduction of the bands in the low frequency region.

Co-adsorption of H_2 + CO_2 on Re/MgO yielded no bands in the CO stretching region. In the low frequency range a broad absorption was observed between 1500 and 1650 cm^{-1} consisting of several components. Deconvolution of this broad peak resulted in at least two bands between 1519 and 1590 cm^{-1} (*Figure 3B*).

In the case of Re/SiO_2 weaker absorption bands appeared at 2008 and 1876 cm^{-1} at 300 K. An increase in the temperature caused an intensification and a slight shift of these bands (*Figure 3C*).

It is important to note that no new spectral features developed in the low frequency region. In certain cases a band was seen at ~1620 cm^{-1}, which is very likely due to the adsorbed H_2O.

Compared the production of new spectral features, Re/TiO_2 was more active than Re/Al_2O_3. Strong absorption bands appeared even at room temperature. Their positions were at 2053, 2010 and 1976 cm^{-1} (*Figure 4*). An increase in the temperature caused a shift of the 2053 cm^{-1} band first to 2043 and then 2037 cm^{-1}, the disappearance of the bands at 2010 and 1976 cm^{-1}, and the formation of new band at 1944 cm^{-1}. In the low frequency region a band at 1583 cm^{-1} formed after CO_2 adsorption is broadened, particularly at 373-473 K. It clearly consisted of two components absorbing at 1585 and 1547-1550 cm^{-1}. At the same time another weak peak developed at 1360 cm^{-1}. It is an important observation that the co-adsorption of H_2 + CO_2 mixture on Re-free oxides did not produce the 1590-1595 and 1360-1395 cm^{-1} spectral features under similar conditions up to 573 K.

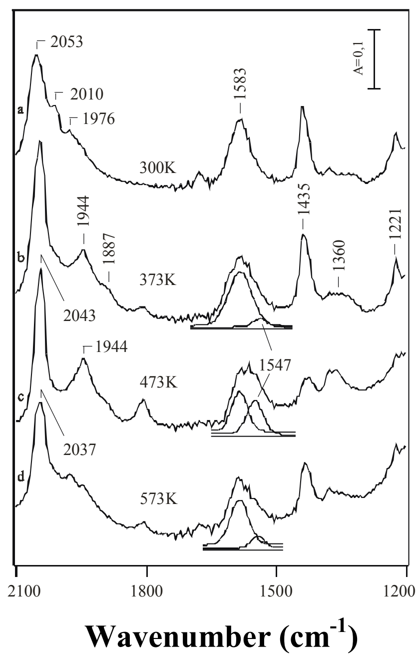

Figure 4. FTIR spectra of Re/TiO_2 following the adsorption of H_2 + CO_2 (1:1) at different temperatures for 15 min (T_R=673 K)

CONCLUSIONS

The adsorption of CO_2 on Re supported by Al_2O_3, TiO_2, MgO and SiO_2 have been investigated by FT-IR spectroscopy. The dissociation of CO_2 was not experienced on the Re/Al_2O_3 reduced at 673 K, it occurred, however, on the sample reduced at 1073 K.
No format was detected following the co-adsorption of CO_2-containing gas mixture on the supporting oxides alone. It was assumed that the format species identified in the surface interactions is located on the support, where it is stabilized.
Addition of H_2 to CO_2, initiated the dissociation on all catalysts as indicated by CO bands at 2022 – 2053 cm^{-1}. Besides, new spectral features were developed at 1600 – 1550, 1395 and 1365 cm^{-1} attributed to format species. This assumption was confirmed by the adsorption of HCOOH vapor on these solids.

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MOTIVATIONS AND THE EFFECTS OF VALUES RELATING TO THE CONSUMPTION OF BIO FOODS

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ABSTRACT
The aim of the study is to examine the psychological and demographic factors influencing the consumption of bio foods. The motivations for consuming bio foods and the effect of values were investigated among students. The respondents consider bio foods as healthier, of better quality, more environmental conscious but more expensive than traditional foods. All in all the respondents have positive attitudes relating to bio foods. Consuming bio foods just for fashion and its prestige is not typical among the consumers. The blocking factors of consumption include the price of bio foods and disbelief in the production way. On the basis of the Rokeach Value Survey traditional values such as self-respect, sense of accomplishment and inner harmony are the most important factors for the respondents. Respondents living in independent households with children find the comfortable, exciting and joyful life and even the social recognition important. As in the values of the respondents family has an outstanding role, this could be utilized during marketing communications.

Keywords: bio food, motivation, value, terminal value

INTRODUCTION

Nowadays stimulating the consumption of bio foods is a highlighted topic from the aspects of health and environment consciousness (TÓTH, 2009). Only a narrow social layer consumes these kinds of foodstuffs regularly, but their consumption reflects an increasing tendency (GYARMATI, 2004). The group of young consumers may play a relevant role in the future as they might have heard about bio foods since their early childhood. It is obvious that it is easier to convince them as their value is still under formation. The contribution of the youth is very important regarding the future, their consumption will influence their environment in a longer term, and they are responsible for the sustainability.

This study shows several results of a greater research. The whole research investigates the motivations, attitudes, beliefs relating to bio foods, environment and health consciousness and willingness for innovation among students, supplementing with value research. This present study focuses on the consumption of bio foods of the students asked in the terms of value.

The Consumption Tendency of Bio Foods

The ratio of the territory of controlled ecological farming is 2% of the agricultural land in Hungary, which equals with 119 thousand hectares (NVS, 2012; ROSZIK, 2013). Favourable tendency may be expected in the following years, as in the Ecological Farming Program in the National Rural Strategy (NVS) for the period of 2012 to 2020, the planned size of ecological farming is 350 thousand hectares (NVS, 2012). The ratio of the produced bio foods is growing higher, but more than 80% of it is exported. Its reason is the narrow consuming layer (TÓTH, 2009). The online survey of NIELSEN MARKET RESEARCH COMPANY (2010) on purchasing bio foods is the biggest research of such a kind in the world. They carried out a survey in 54 countries, even in Hungary. They concluded that every eighth Hungarian consumer (13%) buys bio foods, while this ratio in Europe is 35%. According to their results 84% of the asked Hungarian bio food consumers think that bio foods are healthier, 70% think that they avoid pesticides and other poisons by choosing bio foods. More than 91% of the purchasers are modified by the price when buying. One third of the respondents do not buy bio foods; the majority of those who buy bio foods, buy them monthly and weekly (TÓTH, 2009). On the basis of data of a previous examination 35% of the respondents consume bio foods at least on a monthly basis, the regular consumers take up only 20% of all of the respondents (LENGYEL, 2008). Regarding the consumption of bio foods it is relevant that a positive correlation was revealed between the attitudes towards the environment and the environmental conscious behavior (CORRALIZA AND BERENGUER, 2000; COTTRELL, 2003).

Examining the Major Factors Influencing the Consuming Behavior

The consumer behavior is influenced by cultural and social factors as well as personal and psychological features (KOTLER, 2001; KOTLER AND KELLER, 2006). The culture basically determines people's manners, demand and behavior. The values express the fact that what is considered as important, good or bad by a given culture.

In connection with social factors on the basis of HORVÁTH AND BODNÁR (2009)'s researches regarding rural areas the employment and profit condition, the educational level of the rural population are lagged behind the national average. Furthermore there is a significant setback relating to the ratio of those who graduated from university or college or high school. Due to the lack of proper psychological and demographical conditions there are few opportunities for developing creativity, thus choosing a more health and environmental conscious life and consuming bio foods.

Personal feature may base a further motivating factor during consumption. In this case the age and family life cycle are focused on as there are life periods when consuming bio foods may come forward for the sake of health safety. From the aspect of bio food consumption the fact is important that the consumer lives with parents in one household or lives in a separate household, as this may affect the influence on making decisions relating to the household. It is reasonable to create a third category as well, which is a household being independent from parents, but not fully independent from the family house (MÁDER, 2009; VASKOVICS, 2000). The young adults in the postadolescent period (below 30 years of age) are not fully independent from the family house (MÁDER, 2009).

One of the most determinant elements of the consumers' behavior is the individual value. The values are permanent conceptions or convictions and relate to the desired behaving way. The values prevail in different situations and have a leading role in the evaluation of the happenings. On the other hand the values are organized according to a relative importance (HOFMEISTER-TÓTH ET AL., 2006). Values have motivational tasks as well, as they stimulate to reach objectives considered as being appropriate by us. ROKEACH (1968) classifies two sets of values, such as the terminal values and the instrumental values. The terminal values are individual or social-centered ones. The instrumental values may be classified as moral or competence values. People have much less terminal values than instrumental values. The introduced classification of values was taken into consideration during our investigation.

Objectives

The objective of the study is to examine the previously mentioned factors influencing the consumption of bio foods. The investigation of cultural, psychological and personal factors are detailed, furthermore, motivations for consuming bio foods, attitudes and terminal values are examined. Regarding the reason for consuming bio foods we suppose a difference between students having a joint household with parents and students being independent from parents but not having independent households. It is expected that the general attitudes on bio foods of students having children and independent households are different compared to students under other conditions of life. Our objective relating to the value is the following: terminal value examination is carried out, where the differences are looked for in case of students having children and independent households, student with joint households with the parents and students having independent households.

MATERIAL AND METHOD

Data gathering happened with the help of an online survey. The questionnaire used for the whole research starts with demographic questions, then deals with consuming habits of bio foods, it contains the "New Environmental Paradigm" scale as well and the terminal values determined by Rokeach. Only parts are detailed, which are dealt with in the present study.
Demographic questions relate to sex, age, education, circumstances, number of children of the interviewees and the age of children. The second part of the questionnaire is in connection with attitudes, consuming habits and beliefs relating to bio foods. The third part is the "New Environmental Paradigm" (NEP) scale. The fourth component of the survey contains the terminal values determined by Rokeach. The task of the interviewees was to grade these values by the help of a seven graded scale accordingly to what rate they are important for them. Eighteen terminal values are being evaluated describing the goals that a person wishes to achieve during the lifetime and considers them as being appropriate.
The number of elements in the survey was 312 persons. The respondents of the questionnaire were all students at the University of Debrecen in the Faculty of Arts and Humanities and in the Faculty of Applied Economics and Rural Development. 217 of them were full-time students, 94 students were correspondence (part-time) students (2 of them did not respond). 253 women and 59 men (1 man did not respond) answered to the questions. The youngest respondent was 18 years old, while the oldest answerer was 53 years old. The age does not follow a normal distribution (Kolmogorov-Szmirnov test: $D=0.233$, $p<0.001$), its median is 22. Regarding their circumstances 162 persons have joint households with parents, 73 persons have households being independent from parents and 77 persons (1 person did not answer) have households being partly independent from the family house. Relating to the number of children it turned out that 278 respondents do not have any children, 11 persons have one child, 21 answerers have tow children, 2 persons have three children and 1 respondent has four children.

