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Biotic effects of mycoflora of leaves, glumes and seeds on *Septoria nodorum* following *Triticum aestivum* treatment with fungicides

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Using a biotic series method, interactions between *Septoria nodorum* and associated fungal communities isolated from leaves, glumes, and seeds of spring *Triticum aestivum*, cv. Kolibri treated with Bayleton 25 WP, Dithane M-45, and Funaben K were determined. Control plants were sprayed with water. Most fungi accompanying *S. nodorum* in the field inhibited the growth of this pathogen on a potato glucose agar medium. Fungi which restricted the growth of *S. nodorum* the most were *Chaetomium globosum*, *Fusarium* spp., *Helminthosporium sativum*, *Mucor hiemalis*, *Rhizophus nigricans*, *Stemphylium botryosum*, *Trichothecium roseum*, and two non-sporulating forms. *Septoria nodorum* replaced *Cladosporium* spp. and a yeast-like pink fungus. The biotic resistance to *S. nodorum* increased with the age of plant. The fungal populations recovered from plants sampled in 1982 and 1983 inhibited the growth of *S. nodorum*, whereas most of those isolated in the relatively wet and cold year 1984 favoured the development of this pathogen. The lowest biotic resistance of the fungal communities investigated to *S. nodorum* was generally found following spraying of plants with Bayleton 25 WP, and the highest in Funabed K – and water-treated plants.

Key words: biotic effects, *Septoria nodorum*

INTRODUCTION

Septoria nodorum Berk. is an important disease agent in most areas where wheat is grown (B r ö n n i m a n n, 1968; T y l d e s l e y, T h o m p s o n, 1980; W e b s t e r, 1922). This pathogen demages both leaves, glumes, and seeds (B r ö n n i m a n n, 1968; W e b e r, 1922) and sometimes causes yield losses greater than 50% (B r ö n n i m a n n, 1968; J o n e s, O d e b u n m i, 1971).

The occurrence and activity of *S. nodorum* highly depends among others on the stage of plant development, water conditions, the presence of accompanying microorganisms, and conducted chemical treatments (B a s h i, F o k k e m a, 1977; D i c k i n s o n, W a l l a c e, 1976; J e n k y n, P r e w, 1973).

Fungicides affect a particular pathogen both directly by decreasing its activity or killing and indirectly due to alternations of its interactions with co-occurring microorganisms (D e C a l, M e l g a r e j o, 1992).

The aim of this study was to determine the biotic effects of the mycoflora of leaves, glumes and seeds on *S. nodorum* following plant treatment with fungicides.

MATERIALS AND METHODS

The conditions of the field experiment with spring wheat (*Triticum aestivum* L.), cv. Kolibri, the methods of collections of the plant parts used in the present study, as well as the procedures of isolation and identification of the fungi species associated are as those described by B ł a s z k o w s k i (1994 a, b, 1995).

Biotic effects of a representative number of fungi associated with particular plant parts were determined based on the biotic series method definied by M a ń k a (1974). Before the overall biotic effect was calculated, on individual biotic effect and a general biotic effect of a particular fungus on *S. nodorum* had been assessed. An individual biotic effect of the fungi tested was determined by placement of 0.5 cm-diam fragments of their mycelia 2 cm apart on a potato glucose agar medium (PGA) (M a ń k a, 1953) in 10 cm-diam Petri dishes. Additionally, each fungus was grown alone on the same medium. Plates were replicated four times. The fungi were subsequently incubated at 22 ± 2°C for 10 days. The features assessed were the degree of a surroundings of the *S. nodorum* colony by a saprophytic fungus, the width of an inhibition zone, and the degree of reduction of the *S. nodorum* colony. The general biotic effect of a given fungus associated with *S. nodorum* was calculated by multiplying the number of its individual biotic effect by the number of its occurrences in the mycoflora of the plant part examined. The overall biotic effect of the mycoflora accompanying *S. nodorum* is the sum of the general biotic effect of the fungi considered.

RESULTS

General characteristics.

