Plant Pathology Circular No. 290
December 1986

Fla. Dept. Agric. & Consumer Serv.
Division of Plant Industry

CHARCOAL ROOT ROT OF PINES

E. L. Barnard & S. P. Gilly[1]

The charcoal root rot fungus, Macrophomina phaseolina (Tassi) Goid [= Macrophoma phaseolina Tassi, = Macrophomina phaseoli (Maubl.) Ashby, = Sclerotium bataticola Taub., = Rhizoctonia bataticola (Taub.) Briton-Jones, = Botryodiplodia phaseoli (Maubl.) Thir.], infects more than 300 plant species worldwide (16,18,25). Charcoal root rot and a closely related disease, black root rot caused by M. phaseolina in combination with Fusarium spp. and perhaps certain plant parasitic nematodes (6,11,14), are considered among the more serious diseases affecting pine seedlings in forest tree nurseries in the southern and western United States (6,14,15,18,19). Losses of up to 20 million nursery-grown pine seedlings in Florida in one year (1976) have been attributed to charcoal root rot (15).

Although M. phaseolina has been observed in association with mortality of pines in plantations (2,10,17), charcoal root rot is predominantly a disease of pines in forest tree nurseries. Nurserymen, foresters, plant disease specialists, and government regulatory personnel are well advised to develop a keen awareness of M. phaseolina and its modus operandi. Such an awareness is key to preventing outbreaks of charcoal root rot, minimizing the impact of the disease, and facilitating sound crop management and/or regulatory decisions.

DISEASE OCCURRENCE & RECOGNITION. Macrophomina phaseolina is capable of causing damping-off of pine seedlings during the early part of the growing season as well as progressive, debilitating root infections throughout the summer months (6,14,19). However, most charcoal root rot infections develop typically during the late summer or early fall when soils are hot and dry (6,11,14,18,19). Infected seedlings exhibit above-ground symptoms ranging (and often progressing) from damping-off of young seedlings to stunted growth, to off-color, wilting and/or reddening foliage, and eventual mortality of older seedlings.

Infected root systems often exhibit varying degrees of root discoloration and loss of fine feeder rootlets. A swelling, blackening, and cracking of infected cortical tissues may also occur, especially in advanced stages of disease development on tap roots, larger lateral roots and lower seedling stems. (Note: This latter symptom is not necessarily always present and may be more a function of "black root rot" caused by M. phaseolina et al. than charcoal root rot sensu stricto.) The presence of small (≅50-200 μm), black microsclerotia within and beneath cortical tissues (Fig. 1), and to a lesser extent within the xylem tissues of infected roots and root

[1]Forest Pathologist & Biologist, Respectively, Divisions of Forestry and Plant Industry, P.O. Box 1269, Gainesville, FL 32602.

collars is common, especially where such tissues are moribund. Pycnidia of M. phaseolina have been observed on infected seedling stems, but these asexual spore-producing structures occur far less frequently than microsclerotia (14,19). Microslerotia and pycnidia are visible to the unaided eye. However, they are more readily observed with the use of a hand lens.

