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Fungal communities of the rhizosphere and the rhizoplane of yellow lupine in a crop rotation system

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Fungal community populating the rhizosphere and the rhizoplane of yellow lupine Juno and Markiz cultivated in the crop rotation with the 20% and 33% portion of lupine was analyzed.

The total fungus number was reduced when the participation of lupine in the crop rotation was established at level 20%. Then the pathogenic fungi were replaced by more frequently appeared saprofitic species representing the following genera: *Trichoderma, Paecilomyces* and *Penicillium.* Pathogenic *Fusarium* were more frequently isolated from the lupine rhizoplane cultivated in combination with its 33% participation.

Key words: fungi, rhizosphere, rhizoplane, *Lupinus luteus*, crop rotation.

INTRODUCTION

Leguminous plants, including lupine are a very good forecrop and help in the better utilization of light soils. However, their excessive concentration in crop rotation systems promotes greater concentrations of pathogenic factors in soil. Łacicowa and Pięta (1996) while studying fungi populating soil under beans and peas cultivated in three years monoculture system isolated the following species: *Botrytis cinerea, Fusarium culmorum, F. oxysporum, F. solani, Sclerotinia sclerotiorum, Rhizoctonia solani.* The fungal community structure populating the near-root parts and roots themselves determines the plant wholesomeness (Mańka 1990). It is particularly affected by the saprotrophs representing the following genera: *Trichoderma, Gliocladium, Penicillium.* Their high concentration reduces the development of pathogens. Other authors (Lewis and Papavizas 1987; Łacicowa 1988) treat these fungi as a natural protection against pathogenic infections of roots.

The aim of the experiment was to determine the size and qualitative composition of the fungal population colonizing the rhizosphere and the

rhizoplane of the yellow lupine cultivated in two crop rotations systems with different concentrations of lupine.

MATERIAL AND METHODS

The experiment was carried out in 1998–2000 in Kocibórz near Olsztyn, on a very light soil. The experiment was established in random block system in 4 replications. The crops were planted on the same plots according to accepted crop rotation. The experimental material were two cultivars of yellow lupine: Juno and Markiz cultivated in the following crop rotations: A (20% of yellow lupine participation) – potato, spring cereal, yellow lupine, winter cereal, winter cereal and B (33% of yellow lupine participation) – yellow lupine, winter cereal, spring cereal. Before blooming, the plant samples representing particular combinations were taken for laboratory analysis. Fungi were isolated from rhizosphere and the rhizoplane according to the method described by S t r z e l c z y k (1968) and subsequently identified using the keys by B o o t h (1971) and E l l i s (1971).

RESULTS AND DISCUSSION

Throughout the three-year experiment a total of 11 339 fungal colonies were obtained from the rhizosphere and the rhizoplane of the yellow lupine. These fungi were represented by 55 species and besides 10608 isolates represented yeast-like fungi and 16 isolates represented non-sporous strains (Tables 1 and 2). The widest range of the species (37) was observed in the first year of the experiment. In the same period, the largest number of isolates was obtained. They constituted as much as 45.8% of the total colonies (Table 3).

The crop rotation system applied modified fungi quantitative structure on the roots. 3.4% isolates more were obtained from the yellow lupine cultivated in the crop rotation B with its 33% concentration in comparison with the combination when the lupine was cultivated in the crop rotation with its 20% concentration. An in-depth analysis showed that this difference occurred solely in the rhizosphere, whereas in the rhizoplane the fungi populations in the analyzed crop rotations remained similar.

A qualitative evaluation showed that the fungal community was specific because the yellow lupine environment, mainly the rhizosphere, was widely colonized by yeast-like fungi. They constituted as much as 93.5% of all colonies.

This fact has been reported by M a ń k a (1993). According to this author the rhizosphere of plants, including trees, is most widely colonized by fungi. In the present experiment, the pathogens were represented by few species of *Fusarium* and sporadically by *Aureobasidium pullulans, Phoma exiqua, Pythium debaryanum* and *Rhizoctonia solani* (Fig. 1a). Among saprotrophic fungi

