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NITROGEN MINERALIZATION AND CARBON STATUS IN AMENDED SOIL WITH BIOGAS RESIDUES

Dragan Kovačević[1], Ranko Čabilovski[1], Abou Baker Brayek[1], Klara Petković[1], Mirna Štrbac[1], Maja Manojlović[*][1]

[1]University of Novi Sad, Faculty of Agriculture, Novi Sad, Serbia

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Abstract: The aims of the study were to investigate the N mineralization potential and C status in the incubation experiment after application of digestates (solid and liquid) to the soil, and to compare with the impact of manures (solid and liquid). Biogas residues and manures were collected from three random bioenergy production systems, using cattle manure as the main substrate, and other substrates are residues from sugar and oil industry, corn and wheat silage, etc. The results show that all applied digestates and liquid manure increased NH_4–N and NO_3–N in soil at the beginning of the incubation. However, at the end of the 56 days of incubation, except two liquid digestates, studied organic materials led to immobilization of mineral N in soil.

Introduction: Currently, there are 12 functioning bio-power facilities in Serbia, producing a total of 13,869 MW, and the national action plan for the use of renewable energy sources aims to reach production of 30 MW or 225 GWh of electricity by 2020. Residues from bioenergy facilities can contain large amounts of organic carbon and nutrients, which can be used as organic fertilizer and applied to agricultural soils (Martinov et al., 2012). As a consequence, they can be very attractive as fertilizer, and the intensification of bioenergy production will increase the amount of residues that can be returned to the soil. In addition, given the process of digestates production, its application is also possible in organic plant production. Incubation experiments clearly indicate that short-term net N immobilization usually occurs in the first weeks after manure addition to soil, while net N mineralization is often observed in the following weeks (Bechini and Marino, 2009). In order to improve the use of biogas residues as organic fertilizers in Serbia, the objective of the study was to analyze the impact of the application of different digestates and manures on nitrogen mineralization and carbon status in soil.

Material and methods: Biogas residues and cattle manures samples were collected from three bioenergy production systems (Bačka Topola, Vrbas, Čurug), using cattle manure as the main raw material, than residues from sugar and oil industry, corn and wheat silage, etc. In the incubation experiment, the impact of six digestates: three solid (DS1; DS2; DS3) and three liquid (DL1; DL2; DL3), were studied on soil N mineralization and C status, and compared with the impact of two manures: one solid (MS) and one liquid (ML). The soil characteristics were: pH 7.08 (in KCl), 1.53 % of organic C, 9.4 ppm N (NH_4–N+NO_3–N), 39.21 mg P_2O_5/100g, 37.52 mg K_2O/100g. In the experiment, digestate-soil and manure-soil mixtures were incubated under controlled conditions of moisture (70% of the water-holding capacity which corresponds to the mass of 50 g of absolutely dry soil) and temperature (26±1°C). Containers were covered with semi-permeable wax parafilm in order to reduce water loss. Moisture in the soil was maintained at the same level by weighing the mass of the container every 7 days and adding distilled water when the mass dropped by more than 0.05 g. The digestates and manures were added in the amount of 5 mg N and mixed thoroughly with the 50g of dry soil. Total duration of incubation was 56 days. Three replicates per treatment were removed from the incubator at 0, 7, 14, 28, and 56 days for analysis of mineral-N (NH_4–N and NO_3–N). The N-mineralization (Nm) from the digestates (D) and manures (M) was calculated as: Nm (%) = [(mineral-N 56day – mineral-N 0day)$_{soil\ +\ D\ or\ M}$ − (mineral-N 56day – mineral-N 0day)$_{soil}$] / added total N × 100. Total C and N content were determined using a CHNS Elementar analyzer. Soil organic C content was measured by Turin's method (ISO 14235). The content of mineral N during was determined by extraction with 2 M KCl (KCl: soil, ratio 4:1) using steam distillation method. The results were subjected to analysis of variance (ANOVA), one for C and one for N, and treatments mean results were compared using LSD test ($P < 0.05$), in the software system STATISTICA 13, Stat Soft, Inc.

Results: The results shows that all digestates and manures mixed with soil increased soil organic C at the beginning of the incubation (Tab. 1). At the end of the incubation, digestates and MS significantly supplied soil with organic C in compared to non amended soil, except treatments with DS2 and ML (Tab. 1). Almost all added digestates to soil except DS1, DS3 and MS supplied it with NH_4–N and NO_3–N. At the end of the incubation, digestates and manures mixed with soil led to immobilization of N, except DL1 and DL3 treatment (Fig. 1).

Table 1. Chemical composition of digestates and manures, net N mineralization and C status in amended soil

Digestates/ Manures	C %	N %	C/N	pH KCl	P_2O_5 %	K_2O %	N mineralization (%)	% C	
								0	56
DS1	41.16	1.74	23.65	8.45	1.41	0.92	-4,4	1.74a	1.70abc
DS2	42.67	1.96	21.77	8.48	1.58	0.73	-18,8	1.74a	1.63de
DS3	41.58	2.04	20.38	8.71	0.79	0.66	-88,2	1.79a	1.68bcd
MS	41.49	2.55	16.27	8.82	0.80	1.49	-21,8	1.62bc	1.66bcd
DL1	3.33	0.58	5.74	/	0.19	0.44	11,2	1.66ab	1.75a
DL2	6.55	0.25	26.2	/	0.13	0.18	-64,6	1.77a	1.72ab
DL3	1.01	0.15	6.73	/	0.10	0.08	11,6	1.76a	1.65cd
ML	5.79	0.35	16.54	/	0.12	0.19	-8,8	1.63b	1.55e

* Within the same row and factor, values followed by different letters are significant at $P<0.05$.

