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EFFECT OF MINERAL FERTILIZATION ON THE DYNAMICS OF *Rhizoctonia solani* KÜHN GROWTH

WPŁYW NAWOŻENIA MINERALNEGO NA DYNAMIKĘ WZROSTU *Rhizoctonia solani* KÜHN

Abstract: The research focused on determining the effect of water extracts of soil fertilized with mineral fertilizers: NPK, NPK + S(ammonium sulphate), NPK + S(Potafoska) on the linear growth and biomass of *Rhizoctonia solani* under conditions *in vitro*. The research has shown that *R. solani* fungus is very sensitive to the presence in the medium of water extracts of soils fertilized with mineral fertilizers. It has been reflected both by linear growth rate coefficients, inhibition of linear growth and biomass increments. All investigated extracts and their concentrations significantly affected the dynamics of *R. solani* growth. The strongest inhibitory effect on the *R. solani* hyphae linear growth was observed in the presence of the water extract of the soil fertilized with NPK + S(Potafoska). On the other hand, when 50 mm^3/cm^3 of the extract of the soil fertilized with NPK and 25 mm^3/cm^3 of the extract of the NPK + S(ammonium sulphate) treated soil was added, the tested fungus responded by strong inhibition of biomass increment, respectively by 55.71 and 57.07 %. The experiments conducted *in vitro* may suggest that supplying mineral NPK and other fertilizers, such as ammonium phosphate or Potafoska to the soil may limit the population of *R. solani* pathogenic fungi. However, in agrocenoses one should also consider the complicated interrelations between individual elements of the environment.

Keywords: *Rhizoctonia solani*, mineral fertilization, soil extracts, linear growth, biomass

Fungi from the Rhizoctonia genus cause tiresome diseases in many plants, mainly due to injuries of their underground organs. *Rhizoctonia solani* Kühn species belongs to the *Mycelia sterilia* group and occurs in soil where it is one of the most serious polyphagous pathogens. In the opinion of many authors [1–5] *R. solani* is the cause of shoot rotting and rhizoctonosis of potato and beetroot seedling disease [6]. It causes cereal root diseases and also other diseases [7–9]. Mineral fertilization, beside soil and climatic conditions, is one of the most important factors affecting the quantity of pathogenic

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organisms accumulated in soil [10, 11]. However, the interaction between the fertilization level and the development of pathogens infecting roots has not been fully recognized yet.

The research aimed at determining the effect of water extracts from soil fertilized with mineral fertilizers: NPK, NPK + S(ammonium sulphate) and NPK + S(Potafoska) on linear growth and biomass of *Rhizoctonia solani* under conditions *in vitro*.

Table 1

Contents of macro- and some microelements in water extracts of soils

Water extracts of soil	Macroelements [mg/dm^3]							
	$N\text{-}NO_3$	$N\text{-}NH_4$	P	K	Ca	Na	Mg	S
Non-fertilized soil	1.6	traces	0.31	1.05	2.82	2.02	1.40	0.80
NPK	0.19	traces	0.33	1.79	8.41	2.20	2.10	5.70
NPK + S(ammonium sulphate)	1.84	traces	0.27	2.28	5.91	1.99	1.63	2.39
NPK + S(Potafoska)	0.43	traces	0.40	2.29	5.52	2.31	2.32	6.75
	Microelements and trace elements [mg/dm^3]							
	Cr	Zn	Pb	Cu	Cd	Ni	Fe	Mn
Non-fertilized soil	0.005	0.079	0.004	0.012	0.000	0.008	1.010	0.029
NPK	0.005	0.037	0.001	0.008	0.000	0.004	0.890	0.020
NPK + S(ammonium sulphate)	0.004	0.067	0.000	0.008	0.000	0.003	0.690	0.030
NPK + S(Potafoska)	0.005	0.060	0.000	0.009	0.000	0.006	1.030	0.020

Subsequently individual water extracts were added to the PDA (glucose-potato) medium, so that the extract constituted 50 and 25 mm^3/cm^3 of the medium. *R. solani* was cultured in five replications for each concentration at the temperature of 23 °C. The control were Petri dishes with a medium without the water extract of soil. Before inoculation of the media, their pH was measured; it ranged between 6.31 and 6.45. The effect of individual water extracts of soil on *R. solani* linear growth was presented as a difference between the fungus colony diameter on the control dishes and the mycelium colony diameter on the dishes with individual extract concentrations. Subsequently the value was converted into the growth inhibition/stimulation coefficient according to the Abbot formula and the linear growth rate coefficient of *R. solani* was computed according to the formulas presented by Gleń [12].

R. solani fungus biomass increment was conducted in Erlenmayer flasks on 100 cm^3 of the modified PDA medium (without agar) with added water solutions of soils in the same concentrations as described above. The culture was maintained for 21 days and then the post-culture liquid with mycelium was filtered through filter paper. Dry matter was assessed in the biomass and then in dry mass of the mycelium assessed were the content of mineral components, phosphorus, potassium, sodium, calcium, magnesium and trace elements (Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn) using ICP-AES method on JY 238 Ultrace apparatus.

