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PREFACE

In the name of the Committee of Agricultural and Biosystem Engineering of the Hungarian Academy of Sciences we would like to welcome everyone who is interested in reading our journal. The Hungarian Agricultural Engineering (HAE) journal was published 32 years ago for the very first time with an aim to introduce the most valuable and internationally recognized Hungarian studies about mechanization in the field of agriculture and environmental protection. In the year of 2014 the drafting committee decided to spread it also in electronic (on-line and DOI) edition and make it entirely international. From this year exclusively the Szent István University's Faculty of Mechanical Engineering took the responsibility to publish the paper twice a year in cooperation with the Hungarian Academy of Sciences. Our goal is to occasionally report the most recent researches regarding mechanization in agricultural sciences (agricultural and environmental technology and chemistry, livestock, crop production, feed and food processing, agricultural and environmental economics, energy production, engineering and management) with the help of several authors. The drafting committee has been established with the involvement of outstanding Hungarian and international researchers who are recognized on international level as well. All papers are selected by our editorial board and a triple blind review process by prominent experts which process could give the highest guarantee for the best scientific quality. We hope that our journal provides accurate information for the international scientific community and serves the aim of the Hungarian agricultural and environmental engineering research.

Gödöllő, 20.05.2020.

Dr. László KÁTAI
editor in chief

Dr. László TÓTH
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SMALL AND MEDIUM-SIZED ENTERPRISES WITHIN THE CIRCULAR ECONOMY: CHALLENGES AND OPPORTUNUTIES

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Abstract: Small and Medium Enterprises (SMEs) are playing a vital role in most economies and they are key to the successful adoption of the circular economy, one where many materials are re-circulated, recycled, and re-used. This study aims to understand the concept of a circular economy and increase knowledge about the challenges and opportunities of the implementing circular economy for SMEs through a systematic literature review. For his study, Google Scholar, Web of Science, Research Gate and Science Direct databases have been used. The study concludes that SMEs often lack knowledge about opportunities of circular economy and their main priority is on their core business operation. We need a powerful government agenda, supported programs by policymakers who understand issues faced by SMEs and encourage them to think and act differently.

Keywords: Circular economy, SMEs, sustainability, green SMEs

1. Introduction

The interest towards the Circular Economy (CE) concept gains growing popularity among the academics, consumers, producers and small and medium-sized enterprises (SMEs). The circular economy concept was first introduced at the end of the last century. The first scientific papers on the topic were published in the 1980s. After that, it received increasing attention from scholars (Lieder & Rashid, 2016). Many definitions could be found in literature around harmonizing economic growth and environmental protection. The circular economy has been described as an industrial economy that relies on the "restorative capacity of natural resources" (Bastein et al., 2013) and aims to eliminate or at least minimize waste, utilize renewable sources of energy gradual ending the use of harmful substances (MacArthur, 2012). The circular economy is also defined as "an economic system that represents a change of paradigm in the way that human society is interrelated with nature and aims to prevent the depletion of resources, close energy and materials loops, and facilitate sustainable development" (Ormazabal et al., 2018). Accordion to Schulte (2003), "Circular economy is not just concerned with the reduction of the use of the environment as a sink for residuals but rather with the creation of self-sustaining production systems in which materials are used over and over again." According to Rizos et al. (2016), more SMEs are showing interest in the circular economy because it's closing loops and provides resource efficiency. Saving on material costs, creating competitive advantage and gaining opening ways for new markets are other reasons SMEs are interested in the circular economy. Countries like China, Germany, UK, France and Japan have advanced in the development of policies for the circular economy (Blomsma and Brenan, 2017; Murray et al., 2017). In this way, the circular economy Package launched by the European Commission in 2015 and the EU's contribution of about 119.5 euro million for Circular Economy proposals (European Commission, 2016) is one of the most significant incentives that guide the actions of European countries and companies towards the implementation of the Circular Economy (Gordeeva, 2017).

Small and medium enterprises (SMEs) should have the most important influence in this process because they make up 95% of companies in OECD member countries (OECD, 2017). In the SME definition of European Union (EU) enforced on 1 January 2005 (OECD, 2005) an "independence" dimension, together with the criteria of annual turnover and number of employees are stated, where an independent SME is described as "the one where 25% or more of the enterprise's capital (or equity) is not undertaken by an enterprise or that its capital is not owned by enterprises that are not defined as SMEs" (Yurttadur and Kaya, 2012).

For the enterprises that comply with the independence criterion, the quantitative factors which determine whether a company is an SME or not are, employee number and sales turnover or balance sheet total, as illustrated in Table 1.

Table 1. Quantitative categorization of SMEs in the European Union
Source: Muller et.al., 2014.

	Mikro-Sized SME	Small-Sized SME	Medium-Sized SME
Number of employees	<10	<50	<250
Turnover	≤ EUR 2 million	≤ EUR10 million	≤ EUR 50 million
Balance sheet total	≤ EUR 2 million	≤ EUR 10 million	≤ EUR 43 million

First, based on analysis of current literature, circular economy concept and SMEs introduced. After introducing the methodology, circular economy challenges and opportunities for SMEs discussed. This paper aimed to address the following research questions:

1. Which are the main challenges of Circular Economy implementation in SMEs?
2. Which are the main opportunities of Circular Economy implementation in SMEs?
3. What is the impact of the circular economy on SMEs?

2. Methodology

In this literature review, we used a systematic research method. Cook et al., (1997) state that "Systematic reviews differ from traditional narrative reviews by adopting a replicable, scientific and transparent process, in other words, a detailed technology that aims to minimize bias through exhaustive literature searches of published and unpublished studies and by providing an audit trail of the reviewer's decisions, procedures and conclusions."

Table 2. The scope of the literature review

Criterion	Included
Scope for the search	Google Scholar, Research Gate, Web of Science, Science Direct
Source	Peer-reviewed journal articles
Search parameters	Keywords appearing in the title
Language	English
Period	All years to present
Relevance	Literature focusing on frameworks to enable a circular economy in SMEs

Accordion to Tranfield et al., (2003) "A systematic search begins with the identification of keywords and search terms, which are built from the scoping study, the literature and discussions within the review team. The reviewer should then decide on the search strings that are most appropriate for the study. The search strategy should be reported in detail sufficient to ensure that the search could be replicated".

For the purpose of this study, a systematic literature review on the approach towards CE of SMEs, a computer search of the Google Scholar, Web of Science, Science Direct and Research Gate databases on the literature available on Circular Economy and SMEs has been conducted. Data collection consisted of searching the keywords "circular economy", "SMEs", "sustainability", "green SMEs" and all the combinations of them. After analysis of the existing articles, 41 papers considered coherent for the purpose of this study.

3. SMEs Within The Circular Economy

Small and medium-sized enterprises (SMEs) are increasingly aware of the benefits of closing loops and improving resource efficiency: saving material costs, creating competitive advantages and new markets are among the main reasons for European SMEs to take action. From the SMEs surveyed, more than two-thirds are satisfied with the return on their investments in resource efficiency improvements; more than one-third of the SMEs have experienced reductions in their production costs in the past two years (European Commission, 2013). For instance, by implementing a certified Environmental Management System (EMS), two-thirds of SMEs surveyed in a U.K. Defra study found their sales increased by £14,961 on average per million turnovers per year (Ruth & Burr, 2011). However, as explained, it is not always easy for SMEs to reap the benefits of more circular approaches. SMEs account for 99% of all European businesses and generate two-thirds of the jobs in Europe (OECD, 2010), yet their involvement in the circular economy remains limited as their activities are typically determined by large firms they provide for in supply chains (Klewitz & Hansen, 2014; Ormazabal et al., 2016).

Implementing the Circular Economy in SMEs requires that multiple challenges be overcome; A considerable amount of literature has been published on the challenges that SMEs face to implement the Circular Economy. According to Rizos et al. (2015), the main barriers for an SME taking up Circular Economy initiatives are financial support and resources, in terms of skills and knowledge. Rizos et al.(2015) state that "policy-makers need to first better understand the complex challenges faced by SMEs to develop appropriate supportive policy frameworks." Accordion to Lieder and Rashid (2016), "essential activities for successful CE implementation, such as business models, product design, supply chain design and choice of material are in control and hence finally determined by manufacturing companies with the underlying motivation of gaining economic benefits. In this scenario, it is obvious that a transition towards the CE will not appear favorable for manufacturing companies since it will be perceived as a constraint to industrial activities rather than an opportunity for sustainable business and growth." Law and Gunasekaran (2007) state that "Management mindset thus plays an important role in the sustainability strategy adoption." It is clear that for an SME working towards a Circular Economy, those individual mindsets, the way an individual thinks and behaves, is playing an important role in supporting the transition. Ghenţa & Matei (2018), however, note that the impact of SMEs on the environment is less investigated, although SMEs impact on job creation, innovation, social stability, and growth is recognized.

Lack of support from suppliers and demand network highly recognized as a challenge in the existing literature (Meqdadi, 2012; Rizos et al., 2016). Customers' purchasing decisions are partially affected by sustainability standards. Therefore, their fulfillment is not typically considered a high priority (Wycherley, 1999). Additionally. SMEs have a low impact on engagement of their suppliers (Zhu, 2008).

In a recent study done in Pakistan, Agyemang et al. (2018), flags the deficiency in researching barriers in emerging and developing countries besides China. The study highlights unawareness; cost and financial constraints and lack of expertise are the top barriers for adopting CE in Pakistan. The unawareness of CE includes the inability to understand the incentives for the incorporation of CE in their operations. Lack of expertise and comprehensive technical know-how was among the main concerns raised by the sample of the study. The study also noted the perception among participants in the study, that shifting to CE would mean losing a decay of investment prior knowledge of CE, and a costly new initial investment for the shift. Lack of technical and technological capacity and the ability to embrace CE practices appears as an important barrier. Another barrier to CE implementation was noted as the lack of supply chain integration and supply chain complexity.

Transforming current linear business models would require new technologies and sustainable production to be integrated into business-as-usual operations, and competent experts who can manage them. However, the demand for environmentally friendly technologies is generally quite low and technical capacities are insufficient. Lack of technical know-how may result in adopting linear business models and technologies by SMEs and they are depending on their suppliers' suggestions for innovative technical solutions (Rizos et al., 2016). Other factors that may prevent the adoption of a Circular Economy approach by SMEs as an insufficient investment in technologies focusing on circular product designs and operations, lack of advanced resource efficiency technologies and low pricing signals of raw materials. (Eijk, 2015).

Although there is significant heterogeneity among SMEs in different sectors, their responses and their capacity to receive a "green solution" are generally similar in terms of organization and management regime. The managers of SMEs are usually also the owner of the firm and thus has significant power on the strategic decisions of the company. As such, some SME managers may have a positive attitude towards green business, while others may not. This divergence of views towards 'green business' has been attributed to several reasons in the current literature. SME are generally willing to take 'green' measures and their attitude towards green policies also depends on the sector in which they operate (Bradford & Fraser, 2007).

Given the significance of the financial challenge and suitable sources of funding could be essential for SMEs seeking to improve their sustainability performance and introduce innovation. Studies indicate, however, that the smaller a company is the more difficult it is to understand and assess different funding options, such as EU support programs and government grants, mainly due to staff and management restrictions (Hoevenagel et al., 2007; Müller & Tunçer, 2013). When is the time comes to bank financing, SMEs, and especially very young small businesses, face problems in obtaining the collateral or guarantees required by the banks, which often consider SME financing a risky business (Hyz, 2011; Müller and Tunçer, 2013).

Caldera et al., (2019) state that the main barriers for SMEs for implementation of Circular Economy come from the high risk due to the size of the enterprise, as many lacks of financial support for their survival, in addition to their lack of risk management plans. This is accompanied by high-cost requirements for the shift to CE, and lack of supporting funds for a sustainable shift, or the unawareness of their existence. The lack of government support legislation (through the provision of funding opportunities, laws and regulations, effective taxation policy, etc.) is broadly recognized as an enormous barrier to the uptake of environmental investments. The absence of a concrete, consistent and strict legal framework prevents SMEs from thinking about greening their business. For example, in EU waste legislation there is no coherent definition or classification of waste materials (e.g., to distinguish waste from by product materials used for recycling), thus inducing limitations on cross-border transportation of waste (Rizos et. Al., 2015).

From the economic perspective, Circular Economy is seen to provide opportunities for cost savings, e.g. by reducing waste and energy costs. Circular Economy provides possibilities for new value creation, business growth and increases in margin and profits.

From the organizational perspective, by following CE principles companies may be able to achieve brand benefits, protect and strengthen their image and enable differentiation (Tura et al., 2019). Cost reduction and expected profitability, according to Egyemag et al. (2018), market share benefit and receiving appreciation for taking eco-business principles are listed among the top drivers to adopt CE, among the automobiles industry in Pakistan.

The participants of the study also noted that consumers in Pakistan showing an increasing interest in circular products, and if this interest became strong and form a market demand, then even market-driven firms with no green interest, will shift to CE. The shift was also found aiming "to identify the new source to increase quality market share and subsequently higher profit" (Egyemag et al., 2018).

New technologies not only find cleaner solutions for the future but also help prevent and overcome problems caused by existing technologies. Information sharing platforms collaborate with many stakeholders and lead to better information transparency, thereby helping to adopt Circular Economy business models (MacArthur, 2013).

The increase in prestige is due to the effective communication of the sustainable strategies of the firms. Increasing prestige improves relationships with consumers and their market share (Ormazabal and Puga-Leal, 2016).

Table 3. CE Challenges For SMEs
Source: Prepared by the authors based on the systematic literature review.

Challenges	References	Opportunities	References
The lack of capital/financial support/resources	Hoevenagel et al., 2007; Rademakers et al., 2011; Geng & Doberstein, 2008; Shi et al., 2008; Ormazabal et al., 2016; Rizos et al., 2015; Caldera et al., 2019; Müller & Tuncer, 2013; Hyz, 2011.	Sustainability of the enterprise	Moore & Morning, 2009; Noci &Verganti 1999; Caldera et al., 2019.
The lack of information, awareness, education, expertise & technical skills	Rizos et al., 2015; Caldera et al., 2019; Cagno et al., 2017; Agyemang et al. ,2018; Caldera et al., 2019.	Cost savings from reducing waste energy and material and financial profitability	Tura et al., 2018, Koirala, 2018; Preston, 2012; Ritzén & Sandström, 2017; Agyemang et al. 2018.
The lack of support from the government	Calogero et al., 2010; Studer et al., 2006; Rizos et al., 2015; Hasan, 2016; Agyemang et al. 2018; Caldera et al., 2019.	Open collaboration and communication practices	Tura et al., 2018, MacArthur, 2013.
Lack of practices and systems for collecting, sharing and utilization	Tura et al., 2018; Caldera et al., 2019.	Increase of prestige, adherence to national and international sustainability, social responsibility goals	Rizos et al., 2016; Del Río et al., 2016; Ormazabal & Puga-Leal, 2016; Agyemang et al. 2018.
Lack of clear incentives	Tura et al., 2018; Agyemang et al. 2018; Caldera et al., 2019.	Recovery of the local environment and potential to create value from waste	MacArthur, 2013; Moore & Manring, 2009; Rizos et al., 2016; Tura et al., 2018.
High initial investment costs	Tura et al., 2018, Koirala, 2018; Agyemang et al., 2018; Caldera et al., 2019; Caldera et al., 2019.	Improving existing operations efficiency	MacArthur, 2013; Feng & Yan, 2007; Caldera et al., 2019; Koirala, 2018, Tura et al.
Incompatibility with existing (linear) operations	Tura et al., 2018, Agyemang et al. 2018; Caldera et al., 2019; Rizos et al. 2015; Tura et al., 2018; Koirala, 2018.	Supportive funds, taxation and subsidy policies	Tura et al., 2018; Koirala, 2018.
Lack of support from supply and demand network	Rizos et al. 2015; Tura et al., 2018; Agyemang et al., 2018.	Increased information sharing through enhanced information management technologies and platforms	Tura et al., 2018; MacArthur, 2013
The lack of consumer interest in the environment or uncertainty of consumer's reaction hinder SMEs' ability to deliver inclusive growth	Nußholz, 2017; Ormazabal et al., 2016; Preston, 2012; Geng and Doberstein, 2008; Tura et al., 2018; Koirala, 2018.	Competitive advantage as consumers seem to expect higher quality sustainable products	Ormazabal et al., 2018; Caldera et al., 2019.
Environmental performance is not considered in the assessments of SME funding decisions	Koirala , 2018; Caldera et al., 2019; Koirala, 2018.	Job creation and entering new markets	Koirala, 2018; Ghenţa & Matei, 2018; MacArthur, 2013; Moore & Manring, 2009.

MacArthur (2015) states that the implementation of Circular Economy in food, mobility and built sectors can help the environment recovery because the "CO_2 emissions could drop as much as 48 percent by 2030 and 83 percent by 2050, compared with 2012 levels. Primary material consumption measured by car and construction materials, real estate land, synthetic fertilizer, pesticides, agricultural water use, fuels, and non-renewable electricity could drop as much as 32 percent by 2030 and 53 percent by 2050". In addition, circular economy gives the opportunity to the companies to conquer new markets whose needs have not been met and ıt represents the opportunity to ensure the sustainability of the business in the long term, as it guarantees the availability and accessibility of resources in the future (Moore and Manring, 2009). Consequently, these opportunities are translated in multiple advantages: SMEs might be able to tap to or capture new markets demanding eco-products, (Moore and Manring, 2009 and Koirala, 2018) and thus increase market share and also generate efficiency gains from greening and reduce costs (Koirala, 2018). Consumers expect higher quality than sustainable products, and the creation of sustainable products can lead to the development of eco-innovation cycles; The demand of consumers and the needs of governments and institutions can lead to the development of inventions, designs and new solutions to meet the human and nature needs of companies (Ormazabal et al., 2018).

Due to the high share of the costs associated with the consumption of energy and raw materials, the European Commission has initiated actions to closely monitor the difficulties that SMEs encounter in the process of transforming the challenges of environmental pollution into opportunities. These efforts have been materialized in an action plan through which the European Union and the Member States intend to support SMEs in exploiting the opportunities for moving to a green economy (European Commission, 2014).

A considerable amount of literature has been published on the challenges and opportunities that SMEs face to implement the CE (Table 3).

Summary

This paper reviewed literatures from different regions and different levels of development, for their understanding and application of circular economy. It was interesting to include and feel the variation in literature from the middle east, and far east, as well as Europe and the USA. The authors researched the difficulties and the opportunities facing the shift in SMEs to a circular economy, or a more sustainable policies and practices. One of the most important obstacles came from the very definition of SMEs. Because of their small size and limited budget and resources, taking a risk is not a preferred choice. Taking risk could be in using their limited resources to invest in the transition. But it can also be in a change that might not be welcomed, not to mention favored, by their supply and demand chain. Other obstacles are related to limitation in understanding circular economy and its potential. Also other important obstacles are related to lack or limitation in the know-how and technology, and also in access to funds related to circular economy adaptation and transition.

Opportunities on the other hands, lay in the potential competitive and comparative advantage an SME can gain if it started first, providing that it was a successful transition, and supported both by government's policies and by powerful market players. Funds and supporting the transition, especially from EU are available, but the challenge is in knowing how to have access to them, and benefit from what they offer. The growing consciousness among consumers and NGOs, especially now with Covid19 implications in calling for more sustainable lifestyle, can support the success of transition, and pave the road for more success, and also for more SMEs to follow their footsteps. It is the opinion of the authors, that the first SMEs who will take a calculated risk and pave the road, will gain momentum and achieve leadership and long-term gains.

Conclusion

In this study, 41 papers were examined to determine what challenges and opportunities to developing the circular economy in SMEs. In general, as the interest in the circular economy, which has gained worldwide popularity, the number of publications in this field increases. A systematic content analysis approach has been applied to increase the reliability and validity of this study.

Implementing the CE approach in SMEs requires that numerous barriers to be overcome. SMEs often lack knowledge about circular economy business opportunities, and many SMEs do not consider 'being green' as a priority. But that doesn't mean that SMEs are against greening their business. Their main priority is on their core business operation. Greening their operations may be interesting for them if it supports their core business. That means we should use the terms like "cost reducing" when convincing them to join the circular economy. Policymakers are required who comprehend the issues and challenges faced by SMEs, policymakers who are capable and ready to influence policy support towards providing solutions for SMEs. Additionally, SME management needs reasonable and clear communication on the regional level in order to know what the problems could be and where to turn to solve these problems.

SMEs can be the main drivers of macroeconomic development towards a circular economy, but challenges and knowledge gaps, and strong uncertainties, often stands in the way of greening their businesses. Additionally, current macroeconomic settings such as deflation and low investments may also discourage SMEs to consider using circular economy models. We need to provide sufficient resources and networking opportunities for SMEs. So that way they can explore the benefits of circular economy opportunities themselves and for that purpose we need a powerful government agenda, various programs designed by policymakers to encourage SMEs to think and act different.

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NDVI REMOTE DETECTION AND LABORATORY SOIL TEST RESULTS PRESENTATION IN GIS ENVIRONMENT

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Abstract: Impact of macroelements in soil on NDVI parameter was analyzed in the paper. Remote sensing and laboratory soil analysis results were compared. Macroelements and NDVI parameter values are variables which relations are not linear. Statistic was used in order to define the relations more clearly. Results of soil sampling and laboratory analysis were compared with NDVI values collected by remote sensing. Main causes of variation of the NDVI parameter are the content of organic matter i.e. humus, soil acidity and content of nitrate nitrogen.

Keywords: remote sensing, soil, GIS, NDVI, analysis

1. Introduction

The daily increase in population and standard of living will lead to the need to increase food production. In order to ensure that demands to increase growth of food production and supplies, as well as to maintain the safety of sufficient quantities of healthy food, it is necessary to find a way to achieve these goals from the same area of arable land. One way to increase production is to make more intensive use of basic agricultural resources, such as land. Deforestation, drainage of ponds and wetlands can increase the area of arable land. However, this would not fully meet the increasing needs. Another way would be to increase the use of other agricultural inputs, such as labor, mechanization, fertilizers, pesticides and water. Changes in the technology that farmers use to transform inputs into edible products are also possible. Each of these responses to demand growth is, in fact, a feature of the progress of agriculture in different parts of the world over the last century.

2. Literature

The earth is to disperse the surface layer of the lithosphere. It is located above a solid rock mass and its upper limit is its biosphere, hydrosphere and atmosphere. Physically speaking, land is a multiphase system. It consists of particles (grains) and pores (cavities) (Fig. 1.). Soil is created by a process called pedogenesis, and it takes two stages. The first phase begins with the decomposition of the rocks and the second with the decomposition of dead remains of plant and animal origin. Soil types include: dust, clay, sand, gravel, but also their combinations (Miller, 1953).

Soil as a substrate for plant cultivation is the largest chemical industry in the world. Proper growth and development of plants requires equal balance of nutrients found in the soil. According to the physiological role, the nutrients are divided into macro (essential) and microelements. Macros can be divided into primary and secondary macros. Primary macronutrients are those without which plants cannot grow or develop. Without them, the plants cannot complete the vegetative and reproductive phase of their life cycle, which is why they are present in larger quantities in the plants. The most significant of these are nitrogen (N), phosphorus (P) and potassium (K). Secondary macroelements by role are the same as primary macroelements, but plants need those in smaller quantities. These include sulfur (S), magnesium (Mg) and calcium (Ca). Certain secondary elements are dominant in determining the yield of a given culture (Licina, 2009).

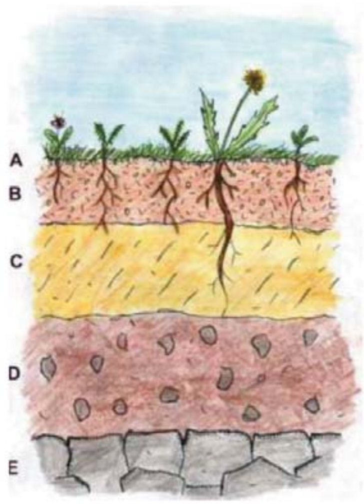

Figure 1. General land profile

Geographic Information System is a system for managing spatial data and associated properties. This system is a computer system capable of integrating, editing, storing, analyzing and displaying geographically defined information. GIS can be considered as a tool for creating a "smart" map that allows users to set up interactive queries, analyze spatial information and edit data. (Magó-Cvetanovski 2019a) GIS technology is nowadays widely used in various fields and can primarily be used for scientific research, development planning, spatial planning, cartography (Bolstad, 2005) (Magó 2009). The use of a geographical information system in the fields of agricultural production is very important. Today the integration of this system with conventional agriculture enables the development of a completely new direction in agriculture called precision agriculture. (Magó-Cvetanovski 2019b) Precision agriculture is not a term that has emerged in the last 20 years; This is supported by the fact that the basic principles of modern precision agriculture were used around 400 years ago, when colonizers of the Americas noticed that local tribes applied different practices in individual places on the plot (Negovanovic, 2018). Further development of this technology has made it possible to gain an understanding of the spatial variability that characterizes most agricultural arable land. Based on this knowledge, there is a need to manage these variability. In addition to GIS, there has been an increasing presence of global positioning systems (GPS) and remote sensing technologies (RS). Remote detection or teledetection is a modern method of gathering information through systems that are not in direct physical contact with the investigated phenomenon or object (Campbell, 2002).

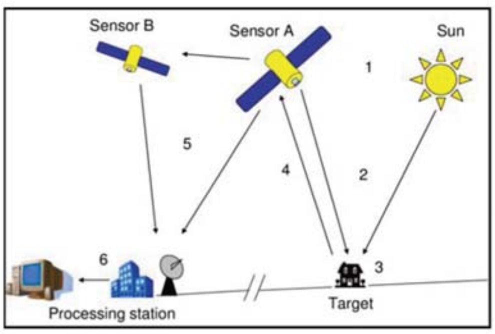

Figure 2. Remote sensing principle

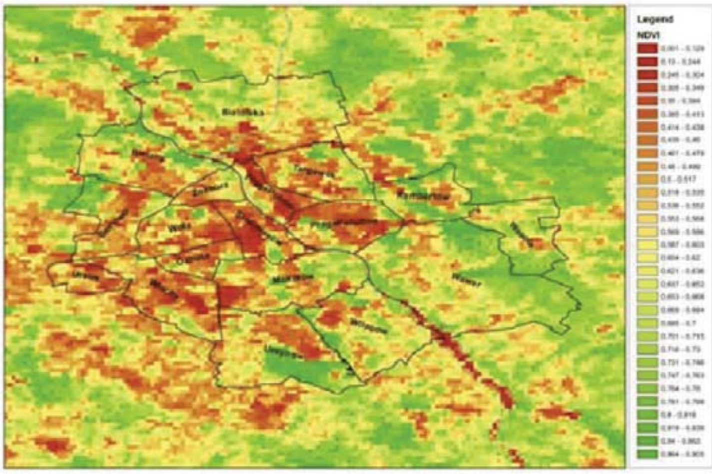

Figure 3. Thematic map of the NDVI parameter values

The principle of remote sensing (Fig. 2.) comes down to the systematic measurement of a certain part of the electromagnetic spectrum and the interpretation of the anomalies found by differences in the properties of the object under study. Remote sensing relies on the wavelengths of reflected light and does not come in direct contact with the object being observed.

The Normalized Difference Vegetation Index (NDVI) is a simple graphical indicator that can be used to analyze measurements obtained by remote detection. The aim of such analyzes is to estimate the amount of green space on the total observed area (Fig. 3). The values of this index vary in the range from -1 to +1. Values approaching the negative extreme indicate the fields where water is on the surface of the earth, and the opposite is the positive extreme indicating the parts with intensive green vegetation.

3. Material and methods

The basic indicators of soil fertility are: total nitrogen, readily available phosphorus and potassium, humus and calcium carbonate content, pH in water and potassium chloride, all of which are determined on the basis of soil analyzes. These fertility indicators are changing during the period of land exploitation in the agricultural production process. Therefore, monitoring them is of great importance for proper land management. Fertility checks must be carried out every four years.

In this fertility control process, the first and very important step is certainly the soil sampling process (Fig. 4.). The soil sampling process consists of several stages: determination of sampling time, preparation for sampling, sampling, preparation and packaging of the soil sample. The best time to sample the soil is after the crop is harvested.

Figure 4. Soil sampling

There are several land sampling systems: diagonal, chess, circle method, combined method, control plots. All of the above systems should aim to have the best coverage of the sampled soil with individual stitches in order to better represent the given plot. The above mentioned sampling systems are in practice the most commonly used systems so far. However, being limited with the approved number of soil samples for laboratory analysis, we have used an adapted sampling method. Namely, through the Internet platform we created thematic maps with values of the NDVI parameter, and in accordance with individual stress and healthy zones, we determined the points from which we took soil samples (Fig. 5.).

