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Microbiological Productivity of Smonitza in Mineral and Organic Fertilization Conditions

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Abstract: A two-year study was conducted on the effect of different rates and combinations of NPK and organic fertilizers on microbiological activity in smonitza soil under spring oats. The trial was set up at the Trial Field of the Faculty of Agronomy, Cacak, according to a randomized block design with three replications. The soil was treated by mineral and organic fertilizers. As regards the mineral fertilizers increasing nitrogen rates (N_1-30 kg ha^{-1}, N_2-60 kgha^{-1} i N_3-90 kg ha^{-1}) and equal P and K amounts (75 kg ha^{-1}) were applied. As regards the organic fertilizers, solid (45 t ha^{-1}) and liquid manure (80 t ha^{-1}) were used.

The effect of the applied fertilizers on soil microorganisms was determined twice during the growing season, by determining the total number of microorganisms and oligonitrophiles.

The research results showed that the number of investigated groups of microorganisms was significantly dependent on the fertilization variants as well as on the sampling period and study year.

The applied mineral fertilizers caused a decrease in the total number of microorganisms, and oligonitrophiles, particularly in the variant with the highest nitrogen rate. The inhibitory effect of the applied fertilizers was more expressed in the second sampling period.

The applied organic fertilizers caused a decrease in the total number of microorganisms and oligonitrophiles, too, particularly at the end of the growing period.

Key words: soil, microorganisms, mineral fertilizers, organic fertilizers, oats.

Introduction

The productive capacity of soil is a complex property, and a major precondition for its maintenance and increase is the existence of diverse and active microbial community. In mid fifties, the process of agricultural production intensification started throughout the world. In this way basic issues of agricultural production such as the provision of good and high-quality yield, better exploitation of

fields, etc. were resolved. However, this concept involves the emergence of a huge number of industries, powerful agricultural techniques, uncontrolled use of mineral fertilizers, chemical meliorants, microelements, nitrification inhibitors, pesticides, etc. With the control over these substances, toxic ones in particular, being lost, they again return to man in the cycle of matter, through food chains.

Nitrogen fertilizers are the biggest danger, due to high nitrate nitrogen mobility bringing about surface and ground water pollution (Byerly, 1975, Commoner, 1975, Schaessler, 1986), death of fish and other aquatic animals, excessive nitrate accumulation in plants (Govedarica et al., 1991 a, b) – both in those used for human nutrition, and in those used for livestock nutrition (Seiz, 1986; Marinkovic and Grcic, 1993), and also, their transformation into nitrites and carcinogenic nitrosamines (Commoner, 1975, Hoffman, 1986).

Phosphorous fertilizers are less harmful. The specific property of phosphorous fertilizers is that when used at high rates they bring about undesired accumulation of a whole range of other elements in the soil: stable strontium, natural radioactive uranium, radium and thorium compounds (Djukic et al., 1997).

The hazardous effect of potassium fertilizers is expressed when they are introduced with a great amount of chlorine which can produce a number of undesired effects on the soil and water, aqueous basins (such as the chlorine effect).

The problems mentioned can be overcome by partial substitution of these fertilizers with microbiological and organic ones in order to inhibit or stimulate certain cellular processes, facilitate mineralization processes, thus improving physico-chemical processes and biological soil properties.

Considering the importance of microorganisms as bioindicators in the soil the aim of these investigations was to examine the effect of different rates and combinations of mineral and organic fertilizers on the number and activity of different environmental trophic groups of microorganisms.

Material and Method

The investigations were conducted in the 1996-1997 period at the Trial Field and Microbiology Department of the Faculty of Agronomy in Cacak. Field, laboratory and mathematical-statistical research methods were used in the trial. The trial was set up on the smonitza soil under spring oats according to a randomized block design with three replications.

Chemical characteristics of the soil where the trial was set up included extreme acid reaction (pH – 5.01), good potassium supply (26.38 mg/100 g soil) and poor readily available phosphorus supply (1.78 mg/100 g soil).

