FERTILIZERS AND LIQUID DIGESTATE WITHIN AGRO-ECOSYSTEMS IN THE REGION OF NYÍRBÁTOR

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Abstract: The EU policies concerning renewable energy systems (RES) have set forward a fixed goal of supplying 20% of the European energy demands from RES by year 2020. In Hungary the planned ratio is 13%. Anaerobic digestion of animal manure and slurries offers several benefits by improving their fertilizer qualities, reducing odours and pathogens and producing a renewable fuel – the biogas. The separated liquid digestate is utilized as nutrient supply of the soil. The soil fertility always changes in spatially and time. However using Global Positioning System (GPS) permit to add coordinates to heterogenic soil spots (yield, nutrition, physical parameters of the soil and so on) to mapping, controlling these areas.
The effect of dosages of biogas digestate and fertilizers on acidic sandy and sandy loan texture soils were studied in the Great Plain region of eastern Hungary. Field measurements were set up in 2009. Treated plants were winter wheat and corn silage. In this study changes will be analyzed the year effects on nutrient supply by corn yields, between 2009 and 2012. Nutrient management differences will be highlighted from 2010 to 2012. The treatments had a beneficial effect on some of physical soil parameters and realization of higher yields.

Keywords: fertilization, fermented by-product**,** precision agriculture

Introduction

Worldwide, nitrogen use efficiency (NUE) for cereal production is approximately 33%. Digestate and other fertiliser applications should be matched with crop nutrient requirements. This will minimise any unintended negative impact to the environment and also maximise farmers' profits (Lukehurst et al, 2010).
The BátorCoop group started to operate its biogas plant in 2003 in Nyírbátor, in the Northeastern Region of Hungary. The biogas production is based on mixed agricultural and food industrial by-products and wastes. The remained "bio fertilizer" in the working digesters is used as nutrient supply on its own arable lands. However, according to the EU Nitrates Directive the fields of the works where the liquid fertilizers are settled are tended to nitrate leaching mainly sand and sandy-loam soil type. Therefore it is difficult to observe and to control the authorized amount of the 170 kg ha^{-1} nutrient (EU Nitrate Directive). However, precision agriculture activities now use Global Positioning System (GPS) receivers to provide the spatial coordinates required to generate mapped information. A detailed description of the application of GPS to precision farming can be found in Tyler et al. (1997). Using this technology, it is possible to provide the optimal or near-optimal nutrient and chemical (Mesterházi et al., 2001) amount and proper cultivation for each part of the field (Jóri and Erbach, 1998).
Animal manures and slurries are rich in plant nutrients. In addition digestate contains a high proportion of mineral nitrogen (N) especially in the form of ammonium which is available for plants. Moreover, it contains other macro- and microelements necessary for plant growth (Makádi et al., 2012). By making the best possible use of digestate as a biofertiliser, nutrients are returned to the land through natural cycles to replace the input

of inorganic fertiliser. Digestate can be used successfully as a substitute for mineral fertilisers and the expected utilisation percentage of nitrogen is greater for digestate than for slurry (Lukehurst et al, 2010).
In 2009, the Regional Biogas Plant of Nyírbátor entered into a research and developing contract with the Department of Water- and Environmental Management, University of Debrecen, within the frame of this research.

Materials and methods

The Regional Biogas Plant of Nyírbátor was established by Bátorcoop Group in 2002. The total amount of raw materials is 110 000 t*year^{-1}, the available capacity involves 17000 m^3 of digester volume, 2600 kW electric energy output; a daily yield of biogas is 20–25000 m^3. The biogas is produced in low digesters. In the biogas plant very different agricultural and food industrial raw materials are used. Mainly animal waste (39%) and manure (29%), and crop product (13%) as well as crop waste (19%) are utilized. Crop resources are produced on 3.000 ha own land, and 5.000 ha contracted with cooperation. After anaerobic digestion the residual (100000 t year^{-1}) is separated. Solid and liquid phases are stored separately (6000 m^2 silo and 10000 m^3 storage) and utilized after or without composting (50000 t year^{-1} capacity) to nutrient supply on local farmlands.
Additional nutrients which are used in nutrient supplement are the following: poultry manure, compost and fertilizer. In 2012 as additional nutrient, green manure plants were planted after crop harvesting.
Digestate and other fertiliser applications should be matched with crop nutrient requirements. This will minimise any unintended negative impact to the environment and also maximise farmers' profits. The most suitable methods of application are: trailing hoses, trailing-shoes, and injection (Lukehurst et al, 2010).
Applied suitable methods of digestate were the following: A) transport in irrigation pipeline and discharge with water cannon having self-propelled drum; B) transport on vehicle and surface discharge with using deflector accessories.
As part of the work, data sets for GIS mapping for the precision control within the land sections were created for both technologies. During the decision making, basic data can be up-dated and optimized according to the actual nutrient and water content, and cultivation plan. In the case of the discharge with water cannon, the main control point is the retraction speed of self-propelled drum, minor changes can be set with changing nozzle size and pressure. In practise the cross inhomogenity factor is lower than 15% at the borders of the neighbouring tracks in the case of the discharge of liquid phase of fermentation with BAUER Rainstar T61 typed irrigation system.