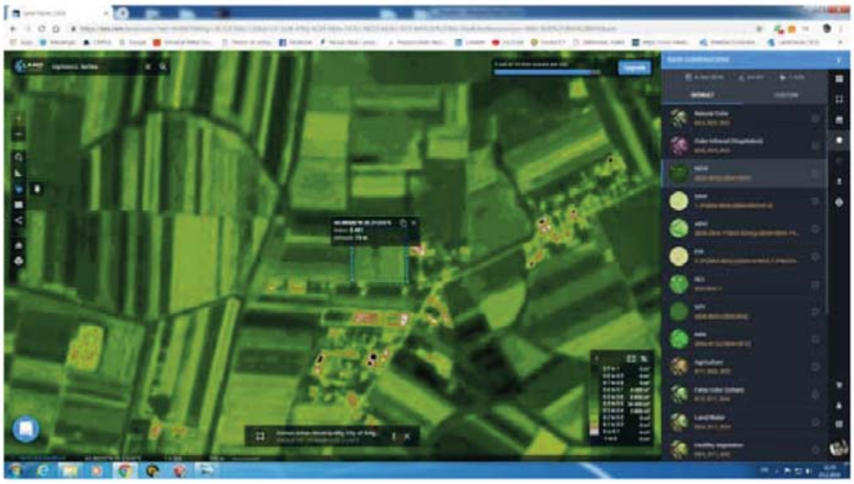

Figure 5. Determining the location for soil sampling

Stress areas are parts of the plot where the value of the NDVI parameter is quite low, which practically means that vegetation in that part of the plot is extremely poor, which further leads to lower yields. On the contrary, there are portions of the plot where healthy and intensive green vegetation is represented, and these portions are destined to carry higher yields than in the case described previously. Once the points bearing the coordinates are marked, it was necessary to find those locations using a GPS unit on the plot (Fig. 6.).

Figure 6. Exact location of the measuring point using the GPS unit

Chemical, biological and micro-biological methods were used to determine soil fertility in order to apply fertilizers for proper plant nutrition. Chemical methods are based on the effect of certain chemical reagents on the soil sample by which the elements are converted into a solution from which the concentration of the test nutrient for plants is determined by a suitable analytical procedure. Before the chemical analysis of the soil, it is necessary to prepare properly the sample, and this procedure involves several work operations (Fig. 7.). It is necessary to dry the sample, then to grind it and remove any impurities from it.

Figure 7. Drying of samples

After drying, it is necessary to inspect the sample once more and remove any residual impurities, and then grind it manually or with special electric mill. Both methods are efficient with the capacity of the electric mill being far greater.

4. Results and discussion

The values obtained show that there are certain variations of this index within one plot. The aim of this paper is to determine the reasons for these variations through soil testing. At the time of taking this data, vegetation on these areas was not in its full stage of development, so it is understandable why the values of this index are not within maximum limits.

Table 1. Comparative presentation of the NDVI parameter value and the results of chemical analysis of soil - Plot 1

	N	E	NDVI	N am.	P_2O_5	K_2O	N ni.	C %	pH	Humus
1	44,8865	20,2135	0,392	0,0049	9,74	35,58	0,0035	1,63	7,96	2,81
2	44,8869	20,2123	0,481	0,0049	2,71	28,95	0,0042	1,89	6,3	3,26
3	44,8878	20,2112	0,576	0,0056	15,48	44,96	0,0014	2,03	6,92	3,5
4	44,8876	20,2135	0,461	0,0042	5,88	31,38	0,0049	1,44	7,89	2,48
5	44,8866	20,2119	0,445	0,0056	6,06	35,99	0,0042	1,78	6,87	3,07
6	44,8862	20,2112	0,502	0,0021	75,88	217,68	0,0091	2,56	7,26	4,41

Based on the statistical data processing, the strongest relation between the observed variables is observed for humus. Namely the content of organic matter causes variation of NDVI parameter on Plot 1. Below are presented results on other plots.

According to the data obtained from Plot 2, significant relation was found between soil acidity and NDVI parameter value. In addition to the acidity, the nitric nitrogen content affected variations of NDVI parameter. Other parameters have the same bond strengths and in this case are not interesting for further consideration.

In Plot 3 analysis, the strength of the dependency between nitrate nitrogen and the NDVI parameter is extremely weak, which is opposite to that found at the previous plot. Other parameters have similar significances of influence to the variations of the observed NDVI parameter.

Table 2. Correlation analysis of observed phenomena - Plot 1

Correlation with NDVI	Value	Correlation
N am.	-0,033868278	Medium
P2O5	0,280301294	Medium
K2O	0,246420108	Medium
N ni.	-0,134214078	Weak
C %	0,531847099	Medium
pH	-0,481038793	Medium
HUMUS	0,53213594	Medium

Table 3. Comparative presentation of the NDVI parameter value and the results of chemical analysis of soil - Plot 2

	N	E	NDVI	N am.	P_2O_5	K_2O	N ni.	C %	pH	Humus
1	44,8912	20,2191	0,62	0,0007	8,1	40,61	0,0056	1,76	6,44	3,03
2	44,8907	20,2185	0,498	0,007	15,95	44,9	0,0056	1,95	7,88	3,36
3	44,8921	20,2192	0,526	0,0063	3,88	33,35	0,0056	1,5	7,81	2,59
4	44,8917	20,2214	0,469	0,0014	11,47	43,97	0,0007	1,75	7,55	3,02
5	44,8922	20,2221	0,431	0,0021	21,36	56,5	0,0014	2,03	7,96	3,5
6	44,8919	20,2221	0,484	0,0007	3,07	32,73	0,0007	1,58	7,86	2,72

Table 4. Correlation analysis of observed phenomena - Plot 2

Correlation with NDVI	Value	Correlation
N am.	-0,05477371	Weak
P2O5	-0,493196204	Medium
K2O	-0,461739335	Medium
N ni.	0,704542836	Strong
C %	-0,342061287	Medium
pH	-0,863729332	Strong
HUMUS	-0,346490345	Medium

Table 5. Comparative presentation of the NDVI parameter value and the results of chemical analysis of soil - Plot 3

	N	E	NDVI	N am.	P_2O_5	K_2O	N ni.	C %	pH	Humus
1	44,8976	20,2171	0,53	0,0021	7,07	39,29	0,0007	2,14	6,87	3,69
2	44,8972	20,2169	0,51	0,0014	4,77	32,33	0,0007	1,62	7,87	2,79
3	44,8974	20,2154	0,494	0,0007	7,75	31,71	0,0007	1,74	7,71	3,00
4	44,8977	20,2161	0,497	0,0014	4,38	33,46	0,0021	2,00	7,34	3,44
5	44,8979	20,2176	0,478	0,0014	9,38	35,53	0,0007	1,84	7,44	3,17
6	44,8983	20,2156	0,507	0,0007	3,65	34,49	0,0007	1,89	7,14	3,26

Table 6. Correlation analysis of observed phenomena - Plot 3

Correlation with NDVI	Value	Correlation
N am.	0,480122629	Medium
P2O5	-0,40384123	Medium
K2O	0,498105204	Medium
N ni.	-0,158422532	Weak
C %	0,418040625	Medium
pH	-0,483075237	Medium
HUMUS	0,421691476	Medium

Conclusions

Data science has a strong influence on the way we consider the data obtained through remote detection, and the large amount of data obtained through this must somehow be correlated with respect to all mathematical and statistical regularities. By sampling and chemical analysis of the soil we obtain all the information that we cannot obtain by remote sensing. By remote sensing we get images that visualize data on the consequences of soil quality, while by chemical analysis we try to find the cause of certain consequences. By combining the two methods, we can come to closer conclusions more clearly, faster and more accurately. The general conclusion is that in all three plots observed, the main causes of variation of the NDVI parameter are the content of organic matter (humus), soil acidity and nitrate nitrogen content.

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DETECTION OF THE EFFICIENCY OF ENZYMATIC HYDROLYSIS AND FERMENTATION PROCESSES BY DIELECTRIC MEASUREMENT

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Abstract: In our work the efficiency of enzymatic degradation of cellulosic biomass was investigated by conventional analytical methods and dielectric measurements. Our results show, that the dielectric measurements proved to be efficient and rapid method to detect the chemical and physicochemical change of biomass during the enzymatic hydrolysis of cellulose. Because of molecular weight decreasing, and the increasing of the concentration of polar and ionic components, the polarization ability of the system has been changed, what manifested in the change of dielectric parameters. Furthermore, dielectric measurements were suitable to detect the efficiency of biomass pre-treatment, as well.

Keywords: fermentation, dielectric parameters, cellulose degradation, biomass

1. Introduction

Development of rapid methods to detect and quantify the efficiency of microbial and enzymatic degradation processes could be one of the key issues of R&D activities in the field of biomass utilization. During the enzymatic hydrolysis, and in anaerobic digestion process the macromolecular components of biomass decompose to lower molecular weight components. In most of the biomass treatment processes (thermal, chemical and enzymatic methods) aim the preliminary hydrolysis of macromolecules and sludge matrix, as well. Dielectric measurements using microwave frequency ranges are suitable for sensing of biological materials and different kind of liquids because of their non-ionising nature, adequate penetration depth inside these samples, and good resolution due to their wavelength (Bircan et al., 2001). Study of dielectric parameters and dielectric behavior of materials helps to better understand the interaction between the materials and electromagnetic field, and has a good potential to detect some physical and physico-chemical change (Holtze et al., 2006).

Among the dielectric parameters the dielectric constant and dielectric loss factor are widely used to characterize the dielectric behavior of materials in radio frequency and microwave frequency ranges. Dielectric constant is the real part, dielectric loss factor is the imaginary part of the complex permittivity (Banik et al., 2003). The former measures the ability of a material to store the energy of electric field and the latter is a measure of the ability of a material to dissipate electric energy converting it into heat. Tangent loss is the tangent of the phase angles between the dipoles direction the irradiated material and the applied field (Metaxas and Meredith, 1993).

There can be found earlier study concerning of dielectric parameters of water and solution in microwave frequencies. Investigation of the dielectric properties of α-D-glucose aqueous solution at microwave frequencies showed that the dielectric constant and dielectric loss factor decreased with concentration (Liao et al, 2001). This is due that the sugar molecules can form hydrogen bonds with the water dipoles, limiting the ability of water molecule for movement and decreasing its polarization capacity. But other study concluded that in higher concentration range of glucose solution (40-60 w%), the change of concentration has any significant effect on the dielectric loss factor. Free water molecules form hydrogen bonds with hydroxyl groups of carbohydrates, suppressing the internal hydrogen bonds in glycosidic bridge. This phenomena contributes to achieve enhanced mobility of glycosidic linkage and worse mobility of hydroxymethyl group. The change of hydrogen bond characteristics can be considered as an explanation of the behavior of relaxation processes in the sample saturated with water (Kaminski et al., 2010). In cellulose contented materials and suspensions the presence of absorbed water significantly changes dielectric properties of polysaccharides (Shinouda and Moteleb, 2005).

At a given concentration, temperature increasing led to increased dielectric constant. It was also verified, that the dielectric constant at lower temperature is more influenced by the glucose concentration than that of observed at higher temperature range (Hochtl et al, 2000). In two component system the dielectric parameters can be estimated based on the observation that the dielectric constant and concentration of carbohydrates has a near linear correlation. It should be noticed, that these simplification presumed that there is no interaction between the two components. Electric conductivity of ionic solutions increases with temperature, because of decreased viscosity and enhanced mobility of the ions. Beside inconsistencies in literature based data, further and deeper investigations are needed to discover matrix effects in suspensions and multicomponent solutions. In fermentation broth produced in anaerobic digestion or enzymatic hydrolysis of lignocellulosic biomass amino acids are presented. If temperature reach a critical value Maillard-type reactions can be occurred between reducing sugars (such as glucose, fructose, xylose, galactose) and free amino acids. Reactive carbonyl group of reducing sugars with nucleophile amino groups of amino acids form heavily characterizable, but higher molecular weight compounds. Maillard-type reactions are accelerated in alkaline condition (Liao et al., 2003). These chemical changes have effect on the complex polarization ability of multicomponent system.

In aqueous solution, especially in supersaturated systems, the effects of concentration increasing on dielectric parameters are influenced by the change of ratio of free to bound water (Fuchs and Kaatze, 2001). Free water molecules have dielectric properties very similar to those that of obtained for liquid water, but the dielectric behavior of bounded water is near to properties that obtained for ice. But it can be noticed that the temperature increment has stronger effect on dielectric parameters of bounded water than that of detectable for free water, because at high temperature the mobility of bounded water increase. In ethanol-water system the ethanol molecule behave as a solute, it forms hydrogen bounds in the hydroxyl groups, decreasing the free rotation ability of the water molecules (Bohigas and Tejada, 2010). These effects led to decreased capability to store and dissipate the energy carried by electromagnetic waves, which manifested in reduced dielectric constant and dielectric loss factor (Sato et al., 2004; Olmi et al., 2007).

Dielectric parameters decidedly provide information about the interaction between electromagnetic field and materials, and has good potential to detect chemical and structural changes, but, however, the change of dielectric constant and loss factor has also effect on the heat generation ability and overall thermal efficiency of microwave irradiation (Leonelli and Mason, 2010). High scale absorption of electromagnetic waves occurs for materials with high dielectric permittivity or high magnetic permeability (Khan et al., 2014). Water molecule, and the high water contented systems and materials have a relatively high dielectric loss factor. Therefore the penetration depth of microwave irradiation in these systems are relatively short. In the frequency range of 900 MHz to 2450 MHz the temperature profile of materials resulted by the exposure to electromagnetic field is dependent on both the dielectric constant and the loss factor, not just on dielectric constants as mentioned often in the literature.

Microwave irradiation, as electromagnetic field, has a specific effect to polarize the side chains of macromolecules. Therefore a change in dipole orientation of polar components can be occurred. Depending of the frequency the water molecules with dipolar characteristics is moving in time with the continuously varying polarity electromagnetic field. Intensity of this movement is influenced by the strength of hydrogen bound formed in materials (Brodie et al., 2014). It is verified for wastewater and sludge matrix that due to hydrothermal and chemical treatment the high molecular weight macromolecular components are partially hydrolyzed, and extracellular polymeric substances and cell walls are disintegrated what increase the concentration of ionic and low molecular weight polar components in liquid phase. With the increment of mobility and concentration of components with higher polarization ability in electromagnetic filed, dielectric parameters are assumed to changed.

In our research work we focused on the applicability of dielectric measurements to detect the degree of biodegradation process for wastewater sludge, and the degree of cellulose degradation in controlled enzymatic hydrolysis process, respectively.

2. Materials and methods

In our work the biodegradation efficiency of microwave pre-treated meat industry wastewater sludge was investigated i) under aerobic condition by using of respirometric biochemical oxygen demand (BOD) measurements (20°C for 5 days) , and ii) under anaerobic condition by using of continuously stirred batch mesophilic (37°C) anaerobic digestion tests. Enzymatic degradation degree of cellulosic biomass (corn cob) was tested by Cellic Ctec2 enzyme (dosage of 30U/g) , reducing sugar (RS) content was measured by spectrophotometric reducing sugar assay (DNSA method).

Beside the commonly used analytical parameters the dielectric parameters (dielectric constant, dielectric loss factor, loss tangent, reflection coefficient) were determined, as well. For dielectric measurements a DAK-3.5 (SPEAG, Switzerland) dielectric sensor connected to a vector network analyser (ZVL3, Rohde & Schwarz, Germany) was applied in a frequency range of 200 MHz to 2,400 MHz. Average values of dielectric parameters was calculated from the data obtained 60 measurements. Samples are thermostated at 25°C during dielectric measurements.

3. Results and discussion

Continuously flow microwave (MW) pre-treatments were carried out with different power intensity (418W and 700W) and varied volumetric flow rate (in the range of 28.5-48.5 Lh-1) for meat processing wastewater sludge. Efficiency of MW pre-treatment was characterized by the ration of biochemical oxygen demand (BOD) to chemical oxygen demand (COD) parameter which corresponds to the ratio of biodegradable (under aerobic condition) to total organic matters. Due to the MW pre- treatments, the concentration of soluble and biodegradable organic matters increased, therefore the BOD/COD improved, as well. Dielectric constant sludge was measured after MW pre-treatment (samples were cooled to 25°C). Figure 1 show the correlation between the aerobic biodegradability and dielectric constant for sludge treated by 418W and 700 W power intensity MW irradiation.

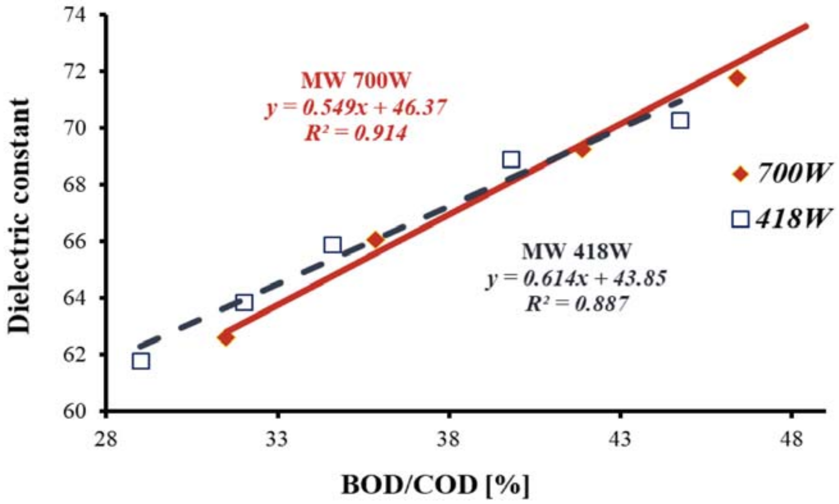

Figure 1. Correlation between dielectric constant (measured at 2400 MHz) and aerobic biodegradability (given by the ratio of biochemical oxygen demand to chemical oxygen demand: BOD/COD) for microwave pre-treated meat processing wastewater sludge (power intensity of 418W and 700W)

Our results verified, that due to the intensive disintegration effect of MW irradiation the free water content, the migrable ionic components and soluble organic matter content increased what manifested in higher ability for polarization in electromagnetic field. Thermal effect of MW resulted in decomposition of macromolecules, disruption of cell walls, liberation of polar and ionic compounds from intracellular space into sludge liquor, and produce of lower molecular weight components (Dogan and Sanin, 2009). These effects led to higher biodegradability and increment of dielectric constant, respectively. Independently from the applied power intensity for MW treatment a strong linear correlation was observed between the BOD/COD and dielectric constant.

To further examination of the efficiency of MW treatment on sludge mesophilic anaerobic digestion (AD) tests were carried out to determine the biodegradability under anaerobic condition. For MW pre-treatments prior to AD tests a continuously flow MW equipment was used with varying the volumetric flow rate of sludge pumping through the MW reactor. Biodegradability under anaerobic condition was characterized by the biogas production, given by the percentage increment of biogas volume related to the control (non-treated) sample (Figure 2).

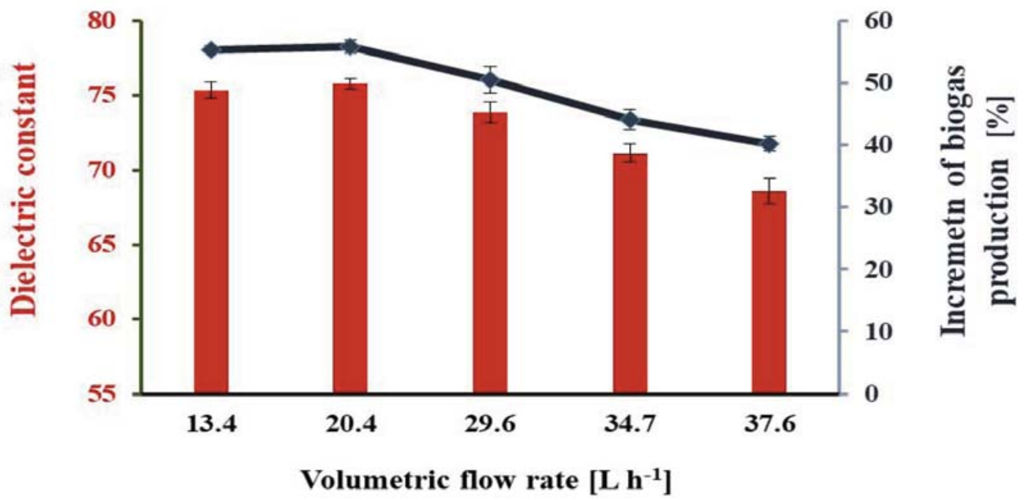

Figure 2. Change of dielectric constant (2400 MHz) and increment of biogas production of sludge (related to untreated sample, produced at 37°) as a function of volumetric flow rate of continuously flow microwave pre-treatment (at power level of 700W)

Results of AD tests show, that MW pre-treatments were suitable to increase the biogas yield from meat processing sludge. Biogas production increased with decreasing of volumetric flow rate of sludge in MW process (which means prolonged residence time in MW reactor). Dielectric constant of MW pre-treated sludge samples was measured after cooling to temperature of AD test (37°) and before anaerobic inoculum dosage. It has been revealed, that the change of biogas production versus volumetric flow rate show similar tendency that of obtained for the dielectric constant measured at the frequency of 2400 MHz.

Applicability of dielectric measurements for detection of biodegradation degree was tested during enzymatic hydrolysis of lignocellulosic biomass (with corn cob residues using high cellulose activity enzyme blend).

Efficiency of enzymatic degradation process was characterized by the concentration of reducing sugars (RS) produced from the hydrolysis of cellulose. Different from the dielectric behavior of sludge, in cellulose hydrolysis process the dielectric loss factor has been proved to be suitable to detect the change of biodegradation degree. In MW processed sludge the dielectric constant at measuring frequency of 2450 MHz was sufficiently sensitive to measure the change of aerobic and anaerobic biodegradability, respectively. Dielectric loss factor decreased with increased sugar concentration, which tendency was observed concluded in preliminary studies (Liao et al, 2001; Shinouda and Moteleb, 2005)

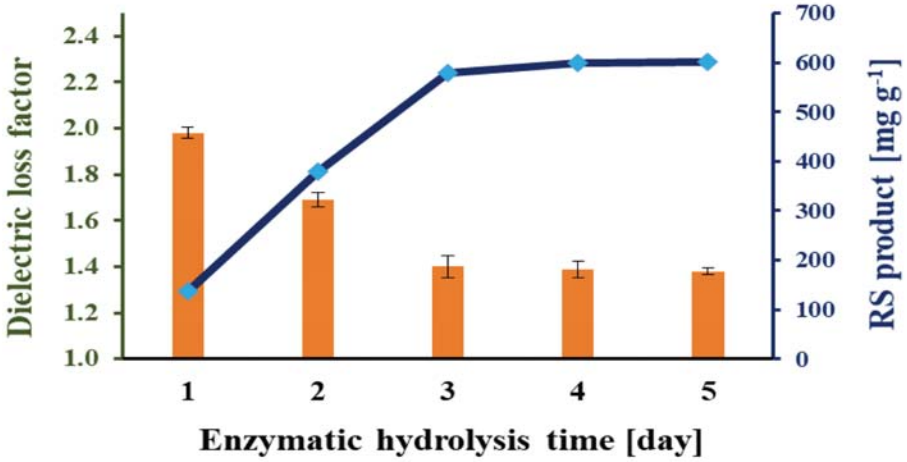

Figure 3. Change of dielectric loss factor (measured at frequency of 400 MHz) and reducing sugar concentration during enzymatic hydrolysis of lignocellulosic biomass (40°C)

In high carbohydrate contented biomass suspension had to decrease the measuring frequency of dielectric loss factor to 400 MHz to find correlation between dielectric behavior and the change of RS concentration. In this frequency the increment of RS concentration caused the decrease of dielectric loss factor. The tendency of the change of loss factor and RS concentration show good inverse correlation (Figure 3).

Conclusion

In our research the applicability of dielectric measurement for detection of biodegradation processes was investigated. Our results verified that both the change of biodegradability of meat processing sludge under aerobic and anaerobic condition, and the change of the degree of enzymatic hydrolysis of lignocellulosic biomass can be detectable by dielectric measurements.
In sludge sample matrix the ratio of biodegradable to total organic matter content (given by BOD/COD ratio) and the improvement of biogas production show good correlation with dielectric constant at the frequency of 2450 MHz. Degree of enzymatic cellulose degradation (characterized by reducing sugars produced from cellulose hydrolysis) correlate with dielectric loss factor measured at the frequency of 400 MHz. Our preliminary results enable to develop rapid, non-destructive method for the control of enzymatic and microbial biodegradation processes, and, however, contibute to define in-line and/or on-line efficiency estimation algorithm and methods for different pre-treatments.

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Faculty of Mechanical Engineering

SOIL MICROBIAL PARAMETERS AND SYNERGIES BETWEEN BEAN GROWTH AND MICROBIAL INOCULUMS AS A DEPENDENCE OF FIVE SOILS WITH DIFFERENT CHARACTERISTICS

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Abstract: The objective of the present study was to monitor the soil biological parameters. We used the bean as a test plant, grown in five soils with different texture and organic-matter content and estimated them (biomass production and shoot length). The seeds of the test plants were inoculated by combined strains. Results have shown that the treatments influence the counts of microorganisms. This study, therefore, was highlighting the importance of soil physical-chemical parameters, so as to result in a successful application of the biofertilizers in the different soil-plant systems.

Keywords: soil biology, Phaseolus vulgaris, MPN, biofertiliser, Hungarian soils,

1. Introduction

Bio-efficient solutions that can biologically deliver nutrient and crop protection in a single step can play an important role in maintaining soil use. Such soil treatments can be microbial inoculants (Dudás et al. 2017a, b; Biró 2017). Depending on the environment, microbial weights per hectare are, according to literature, between 3 and 15 tonnes, not including other participants in the soil-food web; their significance is not negligible (Kotroczó et al. 2009, Fekete et al. 2017, Béni et al. 2017).

The so-called plant growth promoting rhizobacteria (PGPR) can help plant growth in different ways (Kocsis et al. 2018) and may also synergistically strengthen each other (Kocsis and Biró 2015). PGPR functions and synergistic properties of species (Enterobacter ludwigii, Bacillus subtilis, Pseudomonas fluorescens, Kosakonia cowanii, Trichorderma harzianum, és Phanerochaeta chrysosporium) used in the experiment have been reported in several previous studies. E. ludwigii PSB is a phosphorus soluble (P-solubilizing) bacterium, biocontrol species, indole acetic acid (IAA) and iron chelating (siderophore) and increased the biomass of test plants (Shoebitz 2009, Dolkar et al. 2018, Rajnish 2018). B. subtilis is also a known biocontrol species with PSB and cellulose degrading properties (Xiaoying et al. 2015, Ahmad et al. 2019, Kim et al. 2011). P. fluorescens is also a frequent component of bacterial fertilizer due to its biocontrol, PSB, siderophore and IAA production properties (Xiaoying et al. 2015, David et al. 2018). K. cowanii has been described for its biological N2-binding property as well as for its related species, PSB, as well as for producing IAA and siderophore, so it is likely that the K. cowanii strain we use has these capabilities. (Menendez et al. 2016, Brady et al 2013, Zhu et al. 2013, Lin 2012). In addition, extracellular polysaccharide (EPS) producing properties have been observed in E. ludwigii and K. cowanii strains under laboratory conditions, which are capable of improving soil structure. T. harzianum is known for its biocontrol and cellulose-degrading properties (Abdel-Fattah et al. 2007, Haddadin et al. 2009). Ph. Chrysosporium is the most well-known white-rot model organism and thus is a lignin-degrading organism, which, in combination with T. harzianum, may increase the rate of organic matter degradation (Haddadin et al. 2009).

However, in the third generation of agri-environmental applications of bacterial fertilizer, there are still unknown factors that need to be further investigated for their effectiveness (Bashan et al. 2013). bacterial fertilizer may behave differently and may not necessarily function on different soils (Kincses et al. 2008, Balláné et al. 2008). In order to eliminate this and to improve the functionality of the introduced living strains, natural clay minerals can be used to improve the primary Physico-chemical state of the soil, thereby creating a more favorable environment for both plants and microbes. They also help plants grow and gain nutrients with their mineral content (Solti 2000, Tállai 2011). Such a clay mineral is the alginite, which contains nearly 60 mineral elements. Its use is environmentally friendly and presents a low health risk to chemical methods (Kardos et al. 2011). With proper selection and selection of fertilizer strains, it is also possible to implement biotic and abiotic inoculations adapted to the given soil-environment conditions (Kovács et al. 2017).

In the present study, different soils were used to investigate the influence of the physico-chemical properties of soils on the effectiveness of the selected inoculants that favor plant growth.

2. Materials and methods

A pot experiment was set up in the light room of the Department of Soil Science and Water Management at Szent István University, Faculty of Horticulture. Under controlled conditions, light conditions were set for a 16/8 hour day / night period for plant growth. The temperature was 22 ± 2 °C and the relative humidity was 55 ± 5%. The pots were watered as required.

Soils: The plants were grown on five domestic soils with different characteristics. Their origins are shown in Figure 1. The soils have a neutral, slightly alkaline pH, but they are different in binding and also in organic matter content. Soils correspond to the genetic soil types used in cultivation. The most important physicochemical properties of the soils used are shown in Table 1. 850g of dry soil was used per pot.