The biotic effects of the mycoflora associated with leaves, glumes and seeds on *S. nodorum* were determined based on 20 most frequently recovered fungal species (B ł a s z k o w s k i, 1994 a, b, 1995). These fungi represented ca. 75 % of all species and forms isolated from the plant part considered. These included *Alternaria alternata* (Fr.) Keissler, *Aureobasidium pullulans* (de Barry) Arn., *Botrytis cinerea* Pers. ex Fr., *Chaetomium globosum* Kunze ex Fr., *Cladosporium cladosporioides* (Fres.) de Vries, *Cladosporium herbarum* Link ex Fr., *Epicoccum purpurascens* Link, *Fusarium avenaceum* (Corda ex Fr.) Sacc., *Fusarium culmorum* (W. G. Smith) Sacc., *Fusarium graminearum* Schwabe, *Fusarium poae* (Peck) Wollenw., *Fusarium semitectum* Berk. et Rav., *Fusarium sporotrichoides* Sherb., *Helminthosporium sativum* P. K. B., *Mucor hiemalis* Wehmer, *Rhizopus nigricans* Ehrenb., *Stemphylium botryosum* Wallr., *Trichothecium roseum* Link, a yeast-like pink fungus and non-sporulating fungal forms S-1 and Ż-1. The influence of the mycoflora of glumes on *S. nodorum* was examined only in 1983 and 1984.

Most fungi associated with leaves, glumes and seeds higly inhibited the growth of *S. nodorum* (Figs. 1, 3, 5-15, 17, 18). The fungi highest restricting the development of *S. nodorum* (with values of an individual biotic effect at +5 and above) were *Ch. globosum*, all species of the genera *Fusarium, H. sativum, M. hiemalis, R. nigricans, S. botryosum, T. roseum*, and non-sporulating forms S-1 and Ż-1. The fungi being replaced by *S. nodorum* on PGA were *Cladosporium* spp. and a yeast-like pink fungus (-3 to -8) (Figs. 4, 16).

Biotic effects of foliar mycoflora an to *Septoria nodorum*.

In 1982 and 1983, at 10.5.1 and 11.2-3, foliar fungal communities isolated from all the fungicide combinations compared and the control inhibited the development of *S. nodorum* (Tab. 1). Generally, the highest values of summary biotic effects were found at 11.2-3, and lowest at 10.5.1. The fungal communities suppressing *S. nodorum* the most were those recovered from leaves of plants sprayed with water and Funaben K.

In 1984, at 10.5.1 and 10.5.4., foliar fungal populations of plants treated with Bayleton 25 WP, Dithane M-45, and water favoured the growth of *S. nodorum*. At 11.2-3, negative values of overall biotic effects also represented fungal communities obtained from leaves of plants sprayed with Bayleton 25 WP (-129) and Funaben K (-15).

Biotic effects of mycoflora of glumes on *Septoria nodorum*.

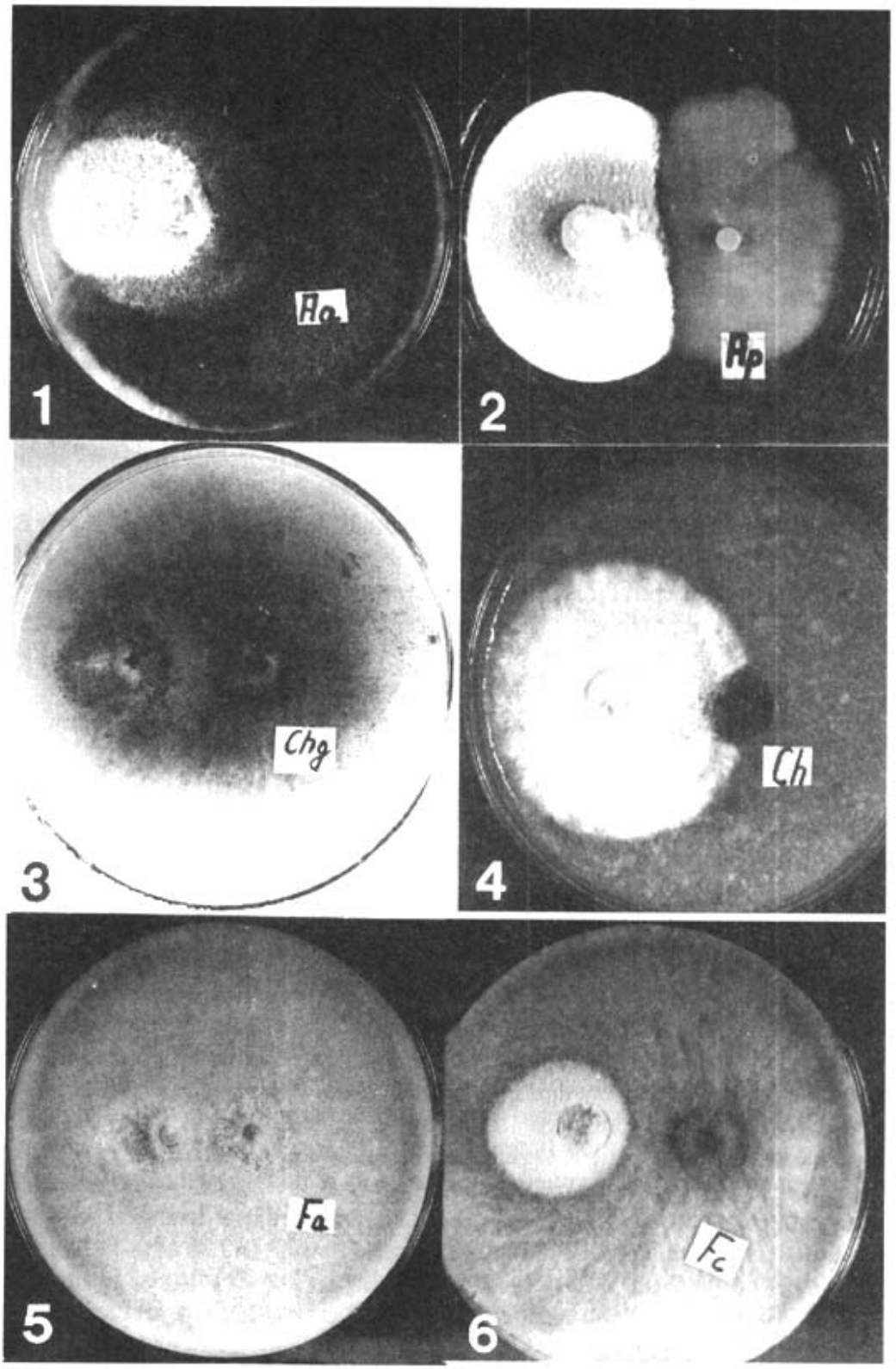
The biotic effects of mycoflora of glumes on *S. nodorum* were investigated only in 1983 and 1984.

