Fungi Associated with the Seeds of Commercial Lentils from the U.S. Pacific Northwest

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ABSTRACT

Kaiser, W. J. 1992. Fungi associated with the seeds of commercial lentils from the U.S. Pacific Northwest. Plant Dis. 76:605-610.

Seeds of commercial lentils (*Lens culinaris*) from the Palouse region of eastern Washington and northern Idaho were sampled for pathogenic seedborne fungi during 1982–1985. *Ascochyta fabae* f. sp. *lentis, Botrytis cinerea, Fusarium acuminatum, F. avenaceum, Macrophomina phaseolina, Phoma medicaginis* var. *pinodella, Rhizoctonia solani*, and *Sclerotinia sclerotiorum* were isolated. *B. cinerea* and *P. m. pinodella* were isolated most frequently. *B. cinerea* was isolated from 55 and 90% of the samples and 2.2 and 8.3% of the seeds within samples in 1982 and 1983, respectively. The incidence of pathogenic and nonpathogenic fungi in commercial lentil seed from the Palouse region varied greatly from year to year. The highest incidence occurred in 1983, when the quality of some lentil seed was reduced because of discoloration of the seeds. Several pathogenic fungi, particularly *B. cinerea*, were frequently isolated from the discolored seeds. Saprophytic fungi isolated most frequently from lentil seed were species of *Alternaria* and *Cladosporium*. The amount of rainfall during July, when the crop was nearing maturity or about to be harvested, appeared to markedly affect the incidence, prevalence, and severity of seedborne pathogenic fungi. In 1983, when 4.3 cm of rain fell during July, seed samples were most heavily infected by seven of the eight pathogenic fungi. *A. f. lentis* was isolated from commercial lentil seeds originating in the Palouse region, Montana, and North Dakota. When lentil samples from Montana and North Dakota were available, *A. f. lentis* was isolated from all samples from North Dakota and from 25 and 35% of the samples from Montana in 1982 and 1983, respectively. *A. f. lentis* was isolated only from 3 and 7% of the samples from the Palouse region in 1982 and 1983, respectively, and from none of the samples in 1984 or 1985.

Commercial production of lentils (*Lens culinaris* Medik.) in the United States is concentrated in the Pacific Northwest, particularly in the Palouse region of eastern Washington and northern Idaho, where 28,700–77,190 ha were grown annually between 1981 and 1990 (20). In this region, lentils are grown under dryland conditions in rotation with wheat, barley, and peas. The crop is usually seeded by mid-April and harvested in late July or early August.

Relatively little is known about the seedborne microflora of lentils grown in the United States. In 1965, Wilson and Brandsberg (22) isolated both pathogenic and nonpathogenic fungi from diseased lentil seedlings in Idaho and Washington. In a study on the incidence of *Ascochyta fabae* Speg. f. sp. *lentis* Gossen et al (= *A. lentis* Vassiljevsky) in lentil germ plasm maintained by the Regional Plant Introduction Station at Pullman, WA, Kaiser and Hannan (7) mentioned that they had isolated several pathogenic fungi from seeds of commercial lentils grown in the Palouse region.

The objectives of this study were to sample seed of lentils produced in the Palouse region over a 4-yr period for seedborne fungi and to identify those fungi that were pathogenic to lentils. Additionally, lentil seed from Montana and North Dakota were tested for the incidence of *A. f. lentis*.

MATERIALS AND METHODS

Source of seed. Lentil seeds from widely distributed commercial fields in the Palouse region of eastern Washington and northern Idaho were obtained from the Federal Grain Inspection Service (FGIS) in Moscow, ID, during August–October 1982–1985. An attempt was made to obtain seed samples from all areas of the region where lentils were grown. The number of samples obtained each year ranged from 103 to 132. Each sample contained about 150–500 seeds and was stored in manila envelopes at room temperature. A few seed samples also were obtained from commercial plantings in Montana and North Dakota. These seed samples were tested primarily for the incidence of *A. f. lentis*.

More than 90% of the seed samples obtained during 1982–1985 from the FGIS in Moscow were of the cultivar Chilean 78. Seeds of other lentil cultivars occasionally obtained were Brewer, Eston, Laird, and Red Chief.

Isolation of fungi. One hundred seeds were selected from each sample (40 seeds of poorer quality and 60 seeds at random). Seeds were surface-disinfested in 0.25% NaOCl for 5 min, dried on paper towels, placed on 2% water agar (WA), and incubated at 20–24 C under fluorescent lights (12-hr photoperiod, 77 $\mu E \cdot m^{-2} \cdot s^{-1}$). Twenty seeds were placed on the medium in each 9-cm-diameter petri dish, with five dishes per sample. Seeds were observed for the incidence of seedborne fungi after 6–7 and 10–12 days. As fungi emerged, hyphal tips were transferred to Difco potato-dextrose agar (PDA) slants and stored at 4 C in the dark. Fungi were identified to genus or species either by me; mycologists at the Department of Plant Pathology, Washington State University, Pullman, WA; or mycologists at the Fusarium Research Center, Department of Plant Pathology, Pennsylvania State University, University Park, PA.

