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Tartalomjegyzék:

ESTIMATION OF CROP EVAPOTRANSPIRATION USING AQUACROP FOR THE RÁKOS AND SZILAS STREAM WATERSHEDS, HUNGARY

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Introduction

Water is essential for humanity. It is a renewable resource, important for precipitation which is contributing to the hydrological cycle. Water resource is nowadays facing a competition (De Fraiture and Wichelns, 2010). Water security became a worldwide emergency concept for both research and policymaking (Varis et al., 2017). Agriculture is known as the major consumer of freshwater (Heermann and Solomon, 2007; Gontia and Tiwari, 2010), with agricultural water demand accounting for more than two-thirds of the global water use (Jason et al., 2009). Water demand continues to increase, and data shows that it will grow up to 50% by 2030 (UN habitat, 2016). Demographic pressures, the rate of economic development, urbanization and pollution are increasing the pressure on water resources, particularly in semi-arid and arid regions. The production of food and feed is known to be responsible for a significant proportion of greenhouse gas emissions (13.5% (IPCC, 2007)) and water depletion (Lovarelli et al., 2016).

Crop evapotranspiration is among the most important parameter in water management under irrigated and rainfed agriculture (Djaman et al., 2018). Crop evapotranspiration (ETc) is the total amount of water use during a crop growth starting from the sowing until the harvest and without no water restriction (Pereira and Pires, 2014). Crop evapotranspiration estimation is important for the understanding of water use and water requirements of a crop. The FAO AquaCrop simulation model aims to investigate crop yield response to environmental stress (Greaves and Wang, 2016). The model simulates crop growth and yield based on a water-driven growth model considering the influence of soil moisture variation. The model is described as a good balance between robustness and accuracy (Farahani et al., 2009). Therefore, this study is using AquaCrop as a tool to estimate the crop evapotranspiration. The aim is to calculate the green water use by maize of two neighboring small streams (Rákos and Szilas) in Hungary, using spatial data.

Study area

The study is conducted in Rákos and Szilas stream watersheds area in, Hungary. Rákos and Szilas stream watersheds flow in concrete channels and both flow into the Danube river (Kelcey, 2015). In the areas closer to the estuary, the built environment dominates (>50%) and the agricultural activities represent a smaller area. However, outside the city limits, agriculture and forest areas are dominant. The geographical features of the stream reach 44 km long and 187 km^2 catchment area. It passes through the capital for about half stream (22km) (Rosivall, 2002). Szilas stream comes from Godollo Hills and

reaches Danube at Káposztásmegyer. Two main springs fill Szilas stream, from west and southeast of Kerepes. From Kerepes, the stream passes through Szilasliget, Kistarcsa, Nagytarcsa and towards Cinkota. From there, it reaches an artificial lake through Mátyásföld, Rákospalota and Káposztásmegyer, where it goes to Mogyoród stream under the Megyeri forest.

Methods

The plug-in version of AquaCrop was used for crop transpiration simulation. In order to be able to apply the model on a raster based spatial dataset, R scrips (R development core team, 2017) have been developed for the automated application of the model for each raster cell in the study area.

In this research, 2 main characteristics was programmed in order to be able to use the AquaCrop plug-in: (i) The characteristics of selected climate conditions including the climate file (.CLI), the temperature (.Tnx or .TMP), the reference evapotranspiration (.ETO) and the precipitation file (.PLU)., (ii) the characteristics of the selected soil profile (.SOL). The other data were extracted from the default program of AquaCrop.

The daily minimum and maximum temperature, daily precipitation and monthly reference evapotranspiration were downloaded from the CARPATCLIM Database for the years 1961-2010 (Szalai et al., 2013). Data were preprocessed in R in order to meet the AquaCrop plug-in input data format. The soil characteristic data (FC, SAT and PWP) were downloaded from EU-SoilHydroGrids ver1.0. The resolution of the raster images is 250 m. In this study, the layers 0, 5, 15, 30, 60 cm were considered (Tóth et al., 2017). The texture data were downloaded from AGROTOPO Database (Hungarian soil maps) (Várallyay et al. 1979; Várallyay et al. 1980). The FC, SAT, PWP and texture data were pretreated in QGIS including the uniformization of the raster resolution to 250 m. Regarding the Ksat calculation, the texture raster data were used and the table from Rawls et al. (1982) was taken as a baseline to calculate the saturated hydraulic conductivity. Using the Ksat, the CN value was determined (Raes et al., 2018). The capillary rise data were evaluated by considering the soil type and hydraulic characteristics. In this study, the equations from Janssens, 2006 was adopted for capillary rise parameters calculation. The AquaCrop program itself is using them as default values (Raes et al., 2018). The default crop data from AquaCrop was used to assess the WF of maize. Maize was considered as a reference crop due to its non-limiting conditions, and its ability to support highly water stress conditions, and its geographical coverage represents a high percentage. The optimum date for sowing maize in Hungary would be around April 10 to May 5 to get most of the nutrients. This is because the heat threshold for the variety is around 10°C (Krishna, 2013). In this study, 10th of April was the selected sowing date.

Results

Rainfed agriculture depends on water from precipitation (green water). Green water refers to the soil water held in the unsaturated zone available to plants. Therefore, the water from precipitation contributes highly to the water footprint calculation result. In 1961, the average precipitation is from 377 to 513 mm which doubled in 2010 with data around 869 to 1069 mm. Regarding the temperature data, together with the climate change, an increase of the general temperature in the study has been seen.

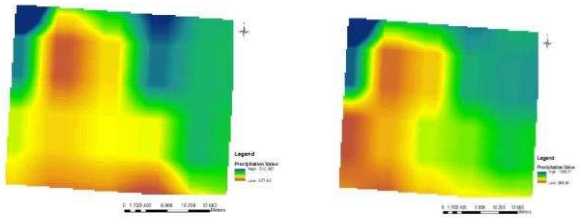

Figure 1: Average annual rainfall for 1961 and 2010 (mm/year)

Evapotranspiration is the key element in water footprint calculation. It is the water transfer to the atmosphere from both evaporation and transpiration. Using the plug-in version of AquaCrop in R, ET has been calculated. In this study, the ET value is attributed from the result of water balance calculations. The result shows that evapotranspiration has increased throughout time. In 1961, the evapotranspiration ranges from 267.4 to 367.1 mm. The value increased by 58 mm for 2010, giving the range from 325.9-416.8. The range for both years remains 100 mm. Therefore, the general evapotranspiration trend has increased in all the study areas during the two periods. The special distribution shows a similar trend from 1961 and 2010, showing an average increase of around 58 mm in all watershed areas. The maximum evapotranspiration is located in the surrounding of the Danube river with a value of around 420 mm. In the opposite, the lowest value can be found in the Rákos watershed area.

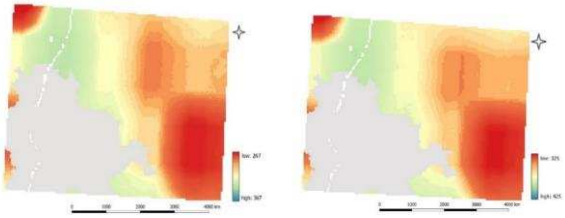

Figure 2: ET 1961 and 2010 (in mm*)*

Yield is an important parameter of WF. The yield was modelled from AquaCrop. The yield response in the study area shows that the value has increased by 1-2 ton/ha for each area. In that, with an increasing amount of precipitation (460-540mm), the yield has increased (1-2 ton/ha).

Figure 3: Yield production in 1961 and 2010

The yield increase can be explained due to climate conditions which is more favorable. Indeed, an increase of temperature and precipitation ameliorate the growing day degrees and therefore is more suitable for crop development. This means that the water use for crop growth in the study area is enough for the development of maize. In general, an increase of precipitation and other environmental conditions (temperature, humidity, soil) leads to an increase of yield and evapotranspiration throughout time.

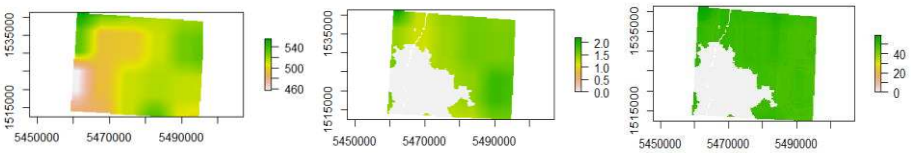

Figure 4: Precipitation, Yield and ET differences 1961-2010 (from left to right)

Figure 5 summarizes the results of the ET and Yield calculations. The results show that the ET and Yield production have increased from 1961 to 2010. In 1961, the mean ET shows a value of 332.5±16.98 mm which reaches 382.5±17.33 mm in 2010. The average yield increased from 11.1 to 12.6 t/ha. This suggest that there is a correlation between the ET and the Yield production. In overall, there is a large variability between the 2 different years.

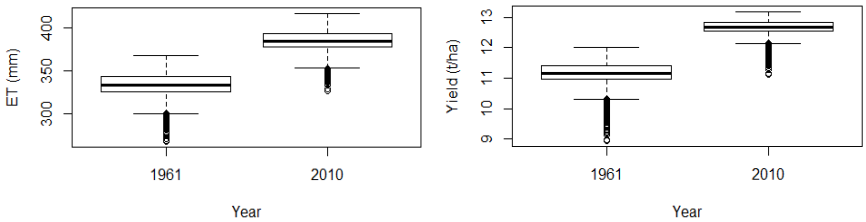

Figure 5: ET and Yield summary

Discussion

The use of AquaCrop model to simulates ET and Yield production under rainfed conditions using satellite based data shows a similar trend that previous studies have conducted. Indeed, the evapotranspiration value calculated, ranging from 267-425 mm, fits with the european calculation of evapotranspiration under maize crop, 373 ± 73 mm conducted in 1992-2012 (Gobin et al., 2017). The slight difference can be explained by the time period. Indeed, the time 1961 suggested a much lower precipitation, which gives a lower ET. Therefore, the yield calculated in this study shows a range from 8.9 to 13 t/ha, this result is slightly higher than the yield calculated for Europe case which is around 7.76 t/ha from 1992-2012 (Gobin et al., 2017). In the global calculation, the rain-fed maize yield is estimated at around 4.07 t/ha (Mekonnen and Hoekstra, 2011). In this study, the highest yield value is seen around the Danube river, which can be favorable for the crop growth. Also, the soil type difference would have contributed to the result difference. In this study, the soil textures were mainly loam, sandy loam and sandy, which are all suitable for the maize development. Indeed, the data from FAO, 2012 shows that under normal conditions, no water stress and high fertility, the maize

yield is between 11-14 t/ha (Studeto et al., 2012). Therefore, this study aligns with previous research results. The spatial scale study can contribute to these slightly different results. With more time, and with more data, mainly regarding the crop management practices, a more precise calculation can be done.

Conclusion

This study aimed to calculate green water use using raster data in AquaCrop. The result showed that the methodology conducted has given similar results to the global research. The use of raster datasets in AquaCrop showed an innovative way to conduct evapotranspiration calculation and therefore water use estimation. This study showed that the green water use of Rákos watershed is slightly lower than the Szilas watershed area. Also, we were able to indicate that the green water use varies over time. In conclusion, this study has presented a novel approachfor the spatial application of AquaCrop for ET calculation aiming for the understanding of spatial green water use which is beneficial for researchers and decision makers.

Acknowledgments

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Estimation of crop evapotranspiration using AQUACROP for the Rákos and Szilas stream watersheds, Hungary

Abstract
Water is related to every activity on earth, though agriculture uses the highest percentage. Increasing population and activities affect the water storage, which results in freshwater scarcity. Evapotranspiration is a key component of hydrological cycle and thus has a primary effect on the water balance. Therefore, the understanding of the spatial and temporal variations of agricultural crop evapotranspiration is a key task for modern agricultural water management. This study aims to estimate the maize evapotranspiration in the watersheds, of two neighboring small streams (Rákos and Szilas) in Hungary using the plug-in version of the AquaCrop software, a widely used water management tool, in order to estimate the volume of green water loss.
Key words: AquaCrop, Rákos stream, Szilas stream, green water, maize

EROSION CONTROL SERVICES OF HUNGARIAN FORESTS – A PESERA-BASED APPROACH

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Introduction

Despite decades of rigorous scientific work and public concern, soil erosion remains a major threat to soil resources. In many regions of the world, soil erosion was identified as the number one challenge to soil functions (Goudie & Boardman, 2010).

One of the ecosystem services provided by forests is the regulation of soil erosion by water (MEA, 2005). At present, approximately 20 % of Hungary is covered by forests. While there is a clearly defined aim to increase this ratio to 27% by 2030, the rate of increase has been slow (MgSzH, 2009).

The aim of the study presented here was to provide an estimation on (1) the soil erosion control services of forests in Hungary and (2) to estimate the potential effects on soil erosion for a significant, but realistic increase in forest cover. The selected methodology for the study was using the PESERA modeling approach (Irvine and Kosmas, 2003), using the benchmark years 2010 for climatic and the 2018 for land cover.

Literature Review

Studies have identified the impacts of climate change on soil erosion by water. The rainfall characteristics (rainfall number, intensity and spatio-temporal distribution) directly impact soil erosion. Additionally, rising temperature also has an indirect effect on soil erosion. The most commonly used models are the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) and the Pan-European Soil Erosion Risk Assessment (PESERA); (Fayas et al., 2019).

Soil erosion in Hungary has been estimated at the national level multiple times in the past two decades (Centeri and Pataki, 2000; Waltner, 2007; Pásztor el al. 2015; Waltner et al, 2018), focusing on soil erosion rates induced by the actual land cover/land use.

Methods

The applied methodology focuses on the application of the PESERA model and uses the same input and methodology as applied by Pásztor et al. (2015 and Waltner et al.(2018), with the exception of updated land cover based layers. A summary of the applied methodology is presented on Figure 1.

Topographic information has been derived from the EU-DEM dataset (Bashfeld and Keim 2011). Climatic layers were obtained from the CARPATCLIM database (Szalai et al. 2013) and appended with information from Agri4cast (http1). Soil information was based on the Digital Kreybig Soil Information System (DKTIR) (Pásztor et al. 2012).

Land cover information was obtained from the CORINE Land Cover dataset in a 100m resolution. Due to processing limitations, all datasets have been resampled for a 120 x 120 m resolution grid. The year 2018 has been used as a most current baseline for land cover, while the year 2010 has been used as a benchmark year due to its extremely high precipitation.

The study has focused on the development and application two scenarios (Table 1), simulating changes in land cover with all other factors remaining unaffected.

Scenario 1 was focusing on the potential erosion control services provided by the forests of Hungary. The scenario assumed an extreme loss of forest cover (-99.71%), with forests remaining only in slopes beyond 40%. Slopes between 25 to 40% have been converted to pastures and grasslands, and all forested areas below 25 % slope have been converted to arable land. The aim was to estimate how much soil loss is prevented by the existence of our forests.

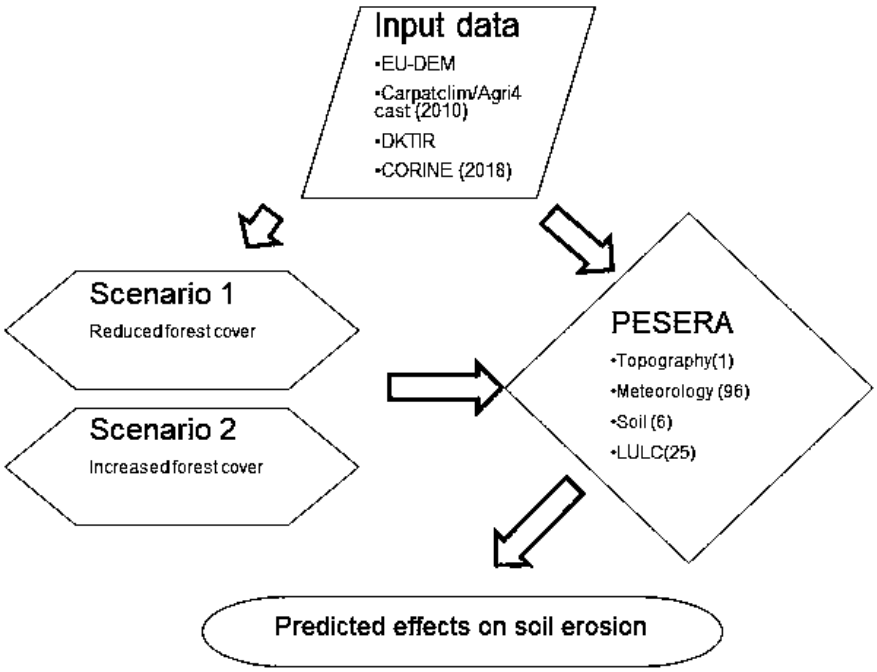

Figure 1. Applied methodology

	2018	Scenario 1			Scenario 2		
Land cover category	**area (ha)**	**area(ha)**	**change (ha)**	**change (%)**	**area(ha)**	**change (ha)**	**change (%)**
Arable land (210)	4667556	6314607	1647052	35.29	4320932	-346624	-7.43
Pastures and grassland (231)	907965	963356	55391	6.10	908666	701	0.08
Forests (310)	1721432	5063	-1716369	-99.71	2069597	348165	20.23

Table 1. Description of the applied land cover scenarios compared to the base year of 2018

Scenario 2 was focusing on the systematic increase of forest cover, with all arable land at or above 5% slopes converted to forest. With an estimated 348165 hectares, this increase is significantly more than the 250000 hectares planned and is therefore unrealistic, it still presents the potential effects of increased forest coverage in Hungary.

Modeling and data processing was carried out in ArcMap 10.1 and ArcMap 9.3 with ArcInfo Workstation.

Results

The resulting potential soil erosion maps have been used to calculate the effects of the scenarios by subtracting the 2018 estimates from the outputs for both scenarios. This resulted in predicted change maps both for Scenario 1 (Figure 2) and Scenario 2 (Figure 3). In both maps (projected in ETRS89-LAEA), increase in predicted erosion rates is presented with dark grey to black, while decrease is indicated by light grey to white colors.

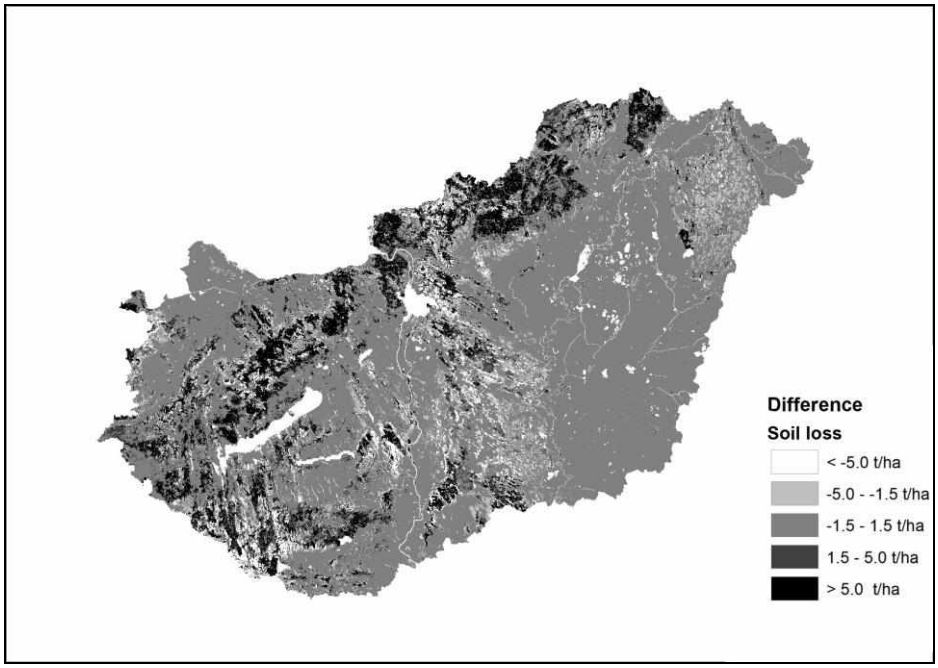

Figure 2. Predicted changes under Scenario 1

For the purposes of this study, negative PESERA output values (representing accumulation zones) have been all set to 0, so only soil loss is indicated. Changes in both maps are primarily visible in hilly and mountainous areas, with lower lying areas more affected by the loss of forest cover under Scenario 1.

Basic descriptive statistics for each output layer have been calculated and are presented in Table 2.

	2018	**Scenario 1**		**Scenario 2**	
Statistics	**erosion (t/ha/y)**	**erosion (t/ha/y)**	**change (t/ha/y)**	**erosion (t/ha/y)**	**change (t/ha/y)**
Min	0	0	-1469	0	-1946
Max	1960	2650	2475	1650	1537
Mean	4.99	11.69	6.68	3.57	-1.43
SD	23.55	51.13	46.76	18.97	21.3

Table 2. Descripive statistics for changes induced by scenarios (t/ha/y)

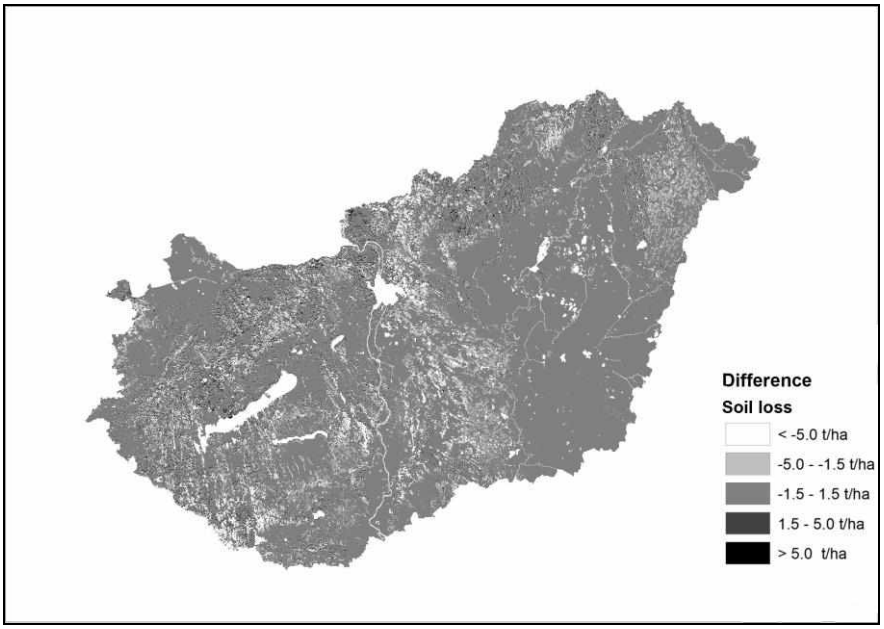

Figure 3. Predicted changes under scenario 2

Discussion

The resulting maps clearly indicate the areas mostly affected by the changes proposed under both scenarios. It can also be observed that there are some reductions in erosion rates in areas seemingly unaffected by land cover changes, these small variations are possible results of both the resampling processes applied and the modeling methodology. However, they don't seem to adversely affect the general estimates.

Scenario 1 has increased both the maximum potential erosion rate and the mean soil loss, as it was expected. This result indicates that the removal of our forests from slopes lower then 40% would result in an average increase of 6.68 t/ha/y in potential soil loss nationwide.

On the other hand increasing our forest cover according to Scenario 2 could reduce soil erosion with about 1.43 t/ha/y.

Conclusion

Based on the model outputs for Scenario 1, we can estimate that the potential annual soil erosion control services provided by the forests of Hungary can be an average of 6.68 t/ha for the whole of Hungary. Based on Scenario 2, with the conversion of 348165 hectares of arable land to forests on slopes above 5 %, potential soil erosion in Hungary could be reduced by 1.43 t/ha on average.

While the changes proposed by both scenarios are extreme, Scenario 1 helps to estimate the importance of our forests in reducing soil erosion. The increase in forest cover under

Scenario 2 is beyond the proposed 250,000 hectares by 2030. In both cases, the generated maps can help identify potential effects changes in forest cover might have in soil erosion rates.

Acknowledgments

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Erosion control services oh Hungarian forests – a Pesera-based approach

Abstract

Soil water erosion can be evaluated quantitatively using soil water erosion models (SWEMs). The Pan-European Soil Erosion Risk Assessment (PESERA) model has been developed to be used as a regional diagnostic tool for assessing soil erosion rates on various types of land uses with different soil and topographical features. Forests can provide a number of ecosystem services, including the reduction of soil erosion by water. In the current study, the PESERA model was applied to the total area of Hungary, with two land use scenarios. Scenario 1 aimed to assess the amount of soil loss avoided by the current extent of forested areas, while scenario 2 was focusing on the potential conservation of soils through the increase of forested areas.

Key words: PESERA, ecosystem services, soil erosion, Hungary

EXAMINATION OF AGRICULTURAL FLEXIBLE DRIVING IN PRECISION MACHINE MANAGEMENT

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Introduction

In order to increase productivity the agricultural sector is characterized by a high degree of mechanization as of the mid-20th century, thus agricultural machines have had to meet high expectations. Proper operation is essential for the optimal utilization of valuable equipment. Machine operation can be optimized based on data collected about the CAN-bus system of the power machine. Our goal is to determine the data necessary for this.

In the development of agricultural machines in addition to the enhancement of performance and reliability an important aspect is economical operation, which is true of all the parts of the machine structure. In order to increase efficiency producers put great emphasis on the development of engines as well as the components of working units and power transmission, which are aimed at improving the overall performance of the machines. In agricultural practice flexible tractive element drive is widely used for the power supply of the units, which encourages our research in the field of belt drives. Through in-depth analysis of the functioning of the drives an accurate picture of the important drive characteristics relevant for the operation can be obtained.

Literature Review

The efficiency of V-belt drive (η) is the ratio of useful and input power. The useful power appears on the driven shaft, which is the product of the peripheral force (F_{t2}) and the peripheral speed (v_2) delivered to the pulley. The input power is fed into the system on the drive side, via the drive pulley (Kátai and Szabó, 2015):

$$\eta = \frac{P_h}{P_b} = \frac{F_{t2} \cdot v_2}{F_{t1} \cdot v_1}, \qquad (1)$$

belt slip occurring during power transmission:

$$s = \frac{v_1 - v_2}{v_1}, \qquad (2)$$

By further converting the efficiency equation, we get an equation of two members. The part in the bracket means the lost motion, and κ means the losses occurring on the peripheral force.

$$\eta = \frac{F_{t2}}{F_{t1}} \cdot (1 - s) = \kappa \cdot (1 - s). \quad (3)$$

Typically, the studies published so far have dealt with the power loss of V-belts through the study of lost motion and other torque losses. According to Gervas and Pronin (Gervas and Pronin, 1967, 1969) the torque loss of V-belt drives is partly derived from the inner friction of the tractive element, which in addition to the deformation caused by the belt side forces mainly comes from its bending, and from the radial friction loss, which is generated by the belt element entering and exiting the pulley groove. The loss of motion is made up of the circumferential belt slips.

Methods

In order to study the drive parameter the measurement program was compiled on the basis of a standard test method (One-Factor-at-a-Time), where at one time one of the drive parameters was modified with the fixed value of the other drive characteristics. A multivariate regression model was used to qualitatively analyze the measured data. The adequacy of the models was verified by variance analysis (ANOVA), and the value of the coefficients of the variables in the model was calculated. The weight of the individual factors was determined i.e. how each drive characteristic affects the dependent variable compared to the other independent variables. The data were analyzed using the software Statistical Package for Social Science (SPSS).

Results

The factors influencing the torque loss among the drive parameters were determined with the help of the temperature rise of the V-belt, i.e. the difference between the initial and saturation temperature. The model of the increase in temperature of the belt:

$$\Delta T = -17.1 + \frac{2317.476}{d} + 0.472 \cdot f + 4.430 \cdot M. \quad (4)$$

During the study of the drive parameters in addition to the belt temperature the drive slippage was measured continuously, by which the existence of operational state was monitored at the same time. The model based on the regression equation set up during the temperature tests:

$$s = 1.147 \cdot M + \frac{49.144}{d} - 0.379 \cdot F_H. \quad (5)$$

By studying the drive parameters it is possible to create the energy balance of the drives included in the experiment. The efficiency of drive is the ratio of useful P_h and input power P_b:

$$\eta = \frac{P_h}{P_b} = \frac{M_2 \cdot \omega_2}{M_1 \cdot \omega_1}, \qquad (6)$$

where the input power is the product of the torque (M_1) measured on the drive side and angular speed (ω_1). The useful power was determined from the torque (M_2) and angular speed (ω_2) values of the driven shaft. During the experiments carried out the efficiency of the V-belt drive varied between $\eta = 0.82$ and 0.97. Power loss can be determined with the help of the drive parameters measured during the tests:

$$P_v = P_b - P_h = M_1 \cdot \omega_1 - M_2 \cdot \omega_2 . \qquad (7)$$

The loss can be further subdivided into power losses resulting from torque and motion loss according to the three equations:

$$P_v = P_{nyv} + P_{mv} , \qquad (8)$$

where the torque loss can be determined by the product of the difference of the measured torques and the angular speed of the driving side:

$$P_{nyv} = (M_1 - M_2) \cdot \omega_1 . \qquad (9)$$

The motion loss reduces the theoretically determined angular speed of the driven shaft, thereby also contributing to the power loss:

$$P_{mv} = M_2 \cdot (\omega_1 - \omega_2). \qquad (10)$$

By substituting equations 9 and 10 in equation 8 equation 7 is obtained:

$$P_v = (M_1 - M_2) \cdot \omega_1 + M_2 \cdot (\omega_1 - \omega_2) = M_1 \cdot \omega_1 - M_2 \cdot \omega_1 + M_2 \cdot \omega_1 - M_2 \cdot \omega_2 =$$

$$= M_1 \cdot \omega_1 - M_2 \cdot \omega_2 . \qquad (11)$$

The power transmission of the test settings varied between 450 and 1660 W, where the power loss (20-153 W) is also a setting dependent value. The further resolution of the loss is estimated by variance analysis, based on the variance of the independent variables (Figure 1).

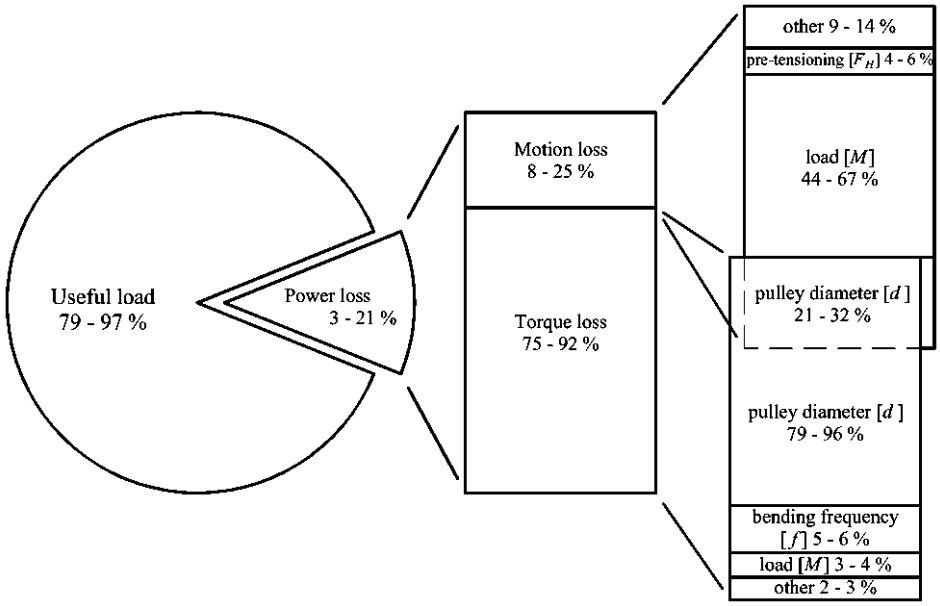

Figure 1. The qualitative energy balance of the V-belt drive

(Profile Z/10; $d = 60 - 180\ mm$; $i = 1$; $f = 10 - 20\ s^{-1}$; $M_1 = 3 - 18.3\ Nm$; $F_H = 50 - 300\ N$; $a = 345 \pm 10\ mm$*)*

3-21% of the input power of the tested V-belt drives is loss. Most of the power loss, 75-92% is torque loss and the remaining part is motion loss. The torque loss originated mainly from the bending of the V-belt (internal friction) determined by the radius of the bending of the belt and its frequency. The frictional loss of the contact surfaces of the force-locking drive is manifested in a complex manner. On the one hand, from the repeated deformation of the surface of the V-belt, which is realized as torque loss and made up of the relative displacement of the belt element. Motion loss is influenced by the frictional conditions of the contacting surfaces determined by the size or change of the transferred peripheral force (the course of the deformation along the curve length) and the pre-tensioning of the V-belt.

Summary

The power loss of V-belt drives comes from the loss occurring on the motion and peripheral force. The mathematical model of the temperature rise of belts was created as a function of the drive parameters, and the impact of each parameter was determined by weighting the individual variables. As a result of the series of experiments the mathematical model of the drive slippage was set up for the whole system, and the impact of the drive parameters on the studied phenomenon was also determined. Using the results the energy balance of the V-belt drive was created, and the impact of each

component was analysed, in this way the drive characteristics important in terms of the operation can be determined.

Keywords: precision machine management, V-belt, Power loss

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Examination of agricultural flexible driving in precision machine management

Abstract

The efficiency of V-belt drives is determined by several factors collectively: the slip, the external and inner friction. In this paper the slip of the V-belt was studied as loss intensity as a function of drive parameters. The individual effects of V-belt drive parameters on speed loss are determined using one-factor-at-a-time (OFAT) test method. It was justified in the scope of the major characteristics affecting power loss that by ideally selecting the parameters of the V-belt drive power loss can be measurably reduced. Based on earlier results as well, a regression model was used to examine the slip of the V-belt. On the bases of the test results optimal parameters can be calculated to give references for V-belt drive design.

Keywords: precision machine management, V-belt, Power loss

A FIELD-LEVEL STUDY OF SOIL PENETRATION RESISTANCE, MOISTURE CONTENT AND INFILTRATION

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Introduction

The soil texture and structure, porosity, organic matter content, vegetation types and cover, water content of the soil, soil temperature, and rainfall intensity all play a role in the rate of infiltration (Singh et al., 2014). Soil moisture content directly influences the distribution of rainfall between surface runoff, infiltration and percolation, causing many hydrological and geomorphological processes in turn (Baghdadi et al., 2007; Laiolo et al., 2015; Zeki & Sertel, 2016). Penetration resistance is both a qualitative and quantitative feature that is expressed by the inherent capacity or strength of a soil to resist penetration, deformation or displacement until reaching the threshold value when subjected to external mechanical force. Soil compaction can be measured through penetration resistance (Lomeling & Lasu, 2015).

The purpose of this study was to determine the penetration resistance, soil moisture content and infiltration of a small experimental field of Szent Istvan University in Gödöllő, Hungary.

Literature Review

The process by which water from surface sources enters the soil is known as infiltration (Prasad et al., 2015). A soil's infiltration rate refers to how well the soil can absorb water (Savva & Frenken, 2002). Infiltration allows the soil to temporarily store water, making it available for uptake by plants and soil organisms (Singh et al., 2014a). It is also an important hydro-physical characteristic of soil and has great importance in the control of watersheds, soil moisture modelling, flood prediction and irrigation design (Chahinian et al., 2005). Gravity and capillarity action are the two main factors that control the process of infiltration. (Brevnova, 2001).

The water conductivity of the soil is an indicator of its water-permeability, while water retention attribute is a representation of the water storage ability of soil (Klute, 1986; Sari., 2017). The saturated and near-saturated hydraulic conductivity of soils is a critical soil structure measure and a primary parameter for the transportation and aeration of solvents (Sarkar et al., 2019).

Several researchers have been attempting to study about infiltration and soil hydraulic properties and reporting their research work. Berglund et al. (1980) found that the forest vegetation and the absence of grazing create a favourable surface condition which increases infiltration. Champatiray et al. (2014) proposed that garden soil infiltrated more rapidly than the forest soil due to high hydraulic conductivity as calculated by Horton's equation. Sari (2017b) stated that high amounts of organic materials in soils increase porosity, hydraulic conductivity and water retention capacity. Penetration resistance increases as the soil dries and decreases as the soil becomes wetter for any

soil at a given bulk density (Yosef & Lambert, 1981). A penetrometer measurement of 2 MPa generally concerned as sufficient to impede the growth and development of plants. At penetration resistance larger than 2.5 MPa, root elongation is significantly restricted (Whalley et al., 2007).

Methods

The study has been conducted at an experimental site located on campus at Szent Istvan University, Gödöllő, Hungary. The area of the experimental field is approximately 20 000 m^2. Random sampling points have been selected to facilitate GIS-based interpolation and analysis of the results. The soil texture of the three analysed points (5, 10 and 15) is the same i.e. sandy loamy.

Infiltration was measured using a Mini Disk Infiltrometer (Decagon Devices, Inc., 2018) at randomly selected twenty different points with a radius of 2.25 cm has been used to determine the relationship between the cumulative infiltration and root square of time. For this field measurement, a suction rate of 2 cm has been used, with infiltration rates recorded every 30 seconds. The square root of time and cumulative infiltration depth (in cm) has been calculated from these data. Based on the area of the disk, cumulative infiltration is determined by dividing the volume of water that infiltrates by the area where water infiltrates. After that a graph is plotted with cumulative infiltration and the square root of time on Y-axis and X-axis, respectively. A polynomial equation has been fitted to the measured data.

Folloring Zhang (1997), the present study computes the near-saturated hydraulic conductivity (K_{h0}) as:

$$K_{h0} = C_2/A_2$$

Where C_2 is the slope of the curve of the cumulative infiltration vs. the square root of time, and A_2 is a value relating the van Genuchten parameters for a given soil type to the suction rate and radius of the infiltrometer disk.

Penetration resistance was measured using an Eijkelkamp Penetrologger to a depth of 0-80 cm, while soil moisture content int he top 5 cm was measured at each point using an attached 4 pin Soil Moisture Sensor Theta Probe. At one hundred and six random points, three penetrations around each point, within a 1 m circle has been measured. At each point the measurements were made with a constant speed of 2 m/s using a cone with a diameter of 2.0cm/s^2 at an angle of 60^0. The soil moisture content has been read out in vol.%.

Data collected were subjected to appropriate statistical analysis using Statistical Package for Social Sciences (SPSS) V. 16 software and Microsoft Excel 2010 software packages. Random point selection and interpolation was carried out using QGIS (version 3.10.4).

Results

In this paper, only three example points (5, 10 and 15) are chosen and describe infiltration. Figure 1 describes cumulative infiltration within the given interval of time.

Figure 2 presents (a) the distribution of sampling points within the field (whipe points indicate penetration and soil moisture measurements, while the numbered black points indicate the infiltration measurements) and (b) the interpolated penetration resistance in

the QGIS map of the Eijkelkamp Penetrologger data. The interpolation was performed using Inverse Distance Weighted (pwr = 2). As the map described, the upper part of the slope has a lower resistance number, also the lower part of the slope. The middle strip is eroded, the black strip highlight that the soil resist against the penetrating force.

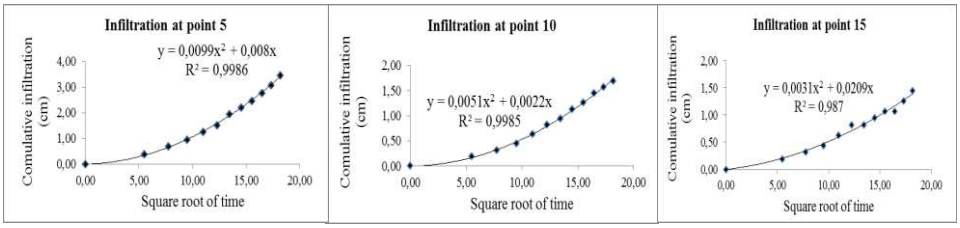

Figure 1: Cumulative infiltration with the square root of time for a point 5, 10 & 15.

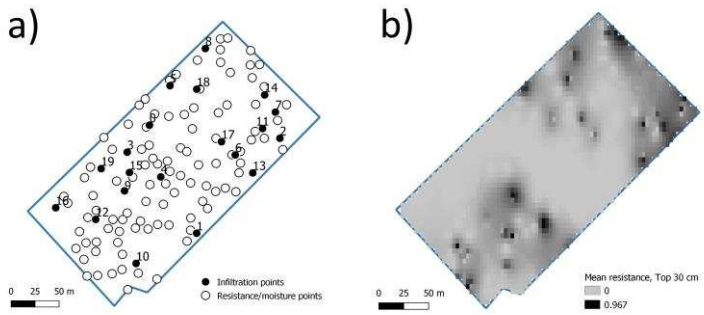

Figure 2: Penetration mean values on the experimental field.

The results of the regression analysis: at all the three points (5, 10 & 15), p-values are less than α (0.05) and r is near to 1. This information suggests that the correlation between cumulative infiltration and time is statistically significant and they have a positive relationship. We can observe from the figures 1 & 2 that total infiltration was decreasing at each time intervals with a fixed suction rate of 2 cm. If we reduce the suction rate applied (applying higher negative pressures), then overall infiltration will also decrease. Generally, soil water infiltration has a high rate in the beginning, decreasing rapidly, and then slowly decreasing until it approaches a constant rate.

Soil water infiltration is regulated by the rate and period of application of water, physical properties of soil, slope, vegetation and roughness of surfaces. Initially, the wetter the surface, the lower the initial infiltrability (due to a smaller gradient of suction), so the faster a constant rate of infiltration can be achieved. The higher the soil's saturated hydraulic conductivity, the greater the infiltrability (Williams et al., 1998).

Decreases in soil infiltration rate from an initially high rate can result from gradual deterioration of soil structure and the formation of a surface seal (Pan et al., 2018).

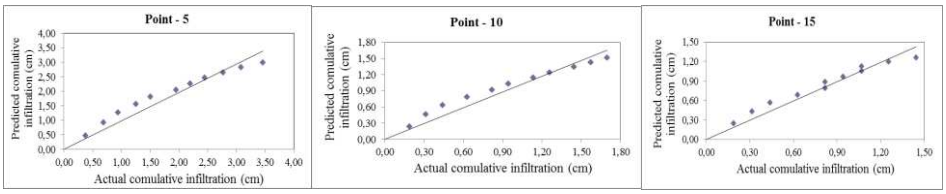

Figure 3: Predicted and actual cumulative infiltration plots for points 5, 10 & 15.

Points	*F*	*P-value*	*F crit*
5	3,01849E-15	1	4,30
10	0	1	4,30
15	4,62936E-15	1	4,30

F = F-statistics & F crit = critical value

Table 1: Single-factor ANOVA for actual & predicted cumulative infiltration

The results of the Single-factor ANOVA (Table 1) for actual & predicted cumulative infiltration data sets at the selected three points (5, 10 & 15) F-values (≈ 0) was less than f- critical (4,30) and P- values (1) was greater than α (0.05) suggest that difference in predicted values and actual values is insignificant.

Points	**Kh0 (cm s^{-1})**	**Infiltration rate (cm/hr)**
5	$2.5x10^{-3}$	45,27
10	$1.3x10^{-3}$	15,09
15	$7.9x10^{-4}$	22,64

Table 2: Value of near-saturated Hydraulic Conductivity, K_{h0} (cm s^{-1}) and infiltration rate (cm/hr) at the three selected points.

The plots for variation of cumulative infiltration with time for all the three points are obtained. The variation of infiltration is maybe by the variation in moisture content and other soil properties. By using the infiltration measurements, hydraulic conductivity is calculated for all the points using the methodology explained in section 2.2.2 using van Genuchten-Zhang method. As shown in Table 2, the hydraulic conductivity which is close to saturation is decreasing at point 5 to 10 and 15 respectively. However, we were not dealing with intact soil samples in the lab, there were not considerable cracks in the soil media. Because of that, it was assumed that the near-saturated hydraulic conductivity at 2 cm suction rate was an acceptable approximation of the value. The initial soil water content and saturated hydraulic conductivity of the soil media are the primary factors affecting the soil water infiltration process. Sari (2017) concluded the soil's physical and chemical properties have a direct or indirect influence on the hydraulic conductivity of soils. The soil texture is known as one of the most important factors in hydraulic conductivity. Hence, hydraulic conductivity usually increases from clayey to loamy and sandy soils, respectively.

Main findings

In the present study, the soil infiltration rate was generally low due to high initial soil moisture content on the smal experimental field. Hence there was a positive correlation between initial soil moisture and infiltration. On the other hand, penetration resistance increases on the areas where the soil was compacted, and decreases as the soil gets wetter. Therefore, resistance to penetration is negatively correlated with soil moisture content. It is also suggested that future studies investigate some soil properties such as soil texture, porosity, bulk density and so on to determine their effect on penetration resistance, soil moisture and infiltration.

Summary

The main objective was to determine the penetration resistance, soil moisture content and infiltration on a small experimental field of Szent Istvan University, Gödöllő, Hungary. The infiltration characteristics of soils at three points of the field were measured using a Mini Disk Infiltrometer. The cumulative infiltration was obtained from the measured volume of water that infiltrates into the soil at different time intervals. The measured infiltration results were used to evaluate soil hydraulic conductivity using van Genuchten-Zhang method. Penetration resistance was measured using a penetrologger with coupled soiol moisture sensor. The IDW method of interpolation was performed using the field measured data to interprate the results. The applied metodology was useful in identifying zones within the field with different levels of soil compaction an can therefore be used to support more precise cultivation and crop production practices.

Keywords: infiltration, mini disk infiltrometer, soil compaction, soil moisture

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A Field-level Study of Soil Penetration Resistance, Moisture content and Infiltration

Abstract
Infiltration is characterized as a physical phenomenon in which water from surface sources like precipitation, snowfall, irrigation etc. penetrates the soil. It is one of the major components of the hydrologic cycle and has a great importance in the control of watersheds and in flood prediction. The soil's resistance to penetration is the resistance of the soil to the force of penetration per unit area. Its information is needed both in agriculture and in civil constructions. Soil moisture is very dynamic both temporarily and spatially, hence it requires continuous monitoring.
The purpose of this study was to determine the relationship between soil penetration resistance and moisture content to the infiltration rate. The study area was a small experimental field of Szent Istvan University in Gödöllő, Hungary. Infiltration was measured by a Mini Disk Infiltrometer, while soil penetration resistance and topsoil moisture content was measured by a Penetrologger equipped with a TDR probe. Sampling points have been selected in order to facilitate GIS-based interpolation and analysis of the results. The cumulative infiltration was obtained from the measured volume of water that infiltrates into the soil at different time interval using scatterplot. Inverse distance weighting method of interpolation was applied to characterize spatial patterns of penetration resistance and soil moisture content. Negative correlation between penetration resistance and soil moisture content was examined.
Keywords: Infiltration, penetration resistance, Soil moisture content, Mini disk infiltrometer, Penetrologger

AUTOMATION AND ROBOTICS IN THE PRECISION FARMING

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Introduction

What is a robot? In general robot is every entity which able to sense the environment, process, and acting based on dynamical changing environment. The most important properties are: sensing, autonomy intelligence, adaptive behaviour and working, able to acting. Another important capability: communication and cooperation. In the agriculture the environment is very challenging. The robot swarm can be a good solution for dynamically changing environment and complex task.

Smart Irrigation

Watering is a key application on agriculture. Using of internet of thing (IOT) devices makes irrigation more effectivy. There are many senors for soil and plant moisture.

A wireless sensor node was deployed in each zone. Each node includes two Decagon EC-5 dielectric soil moisture sensors, as well as a wireless radio. One of the soil moisture sensors was placed in the rooting zone. The other one was placed below the rooting zone, and its readings were not used in the adaptive algorithm. The readings acquired by the soil moisture sensors are transmitted to the adaptive irrigation controller. The latter is coupled with a commercial controller, which receives remote updates. These are used to estimate irrigation scheduling based on EvapoTranspiration (ET).

The adaptive irrigation controller sends the messages over a 3G network to a central server using TCP/IP. These messages contain soil moisture readings from each zone as well as information regarding irrigation events. For evaluating water savings, the system stores both the actual watering events as well as the irrigation events as determined by the commercial controller. The total amount of water delivered based on soil moisture sensors offered 47% of water savings compared to the amount of water only based on the commercial controller.

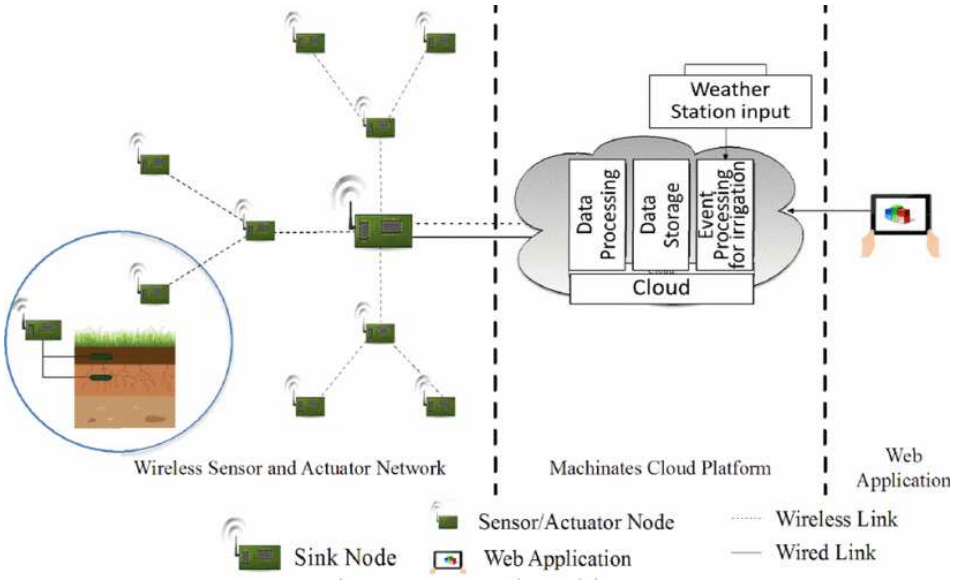

Fig. 1. Architecture (Sales, 2015)

From Industry 4.0 to Agricultural 4.0

According to some definitions, Industry 4.0 is a frame of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of Things and cloud computing. Industry 4.0 includes all those innovative solution, methods that can compose an intelligent production system called „Smart Factory". Within the modular structured smart factories, cyber-physical systems monitor physical processes, create a virtual copy of the physical world and make decentralized decisions. Over the IoT, cyber-physical systems communicate and cooperate with each other and with humans in real time, and via the Internet of Services. Both internal and cross-organizational services offered and used by participants of the value chain. Cloud computing is already a well-known IT technology. It has the following five features: on-demand service, internet access, resource polling, rapid elasticity and calculability. In this way some sensors –controlling the process- connect to the internet ensuring the adequate information. The so called "Smart Agriculture" based on Cloud Computing, and IoT realize concentrated management and control of machine, equipment and personnel, based on the internet and improve production through more detailed and dynamic means. This is useful for effective integration between human society and the physical world, and regards as the third wave of information industry development following computerisation and internet. IoT technologies include RFID, sensor network technology, and internetwork communication, all of which have been involved in the four links of IoT industrial chain, namely: identification, sensing, processing and information delivery (TongKe, 2017).