In 1983, at 10.5.1-11.2-3, all the fungal communities representing the mycoflora of glumes from control plants and those treated with fungicides inhibited the development of *S. nodorum* (Tab. 1). The overall biotic effects increased with the age of plants. The highest resistance to *S. nodorum* was characteristic of the fungal communities from plants sprayed with Funaben K and collected at 11.2-3.

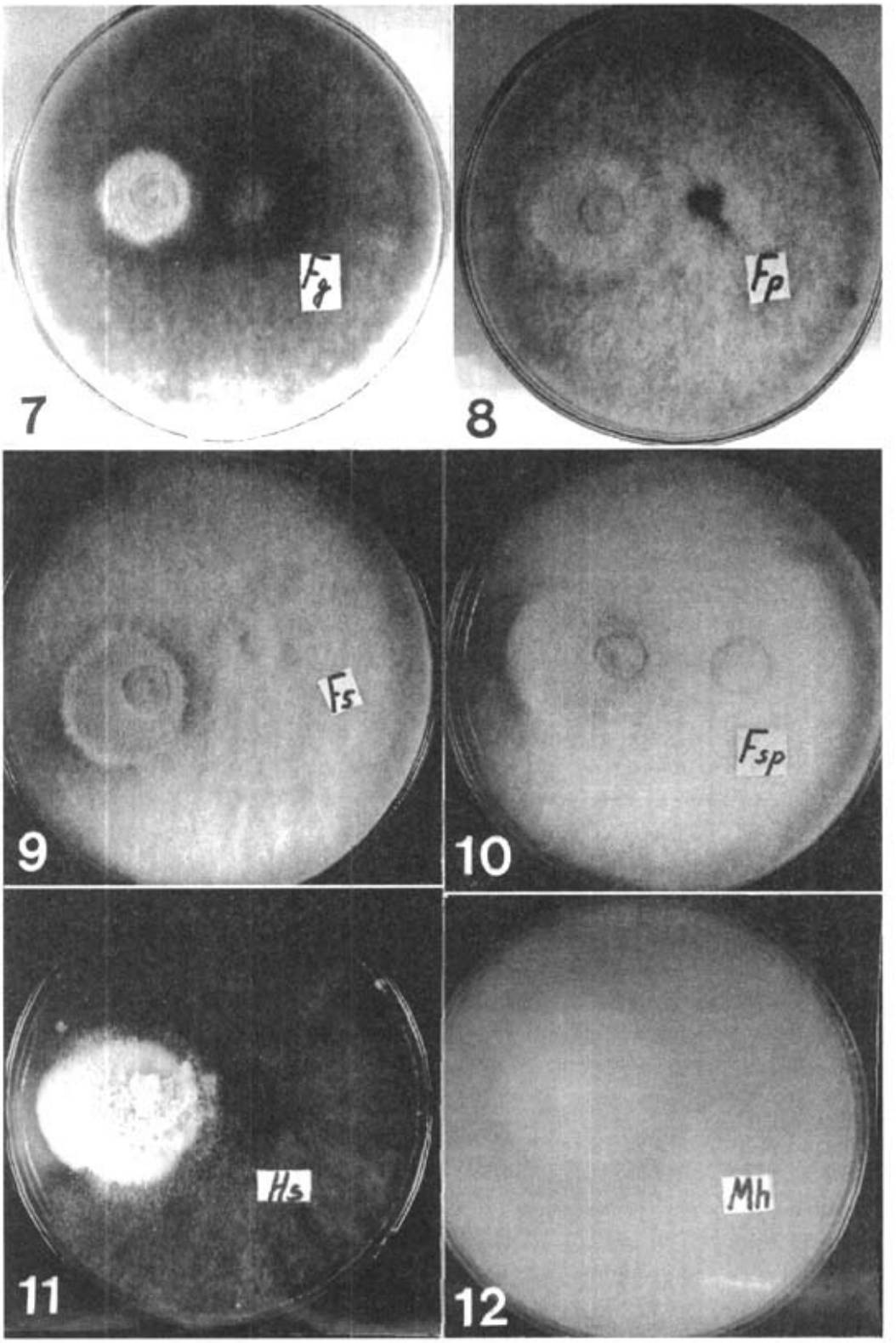
In 1984, at 10.5.1, the glumes collected from both control plots and those treated with fungicides harboured fungal communities favouring the development of *S. nodorum*. The lowest negative value of the overall biotic effect is that regarding Bayleton 25 WP-treated glumes. At 10.5.4, except for glumes from plants treated with Funaben