

## **Spread & Development of the 1997 Blue Mold Epidemic in North America**

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### **INTRODUCTION**

The North America Blue Mold Forecast Center in Raleigh, NC provided the tobacco industry and growers with timely documentation on the occurrences (new outbreaks) and potential for further spread (transport of fungal spores) of the pathogen (*Peronospora tabacina*) during the 1997 growing season. The Forecast Center is located within the Department of Plant Pathology at North Carolina State University. A total of 469 separate forecasts were prepared on 75 days from March through early August. Forecasts were posted on the World Wide Web (<http://www.ces.ncsu.edu/depts/pp/bluemold/>) each Monday, Wednesday, and Friday, and more often when necessary. The forecasts attempt to document new occurrences, gauge the potential for sporulation at the source, evaluate the chances of survival and deposition during long-distance transport of spores, and provide a risk assessment for each separate forecast. New reports and continuing status of disease are monitored daily via a Forecast Homepage Reporting network of coordinators in U.S. states, Mexico, and Canada. Coordinators are in daily contact with the Forecast Center and all other coordinators.

Blue mold occurred in nearly all the tobacco production areas of eastern North America in 1997. First report of blue mold in commercial tobacco was just northwest of Gainesville, Florida on April 23. The most active and widespread movement and development of the 1997 epidemic occurred from late May through mid-June in the mid-Atlantic states. With few exceptions, blue mold occurrences were dominated by metalaxyl-resistant strains of *P. tabacina*. Grower and industry confidence in and usage of the forecasts increased over the 1996 forecast year. Twelve of thirteen first reports by state could be explained by forecasting long-distance transport of spores correlated with favorable weather conditions for spore survival and infection.

A table showing geographic first occurrences is included at the end of this summary. A short executive summary (table included) is available elsewhere on the homepage. For North Carolina growers, an expanded summary of the 1997 epidemic in their state is also available. Growers without Internet access to the Forecast Center Homepage could use toll-free telephone forecasts via 1-800-662-7301 (NC only) and/or 1-888-835-BLUE (2538) for all other states and foreign countries.

### **Chronological Summary of Spore Transport, New Occurrences, and Meteorological Events**

During March and April, the Forecasting Center tracked blue mold development from infected sources in Mexico and western Cuba; forecasts were also produced for source sites on wild tobacco (*Nicotiana* spp.) in southern Texas. Details from these regions were admittedly sketchy early in the season. The epidemic was localized or resulted from short-range dispersal during periods of favorable weather. Blue mold in southern Texas may have been endemic or resulted from inoculum arriving from sources along Mexico's east coast.

During this early period, no transport events threatened the U.S. production areas, mostly due to the prevailing winds and weather. High pressure cells centered in the Southeast were common. Fronts passed through the southern region and either swept onward through Cuba or stalled out nearby. In either case, trajectories based upon the surface circulation patterns near Cuba flowed westward across the Gulf of Mexico, or tracked slowly eastward. This typical springtime pattern, i.e., of weather systems approaching the East every few days, persisted through April until mid-May.

The first incursions of blue mold into the U.S. occurred in April. The first confirmed report of blue mold came on April 23 from plant beds in northern Florida. Blue mold may have been present as early as the 14th, but had gone undetected. Other small outbreaks in the north Florida area were discovered that same week. Isolates from Alachua and Union counties at first tested sensitive to the fungicide metalaxyl. However, by early May, most of the blue mold isolates in that region tested Ridomil resistant. This initial incursion into the U.S. probably occurred during the weekend of April 11-14 via spores from Cuba, as a weather system produced favorable conditions for transport and infection. Other favorable events were not evident.

Blue mold was reported in southwest Georgia on May 9. Spores may have come from Florida or Cuba. The most likely scenario involved spores from Cuba around the 2nd of May. This source was sporulating fairly heavily at the time.

