EFFECT OF NPK FERTILIZER ON THE GROWTH OF SAPROPHYTIC FUNGI IN ALLUVIAL SOIL

UTICAJ NPK ĐUBRIVA NA RAZVOJ SAPROFITNIH GLJIVA U ALUVIJUMU

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ABSTRACT

The influence of different NPK fertilizer rates on the developement of the saprophytic fungi of the alluvial soil planted with plum culture has been studied over the three-year period (2003 – 2005). The trial was set up in the experimental plum orchard established by Fruit Research Institute Čačak (Serbia) and at the laboratory of Department of Microbiology, Faculty of Agronomy Čačak (Serbia). The soil was treated with 8:16:24 + 3% of MgO mineral fertilizer in the following treatment variants: variant N_1 – 400 kgha^{-1}; variant N_2 – 600 kgha^{-1}; variant N_3 – 800 kgha^{-1} and variant N_4 –1000 kgha^{-1}, all treatment variants being applied in three replications. Unfertilized soil served as the control. The size of the trial plot was 68 m^2. The effect of the studied mineral fertilizer rates was determined three times over the growing season. It was checked by identification of the number of saprophytic fungi by the indirect rarefaction method on Czapek nutritive medium. The results of the study suggested that the number of the saprophytic fungi varied by different fertilizer rates, periods of sampling and years of study. The application of fertilizers brought about increase in the number of the saprophytic fungi. Of all studied treatment variants, the one with highest nitrogen rate (variant N_4) exhibited the strongest effect. The influence of the applied fertilizer was highest over the third sampling period. Furthermore, the effect thereof was highest in 2003. The application of 600 kgha^{-1} of mineral fertilizer resulted in the highest plum yield.

Key words: soil, saprophytic fungi, mineral fertilizers, plum culture.

REZIME

Tokom trogodišnjih proučavanja (2003-2005) praćen je uticaj različitih doza NPK na razvoj saprofitnih gljiva u aluvijumu pod zasadom šljive. Ogled je izveden u eksperimentalnom zasadu šljiva, Instituta za voćarstvo i u Odeljenju za Mikrobiologiju Agronomskog fakulteta u Čačku. Zemljište je tretirano mineralnim đubrivom formulacije 8:16:24 + 3 % MgO i to: varijanta N_1 – 400 kgha^{-1}; varijanta N_2 – 600 kgha^{-1}; varijanta N_3 – 800 kgha^{-1} i varijanta N_4 –1000 kgha^{-1}. Kao kontrola korišćeno je zemljište koje nije đubreno. Svaka od navedenih varijanti đubrenja bila je zastupljena u tri ponavljanja. Veličina osnovne ogledne parcele iznosila je 68 m^2.

Efekat primenjenih đubriva određivan je tri puta tokom vegetacije, a praćen je putem utvrđivanja brojnosti saprofitnih gljiva indirektnom metodom razređenja na Čapekovoj hranljivoj podlozi.

Rezultati istraživanja su pokazali da su na brojnost saprofitnih gljiva uticale primenjene varijante đubrenja, periodi uzimanja uzoraka i godine istraživanja. Primena mineralnih đubriva je izazvala povećanje brojnosti gljiva. Od svih ispitivanih varijanti đubriva najizraženiji uticaj pokazala je N_4 varijanta (varijanta sa najvišom dozom azota). Uticaj primenjenih đubriva je bio najizraženiji u trećem periodu uzimanja uzoraka. Takođe, može se primetiti najizraženije dejstvo tokom 2003. godine.

Najznačajnije povećanje prinosa šljive ostvareno je primenom mineralnog đubriva u količini od 600 kgha^{-1}.

Ključne reči: zemljište, saprofitne gljive, mineralna đubriva, šljiva.

INTRODUCTION

Fertilization is one of the most significant cultural practices in modern plant production. Regardless of its major role in tree productivity and soil fertility, the application of nitrogen fertilizers may induce a series of negative consequences, from the microbiological, economic and ecological aspects [2, 6]. This primarily refers to the increased presence of easily driven forms of nitrate nitrogen that pollutes the surface and underground waters [11, 14], and the accumulation of nitrates in plants above the allowed level – not only of those used in human diet but for cattle feed as well [10]. Excessive nitrate nitrogen content provides their transformation into nitrates and nitrozamines which can cause cancer [14]. Somwhat safer are phosphorous fertilizers which, applied at higher rates, lead to undesirable accumulation of a series of the other elements in soil, such as stable strontium, natural radioactive compounds of uranium, radium and thorium. The damaging effect of potassium fertilizers is reflected in the fact that these introduce a large quantity of chlorine which can cause a series of undesirable effects (e.g. chlorine effect) both in water and soil. The intensity of the stated processes is governed by the type and rate of applied fertilizers [12].