K, those of both control plants and plants sprayed with the other fungicides used were also colonized by fungal populations that favoured the growth of *S. nodorum*. At 11.2-3, the fungal community facilitating the development of *S. nodorum* was only that recovered from glumes of plants treated with Bayleton 25 WP.

Biotic effects of mycoflora of seeds on *Septoria nodorum*.

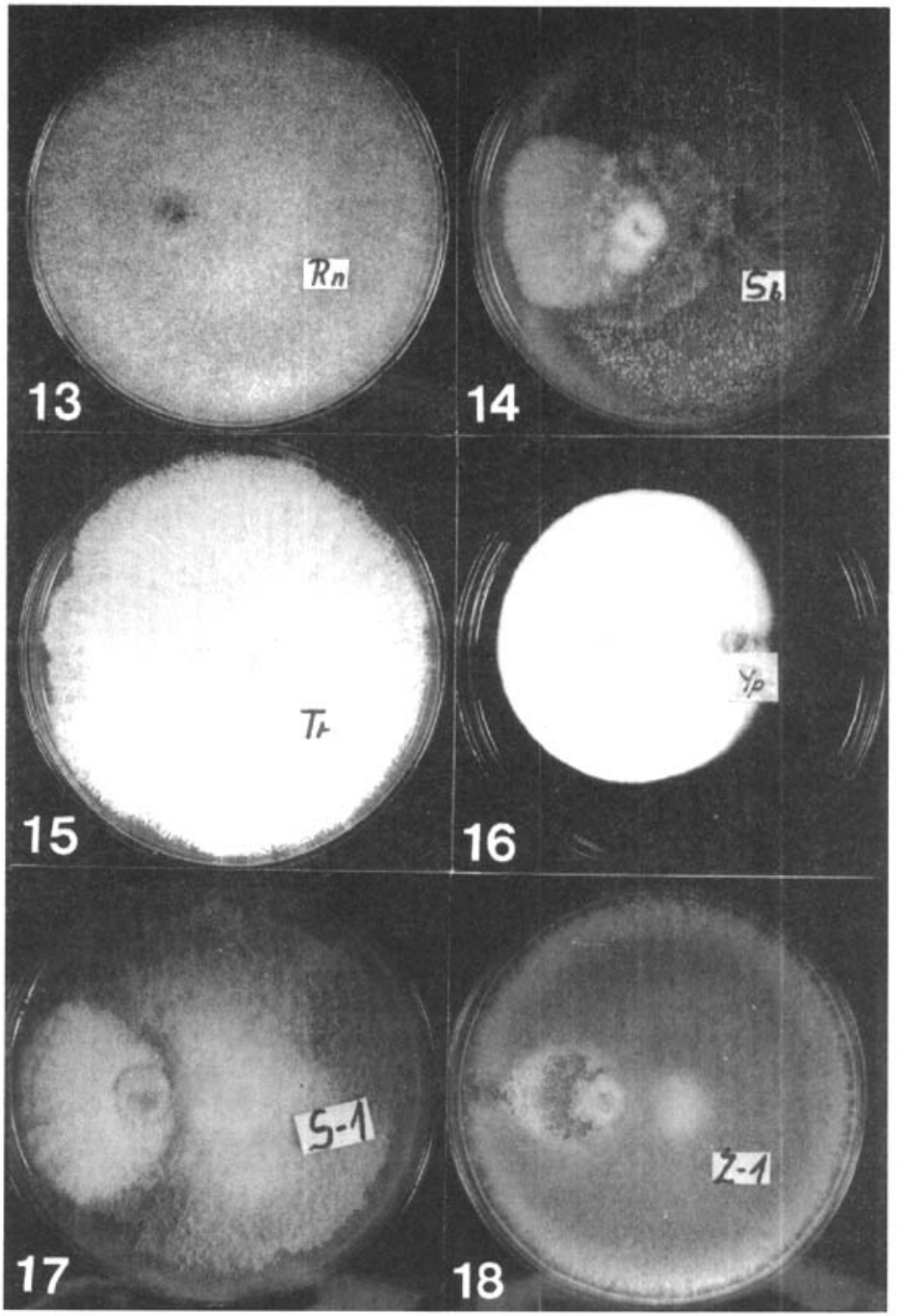
Except for values regarding the biotic effects of mycoflora of seeds isolated from plants treated with Bayleton 25 WP (-627) in 1984, the fungal communities of seeds of the other experimental combinations compared had positive values of overall biotic effects (Tab. 1), ranging from +230 (Bayleton 25 WP, 1982) to +446 (Funaben K, in 1984 and Control, in 1983).