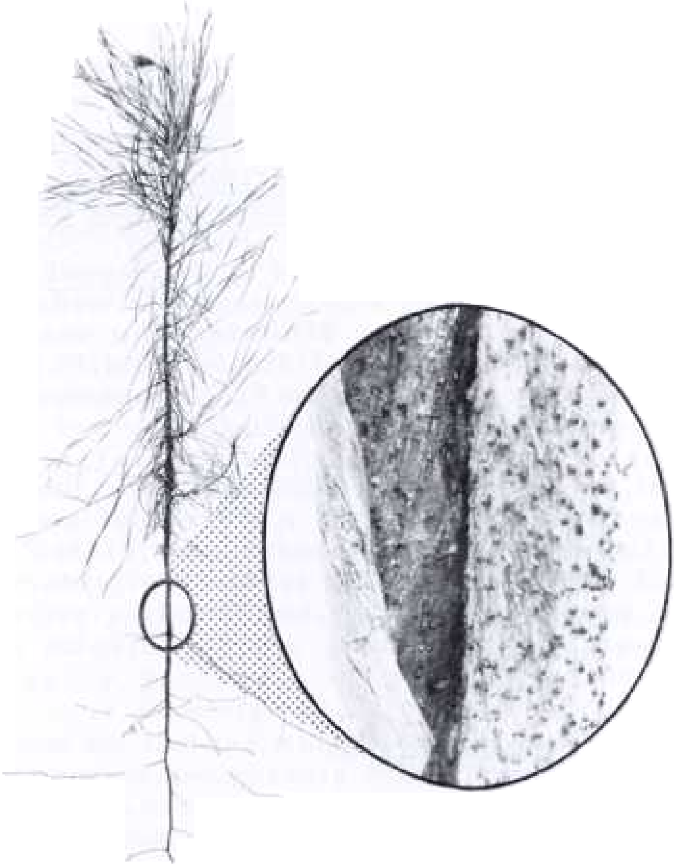

Fig. 1. Pine seedling infected with Macrophomina phaseolina showing root collar where microsclerotia are most prevalent (small circle) and appearance of subcortical microsclerotia on outer surface of xylem tissues and inner surface of bark (blow-up).

Infected seedlings are often irregularly distributed in nursery seedbeds, occurring singly or in clusters of a few to hundreds or thousands of seedlings, depending upon the distribution of infective inoculum (esp. microsclerotia) in seedbed soils and associated predisposing stresses or cultural treatments. For example, it is not uncommon for infection foci to be concentrated at the ends of seedbeds or in seedbeds nearest unfumigated irrigation pipelines where inoculum-laden soil may be mixed with fumigated soil during seedbed shaping/tilling operations. Also, charcoal root rot often "flares up" following cultural practices employed to improve seedling quality (e.g., undercutting or root wrenching) or "harden-off" seedlings for lifting (e.g., withholding irrigation).

PATHOGEN BIOLOGY. Macrophomina phaseolina is a high temperature, soil-borne, facultative parasite possessing a low competitive saprophytic ability (CSA); i.e., it is easily suppressed by the activities of competitive, antagonistic, and/or hyperparasitic soil microflora (5,7,11,13,16). Cultural temperature optima between 30 and 37 C are common for M. phaseolina isolates, and microsclerotia of the pathogen have been reported to survive soil temperatures in excess of 55 C (5,7).

The fungus is capable of surviving in soils for years in the absence of a suitable host (8,24) by means of resistant, resting stage microsclerotia. However, survival of microsclerotia is strongly influenced by interactions of soil moisture and temperatures (8,9). Germination of microsclerotia is stimulated by a variety of organic substances (1), many of which may be supplied by host root exudates (22). Survival and activity of the pathogen in soils is responsive to inorganic fertilizers and organic soil amendments (8,11).

Macrophomina phaseolina is particularly aggressive on hosts subjected to various physiological stresses, particularly moisture stress (7,25). Thus, root disease "episodes" tend to peak late in the growing season when 1) soil temperatures approach their annual highs, 2) reduced rainfall and/or irrigation results in dry soils and sometimes excessively moisture stressed seedlings, and 3) activity of beneficial soil microflora is restricted due to elevated soil temperatures and reduced soil moisture.

CONTROL. Charcoal root rot can be controlled by soil fumigation (11,12,15,20,21,23). Fumigant formulations comprised of 33% chloropricrin and 67% methyl bromide are particularly effective and often recommended (15). Soil drenches with benomyl and captan have provided some measure of control, but fungicide drenches are generally less effective than fumigation. Opportunities apparently exist to exploit potential biological controls (3,4), but more research is needed before such methods are operationally feasible. The possibility of control via manipulation of irrigation schedules, particularly during periods of excessively hot dry weather, so as to 1) prevent excessive moisture stress within susceptible seedlings crops, 2) reduce excessively high soil temperatures, and 3) promote the activity of soil microflora warrants consideration and experimentation.

SURVEY & DETECTION. Look for off-color, wilted and dying seedlings in forest tree nurseries, expecially in late summer/early fall when soils are hot and dry. Feeder root necrosis and cortical blackening, swelling and cracking on larger roots/lower stems may occur. The presence of small black microsclerotia within and beneath necrotic cortical tissues is diagnostic.