Pathogenicity tests. Pathogenicity tests were conducted in the greenhouse with one to eight isolates of selected fungi isolated from seeds over the 4 yr of the study. Greenhouse temperatures ranged from 18 to 24 C. Fungi were cultured on PDA or carnation-leaf agar for *Fusarium* spp. (4,11) under fluorescent lights (12-hr photoperiod, 77 $\mu E \cdot m^{-2} \cdot s^{-1}$) at 20–24 C for 10–16 days.

Pathogenicity tests were conducted by one of the following methods: 1) PDA cultures were cut into small pieces (about 1 cm^2), and the contents of one dish were mixed into the top 3–4 cm of greenhouse potting medium (55% peat moss, 35% pumice, and 10% sand) in 15-cm-diameter plastic pots. Uninfested controls amended with sterile PDA were included in all tests. Fifteen lentil seeds (PI 477920) surface-disinfested in 0.25% NaOCl for 5 min were planted 2–3 cm deep in all pots. There were two or three pots per isolate. 2) Conidia were collected from PDA or carnation-leaf agar petri dishes by flooding the surface of the medium with sterile distilled water and gently scraping the colony surface with a bent spatula. Conidial suspensions of each isolate were counted with a hemacytometer and diluted to about 1×10^6 conidia per milliliter with sterile distilled water.

The spore suspension was used to inoculate lentil seeds or the foliage of young plants as follows: 1) Surface dis-

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Accepted for publication 13 December 1991.

infested lentil seeds were soaked in the conidial suspensions for 15–20 min and then planted 2–3 cm deep in sterile potting medium in 15-cm-diameter plastic pots. Fifteen seeds were planted per pot with two to three pots per isolate. 2) The foliage of four to six 20- to 30-day-old lentil plants (two or three plants per 15-cm-diameter plastic pot) was sprayed to runoff with a spore suspension of each isolate using a DeVilbiss atomizer. Control plants were sprayed to runoff with distilled water. Plants were incubated in a moist chamber for 72–96 hr at 18–22 C with a 14-hr photoperiod and then were moved to a greenhouse bench for symptoms to develop.

Plants inoculated by different methods were rated for disease after 15–20 days. Pathogenicity of each fungus to the roots and/or foliage of lentils was based on a disease index of 1–5, where 1 = healthy tissues, 2 = 1-10, 3 = 11–25, 4 = 26–50, and 5 = more than 50% necrosis of the roots or foliage (7). Isolations were made from lesions on the roots, stems, and leaves by surface-disinfesting the tissues in 0.25% NaOCl for 5 min and placing pieces of tissue on WA and PDA.

Rainfall data. The rainfall pattern in Pullman, WA, is representative of many areas in the Palouse region. Total monthly rainfall for June, July, and August 1982–1985 was obtained for Pullman from monthly records published by the U.S Department of Commerce (19).

RESULTS

Isolation from lentil seeds. Eight pathogenic fungi were isolated from commercial lentil seed sampled during 1982–1985 (Table 1). These included *A. f. lentis, Botrytis cinerea* Pers.: Fr., *Fusarium acuminatum* Ellis & Everh., *F. avenaceum* (Fr.:Fr.) Sacc., *Macrophomina phaseolina* (Tassi) Goidanich, *Phoma medicaginis* Malbr. & Roum. in Roum. var. *pinodella* (L. K. Jones) Boerema, *Rhizoctonia solani* Kühn, and *Sclerotinia sclerotiorum* (Lib.) de Bary. *B. cinerea* and *P. m. pinodella* were isolated most frequently from lentil samples and seeds during 1982–1985. *B. cinerea* was isolated from 55 and 90% of the samples and 2.2 and 8.3% of the seeds in 1982 and 1983, respectively.

In each sample of 100 seeds, the incidence of pathogenic and saprophytic fungi was generally higher in the 40 seeds of poorer quality than in the 60 seeds selected at random. This was particularly so with seeds from the 1982 and 1983 harvest when >50–70% of the total fungi were isolated from the poorer quality seeds. Germination of the poor quality seeds in 1982 and 1983 often was reduced by >60%. The incidence of pathogenic fungi in seeds was greater in 1982 and 1983 than in 1984 and 1985. In 1983, some seed samples showed extensive discoloration. *B. cinerea*, in particular, was frequently isolated from the discolored seeds (Fig. 1).

