Regional IPM Competitive Grants Program – Northeast Region

Final Report – August 31, 2008

Grant Data

Date: August 29, 2008

Category: Northeast Regional IPM Competitive Grants Program (RIPM)

Project Title: A Grower Decision Tool for Optimized Disease Management in Snap and Dry Beans: Development and Implementation

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State(s) Involved: New York, Pennsylvania

Grant #: 2006-34103-16934

Year the grant was awarded: 2006

Length of grant: 2 years

Funding Amount: $46,196

Nontechnical Summary

White and gray molds are the primary diseases that trigger the use of fungicide sprays on snap and dry beans grown in New York. These diseases are caused by two aggressive fungi that thrive during the warm humid summer months when bean production is at its peak. Farmers often spray fungicides as an insurance measure against white and gray

molds, and many retrospectively question whether the sprays were necessary in a particular year. Our goal was to develop a decision tool that farmers could use to decide whether fungicide sprays were needed to save a bean crop. Results from this study show that row closure, row orientation, and soil moisture are the critical factors that influence disease development in New York. Grower recommendations are being revised to reflect the importance of managing these critical factors for successful disease control.

Introduction

Until recently, pod mold control in snap beans was achieved through the use of the fungicide vinclozolin (Ronilan, EPA Reg. No. 7969-85). The outstanding efficacy of vinclozolin allowed snap bean producers to control disease with one low rate, well timed application. Vinclozolin was pulled from the market due its carcinogenic and endocrine disruption properties. Since the loss of vinclozolin, snap bean producers have been forced to rely on less efficacious fungicides to manage white and gray molds in their crops. In many instances, fungicides are applied as an insurance measure against pod molds. Growers do retrospectively question whether all sprays were necessary (i.e. were conditions favorable for white mold in the first place?).

Several factors interact in the development of white and gray molds in a bean field: moisture and temperature during the late vegetative to flowering stages, proximity to fields which have had white and gray mold problems previously, a susceptible host crop in the field within the last three years, a history of white and gray molds in the field, weed populations in and around the field, the presence and type of irrigation, plant population density, plant architecture, length of flowering period, and the presence of apothecia in the field or in a nearby field during bloom. These factors have been used to create a White Mold Risk Index (WMRI) for edible beans (including snap bean), which is available via the Sclerotinia Initiative's website (http://www.whitemoldresearch.com). Several problems associated with the weighting of each factor in the index have been identified. Thus, the index has not been widely used or adopted.

A more simple approach to assessing the risk of white and gray molds is to use a decision tree. Decision trees attempt to group observations (in this case, presence or absence of white mold) based on a number of variables (here, white mold 'risk' factors). The advantages of decision trees include the ability to handle nonlinear relationships among variables, to incorporate both categorical and continuous variables, and the inclusion of uncertainty (e.g. chance of rainfall). They are easy to understand and can succinctly convey complex relationships. Decision trees appeared to be a useful approach to modeling the risk of white mold, given the number of factors (listed above) that are deemed important to varying extents in the development of pod molds. Our objective was to mine the existing knowledge base on white and gray mold risk factors to create a decision tree depicting the risk of pod mold development.

Objectives

To optimize white and gray mold management strategies in snap and dry beans grown in New York and Pennsylvania. A two pronged approach was used to address this objective. We conducted fungicide efficacy trials to determine which fungicides would provide optimum control if needed for white mold (caused by *Sclerotinia sclerotiorum*) and gray mold (caused by *Botrytis cinerea*). We also intensively examined risk factors to determine which of them were most important for disease development in New York and Pennsylvania.

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. We were unable to develop a user-friendly decision tool that could easily be used by farmers. The decision tree approach resulted in a complicated, complex, difficult to use tool that farmers would not find useful. After intense analysis of the data, LOESS regression analyses indicated that canopy closure was the key element in pod mold development, and that row orientation and soil moisture were also important for the development of disease. We redirected our efforts to further study these key factors.

Approach

Our first approach was to collate existing knowledge and data on white mold development into a decision tree structure for predicting the combination of factors which, when met, would place fields at risk of severe mold development. Based on an evaluation of the existing literature, a theoretical decision tree was constructed, using commercially available software (DecisionPro, Vanguard Software, Cary, NC), for estimating the risk of white mold in snap bean. In the process of doing so, it became apparent that in the literature there was a general awareness of individual factors considered important for white mold development, but rather few data on how factors were inter-related and their relative contributions to overall white mold risk. That is, we were able to generate several theoretical decision trees, but there were insufficient data in the literature with which to parameterize the trees (i.e. risk factor weights and uncertainties). Moreover, if one were to consider all the factors listed as being important to white mold development, one ended up with an unnecessarily complicated (and unhelpful) tree structure (Fig. 1). In conclusion, although several environmental and biological factors are generally acknowledged as risk factors for white mold in snap bean, it is still largely unknown how these individual risk factors are related to each other, or the relative importance of each to overall risk of white mold.

The above hindrance therefore led to extensive field surveys of snap and dry beans to develop a database on field conditions and white mold incidence in commercial fields across the Western New York and Pennsylvania landscapes in 2006, 2007 and 2008. Commercial fields in NY were identified with the help of personnel from Farm Fresh First, who provided lists detailing field locations, planting date, cultivar, field size and estimated date of harvest. Lists were used to target fields across several counties and planting times. In each field, data were collected on latitude, longitude, cultivar, growth stage, general row orientation, soil moisture, irrigation, canopy closure and the incidence

of plants with white mold symptoms. The data collection structure was deliberately simple, mimicking what may be available on hand to the general grower or scout. Therefore, soil moisture was assessed on a categorical scale (0 – 25%, 25 – 50%, 50 – 75%, 75 – 100%) using the Soil Moisture by Feel and Appearance Method. Canopy closure was measured as the open (soil visible) space between adjacent rows. Data from 1,405 observation times were collected from 122, 192, and 71 field (or plot) situations in 2006, 2007 and 2008, respectively. Most fields were observed twice or more, with observations being made anywhere from the first true leaf stage to one to two days before harvest.

