# A GROWER DECISION TOOL FOR OPTIMIZED DISEASE MANAGEMENT IN SNAP AND DRY BEANS

## PROJECT SUMMARY:

This research proposal addresses a producer articulated critical need for research-based control strategies for white and gray molds on snap and dry beans grown in New York and Pennsylvania. The immediate objectives are to optimize bean disease management strategies, and develop and implement decision trees that provide guidance to producers on the strategic and prudent use of registered materials for pod mold control. Until recently, pod mold control was achieved through the use of the fungicide vinclozolin. The canceled registration of vinclozolin has resulted in snap bean producers generously applying fungicides as an insurance measure against potential devastating crop loss due to disease. The proposed research does not develop a forecasting tool. Rather, it develops decision trees for action based on research knowledge and understanding of current environmental conditions, pathogen behavior, and efficacy of fungicides and cultural practices for pod mold control. This project has clear stakeholder involvement and is listed as a high priority by the NY Vegetable Growers Association, the PA Vegetable Growers Association, the NYS IPM Program, and the NYS Dry Bean Industry Council. Beans are high value crops (NY $33,946,000; PA $10,158,000) facing two aggressive pathogens that are difficult to control. The project will benefit NY and PA immediately. Adoption of the decision tool will eliminate subjective “insurance applications” of fungicides and reduce the negative environmental impact of those inputs. The high cost of fungicide applications and significant grower interest increases the likelihood of success of the project.

## PROBLEM, BACKGROUND AND JUSTIFICATION:

***The Problem***. White mold caused by *Sclerotinia sclerotiorum*, and gray mold caused by *Botrytis cinerea*, are the primary diseases that trigger the use of foliar fungicides on snap and dry beans in New York, Pennsylvania, and several other states where bean production is concentrated. Both fungi thrive during the warm humid summer months when bean production is at its peak. The diseases are most problematic when plants are vigorous and yields and profit potential are greatest. These two pathogens are quite cosmopolitan and have a very wide host range, which makes rotation from non-hosts difficult.

Until recently, pod mold control in snap beans was achieved through the use of the fungicide vinclozolin (Ronilan, EPA Reg. No. 7969-85), which was initially registered 8/13/1997 following extensive use over a 10-year period of Section 18s. The current supplemental label dated 7/26/2004 permitted use of the product on snap beans (not dry beans) until 11/20/2005. The outstanding efficacy of vinclozolin allowed snap bean producers to control disease with one low rate, well timed application (Shah et al., 2002). No other materials on the market could be used as prudently and still result in excellent disease control. Vinclozolin was pulled from the market due its carcinogenic and endocrine disruption properties. Vinclozolin blocks cell receptors that are normally activated by the hormone androgen, and causes fertility defects in male rats that are passed down to nearly every male in subsequent generations (Anway et al., 2005). The loss of vinclozolin has resulted in snap bean producers using less efficacious materials and generously applying fungicides to reduce perceived and real risks of disease epidemics. Producers are attempting to control disease with multiple fungicide applications (as opposed to one vinclozolin application), using unproven timing strategies, and when affordable, applying the highest labeled rate. With these strategies, neither snap nor dry bean producers are effectively controlling pod molds.

Snap beans and dry beans produced for fresh market and processing are economically valuable crops produced in New York and Pennsylvania. Based on the most recent statistics (2004) from the United States Department of Agriculture National Agricultural Statistics Service, 23,500 acres of dry beans and 28,800 acres of snap beans (fresh and processing) are grown in New York State. Together the value of these beans crops is worth $33,946,000 (dry beans $6,990,000 and snap beans $26,956,000). The snap bean processing acreage for Pennsylvania (2004) is 14,000 acres for a value of $10,158,000.

Farmers attempt to control white mold caused by *S. sclerotiorum* and gray mold caused by *B. cinerea* on beans by applying fungicides during the flowering period when the host plants are most susceptible to attack (Shah et al., 2002). However, efficacy of the registered materials under variable weather conditions, application timing, and number of sprays needed for disease control are not clearly standardized at this time. The substantially longer flowering period in dry beans and the extended harvest season make control in dry beans especially difficult. For many farmers, fungicides are being applied as an insurance measure against potential devastating crop loss due to disease. For example, in New York, entire loads of harvested snap beans can be rejected at the processing plant if pod mold levels are above 5%. In most cases, this results in entire fields being bypassed and a total economic loss to the producer. When loads are not rejected, growers are docked for blemished (diseased) pods that must be removed at the plant. The risk of a field being bypassed fuels the insurance spray mentality, and the outcome has been that many growers apply fungicides every year for disease control without confirmation that fungicides are indeed necessary.