RESULTS

Attitudes and Consuming Habits Relating to Bio Foods

Surveying the attitudes of the respondents in connection with bio foods happened comparing them to traditional foods in parallel. The results of the examinations strengthen the relevance literature data (FÜREDINÉ KOVÁCS ET AL., 2006; TÓTH, 2009) by which the respondents find bio food healthier, having better quality, more environmental friendly and tastier than conventional foods. Even the present research reflects the fact (similarly to the researches of GYARMATI, 2004; SZENTE, 2006) that the interviewees considered bio foods as more expensive. The respondents have positive attitudes relating to bio foods.
The questionnaire dealt with even the causes and motivations of consuming bio foods. The respondents evaluated the potential answers by the help of a scale ranging from 1 to 7 on

the basis that to what ratio they were typical. As the variable does not reflect a normal distribution, the median is used as an average and the results are introduced item by item (*Figure 1*). The most important motivations for consuming bio foods are saving the health, avoiding harmful effects of traditional foods and saving the environment.

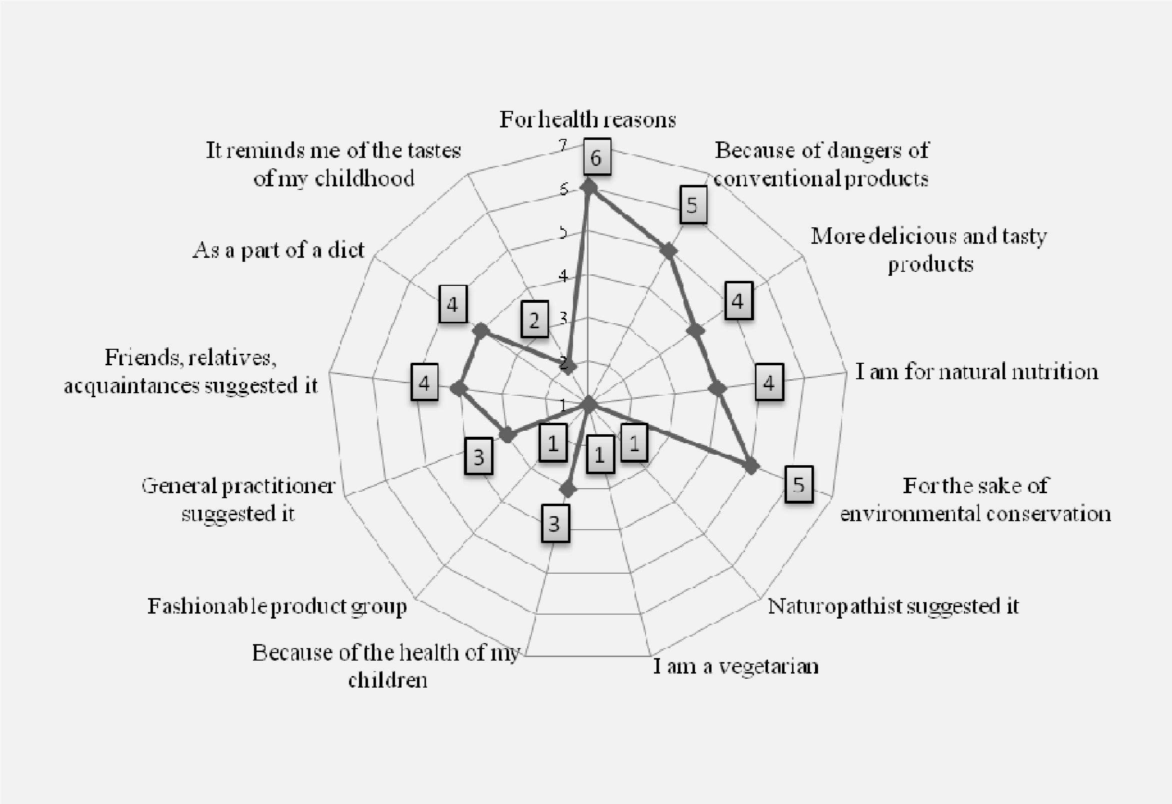

Figure 1. The Medians of Motivations Relating to Consuming Bio Foods
Source: Own research, 2013

It must be highlighted that consuming bio foods just for fashion and its prestige is not typical (M=1) on the basis of the self-assessment. It seems that other factors motivate the consumption of bio foods. In case of respondents having children and independent household the motivating factor called "because of the health of my children" results a significant difference (W=7236, p-<=0,005), respondents having children and independent households are more motivated in purchasing bio foods for the sake of the health of their children (M = 4) than those belonging to other categories (M=2 on the basis of Mann-Whitney test). The biggest blocking factor of the consumption is the price of the bio foods (M=6), a moderate blocking factor is the fact that respondents do not believe in the production way (M=4) and there are few bio shops operating (M=4).

Investigations in Connection With Terminal Values
The medians of the 18 terminal values determined by Rokeach are illustrated in *Figure 2*. We concluded that to the respondents' mind all of the given terminal values are more important than a moderate evaluation. On the basis of the value survey it turned out that traditional values (family security, happiness, friendship) are the most important values for the answerers.

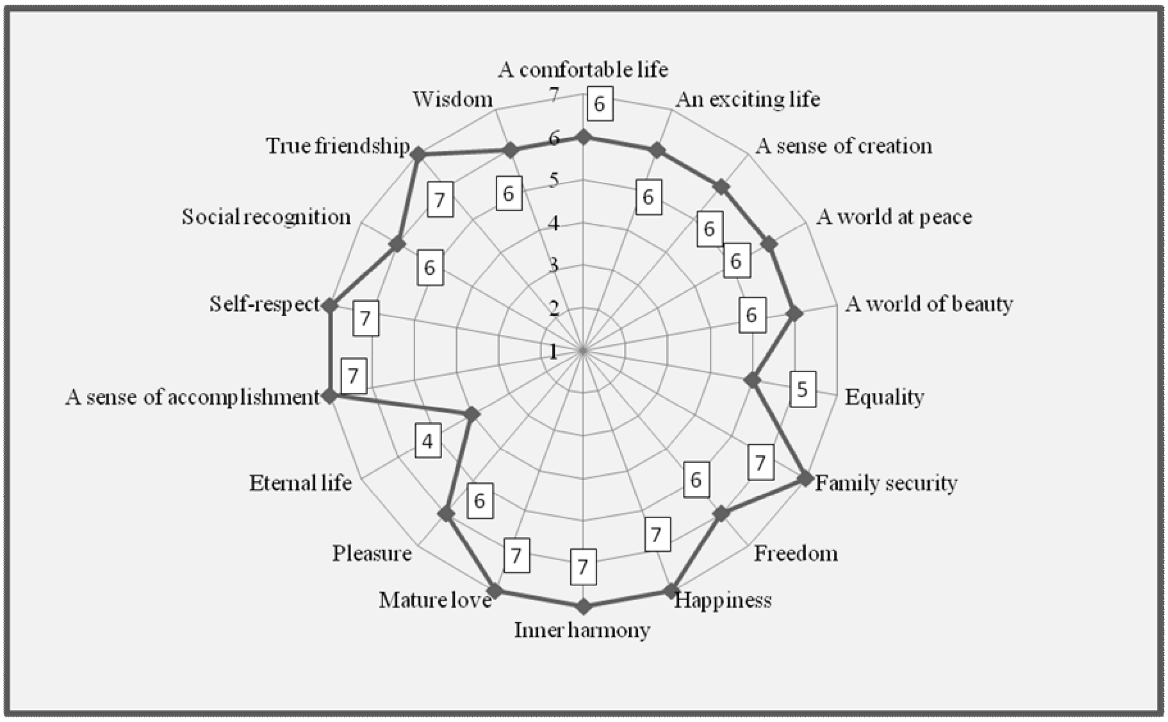

Figure 2. The Medians of Terminal Values of the Respondents
Source: Own research, 2013

These pieces of information may be utilized for increasing the consumption of bio foods in a way that during the marketing communication the outstanding relevance of the family life should be taken into consideration. The long-term advantageous effects of bio foods may be demonstrated in this context as well, as they understand that the consumption of bio foods has a highlighted significance for the sake of the health of the family.
In the sample there are 33 persons who have independent households and children and 280 persons constitute the other category. The two categories were compared by Mann-Whitney test from the aspects of terminal values. Utilizing Rokeach survey we suppose that students having children and independent households, students having joint households with parents and students having independent households from parents prefer other terminal values.
Although those who live in independent households with children (M=5) find the comfortable life important but not such a degree than respondents belonging to other categories (M=6) (Mann-Whitney test: W=5853, p<=0,009). The exciting life is more important for persons living in jointly households with parents and those who are partly independent from parents (M=6) than for answerers in the other group (M=5, Mann-Whitney test: W=6369, p<=0,001). A world at peace (no war) is more important for persons living in independent households with children (M=7) regardless the fact that those belonging to the other category find it important as well (M=6). Regarding pleasure (funny life) differences were revealed in terms of the circumstances (Mann-Whitney test: W=6626, p<=0,001). The respondents of every category judged it important but it is a more important factor for those living together with parents and those who have partly independent households (M=7) than in case of persons running separate households (M=5). The social recognition (respect, admiration) (Mann-Whitney test: W=5609,5, p

<=0,038) is also important to respondents running separate households with children (M=5), though it is more relevant for those belonging to the other category (M=6).
The gained results may help in motivating individuals for consuming bio foods as healthy diet motivates the already existing consumers, thus it is worth aiming at increasing the consumption from another aspect. For students living together with parents and those having partly independent households from parents campaigns would be motivating factors which would connect bio food consumption to exciting, active and funny life. The social recognition, the facts of respect and admiration should be connected to the consumption of bio foods for those having separate households with children.

CONCLUSIONS

The topic of this study was to examine the psychological and demographic factors influencing the consumption of bio foods through a survey. The questionnaire dealt with the motivations and attitudes relating to bio food consumption and even the values of the respondents were examined. During the survey altogether 312 students were asked at the University of Debrecen. The respondents considered bio foods as healthier, of better quality, more environmental conscious and tastier than traditional foods. The respondents have positive attitudes relating to bio foods. It must be highlighted that consuming bio foods just for fashion and its prestige is not typical. The biggest blocking factor of the consumption is the price of the bio foods, a moderate blocking factor is the fact that respondents do not believe in the production way and there are few bio shops operating. On the basis of the value survey traditional values such as self-respect, sense of accomplishment and inner harmony are the most important factors for the respondents. Although those who live in independent households with children find the comfortable, exciting and joyful life and even the social recognition important but not such a degree than respondents living together with parents or living separately but being partly independent from them. As in the values of the respondents family has an outstanding role, this could be utilized during the marketing communication and emphasized that by consuming bio foods they can provide a healthier life for their family.

