Narcissus Fire: Prevalence, Epidemiology, and Control in Western Washington

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ABSTRACT

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Fire, a disease of *Narcissus* caused by *Botryotinia polyblastis*, has been observed in western Washington since 1978, but disease development has often been confused with natural senescence of foliage. Apothecia arose from overwintered sclerotia in naturally infested leaf debris during two of the last 4 yr in experimental plots. Initial apothecial production during 1980 and 1981 occurred in early April and mid-March, respectively. Apothecial numbers reached a peak after 2 wk, then gradually declined during the next 3–4 wk. Subsequent foliar infections by conidia from infected flowers appeared in late April during both years despite differences in the time of apothecial production. Initial foliar infections have been followed by rapid disease spread and foliage death within 3–6 wk. Rapid distal, then proximal, yellowing from infection sites coupled with limited lesion development indicates that a toxin is involved in symptom development. Applications of benomyl in late April and mid-May have consistently provided effective control of this disease.

Fire is a floral and foliar disease of *Narcissus*. *Botrytis polyblastis* Dowson was identified as the cause of this disease in 1928 (2). In 1939, Gregory (3) reported that *Sclerotinia polyblastis* Greg. was the teleomorph of *B. polyblastis*; however, teleomorphs of *Botrytis* spp. are currently referred to as *Botryotinia* Whetzell (8). This disease has been reported from the British Isles, coastal areas of the Pacific Northwest, and recently, from the Netherlands (1,2,9,11).

In the Pacific Northwest, Gould and Byther (6) indicated that fire is an uncommon disease. In fact, it has only been reported on two occasions, in 1935 and 1953 (1,9). During those years, fire occurred on experimental and commercial plantings of *Narcissus* in the Puyallup Valley and experimental plantings near Bellingham in western Washington.

Today, *Narcissus* is commercially produced in two principal locations in western Washington, namely the Skagit and Puyallup valleys. Smaller production areas include the Cowlitz River Valley near Mossyrock and the Woodland area in southwestern Washington. Observations since 1978 indicate that fire is prevalent throughout these production areas even though growers routinely apply fungicides such as mancozeb to control foliar disease. The prevalence of this disease and its epidemiology and control in western Washington have been studied since 1979 and are reported in this paper.

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MATERIALS AND METHODS

Prevalence. During 1979 and 1980, surveys of commercial *Narcissus* plantings in the Puyallup, Skagit, and Cowlitz River valleys were conducted during May and June to determine the prevalence of fire. Foliar symptoms were used to make field evaluations. Representative samples were collected to confirm the presence of *B. polyblastis*. Conformation was based on positive isolation of *B. polyblastis* from surface-sterilized pieces of diseased foliage after plating on potato-dextrose agar (PDA).

Apothecial production. Between 1979 and 1982, production of *B. polyblastis* apothecia was monitored in field plots on the Western Washington Research and Extension Center's Farm 2 located in the Puyallup Valley. Foliage residues were collected from commercial fields known to have had the disease each spring. Residues were stored under cover out of doors and allowed to air-dry. Each year during September or October, Bloemfontein *Narcissus* bulbs were planted in rows on 1.1-m centers. Bulbs were planted 15–20 cm deep with 10 bulbs per 0.3 m of row. Dinoseb (4.5 kg a.i./ha) and chlorpropham (4.5 kg a.i./ha) were applied over the surface of the soil shortly after planting to control weed growth. During October or November, dried foliage residues were evenly spread over the surfaces of the rows.

Production of apothecia by overwintered sclerotia was monitored by examining plots weekly starting in mid-February. After initial apothecial production, apothecia produced in nine 4.5-m-long (1980) or six 3.1-m-long (1981) sections of row were counted at weekly intervals.

Foliar symptom development. Symptom development and rate of disease development were monitored in a commercial planting of Bloemfontein *Narcissus* during 1979 and in experimental plantings during 1980 and 1981. Diseased foliage was harvested weekly from different plots after initial appearance of symptoms. Plots were in a randomized complete block design with three, eight, and five replicates per harvest date during 1979, 1980, and 1981, respectively. Each replicate consisted of 0.7–0.9 m of row. Incidence of infected foliage was determined by counting the diseased leaves in each plot. Infected leaves from individual plots were placed in a plastic bag and stored at 4 C.

The following data were collected for each leaf: 1) total number of fire lesions per leaf, 2) length of each lesion, 3) location of each lesion on the leaf, 4) total leaf length, and 5) extent of leaf yellowing. Leaf yellowing was rated on a 0–4 scale, where 0 = no yellowing, 1 = 1–25%, 2 = 26–50%, 3 = 51–75%, and 4 = 76–100% of leaf area yellowed.

