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The occurrence of *Septoria nodorum* Berk. and associated mycoflora in seeds of wheat cultivated in the Szczecin voivodeship

JANUSZ BŁASZKOWSKI

Department of Plant Pathology, Academy of Agriculture, Słowackiego 17,
PL-71434 Szczecin, Poland

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In the years 1982-1984, the occurrence of *Septoria nodorum* and associated mycoflora in 48 and 23 samples of winter and spring cultivars of wheat were examined, respectively. The following species of fungi were most frequently recovered: *Alternaria alternata, Aureobasidium pullulans, Epicoccum purpurascens,* species of the genera *Cladosporium, Fusarium, Helminthosporium* and *Penicillium, S. nodorum,* and non-sporulating fungi. The occurrence of *S. nodorum* was higher in seeds coming from the wetter years 1982 and 1984. The level of seed infestation by *S. nodorum* was higher in winter cultivars. *Septoria nodorum* was more frequently isolated from shrunken than normally developed seeds.

INTRODUCTION

Septoria nodorum Berk., the cause of wheat glume blotch is cosidered to be important parasite of wheat all over the world (Brönnimmann, 1968; Tyldesley, Thompson, 1980; Weber, 1922). Severe attacks of *S. nodorum* can cause yield losses greater than 50 % (Brönnimann, 1968; Jones, Odebunmi, 1971; Weber, 1922). One of the sources of *S. nodorum* inoculum is a seed lot (Weber, 1922). However, the incidence of *S. nodorum* in seeds differs considerably depending on the plant resistance to this pathogen, climatic conditions in the vegetative period, site of cultivation, and conducted agrochemical practices (Nelson, Morey, Brown, 1974; Sharp, Brönnimann, McNeal, 1972; Tyldesley, Thompson, 1980). The associated mycoflora plays an important role in influencing the activity of *S. nodorum* (Dickinson, Skidmore, 1976; Skidmore, Dickinson, 1976).

The aim of this study was to determine the occurence of *S. nodorum* and associated mycoflora in seeds of wheat cultivated in the Szczecin voivodeship.

MATERIAL AND METHODS

In the years 1982-1984, a total of 71 300-400 g seed samples were obtained from the Szczecin Voivodeship Station of Seed Estimation (Tab. 2). Forty-eight and 23 samples represented winter and spring wheat cultivars, respectively. The mean proportion of shrunken seeds in each sample based on 4 subsamples consisting of 100 seeds was determined.

Forty normally developed seeds and 40 shrunken seeds were selected randomly and surface desinfected in a solution of $HgCl_2$ prior to fungal isolation. The mycoflora was investigated by placement of five seeds in each 10 cm Petri dish containing potato glucose agar (PGA). The Petri dishes were incubated at room conditions for 10-14 days. At the end of this period, fungal colonies growing out of each seed were transferred individually to PGA slants and recognized.

Fungi were identified according to Arx (1970), Barnett (1960), Booth (1971), De Vries (1959), Domsch (1970), Drechsler (1923), Ellis (1971), Gams (1971), Gilman (1945), Raper, Thom (1949), Raper, Fennel (1965), and Zycha, Siepmann, Linnemann (1969). Except for *S. nodorum*, representatives of each the other species were grown from single conidia in Petri dishes of PGA at room temperature with a 12 h photoperiod under cool white fluorescent lamps located 40 cm above cultures. Cultures were grown for 10-14 days. *Septoria nodorum* was cultured on oatmeal agar, since this medium produces distinctive colonies with abundantly sporulating pycnidia.

