BIODIVERSITY OF FUNGI COLONIZING SCORZONERA (*Scorzonera hispanica* L.) CULTIVATED WITH THE USE OF BIOSTIMULANTS

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The necessity of environmental protection and reduction of crop production costs requires modern sustainable agriculture to provide proper methods of plant protection. In modern agriculture, it is possible to use biostimulants that protect the soil against degradation and plants against phytopathogens and stress. Biostimulants increasing the tolerance of plants to abiotic and biotic stress also include microorganisms that induce plant resistance to pathogens and modify the composition of soil microorganisms and microorganisms colonizing under-ground plant organs. Biostimulants are friendly to the soil environment and can effectively improve the plant growth and yielding.

The aim of field and laboratory studies was to establish the effect of biostimulants on the growth and on the health status of *Scorzonera hispanica* L. plants.

MATERIAL AND METHODS

The field experiment was carried out in south-eastern Poland on Haplic Luvisol. The biostimulants Asahi SL (active components: nitroguaiacolate and nitrophenolates), Beta-Chikol (a.s. – chitosan) and Bio-Algeen S90 (extract from seaweed *Ascophyllum nodosum*) were applied for the pre-sowing seed dressing of scorzonera cv. ´´Duplex´´. For comparison, the fungicide Zaprawa Nasienna T 75 DS/WS (a.s. – tiuram 75%) was used. Untreated seeds served as control. Moreover, the biodiversity of soil-borne fungi colonizing the roots of this vegetable was determined. The number of seedlings and the health status of scorzonera plants were determined during three growing seasons. In each year of the study, both scorzonera seedlings with necrosis symptoms on the roots and the infected roots obtained after scorzonera harvest were subjected to laboratory mycological analysis.

RESULTS

The experiments showed that, the emergence and health status of scorzonera seedlings after the application of biostimulants, especially after Beta-Chikol, were significantly better than in the control. The indicator of the protective effect of the applied biostimulants against plant infection by soil-borne pathogens was the value of the disease index of scorzonera seedlings. Biostimulants and a fungicide significantly reduced the occurrence of diseased scorzonera plants. The health status of scorzonera plants was differentiated and it depended on the type of biostimulant. The highest number of infected seedlings was found in control, and the lowest after the application of Beta-Chikol and Zaprawa Nasienna T 75 DS/WS. The mean proportion of diseased seedlings after Asahi SL and Bio-Algeen S90 application was slightly higher, but differed significantly from control. Asahi SL and Beta-Chikol were more effective than Bio-Algeen S90 in limiting the occurrence of fungi pathogenic towards scorzonera plants. Diseased scorzonera roots were most frequently colonized by *Alternaria scorzonerae, Alternaria alternata, Rhizoctonia solani, Sclerotinia sclerotiorum* and *Fusarium* spp., especially by *Fusarium oxysporum.*

Plant density and health status of scorzonera seedlings

Experimental treatment	Field stand per 1m²				Diseased seedlings (%)			
	2014	2015	2016	mean	2014	2015	2016	mean
Asahi SL	54.0 a	50.0 a	59.0 a	54.3 a	5.5 b	5.0 b	8.0 b	6.2 b
Beta-Chikol	58.0 a	52.0 a	60.0 a	56.6 a	3.0 c	2.0 c	4.5 c	3.2 c
Bio-Algeen S90	47.0 b	46.0 b	51.0 b	48.0 b	6.5 b	6.5 b	8.5 b	7.2 b
Zaprawa Nasienna T 75 DS/WS	45.0 b	44.0 b	48.0 b	45.6 b	3.5 c	2.5 c	5.0 c	3.6 c
Control	35.0 c	29.0 c	38.0 c	34.0 c	10.0 a	9.5 a	12.5 a	10.6 a