Following basic soil tillage, sowing was carried out and adequate mineral and organic fertilizer rates were introduced.

Of the mineral fertilizers, three nitrogen fertilizer rates (N_1= 30 kg/ha , N_2 = 60 kg/ha and N_3 = 90 kg/ha) were used, whereas phosphorus and potassium fertilizers were applied at the rate of 75 kg/ha each.

Nitrogen, phosphorus and potassium rates were used in the form of urea (46 % N), superphosphates (18%) and 60 % KCl, respectively.

As regards the organic fertilizers, burned (45 t/ha) and liquid manure (80 t/ha) were used.

The trial plot size was 21.25 m^2. Standard cultural practices were applied during the growing season. The soil that was not treated with the fertilizers mentioned was used as the control.

Results and Discission

The analysis of variance of the total number of microorganisms (F values) showed that there was a statistically highly significant effect of factor A (fertilizer), based on which it could be concluded that the A x B x C (fertilizer x sampling period x research year) interaction was also statistically highly significant compared to A x B (fertilizer x sampling period) and A x C (fertilizer x research year) interactions which were not statistically significant.

Tab. 1. Average total number of microorganisms (10^6/1.0 g absolutely dry soil) in the soil depending on the fertilizers used (A), sampling period (B) and research year (C)

Fertilizer (A)			Ø	N_1	N_2	N_3	Solid manure	Liquid manure	$\overline{X}$
Year (C) 1996	Periods (B)	I	175.00	109.92	97.50	50.49	85,00	47,00	92,19
		II	153.83	105.83	87.67	49.50	98,00	46,50	
1997		I	116.25	110.50	98.67	52.83	100,50	85,00	101,39
		II	264.32	159.16	61.83	42.92	68,66	55,50	
$\overline{X}$		I	145,63	110,21	98.09	51.66	92.75	66.00	94,06
		II	209,08	132,50	74.75	46.21	83.33	51.25	99,52
$\overline{X}$			177,35	121,35	86,42	48.94	88.04	58.5	96.77

lsd	A	B	C	AxB	AxC	BxC	AxBxC
0.05	23.84	13.77	33.72	13.77	33.72	19.47	47.68
0.01	31.84	18.39	45.03	18.39	45.03	26.00	63.69

The research determined that different rates and combinations of NPK and solid and liquid manure had exerted diverse effects on the total number of microorganisms in the soil.

Through comparison of average values for the total number of micro-organisms by variants during the two soil sampling periods, it can be inferred that the highest total number of microorganisms was recorded in the control variants (145.63 $\times 10^6$ in the first and 209.08 $\times 10^6$ in the second sampling period). The introduction of mineral fertilizers into the soil resulted in a decrease in the total number of microorganisms, with the N_3 variant (a variant with the highest nitrogen rate used) having the most depressive effect (51.66 $\times 10^6$ in the first and 46.21 $\times 10^6$ in the second sampling period). Adverse effects of increasing nitrogen rates were stressed by a number of authors (Viblov 1979; Pavlenko 1982; Milosevic 1993; Djukic 1997).

The use of organic fertilizers brought about a certain increase in the total number of microorganisms in both research periods, with the solid manure variant exerting the most stimulatory effect (92.75×10^6 in the first and 83.33×10^6 in the second sampling period) compared to other variants. However, according to these results, the organic fertilizers did not give rise to a significant increase in the total number of microorganisms (compared to the control variants), indicating that they did not exert expected effect in given conditions, which may be due to the fact that organic fertilizers affect heavy soils, such as smonitza, more slowly. According to the results obtained by Misustin et al. (1978), in soils with heavier mechanical composition, due to E_h decrease to 200-250 mV, there may occur reducing processes which lead to a change in valence of certain soluble elements (Fe, Mn, Al et al.), which may become toxic to a majority of saprophyte microorganisms.