Rational and effective application of mineral fertilizers, nitrogen in particular, presupposes delicate approach to this issue whereby microbiological investigations ought to be particularly in the focus.

Given the fact that soil fungi have evolved a complex enzymatic system that also helps them transform chemical compounds that are not easily degradable [9], the underlying assumption of this study was that a change in their number may be used as a reliable indicator of soil biogeny and an indicator of the economic feasibility of applying different rates of mineral fertilizers.

The objective of these investigations was to examine the influence of different mineral fertilizer rates on the number of saprophytic fungi in soil.

MATERIAL AND METHODS

The research was conducted over 2003 – 2005 at the experimental plum orchard of the Fruit Research Institute and at the Department of Microbiology, Faculty of Agronomy, Čačak. The trial was set up according to a randomized block design in three replications on the alluvial soil type. The tested alluvial soil was acid in reaction, poor in organic matter, well supplied with plant-available P and moderately supplied with K. The chemical and physical characteristics of the tested soil are given in Tab. 1.

The plot size was 68 m^2. The soil was treated with 8:16:24 + 3 % of MgO mineral fertilizer in the following treatment variants: N_1 – 400 $kgha^{-1}$; N_2 – 600 $kgha^{-1}$; N_3 – 800 $kgha^{-1}$ and N_4 –1000 $kgha^{-1}$, treatment Ø – the control – unfertilized soil.

All cultural practices, i.e. fertilization, pruning, summer pruning, interrow practices, protection from diseases and pests, etc. were applied over the period of training system formation.

Climate characteristics (temperature and precipitation) of the studied region are presented in Table 2.

Soil sampling was performed three times over the growing season, i.e. 12 May, 17 September and 11 November, in all three years of research.

The count of saprophyte fungi was determined by the indirect dilution-plate method on Czapek's agar, the medium most commonly used for the determination of this group of microorganisms [1, 5 ,7, 8].

Field, laboratory and mathematical/statistical methods of scientific research were used in the paper.

The results obtained from counting saprophytic fungi were subjected to the analysis of variance, whereas LSD test was used for determining significance of differences between individual and interactive means. Effects of different mineral fertilizers rates on plum yield were evaluated using Duncan's multiple range test at P = 0.05.

RESULTS AND DISCUSSION

The investigation has revealed that different NPK rates exerted ununiform effect on the number of saprophytic fungi (Table 3).

Experimentally obtained results on the population density of saprophytic fungi in soil as influenced by different NPK fertilizer rates suggest (based on F value) that, statistically, all studied factors have exerted strong influence on the presence of this microorganism group in the soil (Table 3).

The treatment variant N_4 (14.062×10^5) had the highest impact on the enhancement of the number of saprophytic fungi. With regard to the predominance of fungi in acid soils, it is anticipated that the increased number thereof is due to the rise in acidity brought about by the application of fertilizers. This complies with the results given in [14, 15] which explains the increase in the number and activity of majority of soil microorganisms (under the fertilizing conditions) as the result of the occurrence of weaker C:N correlation and higher mineralizing processes therein, as well as the product of re-destribution within the microbe cenoses complexes on the part of the soil fungi [16].

In general, the applied fertilizers had stronger effect in the third period of sampling, thence their higher efficacy

Table 1. Chemical and physical characteristics of the tested soil

Depth (cm)	pH u KCl	Humus %	Nitrogen %	P_2O_5 mg/100g soil	K_2O mg/100g soil	Soil texture: Fraction (mm) 2-0.2	0.2-0.02	0.02-0.002	< 0.002
	Chemical composition					Soil texture			
0-20	5.9	2.65	0.13	15	20.4	17.60	34.30	18.20	29.90

Table 2 Weather characteristics (Čačak Meteorological Office) and long-term means

The period		Precipitation and mean air-temperatures in Čačak* May	June	July	Aug.	Sept.	Oct.	Nov.	Total	Mean
2003	mm	62	51	69	6	34	77	27	326	
	°C	19.8	25.1	24.2	26.4	17.3	10.2	8.9		18.8
2004	mm	66	121	82	58	35	27	98	487	
	°C	16	21.7	23.5	22.8	18.1	14.3	6.2		17.5
2005	mm	72	84	100	66	91	23	83	519	
	°C	17.2	21	23.7	20.3	18.2	11.8	5.2		16.8
LTM (1965-1994)	mm	89	98	76	60	56	48	59	486	
	°C	16.2	19.5	20.9	20.5	16.9	11.8	5.8		15.9

* About 5 km as the crow flies (eastward from the trial field)