The first report of blue mold in eastern North Carolina (Greene County) came on May 22. Metalaxyl resistance was documented with this outbreak. The estimated time of inoculum introduction (by generations of lesions) was the first half of May. There were a small number of events when this may have happened. One is spore arrival on the 27th or 28th of April. Following this event, disease development could have been slowed by mostly unfavorable weather, and gone undetected until the 22nd. The second and most likely scenario, however, came on the 8th of May. Spore showers approached NC from the southwest under conditions favorable for survivable transport and deposition. Blue mold had not yet been reported from southwest Georgia, so the forecasts could only consider the sources in northern Florida. Activity was light, which was reflected in the risk assessment. However, the very active southwest Georgia site (Grady County, near Reno) was reported the next day. Given the strength of this new source, it's likely this May 8 situation was actually the event that brought blue mold spores to North Carolina.

Localized and short-range disease development continued to occur. Periods of favorable weather were happening with some regularity in the southern GA/northern FL region.

Reports of blue mold continued to come in from northern Florida in late May, and blue mold was introduced into southeast Georgia during mid-May (Wayne County). Infection in field tobacco was reported in Lenoir County, NC (adjacent to Greene) on May 27th. Spores from elsewhere may have been deposited as with the Greene County scenario, or this may have been the result of later localized disease development from the Greene County location.

One of the more puzzling cases of blue mold occurred during May. The first report from Tennessee came on June 2 from Maury County, with information that the disease had been present for two or three weeks. This would place any long-distance introduction of spores around May 5-12. It has been difficult to find a forecast scenario that would have transported spores to this area within this time frame. The introduction of infected transplants can't be ruled out. Spores from southern Georgia could have been deposited in Tennessee May 23/24, but that is too late to fit the observed occurrence. It also clouds the most plausible explanation of Tennessee as the source for the later disease development in western Kentucky. The other possible situation for Tennessee would have been for spores to arrive April 26/27, much earlier than estimated, followed by slow disease development. It appears extremely unlikely that spores from the south Texas region were responsible for this outbreak. No satisfactory explanation for this outbreak is available.

The most significant event of the 1997 season took place the last seven to ten days of May. A cool mass of air in the upper levels of the atmosphere became separated from the main jet stream flow over the Ohio Valley and Southeast regions of the United States. With nothing to steer it away, this "cutoff low" drifted around the central tobacco-growing regions of the eastern U.S. for weeks. The built-in atmospheric instability provided a favorable environment for the formation of clouds, showers, and thunderstorms on an almost daily basis. Surface systems tended to move slowly or not at all, and from the last week of May through the middle of June, unsettled weather persisted over much of the Southeast, mid-Atlantic, and Ohio Valley areas. This is very reminiscent of the situation in June of 1995 when the same weather phenomenon occurred, giving rise to a massive epidemic of blue mold.

With blue mold firmly established in eastern North Carolina and the southern GA/northern FL region, the above-mentioned extended period of favorable weather resulted in serious epidemic spread. Localized and long-range disease development was common. Reports of new outbreaks, and secondary sightings near known sources, came to the Forecast Center throughout the month of June. In virtually every reported case, the estimated time of spore introduction could be attributed to this favorable period. Quantities of live spores were likely deposited on several different days, in most cases.

The first report from Virginia came from Lee County, in the southwest mountains adjacent to the Tennessee border. Coincident with this June 11 report was the confirmation of blue mold in four counties in northeast Tennessee. Estimated time of infection was late May/early June. There were several different occasions in which live spores could have easily been deposited. The most likely is the scenario of May 30 and 31, in which airborne spores traveled north from the southern Georgia region on two

consecutive days. Blue mold was quite active in southern Georgia at this time, and conditions were very favorable for survivable transport and effective deposition.

South Carolina reported blue mold in Horry County on June 11. June 2-6 was the time window of possible introduction. There were no less than four good opportunities during the first week of June when live spores may have been deposited in northeast South Carolina. One was from the south GA/north FL region, and the others were from eastern North Carolina. Any or all may have happened, with the best bet being on June 3, from the Lizzie, NC source area.