In collecting the data, the following assumptions were made: (i) fungicide sprays were protective and (ii) coverage was not 100%. Thus, if conditions were conducive to white mold, the disease would still be present in such fields, even if they had been sprayed. The disease incidence data therefore indicated that conditions in a field were either favorable or not for white mold, but do not represent how severe the disease potential was. Because of the highly skewed nature of the disease incidence data, in addition to the assumptions stated above, percent white mold was recoded as presence (1) or absence (0) and the resultant binary data explored through piecharts, histograms, scatterplots, coplots, and LOESS smoothing. Quantitative modeling included logistic regression, cumulative logits, generalized estimating equations, and ordinal random effects models. All modeling was done with SAS.

In both years of the study, we conducted fungicide efficacy trials in snap beans at the New York State Agricultural Experiment Station in Geneva. Treatments were replicated in a randomized complete block design. The trials were irrigated, inoculated and shaded to encourage disease development.

Progress

During the past year, significant progress was made on all aspects of the project including survey data from snap bean fields in central and western New York, fungicide efficacy data for pod mold control, and extensive data analyses. We were unable to develop a user-friendly decision tree that farmers could easily use. What resulted was a complicated tool that would require extensive data input, and the results from the trees relied heavily on subjective assessments of the relative importance of mold development factors.

Complex statistical analyses by Dr. Shah indicated that the one factor that was universally useful in our studies was measurement of canopy closure. This factor will be more intensively studied in additional studies in the next growing season. Two additional factors were also explored: soil moisture and row orientation.

Results

The survey covered fields planted from the end of May through July (Fig. 2). Several different cultivars were planted, and some were more prevalent than others (Fig. 3). All

snap bean cultivars were susceptible to white and gray molds. Fields were surveyed across several NY counties (Genesee, Livingston, Niagara, Orleans, Wyoming, Yates, Chautauqua), and into northern PA. There was about a 50 – 50 split between fields with rows oriented north-south versus those oriented east-west. Most fields appeared to have been sprayed at least once during the bloom or early reproductive stages, based on observed residues on the foliage during those growth stages.

In 2006, open bean blossoms were collected from 84 snap bean fields to determine the potential levels of gray mold (caused by *Botrytis cinerea*). The bean blossoms were placed on agar media in Petri plates and incubated. *B. cinerea* was isolated from snap bean blossoms from 50 out of 84 fields or 59.5% of the fields.

White and gray molds were not observed in all fields. Gray mold was found in 14% of fields/plots over 2006-2007, and was noticeably lower than white mold in occurrence. Incidence of plants infected with gray mold was generally low (less than 2 out of 50 plants), except for a cluster of fields/plots in PA in 2007. In 2006, white mold was observed in 27.9% of the fields surveyed, whereas 18.1% of fields surveyed in 2007 had some level of white mold. When white mold was observed, incidences ranged from 2 to 83% of plants showing symptoms of the disease in a given field. In fields where the disease was present, levels were mostly less than 5% of the plants infected (Fig. 4). Mean incidence (over all fields surveyed) was 1.9% in 2006 and 3.1% in 2007. The higher overall incidence in 2007 was due to a few extreme cases in PA fields that year.

Histograms and LOESS plots showed that fields with white mold tended to have more closed canopies by the pod stage. LOESS regression showed that canopies closed with time after planting, as expected, but at about 30 days after planting there was the beginning of a trend toward more closed canopies in fields that had white mold (Fig. 5).

The effect of canopy closure was moderated by row orientation. LOESS regression curves showed that fields with rows oriented north-south tended to show white mold more than fields in which the rows were oriented east-west. The effect was much more pronounced when the open distance between rows fell below 20 cm. The odds of white mold in fields with rows oriented in a north-south direction was **2.5 times higher** than the odds of white mold in fields in which rows were in an east-west direction.

Soil moisture is an important component of white mold epidemiology. Soil moisture in surveyed fields was highly variable but there was a trend to higher soil moisture levels in more closed canopies (Fig. 6). Fields without white mold were 1.17 times more likely to be on the drier side than fields with white mold.

There were no discernable trends in white mold status due to planting time (biweekly periods, month), location (county) or cultivar.

Fungicide efficacy studies in both years resulted in publications in Plant Disease Management Reports. These reports are included in the appendices to this report. Fungicide efficacy data from our field trials conducted from 1997-2007 was also

summarized. In these trials, fungicides were generally applied twice at about 30% bloom and 100% bloom plus pin pods. The first column contains the pesticide treatment and rate. The second column is percent of the times tested where the treatment was statistically better than the check for gray mold control and provided good to excellent control. The third column is the percent of the times the chemical provided greater control for white mold than the check and provided good to excellent control. The fourth column represents the total number of times the chemical was tested as a gauge of confidence in the results. Be aware some promising combinations were only tested two or three times.