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Review on Agriculture and Rural Development 2014. vol. 3 (2) ISSN 2063-4803

EXAMINATION OF LOCAL ECONOMIC DEVELOPMENT AND POSSIBILITIES OF ARRANGEMENT FOR SELF-SUFFICIENCY

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ABSTRACT
Local economic development (LED) is essential for realizing self-sufficiency and its continuous operation. Ecovillages are human-scale full-featured settlements of village- or city-typed, try to form a model for sustainable life form. Establishing ecovillages and similar initiatives may be the result of such an economic development conception. Basing on the example of Rozsály situated in the lagged behind Fehérgyarmat subregion the factors of LED, environmental consciousness and arrangement for self-sufficiency are detailed in this study. Regarding the four dimensions of ecovillages, Rozsály meets fully the requirement of the social/community and cultural/spiritual dimensions. The economic dimension is also developed, though there are several fields needed to be developed. Due to the ecological dimension Rozsály cannot be considered as an ecovillage, the denomination 'ecovillage initiative' is more appropriate. The village, however, started a good direction in order to break out from the problems typical to the area.

Keywords: local economic development, eco-village, sustainability, Rozsály

INTRODUCTION

In our study the chances of breakout from the aspects of local economic development (LED), environmental consciousness and arrangement for self-sufficiency are detailed by analyzing a given settlement. The place of our investigation is Rozsály located in the lagged behind Fehérgyarmat subregion in Szabolcs-Szatmár-Bereg county. The aim and the endeavor of the community are exemplary for the sake of maintenance not only in this region but even nationwide, dispite of the fact that migration and continuous decrease in population are typical to the other settlements in the subregion. The causes of its success, however, are not clear. According to certain sources, the success may be thanked to LED; others think that Rozsály may belong to ecovillages. It is indisputable that the realization of public employment and social economy is very successful in Rozsály. Our objectives are to reveal the concrete results of local economic development examining the social and economic conditions of the settlement relating to environmental consciousness; furthermore to investigate the arrangement for self-sufficiency in Rozsály along the four dimensions of ecovillages.

MATERIAL AND METHOD

Our results were strengthened by secondary and primary data gathering. The secondary data were collected from the local government of Rozsály, Hungarian Central Statistical Office, and Labour Centre of Northern Plain Region. The access of the majority of the data needed pre-arrangement and personal meeting. During primary data gathering qualitative research was carried out. The structured critical interview was chosen based on previously set questions in order to understand the cause and effect relationships better and to overview the processes in the community. We made critical interviews with the mayor of the settlement and the president of the Welfare Foundation in Rozsály in 2012. The aim of the critical interviews was to analyze the characteristics of the self-sufficient community, the factors of self-sufficiency, and to reveal the factors for successfully carrying out local economic development and arrangement for self-sufficiency for other communities having similar conditions.

Basing the Chosen Topic by Reviewing the Most Relevant Literature
In this chapter the most important literature sources are viewed and analyzed relating to local economic development and eco-villages.
Local economic development is essential for realizing self-sufficiency and its continuous operation. LED is a consciously directed intervention, which strives to improve the local economy and its processes and to make the economy sustainable (MEZEI, 2006). The aim of LED is to strengthen the economic basis of a local area to increase its economic future and the living standard for all. It is considered as a process by which population, enterprises and non-governmental sectors work together to establish better conditions for economic growth and employment generation (SWINBURN ET AL., 2006). Other purpose is to improve the productivity and competitiveness of local businesses, entrepreneurs and workers and to improve the quality of life of local population (BAJMÓCY, 2011). Each settlement has unique local conditions that either increase or reduce the chance for local economic development, and these conditions define the relative advantage of a community in its ability to attract, generate and retain investment (SWINBURN ET AL., 2006). Several methods and assets of LED are familiar such as community development, use of local money, introduction of money substituting tools, utilization of local renewable energy sources, and operation of social economy. The most effective way, however, is to use these methods in a jointly way.
The history of ecovillages dates back to 40-45 years. The idea to establish such villages arose in the 1970'ies, and then similar initiatives appeared in several parts of the world independently from each other. Global Ecovillage Network (GEN) collects ecovillages and such initiatives. On the basis of GEN's definition ecovillages are communities in cities or in rural areas where local population strives to get the every-day things from the surrounding environment in a way that these activities should not be harmful to the environment (I1). Following the international examples, Hungarian Living Village Network was founded in Hungary (I2). The ecovillage movement appeared in Hungary at the beginning of the 1990'ies, since then there have been several domestic ecovillages and initiatives operating.
The operation of ecovillages may be successful by realizing their four dimensions such as social/community, cultural/spiritual, ecological and economic dimension and by basing on any combination of them.

- ✓ On the basis of social/community dimension ecovillages are communities where population is responsible for those living around ensuring strong community cohesion (I3).
- ✓ Cultural/spiritual dimension includes saving the Earth and every living creature, manifestation of cultural and artistic expression and spiritual diversity (I3).
- ✓ From the aspect of ecological dimension ecovillages strongly belong to the surrounding natural environment, which ensures daily needs, food, clothes, shelter for them. Increasing proportion of the necessary foodstuffs is produced on the territory of the community by realizing ecological farming. Buildings and houses are built from local building materials focusing on passive houses and renewable energy sources. This way of life takes care of biodiversity as well (I3). Ecovillages strive to save the connection between people and nature as well as the universe (BATES, 2003).

- ✓ Regarding the economic dimension ecovillages are independent standing on their own feet and comparing to other local economies self-sufficiency is typical to them (BARTHA ET AL., 2011).

When examining the connections between ecovillages and local economic development the opinion arose by which the creation of ecovillages may be the result of an economic development conception. Several of the assets of local economic development appear in case of ecovillages as well (BANA, 2012), such as community development, development of local products, traditional economy, self-helping system, producing local alternative energy, creating social farms. The connections of the factors of ecovillages and local economic development were investigated in Rozsály.

RESULTS

In this chapter we detail the results relating to our research in Rozsály concerning especially the social and economic conditions of the village focusing on environmental consciousness and the factors for self-sufficiency and community cohesion. Finally Rozsály is investigated according to the four dimensions of ecovillages.

Location and social conditions of Rozsály

Rozsály is situated in the Northeastern part of Hungary, at the Eastern part of Szabolcs-Szatmár-Bereg county, in Fehérgyarmat subregion, close to the Romanian and Ukraine border. Its distance from Nyiregyháza is 96 kilometres.

Rozsály has a population of 820, its territory is 15 square kilometres, the population density is 55 persons per square kilometres. On the basis of its peripheral location and low population density, Rozsály may be considered as a real rural community. The biggest employer in the community is local government. The well-known Start labour program was firstly introduced in Fehárgyarmat subregion, and Rozsály is one of the most successful operators of the program nationwide.

A kindergarten and a primary school function in the settlement, which are maintained by the local government. The educational program of these institutes focuses outstandingly on evolving ecological view in children.

A local foundation has been operating the local TV, which helps strengthening community cohesion and information spreading among people. There has been a traditional folk group in Rozsály since 2009 functioning from different donations and subsidies. Its members sing folk songs and perform traditional folk dances bringing back the ancient's culture. The local foundation regularly organizes the Meeting of Ages, where young and old generations meet to hold joint programs such as cooking jam, baking bread. The aim is to vivify folk traditions for the youth, which only the elderly generation remember. This is the event which is used for strengthening even the civil relationships of the settlement.

Minority in Rozsály constitutes 26% of the population. The cooperation with the local gypsies has been exemplary since the change of the regime. Equality in the social land program has been always highlighted, thus gipsy families are continuously involved in the related activities.

There are several foundations and organizations in Rozsály, which helps in improving the social condition, such as the Local Foundation of Welfare for Rozsály, the Centre of Social Basic Service, Child Welfare and Family Support Service, Caring Centre and Social Bath.

Economic Conditions of Rozsály

The major source of livelihood for the population is agriculture. 180 farmers and primary producers work in the community. The land quality is relatively weak. The ratio of agricultural land is extremely high, from which the proportion of arable land is outstanding. Production of cereals is typical to these areas. Wheat, corn, winter barley are dominant in the crop structure. Besides cereals, the area of orchards, such as apple and sour cherry is high in the village.

The local government's aim was to establish and realize self-sufficiency in the village by organizing a social farm. In 1992 the co-operative was ceased and 85 hectares remained in the property of the local-government. Self-sufficiency was the result of a planned activity. The management of the village firstly surveyed what and how much was necessary, and it was followed by the production. The already mentioned local foundation was created in 1993 by the local government. This foundation rents the majority of the land from the local government, which joined the social land program in 1993. Discounted rental service is available for the population living on agriculture. The machines are able to work in smaller sized parcels as well. The seed is for free for those in need. Within the social land program the animal keepers are also helped in storing and grinding the fodder.

Local government deals with animal husbandry as well. Earlier pigs were taken to families in the frame of the social farm, but this method did not work. Thus today local government keeps pigs of 60 to 70, which are slaughtered in the slaughterhouse owned by the local government. The maintenance of this slaughterhouse is extremely relevant as the next closest one locates in Fehérgyarmat. The produced products of plant and animal origin are mainly utilized by public catering; furthermore they are sold in the local social shop to local population at lower prices.

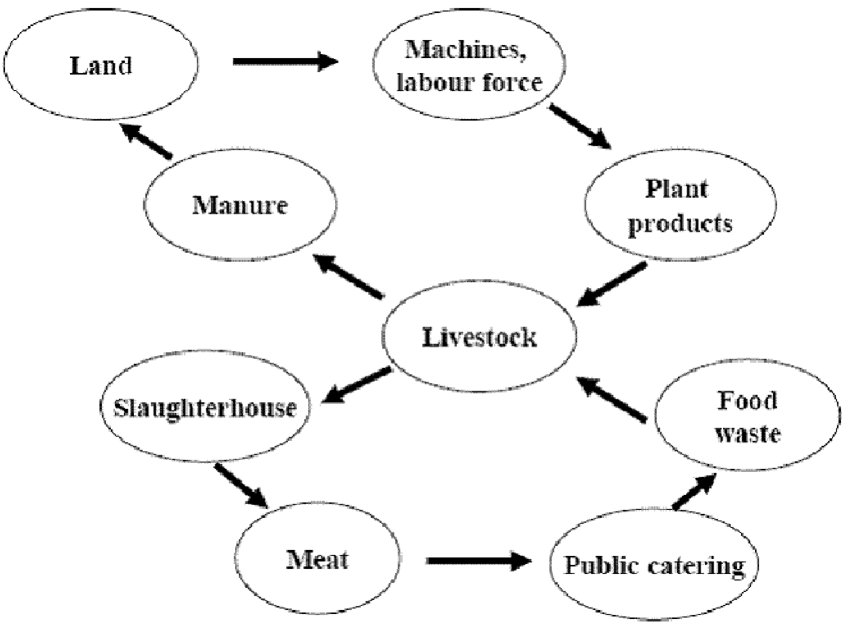

Figure 1. The cyclic progress of the social economy in Rozsály
Source: Local Government in Rozsály

There is a cyclic progress in Rozsály, which basis is the land (BANA, 2012). The cyclic progress contains the following elements (*Figure 1*): the local government owns the land, while the necessary machines and labour force are available in the village. The plant products are used in public catering, while fodders are fed with pigs. The manure is recycled into the soil ensuring the nutrient supply. Pork from the slaughterhouse is utilized in public catering and is sold to the population at a lower price. The food wastes are fed with the pigs getting into the cyclic process. This process is considered as a whole cycle from the aspect of the food, purchasing external resources and services is not necessary, by this self-sufficiency in Rozsály gets to a higher level.

