

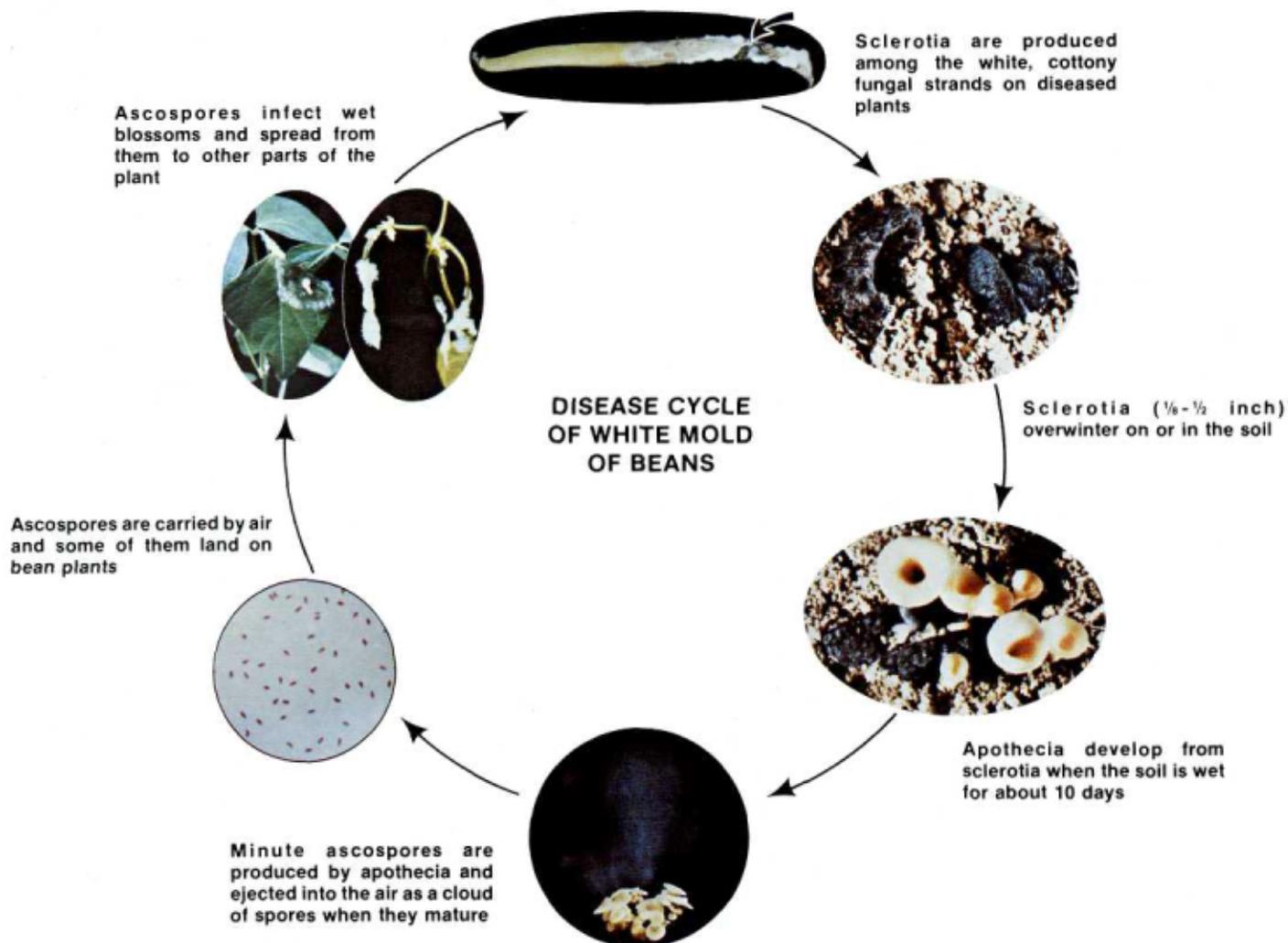
PLANT SCIENCES

PLANT PATHOLOGY (GENEVA)

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White mold of beans in New York

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The fungus that causes the white mold disease of beans, *Sclerotinia sclerotiorum*, has caused serious losses in central and western New York in recent years. The disease has been economically more important in snap beans than dry beans because in addition to direct losses in the field, detection of more than 2 per cent diseased pods in a truckload at the processing plant may result in rejection of the whole load. Furthermore, even a low incidence of white mold may lower the grade or increase the cost of processing.