Treatment and rate/acre	% of times with effective gray mold control	% of times with effective white mold control	Total number of times chemical was tested
Ronilan 1 lb (not used in 2006 or later)	88	87	15
Endura (BAS510) 70WG, various (~5 oz)	83	62	29
Topsin M 1.4 lb or 27.9 fl oz	11	95	18
Endura 5.5 or 5.9oz + Top M 0.7 lb or 14 fl oz	100	93	14
Rovral 4F 2 pt	72	89	18
Rovral 4F 1-2 pt + Topsin M 0.7 lb or 14 fl oz	57	92	13
Bravo WS 1.5 pt + Rovral 1 pt	100	100	3
Bravo WS 1.5-3.0 pt + Top M 0.7 lb or 14 fl oz	67	100	8
Elevate WDG 1.5 lb	50	50	2
Quadris 15.4 fl oz/Amistar 5 oz	44	22	9
Omega 500F 8 fl oz	50	50	2
Kaligreen + Topsin M + sticker	50	100	2
Switch (11 or 14 oz)	69	58	12

Impacts

Snap and dry bean growers were informed and made aware of the implications of this work through oral presentations at the following meetings and workshops:

- December 1, 2006, White mold research report, New York State Dry Bean Advisory Meeting, Canandaigua, NY
- March 15, 2007, Does spraying for white mold pay?, New York State Dry Bean Meeting, Canandaigua, NY
- April 25, 2007, Dry and Snap Bean Disease Control, Workshop sponsored by the Western New York Crop Management Group, Perry, NY
- September 6, 2007, White mold control, New York State Dry Bean Field Day and Tour in Western NY, Pavilion Center area, NY (handout attached on page 23)
- January 29, 2008, Continuing the Search for Mold and Spot Control after Ronilan, 2008 Mid-Atlantic Fruit and Vegetable Convention & North American Berry Conference, Hershey, PA

- February 14, 2008, Progress Update on a Set of Classification Rules for the Risk of White Mold in Snap Bean, 2008 Empire State Fruit & Vegetable Expo and Becker Forum, Syracuse, NY

Growers were made aware of three key factors that influence development of white mold in NY and PA: canopy closure, row orientation, and soil moisture. Canopy closure starting 30 days after planting was most consistent at influencing development of white mold. The odds of white mold in fields with rows oriented in a north-south direction was 2.5 times higher than the odds of white mold in fields in which rows were in an east-west direction. Fields without white mold were more likely to be on the drier side than fields with white mold.

The results of this study indicate that special consideration needs to be given to canopy closure, row orientation, and soil moisture when deciding if a pesticide application is necessary for mold control.

Based on the present study as well as several years of research data and grower experience the current recommendations for growers who need to spray to control white and gray molds are as follows: Use Topsin M 14 to 20 fl oz/A (for white mold control) tank mixed or separate with either Bravo at 1.5 to 3 pt/A or Endura at the 2EE low rate of 5 oz/A (for gray mold control.). The first application should be applied at 10 to 30% bloom with a second application approximately 7 days later if weather conditions warrant.

There is the potential for snap bean producers to reduce fungicide sprays from 2 to 1 or no sprays if the 3 key risk factors (row orientation, canopy closure, soil moisture) are low. Most dry bean producers do not apply fungicides until signs of the disease are present in the field.

Growers who reduce or eliminate fungicide sprays entirely will experience significant in-season cost savings.

Appendices

Appendix 1 – Figures 1 through 6 of Text

Appendix 2 – List of Published Materials

**Cobb, A. C., Dillard, H. R. and Taras, J. L. 2007. Evaluation of foliar sprays for control of white mold in dry beans, 2006. Plant Disease Management Reports (online). Report 1:V082. DOI: 10.1094/PDMR01. The American Phytopathological Society, St. Paul, MN

**Cobb, A. C., Dillard, H. R. and Taras, J. L. 2007. Evaluation of pesticides for control of white and gray mold in snap beans, 2006. Plant Disease Management Reports (online). Report 1:V083. DOI: 10.1094/PDMR01. The American Phytopathological Society, St. Paul, MN

**Cobb, A. C., Strauss, J., and Dillard, H. R. 2008. Evaluation of fungicides for control of white and gray mold in snap beans, field Crittenden, 2007. Plant Disease Management Reports (online). Report 2:V123. DOI:10.1094/PDMR02. The American Phytopathological Society, St. Paul, MN

**Cobb, A. C., Strauss, J., and Dillard, H. R. 2008. Evaluation of fungicides for control of white and gray mold in snap beans, field RN31, 2007. Plant Disease Management Reports (online). Report 2:V122. DOI:10.1094/PDMR02. The American Phytopathological Society, St. Paul, MN

Cobb, Ann, and Dillard, Helene. 2008. Continuing the search for mold and spot control after Ronilan. 2008 Mid-Atlantic Fruit and Vegetable Convention & North American Berry Conference Proceedings, pages 75-78.

Dillard, Helene R., and Cobb, Ann C. 2008. Snap bean quality spoilers: white mold, gray mold, and spots. 2008 Empire State Fruit & Vegetable Expo and Becker Forum Proceedings, pages 148-150.

Shah, Denis A. 2008. Progress update on a set of classification rules for the risk of white mold in snap bean. 2008 Empire State Fruit & Vegetable Expo and Becker Forum Proceedings, pages 140-141.