The excess dependant on energy caused problems in the village, but local government started to solve this in a way that the cyclic process could become more complete. In order to prevent the illegal wood cutting because of the expensive gas local government ensures the household maintenance subsidy in the form of firewood. To reduce the energy dependence and to guarantee jobs for the population the village strives to utilize animal and human power instead of machines. In case of heating the building of the primary school is heated with by-products produced in the social farm, which may cause a reduction of 70% in heating costs. In order to produce sufficient quantity of raw material, an energy plantation of 7 hectares was established. Harvest happens by manpower, providing jobs for the local.

Industry does not play an important role in the economic life of Rozsály. Within the social farm concrete columns and paving stones are produced by public workers for own utilization and for sale. Regarding food industry production and process of local products are outstanding. Apple jam, plum jam, sour cherry jam and palinka are local products of the community. The operation of the local slaughterhouse is also an activity relating to the industry serving not commercial but social purposes. In connection with traditional jobs, the participation of gipsy population is relevant, as many of them deal with basketwork.

The commercial services evolved harmonizing with the requirements of the population. 13 commercial units are available in the village. The social shop has been operated by the Welfare Foundation of Rozsály since 2011. The goods of local farmers have priority when filling the stock of the shop. Farmers do not pay extra costs for the shop for selling their products. The shop sells these products, for example jam, honey, vegetable, fruit, handcraft products, to the population without price margin. Thank to the shop it is easier for the farmers to sell their products and it is cheaper for local people to purchase foodstuffs.

Tourism is not typical to Rozsály, though in several countries sustainability and tourism are connected to ensure the spread of sustainable way of life (HORVÁTH, 2009). Presently a rural cater house is under development. The owner and the would-be operator is the local government. The touristic attractions of the village involve the Greek-Catholic church ornamented with rare icons, the Reformed church and traditional folk house, the monument of János Maróthy in the Béke park and probably the biggest coat of arms of Kossuth in Hungary (I4).

The water supply is fully solved in the settlement. The public sewage network is 8,5 kilometer long, which means that sewage network of 900 meter goes with one kilometer water pipe. Waste management is organized in Rozsály, just like the selective waste collection. The electricity is present almost in every household (99%). The ratio of gas supply is 72% in the settlement. Approximately 30% of the households heat with gas, 40% carry out mixed heating, the remaining part of the families heat with wood. There is a tendency in Rozsály that is more and more households convert into wood heating.

Investigation of Rozsály regarding the four dimensions of ecovillages

The **social/community dimension** of ecovillages realizes fully in Rozsály. Local government focuses on supporting and helping families in socially lagged behind situation and an extra foundation was established with this purposes. The residents form a real community.

The **cultural/spiritual dimension** appears in the life of the village as well. The residents work together for their development, save their traditions together and jointly organize programs,

events and celebrate memorable holidays. The local population understood the fact that the elements of life on Earth and the place of residents for living belong together, they depend on each other, and people realized that the land is the basis for everything for existence.
The realization of **ecological-natural dimension** may be considered as the most critical in Rozsály. Though education for environmental consciousness begins in primary school and farmers try to introduce environmental friendly methods when operating the social farm, the primary aspects are self-sufficiency and job creation in the village while in ecovillages these are the environmental protection and saving the natural values. Furthermore, the majority of the produced products must be bio-products in ecovillages, which does not realize fully in Rozsály. When building houses local raw materials are used in ecovillages by utilizing environmental friendly materials. In Rozsály being an already existing village the houses were built mainly from bricks and clay. The attitude towards using renewable energy sources, however, is much better. The change-over of public institutes for utilizing alternative energy sources has already begun. Selective waste collection operates in an organized way in the village. The major part of the population carries out composting which contributes to strengthening the ecological dimension. Saving biodiversity appears in the form of Natura 2000 territories.
Regarding the **economic dimension** Rozsály has started an exemplary work, and the social farm formed by local people meets the requirement and concepts of ecovillages. Relating to food supply the village achieves self-sufficiency in a higher and higher level and strives to use alternative energy sources in case of energy utilization thus reducing the energetic dependence. Processing raw materials and generating added value are typical in the village. Retaining money in Rozsály and preventing it from leaving the village is advantageous in case of food goods. There are problems in the service sector as the owners of enterprises dealing with different services are residents of other settlements. From the economic aspect the excess dependence of the village on external sources may be considered as another problem.

CONCLUSIONS

On the basis of the results, our conclusion is the fact that Rozsály has started a good direction in order to break out from the problems concerning the area and may be exemplary for other subregions being under similar unfavourable social and economic conditions such as for the Hódmezővásárhely subregion, where decreasing and aging population and unfavourable vitality tendency are major problems (HORVÁTH AND BODNÁR, 2009). In our opinion contrary to several approaches citing Rozsály as an ecovillage the village does not meet strictly the requirements of ecovillages in every aspect. It is better to use the phrase ‘ecovillage initiative’ for Rozsály. Mostly local economic development appears in the village, but the residents and the management of the settlement strive to focus on even ecological aspects as well.
In order to realize the ecological dimension fully, the objective of every resident should be even the protection of natural values and biodiversity besides ensuring their own livelihood. Naturally the results are exemplary and if every settlement followed this direction it would contribute to the global ecological footprint of appropriate size.
Unemployment is the central problem of the settlement which is caused by the narrow possibilities of higher qualified people, the lack of market of local products, the underdeveloped tourism and the less number of enterprises run by local residents. One of the chances of the village is to realize the ecological factors in a more highlighted way and the settlement would meet the criteria of ecovillages. But this is the less real opportunity. Another chance is starting the connection with Satu Mare, which may help in reaching

higher level of employment and ensuring market for products. In this case Rozsály may be relatively independent and ecological aspects may be further improved by using higher ratio of renewable energy sources.

It would be practical to start public transportation between Rozsály and Satu Mare which may result in decreasing the number of the unemployed and in improving the possibilities of people of higher qualification. In order to build cross-border cooperation it is necessary to make the communication more successful. For this purpose it would be useful to educate Romanian and Ukraine languages in primary school or even for adults. In order to make selling of products of animal origin easier a vacuum packing machine would be essential. By renewing the cross-border cooperation the development of tourism may be possible, which is already realized by the local government as a rural catering house is under construction. This ensures further possibilities as tourists may purchase local products and may spread its fame. In order to expand the marketing of local products the House of Szatmár Favours is established. The most important thing, however, is to maintain the achieved results and one must focus on the fact that under such conditions the settlement may only survive which is populated by real community.

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I3: http://gen.ecovillage.org/ecovillages/4pillarsofsustainability.html

I4: http://www.rozsaly.hu/

Review on Agriculture and Rural Development 2014. vol. 3 (2) ISSN 2063-4803

RESULTS OF CO-FERMENTATION EXPERIMENTS IN HALF INDUSTRIAL SIZE

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ABSTRACT

The research work presented proposes the study of the impact for the qualitative and the quantitative property of the biogas production by the co-fermentation of the bio-fuel industrial by-products and the dangerous liquid pig manure of the concentrated stock of the big pig farms.

The energetic utilization of these materials means more profitable technology for the bio-fuel industry with a longer product course, bigger income for the agricultural enterprises selling the electrical energy, the heat energy, getting support for the demolition of the dangerous materials, savings in the replacement of the plant nutrition with the utilization of the bio-manure, increases the performance of the plant production, making harmless the dung which means a big environmental load.

Because of the profitability of bio-energy utilization depends on the local conditions it is necessary to do experiments to try the available composition of organic wastes in the ratio of the formation in advance. We have to investigate the different ways of technology and recipe of basic and by-products to increase the production

Keywords: sustainable agriculture, environmental protection, energy aimed waste utilisation, increasing the profitability of the agricultural production

INTRODUCTION

The biogas production based on the pork liquid dung, and the other waste of agricultural main product of processing known, and accepted technological procedure in the EU's member states, as the result of which biogas and fermented manure is produced (ARTHURSON, 2009). The quantity and the quality of the raw materials and additives, and the biogas forming in the function of the parameters of the applied technology are strongly variable. The target of my experiments aimed the increasing of the proportion of the renewable energy sources application to increase the methane quantity originating from the various organic matters, to increase of the intensity of the formation, to produce stabile gas content. Making the organic matters polluting the environment harmless is the indirect result of the application of the technology (GOTTSCHALK, 1979). The biogas increasing the greenhouse effect with big methane content means concentrated environmental load and source of danger and on the other hand unutilized energy source on a farming area where the use of the exterior power sources is considerable anyway. While the economy size is his principle from below, the relatively little energy content of the biomass in the view of the transportation expense from above limits the firm concentration (GERARDI, 2003). Because of this it is expedient to examine the energetic utilisation of all possible organic waste at least with laboratory or half firm methods.

MATERIAL AND METHOD

The large-scale manure production modelling of biogas experiments used the liquid pig slurry as raw material. The additive is the Róna sugar sorghum press residue. The industrial by-products and wastes suitable for biogas production are defined by the dry matter, organic matter, nitrogen content, C:N ratio, specific gas yield *(Table 1).*

Table 1. The most important parameters of the input materials influencing the biogas releasing process

Measured parameters	pH value	C/N ratio	Dry matter content (%)	Organic dry matter content
Liquid pig slurry	6.8-7.2	5-10	~4	~3.8
Róna sugar sorghum press residue	-	31-33	42	39

The technology of fermentation experiments in the series progress

At the Engineering and Agricultural Faculty of Szolnok College there is an appropriate, semi-automatic experimental system, representing the operating circumstances, providing similar conditions suitable the formation process of the biogas, regulating change of influencing factors and provide the opportunity of all of necessary measurements of typical data. The liquid pig manure was used during my biogas production experiments as basic substance. The research of appropriate technology may decrease the time of fermentation and the measure of the demolition may improve and the methane content of the forming biogas may be growing.