Values of the disease index of scorzonera seedlings

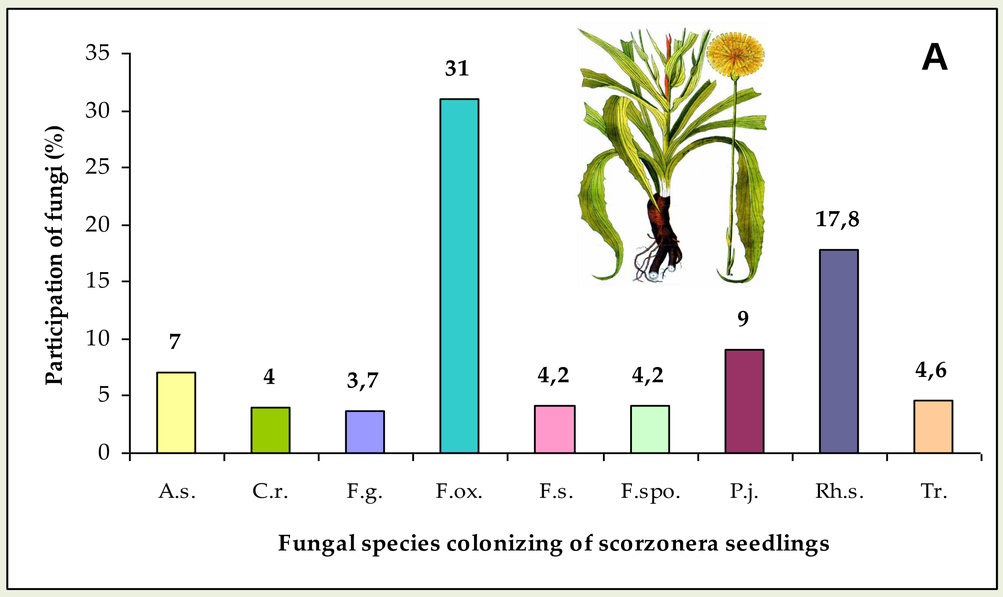
Experimental treatment	Disease index			
	2014	2015	2016	mean
Asahi SL	12.2 b	15.0 b	17.2 b	14.8 b
Beta-Chikol	8.4 c	10.2 c	12.6 c	10.4 c
Bio-Algeen S90	14.3 b	17.6 b	19.4 b	17.1 b
Zaprawa Nasienna T 75 DS/WS	9.0 c	11.4 c	13.3 c	11.2 c
Control	19.6 a	24.6 a	25.0 a	23.1 a

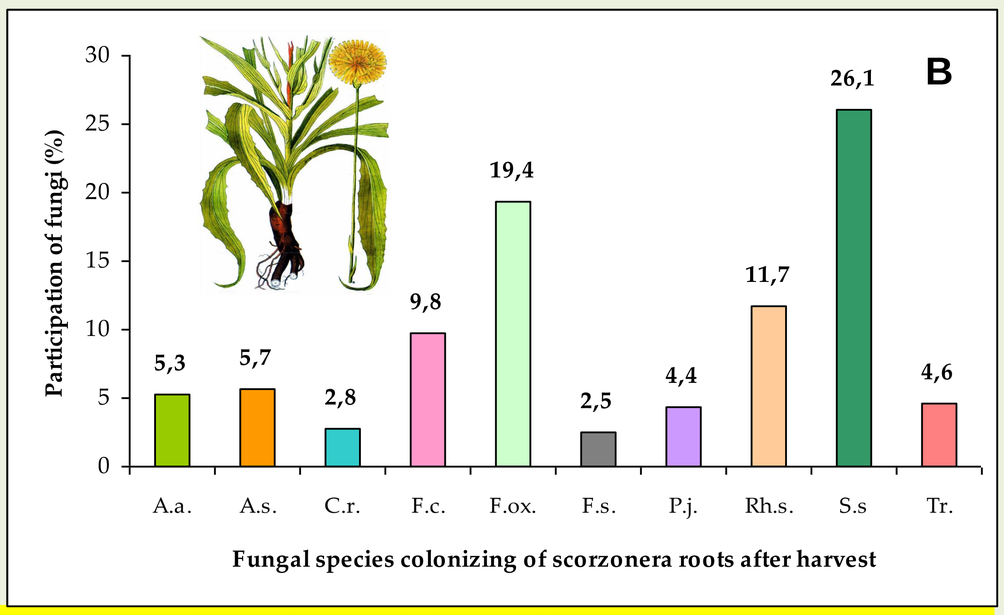
Fungi isolated from infected roots of carrot after harvest

Fungus species	Experimental treatment / Number of isolates																				Total
	Asahi SL				Beta-Chikol				Bio-Algeen S90				Zaprawa Nasienna T 75 DS/WS				Control				
	2014	2015	2016	total	2014	2015	2016	total	2014	2015	2016	total	2014	2015	2016	total	2014	2015	2016	total	
Albifimbria verrucaria (Alb. & Schwein.) L. Lombard & Crous	3	3	2	8	4	3	3	10	1	1	-	2	1	1	-	2	-	-	-	-	22
Alternaria scorzonerae (Aderh.) Loer.	1	2	1	4	-	1	2	3	2	5	4	11	-	2	3	5	5	9	10	24	47
Cladosporium cladosporioides (Fres) de Vries	1	-	-	1	-	-	-	-	1	1	-	2	-	1	-	1	4	6	3	13	17
Clonostachys rosea (Link) Schroers, Samuels, Seifert	2	2	1	5	3	2	4	9	3	2	2	7	2	1	3	6	-	-	-	-	27
Fusarium culmorum (Wm.G. Sm.) Sacc.	-	-	1	1	-	-	-	-	-	1	1	2	-	-	-	-	4	6	5	15	18
Fusarium graminearum Schwabe	1	-	-	1	-	-	-	-	1	1	1	3	-	1	1	2	5	8	6	19	25
Fusarium oxysporum Schl.	11	9	10	30	10	8	6	24	15	13	14	42	12	10	11	33	24	27	29	80	209
Fusarium solani (Mart.) Sacc.	-	-	-	-	-	-	-	-	2	1	1	4	-	-	-	-	9	8	7	24	28
Fusarium sporotrichioides Sherb.	-	1	1	2	-	-	1	1	4	1	-	5	2	1	-	3	8	5	4	17	28
Penicillium janczewskii K.W. Zaleski	3	2	3	8	2	1	2	5	6	5	4	15	4	3	2	9	9	8	7	24	61
Rhizoctonia solani J.G. Kühn	5	6	5	16	4	5	5	14	8	10	7	25	6	7	5	18	15	18	14	47	120
Trichoderma sp.	5	5	5	15	7	5	7	19	2	11	7	20	5	7	6	18	-	-	-	-	31
Total	32	30	29	91	30	25	30	85	45	52	41	138	32	34	31	97	83	95	85	263	674

