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INFLUENCE OF BIOGAS DIGESTATE, WOOD ASH AND THEIR MIXTURES ON THE YIELD AND QUALITY OF CUCUMBERS

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ABSTRACT

The biogas digestate can be as alternative of synthetic fertilizers in agricultural practice. Without additives, the drying of digestate can be unprofitable. The adding of wood ash to digestate dehydration process gives the opportunity for soil liming as well as for soil enrichment with nutrients. Within the framework in the Latvian National Research project, it was necessary to compare digestates from various raw materials and to test the possibility of mixing them with ash for using in cultivation of fast-growing crops. The research aimed to evaluation the influence of biogas digestate and wood ash on the yield and quality of cucumbers in polycarbonate greenhouse. The experiment was provided in 2020, using 11 fertilization treatments as well as peat (pH_{KCl} 5.5) as control. Starting of experiment, no significant differences between acidy of substrates were observed, but at the end of investigations, pH_{KCl} varied from 6.8 till 7.5, that was non-optimal for cucumbers growing. The development of plants under treatments was not significantly different ($p>0.05$). During experiment, cucumbers were harvested 23 times. The count of fruits per plant, depending on variant, per each harvesting varied from 1 till 9 (maximal result was observed for digestate from pig manure and horse manure). The significant influence of fertilization variant to cucumbers yield was observed ($p <0.05$). The organoleptic parameters were not differed significantly throughout the growing season ($p>0.05$).

Keywords: *biofertilizers, fertilization treatment, digestate, wood ash, fast-growing vegetables.*

INTRODUCTION

The content of organic substances in soil is an important indicator of soil quality. It impacts the attraction of chemicals, the formation of soil structure as well as the regime of humidity and air in the soil (Kvasoviene – Petraityte et al., 2019). An uneven soil use, different cultivation and fertilisation practices affect the soil structure, its agrochemical properties and fertility (Koszel & Lorencowicz, 2015; Caruso et al., 2018).

The percentage of soils with an insufficient content of organic matter and pHKCl lower than 5.5 is increasing every year in Latvia. It negatively affects the fertilisation effect as well as the crop yield.

By statistical data, there are currently 49 biogas plants operating in Latvia with a total installed electricity capacity of approximately 56 MW. Currently, 41 agricultural biogas stations use a total of 1.85 million tons of raw materials per year. Not only manure, but also corn silage, water sewage treatment plant slime, grain refuse is used as resources in biogas production in Latvia (Priekulis et al., 2016). In agriculture, there is a high quantity of organic wastes suitable for biogas production (Dubrovskis & Adamovics, 2012; Tampere & Viiralt, 2014; Kall et al., 2016). That is why the composition of locally produced digestate is variable.

The biogas is used for production of electric energy and heat (in form of hot water), but the digestate is mainly used as a liquid fertilizer and is incorporated into the soil (Kalnina et al., 2018).

Digestate can be defined as a liquid from anaerobic digestion of a biodegradable feedstock, it contains nitrogen, phosphorus, potassium (Dubrovskis & Kotelenec, 2014; Koszel & Lorencowicz, 2015; Kall et al., 2016). Usually, it is a semi-solid mass that consists of a semi-degraded plant material, the biomass of microorganisms and a slurry (if it was used in biogas production process). The dry matter content of digestate makes approximately 5-10% (Slepetiene et al., 2016).

Because of the digestate‘s large water content, the transportation costs are relatively high – not only in Latvia, but also in other European countries (Dubrovskis and Kotelenec, 2014; Auburger et al., 2015; Kuusik et al., 2017). For that reason, the separation and drying of digestate is used. Without additives (for example, calcium carbonate - CaCO3), the drying of digestate can be unprofitable. The adding of wood ash to digestate‘s dehydration process gives the opportunity for soil liming as well as for soil enrichment with bioavailable P, K, Ca, Mg and other macro- and micronutrients (Augusto et al., 2008; Schiemenz and Eichler-Lőbermann, 2010; Libiete et al., 2016). The chemical properties of ash are depending on many factors, including subsidiary fuel type, combustion system and season.