Table 2. The parameters measured during the experiment series, measuring devices, methods, frequency

Serial number	Measured parameter	Device	Method	Comment
1	fermentor temperature (^{o}C)	digital thermometer		once a day, at the same time
2	gas yield (dm^3)	gasmeter		
3	gas content (%)	GA45 gas analyser		
4	conductivity (mS/cm)	Hydrolab	electrometry	once a day, at the same time
5	soluted oxigen (mg/l)			
6	pH			
7	salination (PSS)			
8	redoxpotential (mV)			
9	BOD5 (mg/l)	Oxi Top 110	pressure dropping	from samples selected based on professional viewpoints
10	COD (mg/l)	NANOCOLOR	photometry	
11	dry matter content (%)	drying cupboard		once a day, at the same time

The supreme features of industrial by-products and wastes suitable for biogas production:

- dry matter-,
- organic matter,
- nitrogen content,
- C:N proportion,
- specific gas yield.

I measured the most important parameters to follow the degradation process (*Table 2*). *Table 3* contains the different treatments in the different process periods.

The technology of fermentation experiments, the process of the experiment series:

a) Loading of laboratory digesters, setting of the treatment combinations
b) Sampling
c) Measurements, examined parameters

We can dose ~50 dm^3 of liquid dung mixture pro treatment to take the factors in connection with the capacity of the fermentors into account. It is possible the simultaneous examination the effect of 9 treatment combinations with in a heat able room placed, periodically mixed, and hermetically closed fermentors. We applied the continuous (filling up), mesophyll system, which is most widespread in the practice, it can be reproduced the process sections, as the launching, load change, receipt change, according to certain expert opinions each single daily measurement combination for a separate experiment can be qualified (KALMÁR ET AL., 2003).
We divided the process of the fermentation into sections according to *Table 3*.

Table 3. Technology of co-fermentation experiments

Serial number	1.	2.	3.	4.
period of the process	stabilization	refilling period with fresh substance	running-up period	comparative experiments
treatment		running-up period with fresh substance		
duration time	7 days	14 days	21 days	21 days

The statistical methods used for the evaluation of co-fermentation experiments
I used for the statistical analysis Excel spreadsheet and SPSS for Windows 18.0. The data were analysed by variance with independent two-T sample. I examined the homogeneity with Levene test. By the group pair comparison I used Tamhane test in the case of heterogeneity, and LSD test in the case of homogeneity. The relationship between variables was performed with correlation analysis tests (Pearson's correlation coefficient) and linear regression analysis.

RESULTS

Examining the gas production of the reactors it is verifiable that much less biogas was produced in the untreated control in the given period, besides given parameters than in the other two, on pork liquid dung basis, with vegetal by-products added. The sugar sorghum bagasse (press residue) used as additive increased the specific biogas yield more than two times in the experiment *(Figure 1).* In the concern of bacteria treated fermentor verifiable, that the bacterium culture bred between the laboratory circumstances did not increase significantly the production of the biogas or the methane *(Table 4)*. His effect appeared in the faster running-up of the gas production. In the case methanogen bacteria not containing fermentors filled up with pork liquid dung the biogas production after the vaccination under very short time, started up inside 1–2 days.

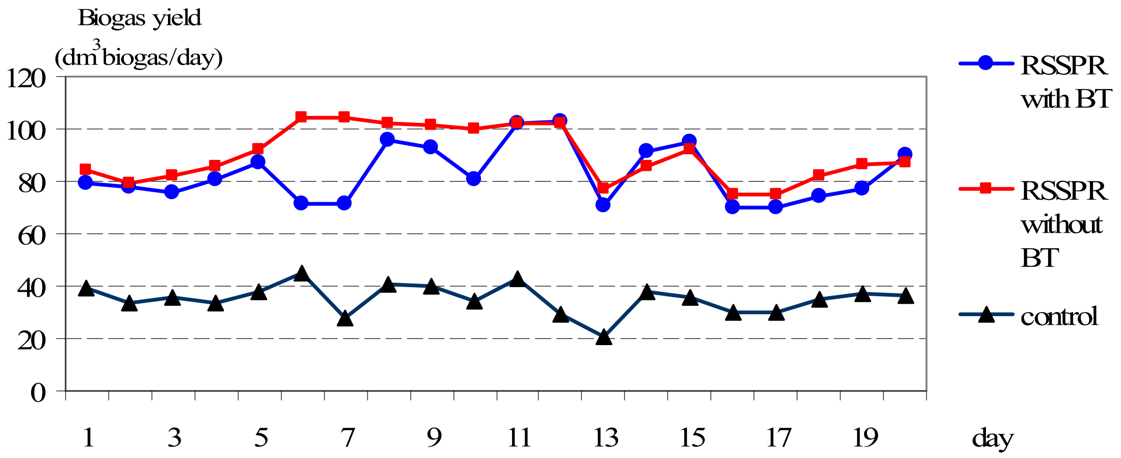

Figure 1. Biogas yield of the fermentors during the comparative period of the experiment (RSSPR=Róna Sugar Sorghum Press residue added, BT-bacteria treatment) on liquid pig dung basis

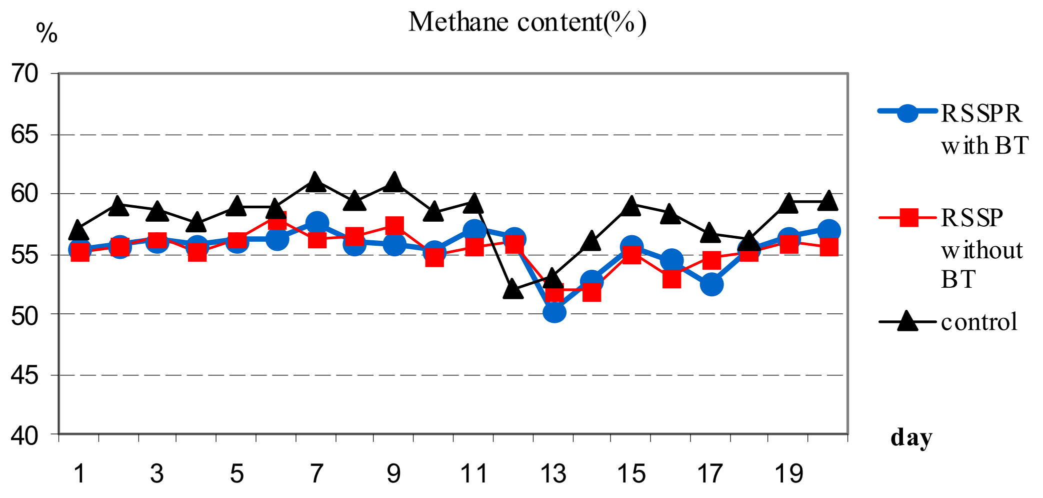

Figure 2. Methane content of the released biogas during the comparative period of the experiment (RSSPR=Róna Sugar Sorghum Press residue added, BT-bacteria treatment) on liquid pig dung basis

The methane content almost parallel oscillated between 50-60% in all fermentors *(Figure 2)*. There was no significant difference among the data of the Róna Sugar Sorghum Press residue treated (55.4%) with or without bacteria and the control fermentor (58.6%).

Table 4. Average biogas yield of liquid pig dung and sugar sorghum press residue added fermentors

Actual production value compared to the control	control fermentor		Róna sugar sorghum press residue added			
			without bacteria treatment		with bacteria treatment	
Treatment to assure the perfect DMC	200 g*		200 g**		200 g**	
Average biogas production (dm^3/day;%)	35.2	100	90.0	257	84	238
Methane content (%)	58.6	100	55.4	94.5	55.4	94.54

* 200 g DMC liquid pig slurry overloaded
** 100 g DMC liquid pig slurry and 100 g DMC additive mix overloaded

The Róna sugar sorghum press residue addition increased the biogas production about 2.5 times compared to the biogas releasing of the control experiment but the methane content decreased only ~3% *(Table 4)*.
From the proportion of the methane measured in the course of our experiments representing half industrial circumstances it is verifiable, that the ratio of the methane is changing according to the intensity of the gas development (*Figure 2*).

CONCLUSIONS

We simulated topping up (continuous) technology with 20 days Hydraulic Retention Time in mesophyll circumstances, that's why we emptied 5% digested effluent substrate and fill up 5% influent row pig sludge into the control fermentor, and the same amount of liquid pig slurry and the by-product of bio-fuel industry sugar sorghum press residue with or without bacteria treatment. To summarize the results we can prove, that the 100 g DMC bagasse additive increased the biogas production almost 2.5 times in the about 2000 g DMC contained liquid manure. On the contrary the methane content didn't decreased significantly, only 3% was the declining. The produced biogas is utilisable for energetic aims.

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Review on Agriculture and Rural Development 2014. vol. 3 (2) ISSN 2063-4803

THE ENERGETIC UTILIZATION OF SOLAR PHOTOVOLTAIC SYSTEMS FOR INDIVIDUALS, PRICE CHANGES IN HUNGARY

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ABSTRACT
The energy consumption has an important role in Human life and one of the biggest challenges is the continuously growing energy demand of the world.
The aim of present study is to review the determination of the characteristics of the Hungarian energy supply, the introduction of renewable energy utilization and the economic determination of the return of crystalline solar systems in Hungary. This study shows us the effect of the changing investment cost to the payback period. This calculation can be important for a household to decide by or against a solar (PV) system.
The main direction of our recent research is the utilization of photovoltaic (PV) solar energy. The studies were performed with crystalline solar systems. The research was carried out in solar-electric power plants extended from 3 kWp to 12 kWp. The study is about the investment of crystalline solar cell systems. The payback period is studied due to the help of static and dynamic indices.

Keywords: renewable energy for individuals, solar energy utilization, static indices, dynamic indices

INTRODUCTION

The PV technology generates direct current (DC) electrical power measured in watts (W) or kilowatts (kW) from semiconductors when they are illuminated by photons. The solar cell generates electrical power. When the light stops, the electricity stops. Solar cells never need recharging like a battery (LUQUE ET AL., 2011).
The solar energy is popular because of it is available for almost every consumer. The solar energy could increase the energy independence of countries or companies. Solar systems do not need transport of row materials, because the solar energy comes to the place of utilization. Solar energy can be planned ahead in a limited way, which is available in the largest quantities in summer. To build a PV system needs significant investment, but they do not contain moving parts (except for the inverter) and ideally it has to be maintained between 10 and 15 years.

MATERIAL AND METHOD

Hungarian energy supply

The energy consumption of Hungary was 1162.4 PJ in 2011, 39.17% was domestic production and 60.83% was import. An average Hungarian family needs 2500-5000 kWh of electricity/year. In our country, the oil, the coal and the gas consumption were almost 76%. The nuclear energy use in 2011 was 14.72% (electricity import ~2%) and the share of renewable energy was more than 7.85% (www.mavir.hu) (*Figures 1, 2*).