Agriculture 4.0 -analogy to Industry 4.0- stands for the integrated internal and external networking of farm operations. Information in digital form exists for all farm sectors and processes; communication with external partners - suppliers and end customers- is performed electronically; and data transmission, processing and analysis are largely automated. The use of Internet-based portals can facilitate the handling of large volumes of data, as well as networking within the farm and with external partners (CEMA/b, 2017).

Other terms frequently used are “Smart Agriculture” and “Digital Farming”. It is based on the emergence of smart technology in agriculture. Smart devices consist of sensors, actuators and communication technology.

Specialities

Another very important working condition is the livestock and bio materials. These materials are very sensitive and vulnerable. Figure 1 shows same sample for harvesting.

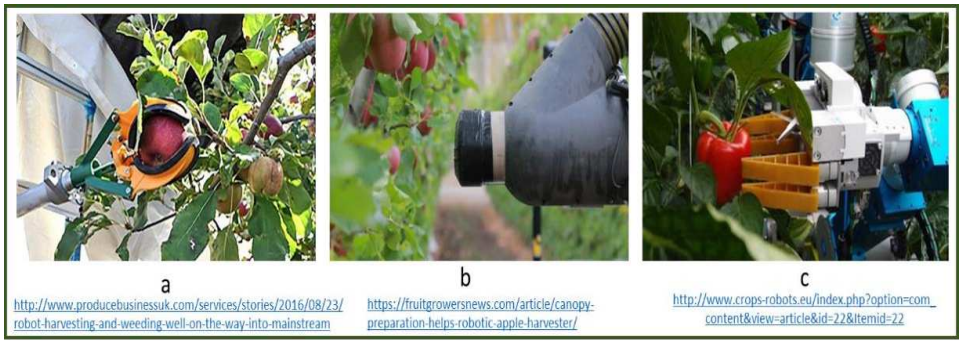

Fig. 2. Bio materials

Section a and c shows mechanical grippers. In the section c the robot use 3D camera for positioning. Section b presents a vacuum gripper, which has a very soft touch.

Sensing the environment is the most important area on agriculture robotization. There are limitations on resolution, range.

Sample: steering

Nowadays autonomous steering getting more popular in the fields. The autonomous unit works on total field, save the tracks and turns. It is able to repeat the whole process autonomously. The sensing base is the Real Time Kinematic (RTK) system. Inertial Measurement Unit (IMU), angle sensors, adaptive controller are for current steering angle. The system is able the turn back at the end of the line, make the working conditions more comfortable for the operator.

Variable Rate Control

One definition for precision agriculture is the location based acting. Location means every plant gets the optimal chemicals, seeds etc. The field is not a homogeny area,

there can be differential demands. The map can be predefined or based on-board calculation. The communication is the general used CAN BUS. Connecting of the smart implements is realised through ISOBUS. ISOBUS connects the tractor ECU to the implement ECU.

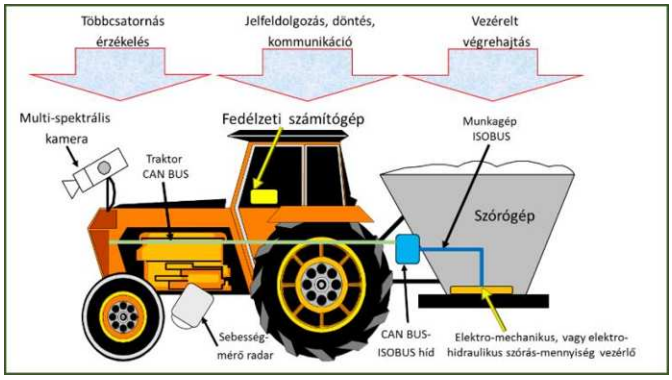

Fig. 3. Real time on-board calculation

Figure 3 shows a tractor using camera for sensing, CAN bus, ISOBUS for data communication and sprayer with variable rate control and section control.

Mini robots and drones

These fields have a big extension. For precision agriculture is an important input value what can be static or dynamic based on time or location. Environment protection is getting more important. Using less (optimal) quantity of chemicals is not only an economical question but environmental too. Collect information from a large area usually use aerial or satellite photos. Drones are getting popular in agriculture too.

Monitoring systems can be:

- Mobil robots
- Drones
- Robot swarm

Currently the development of autonomous soil monitoring systems/robots is in the focus. These sensing technologies can be autonomous or build in tractors. In the EU there are providers for field level aerial photos from drones. They use colour and infra cameras for sensing. The scanning be real time. There are many processes to post process. The infra photos are very useful to monitoring plants. It is also very effective to detect watering deficiency.

Wireless sensor network is a very extensive sensing technology. To install motes (put on the fields) is a simple robot application. Mote is able to measure many environmental parameters.

Drones are good for aerial photos. Motes are good for measuring soil parameters. Synergy of these technologies gives more detailed input data for precision agriculture. Figure 3 and 4 show autonomous information collecting.

Fig. 4. Drone and mini robot

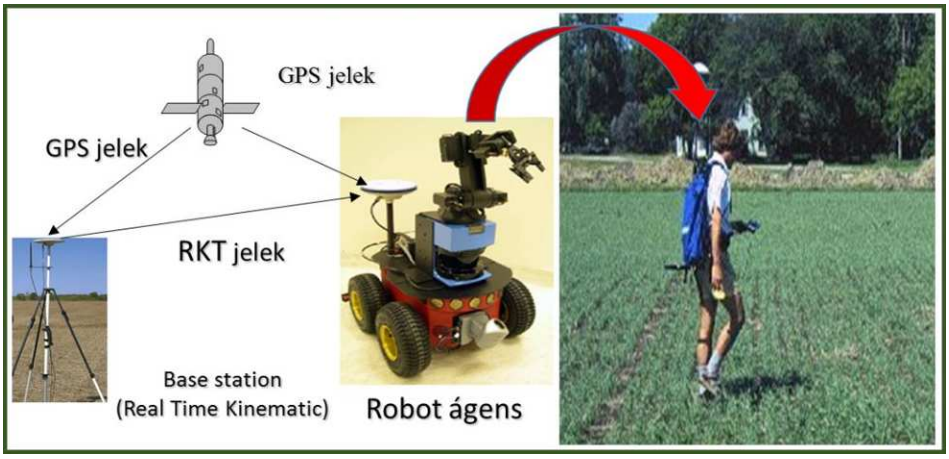

Fig. 5. Mini robot for weed infection

Drones and mobile robots can be utilised in:

- Research, data collection, synergy with wireless sensor network
- Agriculture field work (spray, mote)
- Monitoring

Typical mobile robot sensors:

- GNSS, RTK (location, speed)
- Encoder
- Laser scanner
- Sonar
- Stereo camera
- IMU (acceleration, angle speed)

Camera recognition can be improved artificial intelligence to identify plants and weeds.

Methods

Automation of the agricultural processes has been an important concept in the agricultural mechanisation. Nowadays many tractor developers perform intensive research for autonomous or partial autonomous working. These are mostly conceptual research for machine construction and system architecture.

There are new viewpoints like:

- security,
- safety
- role of the man
- competence
- responsibility
- collaboration
- infrastructure
- autonomous moving on public roads
- economical questions.

Case IH introduced ACV (Autonomous Concept Vehicle). This tractor has not cabin for crew. Wireless connection to control the work. Tractor implement connection is also remote controlled (fig 6).

Fig. 6. Case IH ACV (source:https://media.cnhindustrial.com/EUROPE/CASE-IH/case-ih-autonomous-tractor-development-takes-silver-medal-in-sima-awards-scheme/s/0022424c-da0a-47c4-9bed-d1435d51a1ee)

Robor swarm

Robot swarm can be organized from homogeny or heterogenic robots. The Australian SwarmFarm company introduce a platform for spraying on field. Figure 7 shows the swarm.

Fig. 7. Robot swarm for spraying

Results

In our institute we carry on a unique research on the field of precision agricultural technologies. I this research we concentrate the eye focus of the operator. Human-centred-design approach is considered one of the most effective factors enhancing the productivity of vehicles used in the industrial and agricultural fields. The development of operator's workstation needs to be based on deterministic data which is validated, verified and dependable.

Tractors are companions for many agriculture workers. Well-designed human – tractor interfaces, such as well-accommodated tractor operator enclosures can enhance operations productivity, comfort and safety (Matthews, 1977), (Kaminaka et al., 1985), (Liljedahl et al., 1996) and (Hsiao et al., 2005).
Many studies have been carried on to find preferred locations of in certain types of tractor controls (Casey & Kiso, 1990), moreover; emphasizing how critical is the placement of controls in some tractors stating that; it actually creates an impediment to body movement (Hsiao et al., 2005).
Driving is not only a physical task but also visual and mental tasks. The eyes of a driver are indispensable in performing visual tasks such as scanning the road, and monitoring in-vehicle devices.
A study conducted in 2015 by Gonçalves & Bengler claims that Highly Automated Driving (HAD) will be commercially available in a near feature, yet human factors issues like the influence of driver state can have a critical impact in the success of this driving paradigm and also in road and field safety.
For the purpose of this research, we focus on measuring the focusing scheme of the operator inside the tractor cabin in the lining operation showing by durations the time spent by the operator focusing on selected areas of interest and its change along working hours.
To the purpose of this research, the processes is limited to the data extraction and analysis. The followed methodology is summarized in process map showed in (Fig. 8) However; the scope is subjected to be extended upon the accomplishment of the all research phases to test new design enhancements and engineering solutions.

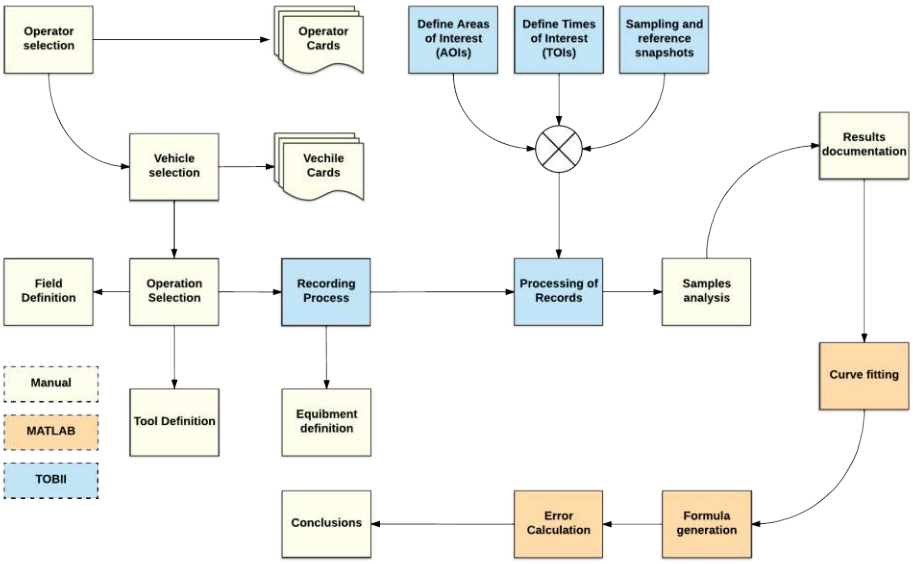

Figure 8. Methodology process map

Soil surface monitoring is another focus area.

Soil parameters are very important for the agricultural production. There are many automated measurement method, some of them are implemented in our research projects. One of our projects focuses on soil surface monitoring. Clot size is the target value on seeding preparation. Clot size also influences the followings:

- surface to connect the air
- hydrology
- life in the soil
- gas emission
- erosion
- working machine vibration.

To optimize these effects, we have to describe the soil surface as detailed as can be. Field work change soil surface significantly. Every implement make a special structure of the soil and shape up the surface. The working direction and the perpendicular direction are usually different. Ploughing make big clot sizes. Seeding preparation makes optimal clot size, where the pieces are mostly small, 3-5 cm for crops in Hungary. In our research project we made lots of measurements on soil surface detection. Clots on soil surface are random place and size. Our method calculate a statistical value, which describe the surface colts. We use Pioneer P3-AT (All terrain) mobile robot to move on the surface. The robot is cruising with a constant speed. The mobile robot platform carry an inertial measurement unit. It measure all direction (3D) acceleration and angle speed.

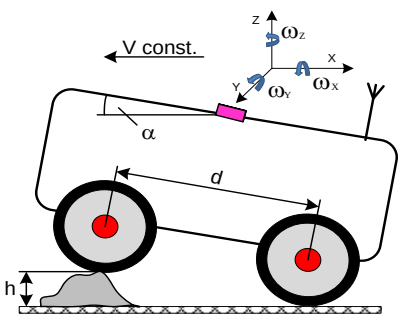

Fig. 9. Mobile robot climb to a clot with IMU

Summary

First measurement was in the floor with same obstacle. The floor is smooth, there is no acceleration and angle speed changing. This environment shows the accelerations what obstacle generate. This way we could calibrate the system to determine the clot size based on acceleration and angle speed. We applied statistical methods classifying the clot size by cm-s. After the validation we drive the mobile robot at well-known clot size

stony walk ways. The developed method turned out a success, able to detect the most representative clot size of the examined surface.
Results can be studied in Fig. 10.

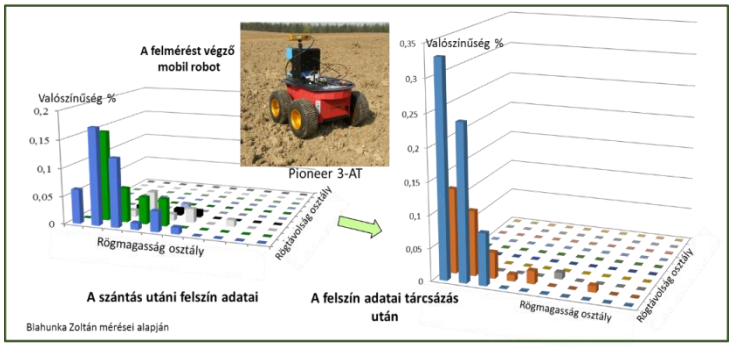

Fig. 10. Significant clot size after ploughing and seeding preparation

Keywords: robots, artificial intelligence, sensor technology, smart farming, smart irrigation

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Automation and robotics in the precision farming

Abstract

There are many concept and technology to robotize in agriculture. The robotization has an intensive synergy with artificial intelligence (AI), information and communication technology (ICT) and sensor technology (ST). These technologies drive into the 4th revolution industry. The industrial processes help the automatization in agriculture. The demand for food products are growing, the working force getting old, these impacts forces the robot applications. This article introduce the robots in the agriculture, and the Szent István University current research on the fields.

Keywords: robots, artificial intelligence, sensor technology, smart farming, smart irrigation

NITRATE LEVEL AND ITS MAIN CHANGING FACTORS IN LEAFY VEGETABLES ESPECIALLY IN LETTUCE (*LACTUCA SATIVA* L.)

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Introduction

Hydroponic is very popular growing system among horticulture producers. This system provides cleaner growing conditions during the growing season and takes the handling of the product easier by using inert medium and nutrient solution instead of soil for the production. However, a high percentage of the growing media ends as waste, it allows to use less water and ensures to produce in those regions where productive lands are limited or the quality of the soil is improper for vegetables, herbs or berries (Gruda, 2019; Maucieri et al., 2019). There are some guidelines, regulations, which ensure that during the production every process have been overseen, and the product meets with all the requirements. In vegetable growing, leafy vegetables have special regulation due to people only consume their leaves where plants accumulate not only beneficial nutrients but nitrate, too (EFSA, 2008; European Commission, 1997). Nitrate throughout its reduction decompose to nitrite and then as reactant with amines/amides does formation of N-nitroso compounds, which in higher amount has harmful effects to humans (Hord et al., 2009; Lijinski, 1999). For this reason, it is important to know regulations related to nitrate content in foodstuff and focus on those technical solutions, which help to reduce disadvantageous metabolites in the leaves during the growing season.

Literature Review

The fast expansion of hydroponic growing is owing to this system offers many new alternatives and opportunities for growers and indirectly for consumers as well. Gives possibilities to produce high quality fruits and vegetables while maximize productions and increase yields in the same area (Aires, 2018). Special modifications of hydroponic system are implemented based on the recycling and reuse of nutrient solution and supporting media (Sharma et al., 2018). Based on Arizona research, lettuce production in hydroponic growing system has a more efficient land and water usage than conventional farming though the high energy consumption. This system could assist to solve the problem of feeding the world's growing population in a sustainable way, if its high-energy consumption become more efficient or it could supplant with cost-effective renewables (Barbosa et al., 2015). However the technical issues of hydroponic system is well developed and the production methods are fully discussed, there are sort of publications about how hydroponic methods impact on the nutritional composition of fresh vegetables and their bioactive compounds (Aires, 2018). In hydroponic system the manipulation of the nutrients is necessary that allows plants to accumulate some beneficial nutrients or some undesirables, such as nitrate. Most of the

bioactive compounds have significant health benefits, which influenced by several factors including genotype and environmental conditions (light, temperature, humidity, atmospheric CO_2) (Buchanan and Omaye, 2013; Sgherri et al., 2010; Frezza et al., 2005). Nitrate is a natural component of the human diet, besides vegetables, water and cured meat are the major source of it; however, fruits, fish, dairy products, beers, cereals also contain. The major contributor of vegetables to nitrate intake are not only but mainly rocket salad, spinach and lettuce (ATSDR, 2015; Commission Regulation (EU) No 1258/2011; Hambridge, 2014). The strength of the evidence that fruits and vegetables have more advantageous effect on health than disadvantageous (Ahluwalia et al., 2016; Bahadoran et al., 2018; EFSA, 2008; Hmelak Gorenjak and Cencič, 2013; Joshipura et al., 2001; Milkowski et al., 2010; Santamaria, 2006) it is important to consider their essential part in human diet. To ensure food safety, leafy vegetables also have regulation for maximum level of nitrate by the European Commission.

However nitrate is unpopular compound in vegetables and it is unavoidable as nitrogen is an essential compound of protein, enzyme, chlorophyll, hormone, nucleic acid, etc. (Kozai et al., 2015). The concentration of nitrate partially depend on the biological properties of the plant culture, light intensity, type of soil, temperature, humidity furthermore, the plant density, maturity, vegetation period, harvesting time, storage time, and form of the nitrogen fertilizer (Tamme et al., 2006; Vahed et al., 2015). These factors have a combined effect on the plant, not only its morphology but its nutrient composition as well. In the early 20th century already have been identified that nitrogen fertilization and light intensity are the major factors that influence nitrate content in vegetables (Cantliffe, 1973), which were affirmed later in several publications and reports. These reports were collected by the governments and the European Commission's committee (Scientific Committee for Food), and surveillance programmes for nitrate monitoring were maintained across the world in purpose to find reason for elevated nitrate level in vegetables. These data mainly based on greenhouse and open field grown vegetables, which still have major contribution at the market.

Amendments of regulations

The first regulation about 'Community procedures for contaminants in food' was done in 1993 and developed specially for 'setting maximum levels for certain contaminants in foodstuffs', which contains the limit for nitrate in various leafy vegetables by the European Commission. That has been constituted in 1997 which has been amended in 1999, 2001, 2002, 2005, 2006 and 2011 (due to that the original document contains several contaminants it was amended more often, but the articles with nitrate relevance have been modified only at the mentioned years). **Council Regulation (EEC) No 315/93** provides that maximum levels must be set for certain contaminants in foodstuffs in order to protect public health. In that reason necessary to keep the amount of contaminants at toxicologically acceptable levels and contaminants must be eliminated more thoroughly everywhere possible by using good professional practice as there were mentioned in the **Commission Regulation (EC) No 194/97** and were set the allowed maximum level of nitrate in fresh and processed vegetables also. In addition, sampling methods were listed for an overall view. Only spinach (*Spinacia oleracea* L.) and lettuce (*Lactuca sativa* L.) in general with 3 harvesting periods per each were included

and as ’other processed vegetables for consumption’ only preserved, deep-frozen spinach was mentioned in that time with the maximum allowance of nitrate level, which were between 2000 and 4500 mg NO_3/kg fresh or processed product. The Commission also noted the importance of the review of the maximum levels provided for in the Annex for lettuces and spinach before 1 October 1998, and if necessary, these levels shall be reduced; and a study should be made, based on the available scientific data, and maximum contaminant levels should be set for baby food for infants and young children meanwhile there is a caution in the Annex’s footnote that do not apply maximum levels to food particularly prepared for babies and young children. **Commission Regulation (EC) No 864/1999** already have been specified that in three year period should be reviewed the limitation for nitrates in fresh spinach which based on monitoring carried out by the Member States and the application of codes of good practice to reduce nitrate levels. For lettuce, lower limits were fixed for open-grown lettuce than for lettuce grown under glass, and in the absence of precise labelling the lower limit should be used to support the effective control. However the phrasing of **Commission Regulation (EC) No 466/2001** was more detailed and young children was mentioned as a sensitive group of population which needs specific attention, still have not been set a maximum contaminant levels for baby food for infants and young children nevertheless have not been concerned any changes according to maximum nitrate level or its grouping. This regulation had been amended by the **Commission Regulation (EC) No 563/2002** where ‘Iceberg’ type lettuces got special maximized nitrate level – without any designation for harvesting time – set to 2000 or 2500 mg NO_3/kg fresh product respectively, depended on that lettuces were grown in open air or under cover. A special regulation unlike the others was the **Commission Regulation (EC) No 1822/2005** amending Regulation (EC) No 466/2001 as regards nitrate *in certain vegetables* which overwritten few articles as ‘Member States shall monitor nitrate levels in vegetables containing significant levels, in particular green leafy vegetables, and communicate the results to the Commission by 30 June each year’. Baby foods and processed cereal-based foods for infants and young children category got place in Annex 1 with the maximum level of nitrate 200 and with the footnote ‘Commission shall review the maximum levels for nitrate in foods for infants and young children by 1 April 2006 taking into account the progress in scientific and technological knowledge’. Meanwhile Annex 1 did not changed in **Commission Regulation (EC) No 1881/2006** and was submitted the **acceptable daily intake (ADI)** of 3,65 mg/kg body weight (bw) (JECFA’s (2002) ADI value (3,7 mg/ kg bw/ day (expressed as nitrate ion)). And this version got a full form which means that for the reader does not need to find out which other regulations, directives, reports have connection with leafy vegetables and nitrate level. Still in force the **Commission Regulation (EU) No 1258/2011** amending Regulation (EC) No 1881/2006 as regards maximum levels for nitrates in foodstuffs, there was concluded that maximum level of nitrate in leafy vegetables are higher than the established, despite of Member States developed in good agricultural practice and the temporary derogation. *Climate and light conditions are the main reason in the presence of nitrates in vegetables, and these climate conditions cannot be managed or changed by the producer.* Therefore in a consistent way nitrate levels in lettuce and fresh spinach cannot be reduced below the current maximum levels in certain regions of the Union, so Annex 1 was absolutely changed by the Commission. The regulation allows higher

amount of nitrate in fresh spinach (from 3000 to 3500 mg NO_3/kg) – aside from harvesting time – preserved, deep frozen or frozen spinach did not changed (2000 mg NO_3/kg); fresh lettuce (protected and open-grown lettuce, harvested from 1 October to 31 March or from 1 April to 30 September) excluding Iceberg type lettuce changed (from 2500-4500 mg NO_3/kg to 3000-5000 mg NO_3/kg), Iceberg type did not changed (2000-2500 mg NO_3/kg); Rucola (*Eruca sativa, Diplotaxis* sp., *Brassica tenuifolia, Sisymbrium tenuifolium*) had been placed (6000-7000 mg NO_3/kg; and processed cereal-based foods and baby foods for infants and young children did not changed (200 mg NO_3/kg).

Based on the regulation it is easy to estimate the amount of daily consumption of leafy vegetables without nitrate intake from other nitrate sources (Figure 1).

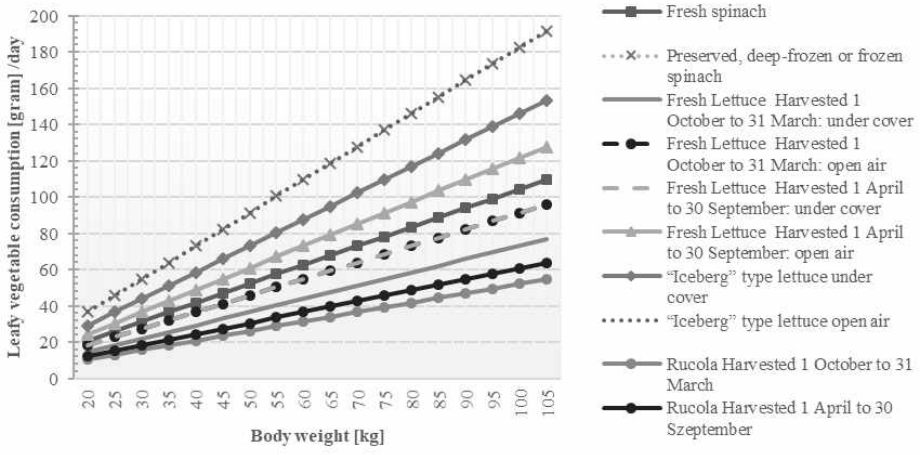

Figure 1: Calculated possible daily consumption of different leafy vegetables per person per day, where vegetables theoretically have the maximum NO_3^- level when they were harvested (Commission Regulation (EU) No 1258/2011), and no other nitrate sources are consumed; for calculation ADI value (3,65 mg/ kg bw/ day was used (in case of usage of JECFA's ADI (3,7 mg/bw/day nitrate ion) the difference is <3 gram in this body weight range).

Results about nitrate level in lettuce

In an early report were mentioned that open leaf lettuce (907-4674 mg/kg) varieties had greater nitrate level than tight headed (Iceberg: 140-1750 mg/kg) varieties; lettuces which were harvested at northern Europe have higher level than samples from Mediterranean countries. Generally in the same region, vegetables had higher nitrate concentration during winter and under cover grown vegetables had elevated nitrate level than outdoor grown vegetables. Application of nitrate based fertilizers also could cause elevated level of nitrate in crops, but it is very complicated to reveal the link between usage and accumulation (Ansorena and Merino, 1992; European Commission, 1997).

Between 1993-1997, Petersen and Stoltze (1999) in **Denmark** were found with food monitoring programme that lettuce had elevated nitrate content followed by beetroot, Chinese cabbage, fresh spinach, leek, frozen spinach, white cabbage and potatoes. The

monitoring showed that Danish grown lettuce had the highest nitrate content in the winter period (average 3000-4500 mg/kg, highest 7820 mg/kg) and the lowest during the summer period (average 1000-2500 mg/kg, lowest 108 mg/kg). The marketing survey showed that the average intake of nitrate from vegetables was around 40 mg/day. Tosun and Ustun (2004) made measurements with small sample size without reported harvesting date in **Turkey**, where nitrate content was between 139-5544 mg/kg. **French** monitoring programmes between 2000 and 2006 were shown, 1973.9-5600 mg/kg was the nitrate content in lettuces. There was found, that nitrate dietary exposure is mainly due to water (mineral, tap water, coffee, tea, soup), potato and tomato, while other vegetables had low consumed mean values (Menard et al., 2008). In **Spain** between 2003 and 2009, samples of plant products and baby foods – mainly from retailers – were tested for nitrate, 6% of these were higher than the maximum allowance. There were shown that the highest contents were in chard (mean around 1400 mg/kg) then in spinach (mean exceed 800 mg/kg) and lettuce – most of them were grown outdoors – (mean around 600 mg/kg). Iceberg lettuces had lower nitrate content, and lettuces which were collected in winter had higher nitrate level than in summer. There were also showed that quantity of the consumption of these vegetables had considerable differences between consumer groups (Nuñez and Gomez, 2011). **United Kingdom** also had surveillance programme, where domestic and imported lettuce, spinach, rocket and other leafy green vegetable samples were collected between 2009-2013 and 2014-2019. In the first monitoring period was observed that summer-grown crops had lower levels of nitrate than those grown in winter. UK grown lettuce crops under cover had higher mean nitrate content than lettuce grown outdoors. Iceberg type lettuce had a significantly lower mean nitrate level than non-iceberg type lettuce. Imported lettuce samples had a lower mean nitrate concentration than domestic lettuce samples just like in the publication of Petersen and Stoltze (1999). In the second period, UK grown rocket had the highest mean nitrate level (4131 mg/kg), the highest maximum nitrate content (8052 mg/kg) and the greatest range of values (7990 mg/kg). For all categories winter samples (3519 mg/kg) had a higher mean concentration than summer samples (2830 mg/kg). Open field grown Iceberg type lettuce had the lowest mean nitrate concentration of all the categories and the smallest range. The mean annual nitrate content in 2018 exceeded their respective long term averages (LTA) for both summer and winter samples of non-iceberg outdoors grown lettuces. There were showed that the percentage of samples (excluding rocket) exceeding the permitted nitrate concentration has fallen by approximately 3% every 5 years (ADAS, 2019). In **Brazil** between 2001-2003 Guadagnin et al. (2005) did sampling on lettuce from organic (O), conventional (C) and **hydroponic** (H) growing system. Nitrate content varied not only by agricultural systems (O (115-1852 mg/kg), C (677-2179 mg/kg), H (1842-4022 mg/kg)), but leaf's parts (stalk (C (1470±118 mg/kg), H (3927±198 mg/kg)), (leaf without stalk (C (577±74 mg/kg), H (3084±93 mg/kg))). They were concluded that nitrate content of each crop species varied among the different producers. Frezza et al. (2005) found difference in productivity and nitrate content of lettuce in both soilless (floating system and substrate culture) and soil culture. Yosoff et al. (2015) observed that both the hydroponic and organic system perform equal in terms of lettuce yield, quality and nitrate content, whereas, delayed harvesting was increased yield and moderated nitrate level. Mathieu et al., (2006) did a comparison between model-predicted and measured values for lettuce

growth and nitrate uptake in hydroponic system. Their main finding was the relationship between the nitrate concentration changes and growth rate, which means that in the shoots carbon production from photosynthesis fills the 'vacuole' during the light period and reducing the need for nitrate. During the dark period, the stored carbon is mobilized to produce structural material, and therefore nitrate uptake increases. This source-sink relationship happens during a day. However, regulations are in force in all production system, these years have more challenges as plant factories became more widespread. Song et al., (2020) demonstrated that the combination of light intensity and nutrient solution could significantly effect growth and quality of lettuce. With this finding they showed that light and nutrient solution are the most effective factors to improve plants' quality and yield in plant factories which could initiate more research in closed growing systems on this topic and could contribute in global development on the combination of usage of plant specific light recipes and fertilization.

Summary

In the light of regulation modifications during the years, it was clearly showed that how complex the reason of the nitrate content changes in lettuces and other vegetables is, and how complicated is to create a uniform regulation for all member state. The geographic location is not responsible in itself for the vegetables' nitrate content, however climate and its factors in relation to nutrient supply do have effect on the production. The availability of the adequate light – quantitatively and quantitatively – with optimized nutrient uptake could mainly help to ensure the quality of lettuce and other vegetables. However, it is well known that nowadays still the weight of the vegetable has an impact on the market.

Keywords: hydroponic, nitrate, lettuce, spinach, rocket, light, regulation

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Nitrate level and its main changing factors in leafy vegetables especially in lettuce (*Lactuca sativa* L.)

Abstract
Lettuce is one of those vegetables that has a well-developed and discussed production methods. There are sort of publications about growing methods on the nutritional composition of lettuces and their bioactive compounds. In leafy vegetables nitrate is usually higher than in others, but it is naturally part of the human diet. There have been discussed in several publications about the possibilities of nitrate reduction and those factors which have higher impact on the decrease. Nitrogen fertilization and light intensity are the major factors that influence on nitrate content, but processing of the food and other growing conditions are have strong effect as well. Also there have been researched the effect of nitrate intake for human health. Based on scientific studies and yearly monitoring, there are guidelines and regulations about maximum nitrate and nitrite intake for humans; as well as about maximum nitrate level in spinach, lettuce and rocket salad considering the growing season and conditions.

Keywords: hydroponic, nitrate, lettuce, spinach, rocket, light, regulation

WATER MANAGEMENT EFFECTS OF DIFFERENT TILLAGE SYSTEMS

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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 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.

Literature Review

Our most important goal is to protect our soils. Soil protection means that you have to create and preserve such condition for the soil in which it can fulfil both its functions, that is it can fulfil its role within the natural ecosystem and also within the ecosystem under human control.

From the agroecological point of view, the soil is such a habitat which is purposely affected by people through physical intervention (cultivation), or growing plants with different biological needs and repercussion. As soil quality improvement is the basis for climate damage mitigation, the cultivation suitable for mitigation has a beneficial effect on the quality of the soil, including its moisture circulation, biological activity and ability to regenerate (Birkás M. Jolánkai M. Gyuricza C. Percze A., 2004).

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 (Gyárfás, 1922). 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).

Methods

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.

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.

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). To preserve these valuable arable lands and to increase their productivity are the main goals of our experiment.

Results

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.

Depth	**Soil penetrance (N)**				
	Traditional deep cultivation	**Shallow ploughing, disc ploughing**	**Semi-deep ploughing**	**Deep disintegrating**	**Applying strip-till technology**
0 - 20 cm	561,0	871,1	488,7	455,2	148,8
20 - 40 cm	657,8	568,6	772,9	415,5	281,3
40 - 60 cm	953,7	778,1	914,2	515,1	878,1

Table 1. Soil resistance values

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.

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.

Estimated average production kg/ha				
Traditional deep cultivation	**Shallow ploughing, disc ploughing**	**Semi-deep ploughing**	**Deep disintegrating**	**Applying strip-till technology**
13430,7	9492,0	12954,7	13906,7	14317,3

Table 2. Production results

Main findings

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.” (Birkás M., 2017)

Summary

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 1ºC 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.
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 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.
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Trample damages caused by cultivation and expenses of production can be reduced.
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By this, the degradation of soil structure can be reduced. The stability of aggregate can be increased considerably.

Keywords: soil cultivation, water management

Acknowledgments

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management, hydrocultural farming, alternative field farming and the related precision operation of machines."

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Water management effects of different tillage systems

Abstract

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 1ºC 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.

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 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.

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 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.

Keywords: soil cultivation, water management

POSSIBILITY OF THE USE OF SMALL SCALE MOBILE HATCHERY IN KÖRÖS VALLEY

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Introduction

The fish production capacity of Hungarian rivers has been declining since the river regulations. Diminution of the floodplains was a direct effect to cause a loss in spawning space, moreover, narrower river meadows result in faster moving floods with higher flood peaks. Contrary to the above processes, most of the fish species spawning in floodplains would need slow floods (lasting at least 1-1.5 months) to create shallow and easily warming water. Another effect of river regulation that in straight, modified riverbed water runs faster, enhancing its deteriorating effect and deepening the bed. As a result, the level of soil water in surrounding areas drops considerably. To hinder the process, dams are constructed which, eventually, segregate fish populations and reduce genetic diversity. A solution could be, beyond habitat management, to develop a stocking strategy with fish of local genotype and special attention to avoid gene drift and hatchery selection. In this study, the theoretical possibility of a mobile fish hatchery is described, which can be a basis of the above stocking system.

Literature Review

River regulation started in the 18th century in the Körös valley, however, extensive modification only started in the 19th century. After the regulation, a considerable length of the riverbed became artificial (Andó 1997). As a result of riverbed modification, the fish population changed drastically and due to further detrimental effects (e.g. eutrophication, overexploitation and water pollution), numerous fish species have disappeared, especially rheophilic ones (Györe et al 2011, Györe & Sallai 1998, Sallai 1997).

The exploitation of the fish population in the river meant commercial fishing for centuries, although angling started at the end of the 19th century. These two kinds of utilizations worked parallelly for decades, but fish management rights were owned by commercial fishermen's organisation. In the modification of the Law on fish management and fish protection (2013/CII) in 2016, commercial fishing on natural waters was ceased and angling became a priority. Therefore, the Association of Körös Valley Angling Organization was conferred by the fish management claim of Körös Valley. This change meant further aims than fish meat production, raised the quantity of stocked fish but the stocked fish structure remained with the focus on pond fish species. Based on the data in 2019, 63 tones of fish was stocked into Körös rivers (including Berettyó and Hortobágy-Berettyó) of which 93% was carp (*Cyprinus carpio*). The rest was shared among wels catfish (*Silurus glanis*) by 3.2%, miscellaneous whitefish (*Abramis spp., Rutilus rutilus, Scardinius erythrophthalmus* etc.) by 1.8 %, sterlet

(*Acipenser ruthenus*) by 0.8 %, pike (*Esox lucius*) by 0.8 %, ide (*Leuciscus idus*) by 0,28%, pikeperch (*Sander lucioperca*) by 0.25 %, and burbot (*Lota lota*) by 0.07 %. It is well visible that the Association is open to stock native fish species of lower economic importance, but stock quantity is very limited in the case of these species (http 1).

Studies of the last decades show a proof that fish stocking has a serious impact on the genetic diversity of fish populations, meaning mainly a negative effect (Perrier et al. 2013., Valiquette et al. 2014, Yokota et al. 2003). The main reason for this effect is that fitness of broodstock and its offspring kept under artificial environment proved to be much lower in the nature than those of wild specimens. A study revealed that this outcome can appear even after one generation (Christie et al. 2014). The least negative reaction can be reached by the earliest stocking of offspring of wild broodstock, confirmed by numerous publications (Araki & Schmid 2011).

Induced fish breeding has a decades-old history (Horváth 2000). Nowadays induced breeding of not only economically important fish species (carp, wels catfish, pikeperch, etc), but also sport fish species (asp (*Aspius aspius),* ide, chub (*Squalius cephalus*)) or some protected or endangered species (e.g. European mudminnow *Umbra krameri*) have been described by researchers. Thus, the production of incubation-ready, fertilized eggs is available in most species if ripe broodstock is at hand (Horváth & Tamás 2011, Müller et al., 2011, Szabó, 2000).

Finally, fish breeding technology went through numerous modernization processes. One of those innovations targeted the recirculation of used water in fish rearing in order to reduce the amount of water necessary to produce a kilogram fish meat (Timmons & Ebeling 2007). Our current knowledge allows the long-term maintaining of the rearing system with only 10% change of the total water amount by applying mechanical filtration to separate suspending components, biological filtration to neutralize the harmful metabolic substances (e. g. ammonia) or to use ozone or UV radiation to control pathogens (Csorbai et al, 2015).

Methods

Since the establishment of the Department of Aquaculture of the Szent István University, fish propagation experiments have been always made. So far, breeding and rearing experiments with 15 fish species resulted with success including chub, ide and barb. The studies were carried out in recirculation systems equipped with different mechanical filtration methods (sedimentation, sponge filter, bead filter), biofilters (bead filter, moving bed biofilter reactor - MBBR) or techniques to reduce pathogens (UV, ozone). Based on all the experience with the above technology and the knowledge on the characteristics of the eggs of different fish species, the following theoretical system has been designed:

The basis of the system is a buffer pool with a capacity of 1.2 m^3, suitable to use temporally for broodstock incubation. Water leaves from here through three sponges of 50 mm thickness with different pore sizes (TM 10-20-45) to the place of 1st UV treatment (4*25 W). From this part of the tank, a pump with a hot reserve capacity moves the water to an MBBR of 0.288 m^3 gauge, in which a biomedia with a volume of

0.144 m^3 and a bulk surface of 600 m^2/m^3 was set. From this reactor, water flows through a reserve tank of 0.2 m^3 capacity with another UV treatment (4*25 W) and finally arrives with the help of gravity to the above-described tank, or to 5 pieces of seven-litre Zuger glasses or, to 5 pieces of 100-litres larva rearing containers. The electrical energy need of the whole mobile rearing unit without heating is less than 1 kW. In this infrastructure, we plan to breed chub, ide, barb and asp.

Results

The parts of the mobile hatchery unit have been tested in the building of our Department. Results of the tests showed that the filtration system is able to deal with a larva rearing technology of a 350 g daily feed of 54% protein content meaning a N load of 30 g/day. Under such circumstances, total ammonia nitrogen (TAN) was measured 0.3±0.2 mg/dm^3, while NO_2^--N was present at the concentration of 0.1±0.05 mg/dm^3. System loadability was also tested under extreme condition by feeding 1100 g/day with a feed of 42% protein content which means a burden of 75 g N. Under these circumstances TAN was measured 3±1 mg/dm^3 and NO_2^-N concentration reached 1±0.5 mg/dm^3, proved to be unsuitable for most fish species.
Knowing the TAN degradation capacity in the practice, it was calculated that the system can be loaded by a maximum of 1000 g of dry, stripped eggs, containing approximately 20-40 g/kg N assuming that in case the whole quantity of eggs degrades in one day, the biofilter can manage that burden. This theory was checked in practice: 1000 g of medium-well-fertilized (approx. 60%) chub eggs was incubated for 10 days. TAN value stayed under 0.1 mg/dm^3 during the whole process and almost 100% of the eggs hatched. After this experiment, an overloading trial was made by stocking 1500 g of weakly fertilized (30%) African catfish eggs for 24 hours and TAN was measured until hatching. Measured value stayed under 0.1 mg/dm^3.

Main findings

The above results and the available data on the parameters of the reproduction biology (e. g. egg number/kg, average fertilisation rate, hatching rate etc.) of each fish species can lead to the conclusion that the mobile hatchery will be able to provide almost 500 000 chub fries, 300 000 ide fries and 200 000 asp fries or to supply with 300 000, 200 000 and 150 000 fingerlings of 20-days age from the above species. This fish quantity would mean a considerable supplement to fish populations of Körös river sectors where natural hatching would be hindered by the loss of floods or unsuitable hydrological circumstances.
The early experience on the hatchery shows that no selection happened in early rearing as all the three species resulted in similar survivor rate around 90%. The advantage of non-selective hatching, combined with the use of native broodstock, would probably take a negligible effect on the prevalence of different genetic variants. Therefore, despite the disappearance of spawning grounds, the negative effect of overexploitation and the weather uncertainties, it would help the conservation native fish species in the Körös Valley.

Summary

Population structure of River Körös fish species seriously changed in the past two centuries. Due to the river regulations and the building of dams, the success of the natural spawning decreased dramatically. The lack of spawn was replaced by stocking programs, but they were based mainly on farmed fish: carp (*Cyprinus carpio*), pike perch (*Sander lucioperca*), wels catfish (*Silurus glanis*), moreover, in the past with alien species like grasscarp (*Ctenopharyngodon idella*) and silver carp (*Hypophthalmichthys molitrix*). Based on the new scientific results, this strategy should be changed and local, native rheophile species (barb *Barbus barbus*, chub *Squalius cephalus*, ide *Leuciscus idus* and asp *Aspius aspius*) should be preferred. However, these species are unsuitable for traditional, extensive pond fish farming. In this publication, we present the theoretical background of a new, mobile, recirculation hatchery unit, which is able to solve this problem taken into consideration the value of local genetic variations.

Keywords: mobile hatchery, Körös, fish propagation

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Possibility of use of small scale mobile hatchery in Körös valley

Abstract

Population structure of River Körös fish species seriously changed in the past two centuries. Due to the river regulations and the building of dams, the success of the natural spawning decreased dramatically. The lack of spawn was replaced by stocking programs, but they were based mainly on farmed fish: carp (*Cyprinus carpio*), pike perch (*Sander lucioperca*), wels catfish (*Silurus glanis*), moreover with alien species like grasscarp (*Ctenopharyngodon idella*) and silver carp (*Hypophthalmichthys molitrix*). Based on the new scientific results, this strategy should be changed and local, native rheophilic species (barb *Barbus barbus*, chub *Squalius cephalus*, ide *Leuciscus idus*, asp *Aspius aspius*) should be preferred. However, these species are unsuitable for traditional, extensive pond fish farming. In this publication we present the theoretical background of a new, mobile, recirculation hatchery unit, which is able to solve this problem taken into consideration the value of local genetic variations.

INTENSITY OF INCOME TRANSFORMATION – TEMPORAL CHANGE OF TERRITORIAL INCOME INEQUALITIES IN BÉKÉS COUNTY

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Introduction

If we look at Békés County or its wider region (Southern Great Plain), territorial units appear as members of a convergence club with a low degree of competitiveness (in factor-driven stage according to competitive development theory) and low income both in Hungary and European Union (EC 2017, Rodríguez-Pose – Ketterer, 2016). In Hungary, as in the other Visegrad countries, the east-west socio-economic divide can be traced back centuries. A significant part of the Great Plain - including Békés County - has become peripheral in the last century from a socio-economic and spatial point of view, and has even become a "periphery of the periphery" (Baranyi, 2004). In Hungary, the transformation and the political-economic turn came with the former developmental differentiation and the increase of territorial differences. The spatial structure of the country has been determined by the outstanding and concentrated development of the capital, the advantage of the north-western region over the others, the appreciation of the dependence on the size of settlements, and the growing fragmentation of micro-regions. (Enyedi 2004, Nemes Nagy 2005, Csite-Németh, 2008, Pénzes, 2014). By now, the economic performance of Békés County (GDP per capita, personal income per capita) has reached the almost the last (18th) place in the rank of the counties. In other words, at the county level, apart from the locational peripheralization, the economic backwardness is also clearly characteristic.

In my study I intend to present the territorial features of the market economy transformation in Békés County, from the period of the change of system to the present day. I would like to highlight the intensity of income transformation, how the changes in the income positions of the settlements over time develop in Békés county. On the one hand, I present the path taken by each settlement between 1988 and 2017, as well as the structural and spatial factors that affect the long-term inequality path of the settlements.

Methods

In the study, I chose the settlement level as the observation unit, which provides an adequate number of items (75) for the analyses. As a basic indicator of municipal income inequality, I have made taxable income per capita. The argument in favour is that it applies to the same observation units measured according to the same methodology and is fully accessible at the time examined (Kiss, 2007).

The change in income over time (the intensity of transformation) is presented using the coefficient of variation (CV), which measures the standard deviation relative to the average of the data series. During the examinations I did the CV as a dependent

variable, using ordinary least squares regression (OLS) and maximum likelihood regression models reflecting spatial features (spatial lag model [SLM], spatial error model [SEM]) to express relationships with explanatory variables (Varga, 2002; Anselin, 2005). The basic data of the analyses was provided by the TeiR (Országos Területfejlesztési és Területrendezési Információs Rendszer).

Results

For the purposes of the analyses, I calculated the income per capita for each municipality and for each year as a percentage of the county average. Based on this, I calculated the coefficient of variation for each settlement income per capita value, in order to express the variability of each settlement income per capita between 1988 and 2017. In each case, the income per capita was measured as a percentage of the county average.

The settlement features of the CV are shown in Figure 1. The income variability over time is between 2.5 percent (Szarvas) and 23.72 percent (Geszt). On the one hand, it can be seen from the map that smaller settlements are mainly affected, and spatial concentration is also characteristic (in the northeast and southeast of the county).

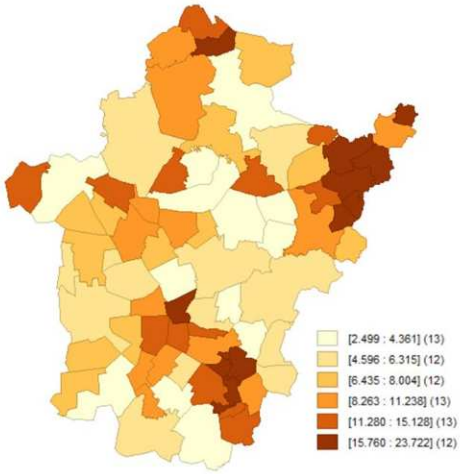

Figure 1. Temporal income inequalities of the settlements in Békés county

First, I compared the coefficient of variation with the 2017 income level. (Figure 2) The best fit between the two variables is achieved by a quadratic polynomial function with a coefficient of determination of nearly 50 percent. According to this, as the income position improves, the CV over the last 30 years is decreasing. The explanation can be partly related to the path dependency of the development, that is, which settlement had higher income in the past, it still has. In each year there is a strong positive correlation between the the income per capita values (the smallest value of the Pearson correlation coefficient is +0,772, p <0,000), but the changes of system affected the settlements with varying intensity, the role of spatiality (east-west location, neighbourhood effects, etc.)

and size of settlement increased. Extreme variability (20.0% ≤CV≤30.0%) affects three low-population communities: Geszt, Újszalonta and Csabaszabadi. The three settlements represent two ways. In the case of Geszt and Újszalonta, located on the border, there is no significant convergence, it gives almost the same performance in 1988 and 2017. On the other hand Csabaszabadi achieved an increase of nearly 30 percentage points as part of the Békéscsaba agglomeration, by today it is 10 percentage points above the county average. At this level of income, the 23.2 percent coefficient of variation is considered to be outlier, and the "elimination" of this local feature improves the goodness of the model by nearly 10 percentage points. The average population of settlements affected by medium variability (10.0% ≤V≤20.0%) is 1.275 (maximum: 2.827). Most of the settlements with a small population can be discovered in the less developed part of terms of income, at the same time many villages with high dispersion (for example, Békésszentandrás, Örménykút) have above-average incomes. The figure also points out that the relationship between the two phenomena is not linear, in the case of more developed settlements the function increases slightly.