Figs. 1-6. Biotic relations between *Septoria nodorum*
1 – *Alternaria alternata* (Aa), 2 – *Aureobasidium pullulans* (Ap), 3 – *Chaetomium globosum* (Chg), 4 – *Cladosporium herbarum* (Ch), 5 – *Fusarium avenaceum* (Fa), 6 – *F. culmorum* (Fc)



Figs. 7-12. Biotic relations between *Septoria nodorum*
7 – *Fusarium graminearum* (Fg), 8 – *F. poae* (Fp), 9 – *F. semitectum* (Fs), 10 – *F. sporotrichoides* (Fsp), 11 – *Helminthosporium sativum* (Hs), 12 – *Mucor hiemalis* (Mh)



Figs. 13-18. Biotic relations between *Septoria nodorum*
13 – *Rhizopus nigricans* (Rn), 14 – *Stemphylium botryosum* (Sb), 15 – *Trichothecium roseum* (Tr), 16 – yeast-like pink fungus (Yp), 17 – non-sporulating form S-1, 18 – non-sporulating form Ż-1

Table 1

Overall biotic effects of mycoflora of leaves, glumes and seeds on *Septoria nodorum* following *Triticum aestivum* treatment with fungicides

Fungicides	Developmental stage of plants	1982		1983			1984		
		Leaves	Seeds	Leaves	Glumes	Seeds	Leaves	Glumes	Seeds
Bayleton 25 WP	10.5.1	+3	–	+25	+70	–	-212	-189	–
	10.5.4	+93	–	+61	+71	–	-34	-43	–
	11.2-3	+178	–	+180	+236	–	-129	-136	–
	After harvest	–	+230	–	–	+283	–	–	-627
Dithane M-45	10.5.1	+16	–	+36	+65	–	-162	-119	–
	10.5.4	+202	–	+196	+234	–	-60	-1	–
	11.2-3	+208	–	+235	+272	–	+101	+89	–
	After harvest	–	+319	–	–	+394	–	–	+412
Funaben K	10.5.1	+61	–	+95	+55	–	+3	-129	–
	10.5.4	+213	–	+218	+198	–	+28	+137	–
	11.2-3	+241	–	+292	+331	–	-15	+37	–
	After harvest	–	+429	–	–	+324	–	–	+446
Control	10.5.1	+130	–	+137	+94	–	-133	-121	–
	10.5.4	+233	–	+202	+234	–	-58	-29	–
	11.2-3	+356	–	+198	+217	–	+194	+233	–
	After harvest	–	+356	–	–	+446	–	–	+396

