Sooty Blotch of Apple: Etiology and Management

Turner B. Sutton and Sharon M. Williamson[1]

Abstract

Sooty blotch is one of the most common diseases of apples in moist temperate growing regions. In 1920, Colby named the fungus that causes sooty blotch *Gloeodes pomigena. G. pomigena* was considered the sole cause of the disease until the 1990's when it was discovered that sooty blotch was a disease complex caused by several fungi. *Peltaster fructicola*, *Geastrumia polystigmatis*, and *Leptodontium elatius* were associated with the disease in the southeastern US although it is likely that other fungi are a part of the complex in other areas. Management of the disease is based on cultural practices and fungicide applications. Removal of reservoir hosts is important in minimizing inoculum and pruning aids in reducing disease severity by facilitating drying in the canopy. The principle method for managing the disease is preventative fungicide sprays. Some fungicides have good eradicant activity and can be used along with a model to minimize fungicide applications.

Keywords

Sooty blotch, flyspeck, *Peltaster fructicola, Leptodontium elatius, Geastrumia polystigmatis,* disease management

Introduction

Sooty blotch and flyspeck are two of the most common diseases of pome fruits in many moist, temperate growing regions of the world. Although the diseases do not result in a yield loss, they cause considerable economic loss to growers of fresh market fruit because of reduced fruit quality. Fungi associated with these diseases were not described until the 1830s but have probably have occurred on apples in the United States since the introduction of the fruit from Europe in the 1600s. However, the diseases did not receive much attention in the early horticultural literature until the late 1800s and early 1900s when fruit quality became more important. The diseases have recently been reviewed (8).

Etiology

In 1832, Schweinitz described a fungus on Newtown Pippin apples, associated with sooty blotch, which he named *Dothidea pomigena* Schw. The name went through several changes including *Asteroma pomi* Schw. and *Phyllachora pomigena* (Schw.) Sacc., which was used until the early 1920s. In 1834, Montagne, described a fungus on pears that he named *Labrella pomi* Mont. mss. (Fr. in litt.). Colby (3) subsequently examined his specimen and concluded that it was associated with symptoms of flyspeck. Saccardo transferred it to *Leptothyrium pomi* (Mont. Microthyriella rubi Petrak. Subsequently, von Arx transferred it to *Schi-*

[1] Department of Plant Pathology, North Carolina State University, Raleigh, NC, USA 29695-7616

zothyrium as *S. pomi* (Mont. Zygophiala jamaicensis Mason. Although *P. pomigena* and *L. pomi* were associated with sooty blotch and flyspeck, respectively at the turn of the 20th century, there was still confusion over the etiology of the diseases and several important texts published in the United States stated that they were caused by the same fungus, *L. pomi.* In 1920, Colby (3) did an extensive study of the disease and concluded that sooty blotch and flyspeck were caused by different fungi. He established a new genus and species *Gloeodes pomigena* Colby, for the apple sooty blotch fungus.

Colby (3) observed considerable variation in the growth of *G. pomigena* on apple fruit and described three mycelial (thallus) types: fern-like, honeycomb, and reticulate. Groves (4) redescribed and renamed the mycelial types as: ramose, punctate, fuliginous, and rimate. Although Groves (4) and subsequent researchers (5) observed considerable variation in the symptoms of sooty blotch, *G. pomigena* was accepted as the sole cause of the disease until Johnson et al. (7) showed that sooty blotch in the United States is a disease complex caused by at least three different fungi: *Peltaster fructicola* Johnson, Sutton and Hodges, *Leptodontium elatius* (Mangenot) de Hoog and *Geastrumia polystigmatis* Batista G. *pomigena* during their study. Since then, Batzer, using a molecular approach, has found that a least xxx different fungi are associated with the disease in Iowa, although their identity is still to be determined (Jean Batzer, personal communication). Kern (Simone Kern, personal communication) working in Germany , and Wrona (Beata Wrona, personal communication) , working in Poland , have recently associated several other fungi, including *P. fructicola*, with the disease .

Causal organisms. Thalli of *L. elatius* are associated with fuliginous colonies which consist of a reticulate network of mycelium, have diffuse margins, and are irregular in shape. These colonies range from small and dark to large and diffuse. Thalli of *P. fructicola* consist of a reticulate network of mycelium and numerous circular pycnothyria. The punctate colonies, produced by *P. fructicola,* may be small and circular or large and irregular in shape. Thalli of *G. polystigmatis* are associated with ramose colonies consisting of a reticulate network of mycelium and many pycnothyria. Colonies are initially diffuse but become darker and denser as the colony develops. These three fungi grow superficially and do not penetrate the apple cuticle. It is hypothesized that *P. fructicola* and *L. elatius* utilize nutrients leached or exuded from the apple and that epicuticular wax does not contribute significantly to their nutrition (1).