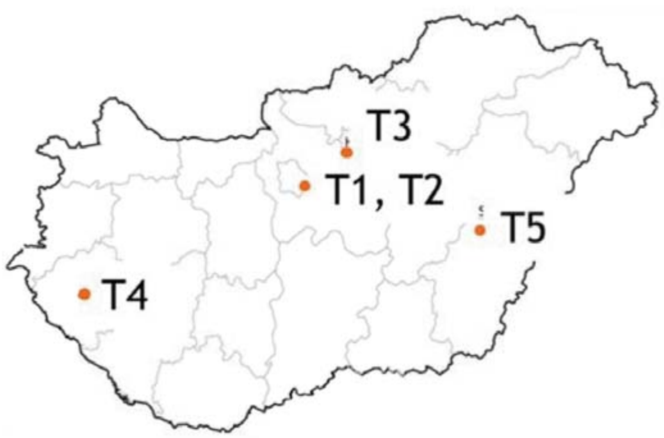

Figure 1. Types of soils used, and their origin are classified according to WRB (2015)
T1: Arenosols (Soroksár 1), T2: Gleysols (Soroksár 2), T3: Chernozems (Hatvan), T4: Luvisols (Tófej), T5: Gleysols (Szeghalom).

Bush beans (Phaseolus vulgaris var. Maxidor) were used as test plants. Plants were seeded in culture pots (4-4 seeds / pot) and after emergence the same number of plants (1 plant / pot) was left. The strains in the inoculation are listed in Table 2, along with their expected pre-laboratory-tested functions. One ml of inoculum was used per culture pots and in cotrol pots killed bacterial suspension was added. Soil samples were taken at 60% flowering at the same time as the experiment.

The number of colonies that can be cultivated on soils was determined by the MPN (Most Probable Number) method using the Hoskins table (Cochran 1949). Thus, the colonization numbers of all cultivable mesophilic aerobic bacteria, microscopic fungi and spore-forming bacteria were examined (Olsen 1996). enzymatic activity of the soil was determined by DHA (dehydrogenase) method (Veres et al. 2013). Even measured the height of the plant shoot, and shoot and root dry weight. 4-4 repetitions were used per treatment.

Table 1. The main physicochemical properties of the used soils in the pot experiment.

Soils and investigated properties	T1	T2	T3	T4	T5
Texture	Sand	Clay loam	Clay loam	Clay	Clay
$pH_{(H2O)}$	7.49	7.42	7.44	7.50	7.61
$pH_{(KCl)}$	6.94	7.13	6.58	6.74	6.45
Water soluble salt m/m%	0.0317	0.0216	0.02677	0.0555	0,0665
Amount of humus (H%)	2.18	4.09	4.63	3.89	3.75

The results were processed using GraphPad Prism 6. The normality test was verified by the Kolmogorov-Smirnov test, the dispersion homogeneity by the Levene test. Statistical analysis of the results was performed by two-way analysis of variance (ANOVA) and Tukey's test, and the results were interpreted at 95% significance level ($p < 0.05$).

Table 2. Potential and expected properties of soil strain microorganism strains

Strain composition	Properties, abilities
Enterobacter ludwigii	PSB, Fusarium fungal antagonism, IAA-, siderophor and extracellular polysaccharide production
Bacillus subtilis	Cellulose decomposition, PSB, biocontrol
Pseudomonas fluorescens	PSB, biocontrol effect, IAA- and siderophore production
Kosakonia cowanii	Nitrogen bonding, PSB- and EPS production
Trichorderma harzianum	Biocontrol effect, cellulose decomposition
Phanerochaeta chrysosporium	Lignin degradation

Legend: PSB: phosphorus solubility, IAA: hormone production, EPS: polysaccharide production

3. Results and discussion

In the subsequent section of this article, all data refer to Table 3.

The greatest effect of the treatments on the measured parameters was on the cultivable germ count of microorganisms.

Inoculated T5 soil showed significantly higher values than all controls when examining the total number of cultivable mesophilic aerobic bacteria. Inoculated soil T1 and T4 showed higher values than the inoculated T1 and T4 soils. Thus, the bacterial components of the vaccine showed the most effective effect on the highest clay content soil.

In all cultivable microscopic fungal counts, the values of inoculated T4 and T5 soils were significantly higher compared to the controls. Among control soils, T4 was significantly higher compared to T1. It is not significant, but the tendency of the soils is higher than that of the treated soils, except for T2. This indicates that the fungal components, presumably primarily T. harzianum, successfully survived application and were able to persist in the soil until the time of measurement. The number of fungi also gave a similar result to the total number of bacteria, ie the treatment was more effective on the highest clay content soil.

The number of cultivable spore-forming bacteria was significantly higher than the inoculated T2 soil compared to the control, and in the control soils the T3 and T4 soils gave significantly higher values compared to the T2 soil. Similarly to the number of fungi, a nonsignificant but tendency-higher value is also observed for the inoculated soils.

This leads to the conclusion that the inoculum increased MPN values in all groups tested. T1 and T2 soils from Soroksar have lower MPN values, especially considering the number of microscopic fungi. This is probably due to the looser soil structure. All bacteria and fungi showed the highest growth on the bound T4 and T5 soils, whereas the sporulated bacteria had a significant effect on the loose T2 soil. Such soils are subject to more extreme conditions in nature, since the looser the structure, the more easily the moisture is removed and the soils are also more exposed to heat fluctuations. This provided information on which soils of the inoculum components perform better.

Table 3. The studied parameters are soil (MPN) and plant. Data are shown as means±SD. Different small letter means there is significant difference between soils, and data written in bold type means there is significant difference between inoculated and control samples by Tukey's multiple test ($P < 0.05$), n= 4.

Sample ID	Treatments	MPN method			Plant growth	
		bacteria (logCFU/g)	microscopical fungi (logCFU/g)	spore-forming bacteria (logCFU/g)	dry weight (g/plant)	shoot length (cm)
T1	Control	6.10±0.42[a]	3.65±0.25[b]	5.45±0.22[ab]	1.00±0.32[bc]	23.5±1.96[ab]
	Inoculated	5.90±0.35[b]	4.12±0.19[b]	5.75±0.43[a]	0.94±0.38[bc]	21.0±1.14[b]
T2	Control	5.97±0.47[a]	3.84±0.41[ab]	4.89±0.17[b]	0.82±0.37[c]	21.4±1.92[b]
	Inoculated	6.29±0.28[ab]	3.40±0.31[c]	**5.54±0.35[a]**	0.62±0.02[c]	24.0±3.90[ab]
T3	Control	6.29±0.28[a]	4.43±0.14[a]	5.63±0.52[a]	1.87±0.44[a]	27.1±2.84[a]
	Inoculated	5.94±0.23[b]	**5.50±0.16[a]**	5.57±0.14[a]	1.70±0.31[a]	26.9±1.67[a]
T4	Control	6.08±0.55[a]	4.12±0.34[ab]	5.72±0.17[a]	1.46±0.18[ab]	24.4±0.74[ab]
	Inoculated	6.47±0.33[ab]	4.50±0.16[b]	5.90±0.35[a]	1.44±0.07[ab]	23.8±1.62[ab]
T5	Control	6.09±0.32[a]	4.23±0.57[ab]	5.54±0.35[ab]	1.41±0.29[abc]	25.5±1.68[ab]
	Inoculated	**6.80±0.19[a]**	**5.33±0.27[a]**	5.73±0.29[a]	1.13±0.41[abc]	22.9±2.32[ab]

The impact of the microbial inoculants in the soil culturable bacteria count

Microbial soil inoculating has been shown to increase the biological status of soils. Thus, beneficial microorganisms can carry out their activities when they enter the soil..

Changes in plant growth as a result of treatments

Statistical analysis of the plant biomass weight showed that the dry weight of the shoot showed no significant difference between the control and the treated soils. In some soils, it was also observed that the dry weight of the inoculated plants was lower compared to the control plants. This tendency has been described previously (Jakab 2014), but relatively little attention is paid to such a negative effect on plant growth compared to expectations. The reason for this is the following effect. Microorganisms entered into the rhizosphere by inoculation should be fed to the root extrudates when plant photosynthetic activity is not yet sufficient and/or when there is not enough organic material in the soil for microbial nutrition. This may initially hold back the growth of the plants, as their photosynthetic product is thus not fully utilized for biomass growth. Further investigations will be needed to determine the actual factors involved.

Examine the shoot length, the inoculated plants did not show significant differences compared to control plants. Examining the soils, similar results were obtained as for the dry weight of the shoot, although the shoot length of the plants decreased in a trend-like manner.

Assessment of differences between soils

Significant differences were found between soils in the evaluation of many of the investigated attributions. Plants grown on T1 Soroksar soil were smaller compared to plants grown on T3 soil. In contrast, plants on T2 soil were smaller than plants grown on T3 and T4 soil. This is due to the Physico-chemical properties of soils, which also affects the nutrient supply capacity of soils.

Examine the shoot length, the treatments did not show significant differences compared to untreated plants. Examining the soils, similar results were obtained as for the dry weight of the shoot, although the shoot length of the plants decreased in a trend-like manner.

We conclude that the initial physical condition of the soils has a major influence on the "susceptibility" of the soil to the effectiveness of the inoculation treatments (Kincses et al. 2008, Balláné et al. 2008). The high clay content of T5 soil provided more habitat for microorganisms, so the soil was generally more responsive to inoculation treatments than T1 soil. The more aerated soil with larger pore space primarily supported the growth of fungi in the inoculum (Trichorderma harzianum , Phanerochaeta chrysosporium) against the bacteria.

Conclusions

All in all, the effectiveness of inoculation is fundamentally influenced by the physical condition of the soil. On soil with higher clay content, MPN values increased as a result of treatments. This is most noticeable in the number of microscopic fungi, especially in T4 and T5 soils (Tófej, Szeghalom). This is likely to indicate the presence of T. harzianum in the inoculum.

It is also possible to deduce from the dry weight of the plant shoots that there are significant differences in the basic Physico-chemical properties of the soils, which also influence the reactions to microbial inoculum treatments. In some soils, inoculations negatively influenced the growth of plants, which is explained by the very early inoculation relative to the stage of development of the plant. The influence of plant physiological properties and environmental conditions should be considered when choosing the time of inoculation.

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DEVELOPMENT OF 3D PRINTING RAW MATERIALS FROM PLASTIC WASTE

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Abstract: Having studied the applied plastic recycling technologies, materials for 3D printing and the 3D printing technologies it is realized that the quantity and quality of plastic waste differs from country to country and from company to other , PET is recycled quite frequently and has the number "1" as its recycling symbol, and after drying PET prepared for extrusion, then material is shredded and dried, its ready to be extruded. The 'Next filament extruder' was used for the extrusion of PET (shredded format), with 3 different diameters of shredded material and constant range of temperature heater and speed of fan speed, the measurement can be ready after 3 or maximum 5 tests. After testing and measuring with different diameters, making filament from shredded PET will work better if it's made with a diameter of 1.75mm which means a thicker diameter is used, the filament will probably collapse under its own weight, causing the filament to swirl and jam in the filament sensor.

Keywords: recycling, 3D printing, plastic, waste management

1. Introduction

Having studied the applied plastic recycling technologies, materials for 3D printing and the 3D printing technologies it is realized that the quantity and quality of plastic waste differs from country to country and from company to other. In the case of waste plastics that are recyclable and reusable, the most widely used are polyethylene terephthalate (PET, used for synthetic ¬fibres and water bottles), and second high-density polyethylene (HDPE, used for jugs, bottle caps, water pipes).

The current applications for using recycled plastics in fabrication and design are fairly limited, on a small scale, plastics (such as ABS, HDPE, or PET) are shredded and formed into pellets, and then either extruded into ¬lament to be used in existing 3D printers, or injection moulded into small parts and pieces of larger components. At a large scale, recycled HDPE is melted into sheets and either used directly as sheets in construction, or then heat formed from a sheet into components for construction. These methods of fabrication using recycled plastics are the norm because of their affordability and straightforward processes, yet each method leaves some complexity to be desired.[1].

Regarding the recycling technology, the previous methods of recycling and recovery routes for solid plastic waste are detailed and discussed covering:
–re-extrusion
–mechanical treatment
–chemical treatment
–energy recovery

Based on the previous research I performed on this field, the main objective of my project is the contribution to the development of sustainable, effective technologies on the field of plastic recycling, both from the economic and ecological point of view

2. Methods and materials

Recycling technology: PET plastic waste aggregate was prepared by grinding waste PET plastic bottles. The preparation process of PET plastic waste aggregate includes the following steps:

–Collecting the PET bottles wastes.
–Removing the cover and trade label.
–Washing and drying the bottles.
–Shredding and grinding the PET bottles to the specified particle size

The grinding process was carried out in the FKF ZRT. (see in Fig. 1):

Figure 1. PET plastic recycling steps

Contacting FKF.ZRT which is recycling company of plastic in Budapest, they provide a table, that shows the types and the ratio of the collected selective waste from the last year. These numbers are based on their monthly sorting.

By selecting few months from all year, it shows the importance and the highest quantity of clean, blue or coloured PET which the main material for the research.

Table 1. Types and ratio of the collected selective waste during 2018

2018		January		February		March	
		Kg	m/m%	Kg	m/m%	Kg	m/m%
PET	Clean	30,4	12,2	27,0	10,6	30,2	11,9
	Blue	38,5	15,4	30,4	11,9	32,6	12,8
	Coloured	10,9	4,4	16,0	6,3	18,9	7,4
Foil	Dyed	6,3	2,5	8,6	3,4	5,6	2,2
	Natural	4,1	1,6	7,3	2,9	5,0	2,0
Flacon		36,5	14,6	25,4	10,0	22,4	8,8
Hungarocell		0,3	0,1	1,0	0,4	1,4	0,6
Metal	Tinned metal	6,0	2,4	6,2	2,4	3,0	1,2
	Aluminium	6,1	2,4	6,4	2,5	3,3	1,3
Other Waste		111,1	44,4	126,3	49,6	131,8	51,8
Altogether		250,2	100,0	254,6	100,0	254,2	100,0
Recyclable		138,8	55,5	127,3	50,0	121,0	47,6
Non-Recyclable		111,4	44,5	127,3	50,0	133,2	52,4

The main production for PET is for the applicability of synthetic fibres (in excess of 60%) with bottle production accounting for around 30% of global demand. In terms of textile applications, PET is generally referred to as simply "polyester". The terminology “PET" is used generally for packaging applications. The polyester industry makes up about 18% of world polymer production and is third largest industry after polyethylene (PE) and polypropylene (PP). [2].

PET is recycled quite frequently and has the number "1" as its recycling symbol. The first PET was patented in 1941 by John Rex Winfield, James Tennant Dickson and their employer the Calico Printers' Association of Manchester and the PET bottle was patented in 1973 by Nathaniel Wyeth. PET is also used as substrate in thin film and solar cell.[3].

Table 2. Thermal properites for PET

Material	Polyethylene Terephthalate
Melting point [°C].	225
Drying time [hours]	4-5
Drying temperature [°C]	160

Some tests will be provided in laboratory of mechanical engineering in Szent Istvan University, probably around 3 to 5 measurement.

First drying PET prepared for extrusion, after the material is shredded and dried, its ready to be extruded. The ‘Next filament extruder’ was used for the extrusion of PET (shredded format).

Figure 2. Example of extrusion machine

Three tests will be done with different diameter of shredded material

With 3 different diameters of shredded material and constant range of temperature heater and speed of fan speed, our measurement can be ready after 3 or maximum 5 tests. Table 3 shows the settings used for every test.

Filaments product for 3D printing: The following materials were used in this research:

–recycled polyethylene terephtalere(rPET), supplied by FKF ZRT

–polyethylene terephthalate (PET).

For the test, it starts by filament quality control contain the measurement of diameter of recycled polyethylene terephthalate and the filament in interval of 1 meter, after will be test the surfaces and cross section of the materials and then find the melting point which shows the thermal properties. Second test will be tensile testing for raw materials

Table.3 Setting and parameters using during the test

TEST	Diameter of shredded material(mm)	Temperature range[°C]	Filament fan speed (%) and extruder(rpm)
1	2,85	240-245	80-5
2	2	240-245	80-5
3	1,75	240-245	80-5

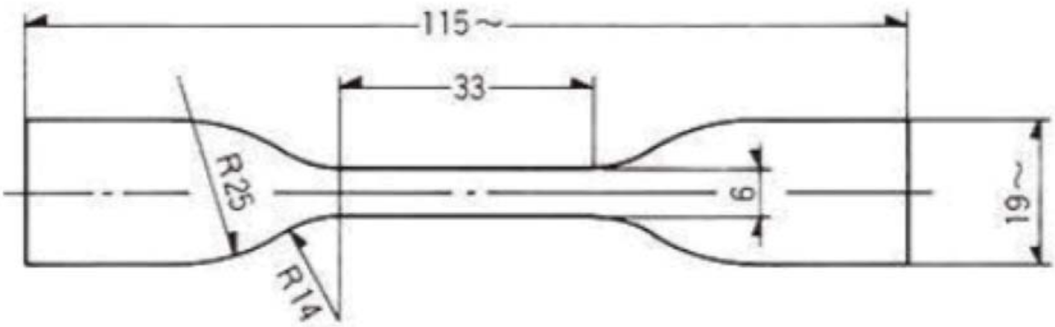

*Figure 3.*Sample type of tensile testing

Tensile testing was performed by using a material testing machine, Testometric M 350- 5CT see Figure 4 (faculty of mechanical engineering SZIE).

Figure 4. Material testing machine, Testometric

3. Results

Recycling technology: Recent research points the way towards chemical recycling methods with lower energy requirements, compatibilization of mixed plastic wastes to avoid the need for sorting, and expanding recycling technologies to traditionally non-recyclable polymers.We mentioned the recycling technologies from which we concluded that mechanical recycling is the only widely adopted technology for large-scale treatment of plastic solid waste. The main steps were the removal of organic residue through washing, followed by shredding, melting, and remoulding of the polymer, which is often blended with virgin plastic of the same type to produce a material with suitable properties for manufacturing.In my previous research supervised by Dr Zoltán Bártfai, It found solution for grinding and extruding plastic using machines with two different parts: crusher, extruder and mixed it together.

The crusher consisted of 12 blades twelve anvil-blades, right axis, left axis, cover, sieve, fourteen casing spacers, four nuts, two pins and crank. [4].

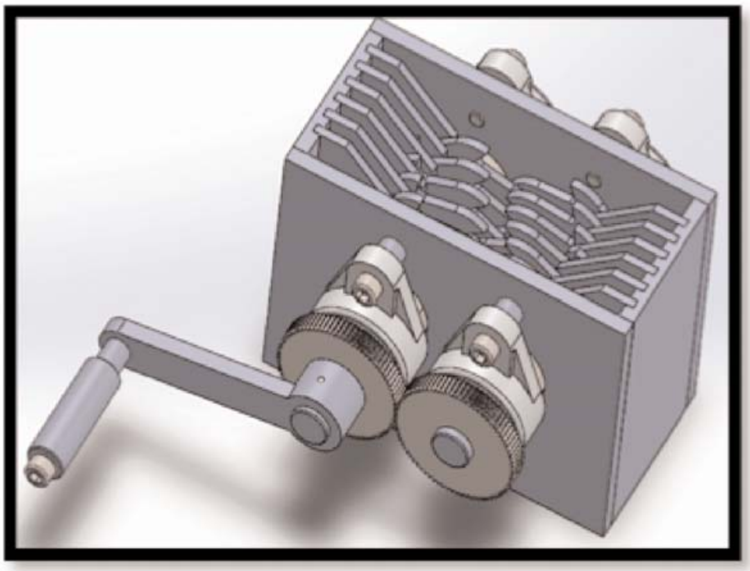

Figure 5. Overview of the complete design of the crusher

Current technologies that move beyond mechanical recycling include pyrolysis (thermolysis) to selectively produce gases, fuels, or waxes through the use of catalysts; are referred to as chemical recycling. Chemical recycling is not a widespread recycling practice, mainly because of energy costs. A further option is the incineration of materials and collection of energy in the form of heat. Incineration is convenient for the treatment of mixed waste because it avoids the need for sorting, but it does not allow for the recovery and reuse of the starting components once burned. It also does not save as much energy as recycling.

Filament product for 3D printers: Within the frame of this research project, performing adequate laboratory test processes we are going to cooperate with the FKF ZRT. This company works in a strong connection with the faculty of mechanical Engineering. They have well equipped laboratory for testing recycled plastic waste.

Previous test show that conductive anti-static ABS has advantages with excellent mechanical strength, impact resistance, dimensional stability, high flow creep resistance and excellent heat and low temperature resistance.

Several trial tests were run but optimal conditions for the rPE extrusion process were not found. The outcome of rPE filament was good. PET filament was better. The main problem during rPET extrusion is the stoppage of the material flow.

In the middle of the extrusion, extrudate stopped coming out of the die that caused rHDPE filament to thin out and eventually to break. Pristine HDPE extrusion went without any complications.

Figure 6. Produced filament from PET

Conclusions

The aim is to test of normal plastic bottles can be turned into 3D printing filament. The following is a quick summary of our tests to turn around 30 bottles into filament. Water bottles were collected, cleaned (properly) and any external caps or seals were also removed, the bottles were then vacuum sealed and heated to reduce their size, once cooled the bottles were cut into smaller chunks with a saw and a pair of scissors, after that, the pieces were shredded into tiny pieces, the pieces were then dried at a temperature of 160°C for 4 hours, The PET was then fed into next filament extruder, after multiple tests at different nozzle diameters and temperatures, our team ended up with a great result of PET filament, Recently, the US Department of Defence (DoD) is exploring 3D printing feedstock made from plastic containers that have been left on the battlefield, which can hopefully be reproduced in other government sectors. There's also Ethical Filament, a company focused on promoting the concept of recycling to produce ethical 3D printing filament that is sold to improve the livelihoods of waste pickers and their communities worldwide. Then there's the Perpetual Plastic Project (PPP), which is an installation which can directly recycle old plastic drinking cups into 3D printing gadgets as well as other plastic products if needed.

While there is more and more aware of using recycled filament for 3D printing, we still have a long way to go. Hopefully, with the rise in 3D printing over the last few years, more emphasis is being placed on plastic recycling.

Nomenclature

PET: PolyEthylene Terephtalate
ABS: Acrylonitrile butadiene styrene
PLA: Polylactic acid
rPET: Recycled polyethylene terephtalate
FKF: Public service company owned by the Municipality of Budapest.
PE: Polyethylene
HDPE: High density polyethylene
MPA: pressure measured in megapascal

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SMART CONTROL ON AGRICULTURAL MACHINES

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Abstract: Precision Agriculture technologies are efficient tools to improve sustainability and productivity in farming. These technologies offer solutions to produce more with less.
Nowadays the increasing of the efficiency of agricultural production and the increasing of crop yields cannot be achieved without modern digital technology and smart machines that are a part of it. Next to the power machines the attached equipment is becoming smarter and smarter.
In this work, without completeness, we present smart solutions from medium-sized innovative manufacturer of agricultural machines which are independent from the size of the machine and which are effective tools for the utilization of machines, for the precision machine work.

Keywords: smart machines, Precision Agriculture, GPS, spreading, variable rate fertilizing

1. Introduction

Many authors have reached to the conclusion that development of digital technology and applications are regarded as an important factor in their economic growth and development in the agricultural production. The improvement of mechanization of field work, machinery and equipment is a continuous process. We are witnessing the spread and agricultural use of the more and more modern equipment, which reflects to the technical and technological level of the area (Kovács and Husti 2018).

Precision Agriculture is just a hypernym and can be divided into three major topics Auernhammer (2002),: “Precision Pasturing”, “Precision Lifestock Farming” and “Precision (Crop) Farming”. While Precision Pasturing focuses on methods for e.g. managing feed supply and stocking rates on pastures (Schellberg, et al. 2008), Precision Lifestock Farming addresses all kind of systems which correspond with animals in husbandry. The last topic, Precision Farming, is defined as technology-supported cultivation of agriculturally used areas (Doluschitz, et al. 2011). (Bauerdick, et al. 2017)

The aim of precision, or site specific agriculture is to handle within field variability (Auernhammer et al. 2001) with input materials to achieve the highest and sustainable profit. The approach mainly benefits from the development of technologies like GPS, GIS, computer technology, automatic control, remote sensing and advanced information processing (Gibbons 2000) Farm field under conventional management receive uniform applications of these inputs like fertilizers, herbicides, seed or irrigation. (Mulla 2013) (Bűdi et al. 2018)

The most popular precision agricultural technologies are the grid soil sampling, the variable rate fertilizer applications, the global positioning systems and yield mapping and the variable rate seeding (Daberkow and McBride 1999, Mackay 1997, Taylor and Whelan 2010, Bullock et al. 1998, Clark and McGuckin 1996, Nafziger 2012).

The biggest problem with the precision farming technology is that the possible advantages and disadvantages of the technology highly depend on the professional knowledge and attitude of the farmers or of the manager and the stuff of the agricultural company. The appearance of a new technology in generally of great interest, the so co-called ‘new technology fun’ farmers try the application, invest in the new equipment – and very often without the proper knowledge, skill – they implement it into their farming. After the first experiments – if they have not got good yield and economic result – many of them give the new technology up, or did not continue the introduction and extension of the new item. The excessive expectation does not match with the reality. After the interest peak, there is almost temporary disillusionment. After the refinement of the technology, its applicability improves, instead of the risks, the benefits come to the fore, leading to its spread in production. (Takácsné 2018)

2. Material and method

Smart Farming

"Smart Agriculture" and "Digital Farming" are based on the emergence of smart technology in agriculture. These technologies are using smart devices which consist of sensors, actuators and communication technology (Kovács and Husti 2018).

Digital systems, sensor techniques and technologies, remote sensing on different platforms, artificial intelligence including machine learning and deep learning, and in particular unmanned or quasi unmanned production systems are developing fast, and these are the tool for dynamic sustainability. In the future there will be the integration of these common players into smart transport, smart organisation, and smart landscape management by smart policy making. (Lundström and Lindblom 2016, Urso et al. 2017, Kempenaar et al. 2016, Neményi 2018)

The Smart Logistic System, integrated with the ERP (Enterprise Resource Planning), enables application of 4.0 industry approach. Its intention is to enable same application to agricultural machinery, e.g. for logging the seeding and fertilizing process (lot, operator, date, quantity) and remote diagnostic by using IoT ready systems. The advantages of own production applied utilization of digital information to trace the different materials and automate their handling, are listed following objectives:

- –to reduce the material handling;
- –to reduce the inventory failures;
- –to implement flexibility with discipline;
- –to find one place for everything and everything in its place;
- –to set a FIFO (First In First Out) rule;
- –to implement the material traceability. (Martinov et al. 2018)

The Company INO Brežice d.o.o.

A Slovenian company INO Brežice produces a variety of mulching machines, vibrating subsoilers, fertilizer spreaders. Among the company's innovative products are so-called "Smart Solutions" which ensure a safe and efficient operating of their basic products:

- –flail mowers by means of continuous measuring vibrations and detecting the outstanding ones,
- –fertilizer spreaders and vibrating subsoilers by efficient specific electronic control of operating. (Šubic 2017)

3. Results

INO Smart Flow

INO Smart Flow ensures the quality work of the FERTI-2 type double-disc mounted fertilizer spreader (Figure 1.) and the VVP 115 vibrational subsoiler with deep fertilizer spreader (Figure 2.). It is well known regarding versatility and an ease of use. Nowadays, site-specific nutrient application comes to the fore. Thus, accurate determination of the amount of fertilizer applied and precise dosing is essential. With this system cost savings can be achieved through efficient production and avoidance of excess nutrients.

INO Smart Flow electronic regulation of fertilizer flow on Ferti-2 is the system, which automatically regulates the position of both shutters on the bottom of the hopper. It is completely developed and designed in INO Electronic Department.The machine ensures equal spreading density (kg/ha) across the spreading area, regardless of the working speed. At faster speed, the shutters must be more open than at lower speed. The optimal position of the shutters is calculated in the electronic box, based on the spreading width, speed of the tractor and fertilizer calibration.

Figure 1. Double-disc mounted fertiliser spreader FERTI-2 (Source: INO)

Figure 2. VVP 115 vibrational subsoiler with deep fertilizer device (Source: INO)

For a proper operation the system needs to get the speed of the tractor. This information is provided by ISO 11786 connector of the tractor or GPS speed sensor. Fertilizer calibration is the procedure, which has to be done just once for specific fertilizer (NPK, Urea, KAN...) ant it takes only ca. 10 min. After this procedure is done, all necessary data are permanently stored in the electronic box and the work can begin.

The interface to the user is INO SmartAssist terminal (Figure 3) placed in the cabin of the tractor, which provides all necessary data on the graphic display. User can also change all necessary parameters from tractor cab.

Before work, the user just selects the fertilizer, which is actually in the hopper and desired spread density (kg/ha). When the user starts driving, the shutters are automatically open to the correct position. If the work speed changes, the shutter position also changes to meet requirements (kg/ha). When the tractor stops, the shutter closes automatically. The user can also additionally increase or decrease the quantity of fertilizer on the area directly by pressing button on the terminal without changing basic parameters stored.

