Incidence and Survival of *Cylindrocladium parasiticum* in Peanut Seed

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ABSTRACT

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Sixty-three commercial seed lots of peanut produced in Virginia were examined for the presence of seed with speckled testae. Speckled seed were present in seed lots from the 1998, 1999, and 2000 growing seasons at average rates of 3, 1.2, and 0.6%, respectively. Speckled and normal seed from 19 seed lots were assayed on a medium selective for *C. parasiticum*. The fungus was isolated from speckled seed at rates ranging from 40 to 96%. *C. parasiticum* was isolated only from a single normal seed from one seed lot. The pathogen was recovered at high rates from speckled seed immediately after pods had been dried in commercial drying trailers at temperatures up to 35°C. Ambient temperatures during winter seed storage that fluctuated from -10 to 28°C in 1999 and -8 to 33°C in 2000 greatly reduced pathogen recovery in speckled seed stored for 16 or 24 weeks. In field plots with naturally infested soil, the number of speckled seed harvested was directly correlated to the number of symptomatic plants in plots on 29 September. Based on this finding, the harvest of seed peanuts in areas of a field with high incidence of *Cylindrocladium* black rot (CBR) should be avoided. Adoption of this policy is expected to lower the number of speckled seed entering commercial seed lots and reduce the risk for spread of CBR.

Additional keywords: *Arachis hypogaea*, *Calonectria ilicicola*, *Cylindrocladium* black rot, groundnut, seed transmission

Cylindrocladium parasiticum Crous, Wingfield & Alfenas is a soilborne fungus that causes *Cylindrocladium* black rot (CBR) of peanut (*Arachis hypogaea* L.), a disease of economic importance to Virginia and North Carolina (2,3,6). Under favorable conditions, overwintering microsclerotia germinate and infect peanut roots, causing decay. Leaves of infected plants appear chlorotic and wilted and infection eventually leads to plant death. Hypocotyls, pegs, pods, and seed are also susceptible to infection. *C. parasiticum* has been isolated from peanut seed on several occasions (10,11,13). Therefore, disease spread from the planting of infected seed is a concern. In early studies, seed transmission was considered unlikely given that *C. parasiticum* could not be isolated from fungicide-treated seed and discolored seed were removed from commercial seed lots during routine handling procedures (10,11). In recent years, a higher-than-expected incidence of CBR has been observed in some Virginia fields treated with metam

sodium for control of soilborne inoculum. For this reason, seed transmission of *C. parasiticum* is being reexamined as a potential means of disease spread.

The symptom description of peanut seed with cinnamon-brown speckling on the testae given by Randall-Schadel recently has been related to recovery of *C. parasiticum* (13). Speckled seed are defined as having dots or flecks 0.1 to 0.6 by 0.1 to 0.4 mm in area clustered on part or all of the testa. Using electron microscopy, Randall-Schadel observed hyphae and microsclerotia of *C. parasiticum* on and within the multicellular layers of the testae of speckled seed (13). Fungal structures were rarely found to penetrate below the inner layer of the testae.

In a survey of 62 commercial seed lots conducted in 1993, speckled seed were found in VC 1, NC 6, NC 7, NC 9, NC 10C, NC-V 11, VA-C 92R, and Florigiant cultivars in the Virginia-North Carolina region (13). *C. parasiticum* was isolated from speckled seed present in seed lots of NC 7 and NC 10C at rates ranging from 4 to 45%, and recent field trials have indicated that seed transmission of *C. parasiticum* can occur when these seed are planted in fields. The levels of speckled seed and viable inoculum found in recent commercial seed lots in Virginia, including additional cultivars important to the peanut industry such as NC 12C, Gregory, VA 98R, and Perry, have not been determined.

In other seedborne diseases, postharvest measures that include heat treatment can

reduce pathogen survival in seed. In rice, sun-drying harvested seed in the field can significantly reduce inoculum levels of *Pyricularia oryzae* in infected grain (7). Dry heat treatments at temperatures of 71, 75, and 84°C reduced recovery of *Xanthomonas campestris* pv. *translucens* from infected barley seed (5). The conditions encountered during the commercial handling and storage of peanut seed from fall harvest to spring planting may affect survival of *C. parasiticum* in infected seed. Following combining, individual growers will dry whole pods in open trailers using forced air and supplemental heat until seed reach a moisture level around 10% (wt/wt). The temperature and duration of pod drying are dependent on weather conditions, but temperatures should not exceed 35°C, or 8°C above ambient temperatures (4). In order to expedite drying large quantities of seed, some growers may dry seed at temperatures higher than those recommended. The effect of high drying temperatures on survival of *C. parasiticum* in speckled seed is not known.

