Effect of Solid Residues from Biogas Plant on Growth and Photosynthetic Characteristics of Cucumber

Marina Putnik-Delić, Ivana Maksimović, Rudolf Kastori, Milica Perišić, Žarko Ilin

University of Novi Sad, Faculty of Agriculture, 21000 Novi Sad, Serbia
e-mail: putnikdelic@polj.uns.ac.rs

Abstract
Renewable energy sources have an important place in most European countries, with a tendency to increase their share. Biomass deriving from agricultural production is used, besides other purposes, for the production of biogass which is then used to produce electricity or for heating. Solid residues, which remain after the passage of biomass through biogass plant, are still quite voluminous and contain significant amounts of nutrients. In this regard, we studied the effect of solid residues, remained after fermentation, on growth and photosynthesis of cucumber in a semi-controlled conditions. One part of the experiment was done with solid residues as they are, and another part with composted solid residues. Mineral elements were in part supplied by nutrient solution. Significantly higher biomass of cucumber shoots was obtained in the presence of composted solid residues. With increase in amount of added solid residues increased dry weight of cucumber shoots, regardless of additional supply of nutrients through nutrient solution. Similar results were recorded for total leaf area.

Introduction
The biogas plant is suitable tool not only for exploitation of renewable energy resources but also for designing organic fertilizers by varying anaerobic process parameters like load rate of the reactor, retention time and mechanical treatment before, within and after the anaerobic process (Schäfer et al. 2006). Any biodegradable material of either plant or animal origin can be used for the production of renewable energy (biogas or methane) through anaerobic digestion process (Karki, 2009, Voća et al, 2005). Composition of solid residues from biogass plant as it is and composted solid residues that remained after fermentation of biomass in the biogas plant “Mirotin Energo” Vrbas, show that these residues could be appropriate fertilizer supplements. This is the way to achieve maximum ecological and economic benefits, while at the same time ensuring sustainability and environmental safety (Al Sadi and Lukehurst, 2012). Input streams were: cattle manure, cattle slurry, maize silage, sugar beet chips, sugar beet residue and chicken manure. The quality of biomass supplied to biogas plant, where solid residues are intended for use as fertilizers, is very important since it can affect plant growth. In this regard, the aim of this study was to investigate the effect of various concentrations of solid residue and composted solid residue (remained after fermentation in the biogas plant) on the growth and photosynthetic characteristics of cucumber during vegetative phase, and to identify potential for application of this type of solid residues in vegetable production.

Material and method
Cucumber seeds, cultivar Tajfun, were sown in the pots (V = 750 ml) containing mixture of agroperlite and various quantities of solid residues and composted solid residues from “Mirotin Energo” biogass plant (Tab. 1). Plants were grown under semi-controlled conditions and watered with respect to evapotranspiration with either ½ strength Hoagland solution (Hoagland and Arnon (1950); control, ½H), ¼ strength Hoagland solution (¼H) or deionized water (W). One month later plants were analyzed for biomass production of roots and shoots, % of dry matter, total leaf area (by automatic leaf area meter L-3000 (Licor, USA)), and

concentration of photosynthetic pigments (following procedure of Holm, G. (1954) and von Wettstein (1957)).

Tab. 1. Mixtures of agroperlite and solid residues or composted solid residues in which cucumber was grown. Each treatment consisted of 400 ml agroperlite and various amounts of either solid residues (P) or composted solid residues (K). 1/4H and 1/2H denote 1/4 and 1/2 strength Hoagland solution.

Solid residue (g)	Treatment	Composted solid residue (g)	Treatment
0 (control)	1/4H	0 (control)	1/2H
5	1/4H5P	5	W5K
25	1/4H25P	25	W25K
50	1/4H50P	50	W50K
5	W5P	5	1/4H5K
25	W25P	25	1/4H25K
50	W50P	50	1/4H50K

Results and discussion

Solid residues and composted solid residues from biogass plant affected significantly cucumber growth. Higher proportions of solid residues lead to significant increase in dry weight of cucumber above-ground parts (Fig.1).

