EXAMINATION OF AN ALTERNATIVE WAY TO PREVENT NITRATE LEACHING IN SOIL BY USING GLYCEROL AS A BIODIESEL BY-PRODUCT

László TOLNER– Gabriella RÉTHÁTI – Attila KOVÁCS

Department for Soil Science and Agricultural Chemistry, Szent István University, Páter Károly Street, H-2103 Gödöllő, Hungary

Abstract: Using nitrogen fertilizer can be a potential contamination to underground water. In general, disposal of an industrial by-product is a potential pollution. There are such cases, when two potential pollutants can extinguish each other harmful effect. Contaminated glycerol as a by-product from biodiesel production is available in increasing amounts. The conventional utilization of glycerol can not be substantially increased, therefore investigation of alternative ways of usage should be searched for. The contamination content of the glycerol by-product mainly consist of useful materials from plant seeds and potassium hydroxide catalyst. Glycerol such as sugars represents an easily accessible source of energy for microorganisms in soil. It is well known that if nitrogen poor organic matter (e.g. straw) added into the soil, it can cause, through assistance of microbes, temporary reduction of the nitrogen supply. Our experiment was performed in small scaled soil columns. Different treatments were applied on a sandy soil. Nitrate leaching can be significantly decreased by using glycerol treatment.

Keywords: Nitrate leaching, C/N ratio, glycerol, nitrogen immobilization, by-product

Introduction

Nitrate is very mobile in soil (Tisdale and Nelson, 1966). The other nitrogen forms (ammonium-N, organic-N) are quickly converted into nitrate in well-ventilated soils. Nitrate can accumulate in the deeper soil zones (Kádár and Németh, 1993), and moving down it can contaminate the groundwater (Németh, 1995). Nitrate leaching was particularly fast in small soil columns under laboratory condition (Lasztity et al., 1994; Lasztity et al., 2010). The added organic materials control the nitrate leaching (Grüner et al., 2007).

In European Union biodiesel is rapeseed-oil methyl ester (Kovács, 2000). Approximately from 100 litres of vegetable oil are produced 75 litres of biodiesel and 25 litres of crude glycerol (Wilkie, 2008). In generally the glycerol used by cosmetic and chemical industry but biodiesel by-product is contaminated by vegetal parts. But this „vegetal contamination" makes it perfect for use by-product like fertilizer on fields. Glycerol of biodiesel production is well utilized by micro-organisms (Papanikolaou et al., 2008; Temudo et al., 2008). A couple of studies have investigated that utilization of glycerol by micro-organisms is a great possibility to convert that into value-added products (Barbirato et al., 1998; Johnson and Taconi, 2007; Yazdani and Gonzalez, 2007).

The carbohydrates and similar organic materials directed in the soil have a strong effect on the nutrition providing abilities of the soil (Gulyás and Füleky, 1994; Kovács et al., 2011). In particular this effect shows through the change of the amount of nitrogen that can be taken from the soil by changing the C/N rate (Tisdale and Nelson, 1966). The glycerol is an easily available and adequate carbon source for micro-organisms (Lee et al., 2001; Tickell, 2003). It can intensify microbial activity which can help to increase availability of vegetal nutrient. Provisionally, microbes immobilize nitrogen of chemical fertilizer and mineral nitrogen part of soil, but later mobilize those (Tolner et al., 2010). The glycerol increase storage capacity of soil and help adsorption of nutrients. There is

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a correlation between organic carbon and mineral nitrogen content of the soils based on the results of long term experiments (Vágó et al., 2005). There are differences in the microbial activities of these soils (Kátai et al., 2005). Szegi et al. (1988) examined the interaction of cellulose and nitrogen according to the kinetics of soil microbial respiration.