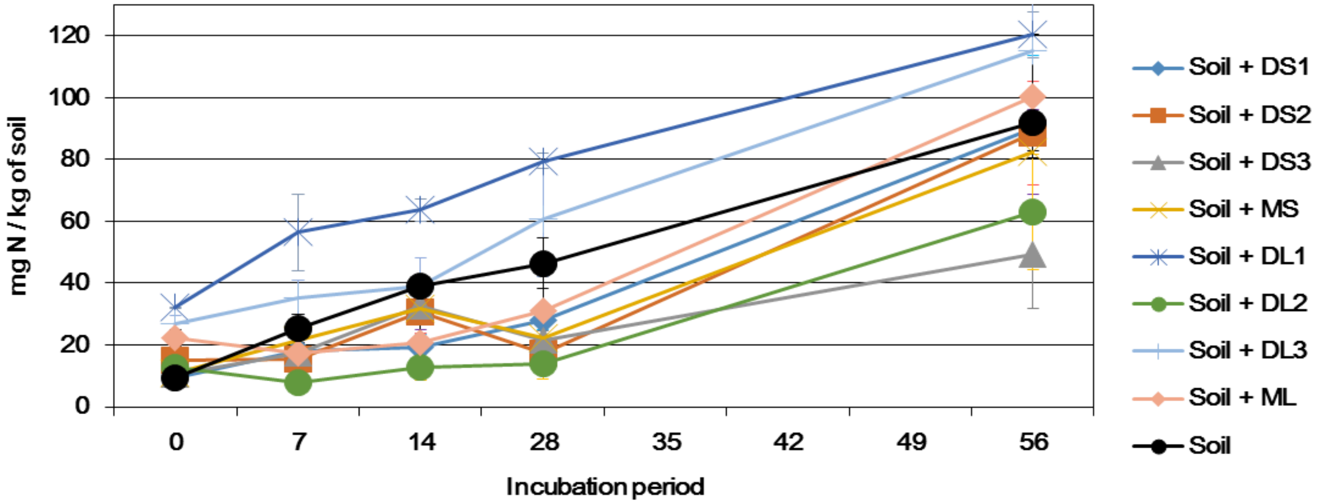

Figure 2. Mineralization of N (NH_4-N + NO_3-N) in soil with added digestates and manures

Discussion: The most of added digestates and manures significantly supplied soil with mineral nitrogen. During the first week of incubation, the mineral N concentration decreased with the most treatments. Liquid digestates potentially supply more readily available N to soil compared to undigested manures and solid fractions, due to lower C to organic N ratio (Cavalli et al., 2017). Similar results were obtained by Alburquerque et al., (2012), where all digestates supplied NH_4–N to the soil, but also during the incubation, the mineral N concentration decreased with the most treatments compared to non amended soil, probably due to microbial immobilization. Decomposition of liquid digestates with a low C to organic N ratio resulted in a net N mineralization, while solid fractions of digestate showed net N immobilization. Cavalli et al., (2017) suggest a critical C to N ratio for microbial N immobilization (the C/N ratio of manures at which net N mineralization is zero) of 21. Kirchmann and Lundvall (1993) were also detected an initial period of inorganic-N immobilization after adding digestates and animal slurries to the soil. Net N immobilization could have been induced by the decomposition of volatile fatty acids in manures, hemicellulose or cellulose (Morvan and Nicolardot, 2009). Digestate added to soil due to high C/N ratio can induce a quick development of the microbial population, immobilizing inorganic N for their biosynthesis. The application of biogas residues could be an important strategy for increasing soil organic carbon. However, compared to solid digestates and cattle manure liquid digestates proved to be a better source of nitrogen in soil.

References: Alburquerque, J.A., de la Fuente, C., Bernal, M.P., 2012. Chemical properties of anaerobic digestates affecting C and N dynamics in amended soils. Agriculture, Ecosystems & Environment, 160, pp.15-22.

Bechini, L., Marino, P., 2009. Short-term nitrogen fertilizing value of liquid dairy manures is mainly due to ammonium. Soil Science Society of America Journal, 73(6), pp.2159-2169.

Cavalli, D., Corti, M., Baronchelli, D., Bechini, L.,Gallina, P.M., 2017. CO2 emissions and mineral nitrogen dynamics following application to soil of undigested liquid cattle manure and digestates. Geoderma, 308, pp.26-35.

Kirchmann, H., Lundvall, A., 1993. Relationship between N immobilization and volatile fatty acids in soil after application of pig and cattle slurry. Biol. Fert. Soils 15, 161–164.

Martinov M., Kovacs K., Đatkov Đ., Biogas Technology (in Serbian), Faculty of Technical Sciences in Novi Sad, 2012.

Morvan, T., Nicolardot, B., 2009. Role of organic fractions on C decomposition and N mineralization of animal wastes in soil. Biology and Fertility of Soils, 45(5), pp.477-486.

Sørensen, P., Weisbjerg, M.R., Lund, P., 2003. Dietary effects on the composition and plant utilization of nitrogen in dairy cattle manure. The Journal of Agricultural Science, 141(1), pp.79-91.

Disclosure of Interest: None Declared

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