To determine if leaf yellowing was a general response to injury or required the presence of *B. polyblastis*, five leaves on greenhouse-grown Bloemfontein *Narcissus* were inoculated with 5-mm-diameter mycelial plugs of *B. polyblastis* taken from the edge of a 3-day-old colony grown on PDA and five leaves were injured by removing a 6-mm-diameter leaf disk from the center of each leaf. Plants were placed in a dew chamber maintained at 20 C with 100% relative humidity and a 12-hr light (3,000–4,000 lux)/12-hr dark photoperiodic cycle. Symptom development was determined after 72 hr.

Control. Effectiveness of foliar applications of benomyl (Benlate 50W), mancozeb (Dithane M45), iprodione (Chipco 26019 50W), and vinclozolin (Ronilan 50W) in controlling disease development was determined in plantings of Bloemfontein *Narcissus* that had not been dug after the first growing season. Treatments were arranged in a randomized complete block design and each treatment was replicated three and four times during 1979 and 1980, respectively. Each replicate consisted of 4.6 m of row. During 1979, applications were made on 27 April and 18 May and in 1980, applications were made on 24 April and 8 May. All applications were made by spraying foliage with the equivalent of 935.4 L water plus 1.2 L Triton B-1956 per hectare with a Solo backpack sprayer (model 425). An unsprayed row in each block served as a check. The effectiveness of each treatment was determined by determining the percentage of infected leaves present at periodic intervals.

RESULTS

Prevalence. During May and June 1979, limited surveys within the Puyallup Valley revealed that fire was prevalent in nearly all commercial plantings of *Narcissus*. More extensive surveys during June 1980 showed that fire was present in 10 of 10, 39 of 44, and 2 of 5 fields in the Skagit, Puyallup, and Cowlitz River valleys, respectively. Incidence of leaves with fire varied among cultivars within a given field but it was not possible to determine any consistent differences among cultivars because of the limited number of samples for a given cultivar.

Apothecial production. Apothecia of *B. polyblastis* were only produced during 1980 and 1981 in our experimental plots although *B. polyblastis* had been isolated from the foliage residues during 1979–1982. Initial production of apothecia during 1980 and 1981 occurred in early April and mid-March, respectively (Fig. 1). Apothecial numbers reached a peak after 2 wk, then gradually declined during the next 3–4 wk during both years (Fig. 2).

Foliar symptom development. Symptom and disease development were monitored in a commercial planting of *Narcissus* in which apothecial production was not monitored during 1979 and in the experimental plots during 1980 and 1981. Initial foliar symptoms consisted of small, elliptical, tan spots. A rapid distal, then proximal, yellowing of leaf tissue was associated with enlargement of these spots. Inoculation of greenhouse-grown Bloemfontein *Narcissus* leaves with *B. polyblastis* or removal of leaf disks from the leaves revealed that leaf yellowing was dependent on presence of the fungus (Fig. 3).

Symptom development was similar during 1979, 1980, and 1981; thus, only data from 1979 will be presented. Lesions were generally located on the distal one-third of the leaf and the number of lesions per infected leaf increased from 1.1 to 2.1 (Fig. 4). Yellowing of leaf tissue distal and proximal to the lesion accounted for most symptom development. Production of conidia and isolation of *B. polyblastis* was limited to the tan-brown elliptical lesions on the leaves.

Although initial foliar infections were first observed during late April and symptom development was similar in 1979, 1980, and 1981, disease development occurred more rapidly during 1979 than during 1980 and 1981 (Fig. 5).

Control. During 1979 and 1980, two postanthesis applications of benomyl provided good control of fire (Table 1). Mancozeb, a standard fungicide used to control foliar diseases of *Narcissus*, did not provide satisfactory control of this disease. Vinclozolin provided control equal to benomyl when applied at 1.12 kg

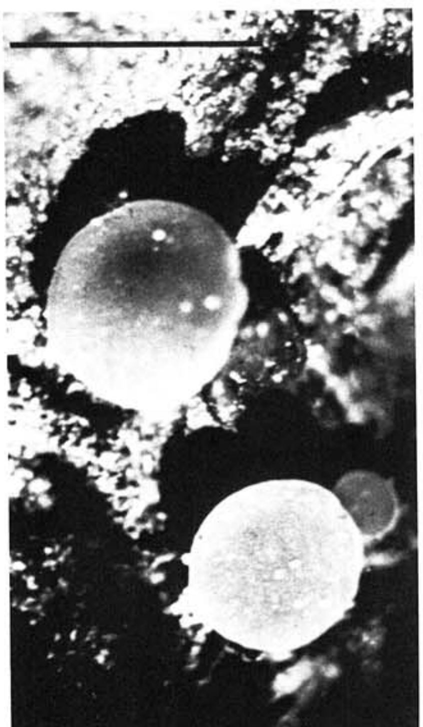

Fig. 1. Apothecia of *Botryotinia polyblastis* produced by overwintered sclerotia. Scale bar = 5 mm.