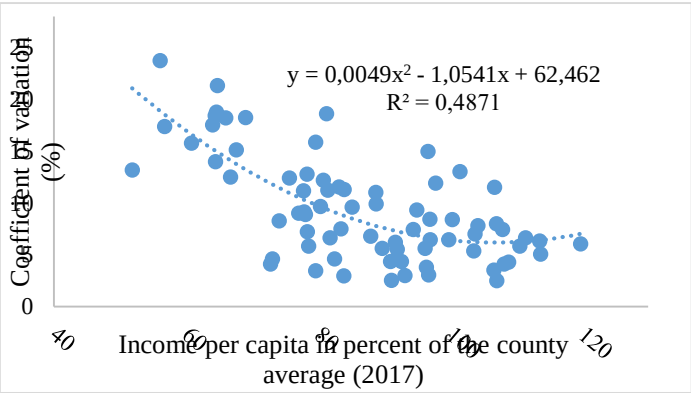

Figure 2. Temporal income inequalities of the settlements in Békés county in relation to the income level (without Csabaszabadi)

Based on the literature on territorial income inequalities and the spatiality of the socio-economic transition (Németh-Kiss 2007, Pénzes 2013, Nemes Nagy 2009, 2017), I included the following factors in the analysis of settlement inequalities: settlement size, initial income level, distance (from county centre, micro-region and/or district centre) (km), proportion of graduates and initial economic structure of the municipality. Since the phenomenon of regionalization cannot be attributed to income inequalities at the territorial level, I want to capture neighbourhood effects using spatial regressions, spatial lag or spatial error models.

According to models 1 and 2, the main determinants of the long-term variability path are the size of settlements (population) and the proportion of graduates, both of which

are characterized by an inverse relationship. That is, the larger the population of a settlement and the higher the proportion of people with tertiary education, the smaller is the variability of income positions. Initial income per capita 1988 and the main economic structure indicators (employment in industry and services) have negative signs in models 3, 4 and 5. That is, in addition to lower initial income levels and secondary and tertiary employment, there was a significantly higher dispersion during the study period. Although the county's industrial tradition is weak and has undergone significant structural transformation, it still contributes to the stability of income positions as a kind of "protective factor" in the settlements where the sector appeared. And the relative predominance of the service sector is largely perceived as a proxy for a central role. Of the variables indicating geographical location, only the distances from the larger centres (mainly from the county centre) have a reliable effect on the change of temporal income differentiation. The role of centre-periphery relations is significantly affect not only in the static position of incomes but also in the intensity of changes. Thus, the closer a settlement is to a major node, the less variable its relative income position is between 1988 and 2017. The distance from local sub-centres (district centres) does not contribute to the explanation of the dependent variable, the sub-centres cannot significantly reduce the temporal variability of their agglomeration's income. This is partly due to the fact that the performance of these cities may be relatively low and variable (e.g. Sarkad), but the low level of urbanization as well as the nature of the market town may not be able to ensure the development and maintenance of spatial synergies. In addition, multiple reshaping of the borders of subregions (or districts), and thus the reorganization of spatial relationships, did not result a balanced urban-rural relationship (BMTK 2014, Csatári 2016). The micro-regional environment is also a relevant determinant of the long-term variability of settlement development, this phenomenon does not appear only in the case of models containing the initial income level. Thus, the changes occurring during the examined period also have spatial dimensions, if changes of greater intensity took place in the neighbourhood of a settlement, the CV of incomes will be similarly high in the case of the given settlement.

	Model 1		Model 2		Model 3	Model 4		Model 5	
	(OLS)	(ML SLM)	(OLS)	(ML SLM)	(OLS)	(OLS)	(ML SLM)	(OLS)	(ML SLM)
intercept	27.116*** (3.528)	22.352*** (3.358)	9.817*** (2.010)	6.250*** (1.977)	20.551*** (2.579)	12.912*** (4.418)	8.519** (4.048)	-10.117*** (4.303)	-10.492*** (3.861)
distance (county centre)	0.070** (0.029)	0.051* (0.029)	0.082** (0.035)	0.060* (0.033)	0.073** (0.030)	0.123*** (0.035)	0.090*** (0.033)	0.085** (0.034)	0.060* (0.0323)
population (ln)	-6.040*** (0.896)	-5.348*** (0.821)	-	-	-	-	-	-	-
tertiary education	-	-	-0.889*** (0.250)	-0.721*** (0.224)		-	-	-	-
initial income	-	-	-	-	-0.165*** (0.025)	-	-	-	-
industry employment	-	-	-	-	-	-0.200*** (0.102)	-0.164* (0.090)	-	-
service employment	-	-	-	-	-	-	-	-0.289*** (0.079)	-0.244*** (0.070)
w	-	0.343*** (0.118)	-	0.407*** (0.125)	-	-	0.456*** (0.124)	-	0.420*** (0.125)
Multicollinearity Condition Number	18.356	-	8.243	-	12.091	19.433	-	20.604	-
R^2	0.516	0.578	0.298	0.428	0.422	0.215	0.386	0.304	0.442
Log-likelihood	-203.07	-198.94	-215.46	-210.728	-208.67	-219.65	-213.82	-215.14	-209.94
Akaike information criterion	414.13	407.88	438.92	431.46	423.34	447.29	437.63	438.28	429.88
Breusch-Pagan test	0.709	0.793	0.845	1.954	0.681	5.913	8.321	3.069	5.711
Jarque-Bera test	7.459	-	9.029	-	2.519	3.437	-	2.856	-
Moran's I	0.095*	-0.125	0.167***	-0.079	-0.020	0.270***	-0.030	0.187***	-0.097

Table 1. Regression models explaining temporal income inequalities in Békés county

Note: *** significant at the 0.01 level, ** significant at the 0.05 level, * significant at the 0.10 level.

Summary

In my dissertation I examined the regional income inequality processes of the county, which has become peripheral for 100 years, and is now peripheral in economic terms, too. The long-term development path of the county is greatly influenced by the historical factor, which is primarily related to the Trianon Treaty, this situation that socialist social-economic and territorial policies could not handle to a large extent.
In my study, I presented the intensity of the transformation in the county, i.e., how settlement incomes change between 1988 and 2017. Models explaining the temporal differentiation of the income situation of settlements point to the role of traditional territorial income inequality factors (for example settlement size, centre-periphery relations, border situation, path dependency, knowledge capital, economic structure, neighbourhood relations), but many historical features (weak urbanisation, lack of balanced urban-rural relationships) also appear as background factors.

Keywords: centre-periphery, Békés county, income inequalities, coefficient of variation

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Intensity of Income Transformation – Temporal Change of Territorial Income Inequalities in Békés County

Abstract
In my study, I presented the intensity of the transformation in Békés county, i.e., how settlement incomes change between 1988 and 2017. Models explaining the temporal differentiation of the income situation of settlements point to the role of traditional territorial income inequality factors (for example settlement size, centre-periphery relations, etc.), but many historical features also appear as background factors.

Keywords: centre-periphery, Békés county, income inequalities, coefficient of variation

EFFECT OF MULCHING ON AM COLONIZATION AND ON SOME QUALITY PARAMETERS OF BATAVIAN LETTUCE

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Introduction

Lettuce is one of the most widely consumed leaf vegetables. Low calorie content makes it even more popular. It is mainly consumed in salad mixtures. During cultivation mulching is often used to keep the crop clean. It can be artificial mulch (black foil) or natural mulch (alfalfa, straw). Beside keeping the crop clean, natural mulch has a positive effect on soil life, it increases the activity of soil-microorganism and symbiont fungi.

Mycorrhiza fungi is a symbiont fungus which inoculate the plant roots and contributes to the supply of nourishing water. Beside this, it also decreases the effect of stress factors such as drought or salt. Plant inoculation with arbuscular mycorrhiza (AM) can be a sustainable technique for the improvement of yield and plant resistance to biotic and abiotic stresses.

Herbicides, fungicides and insecticides are often used in conventional farming systems. These products can have a harmful effect on soil life. In our experiment, we would like to examine the effect of mulching on yield and some other parameters. And test whether there is mycorrhiza fungus in a conventional farming system and its effect on production.

Literature Review

Mycorrhiza colonization

Mycorrhiza fungi is a symbiont fungus which infects the plant roots and obtains photosynthetic products from the plant, and in return, contributes to the supply of nourishing water (Brundrett, 1991; Ishii, 2016). Beside this, it also decreases the effect of stress factors such as drought, salt or heavy metal (Hildebrandt et al., 2007; Andrade et al., 2009). In vegetable growing systems the most common mycorrhiza fungi is arbuscular mycorrhiza (AM).

The arbuscular mycorrhizal fungus is a member of the *Glomeromycota* division. It is a type of endomycorhizza which goes into the root cell. The name is derived to a characteristic structure which occur within the cortical cell. It is a tree-like structure which enlarge the nutrient uptake surface (Smith and Read, 2008). Plant inoculation with arbuscular mycorrhiza (AM) can be a sustainable technique for the improvement of yield and plant resistance to biotic and abiotic stresses (Gosling et al., 2006; Guillermo et al., 2009).

These symbiont fungi help the plant to absorb phosphorus, zinc, ammonium, nitrate, copper and potassium. In addition, the 90% of phosphorus and 20% of nitrogen could be provided by the AM fungus (Cavagnaro et al., 2015).

In recent years, more and more studies have been launched on various vegetables inoculated with mycorrhiza. Bakr et al. (2018) investigated biomass production, phosphate uptake, and various morphological parameters of tomato plants under

deficient irrigation and concluded that plants inoculated with mycorrhizal fungi responded better to drought stress and performed better than control plants in the absence of water.

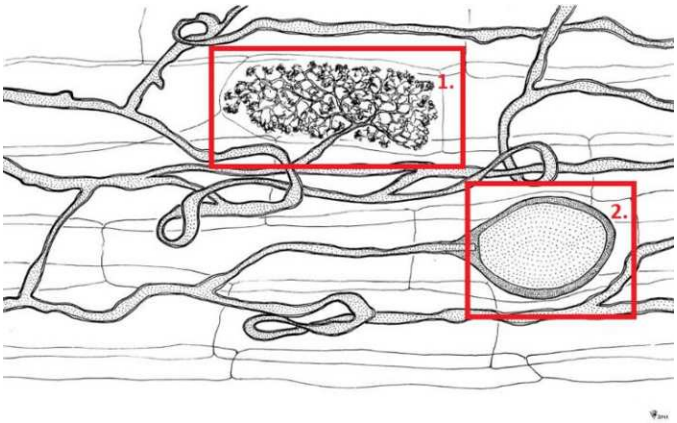

Figure 1. Formation of arbuscular mycorrhiza (1. arbuscule, 2. vesicule and hyphae) (web1)

Lettuce

Lettuce (*Lactuca sativa* L. var. *capitata* L.) is one of the most important leaf vegetables of the *Asteraceae* family. It has many varieties and it is available to consumers throughout the year due to different cultivation methods (Terbe, 1994).

Due to its very low-calorie content lettuce plays a major role in modern nutrition. High levels of unsaturated fatty acids and dietary fiber also reduce the risk of diabetes, cardiovascular diseases and colorectal cancer. In addition, salad contains significant amounts of sodium, potassium, calcium, zinc, vitamins E and C (Kim et al., 2016).

In organic farming lettuce can be grown throughout the year. The most suitable time for seedling: for spring and summer varieties from March to June, for autumn and winter varieties from August to November. Seedlings are planted at 3-5 leaves stadium for a 20-30 cm root and 30-50 cm row spacing (Radics, 2006).

Mulching

The benefits of mulching are the soil warms up much faster, has better nutrient and water management, has fewer weeds, has less chance of developing disease, keeps crops cleaner and has better light conditions due to the reflection of the mulch. Furthermore, the use of herbicides can be eliminated in addition to mulching, and the agrotechnical work could be reduced (less weed control, water supply) (Diver et al. 1999). In addition, according to Racskó (2004), less fertilizer is needed because of the increased activity of microorganisms.

Under black foil the mineralizing of organic residues nitrogen content is faster, but it can also inhibit soil life, which is very important in ecological farming (Runham, 1998).

The use of natural mulch in organic farming is almost essential. Organic mulch decomposes slowly, provides nutrients to the soil and increases its biological activity eg.: the increasing number of earthworms. Organic mulches can increase the physical,

chemical and biological values of soil. The effect of mulch depends on the thickness of the layer applied and on the origin of mulch material (Pannacci, 2017).

Materials and methods

Our experiment took place at the Soroksár Experimental and Research farm of Szent Istvan University in 2019. For the experiment, the lettuce seedlings were grown in one of the 50m^2 greenhouses at the Faculty of Horticulture at Szent Istvan University. We used 'Voltron' Batavia type lettuce from Rijk Zwaan. The seedlings were planted to their final place on 30 April in a (50+15)x20 cm space. One parcel was 200 cm long with 20 plants. An isolation area of 60 cm was left between the parcels. 3 repetition of each treatment were placed in the experimental area.

In the experiment, we applied a control, an alfalfa mulch, a rye straw mulch and a black foil covered treatment. Table 1. shows their abbreviations.

Abbreviations	Treatments
S1	Control
S2	Alfalfa mulch
S3	Rye straw mulch
S4	Black foil

Table 1. Treatments during the experiment and their abbreviations

During the experiment the irrigation was provided with dripping tubes and the lettuces received ammonium nitrate fertilizer twice.

In our experiment we would like to measure the effect of mulching on morphological and inner content parameters, and on mycorrhiza root colonization. And measure the interaction between AM colonization and morphological and inner content parameters.

Results

Head weight

The measured head weight values can be seen on Figure 2.

At 11th June there were no big differences between the measured head weights. The lowest head weight (47g) was measured on the S1, control treatment. The highest value (67g) was measured on S4, black foil covered treatment.

At 19th June the tendency was the same: the lowest measured value (74g) was in S1 treatment and the highest measured value (149g) was in S4.

At 26th June the lowest value was measured again at S1, control treatment. The highest value was measured at S4 treatment: 241g, but at this time S3 (rye straw mulch) treatment reached an average head weight of: 231g.

Due to one-way ANOVA of variance there were no significant difference between the treatments (p=0,89).

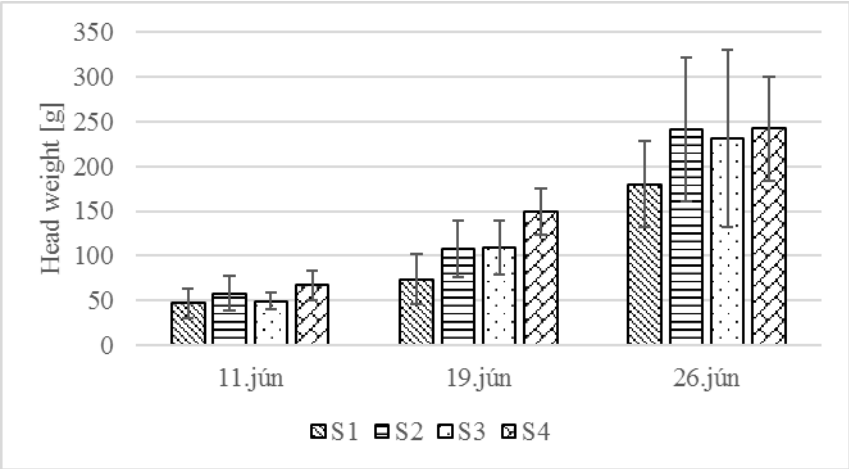

Figure 2. Effect of mulching on 'Voltron' batavian lettuce head weight

Phosphorus and AM colonization

The measured phosphorus values can be seen on Figure 3.

Every sampling time, the highest values were measured at S4 treatment, but there were no big differences at all.

Due to one-factor analysis of variance there were no significant difference between the treatments (p=0,58).

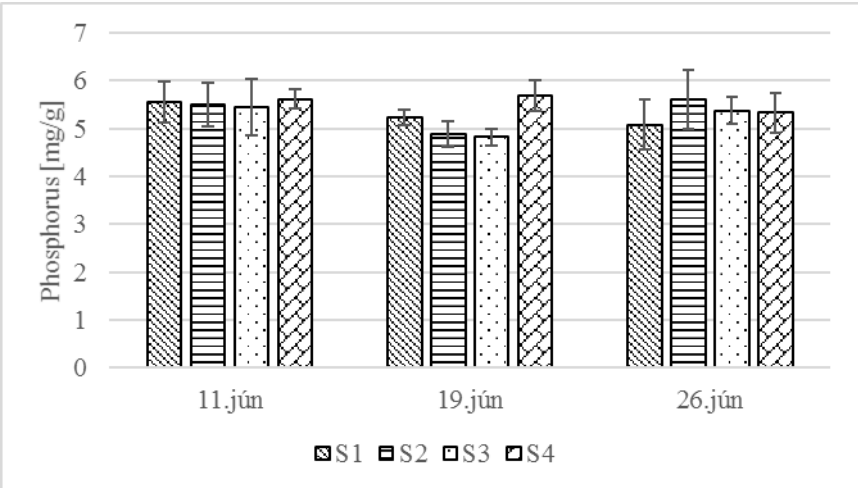

Figure 3: Effect of mulching on 'Voltron' batavian lettuce phosphorus content

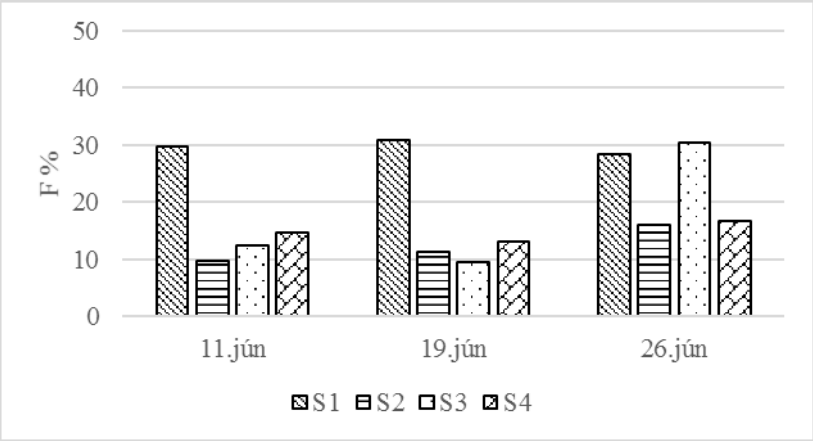

Figure 4: Effect of mulching on ’Voltron’ batavian lettuce root colonization

The measured mycorrhiza frequency (F%) in the root system can be seen on Figure 4.
At 11th June the mycorrhiza colonization was the highest at S1 treatment. The lowest was at S2 (alfalfa mulch) treatment.
At 19th June the highest F% was measured also at S1 treatment and there was a little increase in the values.
At 26th June there was a big increase in the S3 treatment root colonization, but the F% was also high at S1 treatment as well.
Due to one-factor analysis of variance there were significant difference between the treatments (p=0,03).

Discussion
There were no significant differences in head weight among treatments and there were no significant differences in the phosphorus content. It shows that, there is no effect of mulching and mycorrhiza on yield and inner content parameters.
However, it is worth mentioning, although our experiment took place in a conventional farming system, there were mycorrhiza colonization on roots. So, this type of farming system is also good for soil life beside using herbicides and fungicides.

Keywords: mycorrhiza, mycorrhizal symbiosis, AM fungi, inner content, lettuce

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web1: https://www.flickr.com/photos/werdnus_roo/6091498087

Effect of mulching on am colonization and on some quality parameters of batavian lettuce

Abstract

Salad is one of the most widely consumed leaf vegetables. Low calorie content makes it even more popular. It is mainly consumed in salad mixtures. During cultivation mulching is often used to keep the crop clean. It can be artificial mulch (black foil) or natural mulch (alfalfa, straw). Beside keeping the crop clean, natural mulch has a positive effect on soil life, it increases the activity of soil-microorganism and symbiont fungi.

Mycorrhiza fungi is a symbiont fungus which infects the plant roots and contributes to the supply of nourishing water. Plant inoculation with arbuscular mycorrhiza (AM) can be a sustainable technique for the improvement of yield and plant resistance to biotic and abiotic stresses.

In our experiment we would like to measure the effect of mulching on morphological and inner content parameters, and on mycorrhiza root colonization. And measure the interaction between AM colonization and morphological and inner content parameters.

The results show no significant differences in head weight and inner content among treatments. However, it is worth mentioning, there were mycorrhiza colonization on roots in a conventional farming system. So, this type of farming system is also good for soil life beside using herbicides and fungicides.

Keywords: mycorrhiza, mycorrhizal symbiosis, AM fungi, inner content, lettuce

WATER CONSUMPTION OF SORGHUM AT DIFFERENT LEVELS OF NUTRIENT SUPPLY

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Introduction

Sorghum is the fifth most popular grain in the world, with over 40 million hectares, according to 2017 FAO data. The amount of sorghum sown area in Hungary has been extremely fluctuating in the last decades. In 2018, this figure was close to 26,000 hectares. More than half of the sorghum crop in the world is present in the human diet, and therefore their importance is far from negligible. Sorghum is considered to be a drought-tolerant fodder plant and is therefore well suited for use in dry or seasonally drought-prone areas and in areas with poorer characteristics, even as an alternative to maize.

Literature Review

Sorghum is a monocotyledonous plant of the Poaceae family from Africa, characterized by outstanding drought and stress tolerance. It requires 30-50% less water to produce one unit of dry matter than corn, since it is characterized by reducing evaporation by selecting a wax coat in drought conditions. (www.euralis.hu). According to Vinall (1936), the origin of the sorghum is probable in the steppe and savannah areas of Africa and Ethiopia and Sudan. In Hungary, the breeding of sorghum was started in 1959 in Szarvas. The first variety was the Szarvasi Barna sorghum, whose certification was withdrawn in 1967 (Kapás, 1969). The low annual rainfall in the semi-arid zone, which does not exceed 300-350 mm for the sorghum, has adapted well to this environment (Zhang et al., 2010). Since sorghum is not demanding on the soil, it can be one of the plants in disadvantaged areas. (Gyökér, 1978; Siklósné, 2001; Goshadrou et al., 2011). Sorghum can be grown as a second crop, but seed and seed production can only be safely done in the main crop (Antal et al., 1966).

According to researchers, sorghum has the same nutrient requirements as maize and the same nutrient delivery time. (Ross and Dungan, 1957) In his book Bocz (1992), he stated the following levels of fertilizer for sorghum grain:

- Specific Nutrient Requirements: N 29-36; P_2O_5 13-17; K_2O 30-36 kg t^{-1}
- 3.5-5 t ha-1 average yield on weaker soil: N 116-165; P_2O_5 53-75; K_2O 116-165 kg ha^{-1} fertilizer application rate required

According to Buzás (1983), the following specific nutrient requirements should be considered: N, 29; P_2O_5 10; K_2O 31 kg t^{-1}.

The sorghum takes up about 45% of the phosphorus and nitrogen by the end of flowering (Lásztity 1995), the most intensive incorporation of these nutrients can be observed during the period of eye formation and ripening. Other nutrient uptake dynamics are reported by Roy and Wright (1974) according to which nearly 60% of N

and P are taken up by sorghum after flowering. Both corn and rice have higher uptake of nitrogen, potassium and phosphorus in longer sorghum hybrids (Han et al., 2011) Bokori and Kovács (1996) point out that high doses of N-fertilizer can increase the nitrate content of a plant to an extent that may be toxic.

Methods

The experiment investigated the effects of three nutrients N, P and K, where the nutrients were applied in four ascending steps.

Nutrient level	N	P	K
1	0	0	0
2	80	60	60
3	120	90	120
4	160	120	180

Table:1 Levels of nutrient treatments kg ha^{-1} (Source: Author 's own editing)

The size of the experimental plots is 5m x 8m. The 5 m plot width allows for 6 rows spaced at 76 cm row spacing. Seeding was performed using a field pneumatic seed drill throughout the experimental area, from which paths were ground after emergence to form plots. The seed spacing was determined at 5.3 cm, which means approximately 250,000 germs / ha. 2 of the 6 rows can be considered as a border, avoiding any overlap of fertilizer between plots. The samples needed for the tests, which were "destroyed", were taken from rows 2 and 5, while harvesting and other measurements were made in the two middle rows. Harvesting was done by mechanical power with the aid of a plow. According to previous section excavations and soil studies, the soil of the experimental area is deep-carbonated chernozem meadow soil. According to the soil tests, the physical quality of the soil is clayey loam, its acidity is acidic, the cultivated layer does not contain CaCO3, based on the humus content the soil has moderate N-supply, P-supply, K-supply, Zn- from Cu and Mn.

pH (KCl)	K_A	$CaCO_3$	Humus (%)	AL-P_2O_5 $mgkg^{-1}$	AL-K_2O $mgkg^{-1}$	Mg (KCl) $mgkg^{-1}$	EDTA-Zn $mgkg^{-1}$	EDTA-Cu $mgkg^{-1}$	EDTA-Mn $mgkg^{-1}$
4,95	44,6	0,0	2,89	216	260	687	3,26	7,35	428

Table 2. Characteristics of the soil experiment (Szarvas, 0-30 cm soil layer) Source: Author 's own editing

The data in Table 3. present the weather data for the year 2019 for the growing year. For the entire growing year, precipitation fell close to the annual average, but the data show that we had been struggling for several months at the beginning of the year compared to the 30-year average. Then, at the time of sowing and the subsequent early stages of development, the plant had sufficient water. During the dry summer months, we replaced the missing water by irrigation. We watered it twice. In both cases, 25mm irrigation water was applied.

Month (1)	jan.	febr.	march.	apr.	may.	jun.	jul.	aug.	sept.	okt.	sum / average
Temperature (°C)	-0,2	5,0	9,3	13,9	16,2	24,3	22,9	24,1	19,3	12,9	14,9
Rain (mm)	35	9	3	48	103	105	72	27	51	19,4	472,4
Mean of rainfall of 30 years (mm)	30,6	31,4	28,9	41,9	62,9	71,4	74,4	56,4	42,8	36,6	477,3
Difference (mm)	**4,4**	**-22,4**	**-25,9**	**6,1**	**40,1**	**33,6**	**-2,4**	**-29,4**	**8,2**	**-17,2**	**-4,9**

Table 3. Data of weather between jan. of 2019. and sept. of 2019. Szarvas ,Source: Author 's own editing

The hybrid sorghum we chose was Euralis-bred Albanus, whose general characteristics are summarized below by the breeder
- The white color of the fruit is sought after in the special target markets
- Above average adaptability
- Average height plant, strong stem, easy to harvest
-It doesn't tend to tip
- Above average Fusarium tolerance
- He doesn't tend to bounce
(www.euralis.hu)
For measuring the chlorophyll content of sorghum leaves, a portable Minolta SPAD photosynthetic pigment content meter was used.

Results

The yields at different nutrient levels after harvest are shown in Figure 1. It can be seen that yields increase only to a certain level with increasing nutrient supply. Then, at the highest saturation level, yield reduction can be realized.

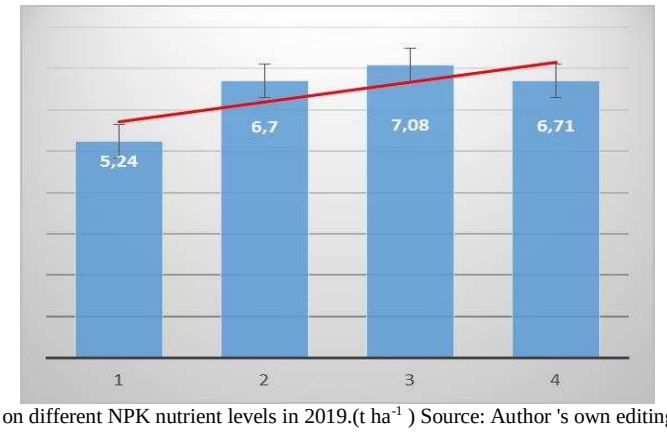

Figure 1. Yield on different NPK nutrient levels in 2019.(t ha^{-1}) Source: Author 's own editing

By analyzing the variance analysis of the yield results measured at nutrient levels, we monitored whether the change occurring reaches the level of significant difference. The variance values are shown in *Table 4*.

Dependent Variable: Yield

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	7,885[a]	3	2,628	108,064	,000
Intercept	662,419	1	662,419	27234,353	,000
Nutrient levels	7,885	3	2,628	108,064	**,000**
Error	,292	12	,024		
Total	670,596	16			
Corrected Total	8,177	15			

a. R Squared = ,964 (Adjusted R Squared = ,955)

Table:4 Table of variance analysis of yield 2019. Source: Author 's own editing

In order to confirm further correlations, we also performed Pearson correlation analysis of the factors. The analysis similarly confirmed the effect of nutrient levels, with significant differences in each case. The analysis shows a strong correlation.

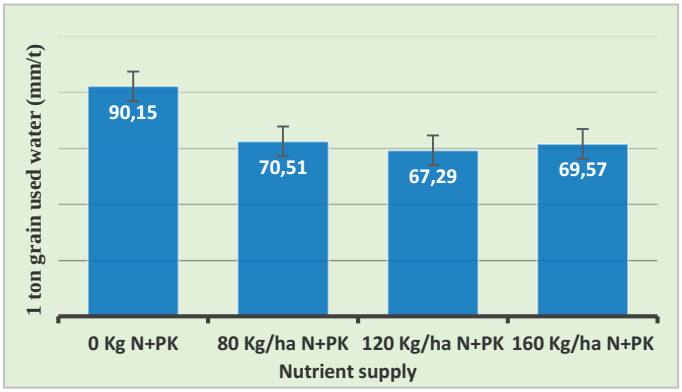

Figure 2. Water use of sorghum in different nutrient supply 2019.(mm t^{-1}) Source: Author 's own editing

In 2019, we examined the water use of sorghum *Figure 2*. Without nutrients, sorghum water consumption was the worst. The amount of water used to produce one tonne of grain has decreased with improved nutrient supply. The most favorable water consumption was at 120 Kg ha^{-1} N + PK level (67,29 mm t^{-1}). Improved nutrient supply resulted in better water utilization for sorghum in 2019. There was a significant difference between the plots without nutrients and those with nutrients in water use.

Conclusions

The results of the experiment clearly show that adequate nutrient supply is an important cornerstone for the cultivation of sorghum. There was a significant difference between nutrient levels in terms of yield and SPAD values. However, both crop yields and the closely related leaf chlorophyll content data showed that under these climatic and soil conditions, the results were adversely affected by over-nutrition. In practice, the highest nutrient levels in both yield and SPAD could barely outperform those of the control plots. Among the nutrient combinations, the most significant positive effect was measured in the case of the 3rd treatment, while the effects of the highest nutrient levels were smaller. In the experiment yields varied between 4.9 t ha-1 and 7.11 t ha^{-1}. The most favorable water consumption was at 120 Kg ha^{-1} N + PK level (67,29 mm t^{-1}). Improved nutrient supply resulted in better water utilization for sorghum in 2019. There was a significant difference between the plots without nutrients and those with nutrients in water use.

Summary

Sorghum is the fifth most popular grain in the world, with over 40 million hectares, according to 2017 FAO data. The amount of sorghum sown area in Hungary has been extremely fluctuating in the last decades. In 2018, this figure was close to 26,000 hectares. More than half of the sorghum crop in the world is present in the human diet, and therefore their importance is far from negligible. Sorghum is considered to be a drought-tolerant fodder plant and is therefore well suited for use in dry or seasonally drought-prone areas and in areas with poorer characteristics, even as an alternative to maize.

In our research, we investigated the nutrient response of white grain sorghum at four nutrient supply levels in a small-plot randomized experiment in Szarvas, Hungary, at the Galambos experimental area of the Szent István University, Faculty of Agriculture and Economics. In our research, we explore the plant physiological, plant physiological and technological relationships that can serve as the basis for modern nutrient management and provide the scientific basis for the efficient development of sorghum production. The soil of the experiment is deep carbonated Chernozem meadow soil, its physical nature: clayey loam, with acidic and slightly acidic pH, its water management is characterized by poor conductivity and high water retention.

The experiment investigates the effects of the 4 nutrient combinations. There were four nutrient treatments, four nitrogen levels (0kg ha-1, 80kg ha-1, 120kg ha-1,160kg ha-1), four phosphorus (0kg ha-1,60kg ha-1, 90kg ha-1, 120kg ha-1) and four potassium levels (0kg ha-1,60kg ha-1,120kg ha-1, 180kg ha-1) was set. In our experiment in 2019, we investigated how water use and utilization of sorghum change at different nutrient levels. In our experiment we found that with the improvement of nutrient supply compared to the control average yield (5.24 t ha-1) the yield average increased to 120 Kg ha-1 (7.02 t ha-1), while the 160 Kg ha-1 N + PK yielded yield depression (6.79 t ha-1). The increase in yield averages resulted in improved water utilization in the experiment. 1 tonne of grain, sorghum used 90.15 mm of water under control

conditions. The best water consumption was obtained with 120 Kg ha-1 + PK nutrient supply with 67.29 mm t-1.

Keywords: sorghum, nutrient supply relative chlorophyll content, yields

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"This publication is created in number EFOP-3.6.1-16-2016-00016 The specialise of the SZIE Campus of Szarvas research and training profile with intelligent specialization in the themes of water management, hydroculture, precision mechanical engineering, alternative crop production"

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ANALYSING THE IMPACTS OF WATERLOGGED AREAS ON BIODIVERSITY BY USING GIS TOOLS

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Introduction

European areas utilised by agriculture have gone under considerable changes in the past four decades due to the expansion and intensification of agriculture. Beside constant increase of parcel size, fragmentation, vanishing of semi-natural and field margin habitats and the excessive use of chemicals water regulation and melioration have also contributed to the overall fragmentation and degradation of semi-natural areas as well as to the decrease of number and range regarding numerous species related to agricultural areas (Horváth – Szitár 2007). Following the EU accession the tension has remained that was inflicted by the continued intensification experienced in agriculture. This trend is indicated, among others, by the decline of bird populations connected to agricultural areas (Mihok et al. 2017). Since two-third of Hungary's territory is under agricultural utilisation, preserving the biodiversity is highly dependent on processes and activities implemented in agriculture. Furthermore, biological diversity plays a vital part in maintaining the health of ecosystems, therefore it is indispensable for the sustainable growth of food production (Keresztes 2019).

Several methods have been elaborated for the examination of biodiversity. One of them is based on the observation of bird populations. Biodiversity indicator indices developed by the population trends of bird species related to a given habitat can correctly describe the actual state of those habitats (Szép et al. 2012). Since 1999 BirdLife Hungary has been regularly examining changes in the populations of 16 bird species connected to agriculturally utilised areas (Farmland Bird Indicator – FBI). In our EFOP research we examine the connection between the surplus water appearing in agricultural areas (waterlogging) and bird species associated with Hungarian agricultural areas. In this article we give an account on the current state of the research.

Methods

Our hypothesis declares that there is a correlation between the increased prevalence and spatial extent of certain waterlogged areas and the presence and number of given agriculture-related bird species. On the one hand, these temporary waterlogged areas appearing late winter and early spring can hinder the breeding activities of some ground-nesting species. On the other hand, they represent a new and semi-natural habitat that may increase the biodiversity of the involved areas. Thus, we examine the database completed by the Institute of Geodesy, Cartography and Remote Sensing (FÖMI) about the frequency of waterlogging (between 1998 and 2016) as well as the results of Monitoring of Common Birds survey as regards of our sample area, i.e. the Körös-Maros köze meso-region.

The Monitoring of Common Birds database and its procession

In 1998 Monitoring Centre of BirdLife Hungary has commenced a new survey programme in order to monitor long-term changes occurring in the population of frequent and well-known resident birds. Randomly determined UTM squares of 2.5 by 2.5 km provide the basis for the survey. Within these sampling squares surveyors select 15 observation points out of the total of 25. During the field work in each observation point they spend five minutes and take notes about the seen and heard bird species within a circle with a radius of 100 metres. The name and number of birds have to be recorded categorised by the distance of 0 to 50 m, 50 to 100 m and over 100 m. Birds shall be counted twice a year. The first occasion must fall between 15 April and 10 May, while the second one between 11 May and 10 June (BirdLife Hungary Monitoring Centre 2011).

27 UTM squares were selected in which surveys have been completed since the beginning of the programme. Considering that not all squares are used in every year, we chose a year (i.e. 2012) in which surveys were made involving the most places (7 UTM squares and 105 observation points).

The database summarising all field data includes all of the observed bird species. However, in our current examination we look for the connection between the surface cover of a well-distinguished, small agricultural area and the birds selecting this area as their spring habitat. Therefore, we narrowed down the available field data. We only use the data regarding the distance categories of 0 to 100 m. We also selected those birds (9 species) out of those connected to agricultural areas (16 species) that cover smaller range during the breeding period. By this selection sample areas can clearly show their habitat preferences (Table 1).

Scientific name	HURING code	Hungarian name	Short-term agricultural species	Nesting type
Alauda arvensis	ALAARV	Mezei pacsirta	x	ground-nesting
Anthus campestris	ANTCAM	Parlagi pityer	x	ground-nesting
Coturnix coturnix	COTCOT	Fürj		
Emberiza calandra	MILCAL	Sordély		
Falco tinnunculus	FALTIN	Vörös vércse		
Galerida cristata	GALCRI	Búbospacsirta	x	ground-nesting
Lanius collurio	LANCOL	Tövisszúró gébics	x	bush-nesting
Lanius minor	LANMIN	Kis őrgébics	x	tree-nesting
Locustella naevia	LOCNAE	Réti tücsökmadár	x	ground-nesting
Merops apiaster	MERAPI	Gyurgyalag		
Motacilla flava	MOTFLA	Sárga billegető	x	ground-nesting
Predix prexid	PERPER	Fogoly		

Sturnus vulgaris	STUVUL	Seregély		
Sylvia communis	SYLCOM	Mezei poszáta	x	bush-nesting
Sylvia nisoria	SYLNIS	Karvalyposzáta	x	bush-nesting
Vanellus vanellus	VANVAN	Bíbic		

Table 1: Bird species connected to agricultural areas and included in the examination

The database of relative waterlogging frequency and its procession

The map of relative waterlogging frequency necessary for our examination was provided by the Remote Sensing Department of Lechner Nonprofit Kft. Geometric and radiometric resolutions of satellite images taken between 12/05/1998 and 04/03/2016 and used for the creation of the map are very diverse and their distribution over time is also uneven. Eventually, a 10 m raster was created out of the data line of 19 years. During the completion of the aggregated map the category of "soil slightly saturated by logged water" has not been defined, because the reliability of this category was insufficient. By "waterlogging hazard" this database defines the random variable that indicates, in a statistically interpretable form, the likelihood of the occurrence regarding the examined hydrological extremity in a given area (e.g. in a map cell). In this sense, waterlogging hazard is a probability value given in percent. It is also important to mention that the relative waterlogging frequency map has only been created for areas considered eligible for support in LPIS. Other areas were masked by using the LPIS 2013 database. Therefore, we eliminate those points (altogether 22) where non-eligible areas represent more that 25% of the observation area (circle with a radius of 100 m) – meaning that no data is available about the waterlogging frequency.

Results

Table 2 includes the geographic location of the selected 7 UTM squares and the 83 observation point as well as the number and extension of observation points included in our examination. It can be seen that the highest number of observation points were eliminated around Újkígyós and Öcsöd (due to the fact that more than 25% of the area was non-eligible) Total size of the areas included in the examination is 1041.9 ha.

Settlement	**UTM**	**Number of observation points included in the examination (pcs)**	**Area of observation points included in the examination (ha)**	**Area not affected by waterlogging (ha)**	**Area not affected by waterlogging (%)**
Kunszentmárton	DS49B4	14	175.6	87.4	49.8
Öcsöd	DS49D4	7	87.8	53.0	60.4
Szarvas	DS68D1	15	188.4	75.0	39.8
Mezőtúr	DS79A3	10	125.5	47.5	37.8
Csárdaszállás	DS98C1	15	188.2	36.6	19.4
Köröstarcsa	DS99D3	14	175.8	21.2	12.1

Újkígyós	ES05A1	8	100.6	88.7	88.2
Total		83	1041.9	409.6	39.3

Table 2: Geographical location and main characteristics of UTM squares involved in the examination

* Area defined by Article 32 (2) to (6) of Regulation (EU) No 1307/2013 of the European Parliament and of the Council of 17 December 2013 establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy and repealing Council Regulation (EC) No 637/2008 and Council Regulation (EC) No 73/2009

The selected units are mainly areas under agricultural utilisation and eligible for support within the framework of the Common Agricultural Policy. Arable crop production and grasslands dominate these areas. An average of 40% of the observation areas are not affected by waterlogging. Areas in Újkígyós (0.4%) and Öcsöd (32.7%) are the least affected, while in Köröstarcsa (86.9%) and Csárdaszállás (79.2%) have the most waterlogged areas. By examining the extension of relative waterlogging frequency (%) categories it can be said that almost 82% of the areas determined as waterlogged belong to the low probability (10 to 40%) category. High probability (70 to 100%) was detected in 1.3% of the total area, primarily around Csárdaszállás and Köröstarcsa (Table 3).

Settlement	**Number of observation points (pcs)**	**Area not affected by waterlogging (ha)**	**Area affected by waterlogging (ha)**	**Relative waterlogging frequency (%) area (ha)**								
				10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-
Kunszentmárton	14	87.4	70.0	41.6	16.2	8.3	3.4	0.0	0.3	0.2	0.0	0,0
Öcsöd	7	53.0	25.8	20.5	3.8	0.5	1.0	0.0	0.0	0.0	0.0	0,0
Szarvas	15	75.0	102.1	43.7	17.7	16.0	18.8	0.2	4.6	1.1	0.0	0,0
Mezőtúr	10	47.5	66.2	29.4	19.4	9.6	5.6	0.1	1.5	0.4	0.2	0,0
Csárdaszállás	15	36.6	139.7	44.6	49.3	22.0	14.5	3.1	2.7	2.8	0.7	0,0
Köröstarcsa	14	21.2	140.1	36.2	33.6	30.6	28.8	0.2	9.2	1.3	0.0	0,2
Újkígyós	8	88.8	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0,0
Total	83	409.5	544.3	216.4	140.0	87.0	72.1	3.6	18.3	5.8	0.9	0,2
Share (%)			100	39.8	25.7	16.0	13.2	0.7	3.4	1.1	0.2	0,0

Table 3: Geographical distribution of relative waterlogging frequency (%) categories regarding the observation points included in the examination (ha)

In 2012, between 15 April and 14 June altogether 77 bird species were observed in the 100 m zone of the 83 observation points. Outstanding results were recorded around Köröstarcsa, Kunszentmárton and Öcsöd with 32, 31 and 31 species, respectively. The least amount of species were observed around Csárdaszállás (17) and Újkígyós (18) (see Table 4). As for the short-term agricultural species, 7 out of the 9 were identified in the examination period, with the exemption of tawny pipit and barred warbler. Eurasian skylarks (in 55 points) and Western yellow wagtails (in 32 points) were seen the most, while common grasshopper warbler was seen only in one observation point. However,

in case we apportion the observation data to the number of observation points, Öcsöd stands as the most diverse area (with 4.42 species per observation point). Csárdaszállás proved to be the least diverse settlement (1.13 species per observation point). When taking the same comparison with the agriculturally important species, Öcsöd remains the most diverse (0.43 species per observation point), but the least diverse area is Újkígyós (0.12 species per observation point).

Settlement	**Kuszentmárton**	**Öcsöd**	**Szarvas**	**Mezőtúr**	**Csárdaszállás**	**Köröstarcsa**	**Újkígyós**	**Total**
UTM	DS49B4	DS49D4	DS68D1	DS79A3	DS98C1	DS99D3	ES05A1	
Number of observation points (pcs)	14	7	15	10	15	14	8	83
Number of observed species (pcs)	31	31	18	23	17	32	18	77
Number of observed short-time agricultural species (pcs)	3	3	3	3	5	3	1	7
Average species number of observation points (pcs)	2.21	4.42	1.20	2.30	1.13	2.28	2.25	0.92
Average number of agricultural species in observation points (pcs)	0.21	0.43	0.20	0.30	0.33	0.21	0.12	0.08
ALAARV	1	1	1	1	1	1	0	6
ANTCAM	0	0	0	0	0	0	0	0
GALCRI	0	1	0	0	0	0	1	2
LANCOL	1	1	1	1	1	1	0	6
LANMIN	0	0	0	0	1	0	0	1
LOCNAE	0	0	0	0	1	0	0	1
MOTFLA	0	0	1	1	1	1	0	4
SYLCOM	1	0	0	0	0	0	0	1
SYLNIS	0	0	0	0	0	0	0	0

Table 4: Bird data of the 83 observation points included in the examination (Monitoring of Common Birds, 15 April 2012 – 14 June 2012)

When comparing the proportion of waterlogging in the area of the observation points and the number of agricultural species observed in those points it can be concluded that parallel to the increase of waterlogged areas the number of agricultural species shows an increment as well. Considerable growth can be detected in case of western yellow wagtail: its observation number increased eight-fold between areas slightly (0 to 25%) and strongly (75 to 100%) affected by waterlogging.

Proportion of area affected by waterlogging (%)	**Number of observation points (pcs)**	**Number of events regarding observed agricultural species (db)**	**Average observation event (pcs/observation point)**	**Average Eurasian skylarks observation event (pcs/observation point)**	**Average western yellow wagtail observation event (pcs/observation point)**
0-25	14	6	0.43	0.29	0.07
25-50	19	23	1.21	0.84	0.32
50-75	16	17	1.06	0.56	0.38
75-100	34	45	1.32	0.76	0.56

Table 5: Connection between the proportion of waterlogging and the number of observed species (Monitoring of Common Birds, 15 April 2012 – 14 June 2012)

Main findings

As for the current stage of our research no clear interconnectedness can be identified between the relative waterlogging frequency values of the observation points and the presence of short-term agricultural bird species nesting either on the ground or in bushes/trees. The year examined by us, 2012, was relatively free of logged water. Between 1936 and 2013 there were only 15 years when the largest concurrent waterlogging did not exceed 10,000 hectares. 2012 belonged to that 15 years. However, a slight positive correlation can be seen between the increase of waterlogged areas and the appearance of certain ground-nesting bird species. This seemingly controversial connection can be attributed to both the cancelled or postponed agricultural activities and the formation of a more diverse habitat.

In the next phase of the research we plan to connect, at species level, waterlogging frequency and the appearance of certain species.

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Analysing the impacts of waterlogged areas on biodiversity by using GIS tools

Abstract

The expansion and intensification of agriculture has contributed to the large-scale fragmentation and degradation of semi-natural habitats, thereby reducing biodiversity. As two thirds of Hungary is under agricultural cultivation, the preservation of biodiversity is highly dependent on the processes and activities taking place in the agricultural lands. Many methods have now been developed to study biodiversity, for example, indices based on the population trends of bird species associated with habitats. It provides a good indication of the condition of the given habitats. In our study, we investigate the relationship between inland excess water appearing in agricultural habitats and bird species associated with agricultural habitats.

Keywords: biodiversity, agriculture, waterlogging, Monitoring of Common Birds

PROMOTION OF ORGANIC FARMING THROUGH TRAINING AND INFORMATION SHARING FOR SAFE NUTRITION AND POVERTY ALLEVIATION: CASE STUDY GEZIRA STATE OF SUDAN

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Introduction

The initial high yields experienced under conventional farming are usually accompanied by adverse side effects sooner or later. The negative environmental impacts associated with increasing industrialization of agricultural production and the belief that agricultural problems can be solved by the appropriate use of machines and chemicals has accelerated the development of alternative farming methods (David ,1995; Njoroge, 2000). The negative side effects include: reduced soil fertility, water pollution and destruction of natural habitat. Lampkin (1994) notes that, developing countries are usually entangled in environmentally unstable production systems which are manifested in severe environmental damage and declining agriculture base making it even more difficult for real development to take place.

Organic farming refers to the increasing use of farming practices and technologies that maintain and increase farm productivity and profitability while ensuring the provision of food on a sustainable basis, reduce negative externalities and gradually lead to positive ones and rebuild ecological resources (soil, water, air and biodiversity) by reducing pollution and using resources more efficiently (UNEP, 2011). Interest in organic farming and its products has widely grown in the world mainly because of the increasing environmental and health hazards associated with the intensive use of chemicals in agriculture.

Sudan, in spite of its high potential of organic farming production along the shores of the Nile, rivers and the seasonal streams has not been able to widely invest in organic production. Over the last years, the paradigm of organic agriculture as a sustainable mode of production has strongly grown among the Sudanese community. Furthermore, the importance of this type of production is progressively increasing amongst researchers as well as policy makers as a good sign for a healthy thinking lead to take serious steps toward organic production in all the states of Sudan (Alkhalifa, Batoul et al 2014).

Organic farming requires asking specific questions such as ‘how has this particular pest or disease become a problem?’, then searching for the answers. It requires an understanding of farms as entire systems and farmers as capable experimenters and innovators with a wealth of knowledge and experience (Von der Weid, 2007). It has a role to play in climate change adaptation, including avoided damage and many farming practices contribute to both processes and provides management practices that can help farmers adapt to climate change through strengthening agro-ecosystems, diversifying

crop and livestock production and building farmers' knowledge base to best prevent and confront changes in climate (FAO, 2004).

Adapt to climate change is one of the main challenges facing the future of agriculture even if strong and effective mitigation measures were taken, even if greenhouse gas emissions dropped to zero immediately, the climate would continue to change for decades (IPCC, 2001). OA offers adaptation options that allow farmers to use on-farm resources to build resilience, rather than rely on expensive external inputs.