Figure 3. Innovations from INO's Electronic Development Laboratory - INO SmartAssist for FERTI-2 Fertilizer Spreader and for VVP 115 Vibrational Subsoiler with deep fertilizer device (Source: INO)

Additionally, the system provides simulation of the fertilizer quantity in the hopper (weight data in kg). To use this feature, the user must enter the quantity of the fertilizer, which is added to the hopper before work. The real quantity of the fertilizer is measured by a TRUE Weighing System attached on the spreader (optionally) and connected with INO SmartAssist.

The side limiter (option) is also electrically driven, so the operator just presses the button and the limiter is placed onto the working position-on and back-off. (Žnideršič 2018)

The system also provides some other useful data:

1. Battery voltage
2. RPM of the discs
3. Hectares done
4. Residual hectares
5. Working hours
6. Recommendation for greasing every 8h
7. Working speed

Using this equipment, the farmer receives necessary information about production technology and about the safe operation of the machine, such as the amount of fertilizer dispensed, the amount of fertilizer in the tank, the speed of work, the size of the cultivated area, the amount of fertilizer that can be used in the tank, the number of hours worked, the battery charge level and the alerts for the machine maintenance.

Winter Smart Flow

Winter PK Smart is a spreader for salt and sand with electronics Winter Smart Flow and terminal SmartAssist. (Figure 4.)

The construction of the spreader consist of plastic hopper, rigid frame, stainless components for regulation, dosing and spreading, stainless deflector consisted of changeable flaps, gearbox with slower rotations and the electronic control SMART package.

The SMART package includes:

- built in three electric actuators, used for:
  - Opening-closing of a dosing flap
  - Adjusting of the spreading width left (flaps on deflectors)
  - Adjusting of the spreading width right (flaps on deflector)
- electronic system Winter Smart Flow together with a terminal SmartAssist for operating control with the following functions:
  - Adjustment of the spreading width on the right and on the left side with lifting flaps on deflector
  - Precise adjustment of the spreading density in g/m2,
  - Automatic adjustment of dosing flap according to the working speed
  - Closing the dosing flap when stopped
  - Measuring the distance travelled
  - Showing the remaining weight of the product in the hopper - virtual weight,
  - Availability for storing 10 different sorts of the spreading product (calibration),
  - Intelligent calibration of the spreading product.

Figure 4. Winter PK Smart is a spreader for salt and sand with electronics Winter Smart Flow and terminal SmartAssist (Source: INO)

Electronics receives data regarding the tractor's speed via ISO 11786 (7-pin socket on the tractor) or GPS antenna or from the sensor on the wheel. (Žnideršič 2019)

INO SMART HOPPER on the flail mower Boxer

Figure 5. Flail mower INO Smart Hopper (Source: INO)

Further, the company has proven INO Smart Hopper as a powerful tool for BOXER type collector containers. The device warns the user with sound and light signal when a container is fool. The control panel is easy to use. (Figure 5., 6.)

Figure 6. Control panel of INO Smart Hopper (Source: INO)

Conclusions

Precision Agriculture technologies have been developed all over the world to help the farmers increasing their crop yields and make agricultural production more profitable. This new developments resulted higher productivity and proved that this technology is very effective. Some of assistance systems, like autonomous track guidance, distribution control or side limiter are standard when investing in new agricultural machines, e. g. fertiliser spreader.

For small, medium-sized, and for the large-scale farm machinery too, the above-mentioned Smart Solutions prove to be beneficial for efficient work, professional utilization of machines and for minimizing the production and mechanization costs.

A common feature of systems described in this article is that they can be operated with or without from the tractor's ISOBUS system. The controller can be operated autonomously, using their own system, by the control panel (assistant) which is specially designed for this purpose.

The design of these electrical systems can also be well realized by an individual, innovative medium-sized machine manufacturing company, as it is shown in the presented work.

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EFFECT OF REUSED ROCKWOOL SLABS ON THE PERFORMANCE OF 'DARAS F1' HOT PEPPER UNDER GLASSHOUSE CONDITIONS

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Abstract: Reuse of rockwool slabs could improve sustainability of soilless cultivation. In this study effects of reused, two-year-old rockwool slabs on yield and quality of 'Daras F1' hot pepper hybrid was investigated, under commercial glasshouse conditions. Special attention was paid to anthocyanin discoloration disorder as the most important quality disorder of this pepper type. Total yield was the same, 15.26 kg m-2, for both treatments, while weight ratio of fruits having anthocyanin discoloration was significantly less for reused slabs (9%) than for the new ones (13%). Possibly higher buffer capacity of reused slabs reduced salt induced osmotic stress causing lower rate of anthocyanin biosynthesis.

Keywords: anthocyanin discoloration, yield, slab electric conductivity, slab water content

1. Introduction

Soilless cultivation is gaining more and more ground in the Hungarian greenhouse industry and it has become the exclusively used production method for year-round glasshouse pepper crops (Szőriné Zielinska, 2019). Rockwool is one of the most popular substrates for soilless production worldwide (Sonneveld and Voogt, 2009) and in Hungary too (Slezák, 2019). Rockwool has excellent physical and chemical properties from the viewpoint of soilless production. However, after the cultivation, it often presents a waste material and an environmental concern, as it is difficult to recycle the rockwool slabs (Raviv et al., 2002). A possible solution for reducing the extent of this problem is to reuse the rockwool slabs for a second or for a third year. Beside the environmental concerns this practice also has some economic advantages, as cost of the substrates per growing season can be reduced. Use of rockwool slabs for two years instead of just one, enhances the sustainability of this high-tech production method. However, most of the growers are afraid of decreasing yield and inferior quality by employing reused rockwool slabs.

Reusing rockwool slabs for a second or third year induces changes in their physical properties. Water holding capacity of reused rockwool slabs is significantly higher, amount of their easily available water content is bigger and their air filled porosity is lower, compared to the new slabs. The changes are sometimes drastic; for example saturated hydraulic conductivity of new slabs was measured to be 17.3 mm s-1 as opposed to 2.3 mm s-1 after just one year of usage. The pattern of water distribution within the slabs is also modified. Changes of physical characteristics starts at the bottom of the slabs, and later appearing in the upper parts too (Acuña & Bonachela, 2005; Acuña et al, 2013). Urrestarazu and co-authors (2007) have explained these changes by the increased organic matter content of the reused slabs caused by the root remnants of the previous culture.

Anthocyanin discoloration is probably the most important quality problem of the Hungarian type hot pepper. The ratio of this disorder should be kept as low as possible, while sustaining high yield. The main anthocyanin component in pepper is delfinidin-3-kumaroil-rutinozid-5-glikozid (Liu, 2016, Kovács et al., 2017). Synthesis of this purplish colored component is genetically determined (Kovács et al., 2017). According to the local Hungarian observations, anthocyanin discoloration of fruits is mainly caused by insufficient phosphorus uptake, cold effect, low light level, high salt content of soil and/or irrigation water, insufficient water uptake. On the leaves this discoloration can be a result of a general stress effect (Ledóné, 2012; Ombódi and Terbe, 2019). Beside the phosphorus, deficiency of other nutrients, like nitrogen, boron, magnesium, sulphur and zinc, can also cause anthocyanin discoloration (Chalker-Scott, 2002). On the other hand, it was found for several different crops that high salt content induced osmotic stress resulted in higher rate of anthocyanin synthesis (Chalker-Scott, 1999).

The objective of this study was to investigate the effects of reused, two-year-old rockwool slabs compared to new ones on yield and quality of 'Daras F1' hot pepper hybrid, under commercial glasshouse conditions, with special reference to ratio of fruits having anthocyanin discoloration.

2. Materials and methods

The experiment was established in one of the glasshouses (46° 40' 55.5" N 20° 20' 04.9" E) of Árpád-Agrár Ltd., Szentes, Hungary, in a commercial hot pepper 'Daras F1' crop during the 2017/18 growing season. The glasshouse was built in 1977 and has an area of 10,500 m2. 1374 J cm-2 was the average irradiation during this season. Climatic conditions were controlled by a Priva Intégro unit; air temperature was 20.2°C, while relative humidity was 69% in the average of the whole growing period.

The pale-green coloured, Hungarian hot pepper type Daras F1 hybrid was used in the experiment. In its market segment it is the leading cultivar in Hungary, and have a berry size of 4 cm width and 20-22 cm length at maximum. Seeds were sown on the 2nd of October in 2017. Seedlings were raised in Grodan Delta rockwool cubes (75×75×65 mm) and were transplanted on the 6th of November at 2.85 plants m-2 density, corresponding to 5.7 stems m-2. Plants were trained in a high-wire system and were pruned weekly leaving two stems on every plant. Fertigation was regulated by a Priva Intégro unit, minimum and maximum time between two irrigations and sum of irradiation for staring the next irrigation were set. Both treatments were fertigated with the same nutrient solution. Fruits were picked weekly until the beginning of June, and then at two-weeks intervals thereafter. The crop was terminated on the 8th of August in 2018.

Grodan Grotop Master 1575B1W (size: 1000×150×75mm) rockwool slabs were used in the experiment. After one year of use, slabs were disinfected with 2% v v-1 hydrogen-peroxide solution. New and reused, two-year-old slabs were compared. The experiment was set in the middle part of the house in one twin rows. One of the rows contained new slabs and the other reused ones. From both rows the middle 36 slabs were monitored for the experiment. Four replications were used, one replication was composed of 9 slabs, corresponding to 27 plants and 9.5 m^2. Plants of the experiment were handled exactly the same way as the commercial plants of the house.

Climatic data were recorded continuously by the Priva Intégro unit. Water content, electric conductivity (EC) and temperature of the slabs of the commercial crop were recorded regularly throughout the whole growing season by Delta-T WET Kit device. These parameters were also measured hourly during three different days (06.03., 07.01., 07.29.) in the slabs of the experiment. The first measurement was performed before the first irrigation, and the last measurement after the last irrigation, in the middle of three different slabs of every repetition. Number and weight of the fruits and ratio of berries showing anthocyanin discoloration were recorded at every harvest. Similarly to the commercial crop, berries were graded into 10 different classes, two of them served for berries with anthocyanin discoloration (under and over 15 cm length).

Yield data were analysed by Student's two sample t-test in case of homoscedasticity or by Welch's t-test in case of heteroscedasticity. Correlation analysis was applied on the data to describe connection between slab water content and EC values of the slabs.

3. Results

Total yield of 'Daras F1' was completely the same, 15.26 kg m^{-2}, either on new or on reused rockwool slabs. Hence, the employment of reused slabs did not decrease the yield of this hot pepper cultivar at all. The number of berries per plant also did not show significant difference between the treatments, it was 97 for the new and 94 for the reused slabs. Hence, average berry weight was slightly, but not significantly higher for reused slabs (57 g) than for new slabs (55 g). Statistically significant difference at 5% error level was also not found for ratio of number of berries classified as first, second and third class. However, ratio of the number of berries having anthocyanin discoloration was significantly lower for the reused slabs than for the new slabs (Table 1.). The same tendency could be observed for the weight ratio of these berries, it was 9.0% (1.36 kg m^{-2}) for the reused slabs and 4.0% more, 13.0% (1.99 kg m^{-2}) for the new slabs (Fig. 1.).

Table 1. Quality distribution of berries of 'Daras F1' hot pepper plants grown on new or reused rockwool slabs

Quality class	New slabs	Reused slabs	P-value
1st class 21 cm +	5.8 ± 0.4 %	6.2 ± 0.4 %	0.3901
1st class 19 cm +	16.5 ± 0.3 %	18.3 ± 1.1 %	0.1706
1st class 17 cm +	19.6 ± 0.7 %	21.2 ± 0.6 %	0.1224
1st class 15 cm +	9.4 ± 1.1 %	8.2 ± 0.1 %	0.3810
2nd class	15.9 ± 1.0 %	17.1 ± 1.7 %	0.5703
3rd class	18.6 ± 0.8 %	19.0 ± 0.3 %	0.6320
With anthocyanin discoloration	14.2 ± 1.0 %	10.0 ± 1.1 %	**0.0271**

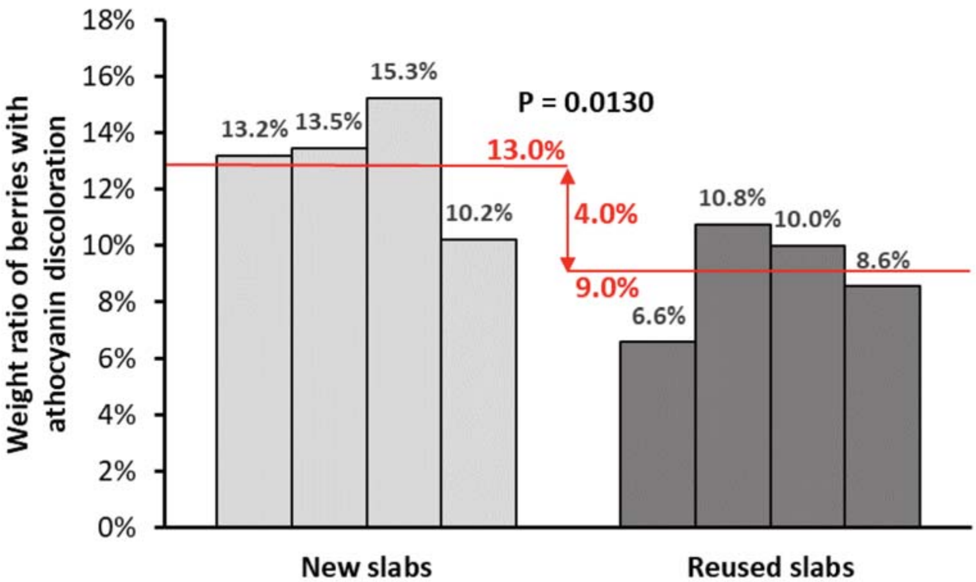

Figure 1. Weight ratio of berries with anthocyanin discoloration harvested from 'Daras F1' hot pepper grown on new or reused rockwool slabs

Analysis performed on the data of previous years of the commercial crop showed positive correlation between EC value of slabs and ratio of berries with anthocyanin discoloration. High EC results in salt stress which could trigger increased anthocyanin biosynthesis (Chalker-Scott, 2002). Analysis of the hourly slab characteristic measurement data showed much stronger correlation between EC and water content for the new slabs (N = 384, r = -0,3657, p = 1,35 x 10-13) than for the reused slabs (N = 384; r = -0,1289; p = 0,0115). Regression analysis performed on these data proved that for new slabs, EC has increased in a twice-bigger extent as result of decreasing water content compared to the reused ones (Fig. 2.). The reason for this phenomenon could be the higher buffering capacity of the two-year-old slabs resulting from root remnants of the previous year's crop (Urrestarazu et al., 2007) (Fig. 2.). Significant correlation was not found between the temperature and the EC values of the slabs.

As described above, it was found that decrease of slab water content due to water consumption of the plants induced twice as high EC increase rate in the new slabs, than in the reused ones. Higher EC means higher salt content which after a certain level causes salt stress for the plants. The changed osmotic conditions in the roots could reduce the water and nutrient uptake rates. The stress effect also could activate genes which are responsible for anthocyanin synthesis (Chalker-Scott 1999, Kovács 2007). Hence, higher buffering capacity of the reused slabs decreased the extent of salt and osmotic stress resulting in lower level of anthocyanin synthesis. Based on these conclusions we can state that time intervals between irrigation could be a very important factor in the appearance and rate of fruits having anthocyanin discoloration disorder. It is advisable to base irrigation strategy of pepper cultivars sensitive to anthocyanin discoloration as much on slab EC value than on the usual climatic factors, like irradiation and temperature, and to irrigate more frequently.

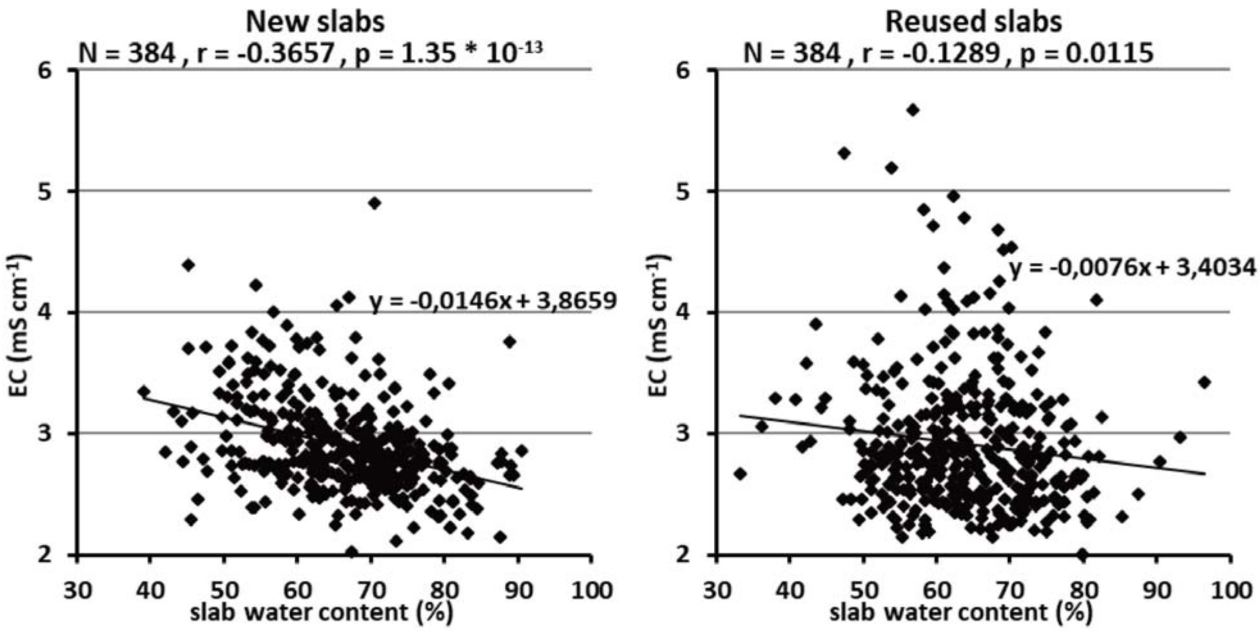

Figure 2. Correlation between water content and electric conductivity measured from new and reused rockwool slabs

Figure 3. Rockwool slabs (upside down) from the experiment: before usage (left), after the first growing season (center), after two growing seasons (right)

Conclusions

Based on our results we have concluded that use of reused, two-year-old rockwool slabs for cultivation of 'Daras F1' hot pepper not just that did not decrease the yield, but also significantly reduced the ratio of berries showing anthocyanin discoloration. Results of correlation analysis between slab water content and slab EC proved that reused slabs had bigger buffering capacity, possibly caused by higher organic matter content, originating from root remnants of the previous year's crop. Higher buffering capacity could reduce the effect of salt stress on the plants grown in the reused slabs, causing lower osmotic stress and as a result lower level of anthocyianin biosynthesis.

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THE EFFECT OF IRRADIATION ON MEDIUM TEMPERATURE AND EC VALUES IN HYDROPONIC LONGTERM TOMATO CULTIVATION

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Abstract: The yield results of long-term hydroponic tomato cultivation range from 40 to 70 kg/m^2, the productivity is significantly influenced by growing conditions. We investigate the effect of irradiation on root-zone temperature and EC values in a greenhouse technology. The irradiation data were provided by the climate controlled irrigation system, root zone temperature and EC values were monitored. During the whole examined period, there was no major fluctuation. Examination of the probe data on two selected days show that the change in EC values is not outstanding, but their overall value is considered to be very high compared to the usual 7-8 mS cm^{-1} values.

Keywords: tomato, irradiation, hydroponic, temperature, EC

1. Introduction

Currently, tomato is forced in approximately 500 hectares in Hungary, approx. one-third of them are grown in modern greenhouses, almost exclusively using hydroculture technology. The yield results of long-term cultivation range from 40 to 70 kg/m^2, the productivity is significantly influenced by growing conditions and technology. High yields can be achieved through precise control (climate, physical/nutrient conditions of the growing medium, irrigation parameters, etc.) and optimal adjustment of environmental factors. Biomass production is induced by irradiation, but the physical/chemical characteristics of the root zone also have a significant effect on yield. The physical/chemical indexes of different growing media are known in the literature, but practical values are constantly changing due to environment-plant interactions.

2. Literature review

The physical and chemical parameters of the root zone have a significant impact on yields. In a hydroponic cultivation, the evolution of the root-zone salinity is monitored through the analysis of the drainage water. Drainage values can vary over a wide range, through the management of irrigation / nutrient solution and complex physiological processes. In hydroponic cultivation, salt accumulation is a common problem, which usually leads to yield depression, but can also have positive effects on fruit content. The effect of the high EC value in the root zone is that the fruit size decreases and the dry matter content increases. The rate of yield reduction is influenced by a number of factors, such as variety, environmental factors and nutrient management.

Depending on environmental factors, salinity greater than 2.3-5.1 mS cm^{-1} causes yield reduction (Dorai et al., 2001). Irradiation directly influences the assimilation material available for crop production, increases the sugar / acid ratio in the fruits, increases the water uptake, and these together affect the EC value of the root zone. Some authors give different optimal EC values for different stages of generative development (Suhardiyanto et al., 2013).

Coconut fiber is a popular growing medium of organic origin. Particle size significantly affected the physical properties, especially the air–water relationships (Noguera et al., 2003). Coconut fiber is a water storage material with high moisture content (Kappel, 2008). Air filled pores provide easy warm-up, while high water content slows down warming. Irradiation quickly raises the temperature of the greenhouse, but at the same time the temperature of the root zone increases. Irrigation retards the temperature rise in the root zone and dilutes the solution, so the EC will decrease. The optimum temperature appears to be approximately 25 °C for uptake of the majority of mineral elements and all plant growth parameters (Tindall et al., 1990).

3. Material and methods

The crops involved in the experiment can be found in Szarvas, in the Galambos educational facility of St. István University. A greenhouse built in 2016 with almost 2,000 m^2 gross and 1,800 m^2 net area and 6 m height was used for the research. The greenhouse has two symmetric and separable areas, where it is possible to set different climatic conditions. The system for providing CO_2 has also been installed. It consists of 12 connected bottles, so called bündels, which have electronic switch valves through which the level of CO_2 can be regulated inside the greenhouse. Perforated KPE pipes with the diameter of 20 mm ensure the even distribution of carbon dioxide all along the rows.

The tomatoes were planted on January 24, 2019. The selected Aruba F1 variety has become one of the most popular vine tomatoes cultivated in Hungary during the past years. Its main positive features are the spectacular sepals, deep red colour and longevity. This latter characteristic is outstandingly important for commercial supermarket chains.

Seedlings were grown in 10 by 15 cm rockwool cubes in Szentes. They were transferred to the greenhouse when reaching six-leaves stage. Each rockwool cube has two plants to grow. These tomatoes were planted in a new growing medium of coconut fibre maintaining the density of 3.8 plants/m^2.

A climate computer operates in the greenhouse, making it possible to constantly record the measured data. Thus, inside radiation, temperature and air moisture at the top of the plants in both blocks of the greenhouse as well as CO_2 concentration at 2 m height have been observed and recorded in 15-minute intervals during the entire production period. CO_2 has been released into the greenhouse on an occasional basis in 2019.

During the experiment, from week 8 on the following data were continuously recorded: a) weekly growth, b) leaf length, c) number of leaves, d) leaf width, e) leaf area, f) stem diameter, g) vine distance, h) flowering vines, i) fruit setting vines and j) yield. These parameters were examined in both climate blocks involving 12 plants in four rows regarding each block.

In our study we used the climate computer's values of the average daily temperature, the daily amount of water irrigated and the daily total radiation. The probe was used by NAKI ÖVKI in the growing medium.

For hourly measurement of temperature (T °C) and electrical conductivity (EC mS cm^{-1}) in the growing medium during the whole season, two sensors (TSC-06 and TSM-06, Boreas Ltd., Hungary) were installed in both blocks of the greenhouse. Both sensor types use time-domain reflectometry (TDR) technique. The TSM-06 contains sensors for temperature (range -40 - +80°C, accuracy 0.3°C) measurements, while TSC-06 has EC (range 0-1000 mS/m, accuracy 2% FSR) registration ability as well. Data were collected by automatic data loggers (EcoLogger-2, Boreas Ltd., Hungary) and transferred to the PC regularly. Data were analysed using MS Excel.

The evaluated period was from February 6 to August 31, 2019, where we compared the measured temperature values in the root zone medium and in the greenhouse as a function of irradiation, and the EC values of the irrigated nutrient with those of the EC values in the quilt.

The lowest and highest irradiated days in the period from May 15 to June 15 were also examined in 1-hour intervals.

The two most important values of the test period were placed on the first figure (Fig. 1), which illustrates how precision cultivation can follow irrigation according to the needs of the plant throughout the growing year:

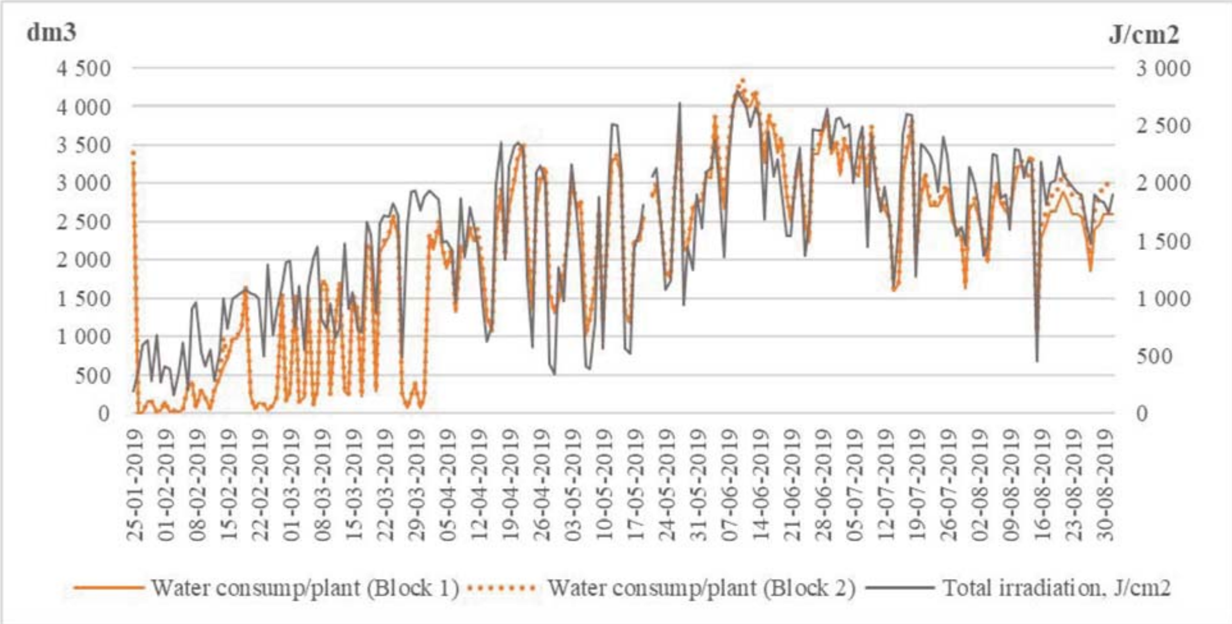

Figure 1. Relationship between water consumption and total irradiation

The figure (Fig. 1) illustrates the changes in extreme irradiation during the production year 2019, which the irrigation system was able to handle except for one or two technical failures. It is essential for modern cultivation to eliminate these problems as much as possible.

In the second figure (Fig. 2), the water consumption is compared with the internal temperature:

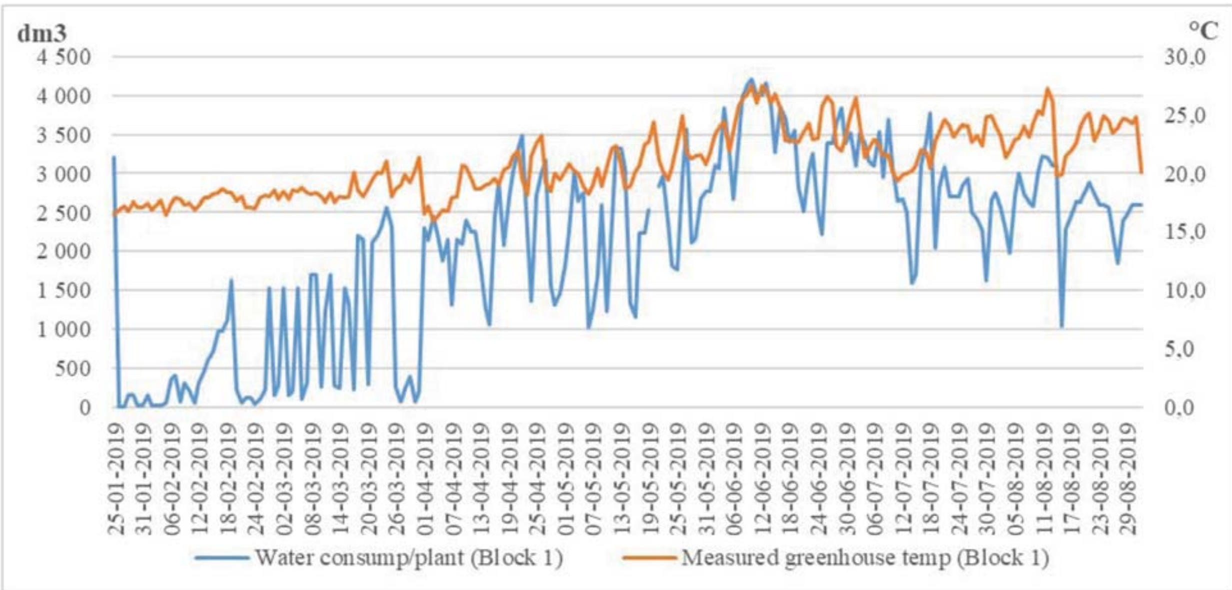

Figure 2. Water consumption and measured internal greenhouse temperature

Heating in the greenhouse was not switched off during the test period, so water consumption and internal temperature are not related. The automatic heating system kept the set parameters in the early period (January April). The heating system operated during the summer to maintain the internal temperature even on cool, rainy days. The summer months (June-July) are characterized by a correlation between the amount of water applied and the internal temperature.