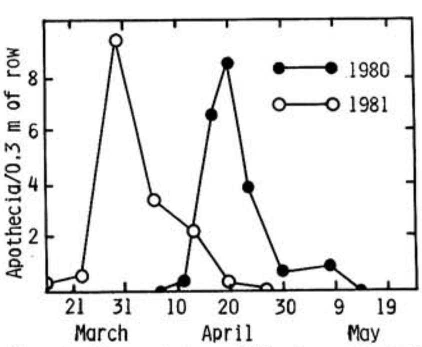

Fig. 2. *Botryotinia polyblastis* apothecial production. Data points are the average of nine (1980) and six (1981) replicates.

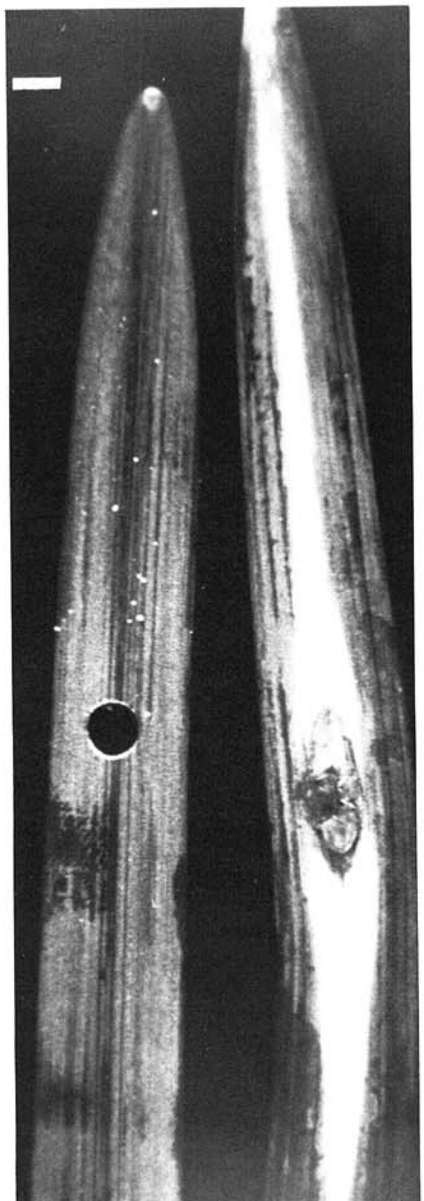

Fig. 3. Symptoms of fire on Bloemfontein *Narcissus* foliage. (Right) Distal and proximal yellowing of leaf tissues 72 hr after inoculation with a mycelial plug of *Botryotinia polyblastis* and (left) lack of yellowing associated with removal of a 6-mm-diameter leaf disk with a cork borer. Scale bar = 5 mm.

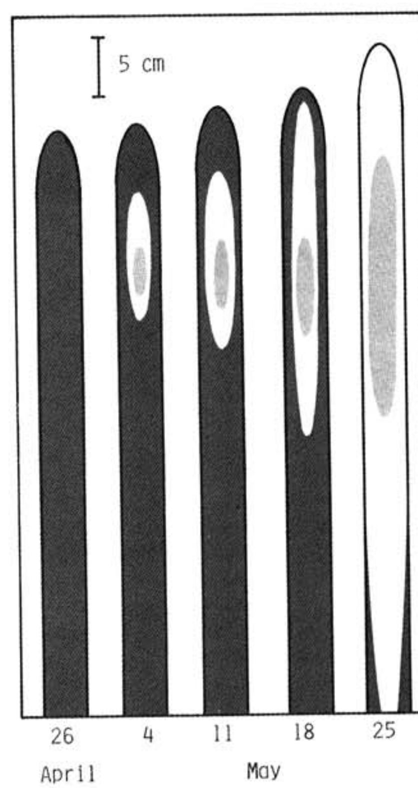

Fig. 4. Disease and symptom development on Bloemfontein *Narcissus* foliage during 1979. Data represent average of three replicates per sample date. Each replicate consisted of foliage from a 0.9-m length of row. Diagram illustrating symptom development shows total lesion length and extent of yellowing. Only lengths are drawn to scale.

