Flower Blight and Scape Girdling of Onion Grown for Seed Production in New York

G. R. Ramsey and J. W. Lorbeer

Research assistant and professor, Department of Plant Pathology, New York State College of Agriculture and Life Sciences, Cornell University, Ithaca 14853.

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ABSTRACT

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An epidemic of onion flower blight occurred in Orange County, New York, during the wet July of 1976. The disease occurred at low levels during the drier Julys of 1977–1981. Blighted onion umbels were categorized into four symptom types (types 1–4), from umbels with a small group of blighted florets to umbels with all the florets or seed capsules blighted. For type 1, infection occurred near the bases of pedicels from which *Botrytis allii* was most frequently isolated during 1980, but *B. cinerea* and *B. byssoidea* were isolated occasionally. For types 2–4, infections occurred above the base of pedicels and the symptom types were differentiated by the number, development stage, and pattern of blighted florets. From umbels of these types, *B. cinerea* and *B. allii* were isolated most frequently in 1980, with occasional *B. squamosa* and *B. byssoidea*. All four *Botrytis* species were isolated each year from 1976 to 1981 from florets excised from umbels with the two most commonly observed symptom types, 2 and 3. During 1976, *B. squamosa* was isolated from blighted florets more frequently, and *B. allii* less frequently, than during 1977–1981. Numbers of conidia of *B. squamosa* trapped in July were 16 times higher during 1976 than during 1977–1982.

Additional key words: *Allium cepa*, epidemiology.

Ellerbrock and Lorbeer (2) reported that *Botrytis squamosa* Walker, *B. cinerea* Pers. ex Fr., and *B. allii* Munn (*B. allii* may be a taxonomic synonym of *B. aclada* Fres.) each caused flower blight of onion (*Allium cepa* L.) when umbels were artificially inoculated in the field during the rainy summer of 1975. *B. squamosa*, *B. cinerea*, *B. allii*, and *B. byssoidea* Walker were isolated from naturally blighted florets collected by Ellerbrock and Lorbeer (2) during 1975. In dew chamber studies, Ramsey and Lorbeer (6) demonstrated that *B. squamosa*, *B. cinerea*, and *B. allii* were each pathogenic on onion umbels and that each species when inoculated individually caused onion flower blight. They demonstrated that open florets were more susceptible to blighting by each of the pathogens than were unopen florets or immature seed capsules.

Girdling of onion seed stalks (scapes) by *Botrytis* species was reported in Orange County by Ellerbrock and Lorbeer (2), where it was less important than flower blight during the rainy 1975 season. In dew-chamber studies, *B. squamosa*, *B. cinerea*, and *B. allii* each formed lesions on onion scapes, but only those caused by *B. squamosa* and *B. allii* expanded sufficiently to girdle the scape and abort the umbel (6).

Each of the *Botrytis* species isolated from onion florets or scapes is pathogenic to other parts of the onion. *B. squamosa* causes Botrytis leaf blight (4), *B. cinerea* causes Botrytis leaf fleck (4) and Botrytis brown stain (1), *B. allii* causes Botrytis neck rot (5), and *B. byssoidea* causes mycelial neck rot (7).

The study reported here was conducted to monitor the incidence of flower blight and scape girdling of onion in Orange County over several years, to observe and classify field symptoms of both diseases into specific symptom types, to demonstrate the incidence of each *Botrytis* species in blighted tissue of umbels and scapes classified into the different symptom types and their relative incidence in blighted onion florets during different years, and to demonstrate if systemic infection of scapes was responsible at least in part for scape girdling under field conditions.

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MATERIALS AND METHODS

Disease monitoring and spore trapping. Blighting of umbels and girdling of scapes were observed in onion seed production fields in Orange County during 1976–1981. If infection was initiated at or below the attachment of the umbel to the scape, the disorder was assessed as scape girdling even if the umbel later became infected. If infection was initiated at a location above the attachment of the umbel to the scape, the disorder was assessed as onion flower blight even if the scape later became infected.

Blighted umbels were categorized into four symptom types (types 1–4) based on the number, the developmental stage, and the pattern of blighted florets on umbels. In type 1, blighting was confined to a small group of florets, usually unopen, near the base of the umbel (Fig. 1A). In type 2, variable numbers of florets were blighted in an apparent random pattern on umbels with the majority of the florets open (Fig. 1B). In type 3, all of the florets were blighted on umbels with the majority of the florets open (Fig. 1C). In type 4, variable numbers of immature seed capsules were blighted on umbels consisting almost entirely of immature seed capsules (Fig. 1D).