Dried pods are transported to commercial shelling plants where they are shelled and seed are sized, sorted to remove discolored kernels, and stored until spring. Seed should be stored under refrigerated conditions (1 to 5°C, with a relative humidity of 55 to 70%) in order to preserve seed quality (4). However, specific storage practices may vary among individual shelling plants. A previous study showed that pathogen survival in speckled seed declined when unshelled pods were stored in a warehouse for 8 months; however, viable inoculum was still present in seed at the time of planting (12). Viability of *C. parasiticum* in shelled, speckled seed from commercial seed lots following storage under recommended refrigerated conditions has not been studied.

The objectives of the present study were to determine the levels of speckled seed in commercial seed lots of popular cultivars in Virginia, to confirm the incidence of *C. parasiticum* in speckled seed, to examine the effects of pod drying and winter seed storage temperatures on survival of *C. parasiticum* in peanut seed, and to examine the relationship between CBR incidence and the production of speckled seed in the field.

MATERIALS AND METHODS

Survey of commercial seed. Seed samples weighing 200 to 1,000 g were collected from commercial shelling plants after pods were shelled and seed were

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electronically sorted to remove discolored seed. Seed of seven virginia-type peanut cultivars, NC-V 11, NC 7, NC 12C, Gregory, VA-C 92R, VA 98R, and Perry, were sampled. The number of seed lots sampled in 1998, 1999, and 2000 was 5, 20, and 38, respectively. The percentage of speckled seed in a sample was determined by count. The number of speckled seed expected in 45.4 kg of commercial seed (the quantity often used to plant 0.4 ha or 1 acre) was determined for each seed lot by multiplying the percentage of speckled seed in a sample by the approximate seed count in 45.4 kg of seed (14).

Seed assays. Commercial shellers began shelling peanut pods from grower fields soon after harvest in November 1999 and continued through January 2000. During this time, seed from 19 different seed lots of four cultivars (VA 98R, NC-V 11, VA-C 92R, and NC 7) were collected as seed lots were shelled. Following collection, 50 seed of each type (normal and speckled) were assayed on the following medium selective for *C. parasiticum*. Peeled potato slices (200 g) were autoclaved in 500 ml of distilled water for 40 min at 120°C and 103 kPa. The resulting potato broth was strained through two layers of cheese-cloth and added to 500 ml of distilled water containing 17 g of melted agar and 20 g of dextrose. Distilled water was added to yield a final volume of 1 liter and the medium was autoclaved for 10 min at 120°C and 103 kPa. The medium was amended with pentachloronitrobenzene (PCNB) (52.5 mg), thiabendazole (2.3 mg), chlortetracycline (100 mg), chloramphenicol (100 mg), and dicloran (2 mg).

Seed with intact testae were rinsed for 1 min under running water, cut latitudinally, and disinfested in a 0.26% sodium hypochlorite solution for 1 min. Both cut ends were placed in contact with the medium and five seed were assayed per petri plate. Plates were incubated at room temperature and observed for growth of *C. parasiticum* at regular intervals for 14 days.

After initial seed assays, speckled seed were stored in polyethylene bags in an incubator at 15°C. Fifty speckled seed from each seed lot were assayed again in June 2000 in order to determine the recovery rate of *C. parasiticum* from seed in early summer, soon after seed are routinely planted in the field. Seed lots were collected from shelling plants over a 3-month period; therefore, the duration between the initial and final seed assay varied among seed lots and ranged from 80 to 189 days.