Table 1

Monthly sums of rainfal in the years 1982-1984

Station		Month											
		IX	X	XI	XII	I	II	III	IV	V	VI	VII	VIII
Swinoujście	a*	40	100	80	45	53	8	38	21	59	61	12	22
	b	5	36	25	37	56	34	45	57	81	37	5	47
	c	46	34	41	34	78	29	7	21	61	107	43	29
Resko	a	36	112	108	64	67	12	25	36	57	60	29	20
	b	6	37	34	58	94	44	72	68	70	19	22	50
	c	72	43	31	29	82	22	8	20	80	167	82	62
Nowogard	a	51	110	106	52	–**	–	20	6	40	–	33	26
	b	9	39	31	53	83	29	57	63	85	6	8	23
	c	–	–	–	–	–	–	–	–	–	–	–	–
Łobez	a	22	97	108	57	59	10	25	38	40	65	32	12
	b	–	–	–	–	–	–	–	–	–	–	–	–
	c	–	–	–	–	–	–	–	–	–	–	–	–
Szczecin-Dąbie	a	28	83	83	49	52	10	30	12	46	57	22	18
	b	5	35	25	34	65	28	37	77	85	7	12	53
	c	26	36	32	23	53	26	5	19	68	88	83	26
Lipki	a	23	89	81	51	47	11	44	23	63	60	13	16
	b	4	32	19	57	62	16	36	86	89	23	23	49
	c	33	31	34	12	52	21	5	23	73	125	100	32

* a – 1982, b – 1983, c – 1984; ** – data not available

RESULTS

Monthly sums of rainfall recorded in some selected meteorological stations of the Szczecin voivodeship in the years 1982-1984 are presented in Table 1. Both autumn and the ripening period, June-August, were much wetter in 1982 and 1984 than in 1983.

The proportion of shrunken seeds in the seed samples examined ranged from 2.0 % in 1982 to 43 % in 1983 (Tab. 2). In winter cultivars, the shrunken seeds constituted 8.7 % (in 1982) to 16.0 % (in 1984), whereas the occurence of shrunken seeds in spring cultivars ranged from 10.1 to 17.1 % in 1982 and 1984, respectively. Samples harvested in 1984 (av. 16.5 %) contained the highest proportion of shrunken seeds independent of cultivars.

Of the 3840 examined seeds of winter wheat cultivars harvested in the years 1982-1984, a total of 5157 fungal colonies representing 37 species from 25 genera and 9 forms of non-sporulating fungi were isolated (Tab. 3). The normally developed seeds coming from the harvests in 1982-1984 harboured 21, 20, and 22 fungal species and 5, 5 and 7 forms of non-sporulating fungi, respectively. The shrunken seeds from the 1982-1984 harvests were contamined by 27, 19, and 20 species and 5, 4, and 7 forms of non-sporulating fungi, respectively.

The 1840 investigated seeds of spring cultivars yielded a total of 1997 colonies representing 37 species from 20 genera and 9 forms of non-sporulating fungi (Tab. 4). The mycofloras of normally developed seeds from the 1982-1984 harvests comprised of 19, 13, and 19 species and 5, 7, and 6 forms of non-sporulating fungi. The fungal communities recovered from shrunken seeds during the three-year study were represented by 22, 25, and 19 species and 5, 7, and 3 forms of non-sporulating fungi, respectively.

The fungi most frequently recovered from the seed samples investigated were as follows: *A. alternata*, *A. pullulans*, *E. purpurascens*, species of the genera *Cladosporium*, *Fusarium*, *Helminthosporium* and *Penicillium*, *Septoria nodorum*, and non-sporulating fungi (Tabs. 3, 4). The mean percentages of seeds from which these fungi were isolated are presented in Table 5.

Septoria nodorum was most frequently isolated in 1982 (273 isolates). The lowest number of colonies of this fungus was recorded in 1983 (38) (Tabs. 3, 4). Among of the wheat cultivars examined, the highest proportion of seeds infested by *S. nodorum* in 1982 was found in Grana , Saga, and Liwilla (Tab. 6). In 1983, the seeds of cultivars which were colonized by *S. nodorum* were those of Gama and Saga. In 1984, the highest proportion of seeds with *S. nodorum* occurred in Liwilla, Saga, and Jana.