The following figure (Fig. 3) shows the water consumption and changes in the EC value of the irrigation water applied:

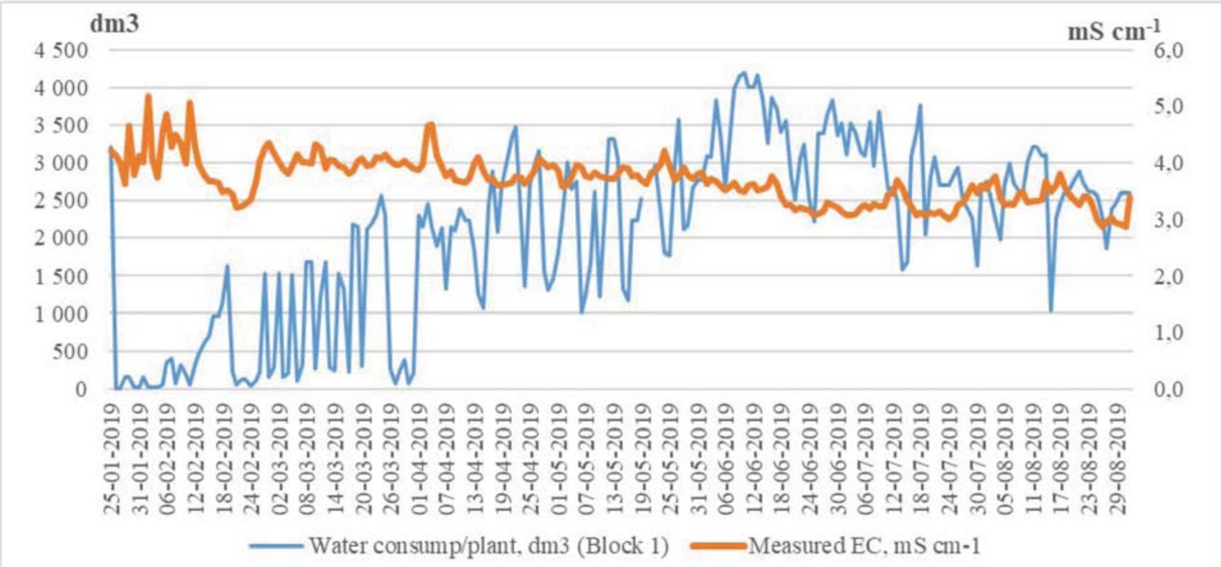

Figure 3. Water consumption and measured EC values of the irrigation water applied

Figure 4. Changes in greenhouse air temperature and growing medium temperature, May 16, 2019

We can say that in today's modern cultivation, EC values are now 0.5-1 mS cm^{-1} higher than those described in the literature. During the growing year, it appears that the EC value of the irrigated water does not decrease proportionally with the amount of the irrigated water, and practically does not fall below 3 mS cm-1 throughout the year. This also shows that as the irradiation increases, the water requirement increases proportionally, but the nutrient requirement is not followed.

Changes in the EC and temperature of the growing quilt are shown on the day with the lowest and highest values of daily irradiation during the whole intensive growing period, May 15-June 15, 2019 (Fig. 4).

The lowest irradiation (1441 J/cm^2) was on May 16, which was a cloudy but not overcast day. The figure (Fig. 4) shows the data of the two separate climate block, the measured air and the medium temperatures.

It can be clearly seen in the figure (Fig.4.) that during the day the temperature of the air fluctuates by up to 8 °C, whereas in the case of quilts it changes only around 5 °C. It is also noticeable that the difference between the two greenhouse blocks is minimal. In the late hours of the night, we can see that during the intense cooling phase, the air temperature in the greenhouse drops below the medium and stays there until dawn heating starts. This is explained by the water content of the medium at about 80%, but it is noteworthy that the temperature of the root zone medium does not fall below 18 °C.

If we look at the change of the EC values of the root zone solution in the medium (Fig. 5), we see changes corresponding to the irrigation cycle and plant nutrient uptake. The balanced value drops during the intensive morning period, which the irrigation replaced only for 12 hours. With small swings, it reaches its original value at about 19-20 hours by the end of vegetation and shows a slight increase until midnight.

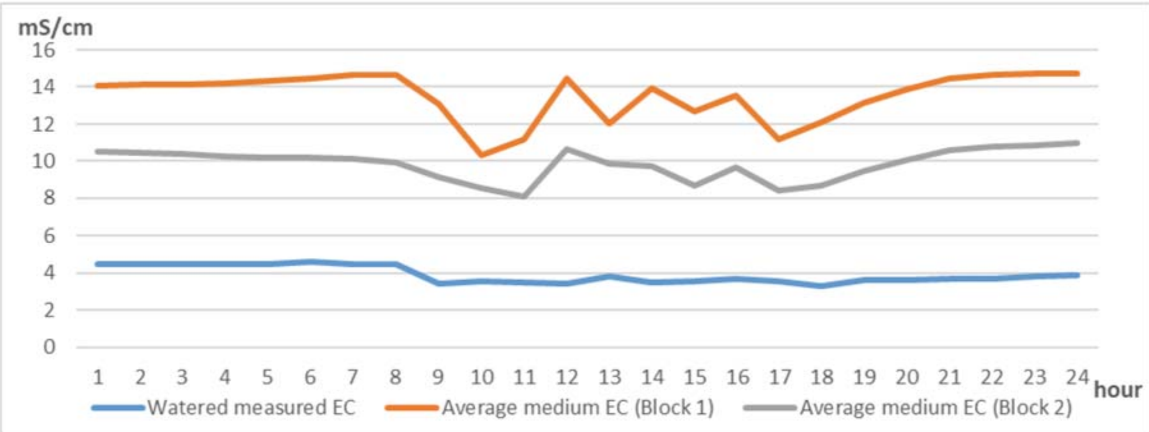

Figure 5. Changes of EC values in the root zone solution, coconut fiber medium May 16, 2019

The next selected day was June 9. (Fig. 6.), which was the highest daily irradiation day of the period with 2719 J/cm^2 value.

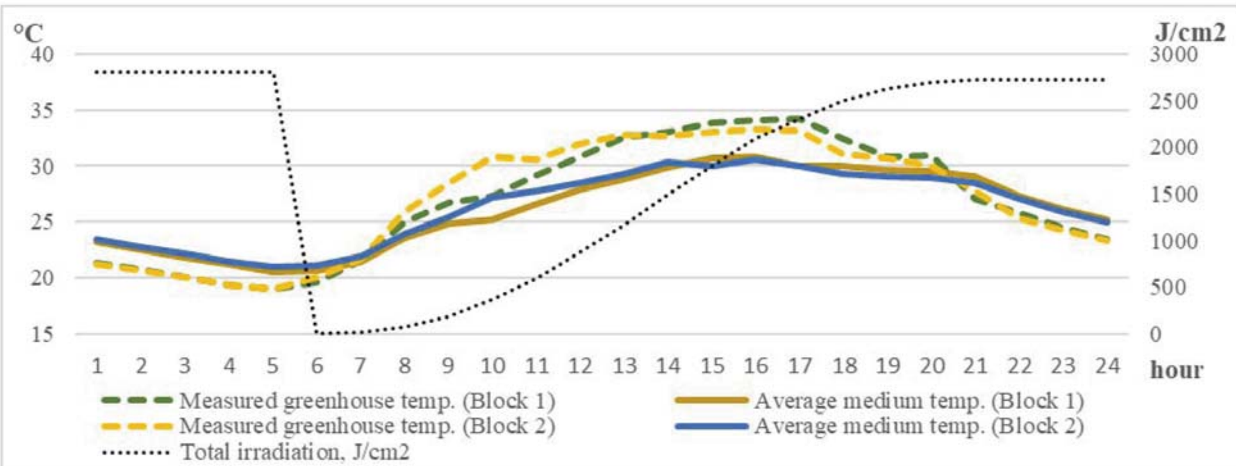

Figure 6. Changes in greenhouse air temperature and growing medium temperature, June 9, 2019

It clearly shows that the daily temperature in the growing medium also exceeds 10°C, however , the air temperature reaches 14°C. During cultivation, it is desirable to keep the temperature of the medium below 25°C, which in this case could not be achieved between 9 and 23 hours. This did not pose a significant problem in cultivation, but in such a case greater attention should be paid to the proper use of water.

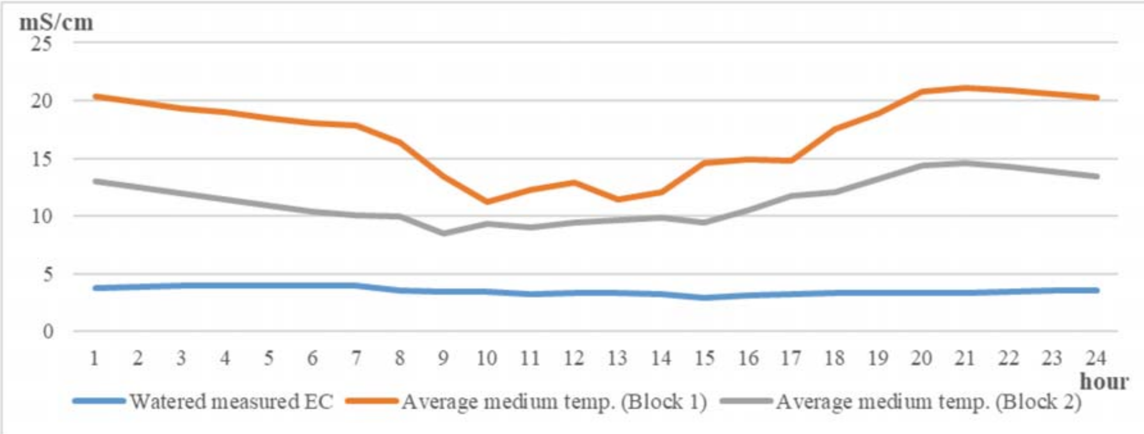

Figure 7. Changes of EC values in the root zone solution, coconut fiber medium , June 09, 2019

If we look at the change in EC values (Fig. 7.), we can see that its daily course is practically the same as in May, only the values have changed. It should be noted that EC values on both days were extremely high in the quilt, probably due to the low amount of irrigation water applied. The EC value of 3.5-4 mS cm^{-1} of the applied medium is also high compared to the practical experience of the indicated period.

Conclusions

It can be stated that with modern cultivation equipment the amount and the exact dosing of nutrient solution to be applied can be solved in time with today's control systems. During the whole examined period, there was no major fluctuation and no longer problem with the irrigation system or the climate control. Examination of the probe data and the two selected days show that the change in EC values is not outstanding, but their overall value is considered to be very high compared to the usual 7-8 mS cm^{-1} values in practise. Further studies are needed to clarify this, but since the EC change value is not high, it will be necessary to increase the amount of irrigated water in general and also recommended to reduce the EC value of the irrigated nutrient solution in subsequent growing seasons.

In the present case, these values did not cause significant or obvious damage to the herd, but in later periods nutrient uptake disturbances may occur, e.g. Ca deficiency.

Summary

In our experimental work, we investigate the effect of irradiation on root-zone temperature and EC values in a long-term greenhouse technology, with open system water management, used coconut fiber as growing medium and planted on January 24. The irradiation data were provided by the climate controlled irrigation system. Root zone temperature and EC values were monitored, 1-1 plants were measured in two different climates (left and right parts of greenhouse) between 6 February and 23 August. The probes collected hourly data during the period under study. Statistical methods were used to evaluate the data. We examined the relationship between the daily dynamics and the measured data, evaluated the data against the optimal values, and examined the development of trends. We have tried to explain the major fluctuations in other technological circumstances.

Acknowledgement

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Faculty of Mechanical Engineering

DEVELOPMENT OF A HIGH PROTEIN CONTAINING FILLING FOR BAKERY PRODUCTS

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Abstract: Development of nutrient-dense foods is one of the most important goals of today's food industry. High protein content of foods helps to provide energy and amino acids for human body.
In our study protein enriched filling was developed for donates. The main ingredients of the product were pudding powder and egg white product (TOTu, ToTu tej, ToTu krém, and ToTu krém extra).
The texture of samples was analyzed by Anton Paar Mcr 92 rheometer and the quality of products was evaluated by sensorial tests. Microbiological decontamination of HHP was investigated (500 MPa, 5 min).
Our results show that high protein content did not influence the sensorial quality of filling, as long the microbiota of the products is highly improved by HHP treatment. Rheological properties are highly influenced by the concentration of egg proteins.
The overall quality will be better, if egg white products are used for the product.

Keywords: bakery fillings, egg white, ToTu, protein enrichment

1. Introduction

Egg white is a key ingredient in many food products as it combines high nutritional quality (Seuss-Baum, Nau, and Guérin-Dubiard 2011) with excellent functional properties (de Souza and Fernández 2013). However, egg white is also one of the leading causes of IgE mediated food allergy in childhood (Moneret-Vautrin 2008; Lechevalier, Guérin-Dubiard, Anton, Beaumal, David Briand, Gillard, Le Gouar, Musikaphun, Pasco, et al. 2017). Hen egg may also one of the leading causes of food allergy in childhood, affecting 1.6–3.2% of young children (Eggesbø et al. 2001). Studies are investigating the role of different allergic reactions in childhood in concection whith egg consumption (Robinson and Lanser 2018).

The high content of essential amino acids in egg white proteins and the high bioavailability of these proteins are of great benefit to human nutrition (Hester 2017; Lechevalier, Guérin-Dubiard, Anton, Beaumal, David Briand, Gillard, Le Gouar, Musikaphun, Pasco, et al. 2017). However, the effects of industrial processing such as dry heating on the nutritional quality of egg white proteins have been poorly documented. Some studies considered the effect of dry heating on the in vitro digestibility of proteins as it is a prerequisite to nutritional quality (Schmidt et al. 2007), but the effects of minimal processing technologies are not investigated in case of egg white. Studies are viable about the digestibility assays confirmed previous findings that exposure of egg white to high temperatures increased digestibility markedly. However, it seems that the effects of pH and salt concentrations were found to be minimal (Lassé et al. 2015).

In the egg product industry, microbiological safety of liquid products is mainly guaranteed by pasteurisation. The USDA requires that liquid whole egg is at least heated at 60°C for no less than 3.5 min, but in the United Kingdom the recommendations are to pasteurize at least at 64°C for 2.5 min (Rossi et al. 2010; Korver and McMullen 2017). In France, there is no statutory heat treatment; only microbiological results are determined by regulations. To achieve this, the treatments classically used to pasteurize whole egg vary from 65 to 68°C for 2–5 min in order to ensure 5 to 6 decimal reductions of vegetative microorganisms and especially

Salmonella Enteritidis and Listeria monocytogenes (F. Baron, Jan, and Jeantet 2010). Pasteurisation temperatures used in the egg industry are limited by the sensitivity of egg proteins to heat treatment. Thus, pasteurisation for 2–10 min from 60 to 68 °C modifies whole egg electrophoretic pattern by especially decreasing ovotransferrin, livetin, ovalbumin, apovitellenin, lysozyme and/or ovomucin band intensity (Bartlett and Hawke 1995; Rossi et al. 2010; Lechevalier, Guérin-Dubiard, Anton, Beaumal, David Briand, Gillard, Le Gouar, Musikaphun, Tanguy, et al. 2017).

Liquid egg white (LEW) and egg white-based products are usually regarded as functional foods for their excellent source of high-quality proteins, trace minerals, and for the ability of their components to coagulate, and to form foams when whipped. HHP is one of the most promising minimal processing technologies in the food industry, but only a few scientific studies are existing about HHP treatment and its effects on egg products (Toth et al. 2017).

On the other hand, egg white products are free from gluten, lactose and containing almost zero carbohydrates, these characteristics led to an increasing market of consumers, like people living on a paleolite, or low carb diet, or living with an allergic disease, or sensitivity against lactose, milk protein or gluten.

The goal of our experiment is to develop a special vanilla taste filling from egg white products, which has an increased protein content.

2. Materials and methods

The Sample preparing

Material used for the development

Cortina

Cortina is a special puddings in powdered form which is used in pastry industry and has excellent sensorial quality. The major advantages of Cortina are the fast and cold solubility and an excellent viscosity during filling procedure. Concentration of Cortina is usually 0,300 – 0,470 kg/L water, depending on desired texture.

Nutritional labelling is summarized in Table 1. containing the different concentrations of Cortina saluted in water.

Table 1. Nutritional labelling of Cortina, with the different concentrations of Cortina soluted in water

Nutrients	dimension	in dry Cortina	0,300 kg/ 1 L water dissolved	0,400 kg/ 1 L water dissolved	0,470 kg/ 1 L water dissolved
energy	KJ/100 g	1662	383,5	474,9	531,4
	Kcal/100 g	392,2	90,5	112,1	125,4
fat	g/100 g	4	0,9	1,1	1,3
unsaturated fatty acids	g/100 g	3	0,7	0,9	1,0
carbohydrates	g/100 g	85	19,6	24,3	27,2
sugar	g/100 g	60	13,8	17,1	19,2
dietary fiber	g/100 g	<0,1	<0,1	<0,1	<0,1
protein	g/100 g	4	0,9	1,1	1,3
Salt	g/100 g	1,4	0,3	0,4	0,4
Water	g/100 g	4	0,9	1,1	1,3
trans-fatty acids:	g/100 g	<0,1	<0,1	<0,1	<0,1
bred unit:	BE/100 g	7,1	1,6	2	2,3

ToTu products

ToTu products are made from egg white due to an enzymatic reaction. The different ToTu products have different textures and taste. The original goal of the ToTu products was to offer a lactose- and milk protein-free dairy analogue for people living with allergic reactions against milk ingredients.

ToTu

ToTu is a cottage-cheese analoge. The texture is cloddish, similar ot Hungarian "rögös túró". ToTu is rich in protein, but has lower energy content compared with cottage cheese.

Figure 1. ToTu, the cottage cheese analogue from egg white

Figure 2. ToTu cream, the sauercream analogue from egg whitecoconut fiber medium , June 09, 2019

ToTu cream

ToTu cream is has a texture similar to sauercream. The texture is spoonable, viscosity of ToTu cream is higher compared with fermented dairy products (like yogurt, kefir).

ToTu cream extra

Figure 3. ToTu cream extra, the butter cream analogue from egg white

Figure 4. ToTu milk, the cow milk analog from egg white

ToTu cream extra has a texture like buttercream, or cheese cream. The product is spreadable.

ToTu milk

ToTu milk is liquid as cow milk. The sensorial attributes are similar to normal milk. Techno functional and sensorial properties like viscosity are similar to normal, or lactose-free milk.

Methods

Protein enrichment of pastry fillings

Pilot experiments pointed out, that the most important attributes of foods are sensorial characteristics, like taste and odor for Hungarian consumers. This point of view led us to develop the fillings according to sensorial tests.

First texture and taste were examined with a sensorial panel. Two different fillings were chosen for the next step of examination. The ingredients of the two types of fillings were:

–150 mL ToTu milk, 45 g Cortina and 0,1 m/m vanilla flavor

–100 mL ToTu milk, 40 g Cortina, 20 g ToTu cream and 0,1 m/m vanilla flavour

Figure 5. Sensorial testing of developed samples

12 panellists were taking part in t5he experiment they had to evaluate the samples between 1 and 5. The best evaluation was 5. Examined attributes were: colour, spoonability, door, out flavour, texture, taste (overall), vanilla flavour, sweet taste, out-taste, overall quality. Finally they had to make a ranking of two developed and original samples.

Rheological methods

Figure 6. Anton Paar MCR 92 rheometer

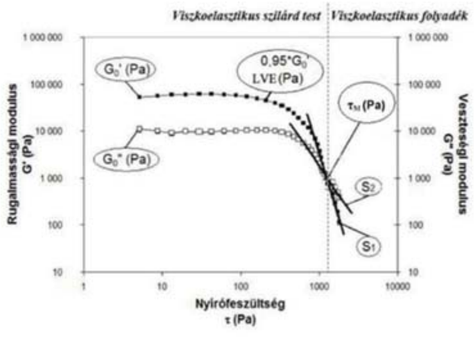

Figure 7. Parameters of amplitude sweeps method

Rheological properties were measured with an Anton Paar Mcr 92 rheometer. The method was an amplitude sweeping between 0 and 100%. From every samples G' and G" curves were measured and yield point and flow point were calculated. Figure 7. demonstrates the different values measured and calculated by using the method.

3. Results

Table 2. Nutritional labelling of ToTu milk, Cortina soluted in watzer, and Cortina soluted in ToTu milk

Nutrients	Dimension	Totu milk	Sample with ToTu milk	0,300 kg/ 1 L water
energy	KJ/100 g	383,5	97	458,2
	Kcal/100 g	90,5	23	108,2
fat	g/100 g	0,9	0	0,9
unsaturated fatty acids	g/100 g	0,7	0	0,7
carbohydrates	g/100 g	19,6	0,1	19,7
sugar	g/100 g	13,8	0,1	13,9
dietary fiber	g/100 g	<0,1	<0,1	<0,1
protein	g/100 g	0,9	5,6	5,2
Salt	g/100 g	0,3	0,1	0,3
Water	g/100 g	0,9		
trans-fatty acids:	g/100 g	<0,1	<0,1	<0,1
bred unit:	BE/100 g	1,6		2,1

Table 2 summarizes the nutritional labelling of developed fillings comparing with ToTu milk and with Cortina. The table highlights that protein content of pastry fillings were higly increased by adding ToTu products.

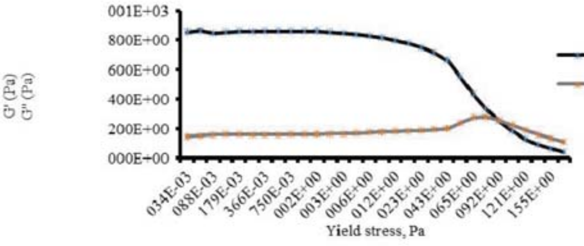

Figure 9. Rheogram of Cortina (300 g /L)

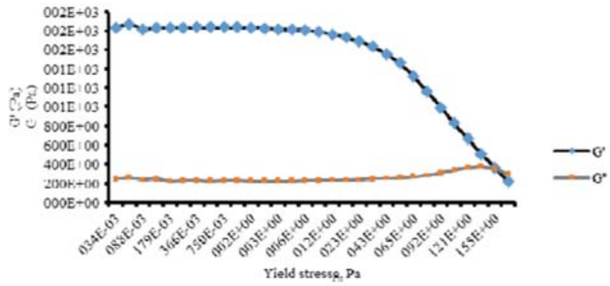

Figure 10. Rheogram of developed filling made with ToTu cream and ToTu milk

Figure 9. shows the rheogram of filling made with Cortina, compairing with Figure 10 and 11has to be considered, that G' increased by adding ToTu cream and milk, mut the highest impact has ToTu milk on G'. In contrast, G" shlightly decreased by adding ToTu products.

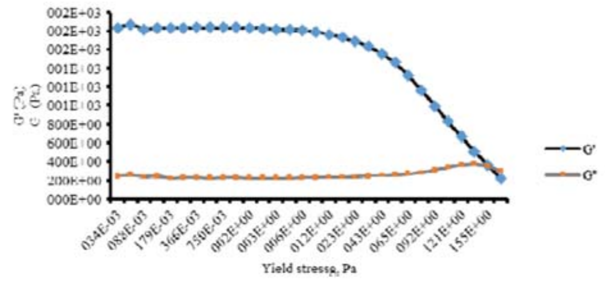

Figure 11. Rheogram of developed filling made with ToTu milk

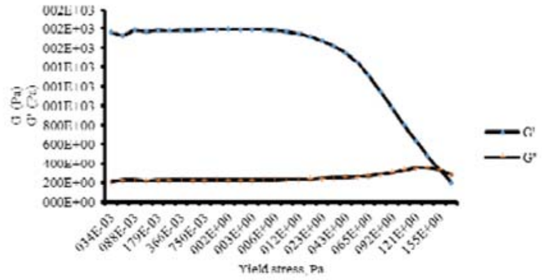

Figure 12. Results of sensorial tests

Rheological properties of developed fillings are summarized in Figure 12. The best sensorial evaluation was fitted to the developed filling with ToTu milk, as long as this sample was the first in ranking of the three different evaluated samples.

Conclusions

The protein-dense foods are getting tzoday a more and more important role in special diets. In our experiment a protein enriched filling for vdifferent bakery and condictionary products, especially donuts was developed. According to our results, the techno-functional properties of the new products are similar, like the original, as long sensorila attributes are liked and nutritional aspects of developed filling are better.

Acknowledgements

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WATER MANAGEMENT EFFECTS OF DIFFERENT TILLAGE SYSTEMS

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Abstract: Due to the climate change and the effect of the resulting warming up the amount of snow is declining in the past few years, so the chances for the autumn sowings to be winterkilled are growing and the amount of water stored in the soil is also significantly reducing. The intensive agricultural production is trying to compensate the conditions for the altered production by changing methods of soil cultivation and building up irrigation systems. The long-term aim of choosing the right method of soil cultivation is the protection of the soil structure and surface, and also the beneficial affecting of its biological activity, moisture and air circulation. The experiment was set in Szarvas, on the experimental area of Szent István University, Faculty of Agricultural and Economical Studies, organised as 5 by 2 repetition. By the planned experiments we were seeking answers for the ways of possible optimisation of soil cultivation in order to reach the highest possible value of water management for the soil, to improve the hydrating ability of the soil and also to provide sustainable agricultural production and to reduce the effects of farming which are hazardous to the water quality to the lowest possible level. The aim of our experiment is the reasonable utilisation, protection and preserving the diverse abilities of functionof the soil resources as parts of our most important natural resources. Within the framework of our monocultural duration experiment we examine the plant physiological and harvest effects of the various soil cultivating systems, deep disintegrating, deep ploughing, semi-deep ploughing, disc ploughing and strip-till cultivation by applying irrigated and non-irrigated cultural techniques. The results of non-rotating soil cultivating techniques show that they have beneficial effects on the water and nutrient management of the soil. The other technology we applied is the strip till technology. The advantage of strip cultivation that instead of the whole area one only cultivates the line/strip. In the cultivated strip the best possible soil conditions are provided for the plant by preparing seedbeds, sowing and fertilizing only in the line.

We were trying to find an answer for the relationship between soil resistance measured on methods of soil cultivation and the estimated average production. The Variance analysis shows significant results, the soil cultivating method influences the soil resistance at 40,231%, and also the expected harvest.

Keywords: soil cultivation, water management

1. Introduction

Considering the effects of climate change, Hungary belongs to the ecologically more vulnerable areas. The average temperature in Hungary grows nearly one and a half times faster than the values of the global climate change. Torrential rains will cause more damages in the future. Hungary is responsible for less than 0.5% of global greenhouse gas emissions; however, Hungary is being heavily struck by global warming, its climate is getting more and more extreme. Due to the changes in the weather in the past few years and the effect of the accompanying warming, the amount of winter precipitation and snow tends to be reducing in the past few years, so that the amount of water stored in the soil is also reducing. 2018 was the 4th hottest year in a row, and increases in global average temperature exceed nearly 1°C any values taken between 1850 and 1900. July of the year 2019 became the hottest month that has ever been recorded. The distribution of the annual precipitation has also changed significantly, considerably wet and dry periods follow each other. During the same year spring floods, possible inland inundations and subsequent summer droughts may appear. The temperature of surface waters has increased, which has had an effect on the water supply of irrigation water canals. The soil conditions of Békés county is considered as one of the most outstanding ones in the country. Spring inland inundations and also summer droughts cause considerable harvest losses year by year, even on these fertile meadow black soils. The climate change globally threatens the living conditions for today's and future generations, and also for the nature excluding humans, which is a considerable challenge for our responsibility for our immediate surroundings. It is getting more and more obvious that human activity alters the climate system resulting global impacts, which has repercussions on the biological, social and spatial living conditions. The conditions changed need responses either by reducing global greenhouse gas emissions and by adapting agricultural producing technologies to the climate change. Since the 1960s technology and science have been improving continuously, the rate of rural population and the utilization of fertilizers and pesticides have been reducing. Besides these, the diversification of crops in the rotation has also been increasing. Due to the decreased number of animals the volume of animal food production has also decreased, only a little good quality previous cropping and livestock manure is used. The new conditions of intensive soil utilisation and also the application of old classical systems (ploughing-rotating) have resulted an increase in the deterioration of the physical condition and structure of soils, plough-soles have appeared, the humus content has decreased, inland inundations have appeared, fertilizers have become less effective, soil acidification, harvest losses and costs have increased. Modern soil cultivating methods shall be used, in order to provide adequate conditions for the germination of the cultivar's reproductive material, its maturing, rooting, then for the growth and harvesting during vegetation. Its long-time purpose is to protect the structure and surface of the soil and to make beneficial impact on its biological activity, humidity and air circulation. These factors in combination describe the physical and biological condition, i.e. the cultivation condition of the soil.