LITERATURE CITED

1. Ayanru, D. K. G. and Green, R. J., Jr., 1974. Alteration of germination patterns of sclerotia of Macrophomina phaseolina on soil surfaces. Phytopathology 64:595-601.
2. Barnard, E. L., Blakeslee, G. M., English, J. T., Oak, S. W., and Anderson, R. L. 1985. Pathogenic fungi associated with sand pine root disease in Florida. Plant Dis. 69:196-199.
3. Cerrato, R. G., De La Cruz, R. E., and Hubbell, D. H. 1976. Further studies on a mycoparasitic Basidiomycete species. Appl. and Environ. Microbiol. 31:60-62.
4. De La Cruz, R. E. and Hubbell, D. H. 1974. Biological control of the charcoal root rot fungus Macrophomina phaseolina on slash pine seedlings by a hyperparasite. Soil Biol. Biochem 7:25-30.
5. Dhingra, O. D. and Sinclair, J. B. 1978. Biology and pathology of Macrophomina phaseolina. Imprensa Universitaria. Universidade Federal de Vicosa. Vicosa, Minas Gerais, Brazil. 166pp.
6. Hodges, C. S. 1962. Black root rot of pine seedlings. Phytopathology 52:210-219.

7. Palti, J. 1981. Cultural practices and infectious crop diseases. Vol. 9 of: Advanced Series in Agricultural Sciences. B. Yaron Co-ordinating Ed. Springer-Verlag. New York. 243pp.

8. Papavizas, G. C. 1977. Some factors affecting survival of sclerotia of *Macrophomina phaseolina* in soil. Soil Biol. Biochem. 9:337-341.

9. Papavizas, G. C. 1977. Survival of sclerotia of *Macrophomina phaseolina* and Sclerotium *cepivorum* after drying and wetting treatments. Soil Biol. Biochem. 9:343-348.

10. Prota, V. and Garau, R. 1974. Il "marciume radicale carbonioso" di *Pinus radiata* D. Don in Sardegna. Bollettino della Societa Sarda di Scienze Naturali 14:133-138.

11. Rowan, S. J. 1971. Soil fertilization, fumigation, and temperature affect severity of black root rot of slash pine. Phytopathology 61:184-187.

12. Rowan, S. J. 1981. Soil fumigants and fungicide drenches for control of root rot of loblolly pine seedlings. Plant Dis. 65:53-55.

13. Sato, K. and Shoji, T. 1959. Sclerotial root-rot of coniferous seedlings caused by *Sclerotium bataticola* Taub. Bull. For. Exp. Sta. Meguro 111:51-72.

Seymour, C. P. 1969. Charocoal root rot of nursery-grown pines in Florida. Phytopathology 59:89-92.

15. Seymour, C. P. and Cordell, C. E. 1979. Control of charcoal root rot with methyl bromide in forest nurseries. So. Jour. Appl. For. 3:104-108.

Sinclair, J. B. (ed). 1982. Compendium of soybean diseases. Am. Phytopath. Soc. St. Paul, MN. 104pp.

17. Smalley, G. W., and and Scheer, R. L. 1963. Black root rot in Florida sandhills. Plant Dis. Rep. 47:669-671.

18. Smith, R. S., Jr. 1975. Charcoal root disease. Pages 11-13 in: Forest Nursery Diseases in the United States. G. W. Peterson and R. S. Smith, Jr., Tech. Coordinators. U.S. Dep. Agric., Forest Service. Agric. Hndbk 470.

Smith, R. S., Jr. and Bega, R. V. 1964. *Macrophomina phaseoli* in the forest tree nurseries of California. Plant Dis. Rep. 48:206.

Smith, R. S., Jr. and Bega, R. V. 1966. Root disease control by fumigation in forest nurseries. Plant Dis. Rep. 50:245-248.

Smith, R. S., Jr. and Krugman, S. L. 1967. Control of the charcoal root disease of white fir by fall soil fumigation. Plant Dis. Rep. 51:671-674.

22. Smith, W. H. 1969. Germination of *Macrophomina phaseoli* sclerotia as affected by *Pinus lambertiana* root exudate. Can. J. Microbiol. 15:1387-1391.

23. Watanabe, T., Smith, R. S., Jr., and Snyder, W. C. 1970. Populations of *Macrophomina phaseoli* in soil as affected by fumigation and cropping. Phytopathology 60:1717-1719.

Watanabe, T. 1973. Survivability of *Macrophomina phaseoli* (Maubl.) Ashby in naturally infested soil and longevity of the sclerotia formed *in vitro*. Ann. Phytopath. Soc. Japan 39:333-337.

Watkins, G. M. (ed.) 1981. Compendium of cotton diseases. Am. Phytopath. Soc. St. Paul, MN. 87pp.

Contribution No. 605, Bureau of Plant Pathology

This publication was issued at a cost of $505.62 or .14 per copy to provide information on proper recognition of plant pests. PI86T-47