Septoria nodorum was more frequently isolated from shrunken (0.8-38.1 %) than normally developed seeds (1.5-36.3 %) (Tabs. 3, 4). Of the other fungi most frequently recovered in this study, only members of the genera *Fusarium* and *Penicillium* were more frequently associated with shrunken seeds. In contrast, *A. alternata* and non-sporulating fungi were more frequently isolated from normally developed

seeds. No correlations were found between the frequency of occurrence of *A. pullulans*, *E. purpurascens*, and *Cladosporium* spp. and the degree of seed development.

The other fungi listed in Tables 3 and 4 sporadically contaminated the investigated seed samples.

Table 2

Wheat cultivars from which seed samples were collected

Year of harvest	Cultivar	Degree of reproduction	% of shrunken seeds	Site of cultivation
1982	Liwilla	original	7.9	Tąpadły
		1st reprod.	8.0	Bielicz
	Jana	original	6.8	Lubanów
		1st reprod.	3.8	Grzybno
		1st reprod.	11.3	Trzygłów
	Beta	1st reprod.	4.8	Koszewo
		1st reprod.	12.0	Żuków
	Maris Huntsman	original	13.8	Barkowo
	Grana	original	12.8	Laskowo
		basic seed	5.3	Cerkwica
		1st reprod.	12.5	Wrzosowo Kamień
	Saga	1st reprod.	8.3	Przelewice
		1st reprod.	13.0	Wyszobór
		original	10.3	Sienno-Dolne
		original	5.3	Przecław
	Salwa	original	11.8	Mołstowo
		original	7.0	Topolinek
		1st reprod.	3.8	Nowielice
		original	3.5	Ostoja
		1st reprod.	7.5	Skrzykocin
	Jara	1st reprod.	18.3	Żabów
		original	6.0	Stróżewo
		original	14.8	Orle
		original	25.0	Kołbacz
		original	12.5	Dobropole
		original	2.0	Koszewo
	Kolibri	1st reprod.	5.5	Witnica
		1st reprod.	6.0	Witnica
		1st reprod.	7.5	Boniewice
		1st reprod.	3.0	Gardno
1983	Beta	1st reprod.	7.3	Karsko
	Maris Huntsman	1st reprod.	43.8	Borkowo

cont. Tab. 2

1983	Liwilla	original	7.5	Recław
		elita	6.5	Lubiechowo
		1st reprod.	8.3	Skarbimierzyce
		1st reprod.	12.0	Cerkwica
	Gama	1st reprod.	16.0	Prusinowo
	Saga	1st reprod.	7.0	Kłodzino
		1st reprod.	11.8	Dargosław
		original	16.5	Krzemlin
	Salwa	elita	3.7	Żabów
	Jana	1st reprod.	9.5	Skalin
	Grana	1st reprod.	5.0	Krzemlin
		1st reprod.	7.5	Krzemlin
	Sawa	original	9.3	Ostoja
	Jara	1st reprod.	18.5	Barzkowice
		1st reprod.	14.0	Drzemień
		original	12.0	Cerkwica
		original	12.3	Kluczewo
		original	11.5	Tąpadły
	Williana	original	7.8	Witnica
	Kolibri	1st reprod.	12.5	Witnica
		1st reprod.	14.6	Gardno
1984	Liwilla	1st reprod.	25.5	Lubanowo
		1st reprod.	10.0	Witnica
		original	18.5	Cerkwica
		original	22.5	Siemieczyn
	Gama	1st reprod.	9.0	Płońsko
		1st reprod.	13.5	Strzykocin
		1st reprod.	6.0	Skarbmierzyce
		1st reprod.	10.5	Przecław
		basic seed	11.0	Strzyżno
	Jana	1st reprod.	15.0	Mołstkowo
		1st reprod.	20.0	Koszewo
		1st reprod.	21.5	Samlino
	Saga	basic seed	12.5	Bielin
		1st reprod.	28.0	Węgorzyno
	Jara	1st reprod.	16.5	Drzemin
		1st reprod.	14.5	Cerkwica
		1st reprod.	18.5	Karnice
		1st reprod.	23.0	Krasne
		1st reprod.	13.0	Krasne