By the planned experiments we were seeking answers for the ways of possible optimisation of soil cultivation in order to reach the highest possible value of water management for the soil, to improve the hydrating ability of the soil and also to provide sustainable agricultural production and to reduce the effects of farming which are hazardous to the water quality to the lowest possible level. The aim of our experiment is the reasonable utilisation, protection and preserving the diverse abilities of function of the soil resources as parts of our most important natural resources.

For choosing the right irrigation method and increasing the utilisation of irrigation water, the water resources of the soil shall be optimised. By choosing the right methods of soil cultivation we are addressing this issue.

2. Bibliographical overview

The physical degradation of soil, in particular, the degradation of soil structure and compaction are the most widespread, most serious injury causing and the most difficult to avoid processes of the soil-threatening degradation processes. (Várallyay 1999) Compaction can occur on the surface or below it. 34.8% of the soils of Hungary is specifically sensitive to compaction. (Várallyay 2005)The frequent or heavy rainfall and evaporation increase deposition caused by the own weight of soils, as a result, disadvantageously compacted soil layers can occur even under natural conditions. Pedologic factors, such as low organic material content and degraded structure, similarly to moisture content, also increase the tendency for compaction. (Birkás 1996)The most striking consequences of excessively compacted soils include water stagnation, siltation, chapping, accumulation of chemicals and blocking of soil moisture circulation. The roots of cultivars grown under such circumstances tend to develop rather vertically, theirgrowth is poor, and suffer water shortages early during heatwaves. (Birkás 2002) All soils have a distinctive penetrance limit value, which varies in accordance with the type of soil. The compaction can be considered favourable where the penetrance limit value is around 1.5-2.5 MPa/mm², and unfavourable where the limit value exceeds 3.0 MPa/mm².

Soil cultivation directly and indirectly alters soil conditions. It alters directly the position of relating particles, i.e. the soil structure. The agronomic structure, apparent specific gravity, porosity and three-phase system of the soil change, the water, air and heat circulation of the soil alter.(Gyárfás1922)The experiences gained through applyingnon-rotating soil cultivating techniques for years show that these techniques have beneficial impact on the water and nutrients management of our soils and result considerable gasoline savings compared to ploughing techniques. Besides beneficial features, plant protection issues raised by the pieces of stem and root remaining after previous cropping, and also factors having negative effects on the sowing quality of follow-up crops keep emerging. (Hajdu 2014)A significant lesson of the past few years' periods of draughts is that to obtain the aims mentioned above one shall pay special attention to provide appropriate moisture conditions for the soil, i.e. to allow as much precipitate reaching the surface as possible to get in the ground, and to make it possible for the soil to store such waters in a considerable amount. According to Beke's experiences gained through his studies on compaction and moisture content, in dry years less moisture results generally higher penetrance limit values. (Beke 2006) While examining interim protective plants Ujj found that the amount of precipitate and the success of weed control greatly affects penetrance. As he puts it, only the protective plants harvested in time can prove their cultivating effect, otherwise when utilising the working water supplies of the soil, compaction can be expected. (Ujj 2004) Rátonyi's studies show that the physical features of the soil significantly affect the growth of crops. For his studies he used linear regression equations with 2 variables of moisture content and compactionto describe soil penetrance. He found that within the range of moisture examined, the decrease in moisture content resulted anincrease in soil penetrance. (Rátonyi 1999)

3. Material and methodology

We found the 'school land' experimental area of Szent István University, Faculty of Agricultural and Economical Studies suitable for our studies and to deliver soil cultivating experiments on this area. The soil type of this area is meadow soil with high clay content and of high consistency. The consistency and tendency for compaction offer excellent conditions for adjusting experiments. Conditions for irrigation are also provided on the area, which offers an opportunity to compare irrigated and non-irrigated control parcels.

Due to the continental impact, the climate of Békés county is dry and warm. The annual average rainfall is 550-560 mm; however, the northern and southern parts of the county, including the experimental area of Szarvas, belong to the driest areas of the country. The average annual temperature and the average number of hours of sunshine is higher than the national average; in July, the south-eastern corner of the county is the hottest region of the country. Considering agricultural production, the best quality fertile soils with a nationally outstanding value can be found throughout most of the region. The middle area of the Körös-Maros region has the best soil properties, where the thickness of the soil exceeds 1 metre almost everywhere, the soil is exceptionally well-drained and has an outstanding water retention capacity, and its quality is worth more than 35 Golden Crowns. Due to its physical geographic features, agriculture has a leading role in Békés county, including arable crops. At present, 402.000 hectares of land are utilised agriculturally in Békés county, which is the second largest area in the country, after Bács-Kiskun county. The rate of utilised areas compared to the entire territory of the county is the highest in the country, more than 77%. 362.000 hectares of the agricultural areas are utilised as arable lands, which is 9.5% of all arable lands of the country. To preserve these valuable arable lands and to increase their productivity are the main goals of our experiment.

Applied soil cultivating methods:

1. Deep disintegrating (at least 60-70 cm deep meliorative disintegrating that discontinues the effects of possible clogged layers with respect to the soil profile)
2. Traditional deep cultivation, deep ploughing (regular rotating cultivation, in accordance with the crop's needs)
3. Semi-deep ploughing (40-45 cm deep disintegrating on annual basis)
4. Shallow ploughing, disc ploughing (20-22 cm deep disc cultivating)
5. Applying strip-till technology (strip cultivating in the rows of crops)

We chose maize as a crop for testing. Maize is grown in the largest quantity in the world, so the sustainable maize production is a major issue in animal nutrition, food industry and biofuel industry, as well. The situation is the same in Hungary; maize is also one of the country's most important export product. When choosing the crop for testing, after taking into consideration three consecutive years, the choice was limited to maize. Our chosen crop, the maize is a good choice, since the crop's dimensions, biomass yield, harvest and its quantity may indicate well-measurable ranges by numbers and appearance. Livestock manure and fertiliser were spread in the same amount on the experimental parcels. Yield is measured by providing the same amount of irrigation water. It is expected to experience differences. Besides yield, the total amount of biomass is measured as well, trying to find the cultivating method that utilizes the provided nutrient and irrigation water the best. When measuring the amount of biomass, the range and composition of weeding are also included. We are also trying to find the answer to the question if various soil cultivating methods affect the composition of stress enzymes and hormones.

Soil penetrance is measured to examine the physical conditions of the soil and also to compare the effects of various soil cultivating systems on soil conditions, using a penetrometer. The penetrance and current physical condition of the soil can be determined fast and relatively accurately. The validity of soil penetrance values taken with a penetrometer is determined by the accuracy of the measuring instrument, the performance of measuring and the inhomogeneity within the experimental parcels. The range of soil penetration variation is considerably affected by the relatively small surface of the probe cone's base and the variability of soil parameters strongly related to soil penetrance (e.g. moisture content). (Rátonyi 1999)

4. Findings and evaluation

We have compared numerous parameters examined. The most important test values refer to the moisture content and water management parameters of the soil. The constant monitoring of moisture content and soil penetrance is a significant part of the test, since we are trying to find the best cultivating method that provides lasting and constant water absorption for our crop. Soil penetrance measurement served as a basis to examine the physical condition of the soil and also to compare the effects of various soil cultivating systems on soil condition. The penetrance and current physical condition of the soil can be determined fast and relatively accurately with a penetrometer. The range of soil penetrance is affected by the moisture content of the soil and soil compaction.

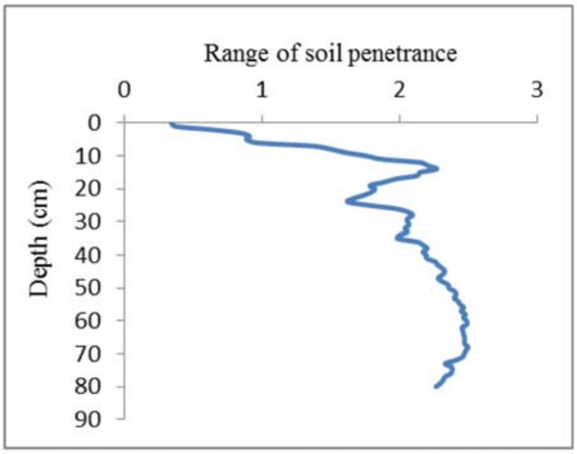

Figure 1. Semi-deep ploughing

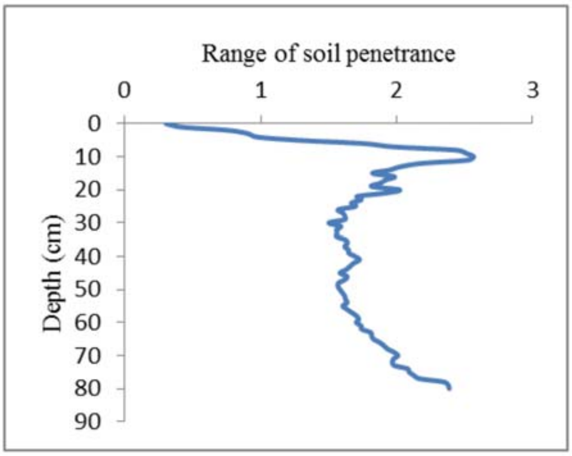

Figure 2. Deep ploughing

Another important part of our experiment are the soil physical measurements, with which we would like to point out how certain cultivating methods with the same cultivating techniques affect soil porosity and how this value alters as an effect of irrigation; also, in which cases and at what quantity of water the values vary positively or negatively. The constant measurement of soil respiration and the climate of stand may provide an answer to our questions.

Together with the absorbable amount of water present in the soil we also constantly measure the water balance coefficient values (VHE), trying to find the answer for how post-rainfall and irrigation values change. Certain parameters of soil life are also measured. We are examining the number of earth worms, in accordance with soil cultivating technologies. Earth worms react rather sensitively to certain elements of modern agriculture, such as plant protection products, or soil compaction. Soil cultivation is a sensitive issue, since it disturbs earthworms and destroys their tunnel systems.

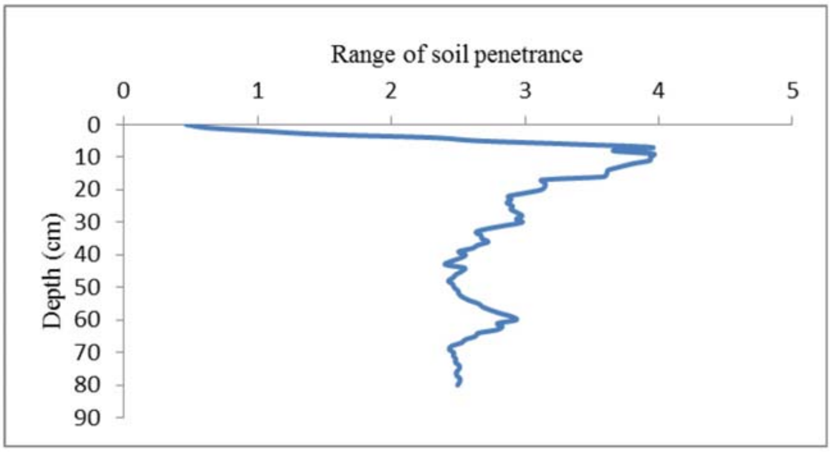

Figure 3. Disc ploughing

The achievable targets using a well-chosen soil cultivating method are:
- –Soil dust prevention or control, thereby reducing degradation caused by wind or rain.
- –Trample damages caused by cultivation and expenses of production can be reduced.
- –The water absorbing ability of the soil can be improved; the loss of moisture can be reduced.
- –By this, the degradation of soil structure can be reduced. The stability of aggregate can be increased considerably.

The experiment average production did not reach the 31.6 tonnes per hectare amount which was measured at an American harvest competition in 2014; however, it exceeded the five-year average production in Hungary and over 6.0 tonnes per hectare could be harvested.

Table 1. Production results

Deep ploughing	Semi-deep ploughing	Disc ploughing
13.680	11.490	8.820
estimated average production kg/ha		

Conclusion

In the past few decades, the pursuit of large average productions and intensive production of plants has overshadowed land use focusing on the productivity, physical, biological and chemical condition of the soil. The findings of the research allow us to choose and apply further soil cultivating methods for the best soil structure. By taking advantage of the opportunities for irrigation experiments at Szarvas, further opportunities become available to optimise irrigation and soil cultivation. The test results can be integrated into the structure of education or into the curriculum of current trainings, such as the Agricultural Water Management specialist training. A well-chosen, adaptive soil cultivation method that fits into the site and climate conditions also provides the conditions for sustainable plant production.

"The only good way is to apply such methods that also ease climate damages in the long-term." (Márta Birkás)

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EFFECTS OF HIGH HYDROSTATIC PRESSURE'S HOLDING TIME ON PROTEIN STURCUTRE OF LIQUID EGG PRODUCTS

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Abstract: Today's consumers require food products with fresh, or fresh-like characteristics. Minimal processing technologies are indicated as technologies with a gentle impact on sensorial and techno-functional properties. High Hydrostatic Pressure (HHP) is a widely used minimal technology considered as a cold pasteurization method in food preservation. The effect of applied pressure of HHP is well understood, but the holding time of HHP treatment is not extensively investigated in topic of proteins.
One of the most important attribute of liquid egg products are the great foaming ability, foaming stability as well as emulsifying properties. These techno-functional properties are highly influenced by the protein structures of egg products.

In our study, liquid egg products were pressurized at 400 MPa, for 1, 3, 5 7 and 10 minutes. The protein structures of liquid egg white (LEW), liquid egg yolk (LEY) and liquid whole egg (LWE) were investigated using Differential Scanning Calorimetry (DSC).

Our study pointed out that after HHP treatment at 400 MPa, for 10 minutes 12% decrease in denaturation enthalpy of LWE was observed. In LEY 30% decrease was detected after 10 minutes HHP treatment. The highest impact of HHP treatment (35% decrease in denaturation enthalpy) in LWE was noted.

The changes in protein structures of liquid egg products were smaller, than the effects of higher pressure applied for preservation. In aspects of techno-functional properties applying a longer holding time is more favourable, than applying a higher pressure.

Keywords: liquid egg products, protein, minimal processing technologies, DSC

1. Introduction

The Egg white is a key ingredient in many food products as it combines high nutritional quality (8) with excellent functional properties (1). The high content of essential amino acids in egg white proteins and the high bioavailability of these proteins are of great benefit to human nutrition (3),(5). However, the effects of industrial processing such as dry heating on the nutritional quality of egg white proteins have been poorly documented. Some studies considered the effect of dry heating on the in vitro digestibility of proteins as it is a prerequisite to nutritional quality (7), but the effects of minimal processing technologies are not investigated in case of egg white. Studies are viable about the digestibility assays confirmed previous findings that exposure of egg white to high temperatures increased digestibility markedly. However, it seems that the effects of pH and salt concentrations were found to be minimal (4).

In the egg product industry, microbiological safety of liquid products is mainly guaranteed by pasteurisation. The USDA requires that liquid whole egg is at least heated at 60°C for no less than 3.5 min, but in the United Kingdom the recommendations are to pasteurize at least at 64°C for 2.5 min [1], [2]. In France, there is no statutory heat treatment; only microbiological results are determined by regulations. To achieve this, the treatments classically used to pasteurize whole egg vary from 65 to 68°C for 2–5 min in order to ensure 5 to

6 decimal reductions of vegetative microorganisms and especially Salmonella Enteritidis and Listeria monocytogenes [3]. Pasteurisation temperatures used in egg industry are limited by the sensitivity of egg proteins to heat treatment. Thus, pasteurisation for 2–10 min from 60 to 68°C modifies whole egg electrophoretic pattern by especially decreasing ovotransferrin, livetin, ovalbumin, apovitellenin, lysozyme and/or ovomucin band intensity [4], [1], [5].

Liquid egg white (LEW) and egg white-based products are usually regarded as functional foods for their excellent source of high-quality proteins, trace minerals, and for the ability of their components to coagulate, and to form foams when whipped. HHP is one of the most promising minimal processing technologies in the food industry, but only a few scientific studies are existing about HHP treatment and its effects on egg products [6].

HHP has gained popularity as an alternative for conventional thermal treatment. It has advantages over thermal processing, including lower temperature and reduced extreme aggregation [7]. HHP is a powerful post-package treatment for controlling growth of microorganisms in different food products. Innovative processes have been reported by several researchers for improving the microbiological safety of eggs and egg products [8], [9], [10]. Different food products require different pressure levels providing microbiological safe products. E. g. meat products are mainly pasteurized, which is generally done in the range of 300–600 MPa, inactivating vegetative cells [11], [12]. High hydrostatic pressure (HHP) treatment could induce the egg white proteins denaturation and aggregation, depending on pressure range, protein concentration, time, pH, and temperature [13]. HHP process has shown a great potential to modify the protein conformational structure (secondary, tertiary and quaternary), which is stabilized by electrostatic interactions, hydrogen bonds and hydrophilic interactions, provoking protein unfolding, while preserving the protein's primary structure stabilized by covalent bonds [14], [15]. Previous works, pointed out the extent of protein modification is strongly affected by the nature of protein as well as by the processing conditions applied, namely pressure level, treatment temperature and holding time [16], [15], [17], [18].

Pressure processing of egg products has been used experimentally as an alternative to heat pasteurization and to eliminate Salmonella in several liquid egg products [19], [20]. The investigations pointed out that higher pressure ranges (above 450 – 500 MPa) minimalize microbiological spoilage of egg products [21], but it may cause a destruction of original structure [20] as well destroy techno-functional properties [22], [23].
In our study the effects of combinations of heat and HHP treatments are investigated on egg white's protein structures and microbiological safety.

2. Materials and methods

Sample preparing. Freshly laid, M size, traditional cage eggs were used for our measurements. Eggs were taken from a Hungarian layer farm, laid by farming Broilers. Homogenized, raw liquid egg products (liquid egg yolk LEY, liquid egg white LEW and liquid whole egg LWE) were taken from the production line of Capriovus Ltd (Szigetcsép, Hungary). Samples refrigerated at 4°C were transported to Sznet Szent István University, Budapest. For differential calorimetrical measurements (DSC) three times 10-10 mL of samples were packaged in polyethylene bags, for every treatment. 3-3 packages were prepared. HHP processing was carried out in a RESATO FPU100 – 1200 HHP equipment at room temperature. Before measurements. Before and after HHP treatments samples were stored at 4°C.

Differential Scanning Calorimetry (DSC) was used to assess the changes in proteins conformation induced by thermal denaturation [24]. Thermophysical calorimetric properties were examined on Micro DSC III (differential scanning calorimeter, SETARAM, Caluire, France). In each case approximately 778 mg of samples were sealed in a hermetic stainless-steel pan, for the measurements, and distilled water was used, in the reference cell. The heat-up ramp was from 20 to 95°C 1.5°C/min, the speed of cooling was 1.5°C/min, controlled by SetSoft2000. The overall denaturation enthalpy (DH) was calculated from the peak area of the thermograms (between 45 and 90°C) using Callisto 7.6 software. For every treated and native samples 3-3 repetitions were measured, measurements were carried out in 24 hours after HHP treatment. Our method was similar to [25], [26], [27] and [28]. According to several literature [29], [30], up ramp and cooling is more depending on characteristics of applied DSC equipment, than on properties of samples. Normalized thermograms of liquid egg samples are standing in this work for illustrating the widely different shapes of HHP treated samples. Numerical results of DSC analysis are summarised in tables.

3. Results

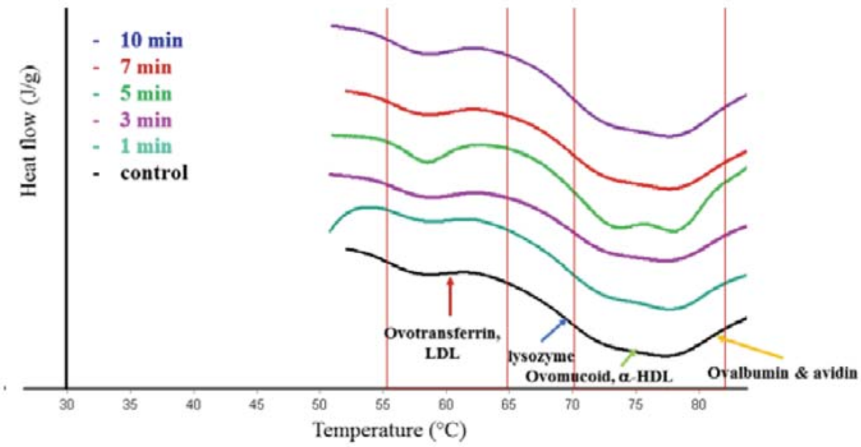

Figure 1. Thermograms of liquid whole egg treated at 400 MPa for 1 – 10 min

Figure 1 shows the thermograms of LWE samples treated at 400 MPa for 1 – 10 minutes. The first peak decrased by longer holding times. It may a result of denaturation of ovotransferrin of egg white and LDL proteins of egg yolk.

Table 1. Denaturation enthalpy and denaturation temperatures of LWE after HHP treatments at 400 M?Pa for 1 – 10 minutes

HHP	ΔH (J/g)	T_{d1}, °C	T_{d2}, °C
control	0,895 ±0,0039	58,11 ±0,78	73,69 ±1,52
1 min	0,839 ±0,0024 ^{AB}	57,78 ±1,01	72,99 ±2,02 ^{AB}
3 min	0,831 ±0,0023 ^{AB}	59,09 ±0,99	77,27 ±1,01 ^{AB}
5 min	0,828 ±0,0081 ^{AB}	57,39 ±0,84	76,48 ±0,45 ^{AB}
7 min	0,814 ±0,0018 ^{AB}	58,23 ±0,95	77,22 ±0,98 ^{AB}
10 min	0,785 ±0,0097 ^{AB}	58,07 ±0,77	77,83 ±1,11 ^{AB}

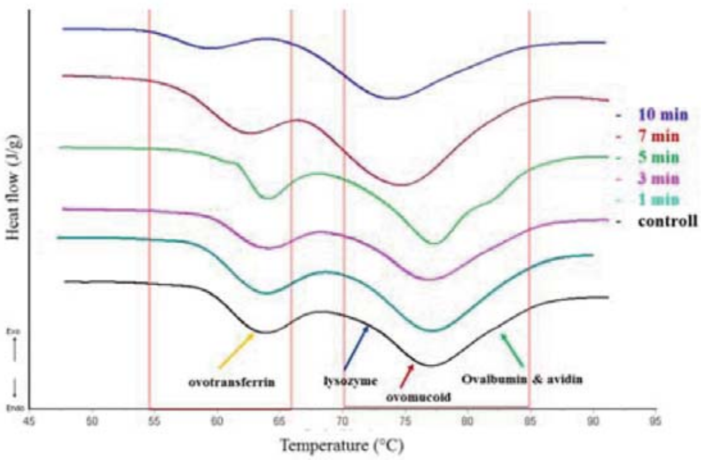

Figure 2 Thermograms of liquid egg white treated at 400 MPa for 1 – 10 min

Table 1 represents the numerical data of DSC measurements of LWE after HHP treatments. Comparing to control, ΔH decreased 13% after 10 minutes of HHP at 400 MPa. First denaturation temperature T_{d1}, was not affected by the different holding times applied in the experiment, in contrast, second denaturation temperature, T_{d2}, showed an increasing tendency by increased holding time. It may a result of denaturation and aggregation of lysozyme and ovomuciod.

Using one way ANOVA and post hoc tests, ΔH, T_{d1} and T_{d2}, were significantly influenced by HHP.

Figure 2 represents the thermograms of LEW samples treated at 400 MPa for 1 – 10 minutes. A similar tendendcy of peak maxima are viable to LWE. The shape of LEW treated for 10 minutes is highly influenced by HHP treatment: both peak maxima are smaller, as well have smaller temperatures compared to control.Denaturation entlaphy of LEW after 10 minutes decreased by 35% compared to control.

Table 2. Denaturation enthalpy and denaturation temperatures of LEW after HHP treatments at 400 M?Pa for 1 – 10 minutes

HHP	ΔH (J/g)	T_{d1}, °C	T_{d2}, °C
control	2,091 ±0,239	64,21 ±0,66	77,02 ±0,59
1 min	1,986 ±0,313	58,75 ±1,67 ^{AB}	75,31 ±0,62
3 min	1,815 ±0,157	64,11 ±0,54	77,09 ±0,37
5 min	1,845 ±0,121	64,23 ±0,71	77,21 ±0,69
7 min	1,756 ±0,103	63,88 ±0,75	73,12 ±0,66
10 min	1,351 ±0,305 ^{AB}	59,61 ±1,54 ^{AB}	73,67 ±1,71

Table 2 represents the data of DSC measurements of LEW after HHP treatments at 400 MPa. A higher denaturation of proteins is viable in egg white compared to whole egg samples. It may a result of the lack of protective effects of egg yolk’s proteins. In changes of temperature of denaturation there are no tendencys. But statistical evaluation pointed out, that HHP for 1 – 10 min at 400 MPa has no significant effects on values of TD2.

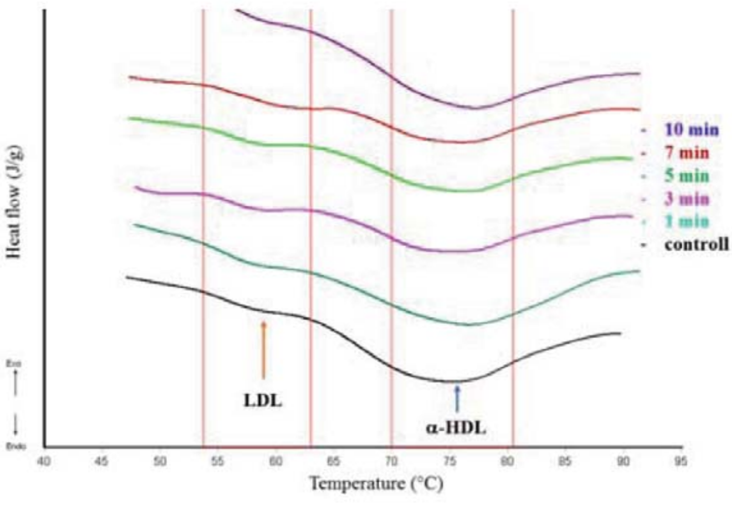

Figure 3. Thermograms of liquid egg yolk treated at 400 MPa for 1 – 10 min

Figure 3 demonstrates the thermograms of LEY samples treated at 400 MPa for 1 – 10 minutes. Peak maxima are moved to a higher temperature after treatments, as long denaturation enthalpy decreased by longer holding time. Two peak maxima are demonstrated [31]. The first may a result of denaturation of LDL (low density lipoproteins) and the second from denaturation of α- HDL (α-high density lipoprotein) fractions in egg yolk [29].

Table 3. Denaturation enthalpy and denaturation temperatures of LEY after HHP treatments at 400 M?Pa for 1 – 10 minutes

HHP	ΔH (J/g)	T_{d1}, °C
control	0,714 ±0,0092	73,74 ±1,36
1 min	0,639 ±0,0078	77,49 ±1,17 AB
3 min	0,567 ±0,0039	74,09 ±0,86
5 min	0,541 ±0,0031	76,04 ±0,27 AB
7 min	0,506 ±0,0034	76,25 ±0,42 AB
10 min	0,499 ±0,0021	76,16 ±0,36 AB

Table 3 summarizes the numerical data of DSC analysis of HHP treated LWY at 400 MPa for 1 – 10 minutes.

The longest treatment affected a decrease of denaturation enthalpy about 13%, which means a statistical unsignificant change in ΔH. In contrast, temperatures of denaturation are highly influenced by the holding time of HHP. It showed an increase after HHP treatment. Every Td1 result is statistical significant compared to the control sample.

Conclusions

Summarizing our data HHP's holding time may affect the protein structures of liquid egg products. The highest influence of HHP was established in liquid egg white. It means that techno-functional properties of egg white may highest changed by HHP holding time as well. In case of liquid whole egg and egg yolk HHP at 400 MPa for 1 – 10 minutes may a relevant solution for decontamination and fulfil the requirements of microbiological food safety.

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MODELLING WATER PRODUCTIVITY OF SELECTED GRAIN CROPS IN RAIN-FED AND SURFACE IRRIGATED FIELDS IN NORTHERN NIGERIA.