**copy attached in Appendix 2

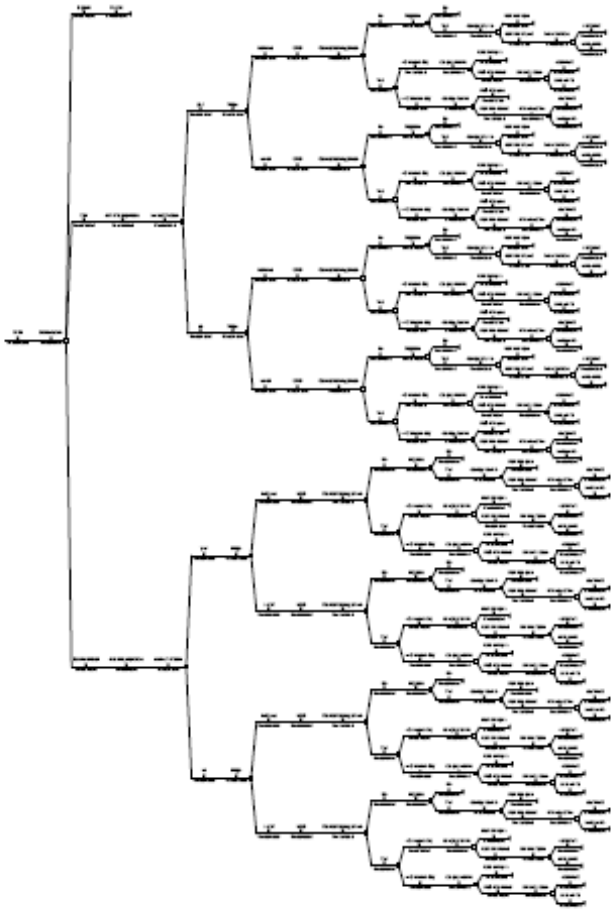

Figure 1. Example of a complex decision tree structure generated by a consideration of factors listed as important to the development of white mold. Such a complex tree structure is not useful for practical decision making.

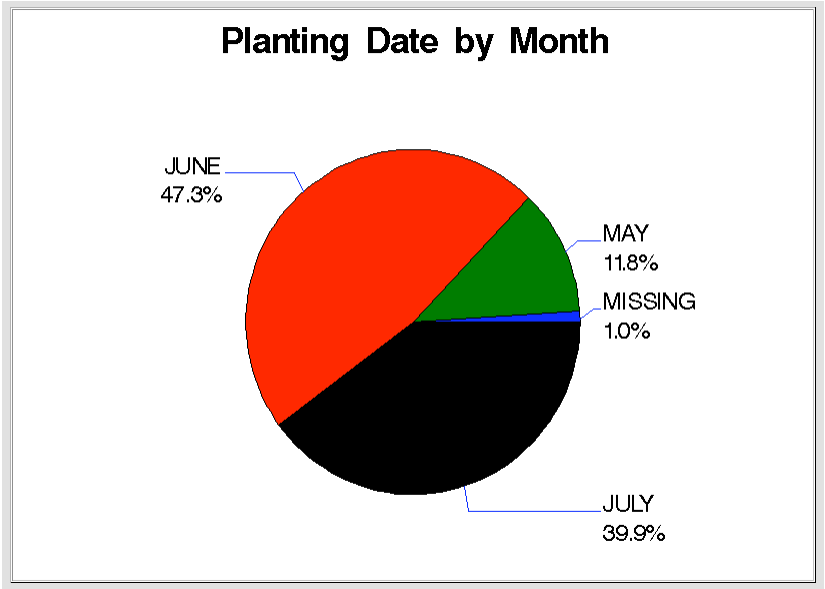

Figure 2. Planting date of fields surveyed for white mold in 2006 and 2007.

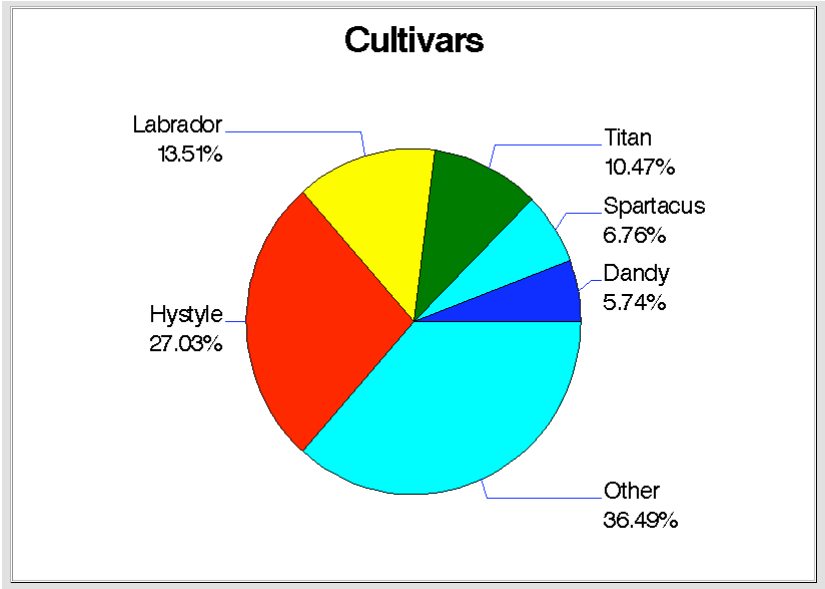

Figure 3. Snap bean cultivars in commercial fields surveyed in 2006 and 2007.

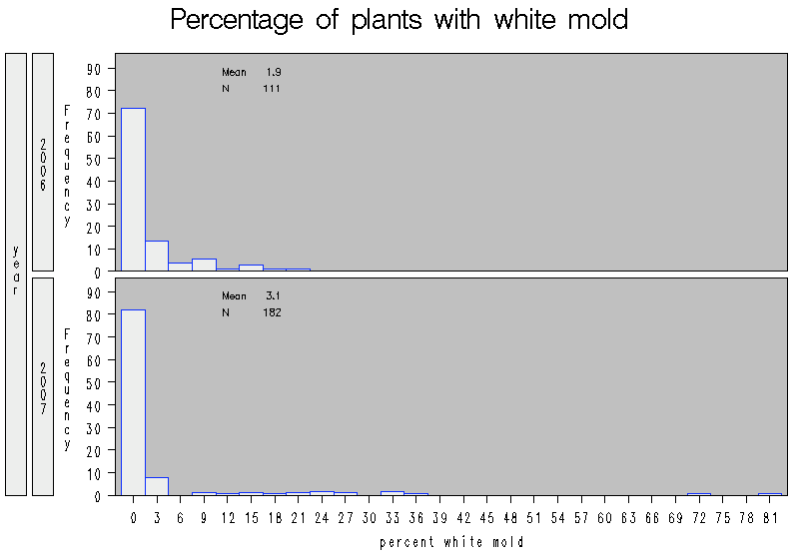

Figure 4. Histogram of the incidence (%) of plants with white mold in fields surveyed in 2006 and 2007.

