COMPENSATION EFFECT OF DIGESTATE OF BIOGAS FACTROY IN CASE OF SOME MACRO ELEMENTS DEFICIENCY

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Abstract:
The aim of the modern agriculture is the sustainable development. It helps to keep the good environment for the next generations. One of the most important expectations regarding sustainable agriculture is the minimization of the use of industrial chemicals. By using by-products, we are able to decrease amounts of chemical fertilizers. One of these by-products is the digestate, also as known as digestate of biogas factory. This fluid contains several essential elements, for example N, K, S, Ca and Mg etc. and we can use it for nutrient supply in the crop production.
The goal of the experiment was that we examined the effect of the fluid by-product of some macro elements (Ca, Mg, P, S and K) deficient maize plants.
The fluid by-products were originated from a biogas factory located in Biharnagybajom. Maize (*Zea mays* L. cv. DKC 5170) seedlings were used in the experiments. We made hydroponics experiment in growth chamber, where the circumstances were controlled. We added 50 ml dm^{-3} digestate to the nutrient solution. At the end of the experiment (on the 21th day) the quantity of photosynthetic pigments (chlorophyll-*a*, chlorophyll-*b* and carotenoids) and the dry weight of shoots and roots were measured in the plants that were grown on nutrient solution.
When we added the digestate to the nutrient deficiency nutrient solution, a more favorable effect was achieved on the measured parameters.
Due to these results, we suggest the usage of the digestate of biogas factory in agriculture.

Keywords: biogas, crop production, macro elements, deficiency

Introduction

The workers, who are working in agriculture have an enormous responsibility for the environment. They have to save the resources of the Earth during the crop production. Nowadays sustainable development is an important issue, because we have to replace the reduced fossil resources with renewable ones. In order to achieve sustainable development, comprehensive utilizations of renewable resources, efficient energy production and the reduction of energy consumption have become our major tasks (Kabasci, 2009). Agriculture workers apply different types of modern agricultural techniques in the tillage towards the efficient production. One of the modern ways is the use of industrial by-products, for example fluid by-product of the biogas factory. With this by-product we can reduce or replace the usage of chemical fertilizers, because this by-product contains several essential elements (Ca, Fe, K, Mg etc.) and we can use it for nutriment deficiency crops. The main macro elements are the Ca, Mg, N, P and K. If the calcium isn't sufficient, the roots do not develop, they become brown and at the end the plants die. The uptake of Mg^{2+} can be strongly depressed by other cations, such as K^+, NH_4^+ (Kurvits and Kirkby, 1980), Ca^{2+} and Mn^{2+} (Heenan and Campbell, 1981). Symptoms of the Mg deficiency are yellow, marble or spotted leaves. Due to deficiency of phosphate, the chlorophyll (Rao and Terry, 1989) and nitrogen content decreases, and the leaf becomes dark and red (Hecht-Buchholz, 1967). Nitrogen deficient plants are typically stunted, with narrow leaves. Chlorosis caused by N deficiency typically begins in the older leaves as N is remobilized to younger leaves. When potassium is lacking, growth is retarded, and net transport of K^+ from mature leaves and stems is enhanced. Under serve deficiency the organs become chlorotic and necrotic.

Materials and methods

The experimental plant was maize (*Zea mays* L. cv. DKC 5170). The seeds were soaked in 10 mM CaSO4 for four hours after sterilization and then germinated on moistered filter paper at 25 ºC. The five days old seedlings were transferred to continuously aerated nutrient solution. The seedlings were grown on Hoagland nutrient solution (Hoagland and Arnon, 1950). Modified Hoagland solutions were used for nutrient deficient solutions (Hankovszky et al., 2015). The examined biogas fluid by-product originated from Biharnagybajom, Eastern-Hungary. 50 ml dm^{-3} digestate was used. The different treatments were the following: 1. control – nutrient solution, 2. Ca deficient nutrient solution, 3. Ca deficient nutrient solution + 50 ml digestate, 4. Mg deficient nutrient solution, 5. Mg deficient nutrient solution + 50 ml digestate, 6. P deficient nutrient solution, 7. P deficient nutrient solution + 50 ml digestate, 8. N deficient nutrient solution, 9. N deficient nutrient solution + 50 ml digestate, 10. K deficient nutrient solution, 11. K deficient nutrient solution + 50 ml digestate. The volume of experiment pots were 1.7 dm^{-3}, with one pot containing 4 plants. The experiment was conducted with three repetitions. One treatment contained 12 plants. The quantity of photosynthetics pigments (chlorophyll-*a*, chlorophyll-*b* and carotenoids) were measured with METERTEK SP 80 spectrophotometer according to Wellburn (1994). The dry weight of shoots and roots were measured with the use of thermal gravimetric analysis, after drying at 65 ºC. The seedlings, 12 for each treatment, were grown under controlled environmental conditions (light/dark regime 10/14 h at 24/20 ^{o}C, relative humidity of 65–70 % and a photosynthetic photon flux of 300 μmol m^{-2} s^{-1}) in growth chamber.

Results and discussion

We couldn’t measure the photosynthetic pigments of the 2nd leaf of potassium deficient plants and of the 3rd leaf of calcium deficient plants, because these plants did not grow accordingly.