Table 1

Fungi colonizing the rhizosphere of yellow lupine during investigation period

Species	1998				Σ	1999				Σ	2000				Σ
	A		B			A		B			A		B		
	Juno	Markiz	Juno	Markiz		Juno	Markiz	Juno	Markiz		Juno	Markiz	Juno	Markiz	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Acremonium strictum W. Gams	5	1	4	2	12	6	3	9	7	25				4	4
Alternaria alternata (Fr.) Keissler												1			1
Apiospora mordagrei Sacc.								4		4					
Arthrinium sphaeospermum Fuckel							1		6	7					
Aureobasidium pullulans (de Bary) Arnaud	1	2		1	4								3		3
Cladosporium cladosporioides (Fres.) de Vries											1	5	3	2	11
Cladosporium herbarum Link: Fries													2	2	
Cladosporium macrocarpum Preuss											1				1
Endothia spp.			1		1										
Fusarium avenaceum (Fr.) Sacc.	1	4			5								2		2
Fusarium culmorum (W.G.Sm.) Sacc.			3		3										
Fusarium equiseti (Corda) Sacc.			1	3	4										
Fusarium fusarioides (Frag.ex Cif.) Booth	1			1	2										
Fusarium nivale (Fr.) Ces.	1				1								6		6
Fusarium oxysporum Schlecht.	4	3	7	1	15				3	3	5				5
Fusarium solani (Mart.) Sacc.	3				3										
Gilmaniella humicola Barron	1		1		2										
Gliocladium catenulatum Gilman and Abbott												5			5
Gliocladium fimbriatum Gilman et Abbott								9		9					
Gliocladium penicillioides Corda														1	1
Gliomastix murorum (Corda) Gueguen		2	3		5										
Helminthosporium sativum Pammel				2	2										
Humicola grisea Traaen												5			5
Monodictys laevis (Wiltshire) Hughes			1		1										

Tabl. 1 cont.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Mortierella alpina Peyronel		1	1		2		5		3	8	10	7	5	4	26
Mortierella isabelina Oudemans						8				8					
Mucor hiemalis Wehmer			2		2		4	1	2	7					
Paecilomyces varioti Bainier	3				3										
Paecilomyces roseum (Thom) Samson	2	3	1	4	10	10		4		14	1	3	1	1	6
Penicillium spp.	1	26	10	10	47	10	11	2	23	15	7	7	14	43	
Phoma exiqua Desm			4		4										
Phoma medicaginis Malbr. et Roum.			1	1	2										
Pythium debaryanum Hesse			3		3										
Rhizoctonia solani Kuhn	1				1										
Rhizopus nigricans Ehrenberg													1		1
Spicaria elegans Corda	10		3	3	16										
Spicaria griseola Sacc.			2		2										
Spicaria simplicissima Oudemans	7				7									1	1
Sporotrichum carmi Brooks et Hansford				1	1										
Sporotrichum olivaceum Fries			2		2		2	4	1	7	6		3		9
Thielaviopsis basicola (Berk. et Br.) Ferraris		4	7	1	12									1	1
Trichoderma aureoviride Rifai			1		1										
Trichoderma hamatum (Bon.) Bain							2			2					
Trichoderma polysporum (Link: Pers.) Rifai									4	4					
Yeast-like fungi	1502	1434	1393	566	4895	450	755	1626	780	3611	543	423	507	622	2095
Non sporulating fungi							3			3	7	3	1		11
Total	1543	1480	1451	596	5070	474	785	1668	808	3735	589	459	539	652	2239

Explanations: A – crop rotation (20% of yellow lupine), B – crop rotation (33% of yellow lupine)

Table 2

Fungi colonizing the rhizoplane of yellow lupine during investigation period

Species	1998				Σ	1999				Σ	2000				Σ
	A		B			A		B			A		B		
	Juno	Markiz	Juno	Markiz		Juno	Markiz	Juno	Markiz		Juno	Markiz	Juno	Markiz	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Acremonium strictum W. Gams	4		1		5										
Aspergillus sp.			1		1										
Cladosporium cladosporioides (Fres.) de Vries													1		1
Fusarium avenaceum (Fr.) Sacc.	1		2		3										
Fusarium concolor Reinking													1	1	2
Fusarium culmorum (W.G.Sm.) Sacc.	4	7	1		12	1	1		2	4	4		5		9
Fusarium equiseti (Corda) Sacc.	3	1		5	9							2		5	7
Fusarium fusarioides (Frag. ex Cif.) Booth				3	3										
Fusarium oxysporum Schlecht	2	4	11	9	26	12	12	9	13	46	6	2	4		12
Fusarium poae (Peck) Wollenweber														4	4
Fusarium solani (Mart.) Sacc.				1	1										
Fusarium sporotrichioides Sherb.		2	1	2	5										
Gliocladium fimbriatum Gilman and Abbott	3				3							1			1
Monodictys laevis (Wiltsh.) Hughes				3	3										
Mortierella alpina Peyronel	2		1		3		3	2	2	7		4		5	9
Mortierella isabelina Oudemans	2	3	1		6		4	2		6		2		2	4
Mucor circinelloides van Tieghem		1	1	1	3						1		2		3
Mucor hiemalis Wehmer	4	1	2	2	9		1	4	4	9	3		2		5
Penicillium spp.	4	1	1		6										
Phoma exiqua Desm				3	3										