Seed storage temperatures and pathogen survival. Two cultivars (NC-V 11 and VA 98R) were chosen to periodically examine the effect of controlled and ambient storage temperatures on survival of *C. parasiticum* in speckled seed. In 1999 and 2000, seed were collected from a commercial shelling plant and 50 speckled seed from one seed lot of each cultivar were assayed in January to determine initial pathogen recovery. Seed then were placed in cardboard boxes (8 by 6 by 5.5 cm) and stored in an unheated building and at controlled temperatures of -13, 4, and 15°C in 1999 and -24, 5, and 13°C in 2000. Differences in controlled temperatures in 1999 and 2000 were due to inconsistencies in equipment. Fifty seed were removed from each storage condition and assayed in March and again in May after 8 and 16

weeks of storage, respectively. In 1999, seed of NC-V 11 initially were assayed in November and assayed again at 8, 16, and 24 weeks after storage (January, March, and May, respectively). Maximum and minimum air temperatures were recorded for each storage location. For each seed lot, Duncan's new multiple range test ($P = 0.05$) was utilized to separate treatment means within each storage interval (SAS 8.0; SAS Institute Inc., Cary, NC).

Pod drying. Whole pods of VA 98R were obtained from a field having a high incidence of CBR in 2000. Pods were dug and harvested in October, separated into 4.5-kg samples, and placed in nylon-mesh bags. Samples were dried indoors using forced air (no heat) or outdoors in commercial drying trailers using forced air with supplemental heat. Watchdog weather sensors (Spectrum Technologies, Concord, NH) were placed in each sample bag and temperatures were recorded every 15 min. Samples to be dried with heat were secured at the bottom, middle, and top level (0, 0.7, and 1.4 m) of drying trailers. Sample bags placed in the bottom of the trailer were closest to the source of air and heat. Trailers then were filled with pods harvested from commercial grower fields. Pods were dried until they reached moisture levels required for pod shelling. Sample bags were removed, pods were shelled, and seed were sorted into normal and speckled seed. Fifty speckled seed were assayed from each sample as previously described. Five trials were conducted using different drying trailers at several locations in Suffolk, VA. Trials were conducted in October over a 12-day period as drying trailers became available from cooperative local growers. Levels of heat applied to drying trailers were decided upon by the growers and were dependent on outdoor temperatures at the time of pod drying. Duncan's new multiple range test ($P = 0.05$) was utilized to separate means for each drying condition. Means were averages from five trials.

CBR incidence and speckled seed. Fifteen field plots having a wide range of CBR incidence on 29 September 2000 (7 to 173 symptomatic plants/30.5 m or 100 ft of row) were selected to determine the relationship between aboveground disease symptoms and the production of speckled seed. Routine management practices (9) were followed for the control of other common pathogens of peanut including *Sclerotinia minor*, *Sclerotium rolfsii*, and *Rhizoctonia solani*. CBR incidence was measured as the number of wilted or dead plants per plot. Plant damage due to diseases other than CBR was minimal. Field plots were selected from three field trials in Suffolk, VA planted with either NC-V 11 or VA 98R. Plots were dug in early October and pods were harvested on 10 October with a two-row, Amadas combine having a bagger attachment for plot re-

Table 1. Incidence of speckled seed in commercial seed lots of peanut from the 1998, 1999, and 2000 growing seasons^a

Year, cultivar	No. seed lots ^b	Average speckled seed (%) ^c	No. speckled seed/45 kg ^d
1998			
NC-V 11	1	4.0	2,400
VA-C 92R	1	1.6	880
NC 7	1	4.0	2,000
NC 12C	1	3.0	1,500
Gregory	1	2.2	990
Yearly average	...	3.0	1,554
1999			
VA 98R	8	1.5	825
NC-V 11	4	1.9	1,125
VA-C 92R	3	0.9	513
NC 7	5	0.5	260
Yearly average	...	1.2	697
2000			
VA 98R	5	1.0	550
NC-V 11	7	0.3	206
VA-C 92R	6	0.5	394
NC 7	14	0.9	439
NC 12C	3	0.5	267
Perry	3	0.0	0
Yearly average	...	0.6	355

^a Speckled seed = seed with cinnamon-brown speckling on the testae (13).

^b Seed lots sampled after routine conditioning procedures at a commercial shelling plant.

^c Percentages determined by seed count.

^d Estimates based on the percentage of speckled seed in a sample and count per 454 g of seed for each cultivar.

search. Whole pods were dried with forced air and supplemental heat as recommended in the region until seed reached about 8 to 10% moisture content. Pods then were shelled and seed retained on a 6.4-by-25.4-mm slotted screen were sampled. For each field plot, a sample weighing 1.5 kg was collected and the number of speckled seed in each sample counted. A linear regression model in SAS was utilized to determine if the percentage of speckled seed was correlated ($P = 0.01$) to aboveground disease incidence.