Research of Bulgarian scientists indicated that for lettuce (*Lactuca sativa* L.) under varying doses of biofertilisers, compared with untreated soil, the best development and quality options can be obtained applying 15% of digestate that contain 70% of pig manure (Kathijotes et al., 2015).

In Italy, digestate was evaluated as an alternative nutrient solution in the hydroponic cultivation of baby leaf lettuce (*Lactuca sativa* L.). In total, three combinations (agriperlite + liquid digestate, solid digestate + standard solution and pelleted digestate + standard solution) enhanced plant growth by affecting the root, the shoot and the total dry weight in all investigated experiments (+32%, +40% and +29% respectively). Based on the obtained results, digestate represents a sustainable and alternative growing media or a nutrient solution for the production of baby leaf lettuce cultivated in a hydroponic system (Ronga et al., 2019).

In the reason of increase of the mineral fertilizers' price as well as in the system of organic crop production, the biogas digestate, wood ash and their mixtures can be as alternative of synthetic fertilizers in agricultural practice. Within the framework of the Latvian National Research project, it was necessary to compare digestates from various raw materials used by the project partners and to test the possibility of mixing them with ash for using in cultivation of fast-growing crops, including cucumbers.

The aim of this research was to evaluate the influence of biogas digestate and wood ash mixtures on the yield and quality of cucumbers in polycarbonate greenhouse.

MATERIALS AND METHODS

The experiment was started in spring 2020 in the laboratory of Horticulture and Apilogy of the Latvia University of Life Sciences and Technologies. Experiment was provided in polycarbonate greenhouse. Seeds of cucumber hybrid cultivar 'Mirabelle' F1 (Seminis/Monsanto) were sown in biodegradable peat pots at 9th May. At the stage of first leaves (27th May) seedlings were replanted in vegetation pots (15 L) filled with peat (producer Laflora LTd., pH_{KCl} 5.5) mixed with 11 different fertilizers.

Cucumber plantation was created using different fertilization treatments with cattle (from JSC "Ziedi JP" = GD) and pig (from LLC "Latvi Dan Agro" (CD) and LLC "Mežacīruļi" (organic agicultural system, MCD) manure digestate and woodchip ash (from LLC "Fortum" = P) in different ratios (digestate - 2500 g per vegetation pot, ash – 200 g per vegetation pot, digestate to wood ash – in proportions 3:1 and 4:1). Horse manure (as traditionally practiced treatment) from university's horse training farm "Mušķi" (ZM) – 650 g per vegetation pot. The same peat substrate ("Laflora" LTd., pH_{KCl} 5.5) was used as control (K).

Figure 1. Cucumbers under fertilization treatments in experimental greenhouse

Each treatment was added to peat substrate 2 weeks before planting of seedlings. During experiment, automatic ventilation, irrigation as well as phytosanitary measures were provided. Forming of plants was made by traditional scheme. As

the aim of the trial was to investigate the efficacy of the fertilizer‘s variant, microelements were not added to substrates.
In the period of experiment, growth and yield dynamic was explored. Fruits were harvested regularly at the size of 12 cm. Data about the number of fruits per plant was collected. Organoleptic test (appearance, color, aroma, taste and aftertaste) for each harvest was provided, using scoring system from 1 (minimal value) to 5 (maximal value).

RESULTS AND DISCUSSION

During growing period the development of plants was not significantly different ($p>0.05$): at 11.06 the average length was about 45.35 cm, at the phase of fruit ripening (26.06) – about 1.25 m, but at the end of the vegetation – about 2.58 m.

Fig. 2. Cucumbers at the start of flowering.