Tabl. 2 cont.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Pythium debaryanum Hesse sensu Middleton				1	1						3	4		3	10
Rhizoctonia solani Kuhn		1		3	4	1	1	3		5					
Rhizopus nigricans Ehrenberg											1				1
Sporotrichum olivaceum Fries	1				1				2	2	1		1		2
Trichoderma aureoviride Rifai															
Trichoderma hamatum (Bon.) Bain	1	2	2		5	2				2			1	1	2
Trichoderma harzianum Rifai		3	1	2	6										
Trichoderma koningii Oudemans	1	2			3										
Trichoderma polysporum (Link: Pers.) Rifai															
Zygorhynchus spp.	4	2			6						2		4		6
Yeast-like fungi			1		1	3				3	1		2		3
Non sporulating fungi	1				1							1			1
Total	37	30	27	35	129	19	22	20	23	84	22	16	23	21	82

Explanations: A – crop rotation (20% of yellow lupine), B – crop rotation (33% of yellow lupine)

Table 3
Percentage of fungi

Years of investigation	Number of isolates	% of isolates
1998	5199	45,9
1999	3819	33,7
2000	2321	20,4
Crop rotation		
A (20% of yellow lupine)	5476	48,3
B (33% of yellow lupine)	5863	51,7
Cultivar		
Juno	6413	56,6
Markiz	4926	43,4
Isolates – total	11339	100

exhibiting antagonistic activity against pathogens many species of *Gliocladium*, *Paecilomyces*, *Penicillium*, *Mortierella* and *Trichoderma* were isolated.

A large concentration of *Fusarium* spp. (47.2% of total isolates) was found in the rhizoplane. The following 9 species were identified: *Fusarium avenaceum*, *F. concolor*, *F. culmorum*, *F. equiseti*, *F. fusarioides*, *F. oxysporum*, *F. poae*, *F. solani*, *F. sporotrichioides*. Among these species *F. oxysporum* was most widely represented. These fungi more frequently colonized soil under the lupine cultivated in crop rotation with its 33% concentration in crop rotation (53.0% of all colonies) in comparison with crop rotation with 20% concentration of lupine (41.3% of all colonies). The domination of these fungi in environment of papilionaceous plant cultivation was also reported by Dorenda (1986). Łacicowa and Pięta (1996) in three years monoculture of pea obtained many fungal colonies represented by *Fusarium* spp. and the following species: *Ascochyta pisi*, *Botrytis cinerea* and *Rhizoctonia solani*. In the present experiment, saprotrophic antagonist fungi were isolated less frequently. They constituted 23.2% and 15.5% of total isolates in the crop rotation A and B, respectively (Fig. 1b.). They were represented by species of *Trichoderma* (*T. aureoviride*, *T. hamatum*, *T. harzianum*, *T. koningii*, *T. polysporum*) and *Penicillium* as well as *Gliocladium fimbriatum*, *Mortierella alpina* and *M. isabelina*. Other authors (Dorenda 1986; Łacicowa 1988; Rodriquez and Cotes 1999) also wrote about the advantageous influence of the above fungi on plant wholesomeness owing to their inhibitory effect on the development of dangerous pathogens.

In addition, the grown cultivar was a factor determining the fungal structure, particularly the quantitative relations in the yellow lupine cultivation environment. The plants of cultivar Juno was more widely colonized with fungi