Girdled scapes were categorized into two symptom types (types A and B) based on the position on the scape at which girdling occurred. In the most common type (type A) of scape girdling, infection was initiated near the base of the umbel and the pathogen progressed downward, girdling the scape. *B. allii* usually was observed sporulating on girdled areas of the scape and occasionally observed sporulating on an umbel which apparently had been invaded from the girdled scape (Fig. 1E). In the less common type of scape girdling (type B), infection was initiated below the attachment of the umbel and the scape was girdled in this area. Scapes often toppled over at the site of girdling and sclerotia of *B. squamosa* usually were observed on the girdled areas of these scapes (Fig. 1F).

Incidence of flower blight and scape girdling in Orange County onion seed production fields was assessed by selecting at random 500 scapes with intact umbels in each field and calculating the percentages of blighted umbels and girdled scapes. Umbels were recorded as blighted or healthy and incidence of the different symptom types was not quantified. Girdled scapes were recorded as either type A or B. These disease assessments were conducted 12–20 July in seven fields in 1976, 11 fields in 1977, and 10 fields each year

from 1978 to 1981. The most common cultivars in the fields were homegrown Early Yellow Globe and Early Yellow Medium. Due to crop rotation it was not possible to monitor all of the same fields each year.

Levels of airborne conidia of *B. squamosa* near onion seed production fields in Orange County were determined by utilizing a Hirst spore trap (D. F. Casella and Co., Ltd., London, England). The spore trap was located in an onion bulb production field within 2.5 km of all the onion seed fields monitored from 1976 to 1981. Seed production fields in Orange County characteristically are interspersed with onion bulb production fields.

Fungal isolations. In all fungal isolations, diseased tissue from umbels or scapes was plated in plastic petri dishes (9-cm diameter) containing 15 ml of potato-dextrose agar (PDA, Difco Laboratories, Detroit, MI) acidified with one drop of 90% lactic acid (APDA). The dishes were incubated for 7–10 days at room temperature under fluorescent lights (Sylvania F20T12/CW, Sylvania Lighting Co., Danvers, MA) with a 14-hr photoperiod. The dishes then were examined for fungal growth and, if necessary, transfers were made to PDA slants to confirm identifications. All fungal isolations were made on APDA from the homegrown onion cultivars Early Yellow Globe and Early Yellow Medium after surface disinfestation for 3 min (florets) or 4 min (scapes) in 0.5% sodium hypochlorite solution.

To indicate the relative incidence of *B. squamosa*, *B. cinerea*, *B. allii*, and *B. byssoidea* in tissue of blighted onion florets, isolations were conducted from surface-disinfested, blighted, open florets excised from the commonest types of umbels (types 2 and 3) from 1976 to 1981. Each season, 150 florets were randomly selected from a sample of 300–500 blighted open florets that had been excised from the umbels.

To determine the role of each *Botrytis* species in the development of each of the four types of blighted umbels, isolations were made from 100 surface-disinfested blighted florets excised from umbels of each symptom type during 1980.

To indicate if a specificity of either *B. squamosa*, *B. cinerea*, *B. allii*, or *B. byssoidea* occurred for infection and/or colonization of a particular part or parts of florets, blighted open florets were surface-disinfested and then dissected aseptically into the constituent parts (ovary, style, stamens, petals, pedicel). The parts of each floret then were plated separately on APDA, but petri dishes were labeled so that all the parts of a particular floret could be identified. Notation also was made of florets that had been excised from the same umbels.

To determine the incidence of each *Botrytis* species in the necrotic tissue of girdled scapes, isolations were made in 1976, 1980, and 1981 from scapes girdled at the attachment of the umbel (type A scape). Isolations also were made during 1976 and 1980 from scapes girdled below the attachment of the umbel (type B scape). In isolations on APDA from either type of girdled scape, a section of scape which included the margin(s) of the blighted area was excised and surface-disinfested for 4 min. Tissue sections were cut from the upper and lower margins of the girdled area of type B scapes. For type A scapes there was no definite upper margin of the girdled area and, therefore, tissue sections were cut only from the lower margin.