When we added digestate to the nutrient deficient nutrient solutions, the quantities of the measured parameters of the 2nd leaf were in higher concentration in all treatments, except in the calcium deficient plants. Compared to the control plants, the quantity of chlorophyll-*b* reduced in all treatments, except in the calcium deficient plants. Compared to the control plants, the quantity of chlorophyll-*a* and carotenoids decreased in all treatments, except in the magnesium and nitrogen deficient plants.

Table 2. Photosynthetic pigments contents of 2nd leaf of maize, n=60±S.D.

Treatments	chlorophyll-*a*	chlorophyll-*b*	carotenoids
2nd leaf of maize			
Control	10.20 ± 1.27	6.59 ± 0.49	5.98 ± 0.85
- Ca	18.07 ± 0.36	10.08 ± 0.81	13.26 ± 0.47
- Ca + digestate	11.81 ± 0.85	3.68 ± 1.16	7.72 ± 0.30
- K	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
- K + digestate	12.83 ± 0.40	4.13 ± 0.70	7.62 ± 0.51
- N	5.75 ± 0.79	1.63 ± 0.23	4.60 ± 0.31
- N + digestate	13.2 ± 0.27	4.25 ± 0.17	8.01 ± 0.41
- Mg	7.11 ± 0.26	1.30 ± 0.08	4.97 ± 0.32
- Mg + digestate	15.38 ± 0.35	5.65 ± 0.30	10.63 ± 0.28
- P	12.68 ± 0.29	4.40 ± 0.41	9.12 ± 0.57
- P + digestate	15.99 ± 0.63	6.28 ± 0.83	11.51 ± 0.67

Table 3. Photosynthetic pigments contents of 3rd leaf of maize, n=3± S.D.

Treatments	chlorophyll-*a*	chlorophyll-*b*	carotenoids
3rd leaf of maize			
Control	12.65 ± 0.33	7.58 ± 0.47	5.73 ± 0.85
- Ca	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
- Ca + digestate	15.11 ± 0.48	5.73 ± 0.60	8.74 ± 0.57
- K	15.62 ± 2.45	6.40 ± 0.97	9.86 ± 0.91
- K + digestate	17.31 ± 0.83	8.68 ± 1.86	13.07 ± 0.82
- N	3.90 ± 0.49	1.02 ± 0.07	2.87 ± 0.42
-N + digestate	16.56 ± 0.30	7.00 ± 0.43	11.68 ± 0.31
- Mg	2.63 ± 0.07	0.29 ± 0.29	3.8 ± 0.36
- Mg + digestate	16.62 ± 0.46	7.06 ± 0.70	11.75 ± 0.70
- P	11.93 ± 0.40	3.79 ± 0.35	9.33 ± 0.74
- P + digestate	17.02 ± 0.10	7.66 ± 0.32	12.22 ± 0.35

When the digestate was added to the nutrient deficient nutrient solutions, the quantity of photosynthetic pigments of the 3rd leaf was in higher concentration in all treatments, compared to the nutrient solutions without digestate.

The dry weight of plants is a complicated bio-chemical process. The dry weight of shoots decrease significantly in all treatments, compared to the control. When digestate was applied, higher dry weight was measured, except in the magnesium deficient plants. The dry weight of roots decreased significantly in all treatments (results are not shown). We didn’t notice so favorable results, than in the shoots.

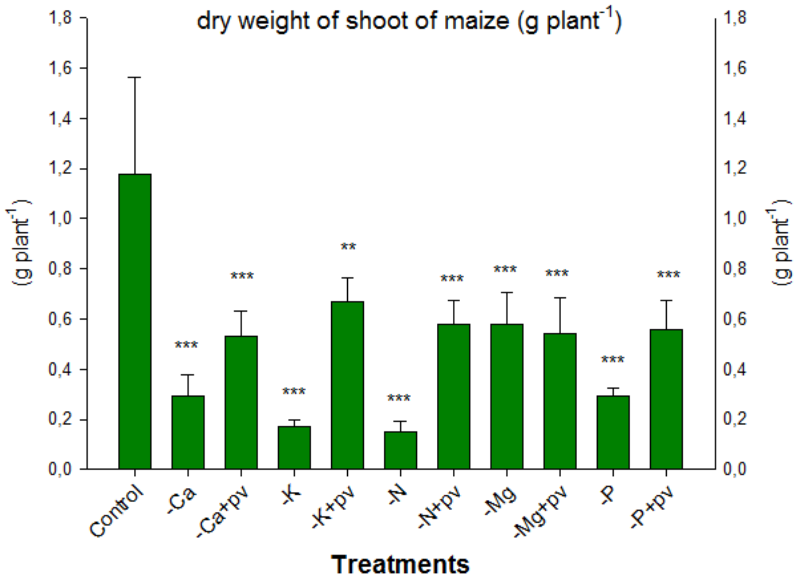

Figure 1. Dry weight of shoots of maize (g plant^{-1}), n=12±S.D., **p<0.01; ***p<0.001 (pv: digestate)

Conclusions

The digestate of the biogas factory contains several necessary and superfluous elements for the plants. This can be suitable for replacing the expensive mineral fertilizers, or replacing the deficient nutrients. During the experiments, the nutrient deficient plants, which complemented with digestate, achieved better results. We maintain that the digestate of newly emerged biogas factories can be useful tools of suitable agriculture from environmental aspects, too.

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