The pathogenic fungi *F. acuminatum, F. avenaceum,* and *S. sclerotiorum* were isolated less frequently in each year, and *A. f. lentis, M. phaseolina*, and *R. solani* were rarely recovered. The three isolates of *R. solani* from lentil seed all belonged to anastomosis group 4 (C. Castro, University of Idaho, Moscow, ID).

Seven *Fusarium* spp. were isolated from lentil seed, including *F. acuminatum, F. avenaceum, F. culmorum* (Wm. G. Smith) Sacc., *F. equiseti* (Corda) Sacc., *F. oxysporum* Schlechtend.:Fr., *F. sambucinum* Fuckel, and *F. solani* (Mart.) Sacc. (Table 2). *F. equiseti, F. acuminatum*, and *F. avenaceum* were isolated most frequently in 1983 when 74, 72, and 44% of the seed samples were infected with these three species, respectively. *Fusarium* spp. isolated less frequently were *F. oxysporum, F. culmorum, F. solani*, and *F. sambucinum*. In these inoculation studies, only *F. acuminatum* and *F. avenaceum* were pathogenic to lentil. An isolate of *F. solani* f. sp. *pisi* (F. R. Jones) W. C. Snyder & H. N. Hans. from lentil seed in 1985 caused a root rot of Alaska pea (*Pisum sativum* L.) and chickpea (*Cicer arietinum* L., PI 489770) but not lentil.

Another 12 genera of saprophytic fungi also were isolated from commercial lentil seed during 1982–1985 (Table 3). *Alternaria* and *Cladosporium* spp. were isolated most frequently, with 12 and 23% of the seeds infected, respectively, in 1983. Other genera detected with a lesser degree of frequency were species of *Aspergillus, Stemphylium, Penicillium, Mucor, Fusarium*, and *Rhizopus*. Other saprophytes infrequently isolated were species of *Chaetomium, Helmin-*

Table 1. Pathogenic fungi isolated from seeds of commercial lentils from eastern Washington and northern Idaho during 1982–1985[a]

Fungus	Samples with infected seeds[b] (%)				Infected seeds[b] (%)			
	1982	1983	1984	1985	1982	1983	1984	1985
Botrytis cinerea	55	90	23	15	2.2	8.3	0.4	0.3
Phoma medicaginis var. *pinodella*	29	53	15	21	0.9	2.7	0.2	0.3
Fusarium spp.[c]	14	27	4	7	0.2	1.0	0.03	0.07
Sclerotinia sclerotiorum	8	18	5	4	0.1	0.4	0.05	0.07
Rhizoctonia solani	4	7	0	0	0.04	0.08	0.0	0.0
Ascochyta fabae f. sp. *lentis*	3	7	0	0	0.03	0.2	0.0	0.0
Macrophomina phaseolina	0	0	0	1	0.0	0.0	0.0	0.01

[a]Seeds were surface-disinfested in 0.25% NaOCl for 5 min and placed on 2% water agar with 20 seeds per petri dish and five dishes per sample.
[b]The number of lentil samples tested was 122, 103, 121, and 132 in 1982, 1983, 1984, and 1985, respectively. There were 100 seeds per sample.
[c]Totals are limited to *Fusarium acuminatum* and *F. avenaceum*, which were pathogenic to lentils.

Table 2. *Fusarium* species isolated from seeds of commercial lentils collected in northern Idaho and eastern Washington during 1982–1985

Fusarium species	No. of isolations from lentil samples[a]			
	1982	1983	1984	1985
F. acuminatum	12	72	3	6
F. avenaceum	10	44	2	4
F. culmorum	0	5	2	0
F. equiseti	24	74	9	34
F. oxysporum	0	10	9	7
F. sambucinum	0	0	0	1
F. solani	1	2	0	2
Unidentified	1	5	0	4

[a]The number of lentil samples tested was 122, 103, 121, and 132 in 1982, 1983, 1984, and 1985, respectively. There were 100 seeds per sample.

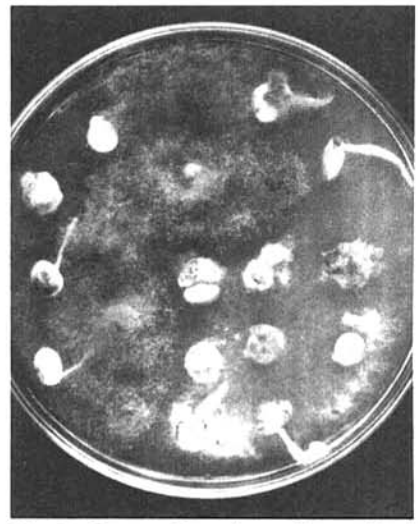

Fig. 1. Two pathogenic seedborne fungi. *Botrytis cinerea* (left, abundant sporulation) and *Sclerotinia sclerotiorum* (bottom right, sclerotial formation) growing from commercial lentil seeds from eastern Washington.

thosporium, Trichoderma, and *Nigrospora*. Several unidentified fungi also were isolated. These fungi failed to sporulate on WA or seeds and did not sporulate when transferred to PDA plates that were incubated under fluorescent lights or in the dark.