The results were elaborated statistically using ANOVA.

Results and discussion

On the basis of conducted laboratory analyses it was found that water extracts of soils and their concentrations had a significant effect on the rate of linear growth of the *R. solani* colony and biomass. The analyses also revealed that the tested fungus was a sensitive species, since it responded by an apparent inhibition of its linear growth and biomass increment to the presence of individual soil extracts. It should be said that the analyzed water extracts of soils were diversified with respect to their contents of individual macro- and microelements (Table 1). The water extract from the soil fertilized with NPK + S(Potafoska) was characterized by the highest contents of PK, Na, Mg, S and Fe and it also inhibited the *R. solani* growth rate the most. The diameter of the *R. solani* colony on the medium with added 50 mm^3/cm^3 of this extract was by 39.01 % smaller in comparison with the control (Fig. 1). Higher (50 mm^3/cm^3) concentrations of extracts of soils fertilized with NPK and NPK + S(Potafoska) revealed a markedly stronger fungistatic activity than in 25 mm^3/cm^3 (Table 2).

Table 2

Growth rate coefficients of *Rhizoctonia solani*

Water extracts of soil	Growth rate coefficients [I]			$LSD_{0.05}$
	concentration [mm^3/cm^3]		Mean	
	50	25		
Non-fertilized soil	63.08	62.91	62.99	8.98
NPK	72.69	82.96	77.83	
NPK + S(ammonium phosphate)	82.99	80.83	81.91	
NPK + S(Potafoska)	54.80	60.72	57.76	
Control (PDA medium)	89.41		89.41	
Mean	72.60	75.36		
$LSD_{0.05}$	4.21			

The *R. solani* culture on the media with added water solutions of soils fertilized with mineral materials contributed to inhibition of biomass growth within the range of 42.92–57.07 % (Table 3). Generally in combinations with 25 mm^3/cm^3 content of soil extracts and therefore more deficient in macro- and microelements ca 5–10 % lower biomass was registered. On the other hand on the medium with the water extract of NPK fertilized soil an opposite response of the *R. solani* fungus was observed to the applied concentrations. Moreover, no significant differences in the obtained *R. solani* biomass were noted between the combinations with the extract of non-fertilized soil and the soil fertilized with NPK + S(Potafoska) (Table 3). Fungal organisms reveal an ability to accumulate both macro- and microelements. They use them to build cell structure or they penetrate into cell organelle where biochemical processes take place and participate in the regulation of secondary metabolism [13, 14]. On the basis of the chemical analysis of the *R. solani* mycelium it was demonstrated that in the presence of 50 mm^3/cm^3 of water extracts of soil in the medium the content of potassium decreases in the mycelium

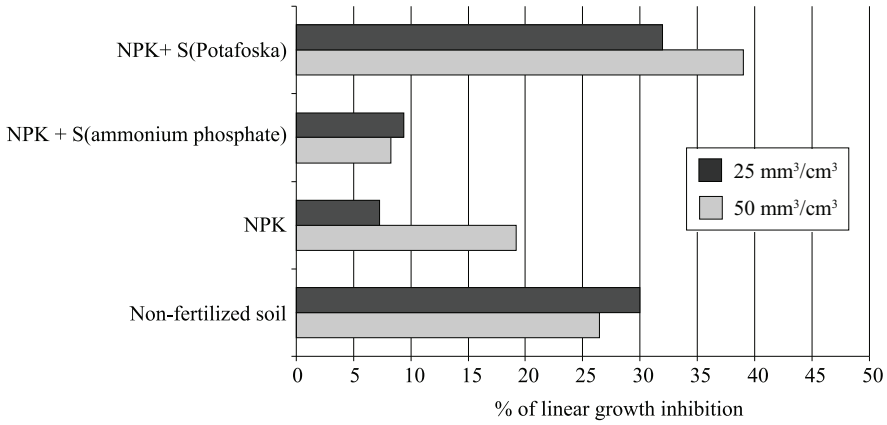

Fig. 1. Effect of water extracts of soil on linear growth of *Rhizoctonia solani*

dry mass but the contents of phosphorus and calcium increase (Table 4). Water extracts of soil fertilized with NPK + S(ammonium sulphate) and NPK + S(Potafoska) contained the greatest quantities of potassium, yet in *R. solani* mycelium cultured in the above mentioned objects the content of this element was the lowest (Tables 1 and 4). It is a common opinion that plant fertilization with potassium and phosphorus favours improvement of their resistance to infectious diseases [14, 15]. In the light of the conducted experiments it may be deduced that the greater amounts of bioavailable potassium in the environment, the lesser its utilization by *R. solani*. It shows that potassium is an element mainly utilized by plants, but it may have a direct inhibitory effect on microorganisms, eg *R. solani*, which settle plants. Soil liming is often used as a measure to disinfect the soil and get rid of phytopathogenic organisms [14]. In the presented experiments, calcium was the element taken up by the tested fungal organism in amounts proportional to its contents in the medium. The fact was corroborated by other research where calcium fertilizer stimulated linear growth and biomass increments of *Fusarium* fungi [16].