DISCUSSION

In the present study, most of the fungi selected, which represented the mycoflora of leaves, glumes and seeds, highly inhibited the growth of *S. nodorum*. The fungi restricting the growth of *S. nodorum* on a PGA medium the most were: *Ch. globosum*, all species of the genera *Fusarium*, *H. sativum*, *M. hiemalis*, *S. botryosum*, *T. roseum*, and non-sporulating froms S-1 and Ż-1. In contrast to *S. nodorum*, the other fungi mentioned above grow rapidly on agar media (L u k e, B a r n e t t, M o r e y, 1977). Additionally, *Ch. globosum* and *T. roseum* are known to inhibit the development of co-ocurring fungi by excerting antibiotic substances to the growing medium occupied and by their direct parasitism (D o m s c h, G a m s, A n d e r s o n, 1980). The fungi being outcompeted by *S. nodorum* were *Cladosporium* spp., a yeast-like pink fungus, and microorganisms known to form slow-growing colonies on agar media (D o m s c h, G a m s, A n d e r s o n, 1980). However, *Cladosporium* species and yeast-like fungi were shown to be antagonistic to many foliar plant pathogens (J e n k y n, P r e w, 1973), including *S. nodorum* (D i c k i n s o n, S k i d m o r e, 1976; F o k k e m a, V a n D e r M e u l e n, 1976). According to W i d d e n and H s u (1987) and C a r r e i r o and K o s k e (1992), substrate type and temperature are major determinants of fungal interactions. H u t c h i n s o n (1980) found the existence of the distinction between fundamental and realized niches for fungi. In the present study, the fundamental niche of *S. nodorum* encompassed a PGA medium at a temperature of 22 ± 2°C. In the field, however, *S. nodorum* grows best at 14-16°C, i.e., at a temperature range much lower than that favouring the development of the other fungi investigated in this study (L u k e, B a r n e t t, M o r e y, 1977). Thus, the realized niche of *S. nodorum* in the field probably did not extend into the 14-16°C habitat. *Septoria nodorum* appears to avoid direct competition with many fungi by occupying a low temperature niche where it functions as an "escaper" of competition sensu P u g h (1980), just as C a r r e i r o and K o s k e (1992) suggested in respect to *Geomyces pannorus* (Link) Sigler et Carm., a forest litter microfungus. This may explain the contradictions between the results obtained in this study and those regarding fungal interactions occurring in the field.

In 1982 and 1983, the fungal communities found suppressed the development of *S. nodorum*, whereas in 1984 most of the fungi associated favoured the development of this pathogen. The rainfalls in June and July of 1984 i.e., at the time of sampling of the plant parts considered in this study, were 2.1 to 7.7 times higher than those in 1982 and 1984. June and July of 1983 were exceptionally dry. Furthermore the mean temperatures of the two months in 1984 were lower by 2.0-3.2°C than those of 1982 and 1983. These weather conditions probably reduced the occurrence (see: B ł a s z k o w s k i, 1984 a, b, c, 1995) of most of the fungi in the field which were found in this laboratory study to inhibit the development of *S. nodorum*. High rainfalls may decrease the numbers of fungal populations due to washing off from the surface of above-ground plant parts of both fungal infection propagules, nutrients and growth regulators (L a s t, W a r r e n, 1972).

The lowest overall biotic effects of fungal communities associated with leaves, glumes, and seeds on *S. nodorum* were generally obtained following plant treatment with Bayleton 25 WP. According to Błaszkowski (1994 a, b, 1995), Bayleton 25 WP-treated plants generally harboured a lower number of fungi, which in this study highly suppressed the growth of *S. nodorum* on a PGA medium. The niches vacated by these fungi were probably subsequently occuppied among others by slow--growing *Cladosporium* spp. and a yeast-like pink fungus, as the earlier results of studies conducted by the author of this paper suggest (Błaszkowski, 1994 a, b, 1995) and those of Edgington, Khew, Barron (1971).

Relatively high positive overall biotic effects of fungal communities associated with leaves, glumes and seeds on *S. nodorum* were obtained after spraying of plants with Funaben K. This may have resulted from the high inhibitory effect of this chemical on *S. nodorum* or from the high resistance of this fungicide to most of the fungi suppressing *S. nodorum* on a PGA medium, as the results of earlier investigations suggested (Błaszkowski, 1994 a, b, 1995).

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