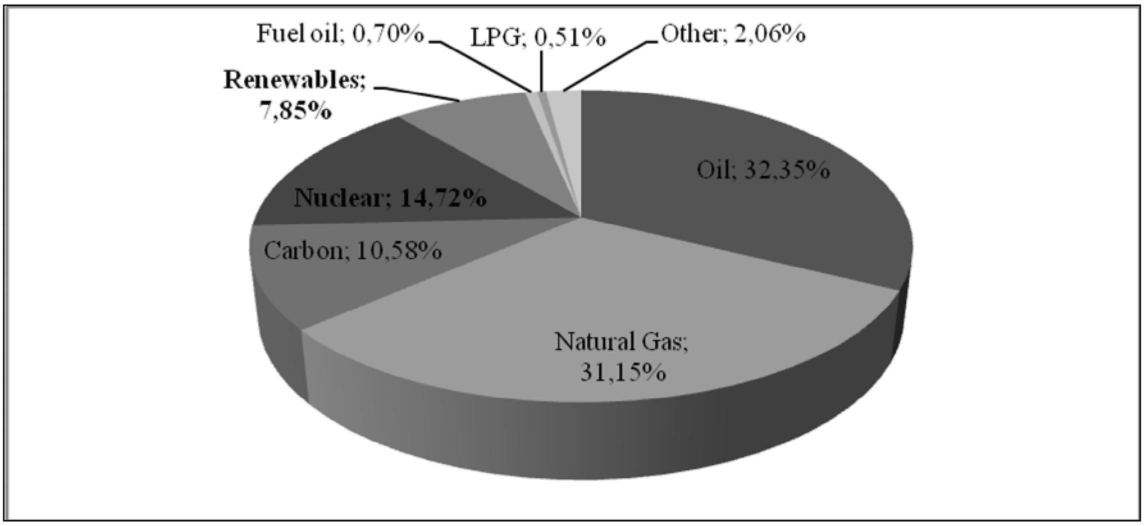

Figure 1. Composition of energy consumption in Hungary (2011)
Source: own work based on www.mavir.hu, 2011

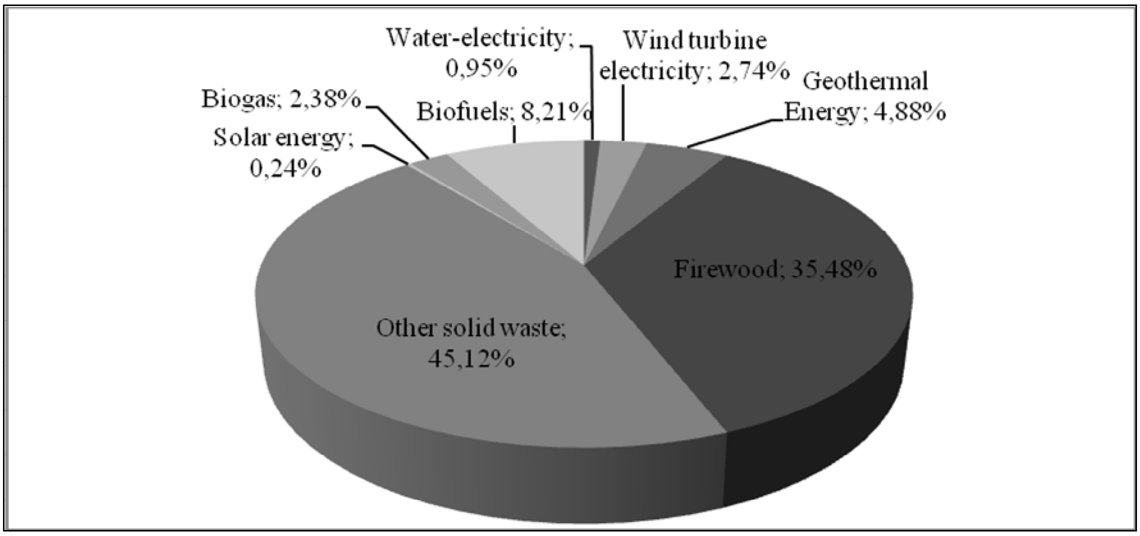

Figure 2. The use of renewable energy resources in Hungary (2011)
Source: own work based on www.mavir.hu, 2011

Solar energy and solar PV systems
Solar power of 1200 kWh/m^2 – 1360 kWh/m^2 comes to Hungary every year. We calculated with 1280 kWh solar energy / year in Hungary based on Photovoltaic Geographical Information System (including losses) (www.www.solargis.info, www.re.jrc.ec.europa.eu). The price/Watt relationship of 6 different solar systems of different performance was compared in February 2014 and in August 2014 (types produced for network, fixed onto slanted roof, finished systems, without any unexpected network development) (www.napelemdepo.hu, www.bacs-napkollektor.hu).
The type of solar panels are Renesola, SolarWorld and ET Solar. The brands of inverters are Kaco Powador, SMA and Fronius.

Static indicators
Their feature is that they do not take the money value of time into account (NÁBRÁDI ET AL., 2008).

Average profitability of the investment
It expresses the efficiency of the investment and the relationship of expenditure and profit in its simplest form (NÁBRÁDI ET AL., 2008).
Br =(E /B)*100
Br the profitability of investment (%)
E the average annual return of investment (EUR)
B one-time investment cost (EUR)

Payback time period
It expresses how many years it takes the investment to return from average surplus (NÁBRÁDI ET AL., 2008).
Bm = B/E
Bm the payback period of investment (years)
E the average annual return of investment (EUR)
B a one-time investment cost (EUR)

Dynamic indicators
Dynamic calculation methods take the time factor into account.

Net present value (NPV)
In finance, the Net Present Value (NPV) or Net Present Worth (NPW) of a time series of cash flows, both incoming and outgoing, is defined as the sum of the present values (PVs) of the individual cash flows of the same entity (Net Present Value).

$$\mathbf{NPV} = \sum_{i=1}^{n} \frac{Ri - Ii - Ci}{(1+r)^{i}}$$

NPV Net Present Value (EUR)
n time of use (years)
Ri receipts in i year (EUR)
Ii investment cost of the i year (EUR)
Ci operating costs in i year (EUR)
r discount rate (%/100)

Internal Rate of Return (IRR)
The internal rate of return on an investment or project is the "annualized effective compounded return rate" or "rate of return" that makes the net present value (NPV as NET*1/(1+IRR)^year) of all cash flows (both positive and negative) from a particular investment equal to zero. It can also be defined as the discount rate at which the present value of all future cash flow is equal to the initial investment or in other words the rate at which an investment breaks even (www.investopedia.com).

PV (R) Present Value of Output (EUR)
PV (I) Present Value of Investment (EUR)
PV (C) Present Value of Costs (EUR)

Profitability index (PI)
Profitability index (PI), also known as profit investment ratio (PIR) and value investment ratio (VIR), is the ratio of payoff to investment of a proposed project. It is a useful tool for ranking projects because it allows you to quantify the amount of value created per unit of investment (www.absoluteastronomy.com).
PI = PV(R)/PV(C)
If PI > 1 then accept the project
If PI < 1 then reject the project

Discounted payback period
It indicates how many years of discounted income is needed to return the sum of the initial investment (NÁBRÁDI ET AL., 2008).

RESULTS

PV systems cost in Hungary in 2014
In the last few years the prices of the PV systems have decreased. The decline in the price of the finished system is not completely in accordance with capacity of the installed power. Up to 5 kWp decrease can be experienced, over 5 kWp there is a smaller price increase and decrease.
The cheapest system regarding the watt / price connection was the 12 kWp in February 2014 and in August 2014 (three-phases, one inverter) (*Figure 3*).

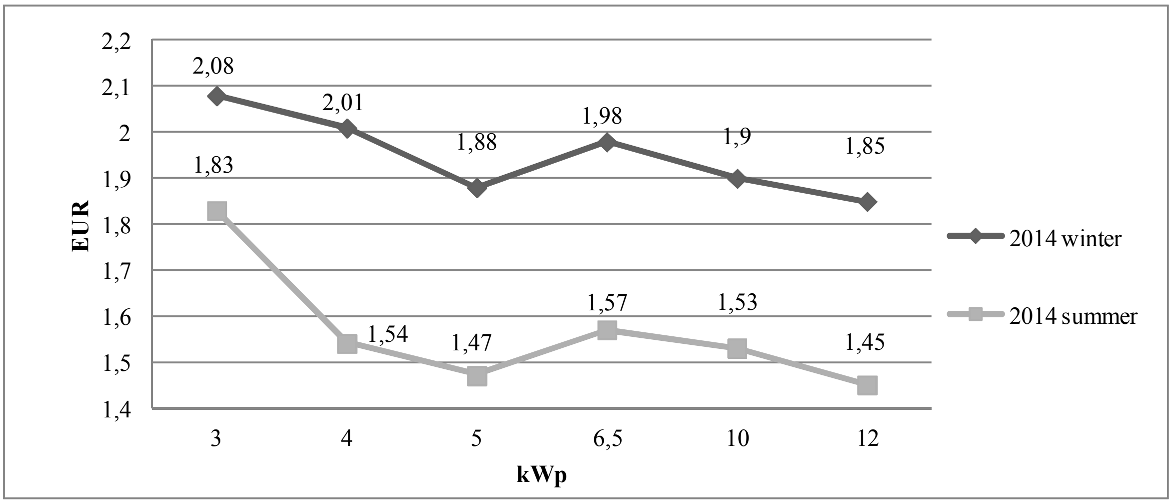

Figure 3. Investment costs of PV systems in 2014 winter and summer (EUR/Watt)
Source: own work

The payback period of domestic small PV systems
Statistic and dynamic indicators have used to examine the payback period. We calculated 305 HUF/EUR exchange rate. The SolarGIS data were used to the planning process, which provides high-resolution climate data, maps, software and services for on-line access to solar energy. A theoretical 1kW solar power plant can utilize 1200 kWh –1360 kWh energy (including losses).
An individual customer can have a saving of 0.1228 EUR/kWh in 2014. Energy measurement is carried out with a two-way measuring device. Excess energy (or all

energy) can be sold at 0.0506 EUR/kWh, so in the current situation solar power plants should be designed, that they do not produce more energy than the yearly used (www.solargis.info/, www.eon.hu).

We have studied the following systems: 3 kWp and 5 kWp (these are the most common categories) solar PVs. Only own capital investments are studied because in Hungary individuals have no financial support. One inverter is necessary to these systems and they do not require any maintenance for 10-15 years. We calculated according to the following method: 1 kWp solar PV system can produce 1280 kWh (the average of 1200 kWh and 1360 kWh). The average annual amortization was 0.3%/year based on practical experience, the returns were examined for 15 years (www.solargis.info/; www.napelemdepo.hu; JORDAN AND KURTZ, 2012).

The life expectancy of inverters is between 10-15 years. The replacement is assumed in 15 years' time. The electricity prices increased about 7%/year between 2000 and 2010. We calculated with a better value because the current market conditions, difficult to calculate the current price increase (artificial price reduction) (MEKH, 2014).