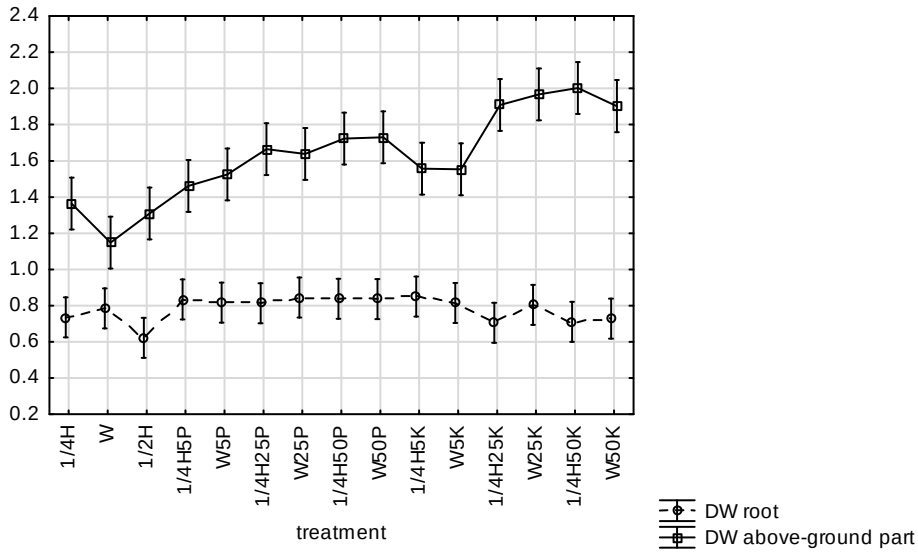

Fig. 1. Effect of solid residues on cucumber dry weight (g/plant). Numbers within labels on the x-axis denote g of solid residues (P) or composted solid residues (K) added to the pot. 1/4H and 1/2H denote 1/4 and 1/2 strength Hoagland solution. Vertical bars denote 0.95 confidence intervals.

Percentage of dry matter increased in comparison to both controls (1/2H and 1/4 H). The highest increase was recorded in leaves under treatment W25K (40% higher % of DW with respect to controls, Fig.2). Total leaf area increased with an increase in the amount of added solid residues. It was the highest in the treatment 1/4H50K: three times higher than the control 1/4H and 1.5 times higher than the control 1/2H (Fig 3).

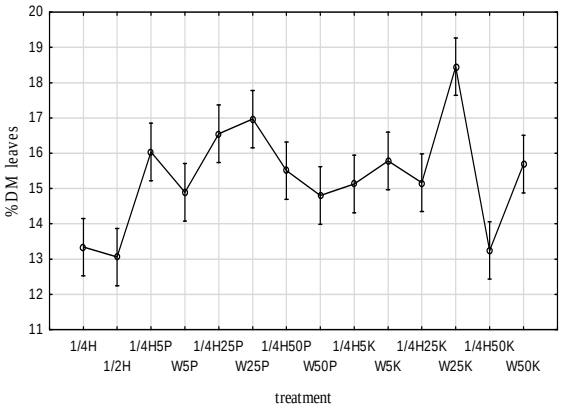

Fig. 2. Effect of solid residues on percentage of dry matter in cucumber leaves.

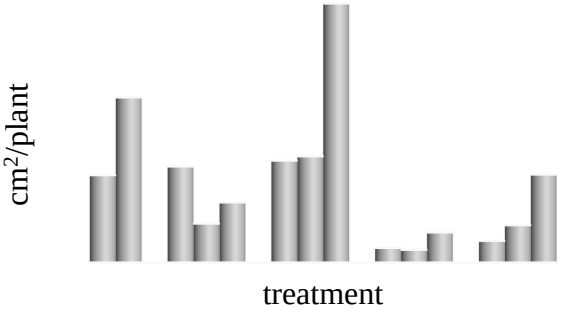

Fig. 3. Effect of solid residues on total leaf area of cucmber

Numbers within labels on the x-axis denote g of solid residues (P) or composted solid residues (K) added to the pot. 1/4H and 1/2H denote 1/4 and 1/2 strength Hoagland solution. Vertical bars denote 0.95 confidence intervals.