According to Gbetibouo (2009) suggested that smallholder farmers can adapt to climate change by changing planting dates and diversifying crops. This can be possible if government provides them with the necessary support. Smallholder farmers can also adapt to climate change by practicing soil and water conservation measures and planting trees (Yesuf et al., 2008).

Traditional farming is the dominant form of agricultural production in Sudan. In the rain-fed sector no agrochemicals or organic fertilizers are used. Flood irrigated areas like Toker, Gash and others are strongly recommended as organic farming areas. The large agricultural irrigated schemes use chemical fertilizers and pesticides with crop rotation but they are still suboptimal, Mukhtar et.al, (2001). Continuous monoculture of sorghum, and or sesame has depleted thousands of hectares and subjected them to noxious and parasitic weeds.

The farmers in Sudan (Gezira) have a considerable period practiced mono-cropping and chemical fertilizer those doing any other kind of farming are poorly equipped and use non sustainable practices responsible for loss of soil fertility, environmental degradation, unsafe and food insecurity. Promotion of organic farming is not an easy option for farmers and it carries with it several barriers (Lampkin 1990, Harriset al. 1998).

The objectives in this study was to bring awareness on the dangers of conventional farming based on synthetic external inputs and to train interested farmers groups on organic farming techniques and practices in order to reclaim the ecological status of the project area and achieve sustainability in food production.

Material and Methods

The study was conducted in selected villages in Gezira district of Sudan, (Fig.1) which is located in central clay plain of Sudan boundary by latitude 1597000 N and 557000 N longitude 1573000 E and 557000 E (Zone 36 N,UTM). Organic farming promotion was developed to gain the necessary data during the period of fieldwork (Questionnaire with 30 farmers). Base line survey questionnaire was developed matching with the study objectives with collection of relevant data. The collected data was mainly derived from the targeted farmers of the study that in addition of interview with researchers that was conducted to develop comparison between conventional and organic farming.

To adopt organic agriculture practices and supportive policy and financial institutions are needed. Again agricultural activities with farming practices skills and technologies that promote organic agriculture all are important. The data from the survey inserted in to computer data base and finally data was analyzed with SPSS v 20 software. Finally discussion with farmers in farmer's schools through manuals of organic farming techniques and practices was implemented.

Results and discussion

Aware on the dangers of conventional farming

The study was aimed to aware the farmers about the organic farming in improving and maintain soil fertility. The results of the study as shown in Table 1 indicate that due to organic farming promotion 53.3% of the farmers' responding that they know about organic farming and 46.7% don't know. The Majority (70%) of them aware about the risk of conventional farming. Furthermore, 63.3% farmers under the study area are thinking in practices organic farming to reduce the uncertainty of conventional farming and this means that organic farmers think positively on the effects of their farming practices on the soil productivity.

Farmers respondent to their knowledge of organic farming			
		Frequency	**Percent**
	They know	16	53.3
	Don't know	14	46.7
		30	100.0
Awareness of risk of conventional farming			
	They aware	21	70.0
	Don't aware	9	30.0
		30	100.0
Thinking in practices to reduce the conventional farming			
	They think	19	63.3
	Don't think	11	36.7
		30	100.0

Table.1 Awareness of organic farming Source: field work

Organic fertilizer versus chemical fertilizer

The results of Table 2 identified that 26.7% of the farmers use green manure 10% of them use compost and 63.3% use chemical fertilizers in the study area. Almost 33.3% of the farmers are telling positive response of organic fertilizers on yield crops in the study area, 20% of them agreed that organic fertilizers are improving soil fertility and 83.3% reported improvement of productivity as response to organic fertilization in the study area. That means farmers in the study area are aware of advantage of organic fertilization. Chemical fertilizers can negatively affect soils and ecosystems if used incorrectly and use of organic fertilizers ensures that the food items produced are free of harmful chemicals.

Use of Fertilizers				
	Type of fertilizers	**Frequency**	**Percent**	**Valid Percent**
	Green manure	8	26.7	26.7
	Compost	3	10.0	10.0
	Chemical fertilizers	19	63.3	63.3

		30	100.0	100.0
Response of crops yield to organic fertilizers				
	There is	10	33.3	33.3
	There isn't	20	66.7	66.7
		30	100.0	100
Improvement of soil fertility				
	There is	6	20.0	20.0
	There isn't	24	80.0	80.0
		30	100.0	100.0
Improvement of productivity				
	Yes	25	83.3	83.3
	No	5	16.7	16.7
		30	100.0	100.0

Table 2 Use of organic fertilization versus chemical fertilization Source: field work

Household farming in the study area:

Results in Table 3 indicate that although farmers in the study area are practicing organic farming however they don't practice household farming 33.3% only of the farmers are practicing household farming and 13.3% of them used organic fertilizers in their house and 10% of the farmers use UREA in the study area. That means there is a real need to know more about the important of household farming. When farmers have access to a broad range of productive resources and use of organic systems, they may be able to increase total yields, diversify their crops and improve their household incomes while ensuring the long-term sustainability of essential resources like soils and water that they use.

Practicing			
		Frequency	**Percent**
	Yes	10	33.3
	No	20	66.7
		30	100.0
Type of fertilization			
	Organic fertilizer	4	13.3
	Urea	3	10.0
		7	23.3

Table 3 Status of household farming in the study area:Source: field work

Climate change on organic farming

The data in Table 4 clearly show that majority (76.7%) of the farmers recognize impact of climate change in their farms, 50% of them facing environment problems and 90% they know that organic farming improves environment. According to Gbetibouo (2009) suggested that smallholder farmers can adapt to climate change by changing planting dates and diversifying crops. Changing weather has always concerned by farmers and they have developed ways to respond. Farmers in in the study area need tools to help them to adapt to these new conditions and they may need to include more inputs to adapt to climate change such as synthetic fertilizers, pesticides capital investments in irrigation and greenhouses to help their crops to survive.

		Frequency	Percentage
Direct impact			
	Yes	**23**	**76.7**
	No	**7**	**23.3**
		30	**100.0**
Environment degradation			
	Yes	**15**	**50.0**
	No	**15**	**50.0**
		30	**100.0**
Positive effect on environment			
	Yes	**27**	**90.0**
	No	**3**	**10.0**
		30	**100.0**

Table 4 Impact of climate change on organic farming Source: field work

Farmers knowledge of crop management with using organic farming

Results in Table 5 identified that among the respondent farmers 36.7% of them using crop rotation, 13.3% using inter cropping, 3.3% reducing chemical, 6.7% using fallowing and 40% of them using crop rotation, reducing chemical use and fallowing these practices are reducing soil erosion and improve soil fertility. 33.3% of the farmers said that organic farming is productive and costs effective, 30% of them said it is improving soil fertility 10% of them said it is useful and healthy and 26.7% of the farmers don't know about organic farming advantages. Based on the results noticed that most of the farmers have knowledge about practices and advantages of organic farming.

The practices and operations		
	No. of farmers	**Percentage**
Using crop rotation only	**11**	**36.7**
Inter cropping only	**4**	**13.3**
Reducing chemical use only	**1**	**3.3**
Fallowing only	**2**	**6.7**
Using crop rotation, reducing chemical use and fallowing	**12**	**40.0**
Total	**30**	**100.0**
Knowing of organic farming advantages		
Productive and costs effective	**10**	**33.3**
Increase soil fertility	**9**	**30.0**
Useful and healthy	**3**	**10.0**
Nothing	**8**	**26.7**
Total	**30**	**100.0**

Table 5 Status of farmers knowledge of crop management with using organic farming Source: field work

Conclusion

Based on the result analysis in the study area found that most of the farmers adopt organic farming practices and climate change in the study area and they are aware of organic farming which maintain and improve soil fertility and increase productivity (70%) of them aware to the risk of conventional farming so that will help to achieve sustainability in food production. Although there is a little information available related to organic farming in the study area, it looks the need of more awareness and encouraging farmers to practice organic farming and reduce the conventional farming is important. From the interview all the researchers agreed support and need to organic farming in Sudan because its importance in improving soil fertility and producing healthy food and on the other hand support to the exports and national income. Support is required from donors, non-governmental organization, private investors and develop appropriate policy and farming communities in joining efforts to support organic farming. Support is need in terms of training and experience sharing program given to the local farmers on use of mixed cropping practices for up scaling and creation of incentives for organic farming and promoting organic farming techniques through agricultural research and extension systems.

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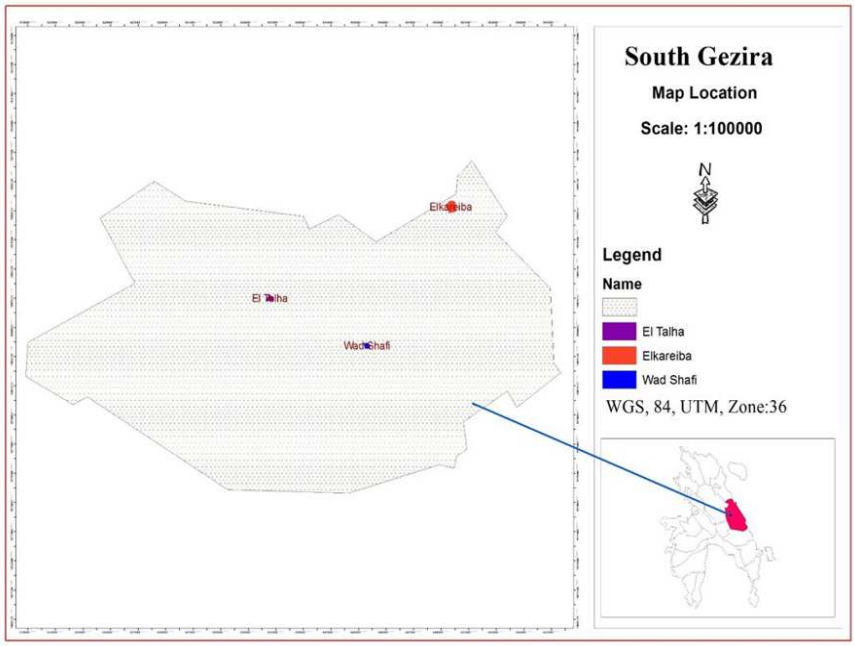

Figure 1. Study area map

Promotion of organic farming through training and information sharing for safe nutrition and poverty alleviation: Case study Gezira State of Sudan

Abstract

Organic farming has been mooted as an environmentally friendly farming practice in response to the growing concern over the environmental risks associated with modern agriculture and can help smallholder farmers to increase yields and be part of the solution.

The aim of the study was to bring awareness on the dangers of conventional farming based on synthetic external inputs and to train interested farmers groups on organic farming techniques and practices in Gezira State. Organic farming promotion was developed to gain the necessary data during the period of fieldwork (Questionnaire with 30 farmers). Base line survey questionnaire was developed matching with the study objectives with collection of relevant data. The results showed that the concept of organic farming is fully accepted by the targeted groups and all the researchers agreed support and need to organic farming in the study area because it's importance in improving soil fertility and producing healthy food and on the other hand support to the exports and national income. Based on the result analysis in the study area found that most of the farmers adopt organic farming practices and climate change in the study area and they are aware of organic farming which maintain and improve soil fertility and increase productivity.

Key words: *soil fertility, conventional farming, organic farming, smallholder farmers, Sudan*

GROWTH AND DROUGHT RESISTANCE OF *SWIETENIA MACROPHYLLA* (KING) AS AFFECTED BY ARBUSCULAR MYCORRHIZAL FUNGI

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Introduction

The Philippines is one of the most vulnerable areas affected by climate change. The country has an average of twenty typhoons per year and vulnerable to severe drought due to El Nino Southern Oscillations (ENSO). The abnormal warming of sea water in the Pacific Ocean as a direct impact of climate change resulted notable increase in the occurrence of El Nino for the last 20 years.

One of the major efforts to mitigate climate change is the restoration of about 17.6 million hectares of denuded lands in the Philippines to forest and serve as carbon sink. The enormous task of restoration of denuded lands in the Philippines had been intensified to augment the unabated loss of our forest. However, the successful regeneration of vegetation in these lands were hampered by physical location and topography of reforestation sites, occurrence of drought, prevalence of fire, poor hydrological properties of soil, low soil fertility, highly acidic soil, extreme plant competition of trees with *Imperata cylindrica* and *Saccharum spontaneum*, and socio- cultural limitations (De la Cruz, 1988).

Certain strategies had been implemented face to face with these constraints for successful regeneration of these lands. These are species selection, fertilization, site preparation, use of nurse trees, fire control and management, gully reforestation, and use of beneficial nitrogen fixers, and mycorrhiza. The use of biological nitrogen fixers and mycorrhiza are some technologies which are not yet extensively exploited in the Philippines to increase the survival and growth rates of trees under extreme field conditions.

Survival and growth of trees planted under field condition is the key to a successful reforestation programs. Most of the tree species that thrive under adverse field conditions usually have mutualistic mychorrhizal associations with beneficial fungi (Pozo, Azcon-Aguilar, 2007). Inoculation of seedlings mycorrhiza can increase their survival rates (Barea et al. 2011).

Mahogany is one of the popular plantation tree species in the Philippines. It is a timber producing tree species of high commercial value. Considering the ecological conditions in the reforestation sites, survival and growth of mahogany is extremely low. Mahogany is not a leguminous tree and is not known to be mutually associated with biological nitrogen fixing organisms. As a host plant it is associated with arbuscular mycorrhizal fungi (AMF) because of known non-host specificity of AMF (Marx and Schenk, 1983)

Mycorrhiza refers to the structure that results from mutually beneficial association between the fine feeder roots of the plants and species of highly specialized root inhabiting fungi (Marx and Schenk, 1983). Mycorrhizal fungi provide the host plant a lot

of benefits. It aids the plant in the absorption of nutrients in nutrient deficient soils, control some pathogenic root infections, produce growth hormones, promotes the activity of other soil organisms, helps in nutrient cycling and increase drought resistance of plants.

Drought is the main environmental perturbation often blamed for limiting growth and survival rates of plants in various regions of the world (Kramer and Boyer, 1997). Under these stressful environmental conditions, mycorrhiza improve resilience of plant against nutrient deficiency and water scarcity (Azcon-Aguilar, Barea, 1997).

Mycorrhizal roots are more efficient in absorbing water than non-mycorrhizal roots. This is very important in marginal reforestation sites periodically subjected to drought (De la Cruz, 1988). Marx and Schenck (1983) also had shown that AMF enhance water uptake in soybeans. Mycorrrhiza also increases the volume of soil where the plant can extract water and nutrients. The major contribution of AMF to plants to drought is mainly due to the larger volume of soil explored by the roots and extra radical hyphae (Gianinazzi et al 2010). Highly developed root systems extracted 80% of available water while less developed root systems extracted only 52 to 57% of soil available moisture (Meyer and Green 1980).

This research activity was carried out to determine which species of arbuscular-mycorrhizal fungi is most effective in promoting growth and drought resistance of mahogany seedlings.

Research Methods

Seedling Preparation and AMF Treatments

Pre germinated (*Swietenia macrophylla*) were transplanted individually in polyethylene bags. The seedlings were inoculated with different species of mycorrhiza were used. The AMF used were *Glomus mosseae* (AMF1), *Gigaspora margarita* (AMF2), *Glomus etunicatum* (AMF3), *G. mosseae* + *G. margarita* (AMF4), *G. etunicatum* + *G. margarita* (AMF5), *G. mosseae* + *G.etunicatum* (AMF6), and uninoculated as control treatmen. Each seedling were inoculated with 100 spores for single species of AM fungi treatment and 50 spores each for combined treatments. Pure cultures of AMF were taken from BIOTECH, UPLB, College, Laguna. The sterilized soil media used were clay gathered in a marginal grassland area. The soil has a pH of 4.9, 1.0 % OM, 0.05% N, 14 ppm P, 1.128 ppm K. Each pot contains 2 kg of sterilized soil. Seedlings were grown four 4 months under greenhouse condition.

Soil Moisture Treatment

After 4 months, the seedlings were subjected to different moisture levels. Soil moisure charaterization curves were determined using presure plate method. Knowing the moisture level the soil can hold at field capacity, the amount of moisture applied as treatments were at 80%, 60%, 40%, and 20% of field capacity. Seedlings with these moisture treatments were grown for another three months. Individual pots were covered with aluminum foil and plastic to prevent soil moisture loss.

Assessment of Parameters

Total plant height (cm) and stem diameter (cm) of the seedlings were monitored and measured for 7 month period. The rate of transpiration (grams/cm2/day) were monitore daily for three months through gravimetric method. Total dry matter weight (g) were measured at harvest. Phosphorus uptake were assesed using Vanado molybdate method.

Experimental Design

Four plant pots were observed per treatment combinations or a total of 112 pots for the whole experiment. The Experimental design used in this experiment is Split plot in CRD. Moisture content serve as the main plot factor and the different AMF inoculation treatments as sub plot factor.

Results

Different levels of moisture significantly affected the height growth of the seedlings (Table 1). Highest plant height were observed on seedlings grown at 80% and 60% available moisture. Lowest plant height were observed at 40% and 20% available soil moisture.

Inoculation of AMF significantly increased the height growth of mahogany seedlings grown under different levels of soil moisture. Seedlings inoculated with AM fungi have higher height growth compared to uninoculated seedlings. Highest height growth were observed in seedlings inoculated with *Glomus mosseae* + *Glomus etunicatum* at 60% available moisture with a value of 49.0 cm. Under water stress condition seedlings inoculated with *Glomus mosseae* + *Glomus etunicatum* also have highest height growth response (39.1 cm). Interactions between different soil available moisture and AMF inoculation were not observed.

Moisture Levels	***Glomus mosseae* (cm)**	***Gigaspora Margarit* (cm)**	***Glomusetunicatum* (cm)**	***Gl. mosseae +G. margarita* (cm)**	***Gl. etun + G. margarita* (cm)**	***Gl. mosseae +G. etun* (cm)**	**Uninoc (cm)**	**Mean**
80%	41.8	42.7	38.5	41.5	41.8	43.5	37.3	41.1 a
60%	39.7	43.0	49.0	39.6	45.2	42.0	38.1	42.4 a
40%	37.7	37.7	36.4	36.5	35.5	39.1	35.5	38.7 b
20%	37.4	37.2	34.1	36.1	36.0	37.0	32.8	35.8 b
Mean	39.2 a	40.2 a	39.5 a	38.4 a	39.9 a	40.2 a	36.0 b	

Table 1. Plant height of seven month old mahogany seedlings as affected by AMF inoculation and different levels of moisture.

***Means followed by the same letter are not significantly different at 5% DMRT**

Moisture Levels	*Glomus mosseae* (cm)	*Gigaspora margarita* (cm)	*Glomus etunicatum* (cm)	*Gl. mosseae +G. margarita* (cm)	*Gl. etun + G. margarita* (cm)	*Gl. mosseae +G. etun* (cm)	Uninoc (cm)	Mean
80%	7.45	7.76	7.68	7.21	7.27	7.61	6.93	7.42 a
60%	7.48	7.41	7.16	7.49	7.58	7.73	6.98	7.41 a
40%	6.86	6.74	6.72	6.94	7.22	7.76	6.81	7.08 b
20%	6.48	6.64	6.91	6.71	6.57	7.46	5.44	6.60 b
Mean	7.06 b	7.14 b	7.12 b	7.09 b	7.16 b	7.64 a	6.54 c	

Table 2. Diameter growth of seven month old mahogany seedlings as affected by AMF inoculation and different levels of moisture.
***Means followed by the same letter are not significantly different at 5% DMRT**

Table 2 shows that different soil moisture levels significantly affected the diameter growth of mahogany seedlings. There is significant differences in seedlings with AM fungi and uninoculated seedlings. Highest diameter growth were observed in seedlings inoculated with *Glomus mosseae + Glomus etunicatum.*

The effect of different levels of moisture and species of AMF on the total dry weight of mahogany is presented in Table 3. Total dry weight of mahogany of the seedlings was significantly affected by the levels of moisture and different species of mycorrhiza. Highest dry weights were at 80% moisture levels and seedlings inoculated with *Glomus mosseae + Glomus etunicatum*.

Moisture Levels	*Glomus mosseae* (g)	*Gigaspora margarita* (g)	*Glomus etunicatum* (g)	*Gl. mosseae +G. margarita* (g)	*Gl. etun + G. margarita* (g)	*Gl. mosseae +G. etun* (g)	Uninoc (g)	Mean
80%	17.26	15.39	15.29	14.75	16.33	19.65	14.07	16.10 a
60%	13.75	16.70	11.98	12.36	12.97	16.73	12.80	13.76 b
40%	12.68	11.82	11.63	12.40	12.24	13.31	13.07	12.34 c
20%	9.63	9.07	7.74	8.96	8.30	10.29	6.33	8.63 d
Mean	13.33 b	13.24 b	11.66 c	12.12 bc	12.46 bc	14.99 a	11.69 c	

Table 3. Total dry weight of seven month old mahogany seedlings as affected by AMF inoculation and different levels of moisture.
***Means followed by the same letter are not significantly different at 5% DMRT**

Moisture Levels	*Glomus mosseae* (mg)	*Gigaspora margarita* (mg)	*Glomus etunicatum* (mg)	*Gl. mosseae +G. margarita* (mg)	*Gl. etun + G. margarita* (mg)	*Gl. mosseae +G. etun* (mg)	Uninoc (mg)	Mean
80%	12.8	11.0	11.4	11.0	12.0	14.6	9.7	11.8 a
60%	10.0	12.0	8.5	9.1	8.5	12.7	8.7	9.9 b
40%	8.8	7.5	8.3	8.4	8.3	9.1	8.9	8.5 c
20%	6.9	5.5	5.7	5.8	5.3	7.3	4.1	5.7 d
Mean	9.6 b	9.0 b	9.0 b	8.6 b	8.5 b	10.9 a	7.9 c	

Table 4. Phosphorus uptake of of seven month old mahogany seedlings as affected by AMF inoculation and different levels of moisture
***Means followed by the same letter are not significantly different at 5% DMRT**

Phosphorus uptake of seedlings were significantly affected by different levels of moisture and AMF inoculation. Highest phophorus uptake were

demonstrated by inoculation of combined *Glomus mosseae* + *Glomus etunicatum* with an mean value of 10.9 mg (Table 4).

Moisture Levels	*Glomus mosseae* (g)	*Gigaspora margarita* (g)	*Glomus etunicatum* (g)	*Gl. mosseae +G. margarita* (g)	*Gl. etun + G. margarita* (g)	*Gl. mosseae +G. etun* (g)	Uninoc (g)	Mean
80%	0.350	0.335	0.288	0.295	0.335	0.300	0.246	0.306 a
60%	0.383	0.327	0.293	0.290	0.320	0.283	0.253	0.307 a
40%	0.373	0.315	0.293	0.305	0.327	0.373	0.220	0.316 a
20%	0.283	0.407	0.443	0.318	0.426	0. 327	0.210	0.345 a
Mean	0.347 a	0.346 a	0.329 a	0.302 a	0.352 a	0.321 a	0.231 b	

Table 5. Transpiration rate (g/cm²/day) of seven month old mahogany seedlings as affected by AMF inoculation and different levels of moisture.
***Means followed by the same letter are not significantly different at 5% DMRT**

Transpiration rate per unit leaf area was not significantly affected by different moisture levels. Inoculation with AMF significantly increased the transpiration rate of seedlings. Seedlings inoculated with *Glomus etunicatum* + *Gigaspora margarita* gave the highest transpiration rate with a mean value of 0.352 grams per cm² as shown in Table 5.

Discussion

Plant height, diameter growth and total dry matter produced by mahogany seedlings were signicantly affected by soil available moisture. Highest growth rates were at 60% to 80% soil available moisture. The result agrees with Suckaseam (1982) who found out that growth of mahogany was best at 70 to 90% soil available moisture. As the moisture levels is lowered to 40% to 20%, the growth rate of mahogany seddlings were severely reduced.

Inoculation of AMF further increased the growth of mahogany seedlings at 60 to 80% available moisture. However, the growth response between inoculated and uninoculated seedlings were highly significant at lower levels of available moisture. Growth responses of seedlings inoculated with *Glomus mosseae +Glomus etunicatum* were not reduced even at 40% available moisture. This showed that AMF truly assists plants in water absorption which enables the host plant to perform its normal physiological functions even at water stressed conditions.

Drought resistance of seedlings were improved by AMF inoculation. This is shown by higher transpiration rates of inoculated seedlings compared to uninoculated seedlings. This could be attributed to the hyphae/mycellia produced by the fungi which penetrates beyond the water depletion zones (Cooper, 1981, Ruiz Lozano and Azcon, 1997). Ouledali et. al (2018), revealed that olive trees inoculated with mycorrhiza were less affected by drought compared with olive trees with out mycorrhizal inoculation.

Association with AMF impoved P uptake of the host plant. AM symbiosis is one of the most important strategy for enhancing P uptake capacity (Smith et al 2011). Hidden P in soils can be be absorbed via mycorrhizal plants under water stress conditions. Improved P uptake and other soil nutrients improve the overall plant growth. Improved nutrient status of plant in association with mycorrhiza is due to the enhanced absorbing surface provided

by the hyphae and the ability of the fungi to uptake water in soil with low water potential. Smith (2011) further showed that the diameter size of fungal hyphae (2-5 micro meter) is two times smaller than the normal roots, enhancing its ability to penetrates smaller soil pores that retain water, P and other nutrients. This lead also to induce dense growth of mycorrhzal roots. Inoculation of AMF improved the uptake P,K, N, Zn and Fe after 40 days of growth period in olive trees inoculated with AMF (Ouledali, et al 2018).

Summary/ Conclusion:

The increased in growth and drought resistance of mahogany seedlings were result of combined effects of enhanced nutrient uptake and improved water uptake. These effects were due to AMF inoculation. Based on the result of the experiment, the best species in improving the growth and drought resistance of mahogany seedlings was a combination of *Glomus mosseae +Glomus etunicatum.* This implies that inoculation using two species of AMF is better than using single species of VAM.

Keywords: arbuscular mycorrhizal fungi, mahogany

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Growth and Drought Resistance of *Swietenia macrophylla* (King) as Affected by Arbuscular Mycorrhizal Fungi

Abstract
This study explored the best species of arbuscular- mycorrhizal fungi in promoting the growth and drought resistance of *S. macrophylla* seedlings. Three species of AMF and combination of each species were used as inoculation treatments. Mahogany seedlings after 120 days growth period were subjected to different moisture regimes. Seedlings inoculated with AMF proved to be effective in increasing height, diameter, and total biomass, as well as water and phosphorus uptake of mahogany seedlings. Highest growth rate of seedlings were those inoculated with a combination of *Glomus etunicatum* + *Glomus mosseae* at all levels of soil available moisture. Growth of mahogany seedlings were significantly affected by availability of moisture. Highest growth rate was at 60% and 80% soil available moisture. The effect of AMF inoculation in improving the water uptake of mahogany seedlings were more evident at lower moisture levels (40% and 20%).

Phosphorus uptake of seedlings was not significantly affected by availability of soil moisture but was greatly affected by AMF inoculation. Seedlings inoculated with *Glomus etunicatum* + *Glomus mosseae* had the highest P uptake among all treatments. Availability of soil moisture demonstrated to be the most important factor in influencing plant growth while AMF inoculation increase nutrient and water uptake of mahogany seedlings resulting to higher growth rates.

Keywords: arbuscular mycorrhizal fungi, mahogany

MAPPING SOIL ORGANIC CARBON USING REMOTE SENSING TECHNIQUES

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Introduction

Remote sensing and aerial photography techniques have been utilized in soil science for many years as tools to help soil surveyors to reduce the time and expense of sampling (Palacios-Orueta and Ustin. 1998).

Some soil properties have been related directly to a soil spectral response or inferred based on remotely sensed measurements of crop canopies, including soil texture, nitrogen level, organic matter content, and salinity status (Mzuku et al. 2015). Because soils start forming from the weathering of the parent material, soil composition is a complex mixture of different minerals at many different grain sizes. On earth, organic matter plays an important role in soil composition as well (Centeri et al. 2014); therefore, the resultant spectra will depend not only on the mineralogical features of the parent material but also on the degree of weathering and the content of organic matter (Palacios-Orueta and Ustin. 1998). Most of the spectral responses in the reflective spectrum can be related to differences in organic matter content, iron content, and texture (Mzuku et al. 2015). In follow, we are going to explain the soil organic carbon definition, its importance and the methods which are useful to determine SOC distribution using remote sensing.

Soil carbon storage is a vital ecosystem service (Nel and Szilágyi. 2018), resulting from interactions of ecological processes (Ontl and Schulte 2012). It is recognized as the third-largest store of the global carbon pool (Lal 2003). The soil C pool comprises two components: the SOC pool estimated at 1550 Pg and results both directly from the growth and death of plant roots, as well as indirectly from the transfer of carbon-enriched compounds from roots to soil microbes (Ontl and Schulte. 2012). The Soil Inorganic Carbon (SIC) pool estimated at 750 Pg.

SOC is a vital component of soil with important effects on the functioning of terrestrial ecosystems. As an indicator of soil health (Rodríguez Martín et al. 2019), SOC is important for its contributions to food production, mitigation, adaptation to climate change (Purghaumi et al. 2013; Zhou et al. 2019), and the achievement of the sustainable development goals. It should be mentioned that terrestrial sources dominate OM inputs to fluvial networks and coastal margins (Marín-Spiotta et al. 2014), most of this organic matter in the water column of lakes and water bodies is generally in the dissolved form. The dissolved organic matter (DOM) in lakes consists to a large degree of colored humic substances. Because DOM and associated compounds used by aquatic biota interact with lake or waterbodies ecosystem processes, variation among lakes in the concentration of DOM has a major effect on ecosystem structure and function. Moreover, the concentration of DOM in freshwater environments has implications for

the further transport downstream to the marine environment, where it may have a significant influence on coastal ecosystems (Kutser et al. 2005).
Regarding the mentioned reasons and the importance of soil organic carbon and its effect on terrestrial and water ecosystems, there is an increasing demand for knowledge of the spatiotemporal variability of SOC. The traditional measurement of SOC content is based on the laboratory analysis of field soil sampling (Stevens et al. 2008), Which is time-consuming, expensive and also soil data of sampling points are discrete and incapable of providing continuous and complete information regarding the total study area, thus spatial variability of SOC through field soil sampling cannot be obtained. Research shows using remote sensing data to provide an indirect measurement of SOC to inform digital soil mapping has the potential to provide more reliable and cost-effective estimates of SOC compared with field-based, direct measurement (Castaldi et al. 2018; Mondal et al. 2017).
The role and importance of remote sensing for the monitoring of soil carbon have been discussed by Post et al. (2001), who indicated that it could be especially useful when used in regions lacking detailed (in situ) geographical information (Post et al. 2001).
Therefore the strong correlation between SOC and spectral reflectance from the soil indicates that it can be modeled and represented by soil reflectance (Ladoni et al. 2010). The objective of this paper is to review the methodologies used for determining SOC content from remotely sensed data. First, there is an overview of the spectral features of SOC, followed by methods to estimate it from reflectance obtained from space remote sensing.

Soil organic carbon spectral features

Soil reflectance varies according to chemical factors, such as soil mineralogy, SOM content and soil moisture, and also physical structure, such as surface roughness and particle size.
Soil spectral signatures are defined by the reflectance of electromagnetic radiation by chemical substances as a function of wavelength (Croft et al. 2012).
The color of the soil is usually closely related to its organic matter content, with darker soils being higher in organic matter, which indicates the relationship between soil organic matter content and its visible light reflectance (Aghababaie et al. 2018). Although, there are a lot of inversion methods used to get the organic matter content from soil reflectance (Karnieli et al. 1998), all of these methods are subject to certain limitations to some extent and display a big error when applied in different soil categories. To date, there is no versatile model, which fits all over the world, and the waveband selection for different study areas is also diverse (He et al. 2009).
The soil generally has reflectance spectra in the 1100–2500 nm range, including three distinct absorption peaks around 1400, 1900 and 2200 nm with a few small absorption peaks between 2200 and 2500 nm (Croft et al. 2012). Organic matter affects the spectra by decreasing the overall reflectance (in the visible wavelengths (Blue, Green, Red; 400–700 nm), near-infrared (NIR; 700–1400 nm) and shortwave infrared (SWIR; 1400–2500 nm) regions of the electromagnetic spectrum (Croft et al. 2012), therefore bands around 1100, 1600, 1700 to 1800, 2000, and 2200 to 2400 nm have been identified as being particularly important for SOC calibration (Stenberg et al. 2010).

The increase of the amount of soil organic matter leads to a reflex less than a normal one. When the amount of organic matter reaches about nine percent, the effects of other soil parameters on reflex will disappear (Aghababaie et al. 2018).
In a study, Henderson et al (1992) found that visible wavelengths (425–695 nm) had a strong correlation with soil organic matter for soils with the same parent material; however, the relationship was sensitive to Fe and Mn-oxides for soils from different parent materials (Henderson et al. 1992). Use of middle infrared bands improved predictions of organic carbon content when the soils were formed on different parent materials (Mzuku et al. 2015)

Measurement scales of capturing spatial variability in SOC

Three key methods are available for getting information on SOC content, which have different spatiotemporal scales. The three measurement domains are: 1. laboratory spectroscopy; 2. ground-based spectroscopy using field-portable techniques (point spectroscopy) and 3. remote spectroscopy, on airborne or satellite mounted sensors (imaging spectroscopy). Whilst each method relies on similar scientific principles, different instruments are used according to the spatial scale of the environmental processes of interest, with the controlling mechanisms on SOC spatial variability (Croft et al. 2012). In the present study, our focus is on remote spectroscopy with emphasis on satellite sensors.
During the last three decades, researchers have been investigating new approaches to increase the accuracy of estimating SOC from remotely sensed (RS) data. As a result, models based on regression, the 'soil line', principal component analysis (PCA) and geostatistics have been proposed (Ladoni et al. 2010).
These techniques have proven valuable; however, limitations with each technique necessitate further investigations in other environments to choose the best technique for predictions (Ladoni et al. 2010). The strong correlation between SOC and spectral reflectance from the soil indicates that it can be modeled and represented by soil reflectance (Ladoni et al. 2010). As it mentioned before, there are different studies to discover most suitable wavelengths for evaluation SOC and most of them showed that organic carbon content of the soil correlated with red, green, and also thermal infrared (TIR) bands (Mzuku et al. 2015; McCarty et al. 2002). However, recent studies have also shown the potential of mid-infrared (MIR) wavelengths for modeling SOC content and emerging technologies such as LiDAR offer the ability to provide ancillary data related to spatial SOC distributions, such as fine-spatial resolution digital elevation model (DEM)s.
Mondal et al. (2017) also showed that SOC distribution is highly correlated with other variables that could be derived from RS data, i.e., brightness, wetness, and vegetation condition indices, as well as first and second derivative products of DEMs (Peng et al. 2015). Table 1 shows some of the useful indices that are frequently applied in different studies.

Indices	Indices name	Define of indices	Equation
NDVI	Normalized Differential Vegetation Index	Indicator for vegetation health and biomass	NIR-Red[1] /NIR+Red
MSI	Moisture Stress Index	The measure of the effects of drought and catastrophic wetness on plants	MidIR/NIR
NDWI	Normalized Difference Water Index	Indexes related to liquid water, it is used to monitor changes in water content of leaves	NIR-SWIR/NIR+SWIR
RSR	Reduced Simple Ratio	Estimation of leaf area index	(NIR/Red)(1-(SWIR-SWIRmin)/(SWIRmax-SWIRmin))
TVI	Transformed Vegetation Index	TVI is a modified version of NDVI to avoid operating with negative NDVI values	((NIR-Red/NIR+Red)+0.5)$^{1/2}$*100
SR	Simple Ratio	Separate green vegetation from soil background	NIR/Red
EVI	Enhanced Vegetation Index	EVI is an 'optimized' vegetation index designed to enhance the vegetation signal with improved sensitivity in high biomass regions and improved vegetation monitoring through a de-coupling of the canopy background signal and a reduction in atmosphere influences	G(NIR-Red/NIR+C1Red-C2Blue+L)(1+L)
NDVI Green	-	Useful for measuring rates of photosynthesis and monitoring the plant stress. (use in cases we have cameras with NIR-GREEN-BLUE and there is no red channel we cannot calculate real NDVI).	NIR-Green[2]/NIR+Green
Clay Index	-	Estimation of clay content in the soil	Band5/Band7 (Landsat 7 ETM)
Carbonate Index	-	Estimation of carbonate content in the soil	Red band/Green band

Table 1 Useful indices as ancillary data related to spatial SOC distribution

Also, Fig. 1 highlights the variety of remote sensed data that can be used to monitor spatiotemporal soil organic carbon dynamics

[1] Red reflectance

[2] Green reflectance

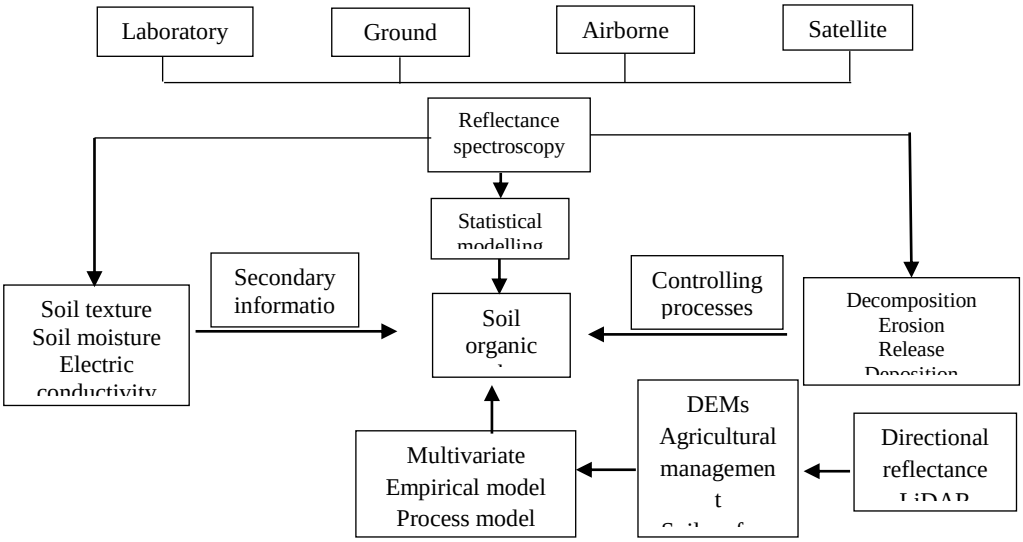

Fig 1 Conceptual model of remote sensing contributions to monitoring and modeling SOC content

The most common and popular method for SOC investigation based on remote sensing data

Simple Regression Model (SRM)

The strong correlation between SOC and spectral reflectance from the soil indicates that it can be modeled and represented by soil reflectance (Ladoni et al. 2010). The regression analysis usually is performed to determine this relationship and compared the observed SOC (field measure) to predict SOC (estimated from satellite images) (Bhunia et al. 2019).

The step of SRM is simple. At first, every sampled soil point should be located in the image, and its corresponding digital value in blue, green, and red (or ancillary factors) is extracted. It should be verified that all variables (i.e. soil properties and spectral values in visual range) are normally distributed. With a statistical method (like Pearson), linear correlations between soil variables and spectral values in blue, green, and red, will be determined to accept a confidence level (i.e. of 95%). Regression equations will be calculated for those soil variables that showed higher significant correlations with digital data. Spatial distribution maps will be constructed applying these equations to the image (López-Granados et al. 2005).

SRM has some drawbacks, for example, when soil samples are taken from large geographic areas with different parent materials or different landscapes, where the relationship between soil organic carbon and reflectance is poor (Henderson et al. 1992). Also, for the soil of arid and semiarid regions, other properties such as $CaCO_3$ and $CaSO_4$ content of the soil can confound the reflectance. Furthermore, it is important to emphasize that the relationships are not universal, which means that field samples should be taken and accordingly, new regression equations should be determined. There is the complexity of the transfer of prediction models from one sensor to another.

Sensor characteristics like wavelength position, bandwidth or number of bands, often differ from one remote sensing instrument to another, which requires new model calibrations for each sensor (Bartholomeus et al. 2008).

The 'soil line' method

The soil line is a well-known linear relationship between the near-infrared and red band reflectance or image intensity of bare soil images.

The soil line concept has been utilized extensively in attempts to characterize vegetation growth.

This technique (soil line Euclidean distance or SLED) is based on relating a pixel's Euclidean distance of the red and near-infrared intensity value to the red and near-infrared intensity value for the lower point on the soil line (Fox et al. 2004).

$$NIR = \alpha R + \beta$$

where NIR and R are the image intensity or reflectance in the near-infrared and red bands, and α and β are the soil line slope and intercept, respectively. The soil line extends from a lower region consisting of the darker soils with low R and NIR reflectance to an upper region of bright soils with high reflectance values in both the R and NIR bands (Fox and Sabbagh. 2002).

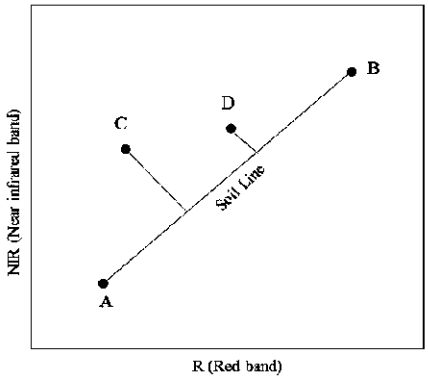

Figure. 2- The soil line concept is illustrating the observed linear relationship between red (R) and near-infrared (NIR) reflectance of bare soil. The soil line extends from darker soil with small R and NIR reflectance (point A) to bright soil with large reflectance in both the R and NIR bands (point B). Point C represents a pure vegetation pixel and D represents a partially vegetated pixel. Modified from Campbell (2004)
(Ladoni et al. 2010)

There are difficulties with SLED, for example, Fox and Sabbagh (2002) indicated that there was a significant correlation between surface OM and image intensity in the B (400–500 nm) and G (500–600 nm) wavelengths, but these bands were not used in their analysis. This was because SLED becomes cumbersome when including information from wavelengths other than R and NIR (Fox and Sabbagh. 2002). Another difficulty with the SLED technique that this method uses only reflectance in the R and NIR bands and disregards significant correlations between other bands and OM content etc. (Ladoni et al. 2010).

Principal component analysis

The principal component analysis is a common statistical technique used to reduce the data dimensionality and to indicate the components and the schematic representation of the distribution responsible for the spectral variability in the dataset (Ray et al. 2003).

For spectral data, in particular hyperspectral data, it is used to indicate those wavelengths that account for most of the variation (Ladoni et al. 2010). Therefore it reduces the variance in data and also in a pure bare soil image (Ladoni et al. 2010). This approach is predicated on the assumption that the spectral variability contained in the data set is due fundamentally to mixing between small numbers of discrete compositional endmembers with unique spectral properties (Palacios-Orueta and Ustin. 1998)

Steps in PCA included calculating univariate statistics, a covariance matrix, a correlation matrix, the eigenvalues and eigenvectors, the degree of correlation and new brightness values (principal components). Finally, new images representing the PC1 values would be obtained as well (Ladoni et al. 2010).

The eigenvalues indicate the percentage variation that each component accounts for, and the eigenvectors show which wavebands are important for accounting for the variation of a given component. The first component accounts for the most variation, followed by component two, and so on. The components are orthogonal to one another, and they can be used as uncorrelated data for other analyses (Ladoni et al. 2010)

Geo statistical techniques

Geostatistics provide tools to describe and predict spatial variation and carry out spatial interpolation. Geostatistics have been applied in soil science for more than 20 years (Zhang and McGrath. 2004).

This technique uses spatial autocorrelation to model spatial variation. Also, there are methods (like Co kriging) that use correlated secondary information that has been shown to improve the estimates of SOC (Ladoni et al. 2010). These methods require modeling of both auto- and cross-correlation functions. Several geostatistical methods can be taken into account, secondary information that is often more intensive and cheaper to obtain than the primary soil variable. Such methods include, Ordinary kriging, Co-kriging, kriging within strata, kriging with external drift and simple kriging with varying local means or regression kriging, these methods differ in the assumptions about the form of relationships between primary and ancillary variables, and how the secondary information is used to estimate the primary variable at un sampled locations. Here ordinary kriging (OK) was chosen to explain because it is widely applied in the spatial prediction of soil properties.

OK is known as the best linear unbiased estimator and as an interpolation method for each soil parameter to minimize the prediction error variance. OK is by far the most common type of kriging, consisting in a form of weighted averaging, and is based on the concept of a variable z(x) that is both random and spatially autocorrelated (Marchetti et al. 2012).

The core theory of OK is that spatial autocorrelation is based on the spatial autocorrelation of soil properties. The soil attributes of a sampled point can be predicted by giving weights to the surrounding observation points (Ladoni et al. 2010). The predicted model can be expressed as follows:

$$Z^*(x_0) = \sum_{i=0}^{n} \lambda_i * Z(x_i),$$

where Z^* (X_0) is the estimated SOC value of variable Z at location X_0, Z^* (X_i) is the measured SOC data, λ_i represents the weights combined with the measured values, and n is the number of measured values within a neighborhood of four or eight (Zhang and McGrath 2004; Bhunia et al. 2018).

Comparison of the above methods

PCA and Soil line techniques are suitable for small geographical areas and homogeneous farms only if the variation in soil characteristics is the source of change in reflectance. In large areas where the effects of topography, plant coverage, soil erosion features, and other factors are dominant, the soil line and PCA techniques are not solely dependable and basic information like soil, land use, and physiographic maps are needed as well (Ladoni et al. 2010).

According to Ladoni et al., (2010), Principal component analysis, appeared to provide equivalent regression coefficients for surface OM content without requiring automated programs to extract soil line parameters or nonlinear regression to quantify regression parameters for the fields.

This is important to notice that the soil line technique and PCA are more universal methods that can help to choose the best point for soil sampling and improve the representation of within-field variation in surface OM content. According to Ladoni et al, 2010, the strength of these techniques (soil line and PCA) in prediction was similar. The Euclidean distance from the soil line and first component of PCA were correlated with SOC; however, their accuracy was not strong enough to estimate SOC (Ladoni et al. 2010).

In another study Granados et al., (2004) compare various prediction methods including statistical (linear regression between soil properties and digital values) and geostatistical algorithms (ordinary kriging, ordinary kriging plus regression and kriging with varying local means) for mapping soil organic matter by incorporating secondary spatial information (remote sensing data) into the mapping. They found that the best prediction method for mapping organic matter is kriging (in their study)with varying local means in combination with the spectral data from the blue waveband with the smallest Mean Square Error (MSE) indicating the highest precision (López-Granados et al. 2005).

In another study Ladoni et al., 2010 compared the techniques of SRM, PCA, and the soil line approach in SOC estimation in a semi-arid environment. The SRM technique provided the most accurate SOC predictions (R2=0.75) but the accuracy for PCA and soil line techniques were R2<0.44 (Ladoni, Alavipanah, et al. 2010).

Main findings

In overall, it has been demonstrated that data from satellite sensors can be used as auxiliary variables for mapping SOC, using of remote sensing data to provide an indirect measurement of SOC to inform digital soil mapping has the potential to provide more reliable and cost-effective estimates of SOC compared with field-based, direct measurement. Despite this potential, the role of different methods related to remote sensing data in estimation SOC is different base on the region, soil type and satellite

image. However, an important benefit of remotely sensed data is to present a sampling strategy that can lead to improved representation of spatial heterogeneity of SOC.

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Mapping soil organic carbon using remote sensing techniques

Abstract
Regarding the importance of soil organic carbon (SOC), there is an increasing demand for knowledge of the spatiotemporal variability of SOC. Because of difficulties with traditional analytical measurement (time-consuming, expensive, and also soil data of sampling points are discrete and incapable of providing continuous and complete information regarding the total study area), spatial variability of SOC through field soil sampling cannot be obtained. Using remote sensing data to provide an indirect measurement of SOC to inform digital soil mapping has the potential to provide a more reliable and cost-effective estimation. The objective of this paper is to review the remote sensing data for mapping and evaluating SOC. There are several statistical methods, including regression models, principal component analysis, the 'soil line'

approach, and geostatistics, which have been applied to investigate the accuracy of such estimates. Results suggest that these techniques have proven valuable; however, the limitations of each technique must be tested under wider environmental circumstances to choose the best technique for predictions. It seems that predictive equations aren't universal, and every scene needs new regression models. However, an important benefit of remotely sensed data is to present a sampling strategy that can lead to improved representation of spatial heterogeneity of SOC.

Keywords: Soil organic carbon, remote sensing, statistical methods, regression models.

ISOLATION AND CHARACTERIZATION OF HYDROCARBON-DEGRADING BACTERIA FROM SEDIMENT-WATER OF SIKLOS CONTAMINATED SITE (HUNGARY)

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Introduction

The mono aromatic hydrocarbons abbreviated BETX, which stands for benzene, toluene, ethylbenzene, and the three xylene isomers, are groundwater, soil and air pollutants, commonly associated with petroleum and petrochemical production. BTEX are volatile, monocyclic aromatic compounds that are usually present in coal tar, petroleum products, and various organic chemical product formulations [1]. They are often found in air emission of several sources such as refiners, petrochemical units, chemical plants, storage tanks, vehicle exhaust [2], waste incinerators and composting facilities [3]. BTEX contamination of soil and groundwater is usually related to petroleum leakages and fuel oil from underground storage tanks, manufacturing of solvent-based paints, lacquers and varnishes and the activities of manufactured gas plants [4]. Since these toxic substances simply move in the air, they have direct and indirect impacts on human health. Short term (acute) hazards of BTEX include probable acute toxicity to aquatic life in the water column (especially in relatively confined areas) as well as potential inhalation hazards. Long term (chronic) potential hazards of these compounds include changes in the liver and harmful effects on the kidneys, heart, lungs, and nervous system [5]. Human subjection to these compounds as a mixture can show to neurological, respiratory, genetic and excretory system damage and other health problems ranging from infuriation of the eyes, mucous membranes, and skin, to weaken nervous systems, reduced bone marrow function, and cancers.