The price of electricity has been considered with 4% annual price increase (Starting from 2014 0.1228 EUR/kWh), assuming 100% consumption of energy. Different kinds of natural damage (lightning, hail) were not taken into account.

A financial discount rate of 8% was calculated because 8% financial discount rate should be applied to the cash flows discounting in Hungary (NFÜ, 2008, www.vati.hu) (*Table 1*).

Table 1. 1kWp solar PV system savings in one year in Hungary for individuals in 2014

Source: own work

1kW solar PV system energy produced (kWh)	1280
Electricity supply retail selling price of electricity in 2014 (Euro Cent / kWh)	12.28
Overcapacity purchase price (Euro Cent / kWh)	5.06
Savings at 100% utilization (EUR)	**157.2**
Savings at 0% utilization (EUR)	**64.8**

The results of our study

Static indicators

The data clearly show that the profitability of a 3 kWp system was 9.8% in winter, while this value was in summer 1.4% better. The 5 kWp system was 3.1 % better in summer than in winter. The payback period by solar power plants is can be made among 7 and 9 years in summer (*Table 2*).

Table 2. Analysis of the profitability of investment and the investment payback

Source: own work

Year	**2014 February**	**2014 August**	**2014 February**	**2014 August**
The size of the system (kWp)	3		5	
E (EUR)	615	615	1026	1026
B (EUR)	6 255	5 496	9 409	7 370
Br=E/B*100 (%)	9.8	11.2	10.9	14
Bm=B/E (Years)	**10.2**	**8.9**	**9.2**	**7.1**

Dynamic indicators

The examined 3 kWp plants are not recommended to be implemented in 15 years but the payback period is 2.3 years better in summer than in winter (*Table 3*).

Table 3. Dynamic indicators analysis in 15 years, 3 kWp system

Source: own work

Year	**2014 February**	**2014 August**
System size (kWp)	3	
Investment costs (EUR)	6 255	5 496
Maintenance costs (EUR)	0	
Electricity charge savings, at the same price (EUR)	9 230	9 230
r = interest (%)	8	
Present value savings (EUR)	5 002	5 002
NPV (EUR)	-1 252	- 493
IRR (%)	4.84	6.63
PI	0.80	0.91
Discounted payback period (Year)	**(18.8)**	**(16.5)**

NPV, PI, IRR:

The examined 5 kWp plant (2014 winter) is not recommended to be implemented in 15 years. In this form the payback period is about 17 years.

The examined 5 kWp system (2014 summer) is recommended to be realized and the payback period is about 13 years. The return of investment is 3.6 years better in summer than in winter (*Table 4*).

Table 4. Dynamic indicators analysis in 15 year, 5 kWp system

Source: own work

Year	**2014 February**	**2014 August**
System size (kWp)	5	
Investment costs (EUR)	9 409	7 370
Maintenance costs (EUR)	0	
Electricity charge savings, at the same price (EUR)	15 384	15 384
r = interest (%)	8	
Present value savings (EUR)	8 338	8 338
NPV (EUR)	-1 071	968
IRR (%)	6.25	9.9
PI	0.89	1.13
Discounted payback period (Year)	**(16.9)**	**13.3**

CONCLUSIONS

A PV system of 3 or 5 kWp can be enough for an average Hungarian family, which uses 2500-5000 kWh or more electricity. The cost of a 3 kWp system is slightly more expensive (also in winter and in summer) regarding watts / price, than the 5 kWp solar power plant. The counted payback period shows us the same result: it is higher at the 3 kWp system than at the 5 kWp system.
It would be important to rationalize the transfer price of the extra energy. This amount is in the size of domestic small power stations 0.0506 EUR net (for individuals).
With an interest rate of 8% has been calculated in the article but the bank rates in Hungary were around 1-2%. Thus the net present value of these investments could be better if the individuals compare the rate with a bank rate and not with a long term stocks.
Our final results show us that the 3 kWp system is too small for a real savings: the investment cost of it is bigger than the net price of the energy saving but at the 5 kWp system the present value of the energy saving is bigger than the investment cost.

ACKNOWLEDGEMENTS

Present article was published in the frame of the project TÁMOP-4.2.2.B-15/1/KONV-2015-0004 A Pannon Egyetem tudományos műhelyeinek támogatása.
We would like to thank all of the private and public sector organizations that kindly provided data and other documentation for research.

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Review on Agriculture and Rural Development 2014. vol. 3 (2) ISSN 2063-4803

THE SOLAR PV SYSTEMS PAYBACK EFFECT OF THE PRICE DECREASE OF COMMUNAL ELECTRIC PRICES AND OF THE INTEREST RATE DECREASE OF THE CENTRAL BANK

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ABSTRACT
The energy is one of the most important needs of the humanity. One of its biggest challenge or danger is that the world's demand for energy continues to grow.
The aim of present study is to review the introduction of solar energy utilization, the economic determination of the return of crystalline solar photovoltaic systems in Hungary, the electricity price reductions for individuals and the change in the payback period. The effect of the changing investment cost to the payback period based on the changes in electricity price reductions and in central bank interest rate is written in this study. An important question is for a household: decide by or against a solar (PV) system.
The main direction of our recent research is the utilization of photovoltaic (PV) solar energy with crystalline solar systems. The research was carried out in solar-electric power plants extended from 1.5 kWp to 10 kWp. The calculation of payback time was performed by dynamic indices.

Keywords: renewable energy for individuals, solar energy utilisation, dynamic indices

INTRODUCTION

The photovoltaics technology is involving the direct conversion of solar isolation into electricity using solar cells. The sunshine used by solar panels constitutes an unfailing energy resource but the oil, the uranium and the coal are the most widely used energy resources today. Basic problem at the photovoltaics technology is that the energy production depends on the weather and it is necessary to use energy storages, which considerably drive up the cost of photovoltaics electricity.
This technology is clean and engenders no noise pollution or toxic waste. The silicon is the main raw material used for solar panels, is one of the most abundant substances on Earth (HÄBERLIN, 2012). PV systems involve significant investment, but they do not contain moving parts (except for the inverter) and ideally it has to be maintained between 10 and 15 years.

MATERIAL AND METHOD

Solar energy and solar PV systems

Hungary has a good solar potential: every year 1200 kWh / m^2 – 1360 kWh / m^2 solar energy comes from the sun to the surface of the country. We calculated with 1280 kWh solar energy / year. The Photovoltaic Geographical Information System (www.www.solargis.info, www.re.jrc.ec.europa.eu) is used for these values.
In the summer of 2014 the price / Watt relationship of 8 different solar systems of different performance was compared (types produced for network, fixed onto slanted roof, finished systems, without any unexpected network development (www.napelemdepo.hu). The type

of solar panels are Renesola, SolarWorld and ET Solar. The brands of inverters are Kaco Powador, SMA and Fronius.

Indicators

We used dynamic indicators at the calculation as Net present value (NPV), Internal Rate of Return (IRR), Profitability index (PI) and Discounted payback period. The definition of these indicators is not written here because we think this is a basic knowledge of the economy.

RESULTS

Cost of solar PV systems built in Hungary in 2014

Household-sized or domestic small power plants (HMKE) (up to 50kVA): In general, a normal household needs less than 10kVA to cover its electricity demand, which means that the capacity of this power plant type fits the needs of small- and medium-sized companies and publicly owned buildings (BOZSOKI EET AL., 2011). In this category we don't have to create energy schedule, so this helps a lot in the spread.

The decline in the price of the finished system is not completely in accordance with capacity of the installed power. Up to 5 kWp decrease can be experienced, over 5 kWp there is a smaller price increase and decrease. The cheapest system regarding the watt / price connection was the 9.8 kWp in 2014 (three-phases, one inverter) (*Figure 1*).

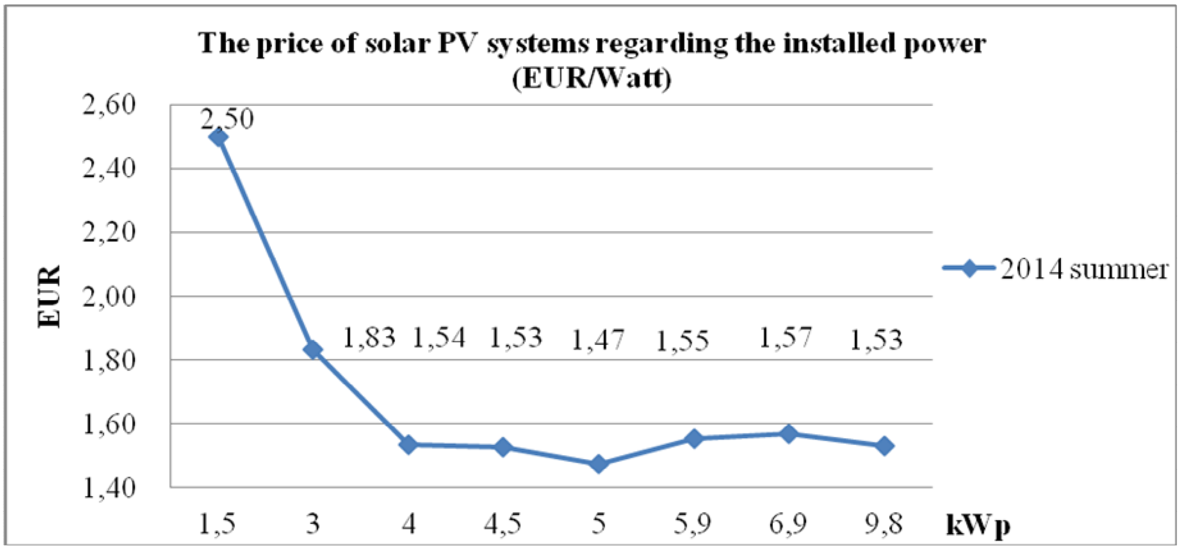

Figure 1. Gross cost of the finished solar PV systems in 2014 summer, depending on the installed capacity (EUR / Watt)
Source: own work based on www.napelemdepo.hu, 2014

The examination of the theoretical payback time of crystalline PV systems, in domestic small power station sizes

We have studied the period of 01.01.2012 – 01.09.2014. In the past there were 4 electricity price reductions for individuals in Hungary (MEKH, 2014). The following table shows the electricity price reductions *(Figure 2*). During this period the rate of the Hungarian Central Bank was also decreasing (*Table 1*). We calculated the payback time with 4 bank rates and we used the current minimum and maximum values (*Figure 2*).