Table 3

Fungi recovered from seeds of winter wheat cultivars harvested in 1982-1984

Fungus	1982		1983		1984		Total
	a	b	a	b	a	b	
Absidia glauca Hagem	2	1	–	–	–	–	3
Acremoniella atra Sacc.	–	2	–	–	1	–	3
Acremonium sp.	–	–	2	2	–	–	4
Alternaria alternata (Fr.) Keissler	354	279	314	279	375	330	1931
Aspergillus ruber (Konig, Spieckermann et Bremer) Thom et Church	–	1	–	–	–	–	1
Aureobasidium pullulans (de Bary) Arn.	21	33	15	24	2	–	95
Botrytis cinerea Pers.: Fr.	4	8	3	9	5	9	38
Chaetomium globosum Kunze	1	2	1	2	–	–	6
C. oliviaceum Cooke et Ellis	–	1	–	–	–	–	1
Circinella rigida Smith	–	–	–	–	1	1	2
Cladosporium cladosporioides (Fres.) de Vries	13	16	8	10	1	–	48
C. herbarum Link.: Fr.	15	12	11	9	3	4	54
C. macrocarpum Preuss	–	–	3	–	1	–	4
Epicoccum purpurascens Link	26	26	17	28	105	65	267
Fusarium avenaceum (Corda: Fr.) Sacc.	1	–	1	–	2	3	7
F. culmorum (W. G. Smith) Sacc.	–	3	1	2	5	3	14
F. graminearum Schwabe	–	3	–	2	–	1	6
F. lateritum Nees	–	–	–	1	–	3	4
F. nivale (Fr.) Ces.	7	7	–	–	6	38	58
F. poae (Peck) Wollenw.	5	3	5	14	4	41	72
Fusidium sp.	–	1	–	–	1	–	2
Gonatobotrys simplex Corda	3	9	4	8	1	–	25
Helminthosporium sativum P. K. B.	3	3	1	–	1	–	8
H. triseptatum Drechsl.	32	17	1	–	–	1	51
Mucor hiemalis Wehmer.	2	7	1	1	1	2	14
M. racemous Fres.	–	–	–	–	1	2	3
M. strictus Hagem	8	15	1	1	1	–	26
Papularia arundinis (Corda) Fr.	4	3	–	1	–	1	9
P. sphaerosperma (Pers.) Hohn.	–	1	–	–	–	–	1
Penicillium notatum Westling	–	–	–	–	6	6	12
Penicillium spp.	23	26	24	34	5	4	116
Phoma eupyrena Sacc.	1	–	–	–	–	–	1
Phoma sp. 1	1	–	–	–	2	–	3
Phoma sp. 2	–	–	–	–	1	–	1
Rhizopus nigricans Ehrenb.	–	–	4	8	6	5	23
Sclerotium sp.	–	1	–	–	–	–	1
Septoria nodorum Berk.	124	149	14	24	131	141	583
Stemphylium botryosum Wallr.	9	5	11	8	2	2	37
Trichocladium asperum Harz	–	1	–	–	–	–	1
Trichoderma viride Pers.: Fr.	2	–	–	–	–	–	2
Trichothecium roseum Link	–	–	–	2	–	–	2
Ulocladium atrum Preuss	1	3	1	2	–	–	7
U. botrytis Preuss	–	1	1	1	–	–	3
Verticillium indicum (Petch) Gams	–	1	–	–	–	–	1
Verticillium sp.	–	1	–	–	–	–	1
Yeast-like pink	5	19	5	5	3	2	39
Non-sporulating	341	275	376	293	154	134	1573
Total	1006	934	824	769	827	797	5157