Colonies of flyspeck on apple fruit are round to irregular in shape and about 1 to 3 cm in diameter, though they may be much larger. Colonies consist of several to 50 or more shiny, black thyriothecia which are superficial on the cuticle. *Z. jamaicensis* does not penetrate the apple fruit but apparently uses the wax on the fruit as a nutrient source.

Hosts. Fungi associated with sooty blotch and flyspeck grow on a wide range of reservoir hosts including trees, shrubs, and vines including, blackberry, willow, sycamore, sassafras, wild grape, bristly greenbrier, wild crabapple, and smooth sumac. *Rubus* spp. are the most common host in the southeastern United States.

Disease development and epidemiology

Life cycle. Details of the life cycle of *P. fructicola*, *L. elatius,* and *G. polystigmatis* are not known; however, these fungi apparently overwinter on reservoir hosts and apple twigs. Conidia are spread by wind and rain to developing fruit and new tissues of reservoir hosts in the spring and early summer. Secondary infections arise from conidia, produced through the summer on apple fruit or reservoir hosts, which are disseminated by wind and wind blown rain to apple fruit. Once apples are infected, it takes about 20 to 25 days for symptoms to develop; however, symptoms may become visible in 8 to 12 days under optimal conditions.

Ecology. Temperature, rainfall, and relative humidity have been shown to affect the development of both sooty blotch and flyspeck in the orchard. Optimum temperatures *in vitro* for mycelial growth of *P. fructicola* and *L. elatius* are 12 to 24°C and 16 to 28°C, respectively (6). Neither fungus grows at 88% relative humidity and mycelial growth is inhibited at relative humidity < 95%. Conidia of *P. fructicola* germinate from 12 to 24°C at relative humidities ≥95%, whereas conidia of *L. elatius* germinate from 12 to 32°C at relative humidities ≥97%.

Control

Cultural practices. Most cultural practices important for managing the diseases are associated with selecting or creating an environment less favorable for disease development. The importance of a good drying site has been recognized since the turn of the 20th century. Similarly, the importance of both dormant and summer pruning to open the canopy and facilitate drying is well documented. Fruit thinning to break clusters is necessary to minimize the disease. Removal of reservoir hosts helps in managing the disease by reducing the inoculum.

There is some variation among cultivars in their susceptibility to sooty blotch and flyspeck but differences are primarily related to maturity date. Differences observed among some cultivars with similar maturity dates may be related to the permeability of the cuticle to leachates which support growth of the fungi (1).

Biological control. Little progress has been made in the biological control of sooty blotch and flyspeck. A cellulose-based formulation of *Chaetomium globosum* has shown some activity but *T. harzianum* strain T-22, applied either every 7 or 14 days from mid-August until harvest, was not effective. *B. subtilis,* used in a standard program, has provided ~ 50% control. With the exception of *B. subtilis,* none of the biological controls has been developed commercially for the control of sooty blotch and flyspeck in the United States. Other products that have been investigated are colloidal suspensions of various biopolymers, kaolin based particle films, and methionine-riboflavin and potassium bicarbonate-polymer sprays.

Chemical control. The chemical control of sooty blotch and flyspeck over the past 110 years has gone through at least four phases.

(i) Control with inorganic fungicides. From the early 1900s until the late 1940s and early 1950s, Bordeaux mixture and lime sulfur were the principle fungicides used for the control of sooty blotch and flyspeck.

(ii) Control with organic fungicides. In the 1940s inorganic fungicides began to be replaced by ferbam and captan; however sooty blotch and flyspeck became a

greater problem in many orchards, possibly because of their shorter residual activity. As research was conducted on the new organic fungicides, their advantages and weaknesses became more apparent and spray programs similar to the one used today in which the cover sprays are applied every 10 to 14 days during the summer were developed. In the late 1950s and 1960s, the ethylene bisdithiocarbamate (EBDC) fungicides were introduced and incorporated in spray programs. Because of their excellent residual activity and broad spectrum activity, the EBDC fungicides became widely used from the mid-1960s through the early 1990s.

(iii) Resurgence of sooty blotch and flyspeck. The period from 1970 through the mid-1990s was characterized by two periods in which sooty blotch and flyspeck became more prevalent. In the early to mid-1970's an increase in the disease was associated with the loss of lead arsenate, which was used as an insecticide until the early 1970s but improved sooty blotch and flyspeck control. Another factor which led to the resurgence of the diseases in the 1970s was the widespread use of concentrate spraying. In the early 1980s, to improve control, the benzimidazole fungicides were inserted into the spray program, often in combination with captan. In 1992, the United States Environmental Protection Agency placed new restrictions on the use of EBDC fungicides. As a result, sooty blotch and flyspeck became a more significant problem. This resulted in a greater use of benzimidazole fungicides, usually in combination with ziram or captan, as well as more frequent fungicide applications at a time when there was increased pressure to reduce pesticide residues on fruit and in the environment.