Isolation of *A. f. lentis* from lentil seeds. *A. f. lentis* was isolated from 3 and 7% of the samples at very low incidences in seeds from the Palouse region in 1982 and 1983 and from none of the samples in 1984 and 1985 (Table 4). Although the number of seed samples from Montana and North Dakota was small, *A. f. lentis* was isolated from all samples from North Dakota in 1982 and 1983, and from one of four and nine of 26 of the samples from Montana in those 2 yr, respectively. In 1982 and 1983, *A. f. lentis* was isolated from 17 and 13% of the seeds from North Dakota, and 6 and 8% of the seeds from Montana, respectively (Table 5). Seed samples from North Dakota in 1982 and 1983 were noticeably discolored, and *A. f. lentis* was isolated from more than 90% of the discolored seeds.

Pathogenicity tests. *A. f. lentis, B. cinerea, F. acuminatum, F. avenaceum, M. phaseolina, P. m. pinodella, R. solani*, and *S. sclerotiorum* were pathogenic to the roots and/or foliage of lentil (Table 6). *B. cinerea* was the most pathogenic fungus to lentils of all tested, frequently causing pre- and postemergence damping-off. The isolates of this fungus varied greatly in cultural characteristics, particularly in the production of conidia and sclerotia (Fig. 2), but all isolates were pathogenic to lentil. All isolates of *R. solani* and *S. sclerotiorum* were highly pathogenic to lentil, causing pre- and postemergence damping-off. The only pathogenic *Fusarium* spp. were *F. acuminatum* and *F. avenaceum*, which caused a root and crown rot of lentils (Fig. 3). *F. avenaceum* was more pathogenic than *F. acuminatum* (Table 6). Of the *Fusarium* spp., *F. equiseti* was isolated most frequently from lentil samples each year, but none of the isolates tested were pathogenic to lentil roots. All isolates of *A. f. lentis* produced lesions on stems, petioles, and leaflets. Included in these tests was one isolate each from Montana and North Dakota. Isolates of *P. m. pinodella* caused necrosis of the roots and crown tissue of inoculated lentils. A necrosis of the foliage occurred when plants were inoculated with a spore suspension. The only isolate of *M. phaseolina* tested was weakly pathogenic to the roots of lentil.

Effect of rainfall on incidence of seedborne fungi. The greater incidence of *B. cinerea* and *P. m. pinodella* in seed samples in 1982 and 1983 than in 1984 and 1985 (Table 1 and Fig. 4A) was associated with greater rainfall in July in 1982 and 1983 (Fig. 4B). This is the time when the crop is maturing. *B. cinerea* was the pathogenic seedborne fungus most frequently isolated from lentil seed samples during 1982–1984.

Table 3. Saprophytic fungi isolated from seeds of commercial lentils from eastern Washington and northern Idaho during 1982–1985[a]

	Samples with infected seeds[b] (%)				Infected seeds[b] (%)			
Fungus	**1982**	**1983**	**1984**	**1985**	**1982**	**1983**	**1984**	**1985**
Alternaria spp.	78	99	67	73	3.0	12.4	1.8	2.9
Aspergillus spp.	16	13	7	15	0.4	0.2	0.2	0.3
Chaetomium spp.	2	3	2	2	0.03	0.03	0.04	0.02
Cladosporium spp.	78	98	90	88	5.5	22.9	5.4	7.5
Fusarium spp.[c]	29	57	14	31	0.4	2.0	0.1	0.4
Helminthosporium sp.	0	0	1	0	0	0	0.01	0
Mucorales[d]	39	41	53	31	0.6	0.7	0.9	0.5
Nigrospora sp.	0	0	1	0	0	0	0.01	0
Penicillium sp.	46	59	50	90	1.3	1.2	1.1	3.4
Stemphylium spp.	58	88	38	53	1.4	8.8	0.7	1.1
Trichoderma sp.	0	1	2	2	0	0.01	0.01	0.02
Nonsporulating fungi	63	63	57	76	1.4	1.6	0.9	1.5

[a]Seeds were surface-disinfested in 0.25% NaOCl for 5 min and placed on 2% water agar with 20 seeds per petri dish and five dishes per sample.
[b]The number of lentil samples tested was 122, 103, 121, and 132 in 1982, 1983, 1984, and 1985, respectively. There were 100 seeds per sample.
[c]Totals are limited to five nonpathogenic *Fusarium* spp. (*F. culmorum, F. equiseti, F. oxysporum, F. sambucinum*, and *F. solani*).
[d]*Mucor* and *Rhizopus* spp.