The usage of BTEX has continued despite all these adverse effects because of the extent of applications. BTEX can pose a consequential risk to soil and groundwater [6] because of their toxicity effect and high water solubility [7, 8]. Due to their consequential adverse impact on human health, the United States Environmental Protection Agency [8] has established maximum allowable levels of these contaminants in water for public use. Since the frequency of groundwater contamination with hydrocarbons, including BTEX, has been increasing, there has been a demand for the development of more efficient methods to remove or minimize the damages caused by these compounds [9].

Release of petroleum hydrocarbons in the environment as of late attracted the researchers. One particular concern is the contamination of drinking water sources by the toxic water-soluble and mobile petroleum components like benzene, toluene, ethylbenzene and xylene (BTEX) compounds [10]. Some BETX compounds persisted in the environment at levels exceeding regulatory thresholds in most of the countries

across the world [11]. Several studies have been carried out in order to find out efficient microorganisms for BTEX degradation, so they could be used in environmental remediation [12]. Hungarian BTEX contaminated site (Siklos) were chosen for this study which was contaminated by leaking oil storage tanks, the samples were collected and Physico-chemical characterization was done using advanced types of equipment, the samples are screened in the laboratory for species level identification by isolating genomic DNA, 16S rRNA amplification, and BTEX degradation efficiency genes 2,3-dioxygenase (C23O) which are responsible for BTEX degradation[13]. The isolated bacterial strain ST2X was shown the presence of genes 2,3-dioxygenase (*C23O*) and it nee to select for BTEX degradation studies in enriched water samples on GC-MS analysis.

Materials and Methods

Isolation and Screening

The groundwater samples were collected in the brown-colored bottle (250 ml) aseptically from the site Siklos center of the contaminant plume (ST2 well) Hungary. Key physical and chemical parameters, such as dissolved oxygen (DO) concentration, redox potential (EH), temperature and pH were measured on-site by means of portable field sensors (HANNA Instruments®, USA). Concentrations of the BTEX compounds and physicochemical parameters were determined by an accredited analytical laboratory (Wessling Hungary Ltd.) [14]. Standard serial dilution with distilled water was performed for the samples and up to 10^{-7} dilution was taken for isolation. The spared plate technique used for sample isolation, samples were spread on R2A agar plates and incubated at 27 ^{0}C for 24hr. Based on colony morphology the fresh colonies are made subculture on R2A agar medium plate having Protease peptone 0.5g, Casaminoacids 0.5g, Yeast extract 0.5g, Sodium pyruvate 0.3g, Agar 15g, pH 7±2, (all chemicals were purchased from Sigma-Aldrich, Germany) the pure culture were performed Grams staining.

Molecular characterization

Isolation of genomic DNA

Pure enriched culture were grown on R2A agar plate an overnight grown culture single colony was picked to DNA isolation, total genomic DNA were isolated by using UltraClean Microbial DNA isolation kit (MoBio Laboratories Carlsbad, CA) according to the manufacturer protocol, and detail quality evaluation was done on 1%(w/v) agarose gel.

16S rRNA and C23O Functional gene amplification

The species level identification of the isolated culture was done on the basis of 16S rRNA gene sequence analysis, 16S rRNA gene sequencing PCR was amplified by using the universal bacterial primers 27F and 1492R,the amplified PCR product were purified for removal of present contaminants by using QIAquick purification Kit after agarose gel assessment. In order to identify the presence of C23O genes in the selected bacterial culture were isolated genomic DNA was amplified in PCR by selected specific primers XYLE1 and XYLE2 [16], PCR amplification performed 50µL reaction contains 5µL of 10X Mg-free PCR buffer, 2mM $MgCl_2$, 0.6 µM of each primer 0.2mM of each dNTP,

4µL RT mix 1µ maxima Hot Start Taq DNA polymerase (Thermo Scientific), and Nuclease free water up to the final reaction volume, the amplification conditions were as fallows 95 ºC for 3 min then 40 cycles of 94 ºC for 30 sec, 50 ºC for 30sec, and 72 ºC for 1 min then a final extension at 72 ºC for 10 min and the final PCR product were analyzed by 1% (w/v) agarose gel stained in Ethidium bromide.
Were analyzed by 1% (w/v) agarose gel stained in Ethidium bromide.

Results

The experimental analysis outcome of this study is presented following order of the obtained results, using well established logical experimentation flow

Sample isolation and screening

As mentioned methodology section samples are collected from site Siklos ST2 well aseptically, general water chemical parameters were taken into account the pH of the water sample is pH 7.5-7.8, Nitrate level (3mg/L), Sulphate(174 mg/L) and the temperature 32 ºC. The serial dilution 10-5 to 10-7 samples are taken for bacterial isolation on R2A agar plates, After 24 hr incubation well-grown colonies were picked on basis of morphology (Fig.1) for enrichment, the enriched bacterial samples were subculture on a fresh R2A agar plate, after proper growth a single colony was taken for Grams staining, the selected culture was conformed as Gram-negative, road shaped bacteria in microscopic observation (Fig. 2)

Fig.1. Bacterial colonies on R2A agar plate

Fig.2. Microscopic image o f the bacterial strain

Isolation of genomic DNA and 16S rRNA gene amplification

Chromosomal DNA was extracted by using UltraClean Microbial DNA isolation (Fig.3A) and was amplified using polymerase chain reaction in a thermal cycler (1500 bp) and was purified using QIAquick purification Kit. (Fig.3B) Purified amplicons were sequenced by Sanger method in ABI 3500xL genetic analyzer (Life Technologies, USA). Sequencing edited using CHROMASLITE (version 1.5) and further analyzed by Basic Local Alignment Search Tool (BLAST) with closest culture sequence retrieved from the National Centre for Biotechnology Information (NCBI) database that finds

regions of local similarity between sequences. And the selected culture was shown highest homology with i.e 99.01 present homology with *Psudomonas moorei* stain RW10 in NCBI database, hence the strain was conformed as *Psudomonas moorei* and it is named as ST2X stain.

PCR detection of C23O genes in the stain ST2X.

Family 2,3-dioxygenase (*C23O*) genes were identified only from the DNA extract of sample ST2X (Fig.5) with PCR by selected specific primers XYLE1 and XYLE2 as per mentioned protocol method in methodology, while 2,3-dioxygenase (*C23O*) related genes were detected in ST2X, the presence of BTEX-degrading ST2X. Thus, bacteria-harboring the subfamily 2,3-dioxygenase (*C23O*) genes may have played a notable role in BTEX degradation in the contaminated groundwater investigated in this study.

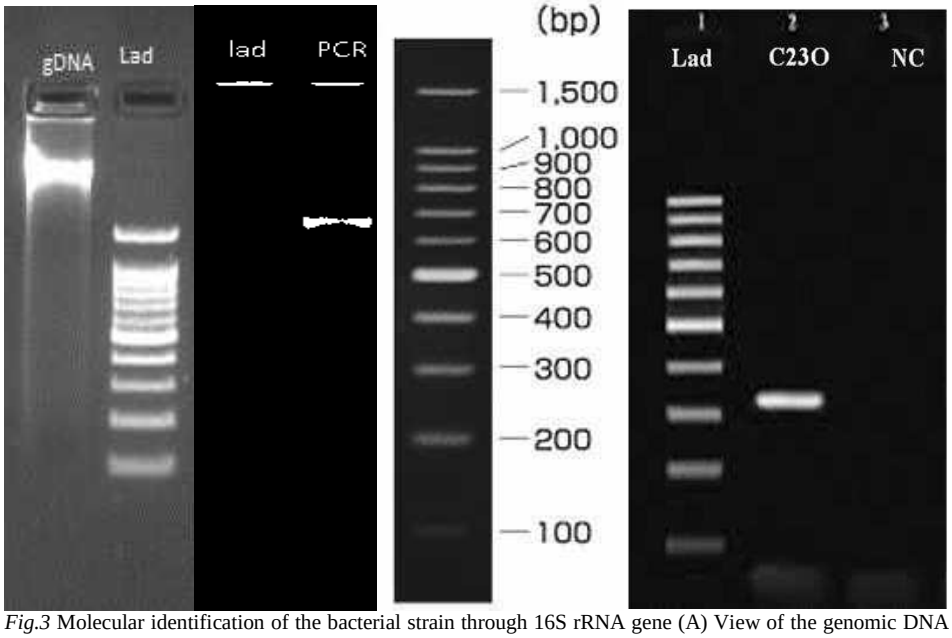

Fig.3 Molecular identification of the bacterial strain through 16S rRNA gene (A) View of the genomic DNA and Ladder (B) 16S rRNA gene amplification (C) Ladder specifications. And (D) 2,3-dioxygenase gene (lad-ladder, C23O-2,3-dioxygenase gene, NC- Negative control)

Main findings

Siklos is one of the most studies hydrocarbon contaminated sites in Hungary. Several studies have suggested that the microbial community of this contaminated site is majorly dominated by genus Pseudomonas. And members of those communities can degrade aromatic hydrocarbons both aerobically and micro aerobically. During our study we have found the same as the previous researches. Where we have found that among the other strains that we have isolated, which are more likely to be soil habitat bacteria , strain ST2X is the only one which posses the C230 gene and also is a member of genus *Pseudomonas* and shares highest 16s similarities with *Pseudomonas moori.*

Summary

These results are only the initial results of the study. In future we would like to investigate more about the strain ST2X. Detailed study of degradation capability of the strain is needed with GC MS to check degradation efficacy of the strain. Moreover, it is also important to know that which or what are the specific BTEX compounds it can degrade or it can consume as sole source of carbon. Furthermore, it would be interesting to study the rate of degradation both individually and as a BTEX compound mixture. But from our initial result of the study we can easily conclude that the Siklos contaminated site is majorly dominated with genus pseudomonas and many of this genus contain the specific genes for the degradation of the BTEX compounds. These indigenous strains can be used for bioremediation or we can bio stimulate this strains in-situ to enhance remediation.

Keywords: BTEX, Pseudomonas sp, 2,3-dioxygenase (C23O), biodegradation

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Isolation and characterization of hydrocarbon-degrading bacteria from sediment-water of Siklos contaminated site (Hungary)

Abstract
BTEX compounds are among the most frequent groundwater contaminants in Hungary. Due to their relatively high-water solubility, soil contamination can considerably threaten subsurface aquifers, the main drinking water resources. Therefore, the cleanup of the polluted ecosystems is always obligatory by law in Hungary. Hence, we look for efficient BTEX degraders from the sediment samples of Siklos contaminated site which is the most studied hydrocarbon contaminated site of Hungary. Several organisms were successfully isolated and screened for species identification with 16S rRNA gene sequencing. Among them, one bacterium showed the highest 16S rRNA gene homology as Pseudomonas moorei strain namely ST2X is the most interesting one with the ability to consume different BTEX compounds as a sole source of carbon. Moreover, we have screened for catechol 2,3-dioxygenase (C23O) genes which encode subfamily I.2.C-type extradiol dioxygenases with the selective primer for isolated ST2X, where it shows the availability of C230 genes that encode dioxygenases enzymes which are responsible for BTEX compounds degradation. The strain needs to be studied for BTEX compounds degradation on GC-MS analysis.

Keywords: BTEX, Pseudomonas sp, 2,3-dioxygenase (C23O), biodegradation

SENSORY QUALITY OF DIFFERENT GALIA AND CANTALOUPE TYPE MELON VARIETIES

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Introduction

Melon (*Cucumis melo* L.) is a member of the Cucurbitaceae family. It is a very important vegetable; its cultivation has a strong tradition in Hungary. Although it seems that in the future the proportion of open field areas will decrease, simultaneously the use of greenhouses is expected to increase. In 2018 in Hungary melon was cultivated on 600 ha, 60% of this was greenhouse cultivation. According to this data we can state that although at a small rate, but the production area of melon has increased compared to 2016. Total yield in 2018 was around 18.000 tons from which 85% was orange-fleshed melon (Cantaloupe type) and 15% was green-fleshed melon (Galia type). Our aim was to establish the sensory profile of different melon varieties and investigate the major differences.

Literature Review

Sensory properties of fruits are very important factors in consumer acceptance; therefore, objective tests for determining the preferred sensory attributes is essential. Sensory test based on ISO standards can be performed by panels for the description of different fruits, such as melon (Vallone et al., 2013; Park et.al., 2018). Electronic sensory instruments like electronic tongues and electronic noses are also available and applied in food science research. Electronic tongues are designed to work based on the analogy with the human tongue, but with a higher sensitivity to flavors and aromas providing specific fingerprint data of the tested samples. Electronic tongues were applied in several fields of food studies, for instance, classification of different varieties of fruits and vegetables, testing the authenticity of foods and beverages (Kantor et.al., 2008; Escuder-Gilabert et.al., 2010) or predicting sweetness and sugar content (Tian et.al., 2013). Hungarian researchers were able to discriminate regions of watermelon samples based on the results of the electronic tongue (Fekete et.al., 2018). The electronic tongue was also used for discrimination between different technological procedures (Guo et.al., 2018) or storage conditions (Kantor et.al., 2008).

Methods

Examinations were performed from late summer to autumn in 2019. Experimental samples were gathered from several farmers. Altogether five melon varieties were examined, three orange-fleshed Cantaloupe type (*Celestial, Donatello, Centro*) and two green-fleshed Galia type (*Aikido, London*).

Aikido F1 (Sakata Seed) is an early, fertile melon of the type of Galia. The sugar content is 17 %, the flesh is light green, thick, melting, tender and juicy. *Aikido* is high-yielding early maturing hybrid immune to powdery mildew and fusarium.

London variety (BASF) is a Galia-type melon which possesses a greenish white flesh colour. Ripens in the medium period, with a round shape, its seeds are small, and its peel is thick, which makes it quite tough. *London* is a fusarium-resistant variety its foliage and fruit peel are more resistant than other green flesh varieties. Its average weight is about 1.3-2 kg.

The *Celestial* (Nunhems) variety is a Cantaloupe type, has dark orange flesh colour which is of high-quality melon. Its fruit is 1.3-1.8 kg, has excellent taste, is well transportable and has a prolonged shelf-life. It can be grown both in greenhouse or in open field.

Donatello (Nunhems) variety is highly suitable for early cultivation; it is also a Cantaloupe type melon. *Donatello* is a very delicious melon with high sugar content and orange colour. The peel is hard, has yellow colour with green strips.

Centro (Bayer) variety is recommended for open field cultivation due to its short growing season. It is an orange fleshed, cantaloupe type melon with a weight of 1.5-1.8 kg.

In our research we've compared *Celestial, Donatello, Centro, Aikido* and *London* varieties. Five different plants of each variety were harvested and later on used in the experiments (variety dataset) resulting in a total of 25 samples (5 varieties and five repetitions from each).

Samples were prepared 30 min before testing. First, the sensory attributes and their corresponding reference values were determined, in order to reduce the variation in the resulting dataset. The sensory profile tests were performed according to ISO 13299 standard by 10 panellists who evaluated the following attributes: presence of fermented aroma, sweet aroma, flesh colour, texture, juiciness, sweet taste, fermented flavour, aftertaste, and taste persistence. At the end of the test sheet panellists had a text box for open ended comments on the samples. The results of sensory data were plotted on profile diagrams, which were prepared by ProfiSens, a sensory analysis software (Kókai et al., 2004). Tests were performed in accordance with ISO 6658. Statistical differences were evaluated with univariate ANOVA and Fisher LSD significance level evaluation procedures.

Results

Results of variety data set for the Cantaloupe type melons showed significant differences in four parameters, based on the results of ANOVA and pairwise comparison at $p < 0.05$ significance level.

Comparing the Galia type melons significant difference can be observed in three parameters: *Aikido* had significantly intense fermented taste, aroma and flesh color

compared to *London*. Most of the panellists had a better opinion about the *London* variety- "Sweet, fresh taste, pleasant texture" - like *Aikido* - "Slightly mild, not very tasty".

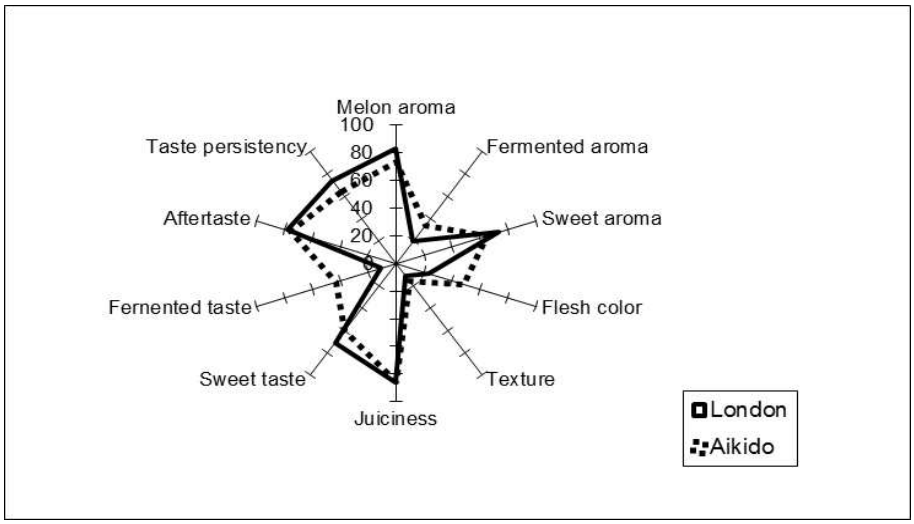

Figure 1. Results of the Galia type melon varieties

Celestial showed significantly higher fermented aroma compared to *Centro*, however, significantly higher fermented taste compared to the other two groups. Texture firmness value of *Donatello* was significantly higher compared to *Centro* and *Celestial*, while *Centro* showed significantly lower juiciness compared to the two other variety.

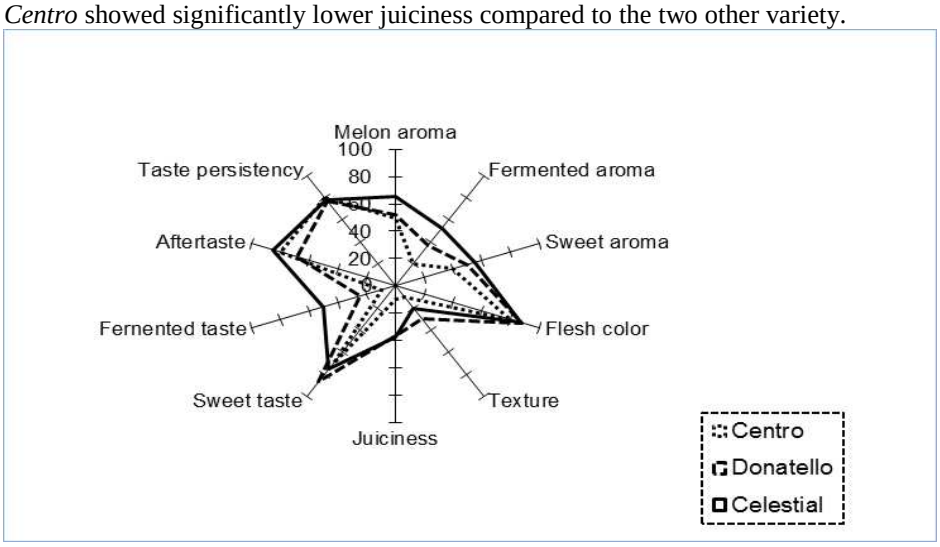

Figure 2. Results of the Cantaloupe type melon varieties

In case of *Centro* variety the following comments were recorded from the panellists "watery," "Excellent texture, but weak sweet taste intensity". This graph also shows that, among the three varieties, the *Centro* has a sweet taste, odor and melon flavor. The watery taste, and the lack of sweet taste, also suggests that in case of *Centro* vareitey the characteristic taste and odor qualities are missing.

Main findings

In the present experiment conducted in 2019 we compared the sensory profiles of different melon (*Cucumis melo* L.) varieties (*Centro, Donatello, Celestial, London, Aikido*). The major conclusions are the followings: in case of Celestial, *Donatello, Centro* Cantaloupe type melons we concluded that *Celestial* showed significantly higher fermented aroma compared to *Centro*. Texture value of *Donatello* was significantly higher compared to *Centro* and *Celestial*, while *Centro* showed significantly lower juiciness compared to the two other variety. *Aikido* had significantly intense fermented taste, aroma and flesh colour compared to *London*. Most of the panellists had a better opinion about the London variety.

Summary

Melon (*Cucumis melo* L.) is a relevant member of the Cucurbitaceae family, its cultivation has a long history in Hungary. Examinations were performed from late summer to autumn in 2019. Experimental samples were gathered from several farmers. Altogether five melon varieties were examined, three orange-fleshed Cantaloupe type (*Celestial, Donatello, Centro*) and two green-fleshed Galia type (*Aikido, London*). Samples were prepared 30 min before testing. First, the sensory attributes and their corresponding reference values were determined, in order to reduce the variation in the resulting dataset. Then, sensory profile tests were performed according to ISO 13299 standard. Tests were implemented in accordance with ISO 6658, and differences between data were evaluated with univariate ANOVA and Fisher LSD significance level evaluation procedures. We found signifcant differences between the different varieties, most of the panelists had a better opinion about the *London* variety.

Keywords: melon, Galia, Cantaloupe, sensory evaluation

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Sensory quality of different Galia and Cantaloupe type melon varieties

Abstract

The melon (*Cucumis melo* L.) is a relevant member of the Cucurbitaceae family, its cultivation has a long history in Hungary. Examinations were performed from late summer to autumn in 2019. Experimental samples were gathered from several farmers. Altogether five melon varieties were examined, three orange-fleshed Cantaloupe type (*Celestial, Donatello, Centro*) and two green-fleshed Galia type (*Aikido, London*). Samples were prepared 30 min before tasting. First, the sensory attributes and their corresponding reference values were determined, in order to reduce the variation in the resulting dataset. Then, sensory profile tests were performed according to ISO 13299 standard. Tests were implemented in accordance with ISO 6658, and differences between data were evaluated with univariate ANOVA and Fisher LSD procedures. We found significant differences between the varieties, in general most of the panellists had a better opinion about the *London* variety.

Keywords: melon, Galia, Cantaloupe, sensory evaluation

THE EFFECTIVENESS OF THE ARBUSCULAR MYCORRHIZA TO INCREASE THE DROUGHT STRESS TOLERANCE IN TOMATO CROP *(SOLANUM LYCOPERSICUM.L)*: A RE-VIEW

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Introduction

Attaining the agricultural aims by high production of vegetable with both quality and quantity, the farmers attempt to find an effective substitution and environmentally-friendly methods to monitor the environmental conditions, create healthy and fertile soil which plays an important role in the generative and vegetative phase of the plants.

Using biological practices such as crop rotation and biological control by mycorrhiza which naturally occur in the soil as a microorganism or apply it in different ways to the plants. AM is a fungus which is forming a symbiotic relationship with up to 80% of earthen plant species. AM is found with the most main vegetable crops families around the world which are highly consumed by the humans for example solanaceae family mainly tomato (*Solanum lycopersicum*. L) which is considered as a main crop in all regions; by a mutualistic symbiosis where the plant gets the minerals through the fungal mycelium (mycotrophism) while the fungus takes the carbon compound from the host plant`s photosynthesis.

Due to the beneficial association between the AM and the plant, which have been proven by many experiments, the inoculated plants with AM are more tolerant to environmental stresses, including both biotic and abiotic stresses. One of the most critical abiotic stresses to horticultural plants is the drought stress, due to water scarcity caused by global warming and more difficult available water resources around the world. Also soil texture plays an important role to the availability of water to plant.

In case of tomato (*Solanum lycopersicum*. L), several experiments have been made to study the effect of the mycorrhizal inoculation to increase the drought stress tolerance in the inoculated tomato plants. These studies concluded that due to the stress influence on the plant there is a changing in the plant physiology to tolerate the stress, for instance, promote the stomatal regulation and root hydraulic conductivity which leads to increase the water and important nutrients absorption by the plant.

General connotations about AM symbiosis

The mutualistic association is known as AM, with some soil fungi have been recognized for more than 400 million years with the plants (Pozo et al., 2007). AM belong to phylum *Glomeromycota* (Kosuta et al., 2005; Pellegrino et al., 2010; Geel et al., 2016; Jamiołkowska et al., 2018; Sakha et al., 2019). The symbiosis between mycorrhizal fungi and plant roots was important in the development of land plants and currently take place with at least 80-90% of all plant species (Azcbn et al.,1997; Kosuta et al.,2005; Füzy et al.,2006; Gosling et al.,2006; Pellegrino et al.,2010; Schmidt et al.,2010; Krishnakumar et al.,2013; Geel et al.,2016; Jamiołkowska et al.,2017; Varma et

al.,2017; Sheng et al., 2017; Jamiołkowska et al.,2018; Bahadur et al.,2019; Garcı´a et al.,2020).

AM fungi are everywhere vastly disseminated in soil ecosystems and nowadays deem as an environmentally way to acquire the former objects, which are represented by the bio stimulant functions demonstrated by AM fungi (Rouphael et al., 2015). Through this interaction the AM boost the plant to absorb more nutrients; especially necessary nutrients for plant growth such as P, Cu, Zn, N, K and water, by the fungal hyphae which is developed further than the nutrient depletion zone (Azcbn et al.,1997; Hodge et al., 2001; Gosling et al.,2006; Schmidt et al.,2010; Pellegrino et al.,2010; Ortas,2012; Marschner, 2012; Rouphael et al.,2015).

The fungi colonize the root cortex and grow an extra-vascular mycelium which helps to obtain the minerals from the soil by the plant. This combination is usually considered a mutualistic symbiosis because of the highly interdependent relationship founded between both partners, where the host plant gets mineral nutrients via fungal mycelium (mycotrophism), while the heterotrophic fungus takes carbon compounds from the host's photosynthesis (Azbon et al.;1997, Krishnakumar et al.,2013). The coexistence of mycorrhiza stimulates resistance mechanisms in mycorrhiza plants after exposure to abiotic stresses, for example, well-documented for drought, salinity and pollution (Lenoir et al.,2016).

AM and drought stress

Drought stress is defined as the minimum water amount which is needed by the plant and can't be available in the root zone. In this case the plant response depends on several factors such as growth phase, stress severity, duration and genetic pattern. Common symptoms of water shortage are stunted growth, reduction of carbon dioxide emissions to green plastids due to the closure of stomata, low photosynthesis and accelerated leaf senescence.

One of the biochemical changes that occur when plants are exposed to harmful stress conditions is the accumulation of ROS*, such as hydrogen peroxide (H_2O_2), hydroxyl radical (OH) and singlet oxygen (O_1), which are inevitable by products for normal cell metabolism (Sohrabia et al., 2012). As a result of this, according to many literatures there is considerable evidence to propose that AM can increase the host plant's tolerance to water stress by changing the plant physiology in a way that treat the drought stress conditions (Hamed et al.,2011). For example, increased root hydraulic conductivity (Posta et al., 2019), improved stomatal regulation, osmotic adjustment of the host and improved contact with soil particles through the binding effect of hyphae (Begum et al., 2019), enabling water to be extracted from smaller pores (Auge´ et al., 2004). Often both water and nutrient uptake are higher in drought- stressed mycorrhizal plants than in non-mycorrhizal plants (Gosling et al., 2006). Numerous vegetable crops were studied to understand the mechanism by the arbusculr symbiosis where the plant can be more tolerant to the drought stress through the mycorrhizal mechanism and many literatures observed this.

Wang et al. (2014) who demonstrated that the colonization of processing tomato (*Solanum lycopersicum*. L) 'Regal 87-5' plants by *F. mosseae a*nd *G. versi-forme* could increase marketable yield by 20% and 32% respectively, compared with those of non-inoculated plants under slight and heavy drought stress conditions. This aspect can be

remarkable because of the nutrient availability; can ameliorate plant tolerance to the drought stress for better formation (Posta et al., 2019). In another study prepared at Szent István University, Gödöllő in a two years' open field experiment (2013 and 2014). The study was carried out to investigate the effect of the AM on various water supply levels on yield parameters, carotenoids concentration. There was a significant effect on yield quantity where it was high in 2013 than 2014 with a consideration of the precipitation and the temperature, while carotenoids accumulation in 2014 was the highest (Helyes et al., 2017). Also the efficiency of the host plant in water uptake will rise (Omirou et al., 2013; Bakr et al., 2017), biomass production and the nutrient uptake mainly phosphorus will escalate (Bakr et al., 2018). The plant secondary metabolism leading to improved nutraceutical compounds which can confer the tolerance to the drought and adverse chemical soil conditions (Rouphael et al., 2015). Emphasized to this, (Sheng et al. ,2017) in their experiment concluded that the inoculation of tomato (*Solanum lycopersicum.* L) by *Glomus spp.* lead to water and nutrient absorption, which can be referred to the increase of the transpiration and stomatal conductance (Augé, 2001).

Treatment with AM species had advantages on the seeds. Ortas in 2012 made experiment on tomato (*Solanum lycopersicum*. L) to see if there is a relation between the inoculated seed and the efficiency of the inoculation, he found that *(G. clarum)* one of the efficient inoculum. In general, a mixture of (G. *clarum*, *G. mosseae*, *G. caledonium*, *G. intraradices* and *G. etunicatum)* significantly colonized plant roots. Other study done by Baker et al., 2017 observed the influence of the AM on the tomato seedlings, in this study; they used Symbivit® mycorrhizal inoculum on (*Lycopersicum esculentum* Mill. 'Uno rosso F1'). This inoculum consists of mixture of (*G. mosseae*, *G. etunicatum*, *G. claroideum*, *G. micro aggregatum*, *G. geosporum*, and *R. irregularis*) manufactured by Symbiom

Ltd (Czech Republic, www.symbiom.cz). The amount of the inoculum which is used is 25 grams Symbivit per liter substrate; the seedlings were subjected to three irrigation regimes: Amply irrigation (IR100), water deficit irrigation (IR50) and non-irrigated (IR_0) depending on crop daily water requirement and by adjusting the irrigation water amount. The influence of water availability, mycorrhizal inoculation, water used efficiency (WUE), their interaction to the plants` growth, fruit quality and quantity was determined. The mycorrhizal plants performed better growth and high water used efficiency (WUE) compared to control plants.

The mycorrhizal Inoculation increased the yield (11%) in IR_0, (9%) in IR100 and the highest yield raised by (59%) in IR50. Water supply increased the yield from (65 t ha^{-1}) to (85 t ha^{-1}) and resulted in a (0.5) ^{o}Brix lose. However, mycorrhizal inoculation slightly enhanced the ^{o}Brix in marketable fruits. In addition to this, Tomato (*Solanum lycopersicum.* L) is most sensitive to water deficiency at fruit setting and intensive fruit development periods. Early flowering of tomato (*Solanum lycopersicum*. L) with water scarcity can cause flower shedding, while during fruit set, the plant will produce a small-sized fruit (Nemeskéri et al. 2019).

ROS*: Reactive oxygen species that is accumulated in the arbuscular mycorrhiza from many crops like *Zea mays*, *Medicago truncatula* and *Nicotiana tabacum*, the accumulation of extra radical hyphae and spores of *Glomus intraradices* in a small level of ROS within their cell wall and produced ROS within the cytoplasm in response to stress (Fester;2005).

Conclusion

The efficacy of the AM symbiotic relationship with the plants and activity is influenced by various mechanisms that contribute to each other. For instance, the association between the AM and the host plant, the relation and the effect of other microbes that can be found in the soil. Which can compete with the AM in water and nutrients especially, the phosphorus which is so important for the plant growth. The studies can describe better how the mutualistic symbiosis can help the plant to tolerate the environmental stress mainly the drought stress. Furthermore, concentrate on the mechanisms and the physiological changes in the inoculated plants. The studies should be done on a large scale experiment in an open field with many repetitions with different AM strains to give more realistic results. Also to detect which AM fungi strain is good to use in the inoculation, make several experiments on different horticultural crops including different plant stages starting from seed level. Flowering and the fruit set which they are important and consumed all over the world whole year, so the farmers can achieve the highest profit with high production.

Keywords: AM, inoculation, vegetable, abiotic stress, drought stress, tolerance, mycotrophism, tomato (*Solanum lycopersicum*. L), horticultural plants.

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The effectiveness of the arbuscular mycorrhiza to increase the drought stress tolerance in tomato crop (*Solanum lycopersicum L.*): a re-wiew

Abstract

For higher quality and quantity of vegetables, the farmers attempt to find an effective substitution, environmentally-friendly methods to monitor environmental conditions. Create healthy and fertile soil which plays an important role in the generative and vegetative phase of the plants. This is done by using biological; practices such as crop rotation, control by mycorrhiza, which naturally occur in the soil as a microorganism. Arbuscular mycorrhiza (AM) is a fungus which is forming a symbiotic relationship with up to 80% of earthen plant species. AM is found with the most main vegetable crops families around the world, which are highly consumed by humans such as solanaceae family especially, tomato (*Solanum lycopersicum*. L) crop; by a mutualistic symbiosis, where the plant gets minerals through fungal mycelium (mycotrophism), while fungus takes the carbon compound from the photosynthesis of host plant.

Due to the beneficial association between the AM and the plant, which have been proven by many experiments, the inoculated plants with AM are more tolerant to environmental stresses, including both biotic and abiotic stresses. One of the most critical abiotic stresses to horticultural plants is the drought stress, due to water scarcity caused by global warming and more difficult available water resources around the world. Also soil texture plays an important role to the availability of water to plant.

According to many experiments which were made on the effects on the mycorrhizal inoculation due to drought stress tolerance on tomato (*Solanum lycopersicum*. L). The results of these experiments shows that the plant can tolerate the drought stress by changing the plant physiology, for instance, increased in root hydraulic conductivity, enhance stomatal regulation and soil particles through the binding effect of hyphae, this lead to raise water and nutrient absorption efficiency by the plant. AM inoculation can aid to increase yield quality and quantity which rise vegetable production in all growing conditions.

Keywords: AM, inoculation, vegetable, abiotic stress, drought stress, tolerance, mycotrophism, tomato (*Solanum lycopersicum*. L), horticultural plants.

REVIEW OF LED LIGHTING FOR LEAFY VEGETABLES PRODUCED IN CLOSED PLANT PRODUCTION SYSTEMS

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Introduction

Plant production in vertical growing systems, completely separated from their environment and equipped with artificial lighting, is getting more and more popular nowadays. Number of these so called PFAL (Plant Factory with Artificial Lighting) farms has exceeded 500 in 2018 and new projects are planned around the world (Kozai 2018). Presently, the very high investment and production costs, the relatively low light intensity (usually under 250 μmol/m^2/s), the need for high harvest index and for added value, the lack of space (less than 50 cm between the shelves) narrow the economically cultivable cultures to leafy vegetables, microgreens, herbs and transplants in these facilities, with the first group being the most important one (Stanghellini et al. 2019).
Recently, light-emitting diodes (LEDs) have become the main light source in PFALs, due to their energy efficiency and several other advantageous characteristics (Sipos et al. 2017, Meng et al. 2020). It was demonstrated in several experiments that plants can be successfully grown with narrow waveband LEDs as sole lighting source (Nicole et al. 2016). As photosynthesis, secondary metabolism and plant morphology are affected by spectral distribution, intensity and duration of light, application of sole source LED lighting provides the possibility to develop and employ the optimal light recipe for a given species, or even for a given cultivar type, in order to achieve high yield with excellent external and nutritional quality (Meng and Runkle, 2019).
The objective of this present publication is to summarise results of previous experiments carried out with LED lighting for leafy vegetables.

Spectral distribution

It is well established that not all wavelength affects plant growth and accumulation of phytochemicals equally (McCree 1971, Bian et al. 2015). Hence, spectral distribution of LED lighting has considerable effects on growth and nutrient content of plants. It was demonstrated in several leafy vegetable studies that with the combination of narrow spectrum red and blue LEDs higher yield can be achieved than with fluorescent lamps or white LEDs (Kim et al. 2004, Stutte et al. 2009, Lin et al. 2013, Mickens et al. 2019). Jishi et al. (2016) have discovered that plant growth even can be promoted by temporally shifting the irradiation hours of blue and red LED lights. The longer monochromatic periods gave better results.
Photosynthetic rate is the highest under **red light** (McCree, 1971) and red lighting enhances growth rate of leaves the most (Stutte et al. 2009, Chen et al. 2014). Experimenting with lettuce, basil and dill, Ahlman et al. (2016) have found that on

photon flux density base, red light (660 nm) was more effective for gross photosynthetic rate than blue and green. Goto et al. (2014) have achieved the highest photosynthetic rate in butterhead lettuce with monochromatic red light. Johkan et al. (2010) have also produced the highest red leaf lettuce head weight under monochromatic red light (660 nm), however red coloration did not develop in those plants. Hence, several authors have noted that it is worth to supplement the red light with other wavebands, especially with blue one (Stutte et al. 2009, Chen et al. 2014, Pardo et al. 2014). Meanwhile, Nicole et al. (2017a) have demonstrated, that 100% red light applied for 2-5 days before harvest significantly reduced nitrate content. Red supplemental lighting was also found to increase phenolic content of lettuce (Li and Kubota, 2009).

Blue lighting decreased length of the hypocotyl and resulted in very compact plants in several studies (Li and Kubota 2009, Johkan et al. 2010, Chen et al. 2014). On the contrary, others have found that for some cultivars, monochromatic blue light was advantageous and produced the highest fresh weight among the treatments (Heo et al. 2012, Pardo et al. 2014). Blue light was also found to enhance anthocyanin synthesis, hence improving red coloration, and to increase chlorophyll and carotenoid contents of the leaves (Li and Kubota 2009, Stutte et al. 2009, Johkan et al. 2010, Kobayashi et al. 2013, Son and Oh 2013, Nicole et al. 2016, Meng and Runkle 2019). Antioxidant capacity, total phenolic and flavonoid concentrations were also promoted by blue lighting (Son and Oh, 2013). However, blue light did not improve fresh and dry weight (Li and Kubota 2009, Kobayashi et al. 2013, Son and Oh 2013, Meng et al. 2020).

Optimal **ratio of blue and red lights** in PFALs is under extensive research. Applying six different blue:red ratios for producing leaf lettuces Son and Oh (2013) have found that 0% blue was the best for fresh weight production and 47% the best for nutritive value. Photosynthetic activity of butterhead lettuce and red perilla also reacted well to higher red ratio, while it did not affect growth of green perilla (Goto et al. 2014). Based on findings of Yorio et al. (2001) and Matsuda et al. (2007) it seems that spinach needs higher blue light ratio than lettuce, 10% is not enough for ensuring optimal growth rate. Nicole et al. (2017b) have found that light recipe with a high blue content (35%) improves shelf life. While selecting the optimal blue:red ratio a compromise should be found between growth rate and nutrient content. For red leaf lettuce production Chung et al. (2018) have proposed a 20% blue and 80% red ratio for the first five weeks, and an 80% blue and 20% red ratio for the last week, as the optimum light recipe.

Addition of other wavebands to the blue-red combination was found to improve fresh weight of leafy vegetables, while often resulting inferior coloration and nutritive content (Kim et al. 2004, Park et al. 2012, Lin et al. 2013, Mickens et al. 2018). **Green lighting** has got the most attention recently. Meng et al. (2019) assumed that substituting green radiation for blue light promotes biomass accumulation through increased radiation interception. Bian et al. (2016) have reduced nitrate content in lettuce by adding continuous green light treatment to red and blue lights. They have suggested a 4:1:1 red, blue and green ratio. Green radiation did not influence leaf coloration and morphology in the experiment of Meng et al. (2020). They have concluded that green lighting maintains or reduces lettuce growth depending on the radiation level of blue lighting.

Although not part of the PAR range, **far red lighting** also significantly affects plant growth through improvement of photosynthetic radiation capture and phytochrome

actions. Far red supplemental lighting in 10 to 25% ratio was found to increase biomass accumulation of leafy vegetables by increasing leaf size (Stutte et al. 2009, Nicole et al. 2016, Meng and Runkle 2019). Meng and Runkle (2019) have concluded that far red effects depend on blue:red ratio and PPFD (Photosynthetic Photon Flux Density) level, being more pronounced under high blue:red ratio and low PPFD. On the other hand, far red lighting was found to reduce nutritive value and coloration of lettuce, while it did not affect chlorophyll content of basil (Li and Kubota 2009, Meng and Runkle 2019).

UV-A light supplementation has similar effects to blue lighting. It was found to increase accumulation of secondary metabolites, especially that of anthocyanins (Li and Kubota 2009, Stutte et al. 2009, Chen et al. 2019). To achieve these favourable effects, it is enough to apply UV lighting during the last 2-3 days of the production period (Goto et al. 2016). Shorter wavebands (310, 325 nm) had more pronounced effects than a longer one (340, nm) (Goto et al. 2016). Beside the favourable nutritive effects, 10 to 30 $\mu mol/m^2/s$ UV-A radiation was also found to increase biomass production of lettuce (Chen et al. 2019).

Level of radiation (PPFD)

Increasing the PPFD usually promotes plant growth. The correlation between PPFD level and net photosynthetic rate (Pn) can be described by a concave function (Jishi 2018, Meng and Runkle 2019). The contact point of a tangent drawn to the curve from the origin is where Pn/PPFD reaches its maximum. The maximum point of the curve is the light saturation point (Jishi, 2018), which is lower for leafy greens than for other vegetables (Tazawa, 1999).

Goto et al. (2014) have found that for lettuce and perilla the maximum Pn/PPFD point is around 200 $\mu mol/m^2/s$, while the light saturation point is over 800 $\mu mol/m^2/s$. For cos lettuce Jishi et al. (2018) have found that light use efficiency has declined over 200 $\mu mol/m^2/s$. Based on measurements performed at PPFD levels between 125 and 620 $\mu mol/m^2/s$. Lefsrud et al. (2006) have calculated a saturation point of 775 $\mu mol/m^2/s$ for 'Melody' spinach, with maximum Pn/PPFD point being around 200 $\mu mol/m^2/s$, based on their data. Investigating effects of PPFD levels from 110 to 540 $\mu mol/m^2/s$, 330 and 440 $\mu mol/m^2/s$ were found to be the optimum irradiance for pak choi and mustard microgreens, considering both fresh weight and nutritive content (Samouilené et al. 2013). For red perilla application of 300 $\mu mol/m^2/s$ was found to be more advantageous than lower PPFD levels (Lu et al. 2017). Li et al. (2009) showed that carotenoid content of spinach was higher at irradiation level of 300 $\mu mol/m^2/s$ than at 100 $\mu mol/m^2/s$.

The applied PPFD for leafy vegetables is lower than the saturation point to avoid photodamage and to maximize the profit (Meng and Runkle, 2019). Maximum profit can be reached with PPFD values between the maximum Pn/PPFD and the light saturation points (Jishi, 2018). Goto (2016) has recommended 200 $\mu mol/m^2/s$ PPFD for lettuce production. Bian et al. (2015) along with Lu and Shimamura (2018) have suggested to apply 200 to 300, and 100 to 300 $\mu mol/m^2/s$, respectively, for the production of leafy vegetables in PFALs.

Photoperiod

Photoperiod is the daily length of the lighting period. Published researches dealing with the effect of photoperiod of sole source LED lighting are sparse. It is generally

accepted, that until a certain limit, longer photoperiod results higher plant mass accumulation. However, continuous lighting can have negative effects, like chlorosis (Bian et al. 2018) and decreased nutrient content (Ali et al. 2009). On the other hand, preharvest continuous lighting for 48 hours has substantially improved nutritive value of leaf vegetables (Zhou et al. 2013). 10 to 18 hours photoperiod is applicable for most of the leafy vegetables; however, presently in PFAL farms usually a photoperiod of 18 to 20 hours is employed (Lu and Shimamura, 2018).

The daily light integral and the growth efficiency concepts

Daily Light Integral (DLI) expressed in mol/m^2/day unit is the multiplication of PPFD and photoperiod. DLI is one of the key characteristics for profitability calculations of PFALs. The same target DLI value can be achieved by the combination of different PPFDs and photoperiods, for example a 12 mol/m^2/day value by a PPFD of 300 µmol/m^2/s for an 11-hour photoperiod or by 210 µmol/m^2/s for 16 hours. Presently in commercial PFAL farms usually longer photoperiod with a lower PPFD is used to ensure a desired DLI value (Lu and Shimamura 2018, Uraisami 2018).
Albright et al. (2000) has recommended the application of 12 to 17 mol/m^2/day DLI for production of butterhead lettuce. Based on their own research results Nicole et al. (2016) have concluded that with sole source LED lighting DLI values over 10 mol/m^2/day can provide a good growth rate for lettuce. Goto (2015) has advised 11,5 mol/m^2/day DLI value for lettuce production.
In a PFAL optimizing the yield and energy cost means achieving the highest weight of lettuce per mol of light used. Hence, higher values of growth efficiency or photon yield, expressed in g/mol unit, indicate better efficiency (Nicole et al. 2016, Chung et al. 2018). Calculating for the whole 42-day growing period Nicole et al. (2016) have got 16 to 17 g/mol growth efficiency values for lettuce production. According to Chung et al. (2018) photon yield is greatly affected by PPFD and light quality. Ombódi et al. (2020) have found that growth efficiency of baby leaf lettuce and spinach based on dry mass production was similar at 220 and 270 µmol/m^2/s irradiance levels. However, based on fresh weight, photon yield was significantly higher with the lower PPFD value.

Conclusions

Extensive research was carried out during the last 10 to 20 years with LED lighting of leafy vegetables. It was found that there are considerable differences between the requirements of species and cultivar types. Different optimum blue light ratio of spinach and lettuce, or UV-A and blue light requirements of red coloured cultivars can be mentioned as examples. Mainly five wavebands (UV-A, blue, green, red, far red) are investigated, each having distinct effects. Based on the findings, it is worth applying higher red and far red ratio for most of the production period for ensuring higher fresh mass accumulation, but employing bigger UV-A and blue ratio during the last few days before harvest. Working with PPFD around 200 µmol/m^2/s seems to be reasonable from the standpoints of growth rate, nutritive value and growth efficiency too.

Summary

Vertical production of leafy vegetables in completely closed production systems equipped with artificial lighting is gaining ground in the developed regions of the world. Due to its advantages, LED lighting is getting more and more popular in these production systems despite its still very high investment costs. By using LED lighting, optimal light recipe, adjusted to the requirements of the given species and cultivar type, can be applied. Light recipe has three main components: spectral distribution, radiation level - expressed as photosynthetic photon flux density (PPFD) (μmol/m^2/s) - and length of the photoperiod. The letter two parameters can be expressed together as daily light integral (DLI) (mol/m^2/day). Based on the findings of extensive research activity carried out in this field during the last decade, there are comprehensive differences between the requirements of the different leafy vegetables. For example, spinach requires higher ratio of blue light than lettuce. Increased red and far red lighting contributes to higher plant mass production, while UV and blue enhances coloration and synthesis of bioactive components. Hence, it is worth changing the spectral distribution during the cultivation period if it is technically possible, especially for red-coloured cultivars. Level of the applied PPFD should be considered with the knowledge of growth efficiency (produced g fresh weight/mol). PPFD levels around 200 μmol/m^2/s usually provide satisfying results. Raising the DLI by increasing length of the photoperiod proved to be more effective than increasing light intensity. Moreover, preharvest continuous light can improve nutritional quality of the produce. DLI of 10 to 12 mol/m^2/day is recommended for lettuce production, for ensuring high growth efficiency.

Keywords: plant factory, spectral distribution, radiation level, daylength, daily light integral, growth efficiency

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COMPARISON OF LAND COVER CHANGES IN PEST AND BÉKÉS COUNTIES IN HUNGARY

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Introduction

It is estimated that almost more than one-half of the world's population is presently living in urban areas (Sakieh et al. 2016). In many parts of the world, increasing urban lands have caused changing land use and land cover (LULC) (Wu 2014).
Urban expansion is an important ecological event which mainly occurs because of increasing population. So the huge amount of valuable ecosystems such as agricultural lands, ranges and forests are destroyed and replaced with urban areas (Sakieh et al. 2014).
Rapid population growth, urbanization, land use and land cover changes have been recognized as the most important challenges for water resources management (Shrestha et al., 2018). Land use and land cover (LULC) changes modify the basin hydrology by affecting evapotranspiration, soil infiltration capacity and surface and subsurface regimes which ultimately affect water quantity and quality (Cuo et al., 2013). Moreover land use change is one of the most critical and direct driving factors of changes in ecosystem functions and services (Millennium Ecosystem Assessment (MEA), 2005b; Metzger et al., 2006; Chhabra et al., 2006; Burkhard et al., 2012; Kindu et al., 2016). It can change the ecosystem productivity, modify the physical parameters of the earth's surface, affect nutritional convey between soil and vegetation by changing biochemical cycles, and influence the element and structure of ecosystems (Huang et al., 2008; Tang et al., 2008; Zang et al., 2011).
Considering the mentioned reasons, in order to achieve sustainable development, it is necessary to detect the trend of LULC changes accurately. The results can be applied for the management and planning of land resources.
The main objective of this research is to analyze the trends of LULC changes in Pest and Békés Counties in Hungary and to detect the prominent changes in different classes of LULC maps.

Literature Review

In the last two decades, land use and land cover (LULC) change became an additional irreplaceable observation feature not only within the Europe but on a global context (Manakos and Braun, 2014), particularly in areas with high population density. Traditionally LULC is a core information layer for a variety of scientific activities and administrative tasks (e.g. hydrological modeling, climate models, land use planning). It is widely recognized that, LULC alterations are generally caused by mismanagement of agricultural, urban, range and forest lands which lead to severe environmental problems such as landslides, floods etc. (Reis, 2008).