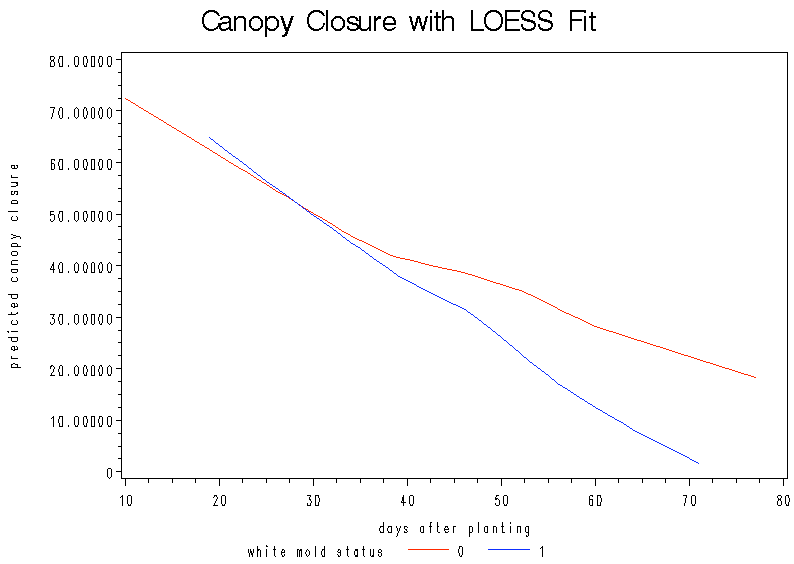

Figure 5. LOESS regression of canopy closure (cm) as a function of days after planting in snap bean fields without (red line) and with (blue line) white mold. Note the divergence between the curves beginning about 30 days after planting.

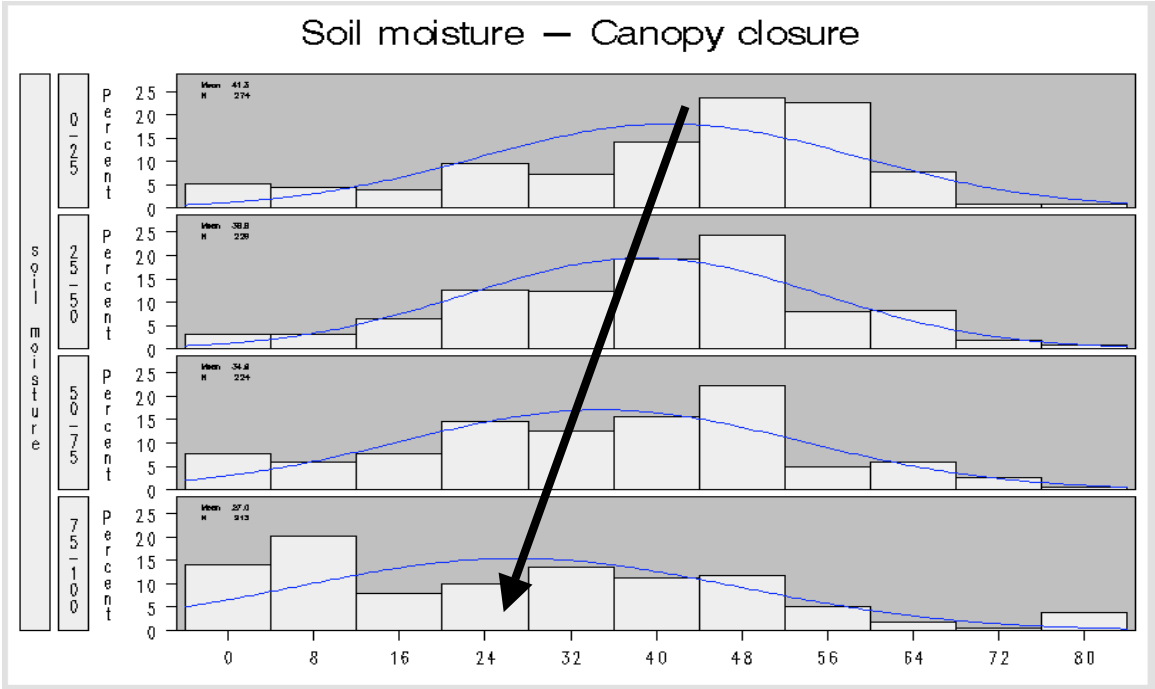

Figure 6. Canopy closure (cm) – soil moisture relationships. Note the tendency to higher levels of soil moisture in closed canopies (less open distance between adjacent rows).

DRY BEAN (*Phaseolus vulgaris* 'Pink Panther')

White Mold; *Sclerotinia sclerotiorum*

A. C. Cobb, H. R. Dillard, J. L. Taras

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Evaluation of foliar sprays for control of white mold in dry beans, 2006.