The pathogens snap and dry bean farmers are attempting to control are formidable opponents! *S. sclerotiorum* is an aggressive fungal plant pathogen that is known to attack over 360 species of plants including dry and snap beans, cabbage, potatoes, alfalfa, tomatoes, sunflower, and soybeans, as well as many common weed hosts such as ragweed and velvetleaf (Abawi & Grogan, 1979; Dillard & Hunter, 1986; Dillard et al., 1991). On June 15, 2005, at the 13$^{th}$ International Sclerotinia Workshop, the host range for this fungus was updated to include 408 species (Boland & McDonald, 2005). In New York State, *S. sclerotiorum* causes diseases in snap beans, dry beans, cabbage, carrots, alfalfa, soybeans, sunflower, lettuce, tomatoes, potatoes, and other agronomic crops and weed species. The pathogen is found worldwide in many different soil types and environmental conditions (Abawi & Grogan, 1979; Boland & McDonald, 2005). The fungus survives in soil as sclerotia, which are hardened structures composed of fungal mycelium (Ben-Yephet et al., 1993). The sclerotia germinate under the appropriate environmental conditions to produce fruiting bodies called apothecia (Abawi and Grogan, 1979; Cobb & Dillard, 2004a,b). Apothecia produce ascospores that are forcibly discharged into the air where they are dispersed to susceptible plant tissues. The dominant mode of survival for *S. sclerotiorum* is as sclerotia, but the fungus may also survive on or in seeds (McQuilken et al., 1997; Mueller et al., 1999). *B. cinerea* has a similar wide host range among agronomic crops and weed species. It also may survive as sclerotia in soil or saprophytically in crop debris. Unlike *S. sclerotiorum*, this fungus produces spores directly on the host plant as it colonizes host tissues. Both pathogens are aggressive necrotrophs, killing host tissue and entire plants as they colonize.

Although snap and dry bean producers rely heavily on fungicides for control of white and gray molds, fungicide applications are integrated with one or more cultural practices to reduce disease incidence and severity. Unfortunately, cultural practices alone are unable to stop disease development. These management practices include:

- Encouraging air movement by avoiding fields surrounded by wooded areas.
- Avoiding narrow row spacing to facilitate good airflow and drying of foliage.
- Avoiding plant injury that provides nutrients for ingress of fungi.
- Avoiding over fertilization and frequent irrigation that keeps the canopy wet.
- Controlling weeds because weeds provide additional sites for sporulation and a favorable microclimate for infection.
- Rotating fields with non-host crops such as grains and corn.
- Incorporating debris immediately following harvest so beneficial microorganisms have the opportunity to feed on the survival structures called sclerotia.

***The specific needs***. This proposal purposely addresses the specific need for research on control strategies for white and gray molds on snap and dry beans. For several years, the New York State Vegetable Growers Association and the Pennsylvania Vegetable Growers Association have expressed the need for management strategies for white and gray mold on snap beans. Snap bean producers in New York and Pennsylvania provided modest funding to the Dillard lab for research on white and gray molds on snap beans in 2005. The 2006 snap bean research priorities outlined by both groups, and the 2006 snap bean research priorities outlined by the New York State Integrated Pest Management Program clearly state the need for additional white and gray mold control research on snap beans (Appendix 1,2,3). At the 2004 New York State Dry Bean Industry Council meeting, the need for white mold research was clearly articulated, and resulted in the Dillard lab receiving modest funding in 2005 to include dry beans in white mold trials. The PI and members of the Dillard laboratory are fully engaged with the snap and dry bean producers, and their organizations and processors in both states.

Producers in the snap and dry bean industries are in serious need of a decision tool that uses an informed database to evaluate the on-site situation, determine the need for intervention with pesticides, provide choices that include less toxic biopesticide alternatives (Cobb & Dillard, 2005a; Dillard & Cobb, 2002; McQuilken et al., 1997), and suggest the most efficacious application rates and timing for pod mold control. The current need among PA and NY producers is for a well-designed, user-friendly decision tree that can be deployed on site that will eliminate subjective “insurance applications” of fungicides. The potential outcome is that producers will be empowered to make informed decisions from research-based knowledge that eliminates unnecessary pesticide applications, while still obtaining acceptable disease control. Optimized use of these materials will result in fewer inputs of fungicides into the environment and will reduce the risk to human health of agricultural personnel and consumers. The database from our previous research trials provides a strong foundation and significant support for the proposed decision tool. Thus, the decision tool will not be solely based on data from the 2 years of the proposed project, but will include data and experience from many years of research on white and gray mold control.

***Beneficiaries.*** The results of this project will immediately benefit snap and dry bean producers in New York and Pennsylvania, with applicability in all regions where beans are grown. Growers will have a decision tool that will provide guidance on the strategic and optimized use of registered fungicides for control of pod molds on snap and dry beans. This will eliminate subjective use of fungicides and unnecessary application costs, and will reduce inputs of pesticide into the environment.