Table 4

Fungi recovered from seeds of spring wheat cultivars harvested in 1982-1984

Fungus	1982		1983		1984		Total
	a	b	a	b	a	b	
Acremoniella atra Sacc.	–	–	–	–	–	2	2
Alternaria alternata (Fr.) Keissl.	125	92	134	111	134	95	691
Aspergillus niger v. Tieghem	1	4	–	–	1	1	7
A. versicolor (Vuill.) Tiraboschi	–	1	–	–	–	–	1
Aspergillus sp.	–	1	–	–	–	–	1
Aureobasidium pullulans (de Bary) Arn.	10	11	15	15	1	1	53
Botrytis cinerea Pers.: Fr.	1	4	6	2	2	1	16
Chaetomium globosum Kunze: Fr.	–	–	1	–	–	–	1
C. indicum Corda	1	2	–	–	–	–	3
Circinella muscae (Sorok.) Berl. et de Toni	–	–	–	1	–	–	1
C. rigida Smith	–	–	–	2	–	–	2
Cladosporium cladosporoides (Fres.) de Vries	11	25	2	4	1	–	43
C. herbarum Link: Fr.	17	22	2	1	3	–	45
C. macrocarpum Preuss	2	–	–	1	–	–	3
Epicoccum purpurascens Link	4	3	–	3	43	28	81
Fusarium avenaceum (Corda: Fr.) Sacc.	–	–	–	–	–	1	1
F. culmorum (W. G. Smith) Sacc.	–	–	–	2	1	2	5
F. graminearum Schwabe	–	2	–	1	–	2	5
F. lateritium Nees	–	1	–	1	–	1	3
F. nivae (Fr.) Ces.	–	3	–	–	1	4	8
F. oxysporum Schl.	–	–	1	–	–	–	1
F. poae (Peck) Wollenw.	1	4	–	1	–	6	12
F. sporotrichioides Sherb.	–	–	–	1	–	–	1
Gonatobotrys simplex Corda	2	4	–	2	1	–	9
Helminthosporium sativum P. K. B.	3	1	–	1	1	–	6
H. triseptatum Drechsl.	1	–	–	–	–	1	2
Mucor hiemalis Wehmer	1	1	1	3	1	1	8
M. plumbeus Bonorden	–	–	–	1	–	–	1
M. strictus Hagem	3	1	3	1	1	–	9
Papularia arundinis (Corda) Fr.	–	6	–	2	–	–	8
P. sphaerosperma (Pers.) Hohn.	–	1	–	–	–	–	1
Penicillium notatum Westl.	–	–	–	–	4	4	8
Penicillium spp.	20	25	5	9	2	2	63
Phoma sp.	1	–	–	–	–	–	1
Rhizopus nigricans Ehrenb.	–	–	2	7	–	–	9
Septoria nodorum Berk.	14	18	6	9	17	31	95
Stemphylium botryosum Wallr.	6	9	3	1	2	–	21
Trichothecium roseum Link	1	–	–	1	–	–	2
Ulocladium atrum Preuss	1	–	–	–	–	–	1
U. botrytis Preuss	–	1	1	1	–	–	3
Yeast-like pink	4	3	9	8	2	1	27
Non-sporulating B-1	191	129	180	173	42	23	738
Total	421	374	371	365	260	206	1997

Table 5

Mean percentage of seeds of winter and spring cultivars from which the most frequently occurring fungi were isolated in the years 1982-1984