The incidence of white mold varies considerably in the major bean producing counties in central and western New York. Oswego, Wayne, Chautauqua, and Cattaraugus counties have had more frequent and more severe outbreaks than Ontario, Yates, Genesee, and Orleans counties. This difference may be due to variation in weather patterns, natural vegetation, and soil characteristics that result in extended periods of wet soil and moisture on the plants.

The white mold fungus is widely distributed not only throughout New York but also throughout the United States and most cool, wet areas of the world. In part, this is because it can infect more than 360 species of plants. In New York, the fungus is capable of infecting many crops, especially vegetables and fruits. It also has been found on weeds, such as dandelion and wild clover, in hedgerows, woods, and in fruit orchards.

SYMPTOMS OF WHITE MOLD

In New York, symptoms are usually first visible about one week after full bloom because blossoms generally are the first part of the plant to be colonized by the fungus. Leaves, stems, and pods in contact with the colonized blossoms can then become infected, provided moisture is present. Initial symptoms on these tissues are pale colored, water-soaked lesions. These lesions enlarge and within a few days, become covered with a white, cottony fungal growth.

Leaves of severely diseased plants become yellow and eventually turn brown and fall off. As the disease progresses, the infected plants wilt and the leaf canopy opens. The fungus may eventually invade and kill all above ground parts of the plants.

DISEASE CYCLE

The white mold fungus produces irregular shaped, hard, black structures called sclerotia that range from 1/8 to 1/2 inch in length. They are produced among the white, cottony fungal strands on the surface of diseased plants as well as inside stems and pods. After they mature, sclerotia become dry and fall off the plants onto the soil surface. They survive in a dormant state on or in the soil during the winter and other periods of adverse environmental conditions. When suitable environmental conditions return, the sclerotia develop small trumpet-shaped, mushroom-like structures called apothecia. Only sclerotia that have gone through an

extended chilling period and are on the surface or in the top 1 inch of very wet soil can produce apothecia.

The first sign of apothecial formation is the development of stalks, approximately 1/16 to 1/32 inch in diameter, growing upward from the surface of the sclerotia. The tips of those that grow above the soil surface become expanded and cup-shaped like the large end of a trumpet. Many minute, sac-like structures called asci are produced on the upper surface of the cup. Each ascus contains eight ascospores. When changes in relative humidity cause drying, the mature asci forcibly eject ascospores into the air to a distance of 1 to 3 inches. These spores then are carried by the wind until eventually some land on the surface of plants. The surface of the ascospores is sticky, causing them to adhere to plants or other objects encountered in flight. Because the ascospores are carried by wind, they may be derived from sclerotia produced on other hosts outside bean fields as well as on weeds or previous plantings of beans within the field.

Ascospores require nutrients to germinate and infect a plant. The surface of fully mature and senescent blossoms is covered with nutrients that have been exuded from the petals and other parts of the flower. Thus, serious outbreaks of white mold only occur within 1 to 2 weeks after peak bloom. Occasionally, white mold is seen on a few scattered plants prior to bloom. In these cases, mechanical injury of the plant tissues or lesions caused by other organisms may have resulted in leakage of nutrients from the plants.

Ascospores germinate and invade blossoms or injured tissues when a film of water is maintained on the surface of the plant. Within 3 days, senescent blossoms will be completely colonized. The fungus may then grow from the colonized blossoms into leaf, stem, and pod tissues in contact with the colonized blossoms. White, cottony fungal growth develops on the infected tissues within a few days, and sclerotia are produced in approximately 10 to 14 days, thus completing the disease cycle.