The unplanned urbanization and increasing pressure of human activities on the hydro-geomorphologic system often results in modification of the existing ground and surface water quality (Li and Ma, 2014). Land use and land cover (LULC) changes are mainly caused by anthropogenic activities (Kilic *et al.*, 2006). Many studies have been carried out using remote sensing (RS) and geographical information system (GIS) to assess LULC changes (Singh et al., 2011). For example Hese et al. (2019) provided land use and land cover change maps for developing sustainable land management policies and practices to maintain agricultural yields and reduce ongoing processes of degradation and desertification. Lü et al (2020) determine the process and spatial pattern of land use change and quantify the spatial relations between oasis expansion and the sources of water and human disturbances in the middle reaches of the Heihe River Basin from 1990 to 2015.

Materials and methods

The study area of this research are Pest and Békés counties. Hungary is subdivided administratively into 19 counties. Pest is a county in central Hungary. It covers an area of 6,393.14 square kilometres. It surrounds the national capital Budapest, the majority of the county's population live in the suburbs of Budapest. Békés is an administrative division in south-eastern Hungary, on the border with Romania. This county has a total area of 5,630 km^2, 6.05% of Hungary.

In this study, four CORINE land cover maps of Europe were used to detect the trends of LULC changes. Land use maps of Pest and Békés Counties in Hungary for the years 1990 and 2018 were created in the Copernicus program and were analyzed using QGIS version 2.18.15. They were pre-processed first in QGIS to be of the same pixel size, coordinate system and scale. Then the entire data set was analyzed by crosstab module to obtain land cover changes in each category and to establish the trend of changes for the study area between 1990 and 2018.

Results

Table 1 shows the area of different classes of land use and land cover of Pest and Békés counties from 1990 to 2018. Figure 1 ilustrates the land use maps of Pest and Békés counties in 2018.

According to figure 2, the largest areas of Pest county belong to Agricultural areas (48.61%). There is a gradual decrease in non-irrigated arable land and permanent crops, while the area of urban fabric and artificial land are increasing from 1990 to 2018. It is apparent that parts of agricultural areas have been replaced by artificial areas within the study period. Based on the results, 10% of Non-irrigated arable land and 27% of permanant crops have reduced, also the area of urban fabric 16.5% and artificial land 46% have increased from 1990 to 2018.

According to figure 2, the largest area of Békés county is Non-irrigated arable land (81%). While the area of artificial surfaces (32%) and urban fabric (8%) have increased, the area of agricultural areas (non-irrigated arable land, rice fields, Complex cultivation patterns) have decreased (30%) from 1990 to 2018, that can be due to conversion of some parts of agricultural areas to artificial surfaces.

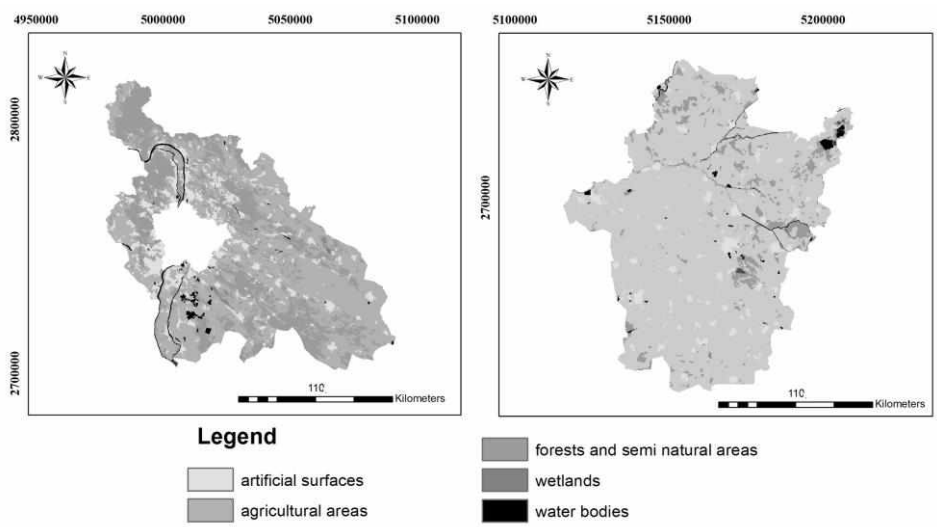

Figure 1. LULC maps of Pest (left) and Békés county, 2018

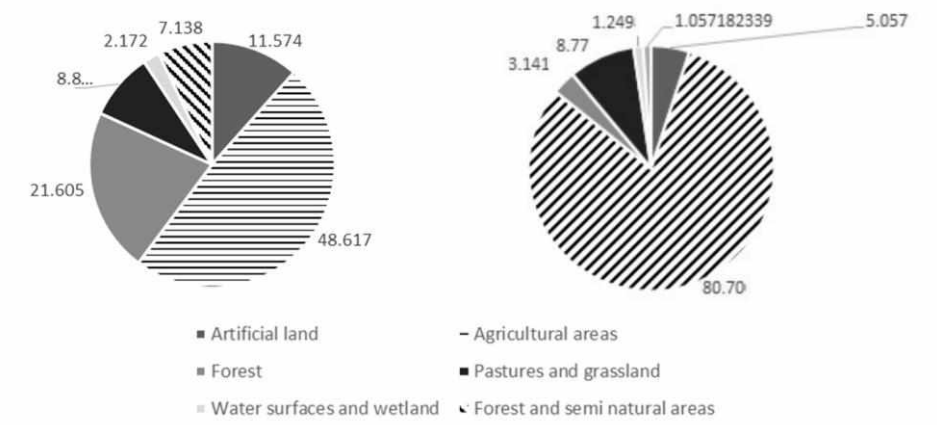

Figure 2. Percentage of different classes of land use of Pest (left) and Békés (right) county in 2018

LULC 1990-2018	1990(ha) Pest	2018(ha) Pest	Changes% Pest	1990(ha) Békés	2018(ha) Békés	Changs % Békés
urban fabric	45112	52547	1.17	21787	23437	0.29
Industrial or commercial units	3870	9067	0.81	2071	3209	0.2
Road, rail networks land	227	1225	0.16	36	27	-0.0006
Airports	1329	1334	0.0008	0	78	0.015
Mineral extraction sites	567	1119	0.09	111	180	0.013
Dump sites	153	252	0.015	72	91	0.004
Construction sites	204	559	0.05	0	0	0
Green urban areas	280	281	0.0001	378	220	-0.03
Sport and leisure facilities	7970	7557	-0.06	1130	1234	0.02
Non-irrigated arable land	298662	266833	-4.98	441294	436376	-0.87
Vineyards	6500	2723	-0.59	0	0	0
Fruit trees and berry plantations	8465	8152	-0.05	644	706	0.011
Pastures	39553	46629	1.18	29924	32021	0.37
Complex cultivation patterns	26914	22390	- 0.71	13612	8807	-0.85
Land principally occupied by agriculture, with significant areas of natural vegetation	11578	10500	-0.17	4549	4527	-0.003
Forest	139679	138028	-0.26	14647	17686	0.54
Natural grasslands	10512	9827	-0.11	16501	17362	0.15
Transitional woodland-shrub	25249	45603	3.19	3133	5953	0.5
Rice field	0	0	0	5020	3934	-0.19
Inland marshes	2561	1824	-0.12	1851	1170	-0.12
Peat bogs	948	849	-0.015	0	0	0
Water courses	6048	5888	-0.025	2813	2226	-0.1
Water bodies	2441	5318	0.45	3433	3641	0.038

Table 1. LULC area of Pest and Békés counties, 1990-2018

Main findings

The largest area of both counties is agricultural area, but 81 percent of Békés County is agricultural area and just 5 percent is urban area, while 48.6% of Pest County is agricultural area, 21% is forest and 11.5% is artificial area. The LULC change of both counties shows the increment in artificial land areas and also the reduction in non-

irrigated arable lands. Finally, it can be concluded that parts of agricultural areas have converted to artificial surfaces, that due to urbanization, the results are reasonable.

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Comparison of Land Cover Changes in Pest and Békés Counties in Hungary

Abstract

Land use and land cover (LULC) influences a number of processes included in the water cycle, such as interception, infiltration, evapotranspiration, runoff and water storage. LULC changes can have significant effects on local water resources, including water quantity and quality. The main objective of this study was to analize the changes in land cover in two Hungarian counties (Pest and Békés). The study was based on the Corine Land Cover datasets for the years 1990 and 2018. Analysis was carried out using QGIS.

Key words: CORINE, land cover, development

ASSESS THE STATUS OF THE MARSHLANDS WITH REGARDS TO INUNDATION AREA AND VEGETATION COVER USING REMOTE SENSING TEST STUDY: AL HAMMAR MARSH (IRAQ)

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Introduction

The marshes are composed of a mosaic of permanent and seasonal fans, shallow and deep-water lakes, as well as mudflats and desert landscapes that are regularly inundated during periods of high-water levels. Lying over clay soils, the marshes are extensive but shallow. Mean water depth in the permanent marshes ranges from half a meter and two meters during the dry and wet seasons, respectively, and reaches depths of up to six meters in the permanent lakes. The marshes are divided into three major units: (i) Hammar marshes; (ii) Central (Qurnah) marshes and (iii) Hawizeh marshes. The Hammar marshes are situated almost entirely south of the Euphrates, extending from near Al- Nasiriyah in the west to the outskirts of Al-Basrah on the Shatt-al-Arab in the east. To the south, along their broad mud shoreline, the Al-Hammar marshes are bordered by the sand-dune belt of the Southern Desert. When the Hammar marshes were still intact, their surface area was estimated to range from 2,800 km2 of contiguous permanent marsh and lake, to a total area of over 4,500 km2 during periods of seasonal and temporary inundation. The 120 km-long Al-Hammar Lake was formerly the largest water body in the lower Euphrates.(Center for Restoration of Iraqi Marshes, 2017).

Indeed, after over a decade of precipitous decline – by 2003, the marshlands had dwindled to less than seven per cent of their 1973 extent – a new phase of active and widespread inundation began in the spring of 2003. At the collapse of the former Iraqi regime in March 2003, local communities immediately started to dismantle drainage structures, breaching embankments and dykes, opening flood gates and sealing diversions. Satellite remote sensing was the only viable tool to observe the changes taking place on a continuous basis (Center for Restoration of Iraqi Marshes, 2017).

Objectives

The overall aim of marshland monitoring is to assess the character and success of the wetland rehabilitation process. the goal is develop a decision support system that would address the following objectives: 1. Conceive and implement a monitoring concept to systematically acquire, analyse and exchange data and information on the rapid changes taking place in the marshland environment; 2. Evaluate the magnitude and character of wetland rehabilitation

Methods

An approach combining satellite sensors to collect data at various scales and multi-temporal analysis was adopted to observe the evolution of marshland re-flooding. A novel methodology using an object-oriented approach, based on initial image segmentation followed by a multi-criteria classification, was developed and applied to MODIS and Landsat imagery.

Satellite imagery was the essential source of primary data available to map and track the evolution of marshland re-flooding. To this end, two axes of study, corresponding to the products, were pursued:

The extraction of land cover (vegetation and water) from MODIS imagery, with low spatial resolution but high time frequency. MODIS imagery is available in the public domain, The extraction of semi-detailed land cover from Landsat

Instead of the classical image interpretation procedure, whereby each pixel is classified in isolation, a novel object-oriented approach was used, in which the image was first segmented into polygonal objects, based on scale and homogeneity criteria (Song et al., 2005), with a possibility to assign weights to various layers. Fuzzy logics, and spectral, textural, shape or contextual criteria could then be applied to interactively Vegetation is separated from non-vegetation using the Normalized Difference Vegetation Index (NDVI<0.125) (Fleming, 2000); Separation between soil and water is done using medium infrared (MIR). Dark soil may be, at times, equivalent to wet soil. Other criteria are under study (McFeeters, 1996), (Huggel, Kääb, Haeberli, Teysseire, & Paul, 2002). In the vegetation category, the density criterion comes into play before the distinction between marsh and land vegetation. Density is a function of (a) number of stands per unit surface; (b) vegetation height; (c) vegetative state (greenness) and (d) type of substrate (water vs soil). This parameter is expressed as sparse (NDVI<0.125), medium (0.25 NDVI 0.50) and dense (NDVI >0.5); Discrimination between marsh and non-marsh vegetation rests on the simplified assumption that the former essentially consists of green emergent hydrophytes (Phragmites sp). Inclusion of other categories such as dry hydrophytes, xerohalophytes and halophytes is attempted only in the classification of higher-resolution imagery (IRS and Landsat). A functional system to monitor marshland re-flooding was developed, providing a synoptic spatial and temporal overview of changes in the marshland environment on a near real-time basis analysis. (UNDP, 2010).

Data collected from the MODIS, Landsat 4, 5, 7, and 8 sensors are used in this report to reconstruct the temporal changes in marshland coverage as well as health

Results

simplified land cover and inundation maps were produced, at an approximate monthly we chosen years 1991 (the marsh before deccication program, 2002 (the marsh was dry) and 2017. which included statistical analysis of water and marsh vegetation surfaces and Normalized Difference Vegetation Index (NDVI) time series.

This classification scheme is satisfactory when the reeds are in a vegetative stage (green). During the winter season, the perennial reeds go into dormancy and become dry (brown), making their spectral identification on images difficult. Hence, it is possible that part of the dry reed beds were mapped as soil, so that the winter decrease in marsh vegetation could be an artefact. Also we testing vegetaion monthly chainging to seperate the water and vegetation monthly 2003 till 2005.

Class	Criterion threshold
Non-vegetation	NDVI < 0.125
Water	MIR < 500
Soil	MIR > 500
Dry soil	Red > 2000
Wet soil or very shallow water	Red < 2000
Vegetation	NDVI > 0.125
Sparse vegetation	NDVI < 0.25
Medium vegetation	0.25 < NDVI < 0.50
Dense	NDVI > 0.50
Marsh vegetation	Albedo < 800 and MIR < 1200 and NIR < 3050

Table 1. Classification criteria

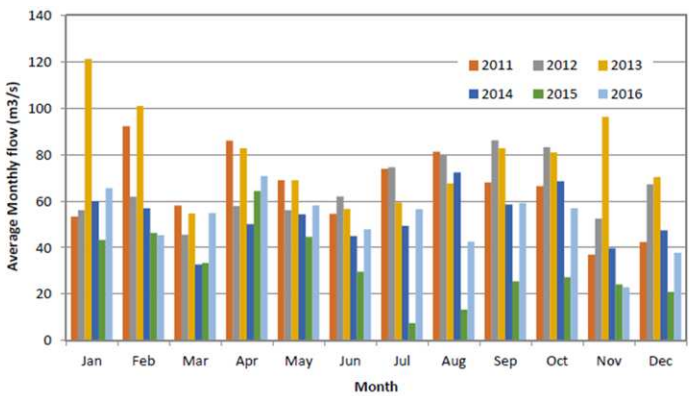

Figure 1. Hammar Marsh-Monthly Avearage flows

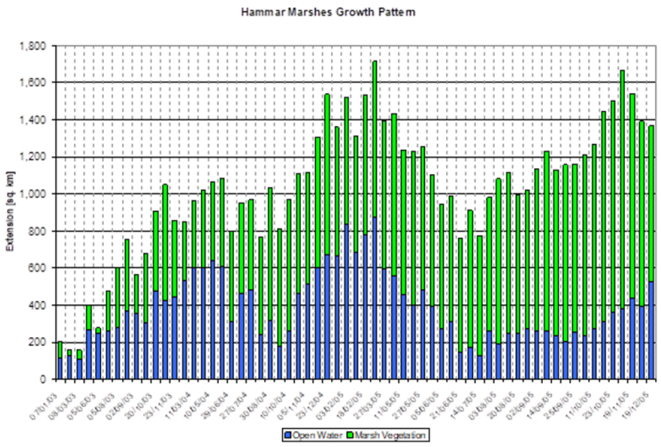

Figure 2. Hammar Marsh recovery from January 2003 to January 2006

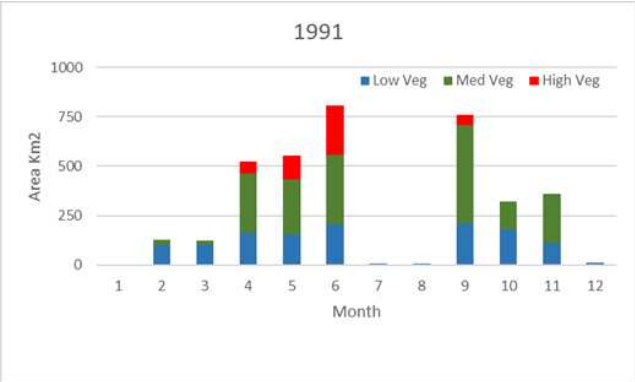

Figure 3. Hammar Marsh vegetation classification 1991

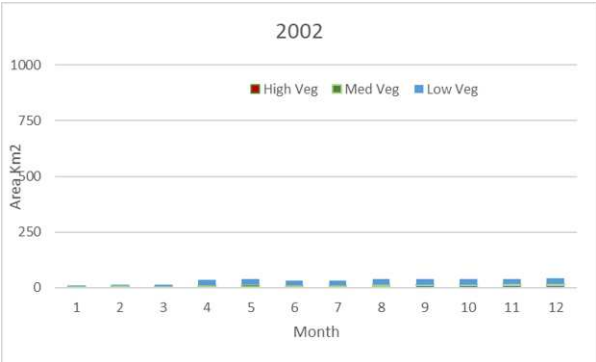

Figure 4. Hammar Marsh vegetation classification 2002, The losses of 2000 appear to be most significant in the period .

Figure 5. Hammar Marsh vegetation classification 2017

Main findings

Changes in vegetation type in the Hammar marshland: a comparison between the year 1991, 2002 and 2017. The spatial extent of the marshlands over time was assessed based on the methodology presented in Figures 3, 4 and 5. This entailed identifying first the wetted regions in each marsh by excluding all areas with an NDMI value less than zero. This region was defined as the spatial extent of the marsh in each satellite image. This areas was further divided into open water, vegetated areas, and wet but non-vegetated areas (wetted soils). Open water regions were then identified as the pixels that had NDWI values greater than zero. Non-water but wetted cells were then divided into vegetated areas and wet soils. Vegetated areas were selected as those regions that are wet (NDMI >0) and that have an NDVI value greater than 0.125. Non-vegetated wet soils in the marshlands were identified as the regions with NDMI above zero, NDWI below zero, and an NDVI below 0.125. Vegetated areas were further classified into densely vegetated, medium density vegetation, and low density vegetation based on the UNEP defined NDVI threshold.

Summary

In conclusion remote sensing and GIS technologies coupled with computer modelling are useful tools in providing a solution for future water resources planning and management to government, analyse and exchange data and information on the rapid changes taking place in the marshland environment. Given the vast size of the Iraqi marshlands and the prevailing security conditions, remote sensing was the only practical approach to observe their evolution.

Recommendations

The criteria for the separation of water and wet soils, of marsh and terrestrial vegetation, and of hydrophytes and other marsh vegetation should be refined. Field data such as photos and vegetation cover descriptions should be integrated more fully into the classification process.

Key words: Marshlands, Remote sensing, NDVI.

Acknowledgments:

This publication is created in number EFOP-3.6.1-16-2016-00016 The specialise of the SZIU Campus of Szarvas research and training profile with intelligent specialization in the themes of water management, hydroculture, precision mechanical engineering, alternative crop production

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Assess the Status of The Marshlands with Regards to Inundation Area and Vegetation Cover Using Remote Sensing Test Study: Al Hammar Marsh (Iraq)

Abstract

The Iraqi Marshlands are the largest wetland in Southwest Asia. Historically, they The Iraqi Marshlands are the largest wetland in Southwest Asia. Historically, they extended over more than 20,000 km2, the Euphrates river, like many other large river systems, have experienced major changes in their landcover and landuses over-time, as a result of major anthropogenic interventions within their contributing areas. These changes have negatively impacted the marshlands both with regards to water availability and water quality. In an effort to capture the impact of these changes on the marshlands, the use of remotely sensed data collected through the Landsat program becomes critical. Remotely sensed data are optimal to cover the large spatial extent of the Iraqi marshlands and to overcome issues related with the limited accessibility to certain regions of the marshlands. Data collected from the MODIS, Landsat 4, 5, 7, and 8 sensors are used in this report to reconstruct the temporal changes in marshland coverage as well as health. Results enable to better plan inundation schedules and restoration efforts. The main objective of study to examination the status of the marshlands with regards to inundation area and vegetation cover was also assessed through the use of Landsat-based remote sensing. The analysis quantifies the spatio-temporal changes that have occurred in marshland over the past 30 years. The analysis was based on tracking changes in water coverage, wetness extent, and changes in vegetation indices. Moreover, water quality and quantity of the main sources feeding the marshes were also examined in an effort to establish correlations between marshland coverage and anthropogenic alterations. Assessing the current health of the marshes using remote sensing, water quality and quantity data. The vegetation density across four years, namely 1991, 2000, and 2017, one can see the dramatic decline that the Al Hammar experienced in the year 2000 both the marshland as well as its core appear to have lost all vegetation. The impact of the marsh restoration appears in the 2008 and 2017 vegetation coverages. Yet, at the marshland level once can still see that the 2017 vegetation coverage is still lower than that of 1991. Moreover, the composition of the vegetation appears to have experienced a change, whereby the levels of high and medium density vegetation appear to have dropped as compared to the sparsely vegetated. Note that the degradation in the core areas was less pronounced than that of the marsh. This shows that the recovery of the marshland has been able to reverse the dramatic degradation seen in 2002; yet the vegetated areas are still lower than those preceding the year 2002. Recovery in the core region appears to have be more robust as expected.

Key words: Marshlands, Remote sensing, NDVI.

THE EFFECT OF DIFFERENT WATER SUPPLY ON THE YIELD AND SOLUBLE SOLIDS CONTENT OF OPEN FIELD TOMATO

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Introduction

Tomato is one of the most widely consumed vegetables in the world, and as a result, its production is also increasing. The success of its cultivation depends mainly on the weather in the case of field crops. The amount and time distribution of precipitation varies from year to year, so cultivation without irrigation is risky.
In this paper, the effect of water supply on the yield and soluble solids content of open field processing tomato was examined.

Literature Review

Irrigation techniques should be an important part of tomato cultivation technology (Nangare et al., 2016). A negative effect of over irrigation on shoot growth was observed (Fiebig and Dodd, 2016). According to the monitoring of Pék et al. (2014) irrigated tomato plants produced higher marketable yields than non-irrigated ones. A definite yield-increasing effect of irrigation has been observed by Le et al. (2018), when the total water supply is between 300-500 mm. Birhanu and Tilahun (2010) found that with the increase in water shortage stress, the total biomass of tomato decreases and the soluble solids content of the fruit increases

Methods

The field experiment was carried out in Szarvas, on the experimental area (School Land) of Szent István University in 2018 and 2019. Processing tomato was grown under field conditions in an irrigation experiment. Soil type was chernozem meadow (physical texture was clay-loam) with 3% humus content and pH 6.68. The amount of nutrients: NO_3-N + NO_2-N: 9.87 mg/kg; P_2O_5> 700 mg/kg; K_2O > 600 mg/kg. The examined processing tomato hybrid was UG812J, with a plant density of 3.57 plant/m^2. Planting and harvesting dates were May 8th - August 15th in 2018, and May 17th –August 28th in 2019. On the experimental area (0.5 ha) 4 water supply treatments were set up on 50 × 25 m plots.
The irrigation was performed with a precision centre pivot irrigation system. Treatments are marked with: K; I_1; I_2; I_3. The I_3 treatment received the same water supply as potential evapotranspiration (PET) (I_3 = 100% PET). PET was calculated using the AquaCrop model (according to Penman-Monteith method). Lower water supply treatments received smaller proportion of I_3.
The original concept was to irrigate the 50%, 75% and 100% of PET, but the weather, the precipitation and plant protection events modified these ratios. The actual irrigation

water amounts were 131 mm, 170 mm and 213 mm in the I1, I2 and I3 treatments respectively in 2018 and 81, 108 and 135 mm in 2019. Control (K) received only the amount of water by the precipitation besides the required irrigation (irrigation right after planting, irrigation after fertilization events to wash off fertilizer from leaves).
Precipitation during the growing season was 127 mm in 2018 and 257 mm in 2019. Sum of precipitation + irrigation water during growing season in different treatments were as follows: 2018: K: 171 mm; I_1: 258 mm; I_2: 297 mm; I_3: 340 mm; 2019: K: 284mm; I_1: 338 mm; I_2: 365 mm; I_3: 392 mm.
The amount of NPK active substance applied in 2018: N: 137 kg/ha; P: 69 kg/ha; K: 174 kg/ha; in 2019: N: 129 kg/ha; P: 89 kg/ha; K: 317 kg/ha, and in 2019: N: 129 kg/ha; P: 89 kg/ha; K: 317 kg/ha.
During the measurement, three size fractions were analyzed, and the data averaged over 3 replicates. The soluble solids content was measured with a refractometer.

Results

In 2018 and 2019, the effects of four water supply levels on tomato raw biomass production, fruit yield and soluble solids content were examined. From each treatment 13 plants were sampled. All fruits were classified into quality categories (red, green, non-marketable) and the red (marketable) fruits were grouped by size (weight of fruits, number of fruits). The marketable fruits were classified into 3 fractions. The small fruits are about 3 cm or less in diameter, medium-sized ones are larger than 3 cm and smaller than 4.5 cm, and the big ones are larger than 4.5 cm.

Results for 2018:

2018 was a dry, warm year *(Figure 1).* Precipitation during the growing season was only 127 mm, and it was 338 mm outside the growing season (01 October, 2017 – 07 May, 2018)

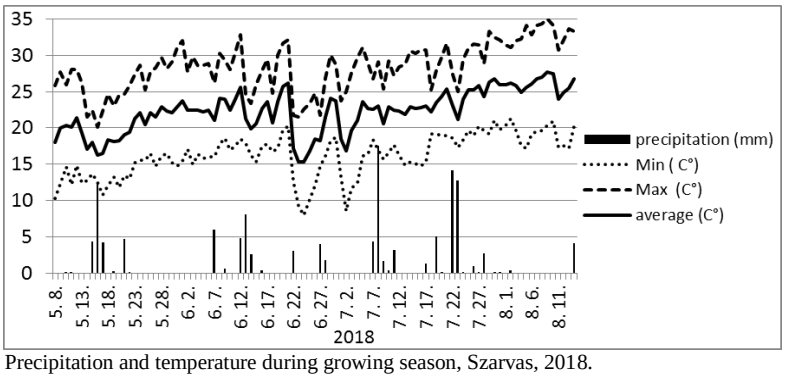

Figure 1. Precipitation and temperature during growing season, Szarvas, 2018.

The given irrigation water doses were 44; 131; 170 and 213 mm in the K, I1, I2 and I3, respectively. Irrigation water applied in the I_3 treatment more than doubled the biomass weight and almost tripled the total fruit yield compared to control treatment. Regarding the ratio of total fruit production to the stem, the total amount of fruit production increased more than the weight of the stem due to the increasing water supply *(Table 1).*

treatment	biomass	total fruit yield	stem	total fruit yield	stem
	kg/m^2			%	
K	6,00	4,68	1,31	78	22
I_1	8,46	6,64	1,82	77	23
I_2	9,92	8,07	1,85	81	19
I_3	13,46	11,57	1,91	84	16

Table 1. Means of the measured tomato biomass, total fruit production and stem (kg/m^2), Szarvas, 2018.

The summarized weight and number of red (marketable) fruits increased *(Figure 2, Table 2).* The amount of red fruits increased from 31.1 t/ha to 90.3 t/ha with increasing irrigation water doses. The proportion of non-marketable fruits was the highest in the control and in the I3 water supply treatment.

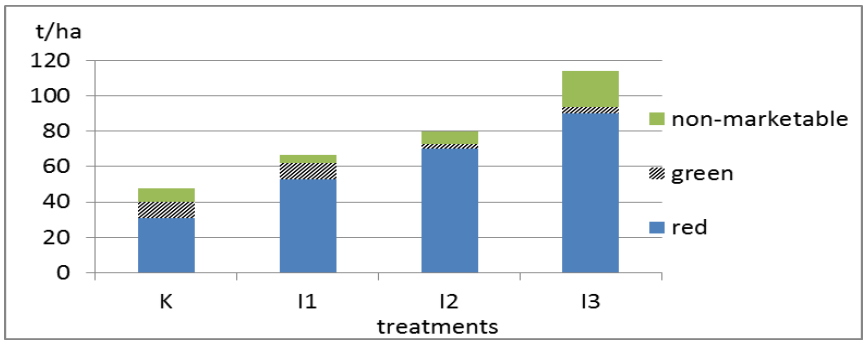

Figure 2. Quality distribution of tomato fruits in water supply treatments (t/ha). Szarvas, 2018.

	pcs/m2			
	K	I_1	I_2	I_3
red	89	136	155	172
green	47	49	20	16
non-marketable	44	28	22	58
total	180	213	197	245

Table 2. Quality distribution of total tomato fruit production in water supply treatments (pieces/m^2). Szarvas, 2018.

Examining the size distribution of red tomato fruits, it can be stated that the increase in the total weight of fruits was mainly due to the increase in the number of medium and large sized fruits *(Figure 3, Table 3).*

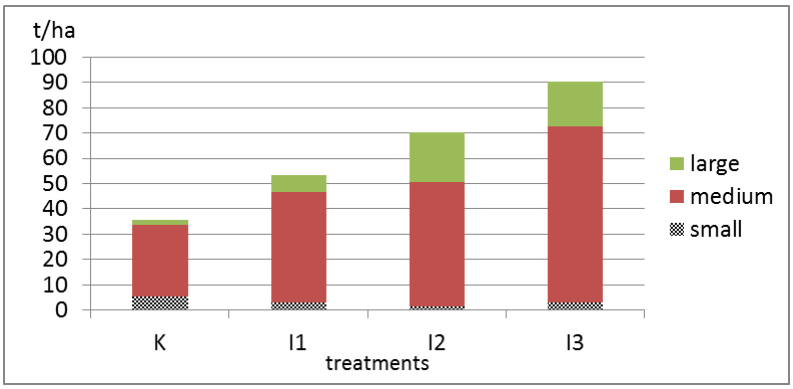

Figure 3. Size changes of red tomato fruits in water supply treatments (t/ha), Szarvas, 2018.

	pcs/m2			
	K	**I_1**	**I_2**	**I_3**
small	6	16	10	15
medium	79	107	113	157
large	5	13	32	29
total	89	136	155	172

Table 3. Size changes of red tomato fruits in water supply treatments (peace/m^2). Szarvas, 2018.

Results of 2019

The year 2019 was wetter than the year 2018 *(Figure 4).* During the growing season, twice as much precipitation (257 mm) was recorded as in the previous year, and outside the growing season 271 mm fell (1 October 2018 - 16 May 2019). In K, I_1, I_2, and I_3 treatment, the irrigation water doses given were 27; 81; 108 and 135 mm.

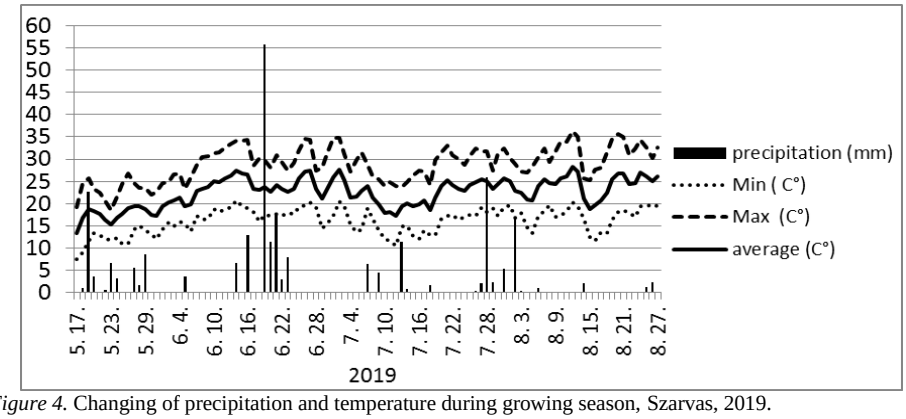

Figure 4. Changing of precipitation and temperature during growing season, Szarvas, 2019.

With the increase in water supply, the biomass and total fruit yields increased this year as well *(Table 4)*, but compared to control, the rise is not as high as in 2018.

treatment	biomass	total fruit yield	stem	total fruit yield	stem
	kg/m2			%	
K	10,67	8,78	1,89	82	18
I_1	11,53	9,94	1,59	86	14
I_2	13,17	11,46	1,71	87	13
I_3	12,89	10,10	2,78	78	22

Table 4. Tomato biomass, stem and fruit in water supply treatments (kg/m^2), Szarvas, 2019.

In the I_3 treatment which received the most irrigation water, the total fruit yield or the proportion of marketable (red) fruits within the total fruit yield did not further increase in this wetter year, compared to I_2 treatment *(Figure 5).*

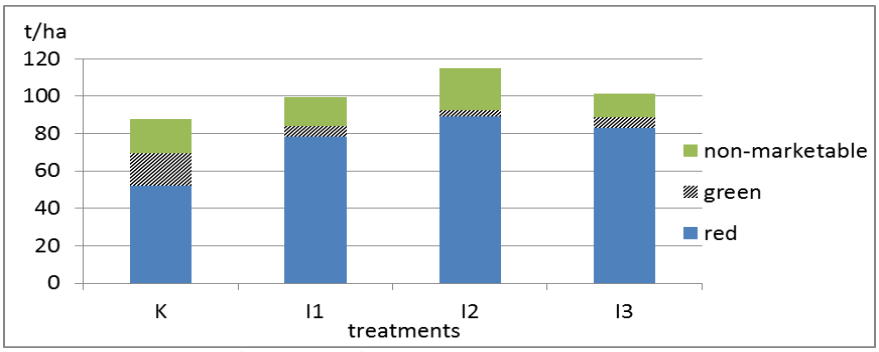

Figure 5. Quality distribution of total tomato fruit yield in water supply treatments (t/ha), Szarvas, 2019.

The highest marketable yield was measured in the treatment I_2 (89 t/ha), which received a water supply of 365 mm. The marketable yield increased by 37.8 t/ha compared to the control in this treatment.
The marketable (red) fruits were further divided into 3 groups by diameter, the results of classification are shown in *Figure 6.*

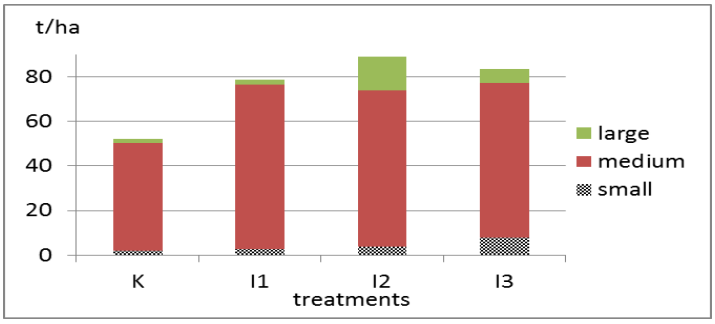

Figure 6. Size distribution of red tomato fruits in water supply treatments (t/ha), Szarvas, 2019.

Regarding the size distribution of red fruits, the weight of medium-sized (3-4.5 cm diameter) fruits increased significantly compared to the control (from 48 t/ha to 70 t/ha)

as water supply improved. The proportion of large fruits also increased as a result of increasing water supply (1.7; 2.1; 15.2 and 6.1 t/ha)
Although the number of red fruits increased in I_3 treatment, this increase was due to the higher number of small fruits (*Table 5-6).*

	pcs/m² t			
	K	**I1**	**I2**	**I3**
red	145	219	221	255
green	86	32	15	30
bad	77	52	69	73
total	308	303	306	357

Table 5. Quality distribution of total tomato fruit yield in water supply treatment (pieces/m^2), Szarvas, 2019.

	pcs/m²			
	K	**I1**	**I2**	**I3**
small	11	17	20	46
medium	13	199	176	198
large	2	3	25	11
total	26	218	221	255

Table 6. Size Changes of Red Tomato Fruits in Water Supply Treatments (pieces/m^2), Szarvas, 2019.

Results of soluble solids content measurement
According to the results in lower water supply treatments fruits have a higher soluble solids content due to less irrigation water. Increasing water supply reduces the soluble solids content. Lower °Brix values are in connection with more irrigation water, and the soluble solids in the fruit is diluted by higher water supply.
Examining the °Brix values for size fractions, smaller fruits have a higher soluble solids content due to less water content, while larger fruits have lower soluble solids content.
The results of the soluble solids measurements are shown in the *Table 7*.

treatment	2018			2019		
	fruit size			fruit size		
	small	**medium**	**large**	**small**	**medium**	**large**
K	7,5	7	4,5	6,6	5	4
I1	6,5	6,5	6	6	5,5	5
I2	6,5	6	6	5	4,5	4
I3	6	5,5	4	5	4,5	3,5

Table 7: Results of soluble solids measurement in tomatoes (°Brix)

Main findings

Regarding the ratio of stems to total fruits, it can be stated that the proportion of total fruits within the total plant biomass product increases to a greater extent - to an optimal limit - than the ratio of stems as a result of increasing water supply. Examining the distribution of the quality fractions of all fruits, it can be concluded that increasing water doses not only increases the total yield but also increases the weight and number of red (marketable) fruits, however the amount of non-marketable fruits also rises. In wetter years, treatment with too much water supply (I_3 in 2019) shows no further improvement in total fruit yield and marketable yield compared to I_2 treatment. With

increasing doses of water, the weight of medium and large fruits within the red fruit increases compared to the control treatment.
According to the results of soluble solids measurement, the soluble solids content of fruits with lower water supply is higher due to less water supply, than the °Brix values measured with higher water supply treatments. Larger tomato fruits have a slightly lower soluble solids content than medium and smaller fruits.

Summary

In tomato cultivation, irrigation is essential (along with the application of appropriate technologies) because it influences yield and the safety of crop production. In this article the effect of various water supplies was investigated on the yield and soluble solids content of processing tomatoes planted under open field conditions in 2018 and 2019. The ratio of stem and total yield to total biomass production was examined. Within the total yield of tomato, the total weight and number of red (marketable), green and non-marketable fruits were also examined, as well as the weight of red fruits in accordance with their size: small, medium and large. Besides this, the soluble solids content was also determined.
The experiment took place in Szarvas at a school field used for agricultural purposes that belongs to Szent István University. The soil type was chernozem meadow soil. The plots received different irrigation water supply treatments. Treatments are marked with: K; I_1; I_2; I_3. The I_3 treatment represents the same water supply as potential evapotranspiration (PET), that is I_3 = PET 100 %. Lower level water supply treatments got smaller proportion of PET. Control (K) did not received regular irrigation but small amounts were applied at the time right after planting and after fertilization events (to wash off fertilizer from leaves). The actual irrigation water amounts were 131 mm, 170 mm and 213 mm in the I1, I2 and I3 treatments respectively in 2018 and 81, 108 and 135 mm in 2019. Precipitation during the growing season was 127 mm in 2018 and 257 mm in 2019.
Regarding the ratio of stems to the total yields, it can be stated that due to the increasing water supply, within total plant biomass products the proportion of total fruits increases to a greater extent than the proportion of stems. The distribution of the quality categories of all fruits points to the fact that increasing water not only increases the total yield but also increases the weight and number of red (marketable) fruits. However, the enhancing amount of water is also responsible for the increase in the number of non-marketable fruits. With increasing water supply the weight and number of medium and large fruits within the red fruits increased compared to the control treatment.
According to the results of the soluble solids measurement, the increasing water supply decreases the soluble solids content of the fruits. Larger tomato fruits have a slightly lower soluble solids content than medium and smaller fruits have.

Keywords: tomato, fruit yield, water supply, soluble solids content

Acknowledgments

This publication has been completed within the framework of project no. EFOP-3.6.1-16-2016-00016 focusing on training and research profiles with intelligent specializations on the Szarvas Campus of Szent Istvan University involving agricultural water management, hydroponic plant systems, alternative crop production related to improving precision machinery in agriculture. The open field experiment was supported by the GINOP 2.2.1-15-2016-00003 project.

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The effect of different water supply on the yield and soluble solids content of open field tomato

Abstract

In this paper we examined the effect of four different water supply treatments on the yield and soluble solids content of processing tomato planted under field conditions in the growing season of 2018 and 2019. At the time of harvest, the ratio of stems and total yields was calculated. Within the total yield of tomato, the amount and the number of red (marketable), green and non-marketable fruits were also examined, as well as the weight of red fruits in accordance with their size: small, medium and large. Besides this, the soluble solids content was also determined. Treatments were marked with: K; I1; I2; I3. The I3 represents the same water supply as potential evapotranspiration (PET), that is I3 = PET 100 %. Plots with lower water supply received smaller proportion of I3. Regarding the ratio of stems and total yields, it can be stated that due to the increasing water supply, within all plant biomass products the proportion of total fruits increases to a greater extent than the proportion of stems. The distribution of the quality categories of all the fruits shows that increasing water not only increases the total yield but also increases the weight of red (marketable) fruits. However, an excessive amount of water is also responsible for the enhancing amount of sick and bad fruits. Increasing water doses increase the weight of medium and large fruits within the red fruit class compared to the control treatment. According to the results of the soluble solids measurement, the increasing water supply decreases the soluble solids content of the fruits. Larger tomato fruits have a slightly lower soluble solids content than medium and smaller fruits have.

Keywords: tomato, fruit yield, water supply, soluble solids content

EXPERIENCES WITH WATER RETAINER IN PROCEEDING TOMATO

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Introduction

Global climate change challenges arable crop production in an increasing manner. Weather extremities become more and more frequent which rises the risks connected to production. The area of Danube-Tisza Interfluve is prone to aridity. The industrial-scale tomato production without irrigation is turning to be uneconomic A considerable share of the soils in these areas have reduced water retention capacity due to their structural characteristics. Nowadays the water is a valuable material. For 200 years ago, we used to have problems with flooding and draining, nowadays drought is the main problem. We need to focus on water retention. If we can save water in the soil, we need less irrigation. The use of Water Retainer® can be suitable for improving the water retention of soil. We wanted to examine, the effect of Water Retainer® by the growth of the seedlings. We want to collect valid information on the use of Water Retainer®. The objective of our research is to determine how the Water Retainer® impacts the amount of irrigated water and the growing of the seedlings. The experiment is conducted by the Kalocsa Reseach Station of National Agricultural Research and Innovation Centre.

Literature Review

Both the production and consumption of tomato, either fresh or processed, show a constantly increasing trend worldwide. Based on FAO statistical data the total tomato production was 182 million tons from 4.7 million acres in 2018. Out of this amount 23 million tons were produced in Europe, 30% of which was grown for industrial purposes. Hungarian production was 204.000 tons. It represents approximately 0.8% of the total European yield. 122.000 tons of the total amount of the Hungarian production was produced in the South-Plains (FAOSTAT 2020, KSH 2020). New investments in processing industry prospect the increase of the amount of tomato produced in Hungary. A large amount of raw material with outstanding nutrient content is needed for domestic processing to create high-quality tomato products. They can also be suitable for improving the average quality concentrates (Helyes, 2015). In the case of countries with a relatively arid climate optimal for outdoor tomato growing average yield can be expected around 100 to 130 t/ha. According to Hungarian data the 100 t/ha production is achievable with the use of intensive field production technology and several highly productive tomato hybrids (Helyes, 2013) Tomato can prevent some human diseases, through the antioxidants in the berry, which are necessary against cancer and cardiovascular diseases (Giovannucci et al., 1995). Several factors influence dry matter

content, such as variety, ripeness of the berry, nutrient and water supply of the plants (Mahakun et al, 1979). A large part of soluble dry matter content (Brix %) consists of reducing sugars: this value is between 50 and 70% according to Davis and Hobson (1981) and Helyes (1999), while Helyes et al. (2008b) set this value at 60 to 70%. Refraction constantly changes in the berries during the different phases of ripening (Davies and Hobson 1981, Jauregui et al 1999). In our country, refraction values of samples are usually higher in August than in September (Milotay et al 2016). Higher levels of sugars and vitamin C are mainly under the condition of a limited and suitable amount of water supply (Veit Kohler et al., 1999). The regular and optimum irrigation can reduce the amount of green fruits and blossom-end rot (Warner et al., 2007)

The amount of irrigation water significantly influences the living conditions of plants. Irrigation positively increased the plant height, the leaf number and the weight of the plant. In the case of water stress, the vegetative growth can visibly decrease. (Ragab et al. 2019) Tomato is highly sensitive to water stress, which reflects in yield. The yield of a unit area is determined by the size and number of berries grown in a plant. It is inversely proportional with dry matter content (Lapushner et al., 1990; Helyes et al., 2008a; Pék et al., 2014). Development type, berry size and the number of set fruits fundamentally determine the productivity of tomatoes, although the method of production and the applied technology play important roles, too (Ho, 2003). According to the research of Macua et al. (2003) the amount of irrigation water significantly influences the living conditions of plants.

The Water Retainer® is an organic soil-conditioning product. During the application. The soil's water retainment ability is substantially increased. The plants can survive twice the time in extreme drought conditions without serious damage, alleviating yield losses, while the lower stress level will show itself in better yield results. Dried out soil might turn water repellent, reducing water uptake from rainfall, which in turn increases the chance of soil panning and it turning airless, resulting in less utilizable water for our plants, causing an overall yield loss. The treated soil is able to additionally trap air humidity during high moisture periods (dawn or night vapour formation). Soil with ideal water content also means long term benefits in farming. Irrigated water consumption may be reduced, since the Water Retainer® reduces evaporation and stops water trickling deeper than ideal, trapping water in the topsoil layer. (Water & Soil, 2020.)

Methods

The sowing was in Kalocsa, using the experimental foil tent of the National Agricultural Research and Innovation Centre Vegetable Crop Research Department. The seeds (Unorosso F1) were put in 66 cells seedling trays (3.5cm*3.5cm*4cm) at 10th of April 2019 in peat. After the sowing we sprayed 1.5 ml/m^2 and 2 ml/m^2 Water Retainer® on the surface of the peat the nutrient supplementing plan has been elaborated by taking the specific nutrient demands of industrial tomato. The pH was about 5-6, EC was between 1.5 and 3, and we used complex fertilizers (NPK 15-30-15). We have 4 treatment (100% Irrigated, 50% Irrigation, 50% Irrigation + 1.5 ml/m^2 Water Retainer® and 50% Irrigation + 2 ml/m^2 Water Retainer®) our experiment and each treatment has 4 repetitions. We used 4 trays (264 plants) in each treatment. We adjusted the irrigation to the water demand of the 100% Irrigated control group. When the surface of the peat

began to dry up and maximum the upper 1 cm was dry, we irrigated it with a watering can, so we have known the exact amount of the water. The wilting of the plant was not allowed, if it was necessary we used emergency irrigations by the 50% irrigated trays. At the end of the experiment we examined from each treatment random 40-40 plant. We measured the height, the number of true leaves and the diameter of the stems. Before, the measuring we defined these categories. The height was measured from the cotyledon to the last crotch on the top of the plant. We counted only the minimum 2 cm long leaves. The diameter of the stems was measured under the cotyledon. After the experiment period, we planted the seedlings to 51 plant parcels to the open field at 20th of May 2019. Complex granulated NPK fertiliser (15-15-15) and granulated poultry manure (Orgevit) was dispensed during the spring machine spading. Ferticare (15-30-15) starter fertiliser was used to promote root development at the time of planting. Planting and row distance was 22 cm and 130 cm, respectively. We used drip irrigation. A tensiometer was put into each band of the experiment to determine the time of irrigation with sufficient accuracy. Following the soil analysis, a nutrient supplementing plan has been elaborated by taking the specific nutrient demands of industrial tomato into account. In case of 80 t/ha yield, the active substance requirements are as follows: 280 kg N; 120 kg P and 352 kg K. Harvest was carried out in three different dates starting on 21 August. Each 16 parcel (51 plants) stands from 3 rows (17 plants in a row), and we harvested weakly one row from each parcel. Machine harvest was imitated: plants were cut, all the berries were shaken off and classified under four categories (ripe, burgeoned green and unhealthy/cull). Red and orange, evenly coloured fruits fell into the ripe category. A berry was considered burgeoned if it contained orange and green patches in varying proportions. Uniformly coloured green tomatoes belonged to the green category. All those tomatoes were considered as unhealthy which showed the signs of bacterial or fungal infections, sun-damage or Ca spots. A sample consisting of 20 ripened berries were taken from each parcel. These samples were pressed by a juicer. From the juice we checked the Brix % value by a portable automatic refractometer (Hanna HI96801).

Results

The amount of the irrigated water shows us, that with Water Retainer® we can successfully grow the plants less water than they optimally water requirement. At the case of the 50% irrigated control trays, we have given 2 times emergency irrigation, because the plants were wilted. At least we have grown, these plants a little bit more water (59.84%), than with Water Retainer® treated plants (50,05%).(Table 1)

	100% irrigation	**50% irrigation**	**50% irrigation + 1.5ml/m^2 Water Retainer®**	**50% irrigation + 2 ml/m^2 Water Retainer®**
Amount of water (l)r	94	56,25	47,05	47,05
Percentage of Water (%)	100	59,84	50,05	50,05

Table 1. Amount and percentage of the irrigated water

By the height of the plants (Table 2), we found any differences. In the 100% irrigated trays were the highest plants (13.87 cm) and the lowest was in the 1.5 ml/m^2 Water Retainer® treated trays (10.07 cm). The 100% irrigated plants have more leaves (3.65 pieces) than the others, but we found, the widest plants in the 2ml/m^2 treated trays (3.6 mm).