The fertilizers used-research year (AxC) interaction had a similar effect. In both research years, the highest number of microorganisms was registered in the control variants (164.42×10^6 1996 and 190.29×10^6 1997). Mineral fertilizers gave rise to a highly significant decrease in the total number of microorganisms. The N_3 variant (49.995×10^6 1996 and 47.873×10^6 1997) had again exerted the most adverse effect on the change in the total number of microorganisms in the soil. The adverse effect of the organic fertilizers used was less pronounced in the variant with solid manure (91.502×10^6 in 1996 and 84.58×10^6 in 1997) and in the variant with liquid manure in 1997 (70.498×10^6).

The total number of microorganisms in the soil during 1996 and 1997 depended also on the sampling period. The highest number of microorganisms in the investigated soil was recorded at the end of the growing season in 1997 and the lowest one in the same period of the previous year, which was due to differences in meteorological conditions. Based upon the data for mean monthly air temperatures (^oC) and precipitation sum (l/ m^2) for the period 1996-1997, it can be seen that in 1996, over the period from III to V month, the average precipitation was 83.4 l/m^2 and average temperature was 10.2 ^oC, whereas in the same period of the following (1997) year, the average precipitation sum was 51.53 l/m^2 and average temperature 9.77 ^oC. In the period VI-VII of 1996, the average rainfall was 28.35 l/m^2 and average temperature was 20.9 ^oC. In the same period in 1997, the average rainfall was 76.4 l/m^2 and average temperature was 21.05 ^oC.

These results showed that higher humidity was registered in the first sampling period in 1996 and in the second sampling period in 1997, which also affected the presence of investigated group of microorganisms in the soil.

Statistical analysis of obtained experimental data on the effect of fertilizers (A), sampling period (B) and research year (C) showed that applied fertilizers and research year statistically highly significantly affected the change in the number of oligonitrophiles in the soil, and that the sampling period had a statistically insignificant effect on the change in their number.

Tab. 2. Average number of oligonitrophiles in the soil (10^5/1.0 g absolutely dry soil) depending on the fertilizers used (A), sampling period (B) and research year (C)

Fertilizer (A)			Ø	N_1	N_2	N_3	Solid manure	Liquid manure	$\overline{X}$
Year (C) 1996	Periods (B)	I	165.09	147.25	139.50	57.00	164.33	55.63	114.80
		II	260.83	130.33	62.00	32.67	144.00	19.00	
1997		I	200.00	78.00	42.66	33.16	81.83	7.33	60.04
		II	130.50	43.17	39.83	10.66	45.16	8.17	
$\overline{X}$		I	182,55	112,63	91.08	45.08	123.08	31.48	97,65
		II	195,67	86,75	50.92	21.67	94.58	13.59	77,20
$\overline{X}$			189,10	99,69	71,00	66.75	108.83	22.53	87.42

lsd	A	B	C	AxB	AxC	BxC	AxBxC
0.05	36.57	21.12	21.12	51.72	51.72	29.86	73.15
0.01	48.85	28.20	28.20	69.08	69.08	39.89	97.70

The experimental results showed that the number of oligonitrophiles in the soil varied between the fertilization variants used, sampling periods and research years.

The experimentally obtained results showed that the fertilizers used had a depressive effect on the number of oligonitrophiles. The effect was more pronounced in the second sampling period (77.20×10^5). With an increase in nitrogen fertilizer rates the depressive effect of the fertilizers used increased, too, so that the lowest number of oligonitrophiles was registered in the N_3 variant (45.08×10^5 in the first and 21.67×10^5 in the second sampling period). Solid manure used brought about a certain increase in the number of these microorganisms (123.08×10^5 in the first and 94.58×10^5 in the second sampling period), but the number compared to the control variant was still statistically highly significantly low. Expectedly, the variant with liquid manure had the most depressive effect on the presence of oligonitrophiles in the soil in both research periods (31.48×10^5 in the first and 13.59×10^5 in the second one), because the concentration of nutrient elements in liquid manure, primarily of nitrogen, was considerably high.