In general, application of solid residues alone, without additional nutrients, resulted in reduced total leaf area, but when applied in combination with (for cucumber) insufficient amount of nutrients deriving from Hoagland solution (1/4H) it exhibited positive effects on cucumber growth (Figures 1, 2, and 3). Similar results were obtained for soybeans where it was shown that application of solid residues from a biogass plant stimulate plant growth, yield and recovery after exposure to stress (Makadi et al., 2012). Qi et al (2005) examined the effect of fermented waste as organic manure in cucumber and tomato production in North China. They found increasing yield (18.4% and 17.8%) of treated cucumber and tomato, respectively.

Concentration of photosynthetic pigments declined with an increase in amount of added solid residues (Fig. 4).

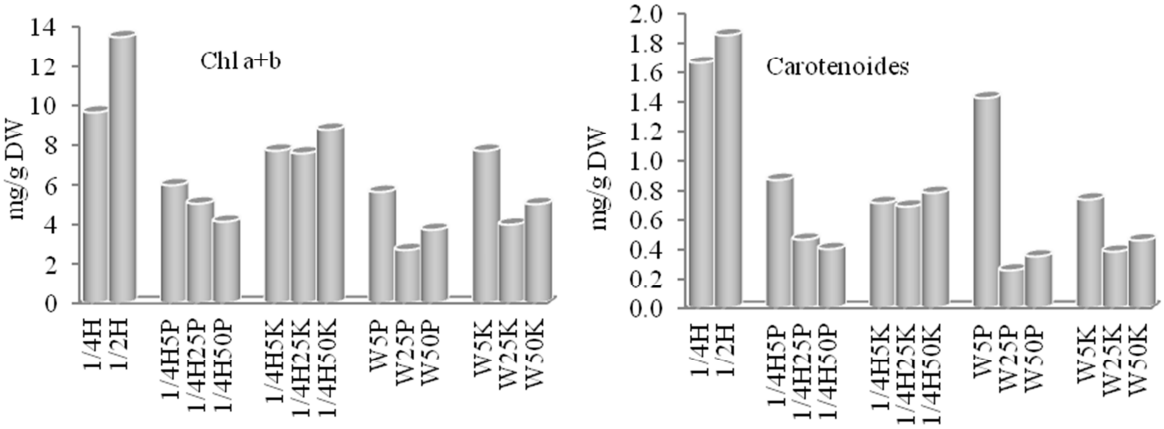

Fig. 4. Effect of solid residues on concentration of photosynthetic pigments

In plants to which was added only water this difference is even more pronounced. In controles (1/4 H and 1/2 H) concentration of chlorophylls was significantly higher (up to 5 times) and carotenoids (up to 7 times) than in plant to which were added solid residues. In spite of reduction in concentrations of photosynthetic pigments, biomass production increased in the presence of solid residues (Fig. 4, Fig. 1). Utilization of solid residues, remained after processing in the biogass plant, as biofertilizers recycles the nutrients and the organic matter, and saves costs to the farmers while enhancing the utilization of their own resources (Al Sadi and Lukehurst, 2012, Liedl, 2006).

Conclusion

Application of both solid residues as they are and composted solid residues stimulated cucumber growth and this effect was proportional to the amount of applied residues. Percent of dry matter in cucumber leaves increased significantly in the presence of solid residues from biogas plant, regardless of H/W. Concentration of photosynthetic pigments in cucumber declined. Composted residues had better impact on cucumber growth than solid residues that were not subjected to composting prior to application.

Acknowledgement

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