Biology and Medicine

Novoselov *et al.*, Biol Med (Aligarh) 2016, 8:7
DOI: 10.4172/0974-8369.1000351

Research Article Open Access

The Influence of Physical Properties of Sod-Podzol Soil on Its Ammonifying and Nitrifying Capacity

Margarita Alexandrovna Evdokimova*, Sergey Ivanovich Novoselov, Ekaterina Sergeevna Novoselova, Asiya Mantsurovna Yamalieva, Albert Nikolaevich Kuzminykh, Galina Ivanovna Pashkova, Olga Gennadyevna Marina-Chermnykh

Mari State University, 1 Lenin Square, Yoshkar-Ola 424000, Republic of Mari El, Russia

***Corresponding author:** Evdokimova MA, Mari State University, 1 Lenin Square, Yoshkar-Ola 424000, Republic of Mari El, Russia, Tel: 836-268-7927; E-mail: myrar@mail.ru

Received: May 23, 2016; **Accepted:** Aug 22, 2016; **Published:** Oct 19, 2016

Abstract

The research was conducted by the Chair of Agricultural Chemistry and Crop Farming of the Mari State University. The model experiment helped to study the influence of temperature, moisture, and density on nitrifying and ammonifying capacity of sod-podzol midclay low-humic soil. It was found out that change of physical properties factors of sod-podzol soil influenced nitrifying and ammonifying capacity and mineral nitrogen content. Maximum content of nitrate and mineral nitrogen and the biggest nitrifying capacity were at a soil temperature of +15°C and had the following corresponding values: 74.4, 81.3, and 31.9 mg/kg. Moistening conditions optimal for developing nitrifying and ammonifying bacteria were formed at a soil moisture of 20-25% (60-75% WFC). At this moisture there were the biggest figures of nitrifying capacity (31.5-35.0 mg/kg) and maximum values of content of nitrate nitrogen (74.0-77.5 mg/kg) and mineral nitrogen (78.7-82.3 mg/kg). Soil firming had a negative effect on the microflora of soil. With soil density increase from 1.1 to 2.0 g/cm^3 nitrifying capacity decreased from 21.0 mg/kg down to 10.4 mg/kg, while nitrate nitrogen content in soil decreased from 63.5 to 32.1 mg/kg. The best conditions for nitrification and ammonification in sod-podzol soil were as follows: soil temperature of + 15°C, soil moisture of 20-25 %, and soil density of 1.1 g/cm^3. Dependence of mineral nitrogen content in soil on its temperature and moisture was curvilinear and was described by a second-order regression equation, while dependence on its density was linear and was described by a first-order regression equation.

Keywords: Nitrifying and ammonifying capacity; Microorganisms; Mineral nitrogen; Soil temperature; Soil moisture; Soil density

Introduction

Agricultural methods applied for crop growing have a great impact on the physical and agrochemical properties of soil and its microbiological activity [1]. The activity of soil microflora is connected with humus synthesis and decomposition processes, mobilization of nutritional chemicals that are hard-to-reach for plants in soil, and transformation of fertilizers introduced into soil [2]. Ammonifying and nitrifying capacity is the important soil parameter that determines nitrogen status and conditions of plants' nitrogenous nutrition. They are sensitive enough to the change of ecological situation and depend on soil and climate conditions to a large extent. It has been established that these processes are intensified by introduction of moderate doses of mineral and organic fertilizers [3]. High doses of mineral fertilizers and pesticides reduce their activity [4]. Soil reaction plays a critical part in these processes. The studies have determined that chalking intensifies the activity of nitrifying agents and strengthens mineralization processes of organic compounds, which improve nitrogenous nutrition of plants [5]. Soil density defining air conditions has a great impact on the activity of nitrifying and ammonifying bacteria. The studies of some authors [3,6] have found out that the increased level of man-caused load decreases their activity. In such a way, microorganisms' life activity is inseparably associated with environment while ecological situation in this or that soil impacts greatly on nitrifying and ammonifying capacity of soil.

This article presents the results of research of temperature, moisture, and density influence on nitrifying and ammonifying capacity of sod-podzol soil in the east of nonchernozem zone.

The main aim of this study is to determine the factors of physical properties of sod-podzol soil that are optimal for nitrifying and ammonifying processes.

Materials and Methods

The research was conducted by the Chair of Agricultural Chemistry and Crop Farming of the Mari State University. The model experiment helped to study the influence of temperature, moisture, and density on nitrifying and ammonifying capacity of soil.

Factors under study:
soil temperature: −10; −5; 0; +15; +25; +35; +45°C;
soil moisture: 0; 5; 10; 15; 20; 25; 30% in absolutely tight soil;
soil density: 1.1; 1.2; 1.3; 1.4; 1.5; 1.6; 2 g/sm^3.