Sclerotia also can germinate by another means, although this is not very important in bean fields in New York. In this case, white thread-like fungal strands similar to those seen on infected plants are produced directly from the sclerotia. These strands can colonize senescent and dead plant material in contact with them. Once the fungus has become established in this manner it can invade healthy tissues in contact with the colonized material. Within a few days, the fungus produces more sclerotia and completes its life cycle. Only sclerotia previously produced within the field being planted to beans are important as a source of inoculum when infection occurs by this means.

In snap bean fields, there is very little spread by direct contact between infected and healthy plants. The fungus does not produce any ascospores from current season infections; thus, there is no significant secondary spread. However, the potential for secondary spread by direct contact between infected and healthy plants may be more important on dry beans because of the longer growing season and denser canopy.

ENVIRONMENTAL FACTORS AFFECTING DISEASE DEVELOPMENT

Moisture. The critical environmental factor governing production of apothecia from sclerotia in the soil is moisture. Likewise, moisture is essential for invasion of plant tissues by ascospores or fungal strands growing from previously colonized tissues. However, the total amount of rainfall is less important than the frequency and duration of rains and dew periods. Equally important are the factors affecting the rate of drying of the soil and plant surfaces. For this reason, white mold is generally more prevalent in fields with higher plant populations, dense vegetative growth, and restricted air circulation caused by low areas and woods surrounding the bean fields.

Sclerotia must be in wet soil (between saturation and field capacity) for at least 10 days before they can produce apothecia. Even slight drying may prevent their development. In addition, exposure of mature sclerotia in soil to extreme drying and possibly high temperatures may completely inhibit or greatly delay production of apothecia. Factors affecting the amount of moisture in the top 1 inch of soil include relative humidity, wind velocity, temperature, and type and density of plant canopy.

A film of water must be maintained for about 48 hours before ascospores can germinate, invade, and become established in mature or senescent blossoms; whereas 16 to 24 hours of moisture are required for infection of stems, leaves, or pods in contact with colonized blossoms. Colonized blossoms that have dried require 72 hours of wetness before the fungus can resume growth and infect green tissues. Expansion of lesions on thin tissues, such as leaves, stops abruptly if a film of water is not maintained but continues relatively slowly on pods or thick stems. When water becomes available again, lesions on leaves resume development.

Temperature. The most important effect of temperature on the development of white mold is the requirement for a long chilling period before sclerotia can produce apothecia. However, temperature is not likely to be of great significance in the production of apothecia by mature sclerotia that have survived a winter. Highest production occurs between 55 and 60 F, but apothecia develop at temperatures between 40 and 85 F. Therefore, temperatures during the growing season are seldom too high or low for production of apothecia, but the rate of production may be affected at the extremes of the temperature range. Under New York conditions, sclerotia have been found producing apothecia as early as April 20 and as late as mid-September, which encompasses the entire growing season.

Temperature exerts a significant effect on the rate of initiation and development of lesions on bean plants, but lesions develop at temperatures between 40 and 85 F. The optimum temperature for lesion development is 68 to 76 F. Thus, under New York conditions, temperature is unlikely to be a limiting factor in the development of lesions.

FORECASTING EPIDEMICS OF WHITE MOLD

Research underway in New York eventually may result in the development of a very practical and accurate system to forecast outbreaks of white mold. The system most likely would be based upon daily measurements of weather and other environmental factors, and require the use of instruments to record these measurements. Such a system would aid growers in timing applications of fungicides, or avoiding their use when disease is not forecast.