Climate conditions
Sunshine hours are between 1850 and 1900. The annual average cloud cover varies from 58% to 62%, and the prevailing wind direction is generally north. Annual average temperature is around 10°C (Gál, 2005). The annual average maximum temperature is 35 °C., and the minimum is -18 °C. The reason of wide range yields is that 2010 was a drought year. Characteristic physical soil types of Nyírség mezo-region are sandy and sandy loam. In field experiment in situ measurements were carried out to measure the effect of different treatments (*Table 1.*) on winter wheat and corn silage yield by planting area conditions. Control treatment was the fertilizer treatment.

Table 1. Nutrient treatments and average yield data (t ha^{-1})

Crop plantation	Fermented liquid biogas by-product	Poultry manure	Compost	Fertilizer
Winter wheat	2.46-5.1	2.37-4.91	2.39-4.96	2.3-4. 73
Corn silage	23.43-27.19	22.55-26.17	26.43-26.68	21.9-25.41

Statistical analysis

The data have been evaluated and analyzed with the computer programmes MS Excel and SPSS 17 statistical programme. For the simultaneous comparison of the mean values were used variance analysis. The relationships between the nutrient treatments and crop yields were evaluated.

Results and discussion

Winter wheat

Data of 2012 was excluded from SPSS One-Way Anova analyses because the year effect. In this drought year the winter wheat yields were so low (~ 2.3 t ha^{-1}). Consequently statistical differences couldn't be detected effect of nutrient treatments on crop yields. Results of compared means are shown in *Table 2*. by 5 % significant level. Characters mean various groups.

Table 2. Results of winter wheat yields analyses (2010-2011)

Treatments	N	Mean±SD*	Minimum	Maximum	Groups
poultry manure	10	4.86±0.02	4.81	4.91	A
Compost	4	4.95±0.03	4.91	4.96	B
Fertilizer	6	4.72±0.00	4.72	4.72	C
Digestate	3	5.05±0.05	5.00	5.10	D
Total	23	4.86±0.11	4.72	5.10	
F value	136.66***				

*Mean ± Standard Deviation (SD) based on triplicate measurements

*** $P < 0.001$

Tukey B test resulted that all treatments are significantly different from the other by winter wheat yields. Variance analyses resulted significant differences between treatments and values were higher than the chosen significance level (0.05). F value was 136.66. N built kg t^{-1} of Tukey B test resulted that fertilizer and compost treatment compose one group and digestate and the second group involve poultry manure and digestate

Corn silage

In the case of corn silage in situ measurements were carried out. Impacts of four different nutrient treatments were examined. Results of drought year (2012) had to be excluded from statistical analyses because of wide range deviation. Results of compared means are shown in *Table 3*. by 5 % significant level. Characters mean various groups.

Table 3. Results of corn silage yields analyses (2010-2011)

Treatments	N	Mean±SD*	Minimum	Maximum	Groups
poultry manure	15	26.09±0.12	25,92	26,17	A
compost	14	26.57±0.12	26,43	26,68	B
fertilizer	14	25.41±0.00	25,41	25,41	C
digestate	8	27.14±0.10	26,93	27,19	D
Total	51	26.20±0.61	25,41	27,19	
F value	615.232***				

*Mean ± Standard Deviation (SD) based on triplicate measurements.
*** P < 0.001

The average corn silage yield was 26 t ha^{-1} and the standard deviation changed between 0.00 and 0.61 in 2010 and 2011. Compared means of corn silage yields had shown statistical differences by variance analyses (Sig. 5%). Tukey B test resulted that all treatments are significantly different from the other by corn silage yields.

Discussion

Both type of crop yields analyses resulted the following yield increasing effect by nutrient treatments (control was fertilizer treatment): poultry manure 3%, compost 5%, digestate 7%. Makádi et al. (2008) studied the comparing the effect of liquid digestate and the equal quantity of water to the yield of sweet corn and silage maize. They found also significantly higher yields in the digestate treatment.

Conclusions

Based on these results it was concluded that digestate had the biggest effect on crop yields, on soil physical parameters and on soil microbial activity by agri-environmental aspects. In addition this treatment affected the less plant stress level.

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