Macrophomina phaseolina: A Soilborne Pathogen of *Salicornia bigelovii* in a Marine Habitat

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ABSTRACT

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Salicornia bigelovii, an annual halophyte found along the seacoast of Sonora, Mexico, is being evaluated as a new forage and oilseed crop for the coastal deserts of Mexico. An indigenous soilborne fungus (*Macrophomina phaseolina*) infected roots and caused mortality of *Salicornia bigelovii* in both experimental plantings and in native populations growing in an estuary. Although *M. phaseolina* is widely recognized as a root pathogen of agricultural crops, its presence and pathogenic activity in a marine habitat has not been reported.

To satisfy increasing demands for food, fiber, and other renewable resources, agricultural research has focused increasingly on the domestication of previously noncultivated plant species (16). *Salicornia bigelovii* Torr., an annual halophyte, is native to the salt marshes of the state of Sonora, Mexico (9). The successful domestication of this plant could provide a new source of forage and cooking oil and extend the agriculture of northwestern Mexico to the subtropical coastal desert (9). Experimental production of *S. bigelovii* involved planting the seed in coastal deserts in February and March, irrigating daily with undiluted sea water, and harvesting the mature plant during September and October (9).

The development of production-limiting diseases often follows in the wake of domestication efforts of native plants (2). In August 1986, numerous wilted plants of *S. bigelovii* were observed in experimental field plots located in Puerto Penasco, Mexico. At harvest (September 1986), plant mortality had reached 25% in some field plots. Examination of the roots of affected plants revealed extensive rotting. *Macrophomina phaseolina* (Tassi) Goidanich was isolated consistently from rotted roots. Subsequent inoculations of greenhouse-grown plants of *S. bigelovii* with pure cultures of the fungus resulted in symptoms of disease identical to those observed in the field. *M. phaseolina* was reisolated from these plants to confirm the causal relationship of the fungus with the disease.

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M. phaseolina, a widely distributed, soilborne fungus of arid and semiarid lands, is a root pathogen of more than 200 species of plants, including many important agronomic and horticultural crops (6). Diseases caused by *M. phaseolina* typically are associated with plants growing under at least two concurrent environmental or physiological stresses (i.e., water deficit, high ambient temperature, or reproductive maturity of the host plant) (7,14,15).

Although this fungus has been reported as an indigenous component of the soil microflora of native desert ecosystems in Saudi Arabia (1), Somalia (10), and the United States (14), the ecological role of *M. phaseolina* in these nonagricultural ecosystems and the possible pathogenic relationship with native plant communities has not been established previously. In July 1989, in a survey of native *S. bigelovii* growing in an estuary, Estero Morua, located on the eastern shore of the Sea of Cortez, we found four wilted and two dead plants in a stand of approximately 800 plants. The stand was approximately 20 m long and 8 m wide. Microscopic examination of discolored, internal root and stem tissues revealed the presence of microsclerotia of *M. phaseolina*. As a result of these observations, a 2-yr study was initiated to examine the temporal progress of the disease in this native stand of *S. bigelovii* and to examine the environmental factor(s) associated with the onset of disease.

MATERIALS AND METHODS

At monthly intervals, beginning in July 1989, the number of dead plants (mortality) was recorded in seven quadrats (each 2 m^2) located in the native population. The cause of death of each plant was assessed by isolation from necrotic roots and microscopic observation of microsclerotia in necrotic root tissue. Air temperatures were recorded daily in experimental field plots near the estuary. Tidal levels were determined by on-site assessment and from the tide calendar for the northern Gulf of California. Microsclerotial populations of *M. phaseolina* in soil within the native stand were estimated in March 1990. The area of the plant stand was divided into three equal sections, and a composite soil sample, consisting of 10 soil cores (each 2.5 cm wide and 15 cm long), was collected at meter intervals along a diagonal transect across each section. Each composite soil sample then was air-dried for 48 hr at room temperature, sieved, and thoroughly mixed. Three 10-g samples were then assayed for *M. phaseolina* for each of the composite samples using a semiselective medium (12).

RESULTS AND DISCUSSION

In 1989 and 1990, disease mortality (<1%) was first observed in July. The number of dead plants increased during the next 3 mo, reaching 80% in October 1989 and 30% in October 1990. Mortality attributable to the fungus did not increase after the October observation.

Of the environmental stresses typically associated with diseases caused by *M. phaseolina*, high ambient temperatures (31–36 C) were associated with the observed mortality of native *S. bigelovii* plants during the summer months. Additionally, *S. bigelovii* reached reproductive maturity beginning in mid-June (9). Thus, the stress of flowering immediately preceded mortality associated with *M. phaseolina*. However, an estuary with twice-daily inundation by seawater seemed an unlikely site for producing the conditions of water deficit typically associated with diseases caused by *M. phaseolina*. During each month, tide levels ranged from −1.8 to +4.8 m. However, analysis of the variation of tide levels relative to the location of the stand of *S. bigelovii* revealed that there were seven to eight consecutive days per month (during neap tides) when the plants did not receive any water. Wilting plants consistently were observed within the native population during the latter part of each monthly drought. Thus, plants in this native population were subjected to a water deficit for several days. This deficit, coupled with the incidence of high ambient temperatures and reproductive maturity during the summer months, was apparently conducive to the development of disease.

In agricultural ecosystems, an inoculum density for *M. phaseolina* of one microsclerotium per gram of soil is sufficient to cause high rates of mortality within populations of susceptible host plants (6,8). Assessment of the population density of *M. phaseolina* in estuary soil in March 1990 indicated a population of 10 $\pm$ 3 microsclerotia per gram of soil. This population was well within the range of populations observed in agricultural soils (6). The difference in mortality between 1989 and 1990 in this native stand of *S. bigelovii* may be attributable to variation in the population density of the fungus and/or annual differences in the magnitude of the environmental stresses that favor infection and disease expression.

The presence of indigenous plant-pathogenic microorganisms in native (nonagricultural) ecosystems is well documented (3–5,11). These reports usually involve fungi or bacteria that cause diseases of aerial plant organs, and these pathogens are known to affect plant fitness either by reducing fecundity or by causing mortality of infected individuals. However, information regarding mortality of herbaceous plants attributable to indigenous soilborne, root-infecting fungi in native ecosystems has not been reported. Thus, our observations of the mortality of a native plant, *S. bigelovii*, in its native habitat, caused by an indigenous pathogen, *M. phaseolina*, are novel. That this interaction should occur in a estuarine ecosystem greatly extends the niche of this fungus, and in a larger sense, should prompt a reevaluation of the breadth of the ecological role of this soilborne fungus.

The mortality of *S. bigelovii* caused by *M. phaseolina* reduces plant fitness within the local habitat of the Estero Morua. Because the disease occurred in that portion of the estuary most affected by the neap tides, the distribution of *S. bigelovii* in the salt marsh habitat of northwestern Mexico may be largely determined by the pathogenic interaction with *M. phaseolina*. Additionally, the ability of *M. phaseolina* to cause mortality of *S. bigelovii* in cultivated systems indicates that the fungus may place constraints on the future production of this potentially valuable oilseed crop.

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