Similar effects can be registered in the interaction of fertilizers applied and research year. Here, too, the depressive effect of the fertilizers used was evident, primarily of the variant with liquid manure (37.315×10^5 in 1996 and 7.75×10^5 in 1997) and the N_3 variant (44.835×10^5 in 1996 and 21.582×10^5 in 1997). A stimulatory effect of the variant with solid manure, particularly in 1996, was registered (154.165×10^5), although the number recorded continued to be statistically significantly lower than in the control variant (212.96×10^5). Govedarica et al. (1991) also stressed the stimulatory effect of lower nitrogen and vermicompost rates (0.5 and 1.0 g/container, respectively) on the number of oligonitrophiles in unfertilized crop rotation, whereas in fertilized areas even 1.5 g/container rates increased the number of the mentioned group of microorganisms.

The sampling period produced at proportionally equal levels effects on the development of these microorganisms during both research years. In both years, a higher number of oligonitrophiles was registered in the first sampling period (121.467×10^5 in 1996 and 73.829×10^5 in 1997), and in the second period there was a statistically insignificant decrease in their number (108.139×10^5 in 1996, and 46.247×10^5 in 1997).

Conclusion

Based upon the research results on the effect of mineral and organic fertilizers on the number and proteinase activity of microorganisms in the soil, the following conclusions can be drawn:

- the number of investigated groups of microorganisms depended on the type and rate of fertilizers used, sampling period and research year;
- mineral fertilizers used brought about a decrease in the total number of microorganisms and oligonitrophiles;
- of all the mineral fertilization variants examined, the variant with the highest nitrogen rate produced the highest inhibitory effect;
- the use of organic fertilizers also gave rise to a decrease in the total number of microorganisms and in the number of oligonitrophiles, particularly in the variant with liquid manure;
- the fertilizers used had a pronouncedly inhibitory effect at the beginning of the growing season and a markedly inhibitory effect at its end;
- the total number of microorganisms was higher in 1997, and the number of oligonitrophiles was higher in 1996.

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MIKROBIOLOŠKA PRODUKTIVNOST SMONICE U USLOVIMA PRIMENE MINERALNIH I ORGANSKIH ĐUBRIVA

- originalni naučni rad -

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Rezime

Tokom dvogodišnjih proučavanja praćen je uticaj različitih doza i kombinacija NPK i organskih đubriva na mikrobiološku aktivnost smonice pod jarim ovsem. Ogled je izveden na Oglednom polju Agronomskog fakulteta u Čačku po sistemu slučajnog blok rasporeda u tri ponavljanja. Zemljište je tretirano mineralnim i organskim đubrivima. Od mineralnih đubriva primenjene su rastuće doze azota (N_1-30 kg/ha, N_2-60 kg/ha i N_3-90 kg/ha) i podjednake količine P i K (75 kg/ha). Organska đubriva primenjena su u obliku čvrstog (45 t/ha) i tečnog stajnjaka (80 t/ha).

Efekat primenjenih đubriva na zemljišne mikroorganizme određivan je dva puta tokom vegetacije, na osnovu praćenja ukupne brojnosti mikroorganizama i oligonitrofila.

Rezultati istraživanja pokazuju da je brojnost ispitivanih grupa mikroorganizama značajno zavisila kako od primenjenih varijanata đubrenja, tako i od periodi uzimanja uzoraka i godine istraživanja.

Mineralnih đubriva su izazvala sniženje ukupne brojnosti mikroorganizama i brojnosti oligonitrofila, posebno varijanta sa najvišom dozom azota. Inhibitorni uticaj primenjenih đubriva je bio izraženiji u drugom periodu uzimanja uzoraka.

Primenjena organska đubriva su, takođe, delovala u pravcu sniženja ukupne brojnosti mikroorganizama i brojnosti oligonitrofila, posebno na kraju vegetacije.