First harvesting was provided at 25.06.2020, the last – at 31.07.2020., that in comparison with other experiments, provided in Latvia, was relatively short period. In total, fruits were picked 23 times, each 2-3 days. At previous investigations, provided at the same greenhouse, in average, cucumbers were harvested 33 times, that is by 10 times more than in our experiment (Sivicka *et al*., 2018). For each harvesting, the count of fruits per plant, depending on variant, was from 1 till 9 fruits (maximal results were showed by CD and ZM), but average count was 1.3 fruits per plant. The average weight of one fruit was 50.79 g, ranging from 37.5 (control) to 153.3 g (MCD) during the experiment.

Table 1. Quantitative parameters of cucumbers‘ yield

Fertilization treatment	Digestate and wood ash ratio in the mixture	Average count of fruits per plant	Total count of fruits per m^2	Average yield, kg per plant	Total yield, kg per m^2
Pig manure digestate (CD)	1:0	39	118	3.67	11.02
	3:1	29	87	2.78	8.30
	4:1	27	81	2.52	7.56
Pig manure digestate (MCD, organic agricultural system)	1:0	29	86	2.53	7.58
	3:1	33	99	2.89	8.64
	4:1	34	101	3.13	9.41
Cattle manure digestate (GD)	1:0	29	88	2.79	8.37
	3:1	23	69	2.31	6.94
	4:1	26	79	2.48	7.44
Ash (P)	1:0	25	75	2.29	6.86
Horse manure (ZM)	1:0	26	82	2.41	7.84
Control (K)	1:0	28	85	2.56	7.96

For all period of experiment, 1213 fruits and 97.91 kg of cucumbers‘ yield were harvested. The maximal total count of cucumbers per m^2 was harvested from CD variant (118), also MCD + P 4:1 and 3:1 was showed relatively high results (101 and 99). Similar results by variants were observed also for total yield, kg per m^2. It means, that higher total yield was characterized by bigger count of fruits per variant.

During the experimental period, the yield of cucumbers was more than 6 kg per m^2 for all variants. The variants such as CD, MCD + P 4: 1, MCD + P 3: 1 showed the highest results. The significant influence of fertilization‘s variant to cucumbers‘ yield was observed ($p < 0.05$). For comparison, in previous experiments (using both synthetical and organic fertilizers), the total yield per unit area was reached 12.81 kg per m^2 – only variant with CD (11.02 kg per m^2) was close to this result (Sivicka *et al.*, 2018).

Non-standard cucumbers were detected in all variants except the P (ash), JPGD, MCD and MCD + P in a 4: 1 ratio (only standard cucumbers were detected in these variants). Per each harvesting time, 1-2 non-standard cucumbers from different experimental variants were detected, but no correlation was observed with fertilizer‘s variant.

A

B

Fig. 3. Fruits prepared for organoleptic test:
A – 27.06.2020, B – 20.07.2020.

The total count of non-standard yield during the trial was 1.81%, which is low result. Non-standard products are usually produced under the influence of the microclimate, with insufficient water and nutrient supply in hot weather, rapid fruit swelling and fruiting on warm nights as well as deformed cucumbers during pollination of parthenocarpic hybrids (as ‘Mirabelle’ F1 is) by bees from the laboratory‘s apiary.

The organoleptic parameters were not differed significantly throughout the growing season, except for the color (it became much duller at the end of the experiment). The average organoleptic score was 4.3 points. It was observed, that for by age younger assessors, the lower count of points was given to the appearance, because they were "worried" about the coarse warts of ‘Mirabelle’ F1 cucumbers.

CONCLUSION

By complex of quantitative indices, highest results were observed for fertilization treatments such as pig digestate (CD) and pig manure digestate (MCD from organic agricultural system) with ash 4:1. It is necessary to continue this research for exploring the influence of fertilization treatment on growing and yield period of cucumbers. The influence of digestate‘s type on the acidy changes of substrate should be observed much more carefully.

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