RESULTS

Survey of commercial seed. Speckled seed were found in 59 of the 63 seed lots sampled (Table 1). In 1998, 1999, and 2000, the average percentage of speckled seed in all samples was 3, 1.2, and 0.6%, respectively. The percentage of speckled seed across all years ranged from 0 to 4% and averaged 1%. The estimated number of speckled seed in a 45.4-kg sample ranged from 0 to 2,400.

Incidence of *C. parasiticum* in seed collected from commercial shelling plants. Among the 19 seed lots, pathogen recovery in speckled seed ranged from 40 to 96% when seed were assayed following collection from shelling plants during November 1999 to January 2000 (Table 2). Twelve lots had isolation frequencies of 80% or higher. *C. parasiticum* was isolated from only one normal seed of VA 98R. Other fungal pathogens of peanut isolated from seed included *Aspergillus niger*, *Rhizopus* sp., and *S. rolfii*. The occurrence of these fungi showed no apparent relationship to seed with speckled testae.

In June 2000, after seed lots had been stored at 15°C following collection from shelling plants, *C. parasiticum* was isolated from all 19 seed lots (Table 2). Recovery rates in June were lower for all seed lots compared with initial recovery rates. At the time of the second assay in June, recovery rates ranged from 4 to 78%. Rates were above 60% in all four seed lots of NC-V 11 and one of three seed lots of VA-C 92R. Lot 337 of VA-C 92R was heavily colonized by *Rhizopus* sp., making identification of *C. parasiticum* difficult.

Seed storage temperatures and pathogen survival. Ambient temperatures over the duration of the study in 1999 ranged from -10 to 28°C, with an average weekly minimum and maximum of 3 and 18°C, respectively. Before storage, *C. parasiticum* was isolated from 1999 seed of VA 98R at a rate of 76%. In May, after 16 weeks of storage, pathogen recovery was significantly lower in seed stored under ambient conditions compared with all other treatments (Fig. 1A). Recovery rates were 62, 76, 38, and 12% for seed stored at -13, 4, and 15°C and ambient conditions, respectively. In NC-V 11, the initial recovery rate was 97% before storage and rates were similar among all treatments

until May, at 24 weeks after storage. At that time, recovery was significantly lower in seed stored under ambient conditions compared with all other treatments (Fig. 1B). *C. parasiticum* was isolated from seed stored at -13, 4, and 15°C and ambient conditions at rates of 92, 88, 82, and 28%, respectively.

In 2000, ambient storage temperatures ranged from -8 to 33°C. As in 1999, storage of VA 98R and NC-V 11 seed at ambient conditions resulted in the lowest pathogen recovery rates by the end of the study in May (Fig. 1C and D). In VA 98R, recovery rates were significantly lower in seed stored under ambient conditions compared with all other treatments. The initial recovery rate of 68% was reduced to 50, 44, 26, and 4%, after storage at -24, 5, and 13°C and ambient temperatures, respectively. In NC-V 11, an initial recovery rate of 78% was reduced to 42, 34, 18, and 8% at the respective temperatures. Pathogen recovery in seed stored under ambient conditions was significantly lower than all other treatments except storage at 13°C for NC-V 11 in 2000.

Pathogen survival after pod drying. Temperatures encountered during the drying of pods varied among drying conditions as well as among the five trials. The maximum temperatures in each trial were highest in drying trailers near the source of heat (i.e., bottom of trailers) and lowest indoors where pods were air dried with no

supplemental heat (Table 3). *C. parasiticum* survived at high rates ($\geq 97\%$) in speckled seed dried under all conditions (Table 3).

CBR incidence and speckled seed. Speckled seed were present in all 15 samples from field plots where plants had exhibited symptoms of CBR. The percentage of speckled seed ranged from 1.5 to 12.3%. A significant linear relationship ($r^2 = 0.70$) existed between CBR incidence in the field and the percentage of speckled seed produced (Fig. 2). Field plots having a high incidence of CBR led to the production of greater numbers of speckled seed than those with low disease incidence.