Table 1. Control of fire on Bloemfontein *Narcissus* with foliar applications of fungicides during 1979 and 1980[a]

Fungicide	Rate (kg a.i./ha)	Percent healthy foliage 1979 22 May	1979 1 June	1980 15 May	1980 3 June	1980 12 June
None	...	7 w	3 x	75 x	22 x	10 x
Mancozeb	1.29	27 x	10 x	75 x	47 y	32 y
Iprodione	1.12	47 y	40 y	80 x	80 y	62 z
Vinclozolin	1.12	90 z	83 z	87 x	67 y	45 yz
Benomyl	0.56	83 z	80 z	85 x	75 y	65 z

[a] Treatments were arranged in a randomized complete block design with three (1979) or four (1980) blocks. Applications were made on 27 April and 18 May 1979 and 24 April and 8 May 1980 in the equivalent of 935.4 L water plus 1.2 L Triton B-1956 per hectare. Numbers in vertical columns followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.

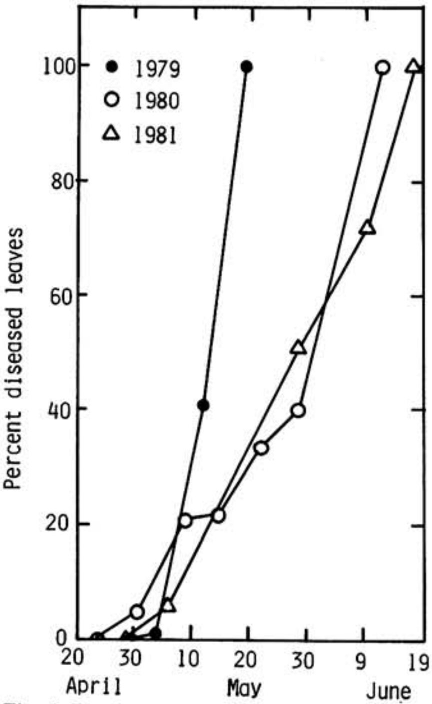

Fig. 5. Development of fire on Bloemfontein *Narcissus*. Data points are the average of three (1979), eight (1980), and five (1981) replicates.

a.i./ha. Control obtained from iprodione was variable.

DISCUSSION

Fire is a disease that commonly occurs throughout *Narcissus* production areas in western Washington. Foliar symptoms of this disease are easily confused with natural senescence, and it is likely that the occurrence of this disease has been frequently overlooked. The ineffectiveness of mancozeb in controlling this disease probably has contributed to this confusion. This disease can also be easily confused with the scorch disease caused by *Stagonospora curtisii* (Berk.) Sacc. Previously, fire has probably been recognized in western Washington only when environmental conditions favored rapid disease development. Muller (11), reporting the first occurrence of fire in the southern growing areas in the Netherlands, suggested the disease may have been previously overlooked in these areas.

Gregory (3,4) has shown that ascospores produced by apothecia of *B. polyblastis* can only infect such flower tissues as petals and perianths. Conidia produced on these tissues are then responsible for initiation of the foliar infections. Apothecia were only produced on overwintered leaf debris in experimental plots during 2 of 4 yr, although isolations at the time of leaf collections indicated that *B. polyblastis* was present during all 4 yr. Lack of apothecial production during 1979 and 1982 and subsequent lack of disease development indicates that understanding the parameters that influence inoculum survival and apothecial production may facilitate development of a predictive model that would eliminate the need for fungicide applications during years when apothecia are not produced.

Differences in initial apothecial production did not result in significant differences in initial foliar infections (Figs. 2 and 5) but may have resulted in differences in flower infections; however, attempts to monitor flower infections have not been successful (G. A. Chastagner, *unpublished*). The difference in rate of disease development during 1979 compared with 1980 and 1981 was probably due to differences in environmental conditions. Compared with the 1980 and 1981 sites, the 1979 site is characterized by limited air movement and prolonged periods of high relative humidity and free moisture.

Rapid yellowing of leaf tissue after infection is a characteristic symptom of this disease (2,8). The fact that *B. polyblastis* can not be isolated from these yellowed tissues and that the presence of the fungus within the tan-brown eliptical lesion is required for this yellowing to occur (Fig. 3) indicates that a toxin is responsible for development of this symptom.

One or two postanthesis applications of Bordeaux mixture effectively control this disease resulting in increased bulb yields and subsequent flower production (5,7), but use of this fungicide has been replaced with organic fungicides. Two postanthesis applications of benomyl have consistently provided effective control in western Washington. Applications of mancozeb, a widely used fungicide in bulb production, have not been effective. Of the two dicarboximide fungicides evaluated, vinclozolin has provided more consistent control than iprodione.

The importance of fire in the British Isles has been reduced since the practice has been adopted of cutting all unopened flowers, thus breaking the disease cycle (10). This practice has not been adopted in western Washington and may not be effective because of the large number of cultivars grown and the resulting overlap of flower production.

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