Sod-podzol midclay low-humic soil was used for the research. At the establishment of a trial, the soil had the following agrochemical properties: pH salt of 6.7, level of humus of 1.98%, labile phosphorus and potassium of 325 and 213 mg/kg correspondingly. Mineral nitrogen forms consisted of 42.5 mg/kg of nitrate ($N–NO_3^-$), 12.7 mg/kg of ammonium ($N–NH_4^+$), and 55.2 mg/kg of minerals (N–min). Water field capacity (WFC) of soil was 33.3%.

Nitrate nitrogen was defined by potentiometry using ion-selective electrode and ammonium nitrogen by colorimetric method using Nessler's reagent. Nitrifying and ammonifying capacity of soil was estimated after two-week composting [2,7,8]. To simulate soil conditions, the soil was firmed with hand-operated press to get design values. Necessary moisture was created by soil drying or moisturizing to get design values. Temperature influence was studied by placing samples into cold storage boxes and thermostats with a preset temperature.

Results and Discussion

The study of temperature influence on nitrifying and ammonifying capacity of soil has shown that at temperatures below zero (−10…−5°C) nitrate nitrogen content was not high and did not exceed 43.9 mg/kg, which is explained by inactivity of nitrifying microorganisms. In these conditions ammonium nitrogen content was 16.0-16.1 mg/kg (Table 1). When soil temperature rose up to +15…+35°C, nitrate nitrogen content increased, while ammonium nitrogen content decreased. Maximum content of nitrate nitrogen and mineral nitrogen was 74.4 and 81.3 mg/kg correspondingly at a soil temperature of 15°C. Nitrifying capacity of soil was the biggest at this temperature—31.9 mg/kg. The content of ammonium nitrogen in soil rocketed at a temperature of +45°C, with decrease of microorganisms. It is obvious that microorganisms died out at this temperature which led to nitrogen release in the ammonium form.

Dependence of mineral nitrogen content in soil on the temperature is curvilinear and described by second-order regression in Equation (1).

$$N\text{–min. mg/kg} = 64.6 + 0.55X - 0.004X^2 \ (r = 0.87) \quad (1)$$
(X—soil temperature, °C)

Studies showed that nitrifying process starts at a soil moisture of 5% (15% WFC). With further rise in soil moisture, $N\text{–}NO_3^-$ content increased reaching a maximum at a moisture level of 20-25% (60-75% WFC) (Table 2). At the same time ammonium nitrogen content decreased. Further increase in soil moisture up to 30% (91% WFC) led to nitrifying process retardation, which had an effect on nitrate nitrogen content reduction and ammonium nitrogen content rise in sod-podzol midclay soil.

Dependence of mineral nitrogen content on soil moisture is described by second-order regression in Equation (2).

$$N\text{–min. mg/kg} = 50.90 + 2.78X - 0.08X^2 \ (r = 0.77) \quad (2)$$
(X—soil moisture, %)

T, °C	Content in 14 days			Nitrifying capacity	Ammonifying capacity
	$N\text{–}NO_3^-$	$N\text{–}NH_4^+$	N–min.		
−10	43.3	16.0	59.3	0.7	3.3
−5	43.9	16.1	60.0	1.4	3.4
0	46.9	16.0	62.9	4.4	3.3
+15	74.4	6.9	81.3	31.9	−5.8
+25	65.0	6.8	71.8	22.5	−6.0
+35	65.8	7.4	73.2	23.3	−5.3
+45	44.3	41.5	85.8	1.8	28.8

Table 1: The influence of temperature on the content of mineral nitrogen and nitrifying and ammonifying capacity of sod-podzol midclay soil (mg/kg in absolutely tight soil)

Moisture, %	Content in 14 days			Nitrifying capacity	Ammonifying capacity
	$N\text{–}NO_3^-$	$N\text{–}NH_4^+$	N–min.		
0	41.9	15.2	57.1	−0.6	2.5
5	45.1	12.6	57.7	2.6	−0.1
10	49.5	13.3	62.8	7.0	0.6
15	69.0	7.5	76.5	26.5	−5.2
20	74.0	4.7	78.7	31.5	−7.9
25	77.5	4.8	82.3	35.0	−7.9
30	50.3	6.1	56.4	7.8	−6.6

Table 2: The influence of moisture on the content of mineral nitrogen and nitrifying and ammonifying capacity of sod-podzol midclay soil (mg/kg in absolutely tight soil)

Density, g/cm^3	Content in 14 days			Nitrifying capacity	Ammonifying capacity
	$N\text{–}NO_3^-$	$N\text{–}NH_4^+$	N–min		
1.1	63.5	7.1	70.6	21.0	−5.6
1.2	50.8	12.4	63.2	8.4	−0.3
1.3	44.9	13.4	58.3	2.4	0.7
1.4	45.3	13.4	58.7	2.8	0.7
1.5	46.2	13.4	59.6	3.7	0.7
1.6	44.5	13.4	57.9	2.0	0.7
2.0	32.1	13.8	45.9	−10.4	1.1