Tab. 3 Average number of saprophytic fungi (10^5 g^{-1} of absolutely dry soil) in soil as influenced by applied fertilizer rates (A), periods of sampling (B) and years of research (C)

Fertilizer (A)			N_1	N_2	N_3	N_4	Ø	$\bar{X}$
Year (C)	2003 Period (B)	I	6.113	4.890	12.223	15.557	9.887	9.734
		II	7.780	8.443	15.223	21.553	4.557	11.511
		III	11.110	13.333	15.777	21.333	8.777	14.066
	$\bar{X}$		8.334	10.554	14.408	19.481	6.074	11.770
	2004 Period (B)	I	7.443	11.780	13.997	16.443	5.113	10.955
		II	2.667	3.333	4.110	4.557	1.667	3.267
		III	6.333	12.667	15.110	18.890	5.443	11.689
	$\bar{X}$		5.481	9.260	11.072	13.297	4.074	8.637
	2005 Period (B)	I	6.553	9.557	10.223	12.223	5.110	8.733
		II	5.553	6.663	9.000	10.557	4.890	7.333
		III	3.223	4.113	4.780	5.443	2.553	4.023
	$\bar{X}$		5.110	6.778	8.001	9.408	4.184	6.696
$\bar{X}$		I	6.703	10.408	12.148	14.741	5.038	9.808
		II	5.333	6.147	9.444	12.222	3.704	7.370
		III	6.889	10.083	11.889	15.222	5.591	9.926
	$\bar{X}$		6.309	8.309	11.160	14.062	5.333	9.035
lsd	**A**		**B**	**C**	**AxB**	**AxC**	**BxC**	**AxBxC**
0.05	1.663		1.228	1.228	2.880	2.880	2.231	4.988
0.01	2.202		1.706	1.706	3.814	3.814	2.955	6.607

Table 4 Average yield of plum cv Čačanska Lepotica (tha^{-1}) fertilized with different fertilizers

Fertilisation variant	Yield (tha^{-1})						$\overline{X}$	
	2003		2004		2005			
N_1	33.332	c	18.212	b	7.392	c	19.646	d
N_2	40.862	a	16.714	e	8.261	b	21.946	a
N_3	36.546	b	17.416	c	8.401	a	20.787	b
N_4	33.382	c	20.716	a	7.135	d	20.411	c
Ø	23.453	d	17.172	d	4.566	e	15.064	e

Duncan's multiple range test was used to compare different varians, $P<0.05$

described as statistically more significant over the stated period than over the second one (9.926×10^5 in the third, i.e. 7.370×10^5 over the second period of sampling). The results seem feasible bearing in mind the fact that soil moisture was considerably higher over the stated period than it had been over the second sampling period (Table 2). Similar reports were given by [6] in the study of the influence of growing nitrogen rates under different moisture and temperature conditions on the number of fungi in soil. Besides, high population of fungi in the autumn is due to the intensified accumulation of fresh organic matter [4, 11].

In conclusion, the population of fungi was largest over 2003 (11.770×10^5), and smallest over 2005 (6.696×10^5).

The experimental data on the effect of different mineral fertilizer rates (8:16:24 + 3 % MgO) on the yield of plum cv Čačanska Lepotica are presented in Table 4.

The experimental data on the effect of different mineral fertilizers rates (8:16:24 + 3 % MgO) on plum yield are given in Table 4.

Yield differences between the applied treatments (based on Duncan test) indicated different effects of application rates across years. Generally, over the three years of the study, the most stimulatory effect was produced by the N_2 treatment (600 $kgha^{-1}$), which resulted in a yield of 21.946 tha^{-1} (Tab.4).

In conclusion, under the stated fertilization conditions the use of rates exceeding 600 $kgha^{-1}$ is not economically justifiable, whereas the application of high rates (800 and 1000 tha^{-1}) should be abandoned after three years [13]. The research results pointed to a somewhat lower-than-expected plum yield, one of the reasons being flower frosting [13], but also a reduction in soil biological productivity and change in agrochemical and agro-physical soil properties as affected by high mineral fertilizer rates.

CONCLUSION

The results of the study of the effect of mineral fertilizers on the number of saprophytic fungi in the soil suggest as follows:

- the number of the studied microorganisms groups varied by different fertilizer rates, periods of sampling and research years;
- the applied fertilizers greatly influenced the number of saprophytic fungi;
- of all studied treatment variants the most effective was the one containing highest nitrogen rate;
- the effect of the applied fertilizers was most pronounced at the end of the growing period;
- the number of saprophytic fungi was highest in 2003;
- the most significant increase in plum yield was attained by the application of 600 $kgha^{-1}$fertilizer.

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