Title: Water and energy efficient precision irrigation system: a Hungarian example

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Detailed Abstract: Production of good quality agricultural products in appropriate quantity can only be privided by the use of high precision agricultural technologies. Nowadays, IT tools provide more and more information on the field and the cultivated plants in agriculture. Irrigation and water management are critical points of agricultural production. Irrigation systems should be well equipped in order to achieve high quality crop, fruit and vegetable production in optimal quantity. In some farms, there are no irrigation applied, or the techniques are improper. The ratio of agricultural fields, which equipped for irrigation, is growing year by year. Nowadays, the total area equipped for irrigation is more than 300 million hectares around the world, which is the 22.5% of the arable lands. This ratio in Hungary is about 2%. There are three main types of irrigation technologies in Hungary; sprinkler irrigation (83.75%), surface irrigation (13.41%) and micro irrigation (2.84%). Considering the spatial and temporal heterogeneity of soil, water management and vegetation on the field, precision agriculture tools can enhance the crop production, water and energy save irrigation. Several experiments were made worldwide to evaluate the efficiency of variable rate irrigation (VRI), and investigate its impact on yield and soil. Companies have already tested own VRI system(s), and some of these are commercially available (Lindsay Corporation, Valmont Industries Inc., Trimble Ag Field Solutions, DuPont Pioneer, etc.). VRI systems can be controlled by speed and by prescription (application based on field requirements). Based on vegetation status, management zones can be created, which can be effective in water control. Soil geological, water management, terrain and vegetation data are useful for planning a precision irrigation system.

Water supply is a critical point in plant production. Hydrological phenomena are the most rapidly-changing process in space and time. Their environmental information assessment is therefore a difficult task even with more advanced technology tools, partly because there is no universal solution for any technical background, even for a single river basin. Spatial decision support should be flexible enough to handle spatial and temporal changes in hydrologic relationships in river basin systems. In this study the research site is 22 ha pasture and 80 ha

arable land near to Nyírbátor city, Hungary. During the research, a new filter system was developed to filter the fermentation sludge from the suspended and floating contaminants. The importance of this is that the purified fermentation sludge as a nutrient solution can be utilized as an alternative water source on such high performance irrigation machines as the linear irrigation system, which established at 80 ha of arable land. In the technical implementation, a linear irrigation system has been developed with an experimental apparatus by which precision utilization of the filtered fermentation sludge can be utilized. During the development, the selection and definition of variable rate nutrient application was made by identifying the management zones. After that the control technology of the precision RTK-based linear irrigation was developed taking into account the agro-ecological properties of the growing area.

In order to identify the elevation characteristic of the agricultural field and pasture, high resolution LiDAR data was analysed. Based on the airborne laser scanned point cloud, digital elevation maps, runoff and aspect maps were created in order to establish the characteristics of water governance. (Figure 1.).