On June 11 the first report was received of blue mold in North Carolina's burley crop from Madison County in the central North Carolina mountains. Infected seedlings from eastern NC had been transported and planted in this area during late May. The estimated time of initial "airborne" introduction was also the end of May. As with the southwest Virginia/northeast Tennessee case, live spores were probably deposited in this area on several occasions, with the most likely scenario being the events of May 30 and 31.

The first report of blue mold in Maryland came on June 12. The estimated time of spore showers into Anne Arundel County was on or before June 1. The most likely of several possible scenarios was May 25. By mid-June it was suspected that blue mold was widely distributed throughout Maryland's crop.

The first confirmed case in Kentucky, from Christian County in western Kentucky, was reported on June 13. The disease was discovered in a plant bed, with initial spore arrival estimated at May 20-25. Of the known sources in mid-to-late May, the Reno, GA source (southwest GA) may have been the most likely to send spores to Kentucky. However, given the existence of an (as yet) undiscovered source in west-central Tennessee at that time, it seems more likely that spores from that closer Tennessee source may have been responsible for the outbreak in Christian County. Significant field infection was discovered at this same western Kentucky location in early July. Dr. William Nesmith's comments at the time of the first Christian County report indicated also that there was probably blue mold present in southeast Kentucky. He reported that the weather conditions were the most favorable and longest persisting that he had observed since 1980! There were reports of blue mold from north-central Kentucky on June 17, from the Shelbyville area, and from Menifee County in eastern Kentucky on June 20. Live spores were estimated to have been deposited during the first week to ten days of June, during the period of favorable weather described earlier.

Periodic reports of localized disease development continued to arrive from various locations. Two other instances of disease development during late May to mid-June proved to be very significant. These cases were in Lancaster County, Pennsylvania (reported on June 6) and in Mecklenburg County in south-central Virginia (reported on June 11). Neither were thought to be due to airborne transport of spores. Blue mold was attributed to transport of infected seedlings purchased in eastern North Carolina in late May. The Mecklenburg County source gave rise to a good bit of disease development in

the south-central Virginia/north-central North Carolina area. Both of these sources later proved to be origin points for spores that caused some long-range disease development.

After mid-June, the meteorological environment in eastern North America was characterized by periods of hot, dry weather and unfavorable conditions alternating with more favorable disease conditions as the occasional front passed through the growing areas. The periods of favorable/unfavorable conditions varied from region to region, and disease activity was either initiated/revitalized or diminished accordingly.

This year's sequence of weather events was especially troublesome for growers in the southern mountain areas and parts of the Ohio Valley. Blue mold, introduced during the extended period of favorable weather in late May and early June, generally continued to persist through the summer even though there were intermittent stretches of unfavorable conditions. Reports from Tennessee, Kentucky, and western North Carolina at the end of June and beginning of July stated roughly the same message:

Blue mold was scattered about the respective regions with mostly low levels of disease activity, some of which probably went undetected. Weather had been generally unfavorable, and response to the fungicide Acrobat-MZ applications had been good when applied early. However, reports continued to trickle in to the Forecast Center throughout July, nearly all of them cases of localized/short-range disease development near known sources in these regions. One such source was reported on July 8 in Madison County, NC. Many generations of lesions were present, with an estimated time of first infection dating back to early June. On June 23, Dr. P.B. Shoemaker's burley update from western NC stated that the two known sources were greatly diminished. By July 23, his update indicated blue mold was present in over 50% of the tobacco fields visited! Contrast these events with those of eastern NC. In mid-June, blue mold had been confirmed in eight counties and was likely present in more. By the middle of July, the unfavorable weather had all but ended the threat of blue mold on the flue-cured crop in eastern NC. This is a prime example of how the climate, terrain, and type of tobacco of the mountain areas provides a more suitable environment for the infection and development of blue mold.