To demonstrate if scape girdling was in part due to an internal infection of the scape in which the pathogen progressed symptomlessly up from the bulb or down from the umbel, fungal isolations were made on APDA from the apparently healthy tissue surrounding girdled areas of type A and B scapes during 1980. Sections of type A scapes that extended from the attachment of the umbel to 20 cm below the lower margin of the girdled area and sections of type B scapes that extended 10 cm above and below the margins of the girdled area were excised and surface-disinfested for 4 min. For type A scapes, small tissue sections were cut aseptically from the margin of the girdled area and at 1-, 2-, 4-, 8-, and 16-cm intervals below the girdled area. For type B scapes, tissue sections were cut aseptically from the upper and lower margins of the girdled area and at 1-, 2-, 4-, and 8-cm intervals both above and below the girdled area.

TABLE 1. Airborne conidia of *Botrytis squamosa* and incidence of onion flower blight in Orange County, New York (1976–1981)

Growing season	Conidia of *B. squamosa* counted (July)[a]	Onion flower blight incidence[b]	
		1%	10%
1976	649	100	100
1977	6	9	0
1978	3	10	0
1979	41	30	0
1980	23	40	0
1981	51	30	0

[a] Daily counts of conidia of *B. squamosa* were determined by mounting a glass slide (petrolatum coated and which had been exposed in a Hirst spore trap for 24 hr) in a compound microscope (×420) and counting the number of conidia of *B. squamosa* observed on the exposed area of the slide during two horizontal passes of the slide through the viewing field. The data represent the total number of conidia counted in this manner for the 31 days of July in the years 1976–1981.

[b] Onion flower blight incidence is the percentage of seed production fields during a given season in which 1% or more, or 10% or more, of the umbels were visibly blighted.

RESULTS

Disease monitoring and spore trapping. A severe blighting of onion umbels occurred in many onion seed fields in Orange County during 1976, the only year in which an epidemic occurred during 1976–1981. Moderate to near total losses in seed yield in these fields occurred in 1976. Rainy conditions prevailed during the flowering period of the umbels, which occurred mostly during July (135 mm rainfall). On 22 June, Botrytis leaf blight was observed at high levels on plants in the seven seed production fields that were monitored. On 6 July, onion flower blight was first observed in five of the same seven fields. The number of blighted umbels in these seed fields steadily increased to over 10% (Table 1) until harvest (4–10 August). During the months of July in 1977–1981, environmental conditions were relatively dry (46, 64, 53, 95, 87 mm of total rainfall from 1977–1981, respectively) and there were few blighted umbels in seed fields (less than 5% of the umbels in a field). The percentages of fields observed in which 1% or more of the umbels were visibly blighted from 1976 to 1981 were 100, 9, 10, 40, and 30%, respectively.

Umbels with symptom types 1–4 were observed each season from 1976 to 1981, but frequencies of each type were not determined. However, types 3 and 4 umbels were observed frequently during 1976 and relatively infrequently during 1977–1981. Type 2 umbels were the most common each season but were observed more frequently during 1976 than during 1977–1981. Observations indicated that infection of types 2–4 umbels occurred above the base of pedicels, usually on either the petals, stamens, or pistil of the florets. Sporulation of *B. squamosa* and/or *B. cinerea* was common on blighted florets during 1976 but was not observed during 1977–1981. Type 1 umbels were rare and usually were observed earlier in the season than were types 2–4 umbels. Observations indicated that infection on type 1 umbels occurred

Fig. 1. Blighted onion umbels and girdled scapes. **A–D,** Blighted umbels with four symptom types (types 1–4). **A,** Type 1—A small group of blighted florets, usually unopened, near the base of the umbel. **B,** Type 2—Variable numbers of florets blighted in an apparent random pattern on umbels with the majority of the florets open. **C,** Type 3—All of the florets blighted on umbels with the majority of florets open. **D,** Type 4—Differing numbers of immature seed capsules blighted on umbels consisting almost entirely of immature seed capsules. **E and F,** Two types of girdled scape (types A and B). **E,** Type A—Scape girdled at the attachment of the umbel. The invasion of *Botrytis allii* from the scape into the umbel is evinced by sporulation on both structures. **F,** Type B—Scape girdled below the attachment of the umbel. Sclerotia of *B. squamosa* are present on the girdled area of the scape.