A very real example illustrative of this need comes from the 2005 growing season. A Pennsylvania snap bean producer, Ryan Ruter in Coudersport, contacted the Dillard lab in New York State to ask for advice on whether or not he should spray a fungicide for white mold control. The decision was difficult to make at the time because of the uncertainty in predicting thunderstorm activity in his area. He also expressed uncertainty over the choice of material to use. He was concerned over the high cost of the Ronilan replacement, Endura, and wanted to make sure his timing was perfect if he used the material, so that he could have effective disease control with only one spray of this expensive material. He clearly needed a decision tool to help him evaluate the choices and the risks. Roger Ward and Mike Gardinier expressed similar concerns on behalf of the farmers producing snap beans for Birdseye Foods. The uncertainty surrounding fungicide efficacy and timing, the inaccuracy of weather forecasts, and the high price of Endura, prompted a request for a “strategy” meeting on June 21, 2005, involving Roger Ward, Mike Gardinier, Helene Dillard, and Ann Cobb. The purpose of the meeting was to determine the best course of action for processing snap bean producers providing products to Birdseye Foods.

***Current vs. Proposed Approach.*** Producers currently apply fungicides during the critical blossom period when bean plants are most susceptible. When vinclozolin was available, many growers were able to control white and gray molds with one application. With the loss of this material, producers are applying 2 sprays during bloom of one or a mixture of two materials at high rates in an effort to control both molds. The proposed approach would provide the grower with a decision tool that first determines if a pesticide application is needed at all. The decision tree would take the grower through a process that would provide choices of alternative materials to use, based on previous knowledge of the mold spectrum in the field, cost and efficacy of registered materials, and cultural practices deployed known to reduce disease incidence. The decision tool would effectively remove the guesswork from disease management practices.

***Review of ongoing and completed work***. Since 1992, the Dillard lab has conducted numerous replicated trials on control of pod molds on snap beans at the New York State Agricultural Experiment Station facility (http://www.nysaes.cornell.edu/pp/faculty/dillard/cv.html; Cobb & Dillard, 2004b, 2005b; Cobb et al., 2004&2005; Dillard & Cobb, 2005; Dillard et al., 2002a,b,c, 2003). This research has included studies on the use of Contans, a biopesticide with a fungal parasite active ingredient (*Coniothyrium minitans*) that colonizes the sclerotia of *S. sclerotiorum* (Cobb & Dillard, 2005a; Dillard & Cobb, 2002). We have consistently published our results, and have used our database as a reference for discussion of alternatives to vinclozolin (Shah et al., 2002). The database from these previous research trials provides a strong foundation and significant support for the proposed decision tool. Thus, the decision tool will not be solely based on data from the 2 years of the proposed project, but will include data from many years of research and experience on white and gray mold control.

The decision tool we are proposing to develop is not a disease-forecasting tool. The etiology and epidemiology for white mold of beans have been well documented, and disease forecasting systems have been developed for white mold on beans (McDonald & Boland, 2004; McLaren et al., 2004; Petzoldt et al., 1998). The forecasting tool developed in New York incorporated information on the prevalence of sclerotia and apothecia, and the history of disease severity in individual fields (Hunter & Petzoldt, 1987; Petzoldt et al., 1998). The forecast included the measurement of soil moisture, rainfall, canopy size, blossom development, and number of apothecia, with scouting visits to individual fields starting 26-28 days after planting and continuing every 3-4 days for approximately seven visits in each field (Petzoldt et al., 1998). Despite its accuracy, the prediction model is not widely used due to the time consuming inputs. Other forecasting models are being evaluated through the Sclerotinia Initiative web site (*www.whitemoldresearch.com*). With frequent weather forecasts in NY and PA for a “chance of rain or a thunderstorm”, we have found that the disease forecasts on this web site tend to over predict the risk of disease, and use of these disease forecasts would have resulted in unnecessary applications of fungicides. Thus, growers in NY and PA would almost always be advised to spray if these disease forecasts were followed.

The proposed research does not develop a disease-forecasting tool. Rather our research develops a decision tree for action based on knowledge and understanding of current environmental conditions and efficacy of fungicides and cultural practices for white and gray mold control. Decision trees are used to select the best course of action in cases where uncertainty is a significant roadblock. Decision trees help the user better understand and act upon the risks involved.

***Applicability to other production regions***. This research will be of considerable interest to snap bean producers in Oregon and Washington, where white mold is considered “the most serious disease affecting snap beans” (DeFrancesco, 2005). It will also be of significance to snap bean growers in Eastern and Western Canada (McDonald & Boland, 2004; McLaren et al., 2004), Maryland, Delaware, and North Carolina, as well as dry bean producers in Nebraska (Steadman, 1983), North Dakota (del Rio et al., 2004), Michigan, and California. White mold in particular, but also gray mold, are problems on snap and dry beans wherever these crops are produced (Abawi & Grogan, 1979). The extensive host range of these pathogens and the long term survival rates of the sclerotia (over several years) increases the probability of these molds becoming established in all regions where beans are grown (Abawi & Grogan, 1979; Adams & Ayers, 1979; Purdy, 1979).

**OBJECTIVES:**

1. To optimize white and gray mold management strategies in snap and dry beans grown in New York and Pennsylvania.
2. To develop a decision tool for growers that will provide guidance on the strategic and prudent use of registered fungicides and biopesticides for control of pod molds on snap and dry beans, while achieving acceptable and economic disease control.