Table 4. The number of commercial lentil samples infected with *Ascochyta fabae* f. sp. *lentis* harvested in Montana, North Dakota, and the Palouse region of eastern Washington and northern Idaho during 1982–1985[a]

	Samples with infected seeds							
	1982		**1983**		**1984**		**1985**	
Location	**No.**	**Percent**	**No.**	**Percent**	**No.**	**Percent**	**No.**	**Percent**
Washington/Idaho	4/122[b]	3.3	7/103	6.8	0/121	0	0/132	0
Montana	1/4	25.0	9/26	34.6	1/12	8.3	0/1	0
North Dakota	7/7	100	4/4	100	0/0	0	0/0	0

[a]Seeds were surface-disinfested in 0.25% NaOCl for 5 min and placed on 2% water agar with 20 seeds per petri dish and five dishes per sample.
[b]Numerator represents the number of samples with infected seeds; the denominator represents the total number of samples tested.

Table 5. The number of lentil seeds infected with *Ascochyta fabae* f. sp. *lentis* harvested in Montana, North Dakota, and the Palouse region of eastern Washington and northern Idaho during 1982–1985[a]

	Infected seeds							
	1982		**1983**		**1984**		**1985**	
Location	**No.**	**Percent**	**No.**	**Percent**	**No.**	**Percent**	**No.**	**Percent**
Washington/Idaho	4/12,200[b]	0.03	16/10,300	0.2	0/12,100	0	0/13,200	0
Montana	22/400	5.5	218/2,600	8.4	2/1,200	0.2	0/100	0
North Dakota	118/700	16.9	53/400	13.3	0/0	0	0/0	0

[a]Seeds were surface-disinfested in 0.25% NaOCl for 5 min and placed on 2% water agar with 20 seeds per petri dish and five dishes per sample.
[b]Numerator represents the number of seeds infected; the denominator represents the total number of seeds tested.

DISCUSSION

The incidence of fungi associated with commercial lentil seeds in the Pacific Northwest varied considerably from year to year. The seedborne pathogens most frequently isolated were *B. cinerea, P. m. pinodella*, and two *Fusarium* spp. In a year such as 1983 when environmental conditions favored seed infection, a high percentage of the seed samples were infected with at least seven seedborne pathogens, some of which (*B. cinerea* and *P. m. pinodella*) infected more than 50% of the seed samples. In a study of the diseases affecting lentil seedlings in the Palouse region during 1963–1964, Wilson and Brandsberg (22) isolated several pathogenic fungi that infected the stems and roots of inoculated lentils. They isolated several of the same pathogenic fungi, e.g. *B. cinerea, P. m. pinodella*, and *S. sclerotiorum*, that were isolated from seed in the present study. Wilson and Brandsberg (22) mentioned that early infection of the stem may occur at the point of attachment of the seed to the stem, indicating that infection results from a pathogen that is possibly seedborne.

The greater prevalence of seedborne fungi pathogenic to lentil in 1982 and 1983 appears to be related to July rainfall, which was highest in these 2 yr. In the Palouse region, lentils are usually seeded (without a fungicidal seed treatment) in mid-April and harvested in late July to August, depending on the weather conditions. Lentils are either harvested directly by combine when mature and dry or are swathed and allowed to dry in windrows. When dry, the windrows are harvested by combine. If excessive rainfall occurs during harvest or when plants are drying in windrows, the lentils will remain on or near the moist soil surface, where conditions may favor colonization and infection of the pods and seeds by several of the soilborne pathogens and saprophytes listed in Tables 1 and 2.

In 1983, 4.3 cm of rain fell during July, which delayed harvest and favored infection of the pods and seeds by different fungi. The longer mature standing or windrowed lentils are left in the field because of excessive wet weather, the greater the likelihood that they will become infected with seedborne pathogenic and saprophytic fungi, which can lead to a reduction in seed quality, as occurred in 1983. The adverse effect of delayed harvest attributable to excessive rainfall on reduced seed quality and increased incidence of seedborne fungi also has been observed in bean (*Phaseolus vulgaris* L.) (18) and soybean (*Glycine max* (L.) Merr.) (21).