DISCUSSION

CBR can be found in approximately 75% of Virginia's peanut acreage; therefore, it is not surprising that infected seed are produced in commercial fields. Metam sodium is routinely applied under bedded soil 2 weeks prior to planting in fields heavily infested with *C. parasiticum* (9). Under favorable conditions, the chemical converts to methyl-isothiocyanate (MIT) and diffuses upward through soil, killing soilborne inoculum in the area of taproot growth (8,15). When pods develop outside the treated zone, they may become infected and result in the production of speckled seed.

In a 1993 survey of 62 commercial seed lots from the North Carolina-Virginia

Table 2. Recovery of *Cylindrocladium parasiticum* from speckled peanut seed from 19 seed lots following collection from commercial shelling plants (November 1999 to January 2000) and again in June 2000 after storage at 15°C

Cultivar/seedlot	Date of initial assay	Seed assay (% positive) ^a	
		Initial	June 2000
VA 98R			
314	23 November 99	90	32
315	23 November 99	88	8
316	23 November 99	94	18
318	11 December 99	88	4
319	11 December 99	66	12
320	11 December 99	64	6
321	12 December 99	44	6
Average	...	76	12
NC-V 11			
322	30 December 99	90	78
323	30 December 99	88	72
324	13 January 00	86	74
325	19 January 00	96	68
Average	...	90	73
VA-C 92R			
330	22 December 99	82	64
331	23 December 99	86	48
337	13 January 00	80	6 ^b
Average	...	83	39
NC 7			
338	19 January 00	80	22
339	21 January 00	76	20
340	22 January 00	74	10
341	12 March 00	40	18
342	12 March 00	40	14
Average	...	62	17

^a Data are recovery percentages of *C. parasiticum* from 50 seed. Seed were assayed on a selective medium.

^b Seed heavily colonized by *Rhizopus* sp., making recognition of *C. parasiticum* difficult.

growing region, Randall-Schadel reported that speckled seed were present at rates from 0 to 5.6%, with an average occurrence of 1.3% (13). In the current study, commercial seed lots from Virginia were sampled in 1998, 1999, and 2000. During these years, the estimated yield loss due to CBR in the state was 3, 4, and 8% of total potential yield in the absence of symptoms. Total acreage planted to peanut was comparable (75,000, 76,000, and

75,000) among all 3 years (1). Speckled seed were found in seed lots at average rates of 3, 1.2, and 0.6% in 1998, 1999, and 2000, respectively. Cooperative work with shellers of seed peanuts may be responsible for the low levels of speckled seed present in seed lots in 2000 despite high levels of CBR that year. Current sorting practices do not remove all speckled seed from seed lots. However, it is expected that increased awareness of the

problem will reduce the number of infected seed entering commercial seed lots in coming years.

Randall-Schadel recovered *C. parasiticum* from speckled seed harvested from research plots of NC 9, NC 10C, and NC-V 11 at rates of 32, 53, and 42%, respectively (13). In the current study, the pathogen was recovered from speckled seed from commercial seed lots of VA 98R, NC-V 11, VA-C 92R, and NC 7 at comparable or higher rates. Of the 19 seed lots assayed, pathogen recovery ranged from 40 to 96% when seed were assayed following collection from shelling plants. Seed lots may have encountered varied conditions prior to our collection from shelling plants, leading to differences in pathogen survival and recovery. Additional studies in which conditions are monitored immediately following pod harvest through winter seed storage may reveal key factors responsible for differences in pathogen recovery among seed lots. *C. parasiticum* was isolated from only one normal seed in one seed lot of VA 98R.

The pathogen was isolated from speckled seed of all 19 seed lots again in June 2000 after seed were maintained at 15°C following initial assays. Recovery rates were greater than 60% in four seed lots of NC-V 11 and one seed lot of VA-C 92R. With these high recovery rates, it is possible that these seed could have introduced viable inoculum to commercial grower fields if they had been stored under similar conditions (15°C) and sold for planting. All other seed lots had recovery rates of less than 48%. Due to differences in duration between initial and June 2000 assays, direct comparisons in pathogen survival rates among seed lots and cultivars cannot be made. Future studies should examine the significance of cultivar in pathogen survival in speckled seed. Physiological or chemical characteristics of the seed testae may impact survival of *C. parasiticum*.