The trial was conducted at the Agricultural Experiment Station in Geneva, NY, in a Lima silt loam soil at a pH of 6.3. On 24 May, light red kidney dry beans were seeded (in an east west direction) using a Monosem planter at 7.4 seeds/ft, at 30-in. row spacing. Fertilizer (10-10-10 + Mn and Zn) was banded at planting at the rate of 300 lb/A. The fungicide treatments were arranged in a randomized complete block design with four replications. The treatments consisted of single row plots that were 42 ft long with 2 ft of untreated beans as a buffer zone between blocks. Weeds were adequately controlled using cultivation and hand weeding. Orthene 75S (0.75 lb/A) was applied on 10 Jul to control leafhoppers and Mexican bean beetles. A CO_2 backpack, single row sprayer calibrated to deliver 68 gal/A of water at 50 psi using three 8002 flat fan nozzles was used for both chemical sprays and spore applications. The sprayer was configured so that one nozzle was positioned over the top of the row and 9-in. drop nozzles were positioned on each side of the row angled down into the canopy. The first fungicide "A" spray was applied on 3 Jul at 31% bloom. The second fungicide "B" spray was applied 10 Jul at 100% bloom to pin pod stage. Percent bloom was calculated by summing the number of plants with one or more open blossoms from 10 consecutive plants from 10 areas of the field and averaging the results. *S. sclerotiorum* ascospore inoculum was applied to the plants within the plot area on 6 and 9 Jul. For the first spore application, *S. sclerotiorum* was applied at 1.41×10^6 ascospores/fl oz. For the second application, *S. sclerotiorum* was applied at 1.11×10^6 spores/fl oz. On 10 Jul, after the final chemical and spore application, several strips (26 ft by 200 ft) of Aluminet (double faced aluminum coated shade cloth with a 40% shade factor) were laid over the entire plot. The shade cloth was used to keep the plants cooler and maintain moisture in the plant canopy to encourage disease development. The covers were removed on 31 Jul. The number of plants with white mold (incidence) and a visual rating of the percent disease of the entire plot (severity) were enumerated on 31 Jul and 18 Aug in 32 ft and in 20 ft of row, respectively. When the dry bean pods for each treatment/rep were sufficiently dry (18 Aug), dry bean plants in 20 ft of row were harvested. Plants were cut near ground level, put in paper bags, and dried in a greenhouse (68-77ºF) to determine yield. Mean monthly minimum and maximum temperatures (°F) were 46 and 67 in May, 57 and 75 in Jun; 64 and 82 in Jul; and 60 and 77 in Aug, respectively. Total monthly rainfall (in.) was 2.1, 5.0, 5.0, and 2.6 for May, Jun, Jul, and Aug, respectively. To enhance plant growth and encourage disease development irrigation was applied on 7, 10, 18, 19, 20, and 22 Jul (2.5 in. total) using an irrigation gun dispensing water from a pond.

Disease pressure was high with excellent separation of means. Up to 54% of the plants were infected in the inoculated check treatment. At 68 days after planting (DAP), all Topsin M treatments significantly lowered disease incidence as compared to the control, followed by Headline, and Champion. At both evaluation dates, disease severity was significantly lower in the Topsin M and Headline treatments. There were no significant differences in total top dry weights or seed weights. No phytotoxicity was observed.

Treatment and rate/A	White mold incidence[z] (% of plants infected)	White mold severity[z] (% of plot infected)		Total dry top wt (lb/A)	Total seed yield (lb/A)
	68 DAP[y]	68 DAP	86 DAP		

Control	53.6 a	13.3 a	12.8 a	1457 a[x]	1270 a
Topsin M WDG 0.7 lb, A, B[w]	1.1 d	0.3 c	1.1 c	1476 a	1294 a
Topsin M WDG 1 lb, A, B.....	0.6 d	0.3 c	0.5 c	1438 a	1294 a
Topsin M WDG 1.5 lb, B.....	1.6 d	0.5 c	0.5 c	1524 a	1160 a
Headline EC 8 fl oz, A, B	16.3 c	5.5 b	6.3 b	1533 a	1318 a
Champion 3 lb, A, B	37.8 b	8.8 ab	12.3 a	1351 a	1174 a

[z]Mean incidence values are shown. Incidence values were transformed using the arcsin square root transformation. Transformed data were analyzed using the general linear models procedure in SAS and treatment means were separated using Fisher's Protected LSD test ($P \leq 0.05$).

[y]Days after planting (24 May).

[x]Means within a column not followed by a common letter differ significantly according to Fisher's Protected LSD test ($P \leq 0.05$).

[w]Chemical application dates: A=31% bloom, 3 Jul; B=100% bloom + pins, 10 Jul.

SNAP BEAN (*Phaseolus vulgaris* 'Gold Mine') H. R. Dillard , A. C. Cobb, J. L. Taras
White Mold; *Sclerotinia sclerotiorum* Dept. Plant Pathology, NYSAES, Cornell Univ.
Gray Mold; *Botrytis cinerea* Geneva, NY 14456

Evaluation of pesticides for control of white and gray mold in snap beans, 2006.