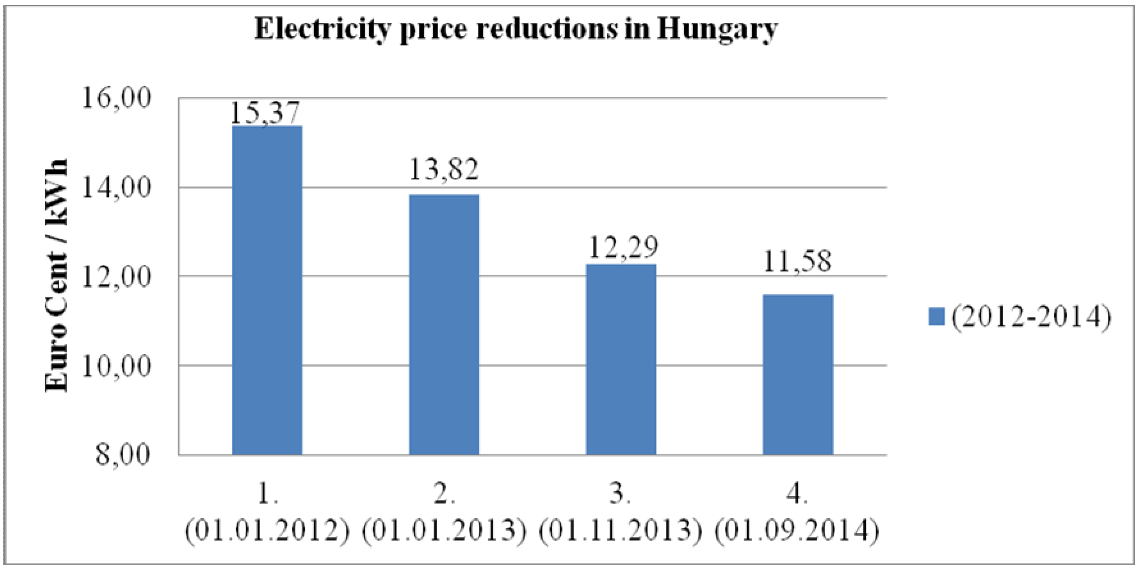

Figure 2. The electricity price reductions for individuals in Hungary
Source: own work based on www.mekh.hu

As *Figure 2* shows us, the price of 1 kWh was 15.37 Euro Cent from 01.01.2012 till 01.01.2013. In the period of 01.01.2013 - 01.11.2013 the price was 13.82 then it reduced to 12.29 and it stayed on that level till 01.09.2014. From 01.09.2014 the price of 1kWh decreased to 11.58 Euro Cent.

We calculated with 4 electricity price reductions and with 305 HUF/EUR exchange rate. Dynamic indicators were used to count the payback period. In the case of a 1 kWp nominal power solar system 1280 kWh were taken into account (www. www.solargis.info, www.re.jrc.ec.europa.eu).

For the energy measurement is need a two-way measuring device. The excess or all energy can be sold to E.ON. A solar power plant should be designed in the current market situation, that it does not produce more energy than it can be used in a given period (*Table 2*) (www.eon.hu). 4 kWp and 5 kWp solar PV systems were examined assuming 100% own capital because the authors mentioned that individuals in Hungary had no financial support. These solar PV systems include 1 inverter, which do not require any maintenance for 10-15 years if the instalment is professional and if the inverter is a good quality brand. The average annual physical amortization (sinking of power) was 0.3% / year at the solar panels based on practical experience, the returns were examined for 15 years (www.napelemdepo.hu, Dirk C. Jordan and Sarah R. Kurtz, 2012). An inverter can be works 10-15 years. The replacement is assumed in 15 years' time. The electricity price increased about 7% / year between 2000 and 2010. But from 2010 the increase of the price has stopped and the level has stayed at the same place.

Table 1. Changes of the interest rate
Source: based on www.mnb.hu, 2014

Years	%
21.12.2011.	**7**
29.08.2012.	6.75
26.09.2012	6.5
31.10.2012	6.25
28.11.2012	6
19.12.2012	**5.75**
30.01.2013	5.5
27.02.2013	5.25
27.03.2013	5
24.04.2013	4.75
29.05.2013	4.5
26.06.2013	4.25
24.07.2013	4
28.08.2013	3.8
25.09.2013	3.6
30.10.2013	**3.4**
27.11.2013	3.2
18.12.2013	3
22.01.2014	2.85
19.02.2014	2.7
26.03.2014	2.6
30.04.2014	2.5
28.05.2014	2.4
25.06.2014	2.3
23.07.2014	**2.1**

We calculated that the reduction of the electricity price has stopped in 2014 and it will have no increase in the next 15 years because any future price increase or decrease gives similar results. Natural damage like lightning or hail were not taken into account.

Table 2. Savings in 1 year in the case of a 1kWh solar PV system for individuals in Hungary (2012-2014)
Source: own work

Years	**01.01.2012**	**01.01.2013**	**01.11.2013**	**01.09.2014**
1kW solar power plant energy produced, (kWh)	1280			
Electricity supply retail selling price of electricity in 2014 (Euro Cent/kWh)	15.37	13.82	12.29	11.58
Overcapacity purchase price in 2014 (Euro Cent/kWh)	7,07	5,92	5.06	4.49
Savings at 100% utilization (EUR)	**196.7**	**176.9**	**157.2**	**148.2**
Savings at 80% utilization (EUR)	175.5	156.7	138.8	130.1
Savings at 60% utilization (EUR)	154.2	136.4	120.3	111.9
Savings at 0% utilization (EUR)	**90.5**	**75.7**	**64.8**	**57.5**

The results of dynamic indicators

We can see on the *Tables 3-6* that the interest rate has influenced the payback period positively while the electricity price reductions increased these values. The two phenomena almost equalized each other. The discounted payback periods were between 27 and 32 years (*Tables 3* and *4*) because the delivery prices were too low with 0% own utilization.

Table 3. Dynamic indicators analysis with 4 kWp in 15 years, with 0% own utilization
Source: own work

Year	**01.01.2012**		**01.01.2013**		**01.11.2013**		**01.09.2014**
System size (kWp)	**4**						
Investment costs (EUR)	6 141						
Maintenance costs (EUR)	0						
Electricity charge savings, at the same price (EUR)	5 316		4 451		3 805		3 376
r = interest (%, min ; max)	7	5.75	5.75	3.4	3.4	2.1	2.1
Present value savings (EUR)	3 240	3 510	2 938	3 448	2 947	3 238	2 873
NPV (EUR)	-2 901	-2 631	-3 203	-2 693	-3 194	-2 903	-3 268
IRR (%)	**-1.76**		**-3.8**		**5.5**		**6.73**
PI	0.53	0.57	0.48	0.56	0.48	0.53	0.47
Discounted payback period (Year)	**(28.4)**	**(26.2)**	**(31.4)**	**(26.7)**	**(31.3)**	**(28.4)**	**(32.1)**

Table 4. Dynamic indicators analysis with 5 kWp in 15 years, with 0% own utilization
Source: own work

Year	**01.01.2012**		**01.01.2013**		**01.11.2013**		**01.09.2014**
System size (kWp)	**5**						
Investment costs (EUR)	7 370						
Maintenance costs (EUR)	0						
Electricity charge savings, at the same price (EUR)	6 645		5 564		4 756		4 220
r = interest (%, min , max)	7	5.75	5.75	3.4	3.4	2.1	2.1
Present value savings (EUR)	4 050	4 388	3 673	4 310	3 685	4 048	3 592
NPV (EUR)	-3 319	-2 982	-3 696	-3 059	-3 685	-3 321	-3 778
IRR (%)	**-1.28**		**-3.35**		**-5.56**		**-6.32**
PI	0.55	0.60	0.50	0.58	0.50	0.55	0.49
Discounted payback period (Year)	**(27.3)**	**(25.2)**	**(30.1)**	**(25.6)**	**(30)**	**(27.3)**	**(30.8)**

The discounted payback periods were between 12 and 13 years and the payback period was only 0.7 year worse in 01.09.2014 than in 01.01.2012.

Table 5. Dynamic indicators analysis with 4 kWp in 15 years, with 100% own utilization
Source: own work

Year	01.01.2012		01.01.2013		01.11.2013		01.09.2014
System size (kWp)	4						
Investment costs (EUR)	6 141						
Maintenance costs (EUR)	0						
Electricity charge savings, at the same price (EUR)	11 562		10 396		9 239		8 712
r = interest (%, min ; max)	7	5.75	5.75	3.4	3.4	2.1	2.1
Present value savings (EUR)	7 046	7 633	6 863	8 054	7 158	7 864	7 415
NPV (EUR)	905	1 492	722	1 912	1 016	1 723	1 274
IRR (%)	**9.3**		**7.5**		**5.65**		**4.76**
PI	1.15	1.24	1.12	1.31	1.17	1.28	1.21
Discounted payback period (Year)	**13.1**	**12.1**	**13.4**	**11.4**	**12.9**	**11.7**	**12.4**

Table 6. Dynamic indicators analysis with 5 kWp in 15 years, with 100% own utilization
Source: own work

Year	01.01.2012		01.01.2013		01.11.2013		01.09.2014
System size (kWp)	5						
Investment costs (EUR)	7 370						
Maintenance costs (EUR)	0						
Electricity charge savings, at the same price (EUR)	14 453		12 995		11 549		10 890
r = interest (%, min , max)	7	5.75	5.75	3.4	3.4	2.1	2.1
Present value savings (EUR)	8 808	9 542	8 580	10 068	8 948	9 831	9 270
NPV (EUR)	1 438	2 172	1 209	2 698	1 578	2 461	1 899
IRR (%)	**10**		**8.2**		**6.3**		**5.4**
PI	1.2	1.29	1.16	1.37	1.21	1.33	1.26
Discounted payback period (Year)	**12.6**	**11.6**	**12.9**	**11**	**12.4**	**11.2**	**11.9**

We can see the same effect of the bank rate and the electricity price at the *Table 5* and *6* because the power is the only different value.

CONCLUSIONS

The energetic utilisation of solar PV systems, in the size of domestic small power stations (HMKE, 0 kWp – 49.9 kWp) are increasingly popular in Hungary, because this category is the most profitable with 100% own utilization. This helps a lot in the spread. The price of 1 kWh changed about 27% from 01.01.2012. to 01.09.2014. During this period the rate of the bank of issue was also decreasing 4.9% and the two phenomena almost equalized each other. It would be important to rationalize the transfer price of the extra energy like in Western Europe. By the help of this rationalisation could be calculated a more predictable payback period.

According to the authors opinion it is really interesting that despite the sinking energy prices in Hungary the profitability of the solar solar PV systems were not decreasing but it could grow a bit because of the sinking rate of the central bank so becomes a better situation for the solar investments in our country in the period of 2012-2014.

ACKNOWLEDGEMENTS

Present article was published in the frame of the project TÁMOP-4.2.2.B-15/1/KONV-2015-0004 A Pannon Egyetem tudományos műhelyeinek támogatása.

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- PV prices
  http://napelemdepo.hu/