Fungi isolated from diseased scorzonera roots after harvest

Fungus species	Experimental treatment / Number of isolates																				Total
	Asahi SL				Beta-Chikol				Bio-Algeen S90				Zaprawa Nasienna T 75 DS/WS				Control				
	2014	2015	2016	total	2014	2015	2016	total	2014	2015	2016	total	2014	2015	2016	total	2014	2015	2016	total	
Acremonium rutilum W. Gams	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	2	3	2	7	8
Alternaria alternata (Fr.) Keissler	-	3	2	5	2	-	1	3	6	4	-	10	4	2	-	6	11	7	3	21	45
Alternaria scorzonerae (Aderh.) Loer.	2	2	2	6	3	1	1	5	5	6	-	11	3	4	-	7	8	9	2	19	48
Botrytis cinerea Pers.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	4	9	9
Cladosporium herbarum (Pers.) Link	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	4	5	3	12	13
Cylindrocarpon didymum (Harting) Wollenw.	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	4	3	2	9	10
Clonostachys rosea (Link) Schroers, Samuels, Seifert	3	2	2	7	4	2	3	9	3	-	-	3	3	2	-	5	-	-	-	-	24
Fusarium culmorum (W.G.Sm.) Sacc.	5	3	3	11	4	2	2	8	9	6	4	19	6	4	3	13	13	11	8	32	83
Fusarium oxysporum Schl.	10	7	7	24	9	6	5	20	14	12	10	36	11	10	8	29	19	18	18	55	164
Fusarium solani (Mart.) Sacc.	-	-	-	-	-	-	-	-	-	1	1	2	-	-	-	-	6	7	6	19	21
Mucor hiemalis Wehmer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	2	2
Penicillium janczewskii K.W. Zaleski	2	-	1	3	1	1	-	2	5	2	1	8	2	1	-	3	10	6	5	21	37
Penicillium chrysogenum Thom	-	-	-	-	-	-	-	-	2	-	-	2	-	-	-	-	5	3	-	8	10
Rhizoctonia solani J.G. Kühn	6	5	3	14	6	5	2	13	9	7	6	22	6	4	4	14	12	14	10	36	99
Rhizopus stolonifer (Ehrenb.) Vuill.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3	-	7	7
Sarocladium kiliense (Grütz) Summerb.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	1	5	5
Sclerotinia sclerotiorum (Lib.) de Bary	13	8	8	29	11	7	6	24	19	14	12	45	15	11	10	36	32	28	26	86	220
Trichoderma sp.	3	3	2	8	4	5	3	12	5	4	2	11	4	3	1	8	-	-	-	-	39
Total	44	33	30	107	44	29	23	96	78	57	37	172	54	41	26	121	135	123	90	348	844

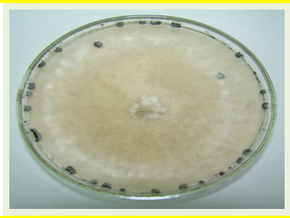




Fungi most frequently isolated from scorzonera plants

(A) scorzonera seedlings; (B) scorzonera roots; A.a.- *Alternaria alternata*, A.s.- *Alternaria scorzonerae*, C.r.-*Clonostachys rosea*, F.c.-*Fusarium culmorum*, F.g.- *Fusarium graminearum*, F.ox.-*Fusarium oxysporum*, F.s.-*Fusarium solani*, F.spo.- *Fusarium sporotrichioides*, P.j.-*Penicillium janczewskii*, Rh.s.-*Rhizoctonia solani*, S.s.-*Sclerotinia sclerotiorum*, Tr.-*Trichoderma* sp.

The roots of *Scorzonera hispanica*



Mycelium and sclerotia of *Sclerotinia sclerotiorum*