A
B
C
D
E
F

near the base of pedicels and then colonization progressed upward into the floret and sometimes downward into the scape, producing an irregular necrotic area below the blighted florets. *B. allii* occasionally sporulated on this necrotic area and on the blighted florets during 1976–1981.

There was girdling of onion scapes in Orange County seed fields from 1976 to 1981. On scapes with the most common type of girdling symptom (type A scapes), infection apparently occurred at the base of the umbel and the pathogen progressed downward, girdling the scape and thereby indirectly causing death of the umbel. Occasionally, the umbels on scapes girdled in this manner apparently were invaded by *B. allii* as evinced by sporulation on florets (Fig. 1E). It was not always determined if the girdling of the scape had killed or weakened the umbel before colonization by *B. allii* occurred because scape girdling at the base of the umbel (type A scapes) usually resulted in total destruction of the umbel. This was observed on 1–3% of the scapes in seed fields from 1976 to 1981 with no pattern of incidence among seasons.

On scapes with the less common type of girdling symptom (type B scapes), infection occurred below the attachment of the umbel and the pathogen progressed both upward and downward, girdling the scape. Usually, the scape toppled over at the site of girdling and umbels on such scapes sometimes came in contact with the soil. Damage to umbels was due to the girdling of the scape and/or to decay which occurred where umbels touched the soil. Girdling was below the attachment of the umbel on 0–2% of the scapes in seed fields in 1976 and on 0–1% of the scapes from 1977 to 1981. Sclerotia of *B. squamosa* often were observed on girdled areas of these scapes.

The number of conidia of *B. squamosa* counted on slides from the Hirst spore trap during July was approximately 16 times higher during 1976 than during any other season from 1977 to 1981 (Table 1).

Fungal isolations. In isolations (1976–1981) from blighted open florets excised from umbels of the two most common symptom types (types 2 and 3), *B. cinerea* was isolated most frequently and *B. byssoidea* least frequently (Fig. 2A). The two species were isolated with similar frequency each season. Isolation frequency of *B. squamosa* and *B. allii* compared to the other species differed each season. Also, *B. squamosa* was isolated more frequently and *B. allii* less frequently during 1976 than during 1977–1981.

Blighted florets excised from umbels categorized into the four symptom types yielded different frequencies of the four *Botrytis* species during 1980 (Fig. 2B). *B. allii* was most frequently and *B. cinerea* and *B. byssoidea* infrequently isolated from florets excised from type 1 umbels. *B. cinerea* and *B. allii* were most frequently isolated from types 2–4 umbels, and *B. squamosa* less frequently than *B. cinerea* or *B. allii* but more frequently than *B. byssoidea*.

B. squamosa, *B. cinerea*, *B. allii*, and *B. byssoidea* were each isolated (often from the same umbel) from petals, pistils, stamens, and pedicels of blighted onion florets, indicating that these fungi had no specificity for infection and/or colonization of any floret part. If a particular *Botrytis* species was isolated from one part of a floret, it usually was isolated from all the parts.

For type A scapes, *B. allii* was isolated more frequently than either *B. cinerea* or *B. squamosa* in 1976, 1980, and 1981 (Fig. 2C). For type B scapes, *B. squamosa*, *B. allii*, and *B. cinerea* were isolated from 55, 10, and 5% of the scapes, respectively, from which isolations were made in 1976 and from 50, 37, and 12% of the scapes, respectively, from which isolations were made in 1980. No type B scapes were observed in 1981.

No fungi were isolated from healthy scape tissue below the girdled area on type A scapes or above and below the girdled area on type B scapes. This indicated that girdling of these scapes had not been due to an internal symptomless infection by one of the *Botrytis* species.