High temperatures (up to 35°C) encountered during routine pod drying in commercial drying trailers had no significant impact on survival of *C. parasiticum* in seed. Pathogen recovery remained high when pods were dried using forced air with or without supplemental heat. In 2000, warm ambient temperatures and dry

Fig. 1. Recovery of *Cylindrocladium parasiticum* from speckled peanut seed during winter storage at ambient and controlled temperatures in 1999 **A**, VA 98R and **B**, NC-V 11, and 2000 **C**, VA 98R and **D**, NC-V 11. Bars with the same letter or no letters are not significantly different according to Duncan's new multiple range test ($P = 0.05$). Bars from left to right are -13, 4, and 15°C and ambient (-10 to 28°C) in 1999 and -24, 5, and 13°C and ambient (-8 to 33°C) in 2000.

Table 3. Recovery of *Cylindrocladium parasiticum* from speckled peanut seed of VA 98R after pods were dried indoors using forced air without supplemental heat or outdoors using forced air with supplemental heat at three positions within commercial drying trailers (top, middle, and bottom) in 2000

Drying condition	Maximum temperature (°C) ^a					Seed assay (% positive) ^b
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	
Air	26.6	22.5	27.0	27.5	26.5	97.6
Heat, top	32.5	24.8	27.8	26.8	26.5	98.0
Heat, middle	33.5	28.3	...	30.8	27.0	98.4
Heat, bottom	35.4	30.0	33.5	32.3	29.5	97.6

^a Maximum temperature reached at each drying condition from five separate trials conducted over a 12-day period.

^b Data are recovery percentages of *C. parasiticum* from 50 seed averaged across five trials. Seed were assayed on a selective medium. Means were not significantly different according to Duncan's new multiple range test ($P = 0.05$).

conditions following harvest provided ideal conditions for pod drying in the field. As a result, the need for supplemental heat in drying trailers to further reduce seed moisture to recommended levels was minimal. Longer exposure to high temperatures encountered during pod drying may have a greater effect on pathogen survival in years with normal rainfall during harvest.

In the present study, recovery of *C. parasiticum* declined in all four seed lots of VA 98R and NC-V 11 during winter seed storage at all temperature treatments. However, *C. parasiticum* still was isolated from some speckled seed at high rates by the end of the study. The fungus survived well in speckled seed stored at temperatures recommended for commercial winter seed storage (1 to 5°C) (4). In May, when seed are planted in Virginia, *C. parasiticum* was recovered from speckled seed of NC-V 11 and VA 98R at rates of 88 and 76%, respectively, after storage at 4°C throughout the winter of 1999. Based on the present study, storing seed at ambient temperatures can greatly reduce pathogen survival, thereby reducing the risk for spread of CBR from seed-borne inoculum. Temperature fluctuations encountered in ambient storage may be responsible for the reduction in pathogen survival. Further research may reveal ideal winter storage temperatures for complete eradication of *C. parasiticum* in peanut seed.

The wide variation in pathogen survival in speckled seed among seed lots makes it

difficult to predict the overall role these seed have in dispersal of *C. parasiticum*. Not all speckled seed pose an equal threat for spread of CBR. However, in some commercial lots, infected seed are present and seedborne *C. parasiticum* remains viable at high rates at planting. Therefore, seed transmission of *C. parasiticum* poses a threat for spread of CBR.

In the present study, the percentage of speckled seed harvested was directly correlated to the number of plants with aboveground disease symptoms. Previous research also has noted a significant linear relationship between disease incidence in the field and the percentage of speckled seed produced in some cultivars (12). These findings suggest that the levels of speckled seed entering the commercial seed industry can be reduced if seedsmen avoid harvesting peanuts for seed in areas of the field where CBR incidence is high. A linear regression model based on data over multiple years may be useful in determining a practical allowable limit for CBR incidence in seed production fields. Careful scouting for CBR incidence prior to harvest will identify areas within fields that exceed the recommended disease threshold and should be avoided during harvest. The number of speckled seed can be further reduced as shellers continue to remove darkened seed during already established routine cleaning procedures. For speckled seed that escape the above management strategies, application of a seed treatment

fungicide effective against *C. parasiticum* will reduce the risk of seed transmission in the field. The continued cooperative efforts of researchers, seedsmen, and shellers can minimize the spread of CBR from speckled seed.

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Fig. 2. Relationship between aboveground symptoms of *Cylindrocladium* black rot and the percentage of speckled seed harvested from test plots in 2000. Data are from 15 samples collected from field plots planted with NC-V 11 or VA 98R.