There were two other very important cases of long-range disease development this season, both of which occurred during one of the periods of favorable weather in the southern Great Lakes and upper mid-Atlantic regions. The first is the report of blue mold from Connecticut on July 9. Live spores were probably deposited sometime in late June or early July, with July 3 the most probable. Shade tobacco, as well as broad leaf, is grown in this area. The style of cultivation readily lends itself to severe disease development, so any report of blue mold here is of a very serious nature. There were two reasonable possibilities for disease development scenarios. Both involved spores from the growing areas of southeast Pennsylvania, a source whose initial infection arose from infected transplants. The most likely occurred on July 3, when the main concentration of spores would have passed directly over the Connecticut Valley. A High Risk situation was forecast, since conditions were favorable for survivable transport and effective deposition. A recent communication from Dr. Jim LaMondia in Connecticut on August

21 indicates that an estimated 50+% of the crop has already been lost this year due to blue mold.

Blue mold was confirmed on tobacco in southern Ontario, Canada on July 25. Blue mold was suspected to have been present since early July. This event focuses on the forecasts of June 30. Conditions were quite favorable for survivable transport of spores and effective deposition in southern Ontario. Spores from as many as four different source regions may have affected this area! The leading source was the Jeffress, VA region. It's likely live spores arrived from sources in the southern Appalachian Mountains and southeast Pennsylvania as well. Finally, sources in north-central Kentucky may have also sent spores to Canada. There were widespread areas of rain near to and south of this location for long periods during this event, which could have washed out the spores. However, spores from many different source areas were flowing towards the north shores of Lake Erie. It's likely that there was simply too much inoculum in the air for too long a time for it all to have been washed out before reaching the southern Ontario growing areas.

We will continue to update this summary as additional reports and impact information come in to the Forecast Center. Check our Web site periodically (<http://www.ces.ncsu.edu/depts/pp/bluemold/>) for the updates and new technologies as they develop.

**First Reports of Blue Mold to the Forecast Center in Raleigh, NC (a)**

<b>State/County</b>	<b>Date</b>	<b>Probable source (b)</b>	<b>Impact (c)</b>
Columbia County, FL	April 23	Cuba	?
Grady County, GA	May 9	Cuba	?
Greene County, NC (flue-cured)	May 22	northern Florida/SW Georgia	0.5-2.0 % avg.
Maury County, TN	June 2	unknown	?
Lancaster County, PA	June 6	Import of infected seedlings	?
Lee County, VA	June 11	southern Georgia	?
Horry County, SC	June 11	eastern North Carolina	?
Madison County, NC (burley)	June 11	southern Georgia	?
Anne Arundel County, MD	June 12	eastern North Carolina	?
Christian County, KY	June 13	western Tennessee	?
Hartford County, CT	July 9	southeastern Pennsylvania	? (possibly 50%)

Gallia County, OH	July 9	southern Appalachian Mountains	?
Elgin County, Ontario, Canada	July 25	Multiple	?

- (a) Occurrence confirmed by a state coordinator or other expert.
- (b) Some first occurrences could be the result of multiple sources.
- (c) Updated periodically as additional reports and impact information came in to the Forecast Center.

## EPILOGUE

The North American Blue Mold Forecast Center in Raleigh was pleased to provide this important service to the tobacco growers of the eastern United States and Canada. We would especially like to thank the state coordinators, extension agents, and other persons who reported blue mold to the Center. You are the eyes and ears of the reporting system! Thanks goes to the Center staff who help put out the forecasts on schedule. Of special note is Thomas Keever, our Forecaster and Meteorologist for the past three years. Without his expertise, dedication, and hard work the system would not operate. In this connection, we also thank Dr. Roland Draxler, Dr. Barbara Stunder, and staff at Air Resources Laboratory in Silver Spring, Maryland whose production of trajectory maps and expertise we depend upon.

Comments on the forecasts, the Forecast Center, and the Homepage (or its contents) are welcome. Address your comments to C. E. Main, Center Leader, at [ce\\_main@ncsu.edu](mailto:ce_main@ncsu.edu) or Department of Plant Pathology, Box 7616, N.C. State University, Raleigh, NC 27695.

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