Table 3

Effect of water extracts of soils on *Rhizoctonia solani* biomass

Water extracts of soils	Biomass			
	Concentration [mm³/cm³]			
	50		25	
	g	[%]	g	[%]
Non-fertilized soil	1.20 cde*	45.2	1.09 bcd	50.23
NPK	0.97 a	55.71	1.25 de	42.92
NPK + S(ammonium phosphate)	1.16 cd	47,03	0.94 a	57.07
NPK + S(Potafoska)	1.19 cde	45,66	1.09 bcd	50.23
Control without extract	2.19 f			

*values in columns marked by the same letters do not differ significantly

Table 4

Contents of macro- and microelement in *Rhizoctonia solani* mycelium

Water extracts of soil	Concentration [mm^3/cm^3]	g/kg d.m.						
		P	K	Ca	Mg	Na	Fe	Cu
Non fertilized soil	50	2.42	72.24	9.66	13.26	1.63	1.40	0.043
	25	2.06	84.40	8.02	12.86	1.57	1.07	0.039
NPK	50	2.99	78.82	15.74	15.11	3.49	0.41	0.046
	25	2.50	88.71	11.40	13.15	1.29	0.30	0.039
NPK + S(ammonium sulphate)	50	2.15	44.75	10.87	16.35	3.83	1.37	0.088
	25	1.99	65.99	10.14	13.73	2.87	1.21	0.079
NPK + S(Potafoska)	50	2.55	69.65	10.16	14.18	1.49	1.32	0.040
	25	1.60	86.41	9.39	13.20	2.10	0.92	0.039
Control without extract		2.44	94.35	7.84	13.84	2.47	0.28	0.043

Water extracts of soil tested in the experiment did not favour the development of the *R. solani* fungus. Under field conditions mineral NPK fertilization also inhibited potato tuber infection by *R. solani* [17]. According to Górski and Gaj [18] high contents of Mg, Cu, and Mn in plants reduce beetroot leaf infection by *Cercospora beticola*, *Erisiphe betae* and *Uromyces betae.* Therefore it is supposed that the presence of these elements in water extracts of soils may contribute to inhibition of *Rhizoctonia solani* fungus development.

Conclusions

1. Under conditions *in vitro* the *R. solani* fungus reveals high sensitivity to the presence in the medium of water extracts of soils fertilized with mineral fertilizers. All tested soil extracts applied in concentrations of 50 and 25 mm^3/cm^3 inhibit both colony surface growth and increments of *R. solani* biomass.

2. The strongest inhibitory effect on linear growth of the *R. solani* mycelium was observed in the presence of the water extract of soil fertilized with NPK + S(Potafoska).

3. The share of 50 mm^3/cm^3 of the extract of NPK fertilized soil and 25 mm^3/cm^3 of NPK with the S(ammonium sulphate) extract contributes to inhibiting *R. solani* biomass growth to the same extent.

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WPŁYW NAWOŻENIA MINERALNEGO NA DYNAMIKĘ WZROSTU *Rhizoctonia solani* KÜHN

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Abstrakt: Badania dotyczyły określenia wpływu wodnych wyciągów z gleb nawożonych nawozami mineralnymi: NPK, NPK + siarczan amonu, NPK + Potafoska na rozrost liniowy i biomasę *Rhizoctonia solani* w warunkach *in vitro*. Z badań wynika, że grzyb *R. solani* wykazuje dużą wrażliwość na obecność w podłożu hodowlanym wodnych wyciągów z gleb nawożonych nawozami mineralnymi. Odzwierciedlają to współczynniki tempa wzrostu liniowego oraz zahamowania rozrostu liniowego i przyrostów biomasy. Wszystkie badane wyciągi glebowe i ich stężenia znacznie wpływały na dynamikę wzrostu *R. solani*. Najsilniejsze oddziaływanie inhibitujące wzrost liniowy strzępek grzybni *R. solani* obserwowano w obecności wodnego wyciągu z gleby nawożonej NPK + Potafoska. Natomiast na udział w podłożu hodowlanym 50 mm^3/cm^3 wyciągu z gleby nawożonej NPK oraz 25 mm^3/cm^3 NPK z siarczanem amonu testowany gatunek grzyba reagował silnym zahamowaniem przyrostu biomasy odpowiednio o 55.71 i 57.07 %. Przeprowadzone badania *in vitro* mogą wskazywać, iż wprowadzanie do gleby nawozów mineralnych NPK oraz innych takich jak siarczan amonu czy Potafoska mogą ograniczać populację grzyba chorobotwórczego *R. solani*. Jednakże w agrocenozach należy uwzględnić wzajemny skomplikowany układ zależności pomiędzy poszczególnymi elementami środowiska.

Słowa kluczowe: *Rhizoctonia solani*, nawożenie mineralne, wyciągi glebowe, wzrost liniowy, biomasa