Wilson and Brandsberg (22) considered *B. cinerea* to be potentially important on lentils in the Pacific Northwest, and it was also the pathogen isolated most frequently from commercial lentil seeds in this 4-yr study. Isolates of the fungus differed greatly in cultural characteristics but all were highly pathogenic to lentil. When the canopy of lentils is dense and the soil surface is moist, *B. cinerea* often sporulates abundantly on decaying lentil tissues, particularly after a rain. The fungus also sporulates on dead and decaying tissues of other food legumes cultivated in the Palouse region, including broadbean (*Vicia faba* L.), chickpea, and pea (W. J. Kaiser, *unpublished*). Under field conditions, *B. cinerea* may produce lesions on the foliage of chickpea and infect the seed (W. J. Kaiser, *unpublished*). *B. cinerea* also has been isolated from seeds of lentil in Canada (16), Chile (5), and India (14).

Several *Fusarium* spp. have been implicated in root rot diseases of lentil in the United States, Canada, Egypt, and Uruguay (2,3,6,9,10,15). In the present study, seven species of *Fusarium* were isolated from lentil seeds, but only *F. acuminatum* and *F. avenaceum* were pathogenic to the roots of lentil. Although isolated most frequently of the *Fusarium*

Table 6. Pathogenicity of fungi isolated from seeds of commercial lentils during 1982–1985 from eastern Washington and northern Idaho to lentils

Fungus	No. of isolates tested	Method of inoculation[a]	Pathogenicity[b]
Alternaria spp.	4	Foliage	1
Ascochyta fabae f. sp. *lentis*	6	Seed/foliage	2.5–3.5
Aspergillus sp.	1	Foliage	1
Botrytis cinerea	8	Soil/seed/foliage	4–5
Cladosporium spp.	4	Seed/foliage	1
Fusarium acuminatum	6	Soil	2–3
F. avenaceum	6	Soil	3–4
F. culmorum	1	Soil	1
F. equiseti	6	Soil	1
F. oxysporum	4	Soil	1
F. sambucinum	1	Soil	1
F. solani	3	Soil	1
Macrophomina phaseolina	1	Soil	2
Mucor sp.	1	Foliage	1
Nigrospora sp.	1	Foliage	1
Penicillium sp.	2	Foliage	2
Phoma medicaginis var. *pinodella*	8	Soil/seed/foliage	2–3
Rhizoctonia solani	3	Soil	3–4
Rhizopus sp.	1	Foliage	1
Sclerotinia sclerotiorum	3	Soil	3–4
Stemphylium	4	Foliage	1

[a] Foliage = plants were inoculated with a spore suspension of about 1×10^6 spores per milliliter. Seed = seeds were inoculated with a spore suspension of about 1×10^6 spores per milliliter before being planted in sterile potting medium. Soil = seeds were planted in sterile potting medium infested with mycelium of the fungus from one potato-dextrose agar culture.

[b] Pathogenicity of each fungal isolate to the roots and/or the foliage of lentil test plants was based on a disease index scale of 1–5 where 1 = healthy tissues, 2 = 1–10, 3 = 11–25, 4 = 26–50, and 5 = more than 50% necrosis of inoculated tissues.

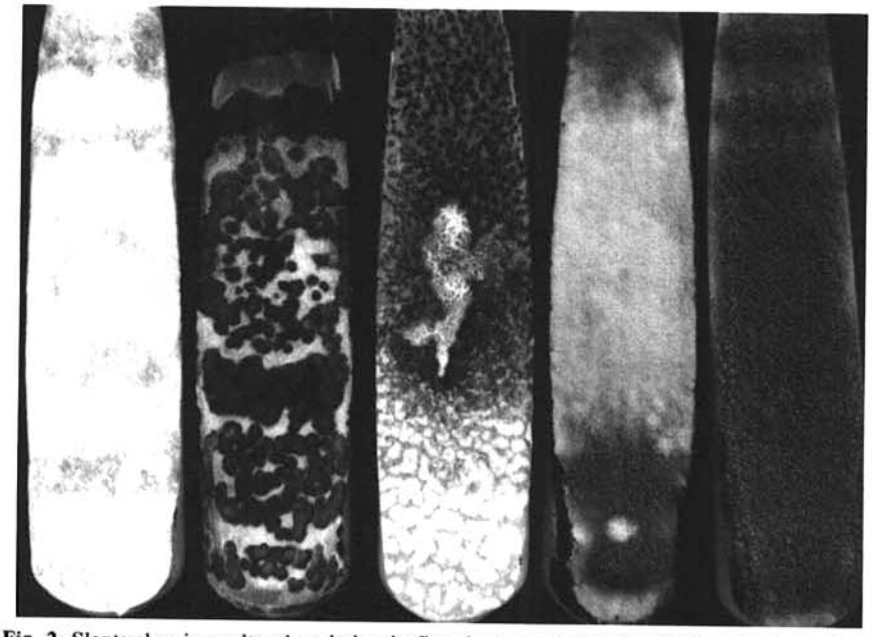

Fig. 2. Slants showing cultural variation in five single-spore isolates of *Botrytis cinerea* from commercial lentil seeds from northern Idaho and eastern Washington.