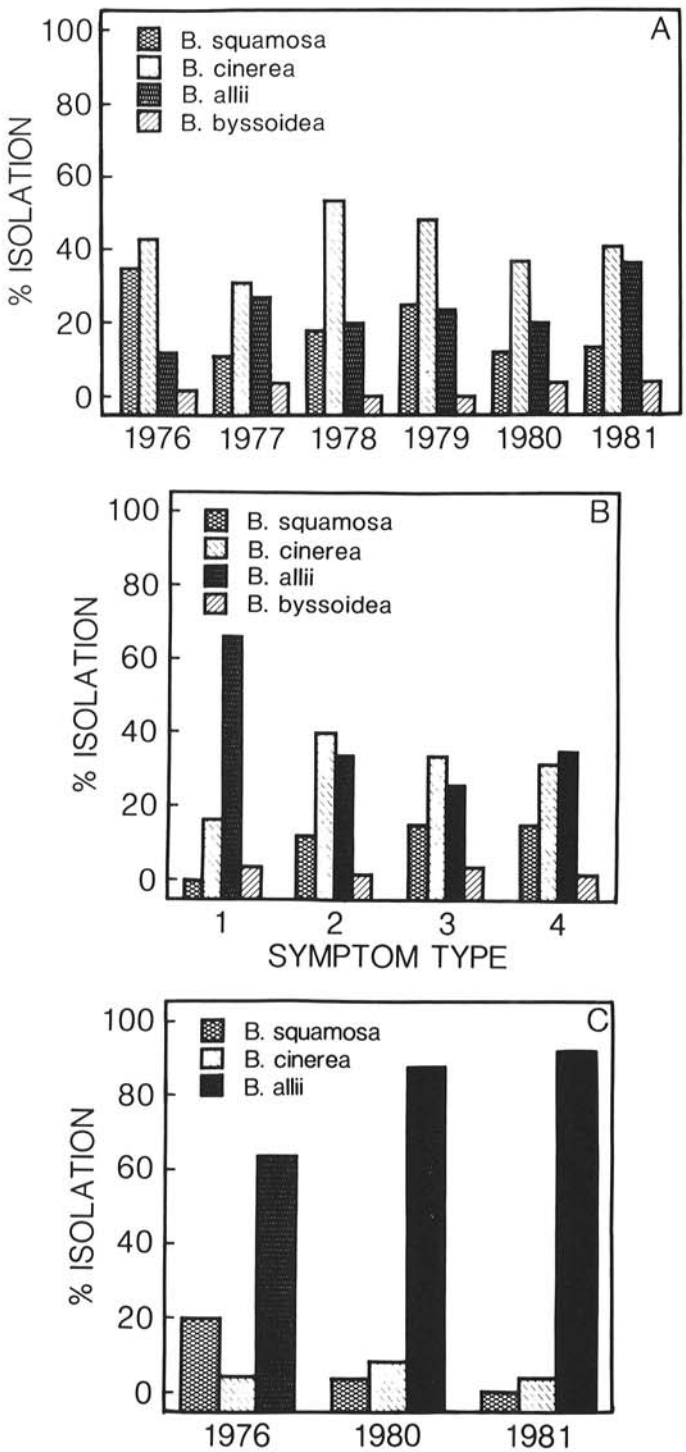

Fig. 2. Percentages of isolation of *Botrytis* species from blighted onion umbels and girdled scapes. **A,** The percentages of isolation of each *Botrytis* species from 150 randomly selected blighted open florets excised each year (1976–1981) from umbels of the two most commonly observed symptom types (types 2 and 3). **B,** The percentages of isolation of each *Botrytis* species from 100 randomly selected blighted florets or immature seed capsules excised from umbels of each symptom type (types 1–4) during 1980. **C,** The percentages of isolation of each *Botrytis* species from the margin of the girdled area of 25 randomly selected scapes girdled at the attachment of the umbel (type A scapes).

DISCUSSION

The range of symptoms of onion flower blight reported by Ellerbrock and Lorbeer (2) would be classified as symptom types 2–4 in the current study. Blighting of umbels categorized in these symptom types in the current study was due to the infection of florets above the base of the pedicel. Therefore, types 2–4 umbels differed only in the number, developmental stage, and pattern of blighted florets on umbels. Type 1 umbels differed from types 2–4 umbels in that infection occurred at or near the base of pedicels and the pathogen progressed upward into the florets and occasionally

downward into the scape, creating a necrotic area below the blighted florets. Because infection occurred at the base of pedicels, and florets were thereby directly infected, type 1 umbels were considered to represent flower blight rather than scape girdling even though the pathogen sometimes progressed into the scape. During the current study (1976–1981), types 2 and 3 umbels were observed more frequently than types 1 and 4 umbels.