Laboratory and preliminary field studies indicate that the soil moisture must be between saturation and field capacity for approximately 10 days for production of apothecia and, thus, ascospores. Therefore, until an accurate forecasting system is developed, growers should observe carefully in the weeks before peak bloom to determine if there is any 10-day period when the soil moisture is continuously between saturation and field capacity. When this occurs, the assumption should be made that ascospores have been produced and some of them transported by air currents to the bean plants. Therefore, in fields with a history of white mold, growers should assume that disease will develop if long periods of moisture from rain or dew occur at the time of bloom.

CONTROL MEASURES

Chemical control. Successful control of white mold with fungicides depends upon spraying at the proper time and completely covering the plants with the chemical, especially inside the plant canopy. Applied in this way, benomyl has proved superior to other commercially available, registered fungicides.

For a single spray program on snap beans, benomyl (50 WP) should be applied at the rate of 1.5 pounds/acre. If two sprays are to be applied, the rate should be 1 pound in each application. The second application should be made 1 week after the first. A two-spray program is usually not considered economical unless conditions have been very wet and a severe outbreak of white mold is expected. For dry beans, two or three applications are required during long wet periods because of the longer period of susceptibility caused by the lengthier period of flowering. Such applications should be at the rate of 1 pound/acre.

Timing of the first application of fungicide is very critical. Best control is obtained if this application is made when 70 to 80 per cent of the plants show the first open blossom. This is usually 4 days before full bloom. Sprays applied more than 1 week before full bloom do not provide adequate control. Likewise, the effectiveness of sprays applied at the pin pod stage is doubtful.

Plants should be sprayed thoroughly to insure that blossoms are covered because these are the parts that support spore germination and lead to invasion of other parts of the plant. Although benomyl has some systemic activity, it is not translocated into blossoms, thus necessitating thorough coverage. Once benomyl is deposited on blossoms it is not easily removed by rain,

even if rain occurs immediately after applying the fungicide.

The best method of applying fungicides to obtain thorough coverage has not been studied carefully. However, in an experimental trial, good coverage was obtained with a ground spray rig equipped with a single over-the-row nozzle and drop nozzles between the rows approximately 5 inches above the ground. These were connected to the main boom by means of a flexible, wire-reinforced rubber hose. Applications were made with 50 gallons of water per acre applied at 60 psi. Airplane application of benomyl for control of white mold of snap beans is a common practice in New York, but the extent of coverage and degree of control obtained has not been studied carefully. Growers using this method of application sometimes experience erratic control.

Resistant varieties. All varieties of beans presently grown in New York are susceptible to white mold. However, some resistant plant materials have been identified recently. Most of these are runner beans, *Phaseolus coccineus*. One of these selections that shows resistance and can be crossed with the common bean (*Phaseolus vulgaris*, the species grown in New York), has white flowers and produces the white seeds desired by the snap bean industry. Studies have shown that this resistance is controlled by a single dominant gene, thus making it easier to transfer this resistance and to develop a new variety by means of the relatively simple backcross breeding technique. In trial studies at Geneva, the resistance gene has been transferred to the Bush Blue Lake and Early Gallatin type snap beans. After limited backcrosses and selections

for disease resistance and horticulturally desirable characteristics, there is considerable optimism that a commercially acceptable, white mold resistant variety of snap bean can be developed in the near future.

Cultural practices. Growers should follow cultural practices that promote drying of soil and plant surfaces. Included in this is avoidance of small fields surrounded by dense woods that restrict air circulation which delays drying. Also, rows should be planted in the direction of the prevailing winds whenever possible to promote air drainage to reduce moisture on the surface of the soil and the plants. In areas where white mold frequently is a problem, it is advisable not to plant varieties that develop a large, dense canopy that holds moisture. High plant populations and especially narrow-row spacing should be avoided for the same reason. In addition to holding moisture, heavy foliage and dense plantings should be avoided because they interfere with thorough coverage of the plants by fungicides.

Plowing of infected fields immediately after harvest will bury and hasten decomposition of sclerotia, thereby reducing the inoculum the following year. In addition, crop rotation may be of some benefit since sclerotia do not survive indefinitely in the soil.

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