Fungus		Winter cultivars			Spring cultivars		
		1982	1983	1984	1982	1983	1984
Altenaria alternata	a	42	52	65	32	42	65
	b	37	44	57	27	37	48
Aureobasidium pullulans	a	3	3	4	3	4	1
	b	4	4	0	3	5	1
Cladosporium spp.	a	4	4	2	8	2	3
	b	4	4	2	12	2	0
Epicoccum purpurascens	a	4	4	19	2	0	19
	b	4	4	10	1	2	13
Fusarium spp.	a	2	1	4	1	2	3
	b	2	2	18	3	3	8
Helminthosporium spp.	a	4	1	1	3	0	1
	b	2	0	0	1	2	1
Penicillium spp.	a	4	2	1	6	3	4
	b	2	2	2	7	4	4
Septoria nodorum	a	13	2	23	4	3	8
	b	19	2	27	5	4	18
Non-sporulating fungi	a	30	63	27	48	55	18
	b	31	51	24	30	52	10

a – normally developed seeds; b – shrunken seeds

Table 6

Mean percentage infestation of seeds of winter (A) and spring (B) cultivars by *Septoria nodorum*

	Cultivar	Year 1982		1983		1984	
		a	b	a	b	a	b
(A)	Beta	8	15	0	0	–	–
	Gama	–	–	14	18	10	16
	Grana	22	28	2	2	–	–
	Jana	13	9	0	0	24	23
	Liwilla	17	20	2	3	35	37
	Maris Huntsman	14	10	0	0	–	–
	Saga	17	23	3	9	25	29
	Salwa	11	12	0	0	–	–
	Sawa	–	–	0	0	–	–
(B)	Jara	5	3	2	1	8	16
	Kolibri	3	1	4	8	–	–
	Sappo	0	0	–	–	–	–
	Williana	–	–	0	0	–	–

a – normally developed seeds; b – shrunken seeds

DISCUSSION

Most of the fungal species isolated during the study discussed in the present paper are known to occur on cereal seeds, including *T. aestivum* (e.g., Flannigan, 1971; Häni, 1980; Hewett, 1965).

The predominance of *A. alternata*, *A. pullulans*, *E. purpurascens*, species of the genera *Cladosporium*, *Fusarium*, *Helminthosporium* and *Penicillium*, *S. nodorum*, and non-sporulating fungi in the fungal populations isolated fits the results of e.g., Flannigan (1971) and Łacicowa (1964).

Except for members of *Penicillium* and non-sporulating fungi,the other fungi listed above are known to be called "field fungi" (Neergaard, 1977). According to Chełkowski (in Gabińska, Narkiewicz-Jodko, Schneider, 1991) and Narkiewicz-Jodko (1991), the presence of *A. alternata*, *Cladosporium* spp., and *E. purpurascens* suggests a good quality of a seed lot. Bateman (1979) found these fungi to inhabit *S. nodorum*. *Aureobasidium pullans* also showed antagonistic properties to *S. nodorum* (Fokema, Van Der Meulen, 1976).

Species of the genera *Fusarium* and *Helminthosporium* are known to produce seed rot either in the crop or during germination (Colhoun, Park, 1964; Häni, 1980; Łacicowa, 1963).

Penicillium spp. are "storage fungi" (Neergaard, 1977) that spread rapidly at a higher moisture content (Hill, Lacey, 1983) and usually replace "field fungi" (Lutey, Christensen, 1963). *Penicillium* spp. decrease germination of seeds (Neergaard, 1977).

The role of non-sporulating fungi in mycoflora of wheat seeds is unknown.

The seeds harvested in 1982 and 1984 yielded many more colonies of *S. nodorum* than those from the 1983 harvest. Weather records from meteorological station suggest that this may have resulted from the wetter vegetative periods in 1982 and 1984. Seed infection by *S. nodorum* is favoured by wet weather (Leiteritz, Focke, 19770.

The proportion of seeds with *S. nodorum* was higher in winter than spring cultivars. This supports the opinion of Obst (1980) than winter cultivars grow in more favourable conditions for establishment of *S. nodorum* infections.

The higher incidence of *S. nodorum* in shrunken than normally developed seeds conforms the findings of many investigators (e.g., Cooke, Jones, 1970; Jones, Odebunmi, 1971) that this fungus is a severe pathogen highly reducing the yield of wheat.

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