	Plant height (average cm)	**Number of true leaves (average piece)**	**Diameter of stem (average mm)**
100% irrigation	13,87	3,65	3,59
50% irrigation	10,59	3,05	3,54
50% irrigation + 1.5 ml/m^2 Water Retainer®	10,07	3,20	3,55
50% irrigation + 2 ml/m^2 Water Retainer®	11,87	3,20	3,60

Table 2. Measured parameters of the plants

Average yields were calculated from the four repetitions per treatment, while the average refractions were determined by the four repetitions per harvest date. P-value was calculated from the 4 repetitions per treatment with Excel in one-way variance. When, the p-value is lower than 0.05, we found a significant difference. Significant means, that the treatment influenced the difference between two groups in 95% probability. In the case of total yield, remarkable differences were not detected. The highest yield was reached in the category "50% irrigation + 1.5 ml/m^2 Water Retainer®", while the lowest value was observed in the "50% irrigation + 2 ml/m^2 Water Retainer®" group (Table 3).

"50% irrigation + 1.5 ml/m^2 Water Retainer®" resulted in the highest Brix %, while the lowest was measured at "50% irrigation" parcels. The Brix yield was calculated from the arithmetical product of ripened berries (tons/acres) and Brix (1/100 Brix %). This value shows us, the average dry matter content of the field. The highest Brix yield was in the "50% irrigation + 1.5 ml/m^2 Water Retainer®" group too.

	Ripened (kg/m^2)	**Burgeoned (kg/m^2)**	**Green (kg/m^2)**	**Unhealthy (kg/m^2)**	**Total yield (kg/m^2)**	**Brix %**	**Brix yield**
100% irrigation	10,56	2,11	1,76	1,14	15,58	4,59	4,85
50% irrigation	10,17	1,99	1,35	1,16	14,66	4,53	4,60
50% irrigation + 1.5 ml/m^2 Water Retainer®	11,06	1,96	2,08	0,89	15,99	4,97	5,49
50% irrigation + 2 ml/m^2 Water Retainer®	9,32	2,15	1,89	0,99	14,35	4,57	4,25
p-value	0,045	0,752	0,185	0,134	0,244	0,024	0,010
Significant	Yes	No	No	No	No	Yes	Yes

Table 3. Datas of the harvesting

Main findings

During the raising young plants, we can save water with Water Retainer®. The differences between the treatments are not significant. The plant height can decrease the effect of water stress. We found a significant difference by the average yield of the ripened berries. The "50% irrigation + 2 ml/m^2 Water Retainer®" group has significantly less ripened berries than the other 3 group. In the case of the burgeoned, green, unhealthy and total yield categories we found not any significant difference. At the case of Brix % the "50% irrigation + 1.5 ml/m^2 Water Retainer®" group has significantly higher measured values, than, the others. The Brix yield is a derived value, from the Brix and the ripened berries, therefore there is a significant difference too by the group "50% irrigation + 1.5 ml/m^2 Water Retainer®".

Summary

For 200 years ago, we used to have problems with flooding and draining, nowadays drought is the main problem. We need to focus on water retention. If we can save water in the soil, we need less irrigation. The use of Water Retainer® can be suitable for improving the water retention of soil. We wanted to examine, the effect of Water Retainer® by the growth of the seedlings. The experiment is conducted by the Kalocsa Research Station of National Agricultural Research and Innovation Centre. During the nursing period, we used successfully only the half amount of the effective water demand of processing tomato. We cannot found any significant differences between the treatments by the plant height, the number of true leaves and the diameter of the stems. After the nursing period, we planted the seedlings to the open field and raised them equally. At the harvesting period, we measured the yield of the ripened, burgeoned, green and unhealthy fruits and made samples from the ripened berries to measure the Brix%. In the case of the yield of the ripened fruits, Brix% and Brix yield we found significant differences. Summary we can say that we can use successfully, the Water Retainer® in the nursing period.

Keywords: tomato, irrigation, water management.

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Waterandsoil 2020 https://www.waterandsoil.eu/how-it-works

Experiences with Water rerainer in proceeding tomato

Abstract

Global climate change challenges arable crop production in an increasing manner. Weather extremities become more and more frequent which rises the risks connected to production. The area of Danube-Tisza Interfluve is prone to aridity. For 200 years ago, we used to have problems with flooding and draining, nowadays drought is the main problem. We need to focus on water retention. If we can save water in the soil, we need less irrigation. The use of Water Retrainer® can be suitable for improving the water retention of soil. We wanted to examine, the effect of Water Retrainer® by the growing of the seedlings. The objective of our

research is to determine how the Water Retainer® impacts the amount of irrigated water and the growth of the seedlings. The experiment is conducted by the Kalocsa Research Station of National Agricultural Research and Innovation Centre. The seeds (Unorosso F1) were put in 66 cells seedling trays in peat. After the sowing we sprayed 1.5 ml/m^2 and 2 ml/m^2 Water Retainer on the surface of the peat. At the end of the experiment, we measured the height, the number of true leaves and the diameter of the stems. After the experiment period we planted the seedlings to the open field. We used drip irrigation. A tensiometer was put into each band of the experiment to determine the time of irrigation with sufficient accuracy. At the harvesting period, we measured the yield of the ripened, burgeoned, green and unhealthy fruits and made samples from the ripened berries to measure the Brix%. In the case of the yield of the ripened fruits, Brix% and Brix yield we found significant differences. Summary we can use successfully, the Water Retainer in the nursing period.

Keywords: tomato irrigation, water management.

YIELD AND PLANT MONITORING ANALYZE IN LONG TERM HYDROPONIC TOMATO CULTIVATION

Tibor Terbe[1]– I. Rácz[2]–Boglárka Ágoston[3]–Barbara Schmidt-Szantner[4]

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Introduction

Farm-level hydroponic cultivation technology started in Hungary 25 years ago. As a result of technological developments, a significant proportion of vegetables and ornamentals are now produced using this system. Thanks to the rapid development of soilless cultivation technology, most of the tomatoes on the market shelves today come from hydroponic technology, approx. 200 ha is the area under tomatoes in Hungary.

Literature Review

Hydroculture technology research focuses on optimizing environmental factors, water and nutrient supply in order to bring yield results as close as possible to genetic potential (Morimoto and Hashimoto, 1996). In recent years, the issue of plant monitoring has also come into research (Huai et al., 2007), which can have several benefits. On the one hand, the monitoring method can be used to control plant development step by step, thus making it possible to correct the growing conditions immediately if the development indicators show differences. On the other hand, yield dynamics can also be forecast (Koller and Upadhyaya, 2007), which has a significant advantage in terms of sales, and affects economic indicators.

In hydroponic cultivation, we can achieve higher yields only with a high level regulation. All cultivation conditions must be taken into account: the type of root zone medium, the controllability of the climate system, the irrigation and nutrient supply management, the characteristics of the plant variety. In modern greenhouses, computers control the climate and irrigation system, with the right setting we can control the vegetative/generative development, which helps to create the optimal fruit-foliage ratio. This ensures continuous yield production throughout the growing season, which is essential for constantly growing tomatoes.

In modern systems, the climate setting is based on the actual irradiation. In tomato cultivation, 100 Joules of energy is needed per day to maintain the plant operation, with an additional 100 Joules per cluster. If there is less irradiation, in the greenhouse should have a lower temperature, if there is more light, it should be kept warmer so that the vegetative/generative balance is not upset. The supply of nutrients and water should also be adjusted to maintain a constant foliage/crop balance. The leaf area index (LAI) is a none-dimensional indicator of vegetative development, a good characteristic of the photon-capture capacity of plants. LAI greatly influences biomass production, water circulation related to crop formation (Firouzabadi et al., 2015). Proper irradiation promotes flowering, and optimal light and temperature values are required for optimal

fruit formation. At low irradiation and temperature, flower formation is poor, fertilization is low, which affects both the quantity and quality of the crop (Marcelis et al., 2009).

Methods

The cultivation experiment took place in the SZIU Szarvasi 2000 m^2 greenhouse in the 2019 cultivation year. The net cultivation area was 1800 m^2. Long-cultivated tomatoes were grown in the greenhouse using the Aruba F1 cluster tomato variety. The plants were planted in the last week of January at a density of 3.4 plants/m^2. The plants were placed on a coconut fiber quilt with a composition of 50% chips-50% fine fiber. Irrigation and climate control were controlled by a Priva climate computer, which started the irrigation mainly depending on the irradiation data. The optimal setting of the climate was helped by the 6m side height of the greenhouse and the coordination of ventilation with heating.

Monitoring of plant development began from the 8th week of cultivation. The greenhouse has 2 climate spaces, so we recorded the growth data of 12 plants on each side in 4 replicates. Repeats were standardized with statistical means and used for results. Harvests were performed by students weekly from week 17 on plants included in monitoring measurements. The outdoor-indoor climate data were extracted from the climate computer backup data, which recorded each parameter in 15 min breakdown. From these data, daily and weekly averages were calculated and used in the evaluation.

Results

In terms of plant growth, the intensity of irradiation has the greatest effect. Figure 1 shows the weekly averages of irradiation and the weekly growth of the experimental plants starting from week 7.

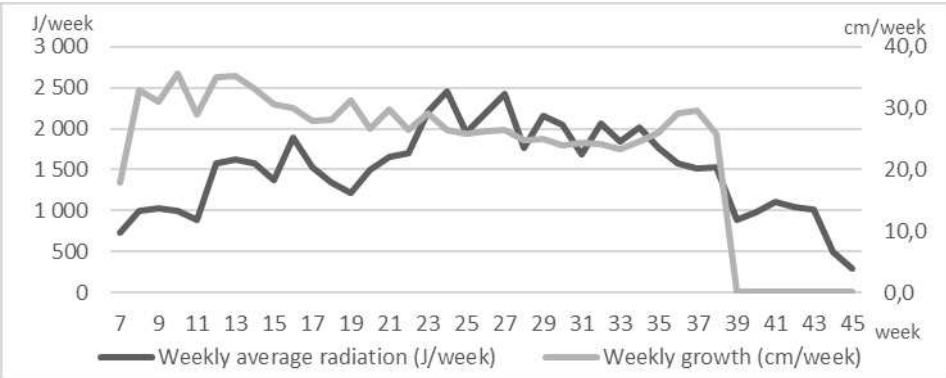

Figure 1. Weekly average irradiation and weekly tomato plant growth rate in 2019

It can be seen that between 7 and 15 weeks the growth of the plants is intense, exceeding 30 cm per week and a cloudy week also restrains the growth. Harvesting starts from the 17th week, from then on the plants are fully loaded and the weekly growth rate also slows to around 25 cm/week. The two curves no longer correlate with

each other, and the higher rate of radiation has no positive effect on weekly growth. It is only from the end of August that there is more intense weekly growth until the 39th week (October), when the weekly growth stops with the pinching of the plant top shoot and only the remaining crops are harvested. The slowdown in intense peak growth in the summer can be explained by the high load on the plant (high number of fruits) and the shading of the greenhouse, after which the weekly growth increases again.

Irradiation and green mass of the plant can be calculated from the monitoring data. The width, length and number of leaves were recorded each week, from which the LAI index (Leaf Area Index) can be calculated, which shows the size of the leaf area per square meter. The Figure 2. shows the change in irradiation and leaf surface index during the growing year.

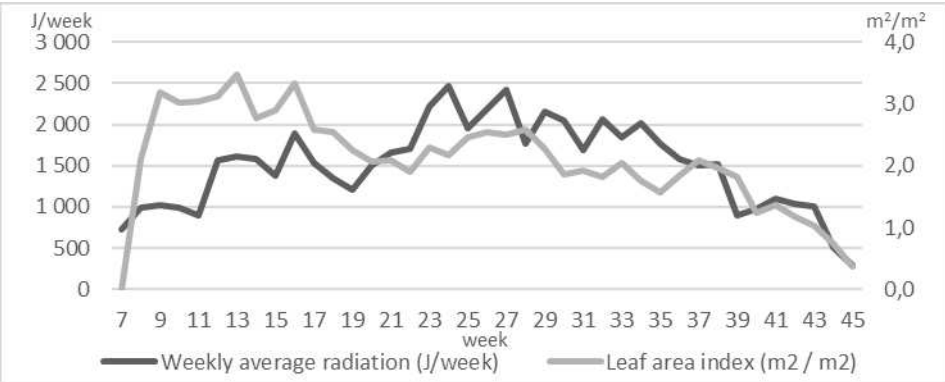

Figure 2. Changes in the weekly average irradiance and leaf area index (LAI) in 2019

The Figure 2 shows that in the initial intensive growth phase, the size of the foliage area increases sharply until week 9, and then, almost completely correlated with the irradiation data, it changes during the growing year. It can be seen from the figure that the outstanding irradiation data of the summer months no longer cause the same increase in leaf area in proportion, as the leaves do not grow large at higher average temperatures and higher plant load. By eliminating the plant stock, the leaf surface is practically completely depleted.

In long-term cultivation, for economic reasons, the primary goal is to achieve the highest possible yield. Our goal is to tie as many clusters as possible during cultivation and grow a marketable crop. The Figure 3. shows the change in irradiation and the number of flowering clusters during the growing season.

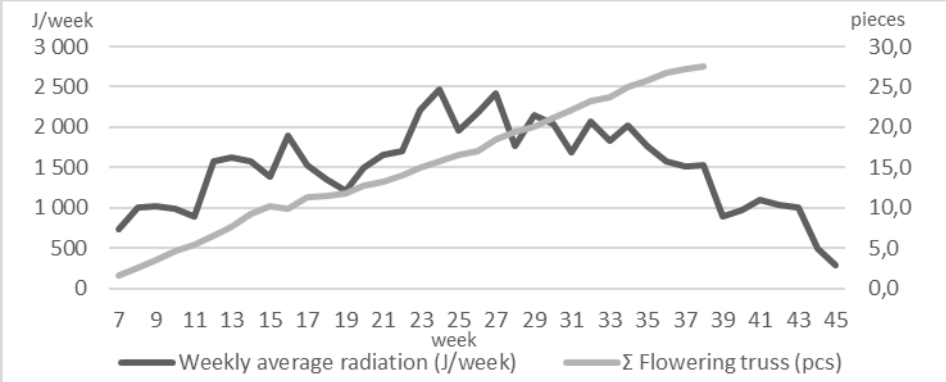

Figure 3. Increase in weekly average irradiation and number of flowering clusters in 2019

It can be seen in the Figure 3 that the increase in the number of flowering clusters increases almost completely evenly, except for one negative deflection, until the shoot apex of the plant erupts. This practically shows the performance of using modern technologies today, because if the irradiation does not fall below 1000 J/cm^2, with the optimal settings of heating and ventilation, the plants can produce a steady weekly growth.

An important element of the experiment was to document the results of regular harvesting, which shows the ability of the plant to generate income. Figure 4 shows the weekly harvest results as a function of irradiation and the moving average of the harvesting results.

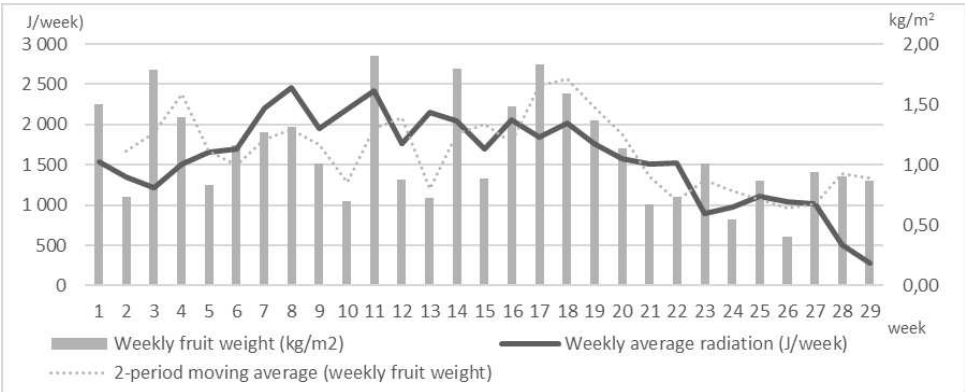

Figure 4. Weekly average of irradiation and weekly harvest quantities in 2019

If we look at the harvest results, the data follow a large average change in irradiation, with a shift of 1 week in most weeks. In the case of small amounts (1 kg/m^2), it can be seen that until the 20th week, an outstanding collection result is followed the following week. The dynamics of ripening and picking were probably not completely in line, and the subjective judgment of the picker also matters a lot, because if only the last berry is not perfectly red and is not picked, it means 2 pickable bunches per plant by the following week. And the result of the last 3 weeks is already a higher result when the stock is liquidated, because due to the lower irradiation and foliage area, there are already more mature clusters on the plant to fully mature the stock.

Figure 5 shows the weekly intake volumes and the currently flowering clusters in the 2019 growing year.

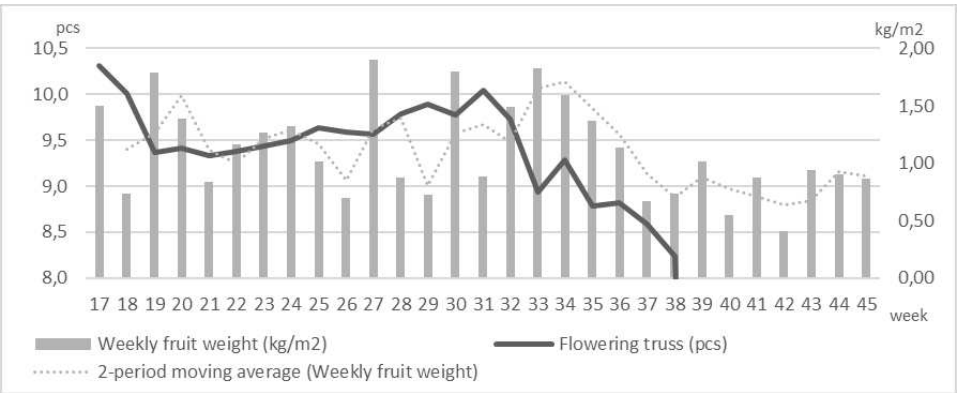

Figure 5. Current number of flowering clusters and weekly harvest quantities in 2019

Figure 5 shows that at the time of the first harvest, there were more than 10 clusters on the plant, as the 11th had already begun to bloom. This extremely strong load fell on 1 full cluster after the first two pickings and fluctuated between 9-10 clusters throughout the end of August and between 8-9 until the herd tip was pinched. There was no difference in the number of clusters in the cluster number.

Main findings

Based on the monitoring data and the development of the harvesting quantities, it can be stated that the modern cultivation technology and precise climate adjustment help the plants to develop evenly. The leaf surface index (LAI) closely follows the irradiation values. For weekly harvests, this not only affects the data, but also the number of clusters that are judged to be harvested. The load on the plants was continuously balanced with small differences, but there were more significant differences in the quantities harvested. During the cultivation, 27 bunches were closed, from which 32.3 kg/m^2 of tomatoes were harvested. This means an average yield of 9.5 kg per plant and a cluster average of 0.35 kg. Additional climate control settings can further increase crop yields.

Summary

During the experiment, the balance of climatic conditions promoted good growth and also allowed continuous harvesting for 28 weeks, covering almost 7 months. This type of cultivation safety provides a good basis for a continuous market presence throughout the period of purchasing primary vegetables.

Keywords: plant monitoring, tomato, hydroponic, climate control

Acknowledgments

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ONE DIMENSIONAL STEADY FLOW ANALYSIS OF THE RÁKOS STREAM

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Introduction

As the widely accepted surmise of climate change has known, the effects of particular alterations are increasing due to human activities (IPCC, 2014) that cause changing precipitation and hydrological system modification. This surmise has become an axiom in the past decades with its core message that the rising trends of severe frequency and intensity of rainfall are detected lately in several catchments signifying higher risks of flooding. Certain contradictions were noticed regarding the close correlation between global warming and change of rainfall regime globally and locally on the base of the comparison of the climate change projection and the observed data (Koutsoyannis, 2020). Precautions are essential, since the origin of floods is affected not only by the rainfalls but also the rapid urbanization, and generally, by the non-deliberated land use, that is unavoidable. The floods, are going to cause damage in essential facilities and to some extent bringing domino effects for economic growth and sustainable development. Moreover, the projected rising of extreme floods will change the ecosystem; thus, changing flood regulation is proposed to manage it. For instance, river hydraulic characteristics have to be studied and analyzed independently since it can contribute to flooding development (Bronstert, 2003). Therefore, in order to perceive and foresee the location of potential floods, hydraulic modeling was performed in the Rákos stream with the one-dimensional (1D) model of the US Army Corps of Engineers Hydrologic Engineering Center's – River Analysis System (HEC-RAS). This 1D model was selected because the stream has no wide floodplains, its riverbed is rectified and deep, furthermore the purposes is to assess the peak flow that might risk crossing infrastructures along the stream.

HEC-RAS has been widely used for river and floodplain modeling, which provides water surface profiles and flood-prone mapping when combined with such modeling of GIS. Ahmad et al. (2016) were using HEC-RAS to simulate flood of 50 and 100 years return period through 1D steady flow for the river system in Kashmir valley. The same method was used in the study conducted by Prastica et al. (2018) to evaluate river capacity based on peak runoff and design storm hydrographs that generated flood loading. Steady flow analysis was also carried out by Agrawal & Regulwar (2016) which focused on the destruction level of various discharges applying calibrated Manning's roughness coefficient as a single value to justify the conveyance of flood in

the river. Additionally, an integrated model was used to analyze overflow conditions of the river basins that performed infrastucture adjacent to the river were vulnerable to flooding hazards (Szopos & Czellecz, 2017).

Furthermore, HEC-RAS has been adopted in Hungary to model the Tisza River to be environmentally acceptable for decreasing flood peaks in flood management. Kiss et al. (2015) conducted a study regarding the effect of levee failure on the hydrological characteristics on the river at Mindszent using the 2006 flood data set in combination with ArcGIS and HEC-GeoRAS. The HEC-RAS was used to analyze how the sedimentation affects the flood levels of the Tisza River and its tributaries; the sedimentation causes the continous rising the terrain level by the floodways. The software package was used to estimate how this process affects the flood levels in the future (Kovacs et al., 2006). The measure of maximum water level of the Tisza River and its tributaries was essentially regulated by hydrometeorological situation, such as long-lasting and high precipitation and/or snow melting in the mountain, and flood waves occur simultaneously on the main river and its tributaries

Study area

Rákos stream is a left side tributary of Danube River with a 41 km total length. The length of the studied reach is 21.8 km from the boundary of Budapest to the mouth of the Danube River, and this is half of the total length of the stream, as shown in **Figure 1**. The water flows in a rectilinear concrete channel with averagely 1 – 3 m width (Nóvak, 2007) in the area of Budapest. Moreover, densely growing aquatic plants and grass cover the bottom the main channel, the streambank as well as the highwater carrying part of the stream. Further development of the green areas should focus on stream restoration of the floodplain (Végh, 2012).

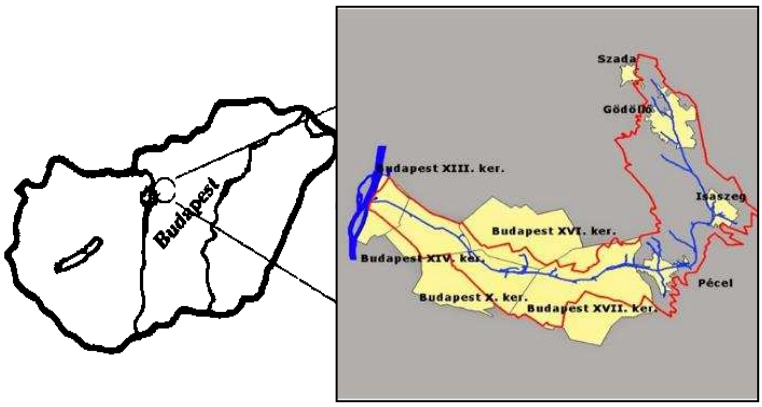


Figure 1. Location and layout of the Rákos stream and its catchment in Hungary *Source: Szabó et al. (2004), http*[1]

Data and methodology

HEC-RAS version 5.0.7 was used in this study to perform a steady flow analysis. The stream reach was subdivided by 447 cross sections which were developed by entering station (X) and elevation (Y) data, setting the downstream reach length of 100 m away, and determining the bank stations from the field survey. The same method was applied for determining *n* values after Chow (1959) who chose 0.024 and 0.383 for the main channel and left and right overbank roughness, respectively.

Moreover, four defined cross sections were used to model 113 crossing bridges and pipe crossings. X and Y data of both high and low chords were inputted as well as the width of the hydraulic structures which resolved using Google Earth, default weir, contraction, and expansion coefficients, and adjusted distance from the upstream cross-section. Additionally, piers data entry was filled for pipe crossings modeling. For the upstream boundary condition, known water surface elevation of 145 m was selected however, normal depth was chosen for the downstream one having a value of 0.002. Moreover, three profiles were added for simulating high flow rates, 10, 15, and 25 m^3/s. After the mixed flow regime was chosen, the model was constructed, and the outputs were calculated.

Results and discussion

The steady flow simulation is done by using energy equation, and head loss is calculated by Manning's equation, contraction and expansion coefficients in the HEC-RAS model. **Figure 1** described the graphical representation of some cross sections when high flow rates applied. The steady flow simulation at 10 m^3/s showed in general, the stream was able to carry the discharge with few overflows were observed in certain river stations in the upstream reach. Overflow took place when the water surface elevation surpassed stream embankment. In this case, the overflows occurred relatively in short reach varied between 100 m and 500 m of downstream reach lengths. However, RS 15700 had the highest bank overflow that was noticed to reach elevation 129.98 m above sea level and exceeded the level of the embankment 129.80 m above sea level. Furthermore, the areas affected by potential inundation were agricultural land and artificial surface areas which laid on the left and right of the stream.

At the 15 m^3/s peak discharge, the spillover took place in longer downstream reach lengths than the previous simulation averagely 1948 m, along with RS 21777 – RS 19843, RS 17153 – RS 15200, and RS 13947 – RS 11990. The water surface elevation increased and contributed to bank overflow that resulted at the Határhalom and Vallós bridges, which were threatened by the higher water level in the model. Additionally, a probable inundation was viewed downward to the Rákosfalva region. This is an agricultural, forest and semi-natural, and partly urban areas by both embankments.

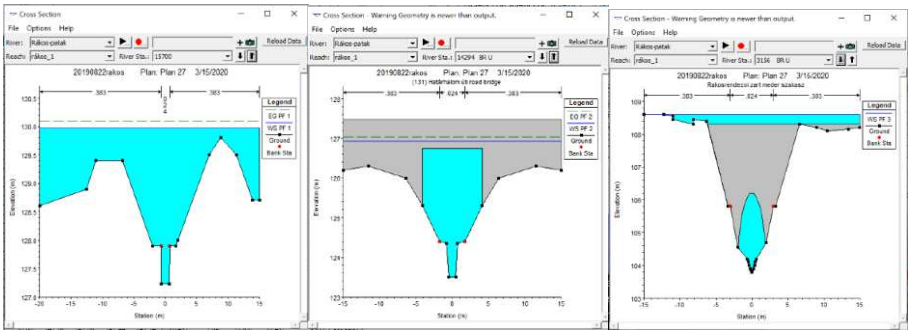
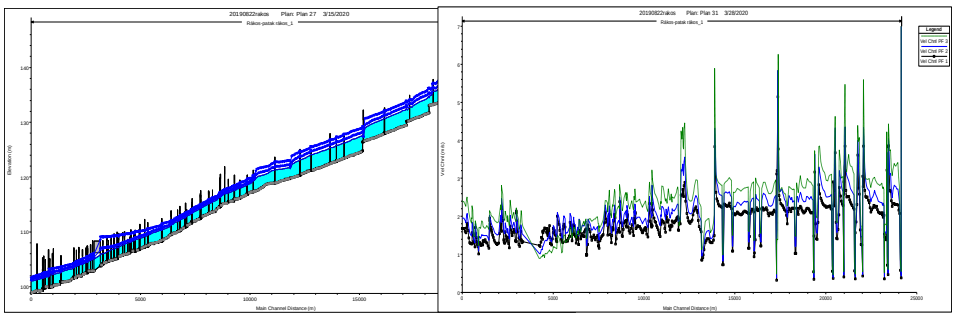


Figure 2. Graphical representation of cross section when great flows simulated a) At 10 m^3/s b). At 15 m^3/s c). At 25 m^3/s

The overflows in the upstream seemed reasonable since the channel geometry in the upper region was dominated by narrow rectangular shape with 1-3 m width, which could not adequate even 10 m^3/s of simulated peak discharge. The geometry alteration along the studied reach can be the reason of conveyance differentiation in the upstream, middle, and downstream. Meanwhile in the middle region, the water flowed through the trapezoidal channel which got severe spillover when 15 m^3/s of discharge was applied. However, the lower reach in the downstream was safe from bank overflow since the channel along was dominated by the semicircular channel bottom with the sloping wall. In distinc hydrological situation, even in the downstream reach can be endangered because of a high waterlevel of the Danube and the occurance of a heavy rainfall on the urban catchment area of the Rákos stream. According to Chow (1959), by assuming Manning's roughness coefficient and slope are constant, rectangular cross section will be arrive at the best hydraulic characteristics when the water depth is half of the channel width or $y \sim ½\ b$ while the trapezoidal channel achieves optimum hydraulic radius R when the wetted perimeter P is minimum or $P \sim 3.46\ y$. Yet for a given cross sectional area, the semicircular channel would have the most effective cross section since the smallest wetted perimeter has that equal to $\pi\ y$. In this state, the hydraulic radius rises thus, the semicircular would carry more discharge than any other channel shape when the slope and roughness are remained constant (Heede, 1992).

Furthermore, the increasing water surface elevation can be analyzed from the backwater point of view because of blockage alike the tunnel section under the wide railway. Hence, water was not allowed to flow within the lower reach and poured out into the left and right urban area neighboring the stream. According to Atabay et al. (2018), loss of energy across the bridge is the effect of backwater due to contraction of the flow, the friction force between water and bridge surface, and the stream expansion which dominates the energy deficiency. In fact, analyzing backwater effect is complicated to some extent considering geometric features of the bridge opening (Seckin & Atabay, 2005) for instance, piers, abutments, length and side slopes of embankments, cross

sectional geometry near to the bridge waterway, and flow inclination with respect to bridge axis.



a: Profil plot *b:*Velocity plot

Figure 3. Plot along the studied reach

In addition, the integrative water surface profile plot as shown in **Figure 2a** emphasizes that the flow along the channel varied at the simulated discharges. The results were also clarified by the velocity plot in the first half of the river station as shown in **Figure 2b**. The fluctuating velocity implies big energy was stored and released in backwater effects that lead to water level rising in the upper reach. These results were confirmed by Tamagnone et al. (2019), the behaviour of the upstream flow can be influenced, commonly for long distances river, by the downstream condition. In this case, backwater effects in the lower sections influence the water level in the upper sections, which causing inundation of large area adjoining the river when exceeds the embankment.

Conclusion and recommendation

Hydraulic simulation using the 1D model HEC-RAS gives an acceptable understanding of the dynamics in the Rákos stream at the given discharge. Overflow and potential inundation are shown to occur along the upstream until the downstream reaches for the most flowrates simulated. Most of the areas affected by the potential flooding are agricultural land, urban area, and forests and seminatural area, but also hydraulic affecting structures, both crossing bridges and pipe crossings are also at risk.

Further development is strongly recommended for improved result as well as better understanding in the area of hydraulic dynamics. The further analysis demands model to be detailed at hydrological investigation. An integrated modeling between hydrology, hydraulic with use of geographic information system based softwares can give new options to develop a plan for the flood prevention or flood control purposes. In addition, secondary data regarding the stage hydrograph from the gauge station should have been

gathered, therefore the hydraulic model could be run under unsteady flow simulation integrated with other related modelings.

Acknowledgments

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One dimensional stedy flow analysis of the Rákos stream

Abstract
With the increasing effects of climate change, the possibility of heavy precipitation is also increasing in frequency and intensity causing severe floods that brings fatalities, major casualties, as well as ecosystem service damages. Therefore, river hydraulic characteristics have to be analyzed independently to identify the location, duration, and extension of floods which might risk infrastructures and surrounding areas. However, the characteristics of flow dynamics in a small river channel have not been studied much, particularly adapted to climate change. For that reason, a hydraulic simulation was performed in the Rákos stream with the one dimensional (1D) model of US Army Corps of Engineers Hydrologic Engineering Center's – River Analysis System (HEC-RAS). The length of the stream is 21.8 km from the boundary in Budapest to the mouth of the Danube River, this is the half of the total length of the stream. The cross-sections along the stream were previously developed and currently completed at crossing bridges and pipes structure. Additionally, bank station and Manning's value *n* were adjusted based on field survey and sustained by the literary data and proposals. Three great discharges 10, 15, and 25 m^3/s were simulated in the model as the flood peak discharge. As boundary conditions, the known water surface elevation and normal depth were used for upstream and downstream respectively for each discharge. The mixed flow regime was selected to generate the output. The model was used to simulate 1D streamflow under steady-state condition, such as water level, profile flow, and velocity. In general, the simulation showed that the stream was able to carry the flood discharge at 10 m^3/s with some overflows in certain river stations. At the 15 m^3/s of flood discharge, some significant inundation has occurred at a number of river sections. However, reaching down to the Rákosfalva region, the area liying on the left floodplain would be endangered the most. Moreover, the water level at this discharge risked Határhalom and Vallós bridges structures as well as all the pipes structure crossing the stream from the upstream to the middle region. In the end, the area adjacent to the bank stream and all hydraulic structures along the Pécel region until the area right before the Rákosvalva region was threatened by the flood if the great discharge 25 m^3/s was simulated. In contrast, the downstream of the Rákos stream was still safe from the inundation, except the area where the riverbed of the Rákos stream was closed. In conclusion, the Rákos stream occupies a small catchment area which can contribute to runoff to the stream. For further study, unsteady-state condition combines with geographical extension and detailed hydrological modeling are recommended to be simulated to determine the characteristics of the catchment area and the design flood waves for the most important scenarios.

Keywords: HEC-RAS, steady flow, inundation, hydraulic structures

WATER QUALITY MONITORING FOR RÁKOS STREAM IN THE WINTER OF 2019/2020

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Introduction

Water is an important element to sustain life and with increasing urbanization and population the demand for water is rising, making maintaining its quality an important goal in today's society as a significant portion is under threat of pollution (EU Water Framework Directive, 2010). Surface water's quality can be affected by different sources, which can especially be influenced by the different land uses of the basin in which the water body is located (Wang & Zhang, 2018). Hungary is abundant in freshwater sources, with most of the country having an excess amount of surface and ground water sources, but most of them being prone to pollution (Barreto et al., 2017). Most of Hungary's water bodies are located in small watershed areas. However, there is no well-organized data to describe their characteristics (Halász et al., 2007).

Knowing the importance of maintaining a desirable water quality standard, monitoring campaigns are necessary for a better understanding and monitoring of the area in interest. For this paper the first results of the water quality monitoring of Rákos stream will be shown and discussed. Rákos stream is one of the smallest streams located in the central part of Hungary, its source originates from Godollo hills and flow across Isaszeg and Pécel until the north part of the Danube river in Budapest (Heltai et al., 1998). Rákos-stream has a 44 km length and the water catchment is 187 km^2. Half of the length (22 km long) the river flow through the capital city (Budapest). In the XVIII century the riverbed was controlled to avoid the further flood damage. These construction works still happen nowadays with shorter or longer interruptions. The ecology of the river, thanks for these constructions, isolated from the wider environment (http1).

According to Báthoryné (2005), the strem was under serious agglomeration load that causes ecological problems. To solve these problems, at the year of 1993 a project started to plan, later it was act in the river catchment (Rákos-river revitalizing program, Gál and Szaszovszky, 1997). This plan had a lot of critics due to the lack of the classical environmental protection content and the lack of a monitoring system implementation. After 1990 the wastewater load on the catchment decreased drastically and due to the legislation changes only illegal effluents enter untreated into the catchment. This change has a greatly positive effect on the wildlife and the agriculture in the area (Rosivall, 2002).

The next plan was established in the year of 2017 by the Local Council of Budapest (http2). Main points of the plan, compared to the 1993 plan, that the wildlife recovery and the green area development get highlights. Also, a new bicycle road was designed into the area. The main focus was on infrastructural development, water management and the development of green areas. The riverbed also received some focus: the plan gives some attention to turn the concrete riverbed back to a more natural state.

The stream passes through different areas with different land uses (residential, industrial, agricultural, forested and mixed) that can influence water quality conditions, especially due to anthropogenic sources (Saedi et al., 2020). It is important to also note that the stream receives an additional water source from communal wastewater treatment facilities in Gödöllő, Isaszeg and Pécel (Halász et al., 2007).

The monitoring campaign that this paper is going to cover started November 14th of 2019 having a biweekly data collection frequency. The last sampling which this paper will cover is the one done on February 5th of 2020. The aim of this monitoring is to analyze the change in some water quality parameters throughout most of the streams length and check if they follow the water quality standards.

Literature Review

For a good monitoring campaign a good understanding of the region is needed as well as which parameters will be analyzed. Rákos stream is divided in different regions which had its usage changed in the last century, becoming more urbanized (Saeidi et al., 2020). As the area around the stream can be considered a mix of rural and urbanized this can give some hints on which parameters to monitor, for example phosphorous forms can be abundant in rural areas or heavy metals could appear in urbanized areas (Grósz et al., 2019, Halász et al., 2007). The EU Water Framework Directive provides the acceptable values for the water quality parameters and the analysis will be done based on them.

Methods

After taking into consideration the monitoring area and prior studies that have been done in it, 8 different sampling locations were chosen, in accordance to Saeidi et al., 2020. The figure bellow presents the sampling locations.

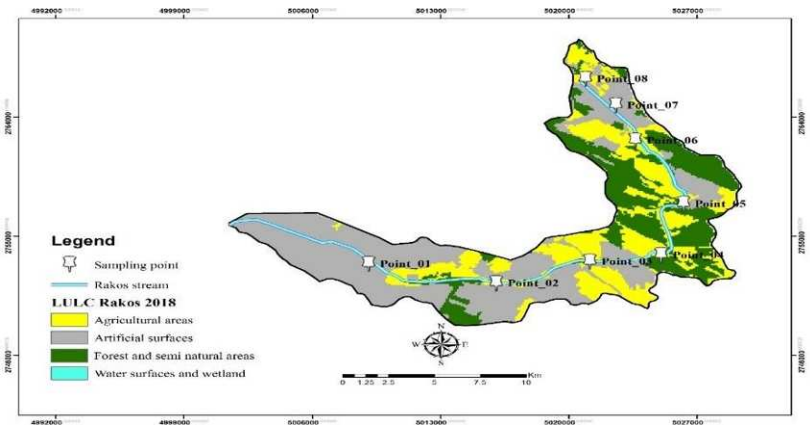

Figure 1. Sampling locations

The sampling points are distributed before and after areas with predominant land use types upstream and after some important points, like point number 3 which is just after the wastewater treatment plant of the town of Pécel. Point number 1 is the start of the continuous urban area of Budapest and point 8 is at the source of the stream in the outskirts of Godollo. By the time this paper has been written, no sample has been taken from point 6 as better analysis of the area has to be done to assure a suitable location for the water collection.

Ten water quality parameters were analyzed, namely: Temperature (C°), pH, Electric conductivity (µS), Dissolved oxygen (%), Nitrite (mg/l), Nitrate (Mg/l), Ammonium (mg/l), phosphate (mg/l), chlorophyll-a (µg/l) and Total cyanobacteria (µg/l). All of the parameters were measured in situ, nitrite, nitrate, ammonium, chloride and phosphate were measured using the Macherey-Nagel PF-12Plus Compact photometer with Visocolor Eco test kits. pH was measured with ADWA AD 14 pH/ORP equipment, Electrical conductivity with the HANNA DiST 3 equipment, dissolved oxygen with ADWA AD 630 DO Meter, Temperature and flow with Flowatch flow meter and chlorophyll-a and total cyanobacteria were measure with an Algae Torch (by bbe Moldaenke GmbH).

Results

For a better overview of the data in the month of monitoring some basic statistics were done, which can be seen in Table 1.

As it's shown in Table 1, the concentration of nutrients (NO_3, NO_2, PO_4 and NH_4) has increased in third sampling point, It might be due to the effects of surrounding water treatment plant, artificial surface (urban area) and agricultural area. However, in all sampling point the concentration of NO_2 is too low what can be expected in a semi-urban area, so further analysis why this is happening will have to happen for future dates of the monitoring. Also concentration of cyanobacteria in point 3 and 4 is high comparison with the other sampling points that could be due to the favorable condition related to wastewater treatment and agricultural area around point 3 and forest area

around point 4. In regards to chlorophyll-a and cyanobacteria concentration they don't seem to be following the same trend as the other nutrients, having their mean concentration at different peaks, but one point that it is important to focus is that the standard deviation has a really high value, being sometimes even higher than their mean value, showing that there might be some outlying values. For pH and Electric conductivity the values are similar in all of the point, besides number 8, as they show lower Electric conductivity mean values and a bit higher mean pH values. At last Dissolved oxygen shows higher mean values in points 1, 2 and 7, that regarding the low concentration of nutrients in these points is reasonable.

Knowing this, for a better overview in the changes in the time period, NO_3 concentration change was picked to be an example, as it shown interesting results, which they can be seen in Figure 2.

According to Figure 2, it can be seen that through time not all points follow the same trends in their concentration change, but usually point 3 has the higher concentration value, with some other points having peaks at some other dates.

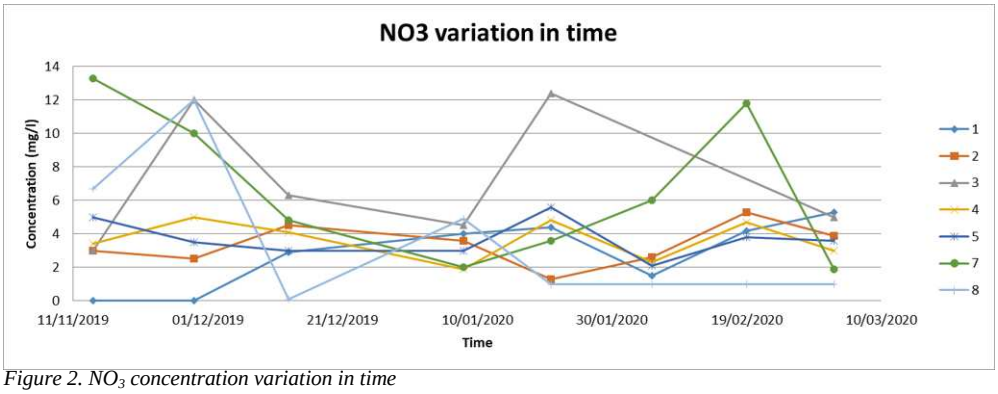

Figure 2. NO_3 concentration variation in time

Point 1	**Temp.(°C)**	**PH**	**EC(µS)**	**DO(%)**	**NO2(mg/l)**	**NO3(mg/l)**	**NH4(mg/l)**	**PO4(mg/l)**	**Cyano(µg/l)**	**Chl(µg/l)**
M	6.36	7.57	1003.88	42.48	0.31	2.79	0.19	0.95	10.48	82.05
SD	2.82	0.44	101.71	14.21	0.43	2.05	0.20	0.77	26.59	190.10
25%	5.28	7.30	1003.25	32.53	0.04	0.38	0.10	0.25	0.00	5.60
75%	9.23	7.94	1047.50	47.50	0.79	4.35	0.33	1.58	3.20	29.88
Point 2	**Temp.(°C)**	**PH**	**EC(µS)**	**DO(%)**	**NO2(mg/l)**	**NO3(mg/l)**	**NH4(mg/l)**	**PO4(mg/l)**	**Cyano(µg/l)**	**Chl(µg/l)**
M	6.23	7.89	992.50	50.33	0.20	3.34	0.39	1.53	2.85	22.85
SD	2.74	0.09	70.65	13.73	0.32	1.26	0.46	0.99	3.35	25.74
25%	5.25	7.80	965.50	36.55	0.05	2.53	0.10	0.90	0.30	10.38
75%	9.00	7.92	1046.75	64.50	0.14	4.35	0.58	2.63	4.00	31.68
Point 3	**Temp.(°C)**	**PH**	**EC(µS)**	**DO(%)**	**NO2(mg/l)**	**NO3(mg/l)**	**NH4(mg/l)**	**PO4(mg/l)**	**Cyano(µg/l)**	**Chl(µg/l)**
M	6.90	7.77	1066.17	32.48	0.77	7.20	0.72	3.67	13.07	35.52
SD	3.22	0.59	213.83	7.32	1.49	4.02	0.64	3.96	15.56	32.16

25%	3.75	7.53	913.75	26.25	0.12	4.13	0.18	0.95	1.73	10.73
75%	10.03	8.05	1214.25	39.83	1.18	12.10	1.45	5.68	21.40	53.00
Point 4	**Temp.(°C)**	**PH**	**EC(µS)**	**DO(%)**	**NO2(mg/l)**	**NO3(mg/l)**	**NH4(mg/l)**	**PO4(mg/l)**	**Cyano(µg/l)**	**Chl(µg/l)**
M	5.83	7.60	1060.38	25.65	0.13	3.65	0.48	2.35	14.11	51.83
SD	3.25	0.27	181.99	16.26	0.15	1.18	0.29	2.58	13.95	51.83
25%	4.18	7.30	957.75	9.65	0.05	2.48	0.18	0.68	0.90	10.03
75%	8.78	7.80	1077.25	40.50	0.14	4.78	0.75	3.05	27.05	74.25
Point 5	**Temp.(°C)**	**PH**	**EC(µS)**	**DO(%)**	**NO2(mg/l)**	**NO3(mg/l)**	**NH4(mg/l)**	**PO4(mg/l)**	**Cyano(µg/l)**	**Chl(µg/l)**
M	6.11	7.43	1044.38	27.75	0.11	3.70	0.28	3.72	7.73	59.65
SD	2.68	0.44	108.17	16.76	0.09	1.13	0.32	6.33	12.54	87.55
25%	4.55	6.95	1000.50	15.28	0.04	3.00	0.10	0.83	0.00	10.05
75%	8.80	7.83	1127.50	40.50	0.15	4.70	0.39	3.98	10.75	105.73
Point 7	**Temp.(°C)**	**PH**	**EC(µS)**	**DO(%)**	**NO2(mg/l)**	**NO3(mg/l)**	**NH4(mg/l)**	**PO4(mg/l)**	**Cyano(µg/l)**	**Chl(µg/l)**
M	7.54	8.09	1029.00	43.68	0.06	6.68	0.15	1.45	10.80	103.58
SD	2.23	0.52	429.81	13.93	0.03	4.46	0.14	1.07	12.62	217.19
25%	5.78	7.77	941.75	33.43	0.04	2.40	0.10	0.35	1.40	14.18
75%	9.45	8.09	1329.25	55.35	0.10	11.35	0.10	2.40	17.05	53.90
Point 8	**Temp.(°C)**	**PH**	**EC(µS)**	**DO(%)**	**NO2(mg/l)**	**NO3(mg/l)**	**NH4(mg/l)**	**PO4(mg/l)**	**Cyano(µg/l)**	**Chl(µg/l)**
M	6.85	8.12	848.00	34.68	0.05	3.46	0.48	1.36	7.60	101.55
SD	2.92	0.92	225.54	19.27	0.06	4.16	0.59	1.14	8.01	227.96
25%	4.43	7.53	856.25	13.88	0.01	1.00	0.10	0.48	0.13	6.08
75%	10.03	8.19	962.50	51.30	0.13	6.25	0.70	1.75	15.13	49.43

Table 1. Statistics of the analyzed water quality parameters. M = Mean, SD = Standard Deviation, 25% = lower quartile, 75% = upper quartile.

Discussion

According to the results of water quality monitoring in study period, the stream is clearly influenced by different sources in all of its length, which is goes on par with what was written in previous studies (Saedi et al,. 2019). When looking at the mean concentration of nutrients, it can be clearly seen that its peak concentration is usually at number 3, which is just after the water treatment plant of the city of Pécel, this value is way below the 50 mg/l (for NO_3) which is the limit determined by the world health organization (WHO, 2004), but it has to be taken in consideration that these values are low because they were measured in winter and they are expected to rise as agriculture starts to function again, which the values will be monitored in future dates. Another interesting point is when looking at how the concentrations change trough time in all of the points, taking NO_3 in figure 2 as an example, it can be clearly seen that all of the points don't follow the same trend, mostly point 4 and 5 follow the same pattern

throughout the time series and point 1 after January as well follow the same pattern as these both points. Since sampling took place in winter, the temperature changes are not large, therefore, a time comparison is not significant. Different responses in all the different points were expected, as they are located in different regions of the stream, but looking at figure number 2, one important information that can be taken from it is that there are different sources of nutrient inputs that happen from the source until downstream of it.

Conclusion

When analyzing the first season of this monitoring campaign, even when knowing that in winter no high concentrations are expected, starting the monitoring in winter has its advantages. Some initial pictures already can be seen, giving a better overview of the water quality in the stream as well as giving some important information for the next seasons of monitoring (which points to look for higher nutrient concentrations for example). With knowing all these information, it is possible to improve the quality and efficiency for the next seasons of monitoring.

Acknowledgments

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Water quality monitoring for Rákos Stream in the winter of 2019/2020

Abstract
Analyzing the water quality of a water body can explain how it is being affected by different sources, such as different human activities; soil coverage; condition of the local ecosystem. The research in which this paper is based on is the biweekly water monitoring for the Rákos stream, starting from its source in the city of Gödöllő until the outskirts of Budapest in a semi urbanized area. As at the time of writing this paper 11 water quality parameters are being monitored, with the possibility of adding more in the following years of monitoring. The parameters are: Temperature (ºC), pH, Electric conductivity (µS), Dissolved Oxygen (%), Nitrite (mg/L), Nitrate (mg/L), Ammonium (mg/L), chloride (mg/L), phosphate (mg/L), chlorophyll-a (µg/L) and Cyanobacteria (µg/L). These parameters were all analyzed in situ, utilizing different methodologies, but mostly utilizing photometric analysis.
This paper presents the initial results that were seen in the first months of this monitoring campaign, focusing on the winter of 2019/2020 period, showing the different results that were seen in this period and how they change throughout the monitoring area due to different causes.