Materials and methods

The experiments were carried out using two types of soil columns. The first type of columns (diameter: 6 cm, length: 10 cm) contained 400 g soil (C1), the second type of the columns (diameter: 4 cm, length: 3 cm) contained 80 g soil (C 2).
A sandy soil from Fót was applied for treatments. The main properties of this soil: saturation percentage, K_A=28.33, lime content, $CaCO_3$ %=8%, pH_{H2O}=8.2, humus content, H %=1.4%., AL-P_2O_5=95 ppm, AL-K_2O=120 ppm.
The solution were: 1000 mg N dm^{-1} KNO_3 (7.221 g of KNO_3 were dissolved in 1000 cm^3 solution) and glicerol 5% C content (128.55 g 95% glycerol in 1000 cm^3 solution). Four types of treatment were used. (*Table 1*).

Table 1. The treatments of the first type of soil columns (C1)

Treatment	N ppm	N-sol. cm^3	C %	G-sol. cm^3	DV cm^3
1. Control	0	0	0	0	100
2. N	100	40	0	0	60
3. Glycerol	0	0	0,5	40	60
4. N+glycerol	100	40	0,5	40	20

The treatments of the second type soil columns (C2) were similar to first type soil columns (C2) (*Table 2*).

Table 2. The treatments of the second type soil column (C2)

Treatment	N ppm	N-sol. cm^3	C %	G-sol. cm^3	DV cm^3
1. Control	0	0	0	0	20
2. N	100	8	0	0	12
3. Glycerol	0	0	0,5	8	12
4. N+glycerol	100	8	0,5	8	4

The columns were leached with 100-100 cm^3 distilled water (C1) and 40-40 cm^3 distilled water (C2) for 3 days. The nitrate and glycerol contents were measured in the effluent solutions. After 3 days this method was repeated using half dose of distilled water.
The nitrate content was determined by diphenylamine test. The glycerol content was determinate with refractometer (CARL ZEISS F1). We used a program for ANOVA which made by Tolner in Microsoft Office Excel (Aydinalp et al., 2010; Sipos et al., 2009; Vágó et al., 2008). This program was created by an algorithm of Sváb (1981).

Results and discussion

The experimental dates of two types of soil columns (C1 and C2) were evaluated using two ways ANOVA. The nitrate-N concentrations are in ppm (mg dm^{-3}) unit (*Table 3*).

Table 3. The means of nitrate concentrations (ppm, mg dm^{-3})

	Control	N	Glycerol	Glyc.+ N	Time mean
3.day	338	2375	0	128	710
4.day	275	1625	0	0	475
5.day	225	1063	0	0	322
6.day	125	838	0	0	241
7.day	30	353	0	0	96
Treat. mean	199	1251	0	26	369

Investigate of treat means it can be seen that the nitrate content in the effluent solutions decreased using glycerol treatment. The effect of the N treatment was reduced by glycerine (Glyc.+N) significantly ($LSD_{5\%}$=231). The glycerol treatment reduced the effect of the control treatment significantly (10% probability) ($LSD_{10\%}$=191). The time means show decreased tendency ($LSD_{5\%}$=213).
The glycerol was not measured in effluent dilution of soil columns which did not get glycerol treatment. The glycerol-C contents in effluent solutions are in *Table 4*.

Table 4. The means of glycerol-C concentrations (%)

	Glycerol	Glyc.+ N	Time mean
3.day	0.50	0.05	0.28
4.day	0.50	0.40	0.45
5.day	0.20	0.35	0.28
6.day	0.30	0.10	0.20
7.day	0.28	0.25	0.26
Treat. mean	0.36	0.23	0.29

The soil in columns blocks the leaching of glycerol. The slow effect significantly forced by the effect of nitrogen treatment. Because of nitrogen treatment the mean concentration of leached glycerol were reduced from 0.36% to 0.23% ($LSD_{5\%}$=0.06%) and the glycerol content appeared in the effluent solution one day later ($LSD_{5\%}$=0.13%).

Conclusions

In summary, the glycerol treatment significantly reduced the flow of nitrate through the soil column. Nitrate treatment reduced the effluent glycerol content. Both effects suggest that the treatments provided favourable conditions for microbial activity, so the nitrogen immobilized totally and the glycerol immobilized partially.

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