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Abstract: Field trials of selected grain crops (rice, wheat and maize) were conducted for three years under rain-fed and surface irrigated systems to evaluate their water productivity and model same. A completely randomized design (CRD) experiment was used at the Irrigation Research Station, Kadawa, Kano State. Rice yield was 11.6, 9.9 and 5.3 tons/ha; wheat yield was 1.46, 1.92 and 2.0 tons/ha, while Maize yield was 0.8, 0.4 and 0.91 tons/ha in the 2009/2010, 2010/2011 and 2011/2012 cropping season, respectively. ANOVA revealed a highly significant difference in the yield of paddy rice, wheat and maize at both 1 % and 5% significant levels (Fcalc>Ftab), with p-value of 0.0002, 0.004 and 0.001 for rice, wheat and maize respectively. Crop – water productivity models developed revealed that optimum crop yield of 12.8 tons/ha of paddy rice, 2.7 tons/ha of wheat and 0.94 tons/ha of maize is achievable with 58.3 cm of rainfall, 34 cm and of 29.8 cm of irrigation water respectively.

Keywords: Water, Crop yield, Productivity, Irrigation, Food security

1. Introduction

Attaining food security is an important endeavour that every developing countries especially in sub-Saharan Africa (SSA) must commit to in order to avert future crisis. According to [9], increasing agricultural productivity is very important to food security in the following ways: it produces the food people eat; and it provides the primary source of livelihood for 36 % of the world's total workforce. In the heavily populated countries of Asia and the Pacific, this share ranges from 40 to 50 %, and in SSA, two-thirds of the working population still make their living from agriculture [15]. The dominant crop production system in SSA is the rain-fed agricultural system; this cannot guarantee the much needed sufficiency in food production. [5] opined that effective food security can only be achieved through irrigated agriculture; this is possible because irrigation ensures all year round food production within the limits of the available water resources. They further argued that irrigation accounts for about 72% of global and 90% of developing – country water withdrawals; and water availability for irrigation may have to be reduced in many regions in favour of rapidly increasing non-agricultural water uses in industry and households, as well as for environmental sustainability.

In SSA, irrigation development is presently low despite the huge potential that exists. In Nigeria, for example, the country has over 74 million hectares of arable land, good for farming; current reliable data shows that only about 0.3 % of this land area is currently developed and equipped for irrigation (FAOSTAT). The implication of these is that a huge potential exist for achieving food security in Nigeria. This scenario presents a great opportunity for Nigeria not to make the same mistakes other nations that invested massively in irrigated agriculture without adequate irrigation water management, especially with the climate change phenomenon in full swing in SSA.

[2] also posited that by 2050, agriculture will need to produce 60% more food globally, and 100% more in developing countries; this will definitely exert pressures on the world's freshwater resources. Inefficient use of water for crop production has depleted aquifers, led to reduced river flows, degraded wildlife habitats, and has

caused salinization of about 20% of the global irrigated land area [10]. According to [16], the quest for food security and improved access to water, have led to tremendous resources being invested in developing water for agricultural uses; but, with the growing demand for water for industry and municipalities, combined with environmental problems, there is bound to be less water for agriculture in the future. In order to avoid a crisis, it becomes imperative for developing nations to begin to plan their water management systems in such a way that all contending water uses will be sustainably catered for. One approach found in literature is increasing the productivity of water by ensuring that more crop is produced from every drop of water [18][14][22]; this will help avert water scarcity and free enough water for other competing needs, other approaches includes wastewater recycling and reuse, conjunctive use of surfacewater and groundwater and managed aquifer recharge [6] From the account of [18], Water Productivity (WP) can be defined as the ratio of net benefits from crop, forestry, fishery, livestock, and mixed agricultural systems to the amount of water required to produce those benefits; this imply a ratio of total weight of harvested crop or monetary value of proceeds to the amount of water used for its production. It is pertinent to point out that WP differ among crop types, production systems and agro-ecological zones. With growing irrigation-water demand and increasing competition across water-using sectors, the world now faces a challenge to produce more food with less water. This goal will be realistic only if appropriate strategies are found for water savings and for more efficient water uses in agriculture.

Several researches have been reported in literature on the subject of water productivity and food security [19][13][24][17][1][12] [11][23]; however, very little efforts have been reported in SSA, especially Nigeria. Water productivity research was pioneered in Nigeria by [14] with a study on onions; [3] investigated the water productivity of drip irrigated Soybeans; [22] also evaluated for rice under various irrigation schedules and tillage practices in Northern Guinea Savannah Region of Nigeria while [4] investigated the water productivity of Cassava under rain fed production system. All these studies have added to knowledge, however, more still need to be done in order to improve our production systems and to better adapt to the changing climate and manage agricultural water effectively. The aim of this research was to develop models for water productivity of selected grain crops in rain fed and surface irrigated systems as a decision support for agricultural planning for adaptation to the changing climate in Nigeria.

2. Materials and Methods

Study location

The research was carried out at the 26.9 ha Irrigation Research Station, Kadawa within the Kano River Irrigation Project (KRIP), Kano State, Nigeria. The station is located about 47 km south of the capital, Kano City between longitudes 8o25.451 and 8o26.151 E. and latitudes 11o38.291 and 11o38.501 N. The area is situated within the Sudan savannah agro-ecological zone of Nigeria; local climate indicate three distinct seasons; namely, wet season (early June – late September (4 months)), cool dry season (October – mid February (4½ months)) and hot dry season (mid-February – early June (3½ months)). The mean annual rainfall range between 700 – 800 mm, while mean daily temperature ranges from 29°C to 38°C [20]. KRIP is cited on a dissected peneplain developed on the crystalline Precambrian rocks of the basement complex, the main rock types are granite, gneisses and schist, complex glimmer schist and quartzite. The top of the basement complex is deeply weathered and soils of the experimental farm belong to the upland plain, about 60% are deep and well drained, and the remaining 40% are poorly drained and are underlain by an iron pan of Ferruginous Feldspar found at an average soil depth of 1.52 m; the soils are mostly sandy loam textured top soil and sandy clay loam textured subsoil. The IRS experimental farmland is divided into four blocks namely: F-3.4, F-3.5, F-3.6 and F-3.7 as shown in figure 1 and intensively cropped with vegetables, wheat, onions, tomatoes, rice, etc. Each block was well laid out and generally slopes in the south easterly direction with water canals running along their northern side and drain on the south, the water canals run over a gradient and have several drop structures along their length to control the velocity of flowing water.

Field Layout and Experimental Design

The field trials were established on a 0.15 ha land in the F-3.4 block as shown in figure 1; plot size of 5 m x 80 m divided into 16 basins of 5 m x 5 m each was laid out in a completely randomized design (CRD) with three replicates to make a total of 48 basins as shown in figure 1, equal treatment was given to all the replicates in the trials; basin irrigation method was used for dry season cropping while, wet season cropping was rain fed. For the purpose of irrigation, a 75 mm internal diameter siphon tube was used to supply water to a 5 m x 3 m buffer basin at the beginning of the plots to stabilize the flow before passing through cut – throat flumes (for measurement of irrigation depth) and into the experimental basins; the water was thereafter controlled to cascade from one basin to the other and no runoff was allowed out of the plots during irrigation, neither was cross flows allowed from adjoining plots; this was achieved by constructing dykes at the plot borders and ensuring that irrigation water was cut out after the 13th basin was satisfied, water continues to flow till the last basin was irrigated, this strategy ensured that the trials were not over irrigated. The cropping schedule for the three years of trials (2009/2010, 2010/2011 and 2011/2012) is presented in Table 1.

Cultural Practices

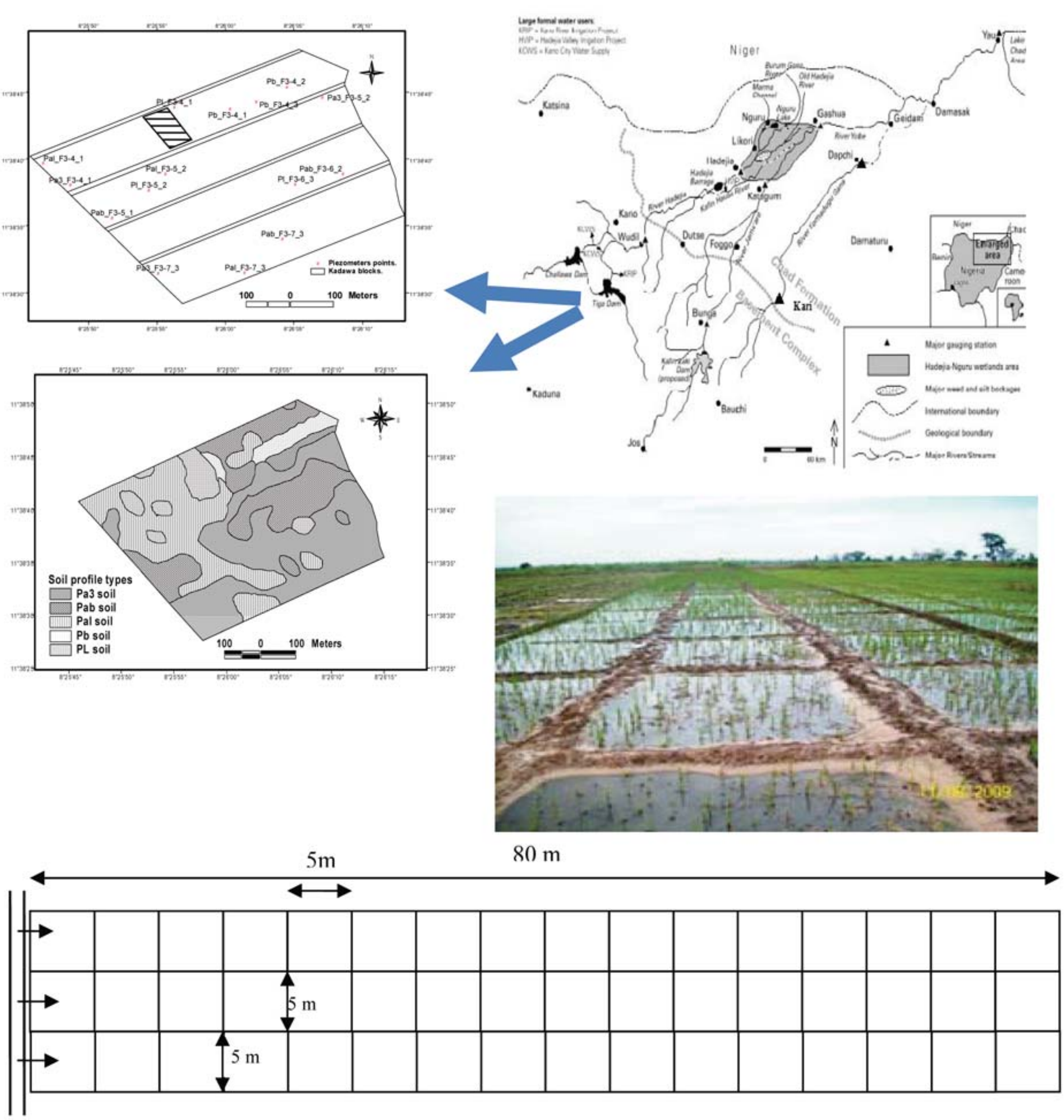

Figure 1. Location, soil classification, and experimental plot layout at the study site

Table 1. Cropping schedule for field trials

Season	Period	Crop	Botanical Name	Cultivar	Number of Days
Cool dry	Dec – March	Wheat	*Triticum aestivum*	SAM-WHIT-5	120
Hot dry	April – July	Maize	*Zea mays*	Sammaz 13	80
Wet	August – Nov	Rice	*Oryza sativa L*	CP	130

The crops were cultivated in succession for the three years, wheat was planted using a seed rate of 100 kg/ha and was sown by hand drilling at a row spacing of 20 cm; rice was sown by broadcasting on a seed bed and then later transplanted to the basins using a row spacing of 20 cm, while Maize, on the other hand was also planted manually using a row spacing of 30 cm. Fertilizer application of 50 kg N, 50 kg P2O5 and 50 kg K2O /ha in the form of NPK 15: 15: 15 was given at planting while 50 kg N/ha was applied in the form of Urea (46% N) at four weeks after planting by top dressing. Pre and post emergence herbicides were applied to the field as at when due, this was also supplemented with manual weeding to remove weeds; this same process applies to maize and rice cropping. The rice specie cultivated was lowland rice since the areas is completely waterlogged in the raining season. Day guards were employed to wade off birds manually when necessary. It should be noted that the use of basin to grow maize crop is not ideal for the area; however, it was needful to ensure uniformity in the planting method for the three years of study.

Data Collection and Analysis

Pertinent data collected during the trials includes irrigation water application depth, irrigation time, rainfall, temperature, relative humidity, solar radiation and crop yield. Evapotranspiration on the farmland was estimated using the Blaney-Morin-Nigeria (BMN) model developed on the farmland and crop coefficient factor Kc by [7]:

$$Et_o = \frac{r_f(0.45T + 8)(520 - R^{1.31}}{100} \quad (1)$$

where, Et_o = potential evapotranspiration,
r_f = ratio of maximum possible radiation to the annual maximum, T = Mean temperature (°C), and R = Relative humidity (%).

$$Et_c = Et_o * k_c \quad (2)$$

where Etc = crop evapotranspiration and kc = crop coefficient (for maize ~ 0.84, wheat ~ 0.675, and rice ~ 1). Daily crop evapotranspiration data was used to design for appropriate irrigation water application depth for each crop. The data collected were analysed using R statistical software to obtain pertinent descriptive and inferential statistics; regression analysis was used to develop crop yield models using irrigation and rainfall depths for the three seasons identified in the area.

3. Result and Discussion

Rainfall and Temperature Distribution

Rainfall during the trial period followed a similar pattern with what obtains in the agro-ecological zone, the onset of the rains fell majorly in the month of June except for year 2010, when it occurred in the month of May. The Cessation of the rains took place in October for the year 2009 and 2010 while it occurred earlier in September of year 2011. The total amount of rainfall received annually for the three years of study range from 29.0 - 77.5 cm, year 2011 was a drought year having the lowest amount of annual rainfall in the study period, thus requiring supplemental irrigation in the wet season; this has direct implication for yield of crops in the area. Figure 2 shows the trend of daily temperature all through the three years of the study. Daily temperature in the period was lowest at 16°C and occurred on 17^{th}, 21^{st}, 22^{nd}, and 23^{rd} of November 2009, while the highest temperature in the period was 42°C and occurred on 8^{th} of April 2012. Total irrigation water applied annually range between 65.4 and 91.5 cm from 2009 – 2011.

Yield of Selected Crops

Table 2 presents the yield and the analysis of variance (ANOVA) results for the selected crops in the three years of study; rice yield was 11.6, 9.9 and 5.3 tons/ha in 2009/2010, 2010/2011 and 2011/2012 cropping year respectively. The lower value obtained in the 2011/2012 season was directly linked to the low rainfall in the period, the farmers generally experienced very low harvest of paddy rice in the entire irrigation scheme. ANOVA revealed a highly significant difference in the yield of paddy rice at both 1 % and 5% significant levels (Fcalc>Ftab), this was further confirmed by a p-value of 0.0002. According to [21], the average world yield for paddy rice was 4.3 tons/ha (1961-2009) while the Nigerian average production figure was 1.01 tons/ha; the results obtained from the field trials are novel indeed despite the limitation of climate change, the result is a pointer that Nigeria can achieve more productivity and food security with paddy rice production, but irrespective of this outcome, more cultivars of rice presently grown in Nigeria need to be tested using basin irrigation. It should be noted that the more the lowland rice is submerged in water, the more its productivity [24]. The dykes constructed to prevent runoff from the plots were very effective leading to maximum water availability for crop growth and development. The average yield was found to be above the world average by 62.3 %.

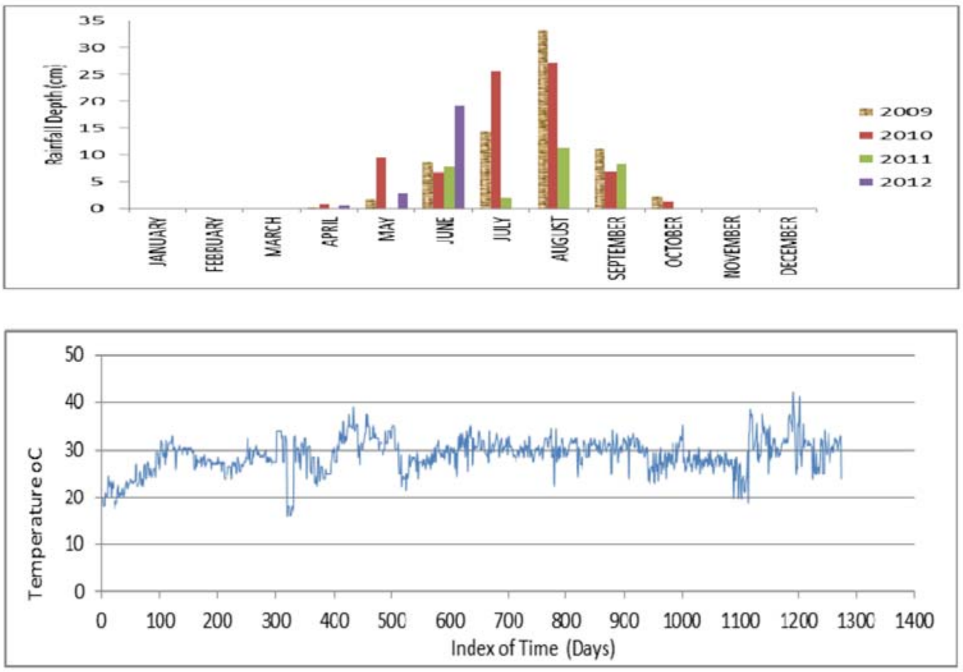

Figure 2. Rainfall and Temperature distribution during the study (2009 – 2012)

Wheat trials using basin irrigation method in the cool dry season took place between the month of December and March/April (depending on the sowing date), this in contrast to what obtains in the area in the past, sowing in December was due to the change in the arrival time of the North East trade winds responsible for the harmattan winter season. This is an evident impact of climate change on crop production systems in the area. The yield data of the three years of wheat cropping is presented in Table 2. The average yield obtained during the trials was 1.46, 1.92 and 2.0 tons/ha in the 2009/2010, 2010/2011 and 2011/2012 cropping season, respectively. These values were generally lower than the world average of 3.1 tons/ha (1961-2009), but are higher than the Nigerian average wheat production figures of 1.1 tons/ha. ANOVA revealed a highly significant difference in the yield of wheat at both 1 % and 5% significant levels (Fcalc>Ftab), this was further confirmed by a very low p-value of 0.004. Nigeria is not an important wheat producer; the entire wheat crops produced are consumed locally. Averagely, the harvests were good owing to the proper water management on the experimental plots. Field observations showed that the yield was better than the ones obtained by local farmers in the area due to over-irrigation. Farmers in the area practice wild flooding without any water management, forgetting that the wheat crop is not as water loving as rice; the rather poor yield obtained by farmers was found to be responsible for many of them shying away from planting wheat but prefer to plant tomatoes and onions in the cool dry season.

Table 2. Variability of yield and water productivity of selected crops (2009 – 2012)

Rice

Years	*Yield (tons/ha)*	*Water Productivity (ton/ha/cm)*
2009/2010	11.6	0.16
2010/2011	9.9	0.13
2011/2012	5.3	0.18

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Years	64.7	2.0	32.3	46.935	0.0002	5.143
Within Years	4.1	6.0	0.7			
Total	68.8	8				

Wheat

Years	*Yield (tons/ha)*	*Water Productivity (ton/ha/cm)*
2009/2010	1.5	0.03
2010/2011	1.9	0.08
2011/2012	2.0	0.05

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Years	0.6	2	0.28	16.18	0.004	5.14
Within Years	0.1	6	0.02			
Total	0.7	8				

Maize

Years	*Yield (tons/ha)*	*Water Productivity (ton/ha/cm)*
2009/2010	0.83	0.03
2010/2011	0.37	0.02
2011/2012	0.93	0.03

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Years	0.55	2	0.27	27.4	0.001	5.1
Within Years	0.06	6	0.01			
Total	0.61	8				

Maize traditionally is planted in ridges in the area, but because of the need to maintain uniformity in the production system, basin irrigation method was used. Yield data of 0.8, 0.4 and 0.91 tons/ha were obtained in the 2009/2010, 2010/2011 and 2011/2012 cropping season, respectively. This was found to be lower than the world average of 5.3 tons/ha, it should however be noted that the yield figures given here are for dried shelled grains. The yield obtained in the 2011/2012 year was just slightly lower than the Nigeria average. The generally low yield in the first and second year could be adduced to the planting of the maize in basins rather than ridges. The yield however increased when planted on ridges in the third year. This confirms that the method of seed bed preparation has a great influence on crop productivity. ANOVA revealed a highly significant difference in the yield at both 1 % and 5% significant levels (Fcalc>Ftab), this was further confirmed by a low p-value of 0.001.

Understanding the relationship between crop yield and water utilization is very important for planning of irrigation water and management of available water resources [25]; Table 3 presents the crop-water models developed from the crop yield and water use data obtained from the three years of trials. The regression models reveals an excellent relationship between the two variables and are useful for planning rain-fed cropping of rice and irrigation planning for wheat and maize in the area.

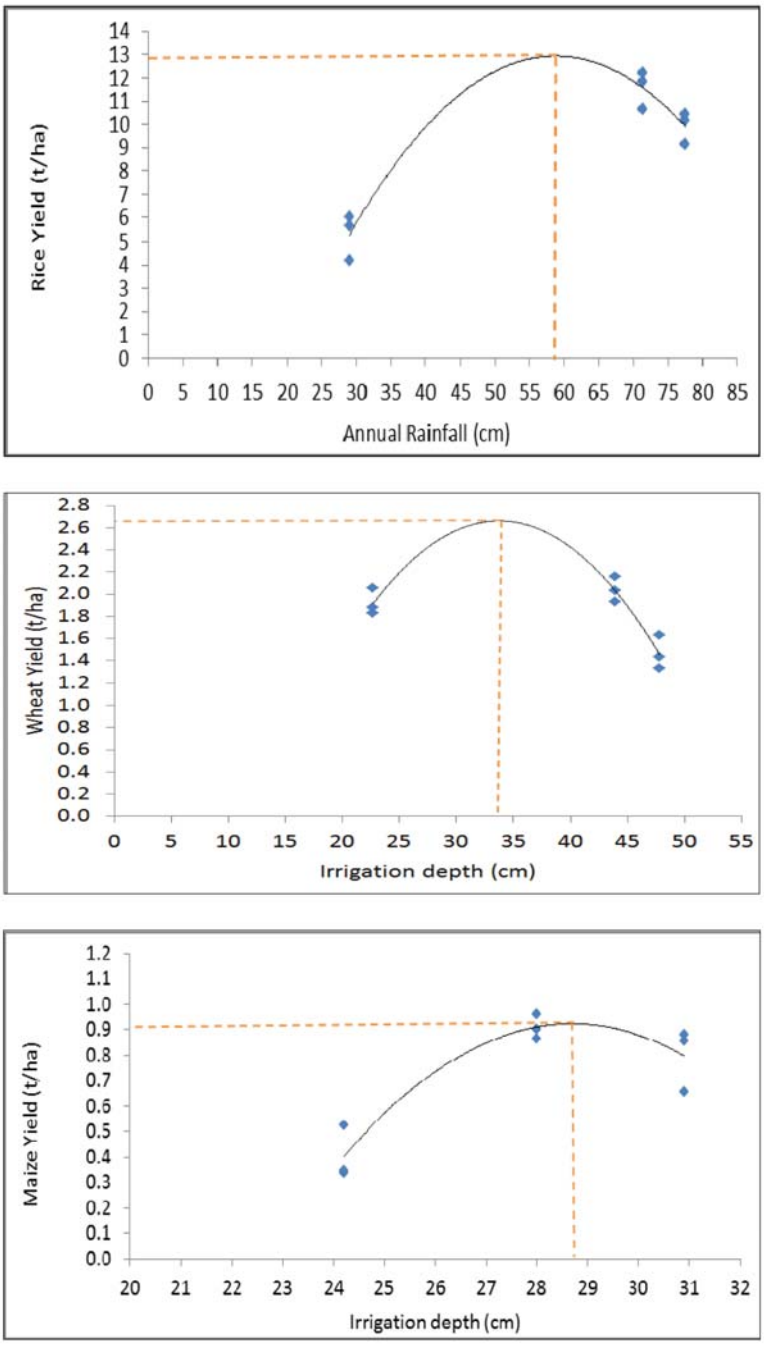

Figure 3. Simulation of crop yield as a function of rainfall and irrigation depth (2009-2012)

Table 3. Crop Water productivity models of selected crops

Crop/Cultivar	Model	R^2
Rice (cp)	$y = -0.0087x^2 + 1.0177x - 16.978$	0.9399
Wheat (SAM-WHIT-5)	$y = -0.0061x^2 + 0.412x - 4.2912$	0.8452
Maize (Sammaz 13)	$y = -0.0026x^2 + 1.4702x - 20.175$	0.8801

Key: y = yield (tons/ha), x = Irrigation depth in cm for wheat and maize, but rainfall for rice

Figure 3 shows the yield curves generated from the models for rice, wheat and maize respectively. Pertinent information obtained from the analysis is the optimum yield of the crops possible in the area and the rainfall and irrigation water amount that can deliver such yield, all things being equal.

In view of the prevailing environmental conditions, the models can be used to predict the yield of rice on the farmland provided the agronomic practices and land preparations are the same. Further analysis show that optimum crops yield of 12.8 tons/ha of paddy rice is achievable with 58.3 cm of rainfall in the area; this imply that the 70 – 80 cm of rainfall received in the area annually can adequately support rice cultivation in the area. Likewise for wheat, an optimum yield of 2.7 tons/ha can be achieved with 34 cm of irrigation water application all things being equal. This implies that more crop yield can be achieved with less water in the area. Literature shows that winter wheat does not require more than 4 – 5 irrigation cycles from sowing to maturity depending on climate and length of the growing period [8]. The model also revealed that optimum crop yield of 0.94 t/ha of maize is achievable with irrigation water application of 28.8 cm all things being equal. The above results indicate that higher productivity is possible with appropriate amount of water application for each crop; this has profound implication for food security in the area and improved income and livelihood for smallholder farmers which constitute the largest percentage of farmers in SSA. It is however, pertinent to state that the crop yield models developed for these crops are not conclusive as further studies still need to be carried out to appropriately verify them using various levels of the model variables and other cultivars of the selected crops. However, for rough estimations, the models can be used.

Conclusion

The research focussed on the development of water productivity models for rice, wheat and maize in rain-fed and surface irrigated fields in the most active irrigation scheme in Nigeria. The results of the field trials indicate that appreciable yield of the crops is feasible within the limits of the changing climate in the area. The southern shift of the Sahara notwithstanding, food security can be achieved with adequate water management strategies in place; the water productivity models developed revealed that an optimum crop yield of 12.8 tons/ha of paddy rice, 2.7 tons/ha of wheat and 0.94 tons/ha of shelled maize is achievable with 58.3 cm of rainfall, 34 cm and of 29.8 cm of irrigation water respectively. The study revealed that poor irrigation water management is largely responsible for the low yield of crops from farmer's field in the area. This brings to the fore the need to revamp irrigation extension services in the area; many of the farmers practice wild flooding which and they lack basic information about crop water requirement. The outcome of this present study is an important decision support for agricultural planning in the area. Further studies are however required particularly for other crops of economic importance to the region.

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Faculty of Mechanical Engineering

APPLICATION POSSIBILITIES AND BENEFITS OF IOT (INTERNET OF THINGS) IN AGRICULTURAL PRACTICE. QUO VADIS IOT?

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Motto: "Using gadgets is not a goal but a tool"

Abstract: Nowadays we are not able to exploit the technical and IT advantages provided by precision technologies from an ecological or economic point of view.

More than 20 years of experience unfortunately proves that we do not have adequate applied biological knowledge.

Today, our technical and IT knowledge provides us with many opportunities, e.g., during sowing we can change the distance between seeds, therefore altering the density of plants, or even switching to another variety. We can collect a lot of data during sowing but we can also take into account previous experience with the soil. The problem is that the relationship between the known data and the optimal number (density) of plants is still not yet known satisfactorily.

In this article we present the opportunities that IoT offers, primarily in terms of sustainable agriculture. The worldwide spread of IoT can also be considered the 3rd green revolution

Keywords: internet of things (IoT), sensor networks, big data, automating data collection, artificial intelligence

1. Introduction, chronology of technological development in plant production

The first Green Revolution

In the early years of the 1940s, Norman Borlaug's name became associated with the Green Revolution. It was the first technology-level production system using state-of-the-art wheat genotypes, chemicals, and technical background. The result was that in only a few years Mexico became self-supporting in cereal grain despite a drastic increase in population, despite previously needing to rely on significant imports. This program was also successful in Pakistan and India.

The second Green Revolution

Among the first in Europe, research activities started in 1998 in Mosonmagyaróvár (Hungary) with grain yield mapping. Additionally, the project included data collection, sensor techniques and sampling methods needed for precision agriculture (site-specific plant production activities). These were complemented with remote sensing: the evaluation of UAV (unmanned aerial vehicles or drones) and satellite imaging techniques. The results obtained also contributed to the examination of climate change effects on yield with the development of decision support models (e.g., DSSAT). [10]

The formal official definition of precision farming by the Board of International Society for Precision Agriculture (ISPA) is: "Precision Agriculture is a management strategy that gathers, processes and analyses temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production" [1]. In the field of animal husbandry, this definition can be supplemented by the following: Precision animal husbandry is intelligent farming that can improve, or at least objectively document, animal welfare on farms [2].