When Ellerbrock and Lorbeer (2) made fungal isolations from blighted onion florets collected in Orange County, they isolated *B. cinerea*, *B. squamosa*, *B. allii*, and *B. byssoidea* from 40, 29, 15, and 3%, respectively, of the florets assayed. During the current study, the same four *Botrytis* species were isolated in 1976 from blighted florets from umbels of the two most common symptom types (types 2 and 3) in approximately the same proportions as reported by Ellerbrock and Lorbeer (2). In isolations conducted from 1977 to 1981, *B. cinerea* again was isolated most frequently from blighted onion florets from types 2 and 3 umbels. The relative incidence of the other three *Botrytis* species differed each year. Following dual inoculations, *B. cinerea* and *B. allii* were more readily reisolated from the resultant blighted florets than was *B. squamosa* (6). In addition, *B. cinerea* has been well documented as a secondary invader of diseased plant tissue. Therefore, isolation frequency could not be used to indicate the relative incidence of each of the *Botrytis* species in the tissue of blighted florets during any particular season. However, isolation frequency was considered valuable as an indication of the relative incidence of a particular *Botrytis* species in the tissue of blighted florets among seasons (1976–1981).

B. squamosa, *B. cinerea*, and *B. allii* are each pathogenic on onion umbels, but *B. squamosa* is more virulent than the other two species (6). The symptoms of onion flower blight caused by each pathogen are indistinguishable. Our isolation frequencies of these fungi complement the earlier work (6) and indicate that *B. squamosa*, *B. cinerea*, and *B. allii* comprise a pathogen complex causing onion flower blight as it occurs in Orange County. It also appears that the relative importance of each species in causing flower blight may vary each season. Two factors suggest that *B. squamosa* was an important pathogen in the 1976 onion flower blight epidemic: *B. squamosa* was isolated more frequently from blighted florets during 1976 than during 1977–1981; levels of airborne conidia of *B. squamosa* in the vicinity of onion seed production fields were approximately 16 times higher during July of 1976 than during the Julys of 1977–1981. Since *B. squamosa* is significantly more virulent than the other two species (6), it appears that this pathogen may have been the most important pathogen in the 1976 onion flower blight epidemic.

Blighted leaves in onion seed production fields in Orange County are major sources of primary inoculum contributing to Botrytis leaf blight epidemics (3). A Botrytis leaf blight epidemic coincided with the only onion flower blight epidemic (July 1976) that occurred during the current study (1976–1981). Blighted onion leaves in seed production fields probably acted as a source of inoculum during June to initiate the Botrytis leaf blight epidemic that occurred in July and August. The large numbers of conidia of *B. squamosa* produced in heavily blighted onion bulb production fields during July (1976) probably served as the inoculum for the onion flower blight epidemic that occurred at that time. During 1977–1981, outbreaks of Botrytis leaf blight occurred after onion seed had been harvested (August) and, therefore, onion bulb production fields most likely did not serve as a major source of inoculum for onion flower blight during these years. Epidemics of both Botrytis leaf blight and flower blight of onion occurred during periods when rainy conditions prevailed.

Ellerbrock and Lorbeer (2) suggested that in addition to blighting onion umbels, *B. squamosa* and *B. allii* could girdle onion scapes. In contrast to onion flower blight in which direct infection of florets by a *Botrytis* species destroyed part to all of an umbel, girdling of scapes affected umbels indirectly. Umbels on girdled scapes were partially to totally destroyed by lack of water and nutrients and/or by decay that occurred where toppled umbels touched the soil. During 1975 in Orange County, girdling at or below the attachment of the umbel was observed on less than 5% of the scapes in seed fields monitored, and the disease was of minor importance relative to onion flower blight (2). In the current study, 0–3% of the scapes were girdled in the seed fields monitored. *B. squamosa*, *B. cinerea*, and *B. allii* can each form lesions on onion scapes in the dew chamber (6). However, only lesions caused by *B. squamosa* and *B. allii* girdle the scape. Field observations made during the current study and observations by Ellerbrock and Lorbeer (2) indicated that girdling of scapes occurred more commonly at the attachment of the umbel than below this area. Scape girdling occurs as frequently below the attachment of the umbel as at the attachment when the scapes are incubated in the dew chamber following inoculation (6). Therefore, it seems probable that the higher incidence of scape girdling at the attachment of the umbel as observed in commercial seed fields in Orange County was due to this area remaining wet longer than areas lower on the scape. In furrow-irrigated onion seed fields in California, we have observed that *B. allii* may girdle the base of the scape. Girdling near the base of the scape was not commonly observed in Orange County during the current study, and scape girdling by *Botrytis* species presently appears to be of minor economic importance in New York.

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