spp. from lentil seeds in the present study, isolates of *F. equiseti* failed to cause a root rot of lentil in repeated inoculation tests. Lin and Cook (9) demonstrated that *F. avenaceum* caused a root rot of lentils in the Palouse region, particularly under certain field conditions, such as direct-seeding lentil into undisturbed, dead bluegrass sod. Carrera and Noll (3) found several *Fusarium* spp., including *F. avenaceum*, associated with a root rot of lentil in Uruguay. Sumar and Howard (16) isolated *F. acuminatum* from lentil seeds in Canada, but they did not test the pathogenicity of the fungus to lentil. One isolate of *F. s. pisi* from lentil seeds collected in 1985 was highly pathogenic to the roots of chickpea and pea but not lentil. Lin and Cook (9) showed that *F. s. pisi* caused a black root rot of lentil at high (25–30 C) but not at low (20 C or below) soil temperatures. In the Palouse region, *F. s. pisi* would not normally be a pathogen of lentil because mean soil temperatures during the lentil growing season are less than 25 C.

With lush plant growth, a dense canopy, and high moisture conditions, *S. sclerotiorum* can severely damage lentils in the Palouse region (1). Sclerotia of *S. sclerotiorum* often are observed on tissues of infected plants, particularly stems. The pathogen was isolated most frequently from commercial lentil seeds in the Palouse region in 1983, when 18% of the samples were infected. Sclerotia of *S. sclerotiorum* were not detected among or on seeds from which the fungus was isolated, indicating that the fungus survived in infected seeds as mycelium. Mycelial infection of seeds by *S. sclerotiorum* has been reported for several plant species, including bean (17), *Trifolium incarnatum* L. (8), soybean (13), and *Brassica* spp. (11).

Ascochyta blight is a relatively new disease of lentil in the Pacific Northwest (7). The pathogen was isolated from a small number of seeds from commercial fields in Idaho and Washington in 1982 and 1983. However *A. f. lentis* was not observed infecting lentil plants in commercial plantings until the 1991 crop season. In 1991, Ascochyta blight was observed in several fields of lentil cv. Spanish Brown in Nez Perce and Latah counties of northern Idaho. Apparently, seed of Spanish Brown planted in the spring of 1991 was infected with the blight pathogen. The incidence of Ascochyta blight was high in many fields. Environmental conditions (cool, wet weather) during May and June favored disease spread and development. In some heavily infected fields, yields were reduced by 30–50%.

Until the present study, little was known concerning the incidence and importance of seed transmitted fungal pathogens of lentil in the Pacific Northwest. The incidence of eight seedborne pathogens varied greatly from year to

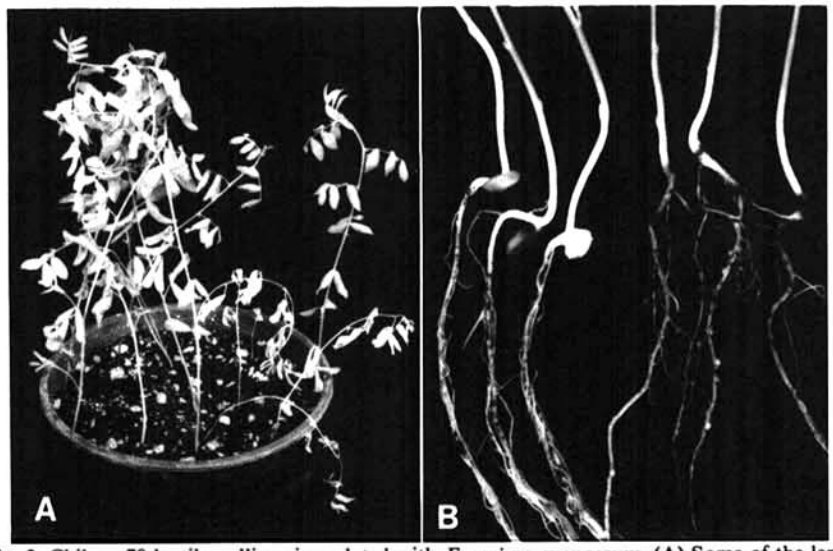

Fig. 3. Chilean 78 lentil seedlings inoculated with *Fusarium avenaceum*. **(A)** Some of the lentil seeds planted in greenhouse potting mix infested with *F. avenaceum* are beginning to wilt and die (right). **(B)** Roots of lentils inoculated with *F. avenaceum* are necrotic and discolored (three on right); roots of healthy plants (three on left).