(iv) Eradicant spray programs. The eradicant properties of the benzimidazole fungicides against the sooty blotch and flyspeck fungi have been known since the late 1970s. Brown and Sutton (2) observed that symptoms of sooty blotch and flyspeck appeared in the orchard from early June until mid-July and reasoned that if they could predict the onset of symptoms, then the eradicant properties of the benzimidazole fungicides could be utilized more effectively. They monitored hours of leaf wetting, rainfall, and temperature during the 1987 to 1994 growing seasons and noted that first symptoms of sooty blotch and flyspeck appeared after an average of 273 hours of leaf wetting of 4 hours duration or greater had accumulated, beginning with the first rain that occurred 10 days after petal fall. When benzimidazole applications were included in the spray program at 209 and 270 hours of leaf wetting, using the criteria above, the control of sooty blotch and flyspeck was similar to that of the standard protectant treatment. They recommended that a threshold of 200 or 225 hours of accumulated wetting should be used to time benzimidazole applications; but, suggested that under low inoculum situations, a higher threshold could be used. The model has subsequently been modified by several researchers.

Currently used fungicides. The activities of some of the fungicides currently used to control sooty blotch and flyspeck are listed in Table 1.

Table 1. Relative activity of fungicides or fungicide groups on sooty blotch and flyspeck.

	Relative activity	
Fungicide and rate (a.i.)/ha	Sooty blotch	Flyspeck
captan 3.36 kg	++++[a]	+++
EBDC[b] (maneb, mancozeb, metiram) 5.38 kg	++++++	++++++
EBDC 2.68 kg	+++	++++
dithiocarbamates (ziram, thiram ferbam) 5.15 kg	++++	+++++
EBI[c] (fenarimol, myclobutanil, triflumizole) 0.14-0.28 kg	+	++
benzimidazole (benomyl, thiophanate-methyl 0.28-0.85 kg	+++++	++++++
strobilurin (kresoxim-methyl, trifloxystrobin) 0.07-0.22 kg	+++++	++++++
sulfur 6.7-13.5 kg	++	++
Bordeaux 4.8-12.1 kg	+++++	+++++

[a] The number of pluses reflects the relative activity of the fungicide or group of fungicides. + = little activity, ++++++ = high activity.
[b] Ethylene bisdithiocarbamate fungicides
[c] Ergosterol biosynthesis inhibiting fungicides

The activity listed for each fungicide or group of fungicides is based on its use every 14 days during the summer growing period. Rates listed are in the mid- to upper range labeled for use by the United States Environmental Protection Agency. Many of the fungicides listed are used in combination with one another to enhance their activity or increase their spectrum of activity against other diseases in the apple summer disease complex. There is no report of resistance of the fungi in the sooty blotch/flyspeck complex to these fungicides.

Postharvest control. The extent of sooty blotch and flyspeck development in storage is usually related to the fungicide used in the preharvest sprays and length of time between the last fungicide application and harvest. The use of a chlorine dip as an eradicant was popularized in the 1990s for use in an IPM program. Most symptoms can be removed by dipping fruit for 5 to 7 minutes in a 500 ppm solution of chlorine, followed by brushing and a fresh water rinse.

Conclusions

It is probable that additional fungi will be associated with sooty blotch as it is studied more. Differences in the sensitivities of these fungi to fungicides may result in variation in the ability to control the diseases in different areas of the world. At least in the immediate future, management of the diseases will continue to be based on cultural practices designed to create an environment less favorable to the diseases and reduce the inoculum levels, and fungicide sprays. In the future, we will likely see periods during which sooty blotch and flyspeck become more important as older broad-spectrum fungicides are no longer-used and newer, site specific fungicides are introduced.

Literature Cited

Belding, R. D., Sutton, T.B., Blankenship, S.M., and Young, E. 2000. Relationship between apple fruit epicuticular wax and growth of *Peltaster fructicola* and *Leptodontium elatius*, two fungi that cause sooty blotch disease. Plant Dis. 84:767-772.

Brown, E. M., and Sutton, T. B. 1995. An empirical model for predicting the first symptoms of sooty blotch and flyspeck of apples. Plant Dis. 79:1165-1168.

Colby, A. S. 1920. Sooty blotch of pomaceous fruits. Trans. Ill. Acad. Sci. 13:139-175.

Groves, A. B. 1933. A study of the sooty blotch disease of apples and the causal fungus *Gloeodes pomigena*. Va. Agric. Exp. Stn. Bull. 50:1-43.

Hickey, K. D. 1960. The sooty blotch and fly speck diseases of apple with emphasis on variation within *Gloeodes pomigena* (Schw.) Colby. PhD diss. The Pennsylvania State University, University Park.

Johnson, E. M., and Sutton, T. B. 2000. Response of two fungi in the apple sooty blotch complex to temperature and relative humidity. Phytopathology 90:362-367. Johnson, E. M., Sutton, T. B., and Hodges, C. S. 1997. Etiology of apple sooty blotch disease in North Carolina. Phytopathology 87:88-95.

Williamson, S.M. and Sutton, T.B. 2000. Sooty blotch and flyspeck of apple: etiology, biology and control. Plant Dis. 84: 714-724.