Key words: water quality, nutrients, Gödöllő, Pécel, Isaszeg

A STUDY OF FORMATION OF SOIL CULTIVATION ERRORS AND THEIR ENVIRONMENTAL EFFECTS ON BOUND SOIL

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Introduction

The quality of cultivation and the formation of cultivation defects are primarily influenced by the moisture content of the soil. If the moisture content is low, the adverse physical effects associated with clodding are more intense. The soil is harder to work on and with more energy, and the clodded state thus created will only be suitable for crop production with further intervention.

With sufficient moisture content for cultivation, the adverse effect of soil hardness and clay content is reduced. In this case, the soil is crumbled due to the cultivator, its friability without dusting is proceeded favorably, and no further crushing operations are usually required. Moisture content is sufficient if the cultivator performs its typical operations efficiently, with minimal soil damage and low energy input.

Lack of adaptation to soil moisture in any cultivation process results in damage to the structure and an increase in energy demand. Due to their construction and impact on the soil, cultivation equipment can only be used under a relatively narrow range of humidity considering the least risk. However, deviating from it increases the chances of error and costs.

In my study I investigated the occurrence of the most common soil cultivation errors and their environmental effects on bound soils. My choice of topic was mainly motivated by the soil conditions typical of Szarvas and its surroundings and the extreme weather conditions that change from year to year. 50% of the area is susceptible to structural degradation and compaction, has a hard soil and is difficult to cultivate. Winter wheat, sunflower, maize and rape are generally grown in the areas studied, with varying results. During the research I was interested in the harmful effects of the applied technology and agrotechnology on the cultivation and the environmental risks of these.

Methods

The investigations were carried out in the fields cultivated by Körös Agrár Kft. The investigations were carried out with the help of the experts of the farm on the tillage tools used in the Ltd. For the investigations I applied the environmental impact assessment developed by Birkás and Csík with a minor modification. The 6 most important risk factors related to cultivation were identified below:

- Soil compaction
- Grounding of soil
- Dusting of soil
- Kneading and lubrication of soil
- Erosion, deflation
- Preservation of soil moisture

The factors listed are of equal environmental importance. The effect of a given procedure on a given soil moisture, if it mitigates environmental damage - 1, if it is

indifferent 0, if it increases the damage, it can be evaluated with + 1 points. The total effect on the risk factors - that is, the sum of the score of the factors - shows the environmental impact of a given process. When looking at the influence on the 6 risk factors, the environmental number can be in the range of - 6 to + 6. The evaluation was based on the data of *Table1*.

Total effect of cultivation process	*The environmental impact of the cultivation process*
$\leq$ -3	***Really good***
- 1, - 2	***Good***
0	***Medium***
+1, +2	***Weak***
$\geq$ 3	***Very weak***

Table1. Evaluation categories of cultivation practices

Results

Environmental Impact Assessment of Basic Cultivation Equipment

Table 2. shows the test results and the environmental effects of the basic cultivation procedures on soils with different moisture contents. From this it can be concluded that rotary tillage and the use of plow in any soil moisture is risky. The plow fixes on dry soil, kneads and compactes on wet soil, especially with a ***Conventional plow***. Moisture loss is too high during rotation.

Soil condition	*Plow*		*Disc harrow*	*Heavy cultivator*	*Medium deep loosener*
	Conventional plow	*Reversible plow*			
Dray	+4	+1	+3	-5	-4
Damp	+3	0	0	-6	-5
Wet	+3	+2	+2	-2	0
Environmental impact	***Very weak***	***Weak***	***Very weak***	***Really good***	***Really good***

Table 2. Environmental impact of different basic cultivation practices

Conventional plowing produces furrows and ridge gaps, which increases the risk of erosion / deflation. *(Figure 1.)*

Reversible plowing is more economical and has a better environmental impact. Fewer idling speeds reduce tread damage and reduce the need for machining, since no furrows or ridge formation occurs. *(Figure 2.)*

In many cases, however, rotary tillage is preferred, especially on wet soils, since disc cultivation or the use of loosener in these areas is risky.

Figure 1. Plowing with conventional plow

Figure 2. Plowing with reversible plow

The overall environmental impact of ***heavy cultivator cultivation*** is very good. No compaction, dusting, minimal soil moisture loss. The cultivator does a good job on dry and damp soils, its use on wet soils is a bit risky as the loosening effect is less pronounced. *(Figures 3. and 4.)* The quality of the cultivators combined with the contractor is particularly good, so the company prefers to use these tools**.**

Figure 3. Heavy cultivator mounted

Figure 4. Heavy cultivator towed

In many cases, the economic benefits of ***disc cultivation*** - low fuel consumption, high area performance, wide applicability - are neglected due to environmental damage. The effect of the disc on the soil is unfavorable at any moisture, and therefore its environmental performance is very poor. It fixes and dusts dry soil, reduces the moisture content of the soil. After stubble cultivation, it is therefore absolutely necessary to close the stubble, eg. with ring roller. On wet soil, it kneads, compactes, and easily clogs in residual areas. Its use carries less risk than favorable humidity (damp soil). Advantageously, the disc harrow is combined with a cultivator. *(Figure 5.)* As I mentioned in the introduction, most areas of the economy are prone to compaction. Deep layers (30 - 40 cm) to remove harmful compaction (eg plow sole) are best suited for medium deep loosener**.**

The environmental impact of a ***medium deep loosener***, like a heavy cultivator, is very good. No compaction, no dusting, no moisture loss. Clogging may occur on dry soil, but can be eliminated by a contractor. The risk is that the soil is too moist, in which case the use of a mid-leveler should be avoided. *(Figure 6.)*

Figure 5. Application of disc harrow

Figure 6. Medium deep loosening

Environmental impact assessment of working (seedbed) tools

When designing the cultivation system in an environmentally-oriented manner, the environmental effects of working (seedbed) processes must also be taken into account. The environmental effects of the mostly loosening, crushing, compacting and surface forming processes are summarized in *Table 3***.**

Soil condition	***Spade harrow***	***Combiner***	***Multitiller***	***Compactor***
Dray	-3	-5	-4	-5
Damp	0	-3	-1	-3
Wet	+2	+1	+1	+1
Environmental impact	**Medium**	**Really good**	**Really good**	**Really good**

Table 3. *Environmental impact of tillage tools*

From an agronomic point of view, cultivating and seedbed production methods can be qualified primarily by improving the quality of the basic cultivation and by creating the conditions for sowing. The qualification is supplemented by the fact that the given tool mitigates or enhances the environmental impact of the basic cultivation - favorable or unfavorable - or its effect is neutral.
The overall effect of the ***spade harrow*** used on the farm is medium. Extremely good on dry soil, indifferent on wet soil, but weak on wet soil. On wet soil, it kneads the soil like a disc and easily clogs. *(Figure 7.)*

Figure 7. *Seedbed preparation with spade harrow*

Figure 8. *Seedbed preparation with combiner*

The ***Combiner, Multitiller*** and ***Compactor*** have a very good environmental performance, especially on dry and damp soils. ***(Figures 8., 9. and 10.)*** Risk is the wet soil. In this case, they should be avoided as much as possible due to the risk of compaction, kneading / lubrication and clogging**.**

Figure 9. *Rau Multitiller Seedbed Maker*

Figure 10. *Seedbed preparation with Compactor*

Summary

The primary purpose of soil cultivation is to mechanically create a soil physical state that satisfies the needs of the crop to be cultivated optimally. Lack of adaptation to soil moisture in any cultivation process results in damage to the structure and an increase in energy demand. In my dissertation I investigated the occurrence of the most common soil cultivation errors and their environmental effects on bound soils. During the research I was interested in the harmful effects of the technology and agro-technology applied in the given farm on the cultivation and the environmental risks involved.

Keywords: soil tillage, basic tillage, seedbed preparation, tillage errors, environmental impact

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A study of formation of soil cultivation errors and their environmental effects on bound soil

Abstract:

The quality of cultivation and the formation of cultivation defects are primarily influenced by the moisture content of the soil. With sufficient moisture content for cultivation, the adverse effect of soil hardness and clay content is reduced. In this case, the soil is crumbled due to the cultivator, its friability without dusting is proceeded favorably, and no further crushing operations are usually required. Moisture content is sufficient if the cultivator performs its typical operations efficiently, with minimal soil damage and low energy input In my study I investigated the occurrence of the most common soil cultivation errors and their environmental effects on bound soils. During the research I was interested in the harmful effects of the technology and agro-technology applied in the given farm on the cultivation and the environmental risks involved**.**

Keywords: soil tillage, basic tillage, seedbed preparation, tillage errors, environmental impact

GREEN HOUSE CONTROL SYSTEM APPLYING LED LIGHTING –WITH IOT SOLUTION

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Introduction

In the beginning the plant grow container was built for the plant growth researches. This alu-profile container frame has a length of 3 meters, and it is capable for adjusting the distance of the LED lights according to the height of plants. This container frame has divided up to two part for two different LED grow light. Both LED grow light purchased from different distributors.
The irrigation system consists of a barrel with pipe-system and a pump, with Jr drippers and 45°arrow stakes. In the barrel a premixed fertilizer nutrition solution can be found, which is dispensed through the dripper stakes to the roots of the plants. The nutrients are equally spreaded out across the whole growing container's substrates, so we can measure the different effect on plants caused by the different LED grow light spectrum. The difference in spectrum was measured with a spectroscope.
One year later another growing container frame has built with same sizes as the first one. The irrigation of the new frame was joined with the older frame's pipeline, to have the same amount of nutrition for both frames ensured. The substantial difference is in the LED growth lights. The second frame has received an individually developed LED growth light, which consist of different wavelength power LEDs and all of them can be set individually from zero to max intensity. With this we are able to switch off spectrums, or to set them for different performance. The need of this is to set the ratio of different spectrums to examine the effect of different light sets on plants with constant fertilisation.

Literature review

The goal of the IoT is to create an opportunity to use all of the devices at same time with the use of communication services. [1] The advantage is that the high precision controlling has significant effect on quality and quantity growing. The plant growth frame supported by IoT is a logical controller which has inputs and handles outputs for interventions. This pairs up with an electronic device that handles the communication with the web server, which is also in connection with the user devices such as PC, tablet or smart phone. In special cases, this web server forwards the data to the cloud based, big performance artificial intelligence, where quick calculations are possible for predictions, artificial learning and other algorithms which are sent back to the user interface.[2][3][4][5]

Laboratory and plant growth frame:

To keep the appropriate temperature stable, the room is provided with an air conditioner. The area of the room is 21 m^2, where the 3 m long, 0,3 m wide and 2,3 m high plant container frame was created using aluminium profiles. The frame is separated into 2 section by a shadowing plate. The common nutrition is solved, while the LED illumination could be differing.

Irrigation:

There are installed 2 pcs of 120 liter barrels, which are equipped with two pumps for the irrigation of the two different frames. This gives an opportunity to irrigate the two frames with different nutrients. At the same time, the irrigation system is capable of irrigating both frames from one barrel. Besides, the irrigation system is equipped with an adjustable timer. With this device it is possible to make set of timings for daytime and night-time. The nutrient solution is prepared externally and poured into the barrel. A microcontroller is installed in order to collect EC and pH data, and for checking the nutrient-solution level in the barrel. The drain water is collected in buckets. If the level of the drain-water reaches the max level provided by a water level sensor, the pump is switched on to remove and lift it back to the barrel. If there is no need of recirculating, the pump it into the sewage system.

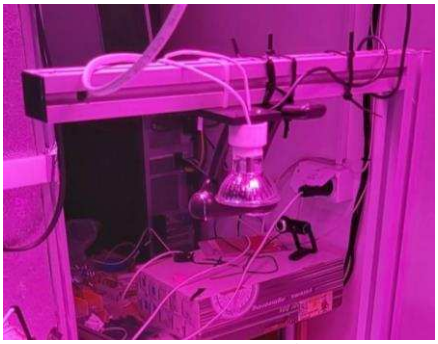
Illumination:

The first container frame is equipped with industrial LED growth lights and appropriate timing is set for switch on/off. Besides, the heights of the LED lights are adjustable. There are installed two different brands of LED growth light. The first one has seven spectrum, the other one has 5 spectrum. One of them able to radiate in IR range, and the red-blue ratio of the light also differs from the other LED light. Besides, the first LED which has 7 different spectrum, include “green” color spectrum, which has evidence, that has good effect on plant growing.
On the second frame, there is an individually designed LED light system, which has 12 different spectrums. These wavelength are 365, 390, 440, 460, 520, 570-610, 610, 630, 660, 735, 850, and 940 nm. These LEDs with different spectrums are sorted by the wavelength (color) into different groups. These groups can be adjusted independently from other color groups. These LEDs are controlled by two microcontroller (MCU), because each half of the frame has a microcontroller, therefore they can adjusted separately. On the frame, the LED groups are installed in a variety of colors. In this way, the illumination of both side of the frame can be same, or different, depends on the settings. As mentioned, two different microcontrollers controls the LEDs through PWM-modules. The settings for light intensity of each group of LEDs can be set in a PC GUI interface, which sends the settings to the MCUs via UART serial communication. Also, the daytime/night-time timing of the LEDs can be adjusted via this GUI interface. The importance of timing is to optimisate the interval of illumination for the right progression of given plant. The power consumption can be decreased without the deterioration of plant quality. In the life period of plants, the UV and IR spectrum ranges are also significantly influencing factors. In case of strawberry, where

different stages of plant growth require different amount of UV and IR, e.g.: in blooming, fruit ripening, etc.

1. Figure LEDs and the lettuces

2. Figure Control board of LEDs.



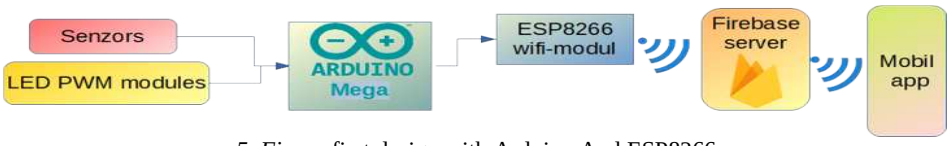
3. Figure WebCamera and flash

4. Figure Picture from the arrangement of container frames

LED light control and IoT data acquisition with common microcontroller, and development of webserver and application.

Full monitoring and climate control

The data acquisition (DAQ) was done by Labview software and its own USB DAQ device. After one year of testing, an issue has risen: Nor the Windows PC, nor the Labview software was not enough stable and reliable, to run uninterruptible and without unpredictable software crash. In spite of stability, we had to made changes: Using low-cost IoT devices.

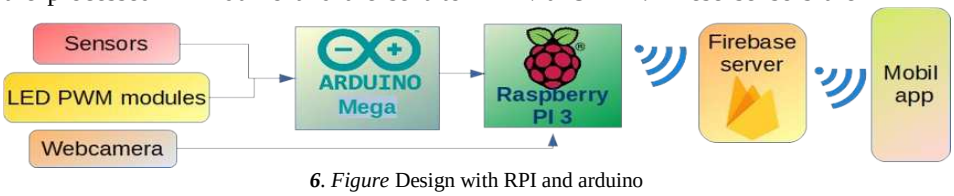


5. Figure first design with Arduino And ESP8266

First design of the IoT system run besides Labview:
The following concept for theautomatisation is a more complex solution. A Raspberry Pi 3B+ has enough performance in its ARM Cortex CPU, to execute image-processing.

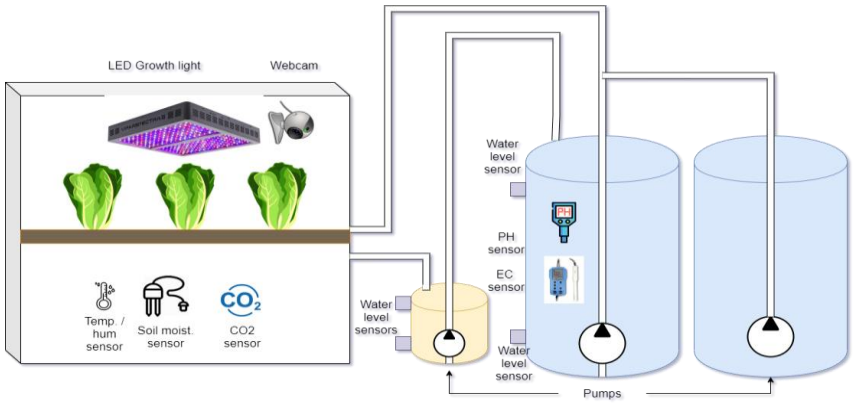
Design with Raspberry:

The automatization of farming facility includes the monitoring of nutrition barrel water and drain-water level. The pH and EC measurements are included as well. The control of sensors and the LEDs are made by three Arduino boards, the signals from the sensors are processed in Arduino and are sent to RPI via UART. These sensors are DHT11



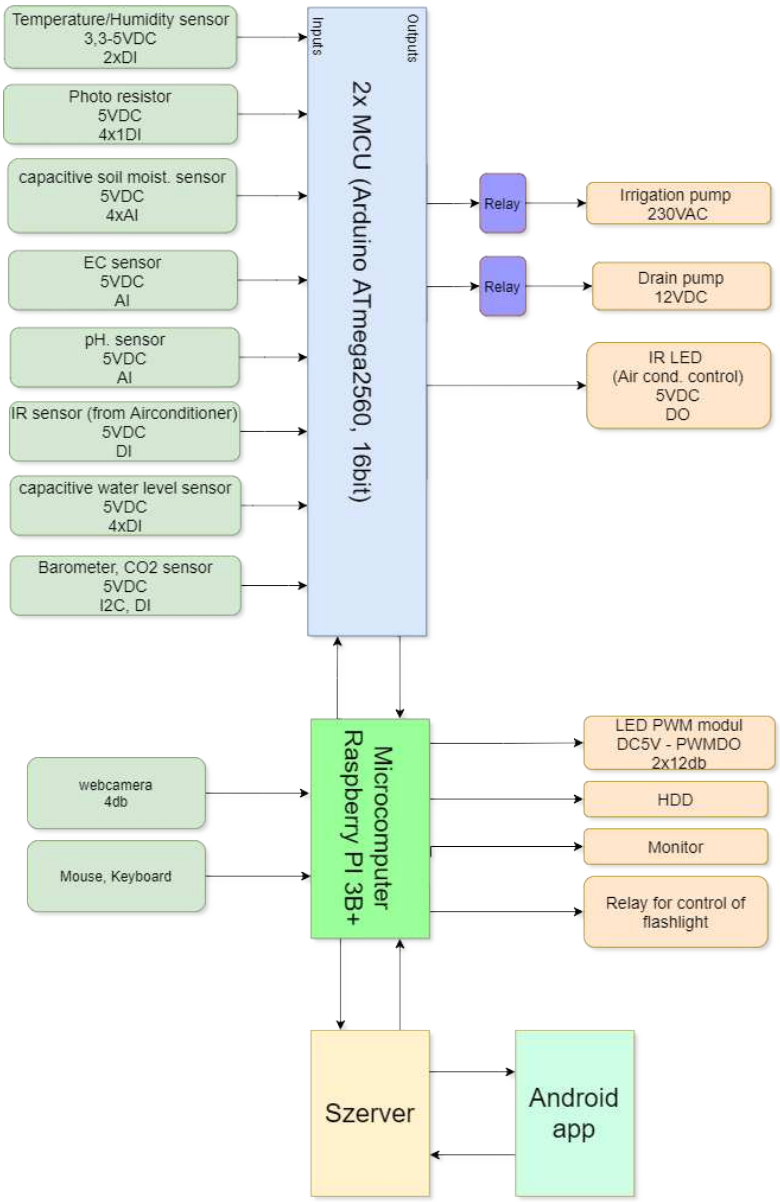
6. Figure Design with RPI and arduino

temperature and humidity sensors, SEN0193 capacitive "soil moisture" sensors, GL5528 photoresistors, a BMP280 barometer, and a CO2 sensor. Also planned to control the air-conditioner with IR transmitter. There are four web cameras attached to the RPI which captures still pictures in every 4 hours per a day and from 1 to 4 am in every hour. This is done by python scripts, which are timed in Crontab in-system app in Linux. The data from sensors are acquired in every one hours. The data are saved into .CSV and .JSON format, which is posted to the webserver. In this site we can monitor the whole farming facility. In case of any issue, the data are synchronised to an external HDD too.



7. Figure An illustrative figure for demonstrating the working of experiment indoor farm

The next block diagram shows the connections between each element of this project.



8. Figure The connections between each element of this project.

Summary

The result of the several years of development is that the system is suitable for remote controlling and monitoring. The system is able to satisfy unique needs for running algorithms of specific controlling and creates the opportunity for cloud based monitoring with regards to temperature, RH, and the composition of nutrients and lighting spectrum.

Keywords:spectral distribution, LED light control, IoT data

Acknowledgements

This article was funded by EFOP-3.6.1-16-2016-00016, "Specialisation of research and education profile of SZIU Campus in Szarvas by Smart Diversification: agricultural water management, hydroponic cultivation, alternative arable crops, development of related precision machine management'.

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Green house control system applying LED lighting –with IoT solution

Abstract

IoT has a greater role in agricultural nowadays, which support the development of greenhouses and indoor growing facilities. It helps not only to adjust microclimate but also the application of cloud based artificial intelligence with big calculating capacity as well which contains many opportunities of artificial learning. This article describes remote controlled and monitored system which is specifically corresponding to the new challenges of the IoT.

Keywords: spectral distribution, LED light control, IoT data

ANALYSIS OF TOPOGRAPHIC WETNESS INDEX AND VEGETATION INDICES IN THE RÁKOS AND SZILAS WATERSHEDS

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Introduction

Remote sensing and GIS have relieved some of the stress from the large time and effort that has been invested in realizing spatial and temporal patterns and characteristics of individual hydrologic processes by providing access to spatial and temporal information on watershed, regional, continental and global scales (Bakir & Xingen, 2008; Mahmoud et al., 2014). The aim of the present study was to use available GIS techniques to examine the relationship between vegetation, land use and topography in the Rákos stream basin.

Literature Review

Digital Terrain Modelling is a very useful branch of technique that we can use for Earth surface mapping. (Bashfield et al. 2011) Digital Elevation Modell includes data processing or representation options, land surface sampling, representation and development of a surface model from the measured heights, and correction of errors and artefacts in the surface model. (Grabs et al. 2009; Chen et al. 2004)

Topographic Wetness Index (TWI) that was originally created by Beven and Kirkby (1979) is a widely applied index based on the topography of the surrounding area and explains the probability of a point to be saturated.

Normalized Difference Vegetation Index (NDVI) is one of the most commonly used type of satellite data that is generally computed using image data from the polar revolving satellites which are carrying sensors that discover the radiation in both red and infrared wavelengths. (Hengl et al. 2009; Verstappen 2011) The NDVI has been designed specifically for the separation of green vegetation from many other surfaces.

Rákos Stream is located in Hungary, originating near Gödöllő and flowing to the river Danube at Budapest. The length of the stream is 44,3 km and the catchment area is 185 km^2. (Saeidi et al. 2019)

Methods

Our methodology primarily focused ont he calculation of the normalized deference vegetation index (NDVI and the topographic wetness index (TWI) for the study area and their comparison to the existing land use/land cover.
DEM data from the EU-DEM dataset have been used as an input for the geomorphometric indices. Topographic Wetness Index (TWI) have been calculated using SAGA GIS (Weiss 2001, Jenness 2006, Beven and Kirkby, 1979).

NDVI layers have been calculated based on Sentinel-2 data using QGIS for four different dates in 2019 and 2020. (QGIS Development Team 2020; ESA Sentinel 2 Mission 2020)
Land use/land cover information was derived from the 100 m resolution CORINE Land Cover dataset for 2018. (CORINE Land Cover 2020)
Statistical analysis was carried out using the R software (R Development Core Team 2017), calculating the mean NDVI values for each grid call, along with the reange of NDVI values. For interpretation of the results, boxplot figures have been created.

Results

The Normalized Difference Vegetation Index (NDVI) has been calculated by using QGIS to evaluate the vegetation cover. The NDVI values for April, September and October 2019 and February 2020 have been initially calculated and mapped into five classes. NDVI map of the basin for April of 2019 is presented in Figure 1.
Figure 2 presents the boxpot diagrams indicating the distribution of NDVI mean and range values and the TWI values based on the Corine Land Cover classes.

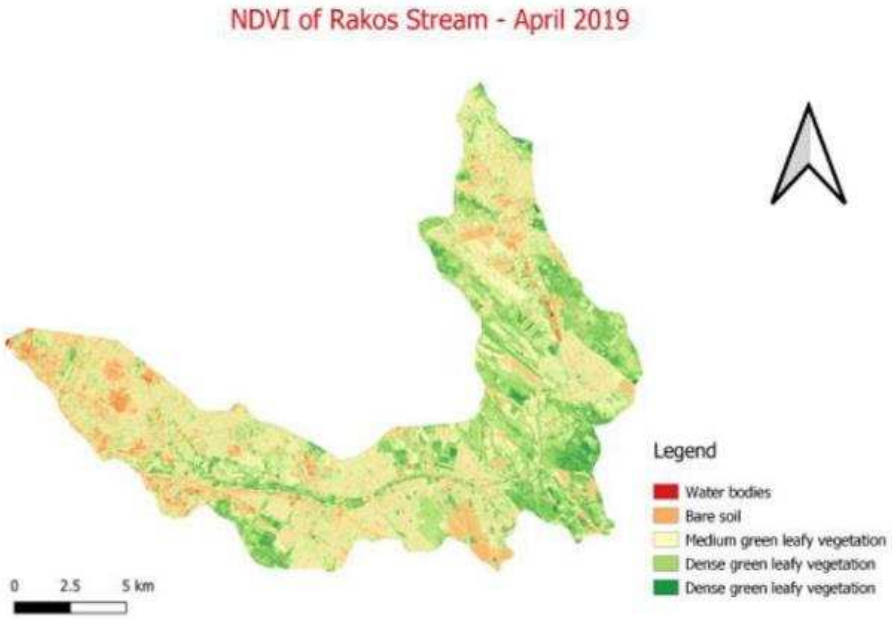

Figure 1 NDVI map of Rákos Stream (April 2019)

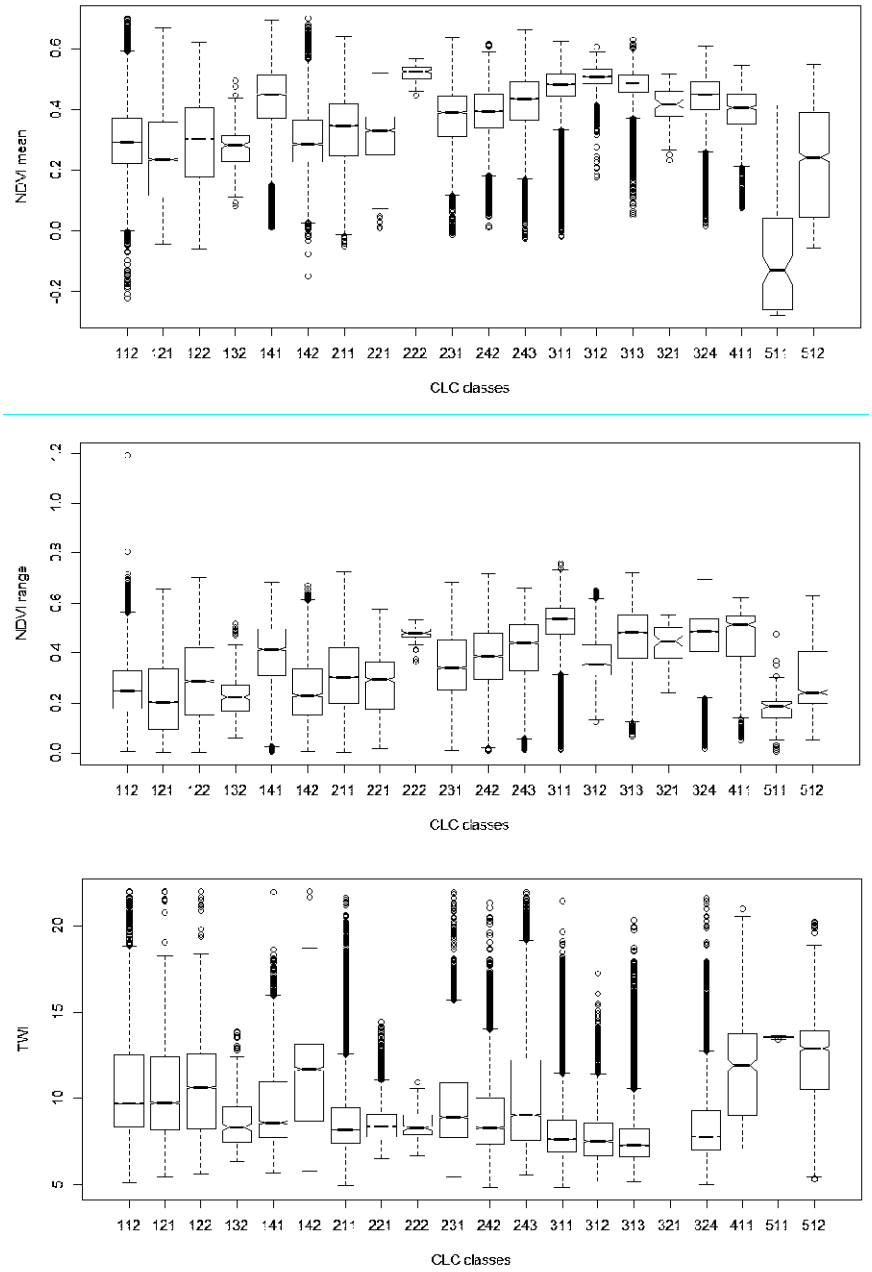

Figure 2. Predicted changes under scenario 2

Discussion

The distribution of NDVI mean, range and TWI values generally indicate a large variation. However, some differences are present between different CLC calsses.
Mean NDVI values indicate that as expected, forested areas generally have higher NDVI values with lower variation. Also, waterbodies seem to have significantly lower NDVI values than waterbodies, indicating potential eutrophication in the latter.
NDVI ranges indicate that most land cover classes have high variability, due to seasonal variation, wih orchards having a generally high range value, exemplifying the effect that also occurs in forested areas, there large differences can occur due to seasonal variation on foliage.
TWI values inidicate that forested areas and orchards are generally present at hillsides, with lower TWI values. Ont he other hand wetlands and waterbodies are generally present at areas of high TWI.
The above results indicate that there were topographic factors present at the development of the current land cover. However, the results are also not conclusive enough. This might pe partially due to the relatively short time series for NDVI, or the small size of the study area in case of TWI.

Conclusion

The analysis of NDVI and TWI indices indicated some correlation with land use/land cover. Wetlands are typically present in lower lying areas with higher accumulation of water, while forests and orchards are more present in steeper hillsides. Further research should focus ont he expansion of the study area and also on a longer time series for NDVI data, in order to increase the potential for statistical analysis.

Acknowledgments

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Our work has been supported by the National Research, Development and Innovation Office [NKFIH; Grant No. FK-124803].

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ANALYSIS OF TOPOGRAPHIC WETNESS INDEX AND VEGETATION INDICES IN THE RÁKOS AND SZILAS WATERSHEDS

Abstract

Landscape topography plays a key role in the accumulation and storage of water at or near the surface. The current study aims to assess the spatial connection between topography and vegetation in two adjacent small watersheds (Rákos and Szilas streams). The analysis was carried out using the Topographic Wetness Index (TWI) and Normalized Difference Vegetation Index (NDVI) as indicators. TWI has been derived from the EUDEM dataset using SAGA GIS, while NDVI been calculated from Sentinel-2 imagery using the SNAP Toolbox.

Keywords: topography, vegetation, TWI, NDVI, Hungary

DEVELOPMENT OF IRRIGATION TECHNIQUES BY MODERNISATION OF SPRINKLER IRRIGATION SYSTEMS

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Introduction

Water plays a key role in arable crop production. Precipitation administered at the adequate time and in sufficient quantity increases yields and protects plant cultures from damages caused by drought. Irrigation can provide a solution to this problem by establishing new irrigation systems or modernising existing ones. I often prefer the refurbishment of old systems: in case irrigation has already been implemented in the given area it had acquired a legal water permit. If water abstraction was possible in the past, then the system can also be utilised today following the necessary reconstruction or modernisation.

The Valmont 6000 self-propelled, frontal movement linear irrigation equipment used in this research is situated at a partner of Magtár Ltd. in Fábiánsebestyén, Csongrád county. I set an objective of describing the modernisation of this system as a case study as well as conducting and assessing work quality examination before and after the modernisation. I consider this topic relevant due to the ongoing climate change resulting precipitation deficit and long drought periods in Hungary.

Literature review

The type and quality of the area to be irrigated, the plant species and their water demand as well as the size of the available water supply determine the method of water placement. Out of all irrigation methods **surface irrigation** is the oldest. By this procedure water is transmitted to the plants on the soil surface. Based on the movement of water flood irrigation, furrow irrigation and border strip irrigation can be distinguished.

During **subsoil irrigation** water moves and disperses in pipelines set up under the surface in soil layers not affected by cultivation. The water soaks the fertile layers from below.

Micro-irrigation is a method that makes the utilisation of limited water supplies possible. This method provides the best opportunity for energy saving and an environmentally aware approach. Small amount of water is inserted into the soil by using a closed pipeline system and low pressure. The entire surface area is not irrigated, water is transported directly to the plants and rows. Dripping and micro-sprinkler irrigation are the two types of this category. (Ligetvári, 2011)

Sprinkler irrigation is the most common form of water placement in arable fields. Irrigation water arrives from the air in the form of small drops – similar to the natural rainfall. Water is transported in pipelines under pressure to the sprinkler heads set up at the place of irrigation. The quality of this process is determined by the water

distribution steadiness of these sprinkler heads. It is also possible to apply nutrients, solutions and fertilisers together with the water. (Szlivka 2002)
One of the most popular types of sprinkler irrigation systems is the ones with **reelable pipes**. In order to facilitate the relocation of the equipment hoses can be reeled up. These hoses can be either semi-rigid or soft. These machines include a wheeled frame, winding spool, hose, sprinkler head vehicle, engine and security and regulatory structural elements.
In case of **centre pivot irrigation** equipment pipelines are set on vehicles (towers) established 25 to 55 m distance from each other. One end of the pipes is connected to the water supply, while the machine makes a circular movement around this place and irrigates during the constant motion.
The structure of a frontal movement linear irrigation system is similar to that of the previous type, although it does not follow an orbit. It moves perpendicularly to the pipeline and continuously irrigates. It works in a totally automated way. Certain types can use hydrant systems, while others utilise the water of open channels.
The concept of **precision irrigation** is more and more widespread even in sprinkler irrigation. Precision farming is the result of the recognition that production areas cannot be considered as homogeneous from several aspects. In these new agricultural technologies adjusted to the production area cultivation and the placement of different materials – e.g. irrigation – follows the demand of the given area, thus it can vary even within the same parcel.
Out of the different kinds of sprinkler irrigation **centre pivot and linear** systems are the most suitable for implementing precision irrigation both in theory and in practice. Important companies have carried out really important developments since the beginning of the 2000s in order to make the special technique available that is a precondition of area-specific irrigation. **Variable Rate Irrigation (VRI)** implemented by self-propelled irrigation equipment ensures adjustable amount of water in order to provide demand-based water replenishment of the involved areas.

Material and methods

The Valmont 6000 self-propelled frontal movement equipment has been installed in 1982. The machine acquires the necessary amount of water from the Holt-Körös by using open-air surface channels. Water and energy supply of the equipment is provided by a diesel engine pump and generator placed in the central unit. Electric engines are responsible for the movement of the irrigation spans. These engines can be controlled by an operating panel installed in the central vehicle.
The equipment consists of nine spans in both directions. Its total length together with the two end consoles is 1024 metres. Sprinkler heads with kick plates are set on the spans. The size of nozzles increases toward the two ends of the pipeline. Sprinkler heads are placed at varied distance from each other in order to ensure the even placement of water.
Following the examination and inspection of the system a test run was conducted and we have completed the measurements related to the water distribution of the original, untouched irrigation machine.

Following this survey all sprinkler heads have been replaced by Nelson Rotator sprinkler heads and a new set of measurements were taken.
It was followed by the total modernisation of the irrigation system: diesel engine pump, generator, operating panel, electric engines, wheel engines, spiders, tires, equipment ensuring the steering of spans and their junction boxes were all replaced. Another set of data were recorded after the modernisation.
All measurements were implemented by using the precipitation meters installed parallel to the pipeline. 5, 20 and 30 mm of irrigation water was administered. Measuring vessels were placed 10 metres apart 0.6 metre above the soil surface.

Results and evaluation

Measurements before the modernisation

Following the general screening of the equipment it was put into service and the first measurements were taken with the measuring vessels.
When the machine was set to use 5 mm of water the speed of the equipment was 71.4 m/hour. The performance was 60%. Figure 1 shows the distribution of the irrigated water that followed a very uneven pattern. Average water cover h=5.3 mm; the evenness of the water dispersion C_u = 51.88% which is far behind the required 75 to 92% The main reason of it the insufficient incoming water pressure (260 kPa) that declines even more (130 kPa) when reaching the end of the line. Another problem was that the steering ability of the equipment was inadequate and also the drifting of water was considerable due to the high altitude of sprinkler heads.

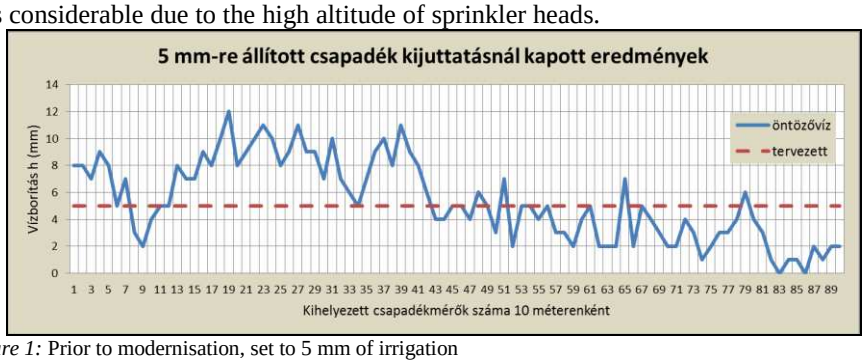

Figure 1: Prior to modernisation, set to 5 mm of irrigation

In case of 20 mm the speed was 17.85 m/h that corresponds to a 15% performance. The distribution can be seen in Figure 2. Average water cover is 13.15 mm, its evenness C_u = 69.87% that is still below the requirement. Fixed side shows great fluctuations again, while the free side displays a more balanced distribution. Steering issues were the same as experienced during the previous run.

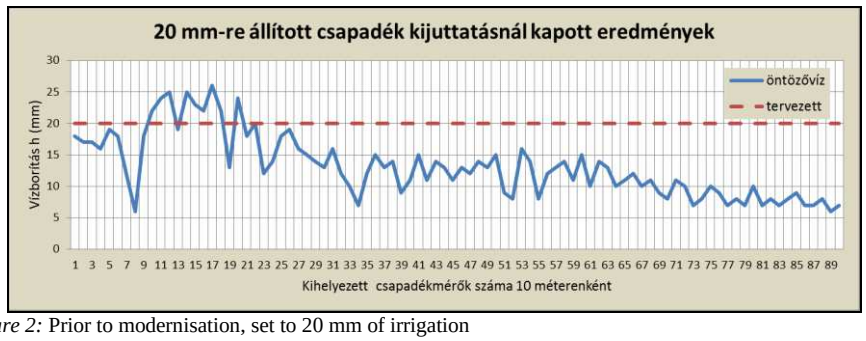

Figure 2: Prior to modernisation, set to 20 mm of irrigation

In case of 20 mm irrigation water the moving speed of the system was 11.9 m/h that means 10% of the performance. Figure 3 contains the results of the water distribution. The average amount is 20.17 mm, while the rate of dispersion C_u = 72.03%. Steering of the linear showed the opposite effect as in the previous two occasions. The system tries to keep itself in the set path causing a remarkable distribution difference between the two end points of the machine.

Figure 3: Prior to modernisation, set to 30 mm of irrigation

Measurements after replacing the sprinkler heads

Original sprinkler heads were equipped with kick plates. Due to their size, nozzles often got clogged and therefore created really small droplets. The result was rather fog than irrigation water. They were also placed too high from the surface and the drifting loss was remarkable. These upper sprinkler heads were replaced by hanged downpipes.

Figure 4 shows the distribution when the amount of water was set to 5 mm. The average water collected was 4.98 mm while the distribution C_u = 76.5%.

Unlike in the original test run the highest water cover exceeds the set value only by 3 mm and the lowest water cover is 3 mm less that it was intended. The uneven distribution resulted by the steering can also be observed here with the difference that the extent of this unevenness is smaller due to the decline in the amount of drifting water.

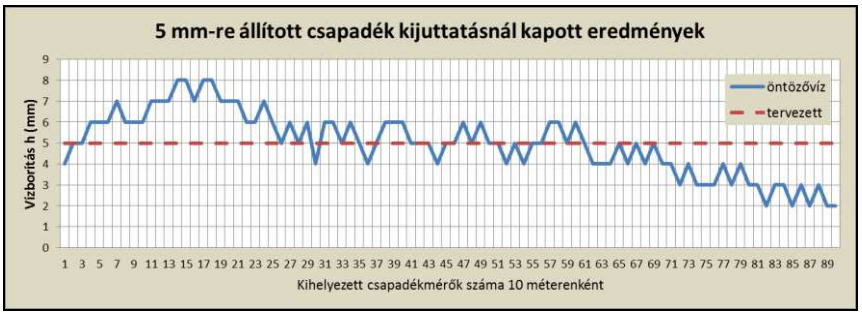

Figure 4: After replacing sprinkler heads, set to 5 mm of irrigation

In case of 20 mm water cover Figure 5 shows the measured results. Average amount is 19.27 cm, C_u = 88.42%. Starting from the middle of the machine four spans to both directions worked very well and showed a balanced performance. It can be explained b the fact that the speed differences due to steering cannot be experienced so severely than at the end points of the machine.

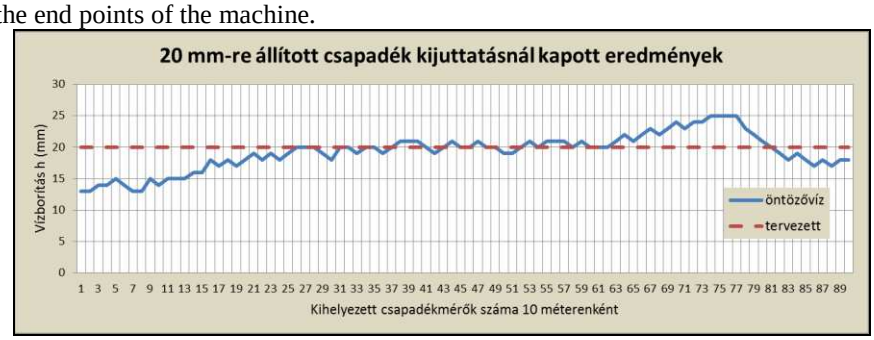

Figure 5: After replacing sprinkler heads, set to 20 mm of irrigation

Figure 6 summarises the results when the amount of water was set to 30 mm. The average water cover is 29.14 mm, its distribution C_u = 91.25%. The system pressure is similar to that of the previous measurements. It can be seen that values deteriorate toward the ends of the machine. The reason of it is the steering and also the loss of pressure.

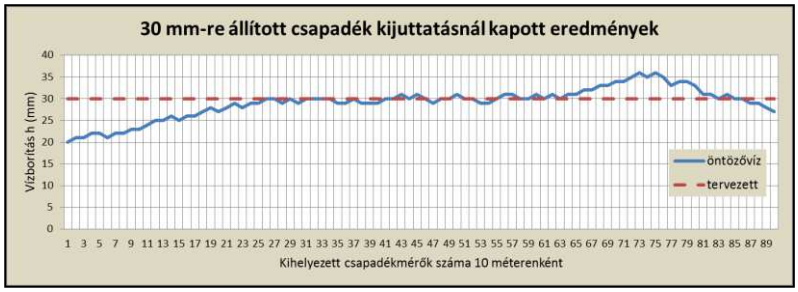

Figure 6: After replacing sprinkler heads, set to 30 mm of irrigation

Measurements after complete modernisation

Results of 5 mm water cover are demonstrated in Figure 7. Average water cover is 4.7 mm, the distribution C_u = 78.5%. Entering pressure of the water 330 kPa measured right after the water pump with the revolution of 1820 1/min. In this case also a loss of pressure was detected at the two ends of the system: we measured 240 to 245 kPa. The lowest and highest water cover was 2 mm and 8 mm, respectively. The alteration was much more moderate than before the modernisation.

Figure 7: After modernisation, set to 5 mm of irrigation

The next set value was 20 mm; results are displayed in Figure 8. Average water cover is 19.61 mm, distribution C_u = 92.81%. This diagram excellently demonstrates how the evenness of the distribution has changed. The pressure is sufficient at both ends of the equipment, therefore water is administered properly. Modernising the steering system of the machine also contributed to the more balanced dispersion.

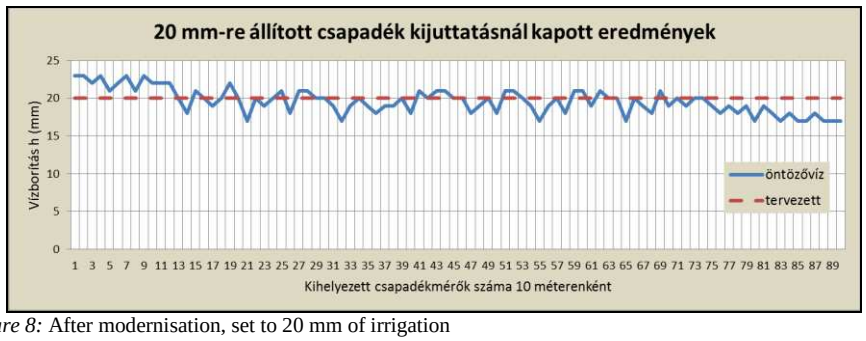

Figure 8: After modernisation, set to 20 mm of irrigation

In case of 30 mm water cover the average reaches 29.62 mm with a distribution of C_u = 94.25%. This run is summarised in Figure 9. The lowest water cover was 25 mm, the highest 34 mm. System pressure is similar than during the previous two tests. It also can be seen that at the centre of the machine seven-seven spans provided more or less even water cover.

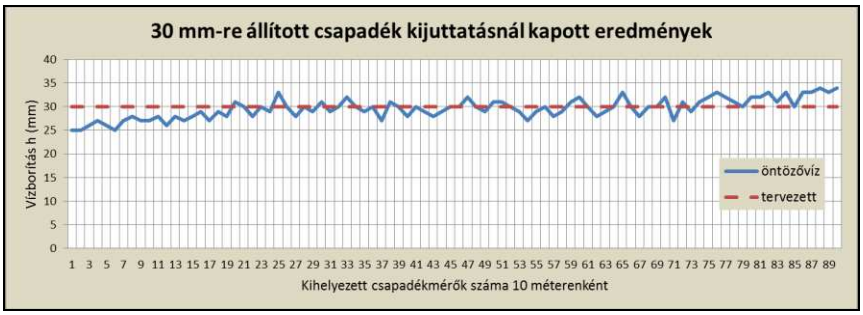

Figure 9: After modernisation, set to 30 mm of irrigation

Comparing water distribution before and after the modernisation

Figure 10 shows the distribution of the precipitation when set to 20 mm of irrigation. Prior to the refurbishment the lowest and highest water cover were 6 and 26 mm, respectively with an average of 13.15 mm. Following the replacement the highest value became 23 mm, the lowest one 17 mm while the average was calculated at 19.61 mm. It justified that much better distribution can be achieved by using modernised equipment that performs in line with the requirements.

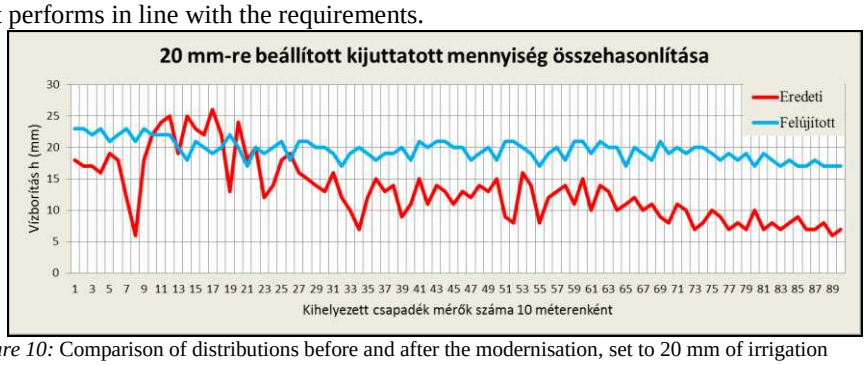

Figure 10: Comparison of distributions before and after the modernisation, set to 20 mm of irrigation

Summary

The goal of my research was to describe the modernisation of a Valmont 6000 self-propelled, frontal movement linear irrigation equipment as a case study as well as conducting and assessing work quality examination before and after the modernisation. Irrigation has an increasingly important role on agriculture due to climate change, temperature rise and uneven distribution of precipitation. Farmers want to achieve higher yield safety alongside with increasing average yields. It generally can be reached by economical ways of irrigation. There are many outdated irrigation equipment in Hungary, such as the one I studied. Their working quality has severely deteriorated. The modernisation and utilisation of these irrigation machines would lead to considerable water and energy savings on country-level.

Keywords: precision irrigation, modernisation, linear, precipitation patterns

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