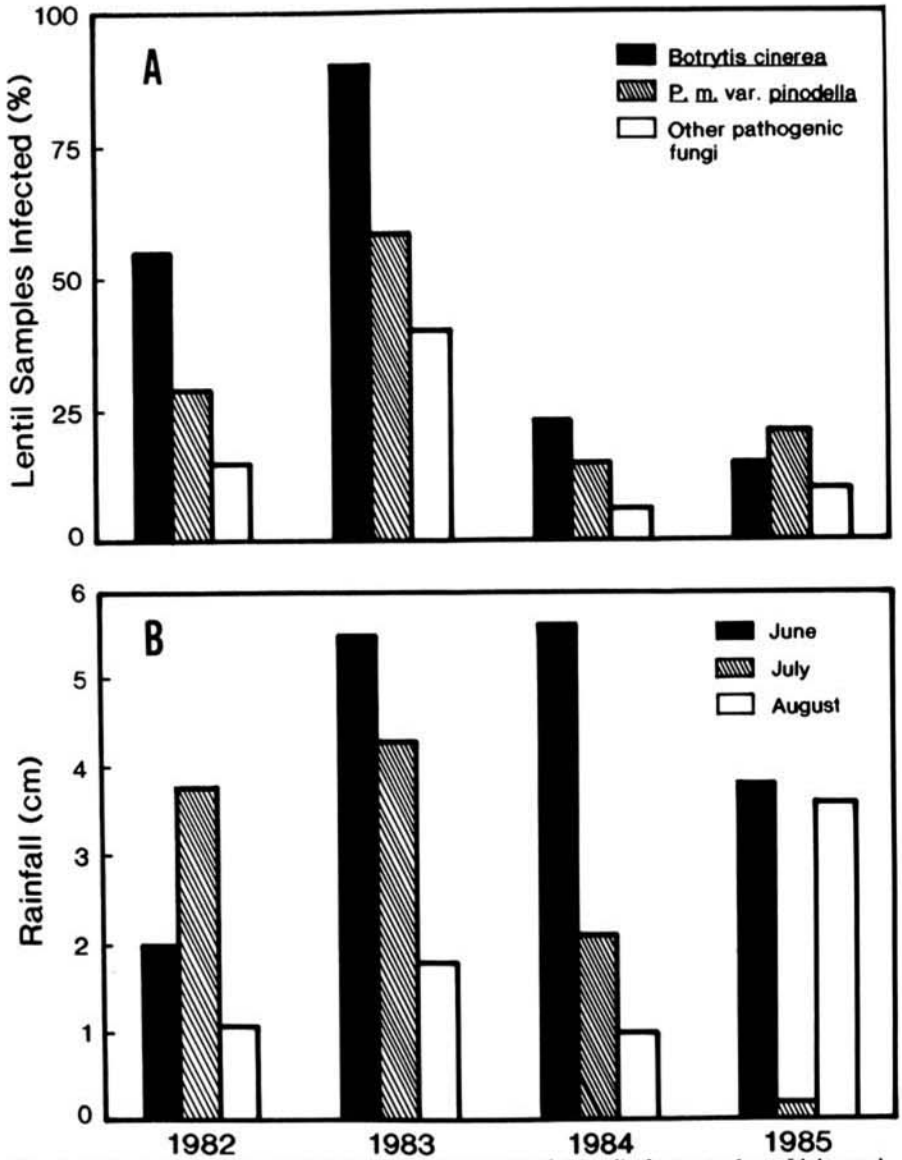

Fig. 4. Pathogenic fungi isolated from seeds of commercial lentils from northern Idaho and eastern Washington. **(A)** Incidence of *Botrytis cinerea, Phoma medicaginis* var. *pinodella* and other pathogenic seedborne fungi isolated from lentil seeds during 1982–1985. **(B)** Total rainfall for the period June–August 1982–1985 in Pullman, WA.

year but appeared to be associated with rainfall during July when the crop was maturing. These fungal pathogens adversely affected lentil seed quality and contributed to the poorer quality observed in the 1983 crop. Research is needed on the effects of different environmental conditions, such as rain, temperature, humidity, and dew, on infection of lentil seeds under field conditions, and on whether the method of harvesting the crop, e.g., direct combining vs. windrow, affects the frequency of seed infection by fungal pathogens.

ACKNOWLEDGMENTS

I thank Larry Zehm, Leroy Baker, Lavoir Duvall, and Vicki Kottke, Federal Grain Inspection Service, USDA, Moscow, ID, and Gary Bergley, Washington State Department of Agriculture, Grain Inspection Office, Colfax, WA, for their help in providing lentil samples from 1982 to 1985. I also thank Charles Sulzbach and Barbara Hellier for their technical assistance and all who helped in fungal identification.

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