Table 3: The influence of density on the content of mineral nitrogen and nitrifying and ammonifying capacity of sod-podzol midclay soil (mg/kg in absolutely tight soil)

The increase in soil density had a negative effect on nitrate nitrogen content and its nitrifying capacity (Table 3). With soil density increase from 1.1 to 2.0 g/cm^3 nitrate nitrogen content in soil decreased, which is connected with air quantity decrease in soil, leading to worsened conditions for nitrifying agents' development. Maximum content of nitrate nitrogen of 63.5 mg/kg was at density of 1.1 g/cm^3, minimum of 32.1 mg/kg at density of 2.0 g/cm^3. Nitrifying capacity of soil decreased in the same way. Soil firming led to the increase in ammonium nitrogen content. Thus, with the density of 1.1 g/cm^3 ammonium nitrogen content was 7.1 mg/kg, and with the density of 2.0 g/cm^3 the content was 13.8 mg/kg.

Dependence of mineral nitrogen content in soil on its density was linear and is described by first-order regression in Equation (3).

$$N\text{–min. mg/kg} = 92.270 - 22.94X \ (r = 0.93) \quad (3)$$
(X—soil density, g/cm^3)

The correlation of the undertaken studies allowed calculating the level of multiple regression of mineral nitrogen content dependence in sod-podzol midclay soil on its temperature, moisture, and density (4).

$$N\text{–min. mg/kg} = 86.81 + 0.34 X_1 + 0.48 X_2 - 32.64 X_3 \ (r = 0.75) \quad (4)$$
(X_1—soil temperature, °C; X_2—soil moisture, %; X_3—soil density, g/cm^3)

This equation allows forecasting mineral nitrogen content depending on definite values of soil temperature, moisture, and density.

Conclusions

1. Change of physical properties factors of sod-podzol soil influenced the developing nitrifying and ammonifying bacteria, nitrifying and ammonifying capacity, and mineral nitrogen content.
2. Maximum content of nitrate and mineral nitrogen and the biggest nitrifying capacity were at a soil temperature of 15°C and had the following corresponding values: 74.4, 81.3, and 31.9 mg/kg.
3. Moistening conditions optimal for developing nitrifying and ammonifying bacteria were formed at a soil moisture of 20-25% (60-75% WFC). At this moisture there were the biggest figures of nitrifying capacity (31.5-35.0 mg/kg) and maximum values of content of nitrate nitrogen (74.0-77.5 mg/kg) and mineral nitrogen (78.7-82.3 mg/kg).
4. Soil firming had a negative effect on the microflora of sod-podzol soil. With soil density increase from 1.1 to 2.0 g/cm^3 nitrifying capacity decreased from 21.0 to 10.4 mg/kg, while nitrate nitrogen content in soil decreased from 63.5 to 32.1 mg/kg.

5. Dependence of mineral nitrogen content in soil on its temperature and moisture was curvilinear and was described by a second-order regression equation, while dependence on density was linear and was a described by first-order regression equation.
6. The best conditions for nitrification and ammonification in sod-podzol soil were as follows: soil temperature of + 15°C, soil moisture of 20-25%, and soil density of 1.1 g/cm^3.

References

1. Novoselov SI, Zavalin AA, Gordeeva TKh, Kruglov YuV (1997) Influence of means of soil chemization and treatment on the yield capacity of winter rye and microbiota of sod-podzol clay soil. Agrokhimiya 8: 31-36.
2. Yemtsev VT, Mishustin EN (2005) Microbiology. Moscow: Drofa, p. 445.
3. Novoselov SI, Novoselova ES, Zavalin AA, Gordeeeva TKh (2006) Microbiota of nitrogen cycle of sod-podzol soil. Plodorodiye 6: 26-27.
4. Vakkerov-Kouzova ND (2010) Xenobiotics influence on microbiological and argochemical points of sod-podzol soil. Pochvovedenie 8: 979-983.
5. Shilnikov IA, Lebedeva LA (1987) Soil Liming. Moscow: Agropromizdat, p. 169.
6. Zvyagintsev DG, Babyeva IP, Zenova GN (2005) Soil Biology. Moscow: MGU Press, p. 445.
7. Aleksandrova LN, Naydenova OA (1976) Laboratory and Practical Lessons on Soil Science (3rd edn., revised and enlarged). Leningrad: Kolos, p. 280.
8. Samohvalov SG, Prizhukova VG, Arsenyev MN, Gruzdev TC (1984) Methodological Guidelines on the Determination of Soil Nitrification Capacity. Moscow: Central Institute of agrochemical service of agriculture of the Ministry of agriculture of the Soviet Union, p. 16.