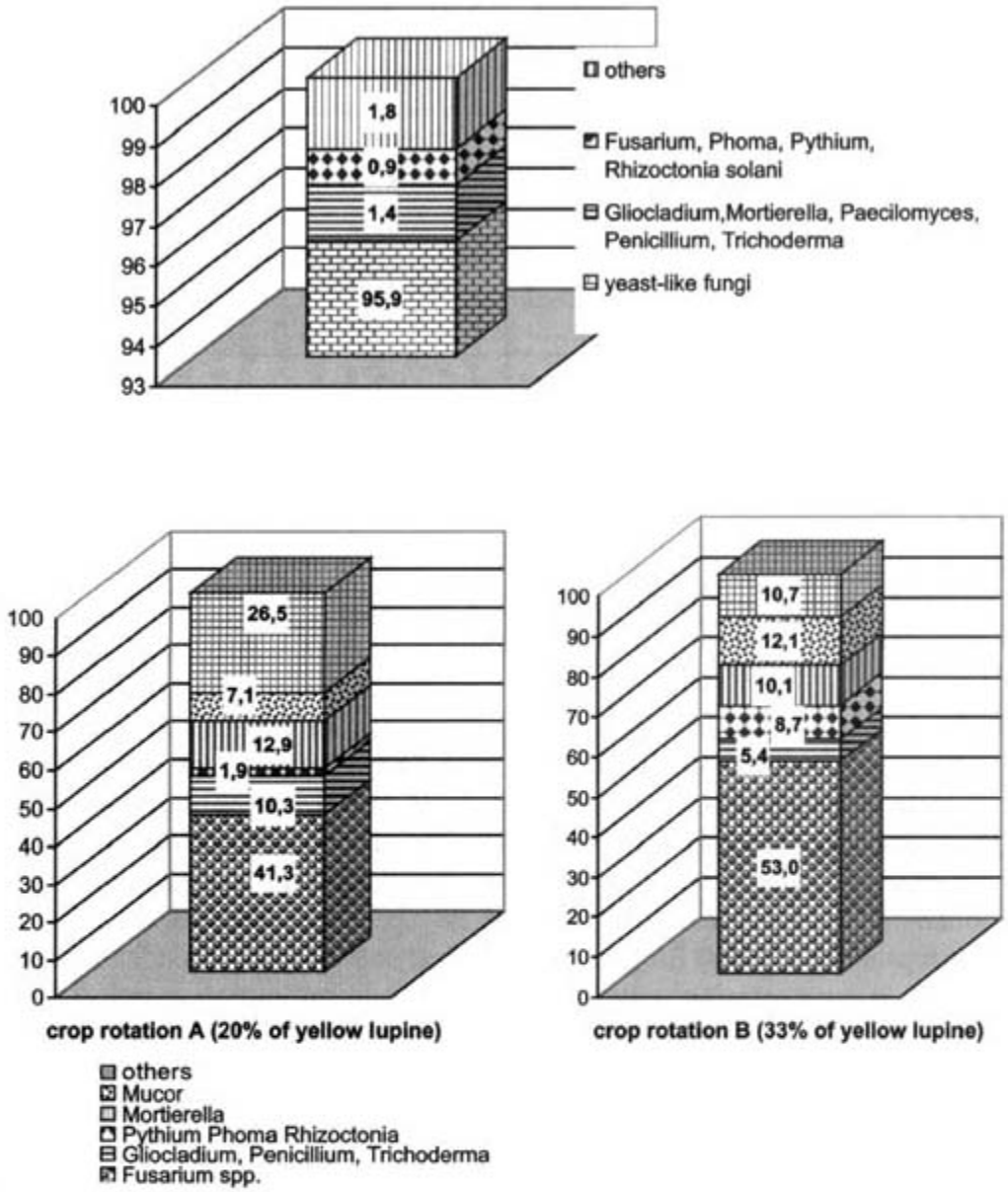

Fig. 1. Percentage of fungi isolated from yellow lupinus: a – rhizosphere, b – rhizoplane

in comparison with the plants of cultivar Markiz. The difference in colonization of both cultivars achieved 13.2%. The fungal community qualitative structure of both the rhizosphere and the rhizoplane in the analysed cultivars was similar, however, the saprotrophic fungi representing *Mortierella, Trichoderma* and *Penicillium* were more frequently isolated from cv. Markiz. Population size of saprotrophic and pathogens colonizing both cultivars were similar.

CONCLUSIONS

1. The cultivation of lupine in the crop rotation with 20% lupine concentration reduced the total fungal population. The saprotrophic fungi from the

genera *Trichoderma, Penicillium, Paecilomyces* were more frequently isolated in this combination in comparison with combination with 33% lupine concentration.

2. The yellow lupine rhizosphere was dominated by yeast-like fungi. Pathogenic fungi from *Fusarium* were more frequently isolated from the lupine rhizoplane in the crop rotation with 33% lupine concentration.
3. A large number of isolates was obtained in the cultivation of yellow lupine cultivar Juno.

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Zbiorowiska grzybów ryzosfery i ryzoplany łubinu żółtego w aspekcie płodozmianowym

Streszczenie

Badania nad składem zbiorowiska grzybów ryzosfery i ryzoplany łubinu żółtego przeprowadzono na obiekcie doświadczalnym w Kociborzu k. Olsztyna. Obejmowało ono dwie odmiany Juno i Markiz uprawiane w dwóch płodozmianach z 20% i 33% udziałem łubinu żółtego.

Uzyskano dużą liczebność izolatów (11339 kolonii grzybów) oraz różnorodność gatunkową (55). Wśród patogenów dominowały gatunki z rodzaju *Fusarium*, mniej liczne były z rodzaju *Phoma* oraz *Aureobasidium pullulans*. Częściej zasiedlały one środowisko glebowe łubinu w kombinacji z jego 33% udziałem. Grzyby saprotroficzne reprezentowane były przez grzyby z rodzaju *Trichoderma, Paecilomyces, Penicillium*. Większy ich udział zaznaczył się w uprawie łubinu z jego 20% koncentracją w płodozmianie. Spod uprawy łubinu żółtego odmiany Juno otrzymano o 13,2% więcej izolatów w porównaniu z odmianą Markiz.