The initial results of the PA (Precision Agriculture) research group in Mosonmagyaróvár were reported in 2003 in the scientific journal Computers and Electronics in Agriculture. This study was for a long time one of the most cited articles in the journal and it is still regularly cited today [3].

The world has also changed in this area. David Tilman has drawn attention, as early as 1998, to the need for greening the Green Revolution, i.e., to take sustainability into account [4]. He also indicated that precision agriculture could be the solution and suggested that our knowledge of soil biology should be expanded. In 2002 Tilman shared startling data with his colleagues. In that data, it should be emphasized that only 30-50% of nitrogen fertilizers and 45% of phosphorus fertilizers are used by crops [5]. Following the chronology of events, in 2006 a Ph.D. dissertation was written at the Department of Biological Systems and Food Technology, University of West-Hungary (today: Széchenyi István University) in which artificial intelligence (AI) and neural networks were applied to the size definition of management zones [6]. We have achieved remarkable additional results in several respects including: soil resistance mapping [7], the specification of the continuous crop moisture measurement in the combine thresher [8], and ECa mapping [9]. We have achieved significant results in the development of the above-mentioned plant physiological models, specifically and primarily DSSAT [10, 11, 12]. Despite the effort in scientific activities around the world, it seems that precision technologies have not fully lived up to their promise. This finding applies in particular to sustainability criteria, environmental and nature protection.

After 16 years the alarm bells published by Tilman et al. (2002) [5], at the International "Precision Conference", Longchamps et al. (2018) [13] – along with N. Tremblay, then president of ISPA – indicated that adverse ecological challenges and the time distance between the answers to it is constantly increasing. From this, a legitimate conclusion was drawn that a paradigm shift is needed, which means increasing databases by many orders of magnitude. We need to consider Albert Einstein's idea: "The significant problems we face cannot be solved at the same level of thinking we were at when we created them."

Authors, with more than two decades of research experience, are showing that we need to go further, and the IoT (Internet of Things) provides an opportunity to do so.

2. The third Green Revolution

Definitions of IoT

The definition of the Internet of Things has not yet been clarified in the same way as precision agriculture.

The IoT can also be considered the fifth industrial revolution, as it first brought a fundamental change to large industrial companies in the monitoring of the production chain, in quality assurance. It can also be called a revolution in that it completely changes our living conditions. Not only will it be possible to explore contexts for which the appropriate database and modelling methods have not been suitable so far, but also because the system can predict changes, not only climate change. Society can prepare for that change. IoT is a global system of computer networks. "Everything connected to everything" means that living and inanimate "objects" come into contact with each other, the possibility of technical-IT interaction of which has not been given so far. Information about individuals is provided by sensors. These sensors are programmable, can analyse the signal, and both detect and transmit this information (edge and fog computing).

In summary: "The Internet of Things is a technological revolution that represents the future of computing and communications, and its development depends on dynamic technical and IT innovation in a number of important fields, from wireless sensors to nanotechnology" [14]. In a small environment scenario, "An IoT is a network that connects uniquely identifiable "Things" to the Internet. The "Things" have sensing/actuator and potential programmability capabilities. Through the exploitation of unique identification and sensing, information about the "Thing" can be collected and the state of the "Thing" can be changed from anywhere anytime, by anything" [15].

What is IoT

In the case of IoT technologies (fig. 1), the data transmission takes place using a network in such a way that human-human, human-computer interaction will not be necessary, instead, in the future the M2M (machine to machine) connection system will be realized. In the future, IoT will connect millions of devices with different technical features, which differ in terms of their technical characteristics (power supply, environmental adaptability, compatibility with other devices, etc.).

The evolution of IoT is increasingly taking the development of the network in that direction and revolutionizing the way it processes information from different locations with a unified approach to inform decision-making.

Big Data can only be processed with the help of artificial intelligence (AI).

It is important to note that while traditionally, e.g., in plant physiology models, the number of independent variables is limited, in AI it is theoretically possible to process infinite data if the computer capacity allows it. AI data mining "draws attention" to the most important factors influencing dependent variables, e.g., yield (weeds, pests, the appearance of pathogens, groundwater nitration, etc.).

From an agricultural technical point of view, it is important to note that the machine manufacturers, currently only actuators and self-propelled machine manufacturers, are placing more and more online sensors in their equipment with which they are in constant contact and obtain data from (continuous power measurement, engine diagnostics, etc.). This trend also contributes to the revolution of machine design, as operating conditions do not need to be modelled and direct information can be obtained from them. [16].

Architecture of IoT

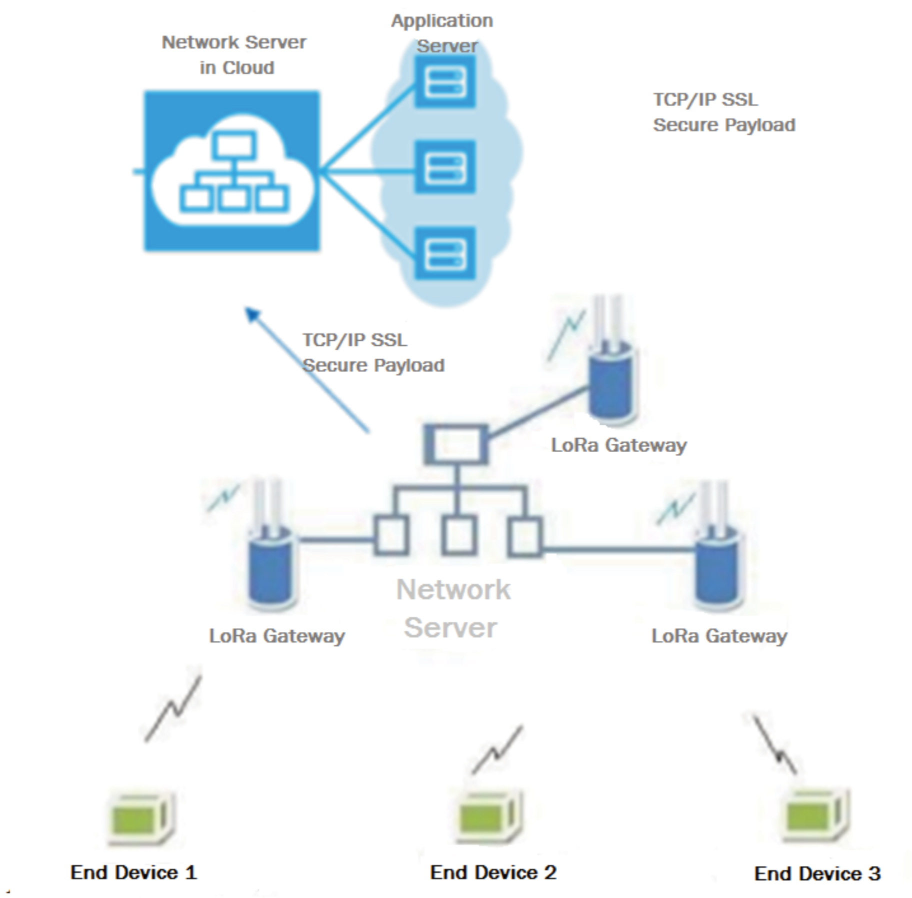

Figure 1. Architecture of LoRaWAN system

In agriculture, the most important requirements for IoT systems are having a range of 10-15 km and low energy consumption of data transmission devices. Currently, the LoRa system is the most suitable for this. LoRa (Long Range) is a wireless communication technology, which has two parts: LoRa (Long Range; the physical layer enabling more than 10 km transmission in rural areas, with a low power consumption); and LoRaWAN, which is the communication layer of system.

General structure of IoTs:

I. End nodes: 1. Sensors; 2. LoRa Transponders that transmit signals with radio transmission methods; 3. Microcontroller (optional), which is programmable by Phyton or Java.

II. LoRa Gateways are connected to the Internet through IP protocols and transmit data from sensors to a network, server or cloud.

III. Network: WSN (Wireless Sensor Network). It can be a cloud-based platform like TTN (The Thinks Network), or LoRa IoT.

IV. Application Servers

New Opportunity, the NB-IoT

"LoRa are non-cellular, NB-IoT are cellular IoT communication systems (NB-IoT: Narrow Band IoT).

Ranges of both LoRa and NB-IoT are 10–15 km. NB-IoT devices rely on 4G-5G coverage, so they are able work well indoors and in crowded urban areas.

LoRa devices work well when they are in motion, e.g., data collection with robots, tracking of shipments, etc.

Since LoRaWAN does not rely on cellular data or wifi for operation, its coverage remains relatively steady across all types of locations." Details can be found in [17].

3. Potential applications, Agricultural IoT in Mosonmagyaróvár: M-AIoT

This study mainly presents the objectives and the framework of our Agro-IoT system. Precision plant production is based on management zone delineation. A decision support model, such as DSSAT, requires more than 50 input parameters per management zone (out of them 22 data from the soil). To enhance the accuracy of the description of physiological characteristics of plants the amount of measured data has to be increased further. The Agro-IoT (Mosonmagyaróvár) system's main purpose is to collect data from crop fields and from the surrounding natural (or quasi-natural) areas. Thereby, the relationship between natural ecology and agro-ecology can be profoundly studied. One of the tools of processing Big Data is using artificial intelligence. The long-term aim is the continuous automatic validation of data provided by the on-the-go measuring systems that occurs while passing by the installed stations and making wireless corrections in the measurement of mobile devices. Based on previous experience collected by research, the IoT system will be expanded and operated.

In the first stage of our "Agro-IoT" project the aims are to compile soil and micro-climatic information and their effects in site-specific crop production. First of all maize and winter wheat cultivation needs to tested, in order to utilize Big Data that later will support the decision system for farmers. The core part of this activity is automating data collection, extending remotely obtained parameters of crops, and accessing real-time data from any device at any time. The real challenge is the fusion of data gathering from different platforms. The installed sensors (fig. 2) are measuring parameter samplings every 16 minutes. The monitoring parameters are soil electrical conductivity, soil water content and soil temperature at different depths (5, 20, 40, 60 and 80 cm), air temperature, humidity and pressure, and leaf surface humidity.

Other devices detect the environmental factors, such as ground water pH and nitrite-nitrate content, soil CO_2 and ammonium emission. A complex meteorological station will analyse ten parameters from the crop microclimate.

The information, automatically gathered by the sensors, is analysed using a traditional method and these are compared with different computations (e.g., artificial intelligence). Until now, parameters were measured manually in a difficult, long and expensive process.

This new sensor network hopefully offers useful "Big Data" results. As our measurements and findings will grow, we hope to get closer the final aims of the project namely a fully automated sustainable crop production systems based on proper Big Data evaluations.

Figure 2. Installed sensors in a research crop field (Mosonmagyaróvár, 2019)

Conclusion

The reason for IoT progress is that the amount of data in precision Agriculture is increasing significantly. The system that will be built in agriculture will be able to collect data on the soil, plants, and their environment using long-range wireless transmission. The installed systems, the on-the-go (mobile), the UAV (Unmanned Aerial Vehicle), and satellite sensors can provide long-range data transmissions with low energy consumption. Big Data meets the needs of data processing with artificial intelligence methods. The purpose of all this is to serve the precision, site-specific crop production, in order to accomplish more accurate forecasts with sustainable approach.

The complete system prepares application plans and designs precision work operations based on field-specific sensors and information obtained by IOT system. Some elements have already been realised for this, e.g., modification of robot detectors in order to be capable of colour recognition. The data collected from the sensors are stored on an online site. In addition, the installed IoT stations continuously measure the incoming data, if necessary, they calibrate the data provided by robots or other platforms. At the same time, the processing of data in a unified system (data fusion) should be mentioned as a challenge in which IOT systems and artificial intelligence will play a role. Filtering out the right information from the data and using it in production is still not possible. Wireless data transmission methods will facilitate the development of a unified data structure in farming as well; these solutions will require less manual data collection and will be available to the farmer at any time. At the same time, the M2M unmanned system is becoming more and more realized

In animal husbandry, in addition to real-time automatic monitoring of production parameters, animal health and welfare, and environmental impacts, these systems also support farm management decision-making, which results in cost reductions. We achieve fewer negative environmental impacts with increased productivity and product quality. In cattle breeding, for example, IoT solutions are able to detect the microclimate change. This includes the detection of heat stress and the negative effects it causes, such as reduced feed intake, unfavourable pregnancy rates, and so on. They can also provide a solution to the needed intervention [2].

Practical applications and research are not always in line. Farmers are not always able to apply and adapt all results. Technical IT solutions have exceeded agronomic knowledge. There are all opportunities to harmonize the aims of technical-IT and applied biology (agronomy) research.

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MONITORING OF DIFFERENT PROBIOTIC ACTIVITY LACTOBACILLUS STRAINS' GROWTH BY DIFFERENT PHYSICO-CHEMICAL PARAMETERS

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Abstract: Lactic acid bacteria (LABs) are Gram+, anaerobic or facultative anaerobic bacteria requiring specific nutrition environment whose major metabolite end product is lactic acid. The aim of our study was to describe the behaviour of the different bacteria strains during the yoghurt fermentation by various microbiological, physical and chemical methods. The formation of the yoghurt character was monitored for 20 hours at 37°C by viscosity and pH measurement methods. The tested physical and chemical properties of the yogurt samples prepared presented high variability which can be useful in the product development of probiotic yogurt.

Keywords: yoghurt, Lactobacillus, viscosity, pH

1. Introduction

Lactic acid bacteria (LABs) are non-pathogenic, Gram+ bacteria with anaerobic of facultative anaerobic metabolism. They require specific nutritional environment and the end product of their metabolism is lactic acid (Slavchev et al., 2015).

LABs are commonly associated with the human gastrointestinal tract (GIT), due to their beneficial effect on digestion and physical condition (Remagnia et al., 2013). The industrial importance of LABs is given by their fermentation activity and nutritional advantage originating from their probiotic activity. Probiotics have numerous beneficial attributes in health such as supporting the immune system, decreasing risk of colon cancer, decrease the symptoms of lactose intolerance and relieve irritable bowel syndrome. The most important property of probiotics is that they can survive in the upper gastrointestinal tract despite the low pH (Slavchev et al., 2017).

The demand for probiotic containing food has increased recently (Michael et al., 2015). Yoghurt is known as the most popular carrier for probiotic bacteria (Fazilah et al., 2018). Yoghurt is a dairy product produced from mammalian milk such as cow, goat, buffalo, or sheep. In the industry cow milk is the most commercial, it is produced by the inoculation of milk with the starter culture after setting fat content and homogenization. The starter culture usually contain Streptococcus thermophilus and Lactobacillus delbrueckii subsp. bulgaricus strains (Tamime & Robinson, 2010).

L. delbrueckii subsp. bulgaricus and S. thermophilus were obtained in fermented milk product and in gel by rotational viscosity measurements were made with a coaxial cylinder Rotovisco RV2 reometer at 25°C. Viscosity was measured before and after stirring to test the resistance of the yogurt to mechanical handling. For that, yogurts were stirred on a magnetic stirrer for 1 min, and viscosity was measured thereafter. The viscosities measured after stirring were lower than those measured before stirring. In comparison, the viscosities of milks fermented with the S. thermophilus single-strain cultures increased only slightly and reached values of only 100 mPas. The gels were lumpy, and syneresis was apparent. The chemically acidified gel was fragile and reached a viscosity of only 90 mPas at pH 4.0, which is close to values obtained with the nonproducing strains. The stirring technique cannot be compared with industrial conditions, and, therefore, conclusions cannot be drawn for yogurt manufacture, but the comparison of viscosities measured before and after stirring is nonetheless instructive (Bouzar et al, 1997).

Afonso and Maia (1999) studied the rheological changes of the yoghurt at different point in the manufacturing process and to try to gain some measure of understanding of the morphological changes that occur. Development of structure during manufacture of stirred yoghurt was measured in shear rate sweep mode by oscillatory rheometer. The structural and rheological changes that occurred during post-incubation stages were observed during the analysis of cooled stirred yoghurt, stirred yoghurt with fruit and final stirred yoghurt samples after 3h incubation time, confirming that strong structural degradation occurs as shear forces are increased.

The aim of our study was to describe the behaviour of the different bacteria strains during the yoghurt fermentation by various microbiological, physical and chemical methods. Furthermore aim was to discriminate bacteria with different probiotic activity using with above mentioned method.

2. Materials and methods

Materials

In this study 15 different bacterial strains (genus Lactobacillus bulgaricus) were analyzed. These strains can be divided into three main groups based on their probiotic activity: non-probiotic, moderately probiotic and probiotic based on their standard microbiological properties (Table 1).

Table 1. Selected Lactobacillus bulgaricus bacterial strains (Slavchev et al, 2015 and Slavchev et al, 2017)

Strains	Maximal growth rate (μ_{max}) in MRS broth, h^{-1}	Maximal optical density (λ=665nm) in MRS broth	MIC of Bile, mg/ml	Yield of biomass after 3 h stay at pH 1.80 and 9000 U/ml pepsin	Strain's group
R1	0.07±0.012	1.676±0.046	1.250	0.036±0.004	Probiotic strains
S06	0.301±0.012	2.960±0.075	1.250	0.080±0.010	
S10	0.115±0.012	2.950±0.075	2.500	0.126±0.014	
S11	0.118±0.013	2.950±0.066	2.500	0.100±0.014	
S22	0.106±0.012	2.677±0.092	2.500	0.117±0.016	
S01	0.121±0.011	1.692±0.058	0.625	0.038±0.010	Moderate strains
S07	0.075±0.012	1.919±0.068	0.625	0.049±0.013	
S08	0.08±0.010	2.940±0.093	0.625	0.049±0.007	
S09	0.118±0.017	2.880±0.081	0.156	0.029±0.005	
Y12	0.150±0.027	2.023±0.074	0.625	0.041±0.006	
S02	0.070±0.011	1.521±0.035	0.156	0.006±0.001	Non-probiotic strains
S03	0.060±0.009	1.343±0.039	0.313	0.005±0.002	
S04	0.060±0.012	0.841±0.046	0.156	0.007±0.002	
S29	0.060±0.010	1.440±0.046	0.625	0.005±0.002	
S30	0.050±0.011	1.360±0.065	0.625	0.006±0.002	

Strain suspension

Skimmed milk powder was diluted to reach 3.5% protein content from reconstituted milk with sterilized distilled water and inoculated with the freeze-dried monoculture bacteria. 10 mg of freeze-dried bacteria was weighted in and filled up to 10ml with the reconstituted milk. This strain suspension was cultivated for 24 hours at 37°C to produce activated bacteria suspension.

Reconstituted milk product

The reconstituted milk product was inoculated with this activated bacteria suspension to have initial cell number of 104/ml milk. This suspension was incubated for 11 hours at 37°C to produce yogurt and the cell count was determined at 4th and 11th hours of incubation by Breed Staining Method. The cell count was determined after the activation of bacteria and at the mentioned measurement times with three parallel measurements by layered plating method on MRS agar. For the plates 10 times dilution was prepared in six steps. The plates were incubated for 72 hours at 37°C.

Methods

The formation of the yoghurt character was monitored for 20 hours at 37°C by viscosity and pH measurement methods. The pH value was detected with Mettler Toledo Seven Multi pH meter in every four minutes and resulted in 300 pH values for each yoghurt product.
Viscosity of the yogurt formation was monitored by Haake RotoVisco1 rotational rheometer at 2 1/s maximal angular velocity. The shear stress was detected in every 5 seconds and resulted in 14400 data values for each yoghurt sample.
In case of each yoghurt formation the determined and calculated parameters were as the follows: inflection point of pH curve, pH values and viscosity at 4th and 11th hours, maximum value of the viscosity, the time at the maximum point of the viscosity and viscosity at the time of pH inflection point. The relative cell number was determined based on the change in cell number relative to initial cell number at 4 and 11 hours. The calculated relative cell number shows how many times larger increased the cell number since the beginning of experiment. Significant different was investigated by ANOVA test and Tukey HSD test.

3. Results and discussion

The Figure 1. shows the relative cell numbers at 4 hours and 11 hours relative to the initial cell numbers in case of probiotic, moderately probiotic and non-probiotic bacteria strains.

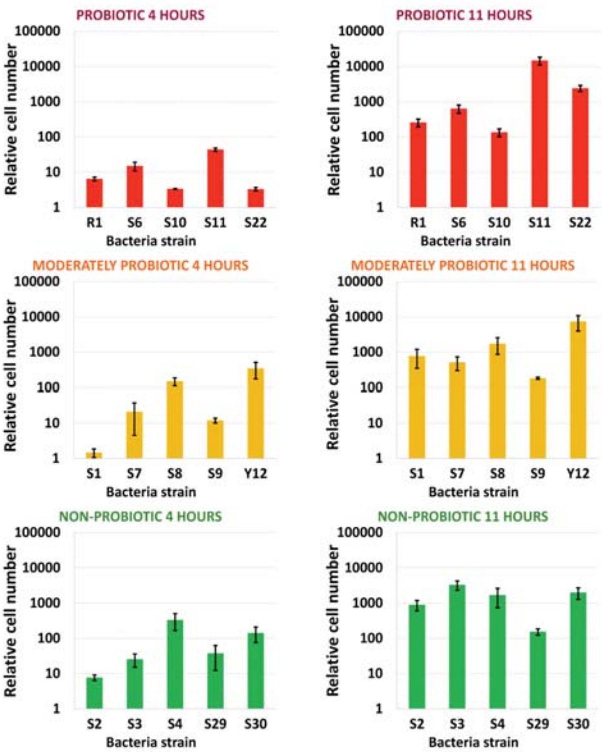

Figure 1. Relative cell numbers of the 15 different Lactobacillus bulgaricus bacteria strains at 4 and 11hours

The figure contains the average and standard deviation of the three parallel measurements in the case of the cell numbers. Cell numbers increased during the incubation time, those reached the cell number from the initial 103 – 104 scale up to the 108 – 109 scale. However, the samples show some deviations within the groups. The largest difference was observed among the different strain of moderately probiotic group, and the lowest one among the different strain of probiotic group based on cell number.

Some differences were found between the cell numbers at 4 and 11 hours, furthermore differences was found between the probiotic, moderately probiotic and non-probiotic groups. Significant differences was found between the average relative cell numbers at 4 hours. The Figure 2 shows the average value of the bacterial strain groups at 4 and 11 hours. The rate of the cell multiplication was the largest in the case of the probiotic group between the 4 and 11 hours, furthermore this group showed the largest cell numbers at the end of the experiment.

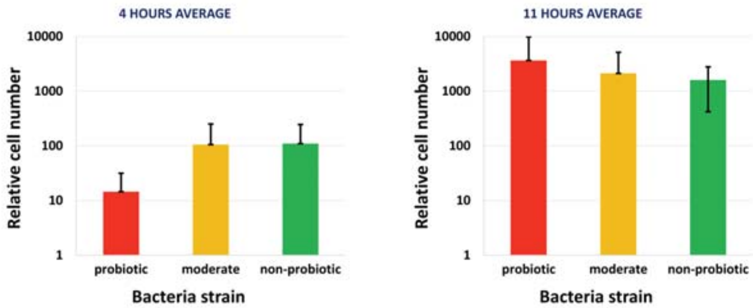

Figure 2. Group average of the relative cell numbers of Lactobacillus bulgaricus strains at 4 and 11 hours

The pH values were detected during the formation of the yoghurt. Line chart was represented from the recorded points, and the inflection point was determined according to article of Torrestiana et al. (1994). The Figure 3 shows the pH inflection points of the 15 bacterial strain samples.

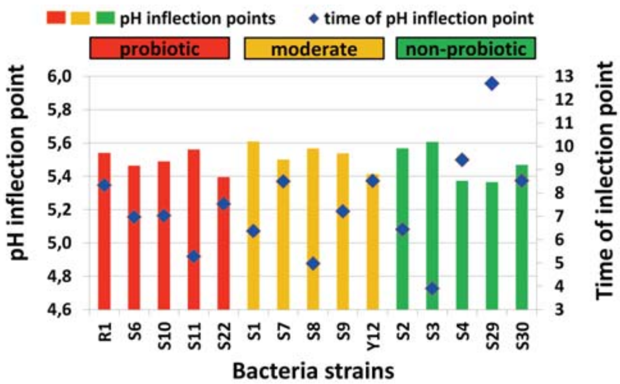

Figure 3. The pH inflection points of the different Lactobacillus bulgaricus strains

The Figure 3 shows the pH and time values at the inflection point. Weak differences were found between the bacteria groups, however the differences are larger within groups than between groups. The time of the inflection point showed the largest standard deviation in case of the non-probiotic group.

The average pH and time values at the inflection point can be seen on the right side of Figure 4. This diagram shows the average of the samples. Significant difference was not found between the groups.

The viscosity values were determined from the flow curve at 4 and 11 hours and at the time of pH inflection point. The Figure 5 shows these values in the case of the bacteria strain groups. The results of viscosity showed differences between the probiotic, moderately probiotic and non-probiotic groups. The viscosity values were the largest at 4 hours for the most of the samples. With the exception of S3, non-probiotic samples had the highest viscosity, while probiotics had the lowest viscosity.

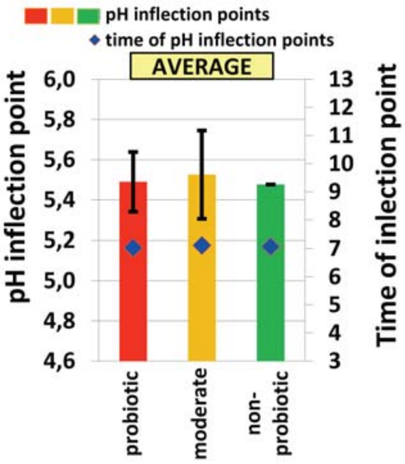

Figure 4. The pH inflection points of the bacteria strains

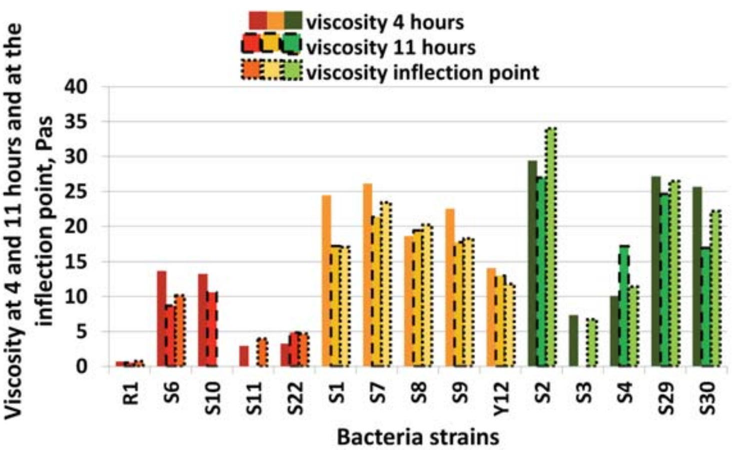

Figure 5. Viscosity at 4 and 11 hours and at the time of pH inflection point

The Figure 6 shows the average values of the viscosity of the probiotic, moderately probiotic and non-probiotic groups. Significant difference was not found between the viscosity at 4 and 11 hours and the time of pH inflection point. The standard deviation of the non-probiotic group was the largest, while the moderate group had the lowest one.

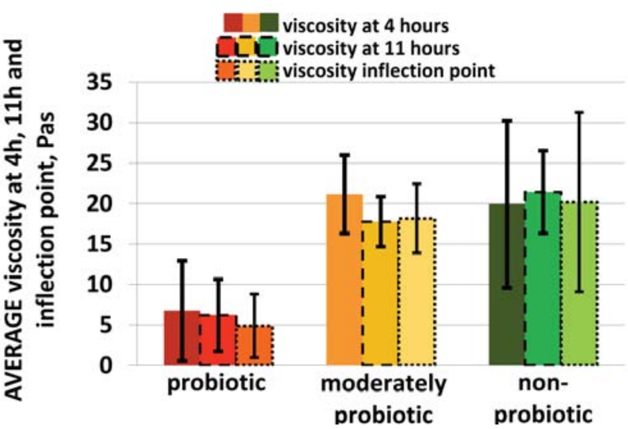

Figure 6. Average viscosity at 4 and 11 hours and at the time of pH inflection point

Significant differences were found between the probiotic, moderately probiotic and non-probiotic groups based on viscosity values at 4 and 11 hours, furthermore at the time of pH inflection point. The probiotic group is significant different from the other two.

Conclusions

Different bacterial strains showed variable behavior properties in each measured parameter. According to the probiotic activity the cell number and the viscosity parameters showed significant difference. The variability of the strains shows that there is an industrial meaning of which strain is used for the yoghurt production, so our result can be useful to find the most appropriate strains for starter cultures. The tested physical and chemical properties of the yogurt samples prepared presented high variability which can be useful in the product development of probiotic yoghurt.

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