The trial was conducted at the Agricultural Experiment Station in Geneva, NY, in a Lima silt loam soil with a pH of 6.3. On 24 May, snap beans were seeded (in an east west direction) using a Monosem planter at 8.7 seeds per ft at 30-in. row spacing. Fertilizer (10-10-10 with supplemental manganese and zinc) was banded at planting at 300 lb/A. The fungicide treatments were arranged in a randomized complete block design with four replications. The treatments consisted of single row plots that were 32 ft long with 2 ft of untreated beans as a buffer zone between blocks. Orthene 75 S (0.75 lb/A) was applied on 10 Jul to control leafhoppers and Mexican bean beetles. On 22 Jun, single rows adjacent to the plot and 3 ft of row on each end of the plot were damaged by crushing with two bricks. Subsequently, *B. cinerea* was applied at 8.8 x 10^6 spores/fl oz to the damaged plants using a Swiss-Mex SP1 backpack sprayer with a single 8003 nozzle at 25 gal/A. On 11 Jul, the same sprayer was used to apply a mixture of *B. cinerea* at 6.5 x 10^6 spores/fl oz and *S. sclerotiorum* ascospores at 1.1 x 10^6 spores/fl oz to the actual treatments. A CO_2 backpack, single row sprayer calibrated to deliver 68 gal of water at 50 psi using three 8002 flat fan nozzles was used for both chemical sprays and all other spore applications. The sprayer was configured so that one nozzle was positioned over the top of the row and 9-in drop nozzles were positioned on each side of the row angled down into the canopy. The first "A" fungicide spray was applied on 5 Jul at 20% bloom. The second fungicide "B" spray was applied 11 Jul at 100% bloom to pin pod stage. Percent bloom was calculated by summing the number of plants with one or more open blossoms from 10 consecutive plants in 10 areas of the field and averaging the results. Spore inoculum, consisting of a mixture of *B. cinerea* and *S. sclerotiorum* spores, was applied to the plants within the plot area on 6 and 9 Jul, as noted above. For the first spore application *B. cinerea* was applied at 7.6 x 10^6 spores/fl oz and *S. sclerotiorum* was applied at 1.4 x 10^6 spores/fl oz. For the second application, *B. cinerea* was applied at 8.0 x 10^6 spores/fl oz and *S. sclerotiorum* was applied at 1.1 x 10^6 spores/fl oz. On 11 Jul, following the second pesticide and third spore applications, several strips (26 ft by 200 ft) of Aluminet (double faced aluminum coated shade cloth with a 40% shade factor) were laid over the entire plot. The shade cloth was used to keep the plants cooler and maintain moisture in the plant canopy to encourage disease development. Snap bean pods in 20 ft of row were harvested and evaluated 26, 27, and 28 Jul. Mean monthly minimum and maximum temperatures (°F) were 46 and 67 in May, 57 and 75 in Jun, and 64 and 82 in Jul, respectively. Total monthly rainfall (in.) was 2.1, 5.0, and 5.0 for May, Jun, and Jul, respectively. To enhance plant growth and encourage disease development, irrigation was applied 7, 10, 18 19, and 20 Jul (2.5 in. total) using an irrigation gun pumping water from a pond.

The processor imposed threshold for rejection of beans at the processing plant ranges from 3 to 6% pods with mold. Disease pressure was moderate for both gray mold incidence (9.3%) and white mold incidence (8.3%) on the pods in the inoculated check treatments. All treatments except Bravo 3pt/A and Endura 5 oz/A achieved excellent control (less than 3% incidence) of white mold. The most effective gray mold materials

as well as combinations to control both molds and that also reduced total mold incidence to below 3% disease were Endura 5 oz + Topsin M 0.7 lb or 1.0 lb, Endura 3 oz + Topsin M 1 lb, Rovral 1.5 pt + Topsin M 0.7 lb, and Quadris 6.2 fl oz applied prebloom, followed by Endura 5 oz + Topsin M 1 lb during bloom. The treatments that reduced one or both molds to above the 3% rejection threshold, but less than the 6% rejection threshold were Rovral 2 pt, Switch, Bravo + Switch, Rovral 1.5 pt + Bravo, Bravo + Topsin M, and Trilogy + Endura 5 oz. There were no significant differences in marketable and total yield among the treatments. No phytotoxicity was observed.

Treatment and rate/A	Gray mold (%)	White mold (%)	Marketable yield (t/A)	Total yield (t/A)
Control	9.3 a*	8.3 a	1.5 a	1.8 a
Endura 70 WDG 5 oz, A, B **	5.6 bcde	4.2 b	2.3 a	2.5 a
Endura 70 WDG 5 oz + Topsin M WDG 0.7 lb, A, B	2.1 f	0.3 c	2.4 a	2.5 a
Endura 70 WDG 5 oz + Topsin M WDG 1.0 lb, A, B	1.8 f	0.2 c	2.3 a	2.3 a
Endura 70 WDG 3 oz + Topsin M WDG 1.0 lb, A, B	2.2 f	0.0 c	1.9 a	2.0 a
Rovral 4F 2 pt, A, B	3.2 ef	0.7 c	1.9 a	2.0 a
Rovral 4 F 1.5 pt + Topsin M WDG 0.7 lb, A, B	1.4 f	0.1 c	1.8 a	1.9 a
Topsin M WDG 1.0 lb, A, B	7.4 ab	0.0 c	1.9 a	2.0 a
Switch 62.5 WG 12 oz, A, B	4.1 cdef	1.3 bc	2.3 a	2.5 a
Bravo WS 3 pt + Switch 62.5 WG 12 oz, A, B	4.1 cdef	1.7 bc	1.7 a	1.9 a
Bravo WS 3 pt, A, B	7.3 abc	8.6 a	2.1 a	2.5 a
Quadris 6.2 fl oz, applied 12 days before A;	-	-	-	-
Endura 70 WDG 5 oz + Topsin M WDG 1.0 lb, A, B	2.6 ef	0.2 c	2.4 a	2.5 a
Rovral 4 F 1.5 pt + Bravo WS 3 pt, A, B	2.1 f	2.2 bc	2.2 a	2.3 a
Bravo WS 3 pt + Topsin M WDG 0.7 lb, A, B	4.2 cdef	0.6 c	2.4 a	2.6 a
Trilogy 5.4 pt + Topsin M WDG 0.7 lb, A, B	6.7 abcd	0.0 c	1.9 a	2.0 a
Trilogy 5.4 pt + Endura 70 WDG 5 oz, A, B	3.7 def	0.6 c	1.9 a	2.0 a
LSD ($P \leq 0.05$)	3.2	3.5	NS	NS

*Means in the same column with different letters differ significantly according to Fisher's Protected LSD ($P \leq 0.05$).

** Chemical application dates: A=20% bloom, 5 Jul; B=100% bloom + pins, 11 Jul.

SNAP BEAN (*Phaseolus vulgaris* 'Gold Mine') A.C. Cobb, J. Strauss, and H.R. Dillard
White Mold; *Sclerotinia sclerotiorum* Dept. Plant Pathology, NYSAES, Cornell Univ.
Gray Mold; *Botrytis cinerea* Geneva, NY 14456

Evaluation of fungicides for control of white and gray mold in snap beans, field Crittenden, 2007.