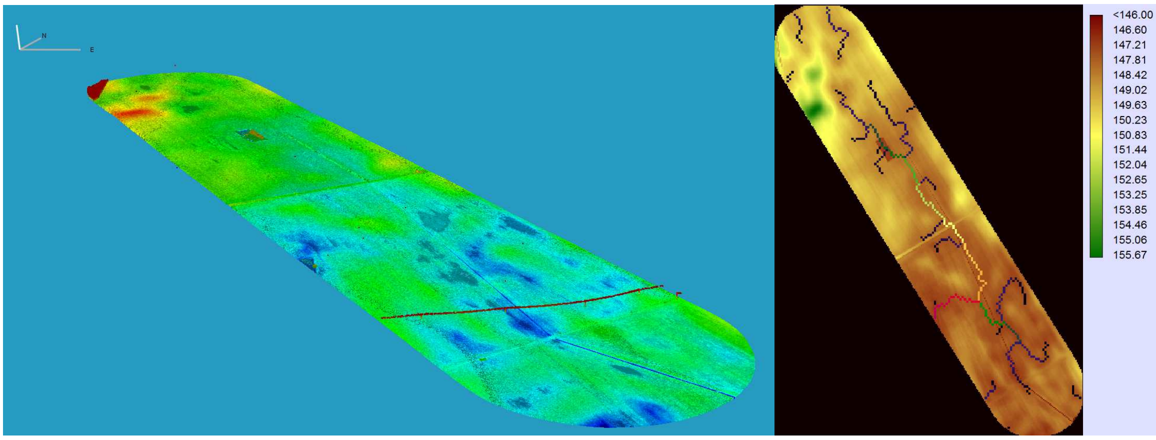

Figure 1. LIDAR DEM and runoff properties of the arable land

In our investigation, precision grid-based soil sampling was carried out on an agricultural field (85.5 ha) and a pasture (22 ha). Different databases and maps (AGROTOPO soil database, Géczy-soil map, digital aerial photo archive (http://www.fentrol.hu/hu/) by the FÖMI, geological map by the Mining and Geological Survey of Hungary) were used to elaborate the soil sampling strategy, involving the application of high resolution LiDAR data. Disturbed soil sampling in five soil layers (0-20 cm, 20-40 cm, 40-60 cm, 60-80 cm, 80-100 cm) and core soil samples in two layers (30 cm and 60 cm) were taken. Besides, deep soil sampling (up to 300 cm) was made in certain points. After laboratory testing (for soil density, pH nutrients, certain microelements, hydraulic conductivity, matrix potential etc.) (Figure 2), high precision soil maps and 3-D model of deep root zone were created to support the establishing water saving variable rate irrigation system by selecting and identifying sites for different agrotechnical implementations and precision management zones.

Water balance calculation were also cried out. Though, evapotranspiration can be estimated with a large error as the commonly used measuring instruments are point-like.

For linear irrigation system 12 pieces of Greenseeker sensor system was set for monitoring vegetation status. Beside Greenseeker, areal multispectral orthophotos were also used for vegetation monitoring. By time series analysis and crop mapping, we can monitor the nutrient and water supply of plants, producing standard maps of vegetation conditions, allowing. The Greenseeker sensor system can track the changing water supply conditions during the vegetation period through the plant's vegetation state.

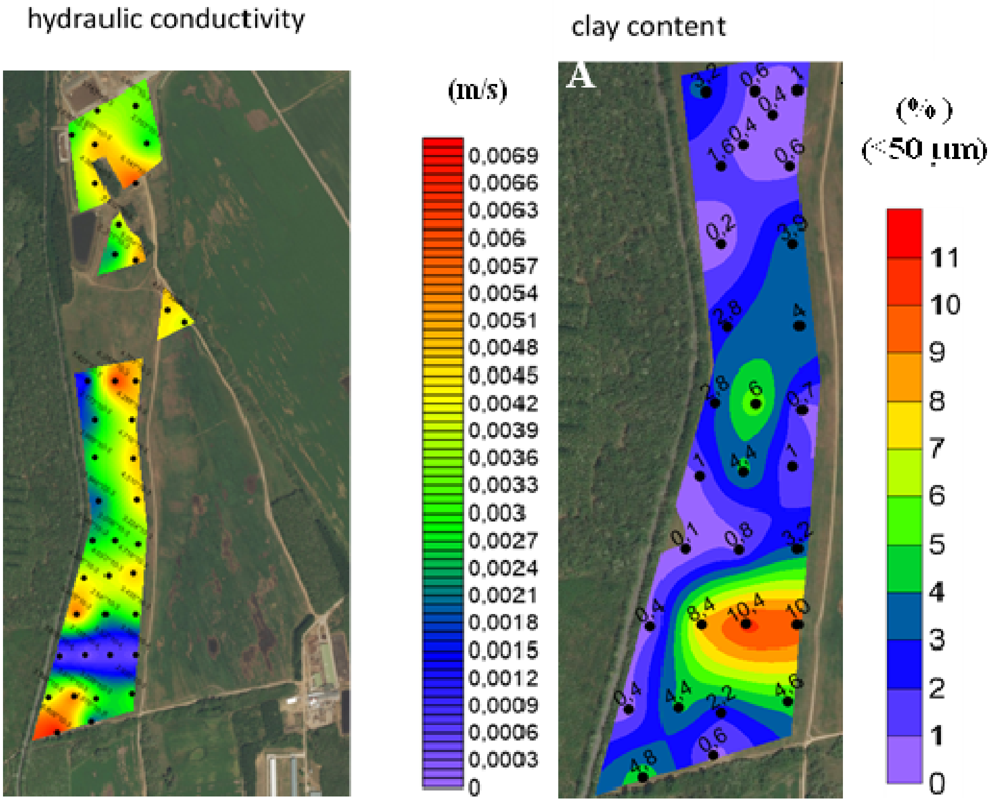

Figure 2. Hydraulic conductivity and clay content of the pasture site

DGPS system used for continuously monitoring of the position of the linear irrigation system and, controlling the amount of water irrigated. Due to the results, it is possible to continuously process hydraulic water balance elements in 2-3 dimensions to control the water supply and water governance in real-time. Irrigation system is suitable for irrigation of alternative water resources resulting the utilization of agricultural biogas fermentation outlet and locally collected excess water, in addition to GPS control, it is able to adapt to continuous changes in soil and plant water balance while irrigation. Suitable for other special functions (humidification, frost protection) within the same system.

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