The trial was conducted at the Agricultural Experiment Station in Geneva, NY, in a Lima silt loam soil with a pH of 7.0. On 12 Jun, Gold Mine snap beans were seeded (in an east west direction) using a Monosem planter at 8.7 seeds per ft at 30-in. row spacing. Fertilizer (10-10-10 with supplemental manganese and zinc) was banded at planting at 300 lb/A. Dual Magnum (1.0 pt/A) was applied postplant on 14 Jun. The fungicide treatments were arranged in a randomized complete block design with four replications. The treatments consisted of single row plots measuring 32 ft long with 2 ft of untreated beans as a buffer zone between blocks. On 20 Jul, single rows adjacent to the plot and 3 ft of row on each end of the plot were damaged by crushing. Subsequently, *B. cinerea* was applied at 2.2 x 10^7 spores/fl oz to the damaged plants using a Swiss-Mex SP1 backpack sprayer with a single 8003 nozzle at 25 gal/A. Orthene 75 S (25 gal/A) was applied on 26 Jul and 2 Aug to control leafhoppers and Mexican bean beetles. A CO_2 backpack, single row sprayer calibrated to deliver 68 gal of water per acre at 1.8 mph, 50 psi, using three 8002 flat fan nozzles was used for all following fungicide and spore applications. The sprayer was configured with one nozzle over the top of the row and a 9-in drop nozzle on each side of the row angled into the canopy. The first fungicide spray “A” was applied on 26 Jul at 10% bloom to the treatment plots. The second fungicide spray “B” was applied 2 Aug at 100% bloom to pin pod stage. Percent bloom was calculated by summing the number of plants with one or more open blossoms from 10 consecutive plants in 10 areas of the field and averaging the results. A mixture of *B. cinerea* at 2.8 x 10^7 spores/fl oz and *S. sclerotiorum* at 2.2 x 10^6 spores/fl oz was applied to the plot on 31 Jul. The plots were inoculated again with *B. cinerea* at 2.1 x 10^7 spores/fl oz and *S. sclerotiorum* at 1.5 x 10^6 spores/fl oz 2 Aug. Following the second fungicide and spore applications 2 Aug, several strips (26 ft by 200 ft) of Aluminet (double faced aluminum coated shade cloth with a 40% shade factor) were laid over the entire plot until harvest. The shade cloth was used to keep the plants cooler and maintain moisture in the plant canopy to encourage disease development. Snap bean pods in 20 ft of row were harvested and evaluated 20, 21, 22, and 23 Aug. Pods were categorized as healthy, gray mold infected, or white mold infected, and counted and weighed. Disease incidence and yield were calculated. Mean monthly minimum and maximum temperatures (°F) were 56 and 80 in Jun, 59 and 79 in Jul, and 60 and 81 in Aug, respectively. Total monthly rainfall (in.) was 1.6, 2.6, and 1.5 for Jun, Jul, and Aug, respectively. To enhance plant growth (very dry season) and encourage disease development, irrigation was applied 16, 31 Jul, and 1, 3, 4, 6, 7, 9, 14, 15, 16 and 17 Aug (11 in. total) using risers delivering city water.

Processor imposed thresholds for rejection of beans at the processing plants ranges from 3 to 6% pods with mold. Disease pressure was low for gray mold incidence (2.3%) and moderate for white mold incidence (6.4%) on the pods in the inoculated

check treatments. All treatments achieved excellent control (less than 3% incidence) of white mold except Bravo WS and EF400. The most effective gray mold materials and combinations to control both molds were Endura, Endura + Topsin M at 14 or 20 fl oz, Rovral, Rovral + Bravo, Bravo + Topsin M, Bravo, Endura + Trilogy, and Topsin M + Endura "A" followed by Topsin M + Headline "B". No treatments were significantly better than the control for marketable and total yield. Phytotoxicity on the foliage was observed with Endura + Trilogy.

Treatment, rate/A, Application timing ( ) [z]	Gray mold (%)	White mold (%)	Marketable yield (t/A)	Total yield (t/A)
Untreated Control	2.3 b [y]	6.4 a	5.0 ab	5.3 a
Endura 70 WDG, 5 oz (A, B)	0.1 f	1.1 b	4.4 abc	4.4 bc
Endura 70 WDG, 5 oz + Topsin M 4.5F, 14 fl oz (A, B)	0.4 ef	0.0 b	4.1 bcd	4.1 cd
Endura 70 WDG, 5 oz + Topsin M 4.5F, 20 fl oz (A, B)	0.3 f	0.1 b	4.6 abc	4.6 abc
Rovral 4F, 2 pt (A, B)	0.3 f	1.7 b	3.4 d	3.4 d
Rovral 4F, 1.5 pt + Bravo WS, 3 pt (A, B)	0.5 def	1.7 b	4.3 abcd	4.3 bcd
Rovral 4F, 1.5 pt + Topsin M, 4.5F 14 fl oz (A, B)	1.5 bcd	0.2 b	4.0 cd	4.0 cd
Topsin M 4.5F, 20 fl oz (A, B)	3.4 a	0.1 b	4.7 abc	4.9 abc
Bravo WS, 3 pt + Topsin M 4.5F, 14 fl oz (A, B)	0.9 cdef	0.1 b	4.5 abc	4.5 abc
Bravo WS, 3 pt (A, B)	1.0 cdef	6.9 a	4.3 abcd	4.6 abc
Endura 70 WDG, 5 oz + Trilogy 5.4 pt (A, B)	0.2 f	0.6 b	4.0 cd	4.1 cd
EF400, 4.1 pt + Topsin M 4.5F, 20 fl oz (A, B)	1.7 bc	0.0 b	4.3 abcd	4.4 abc
EF400, 4.1 pt (A, B)	1.5 bcde	4.8 a	3.9 cd	4.2 cd
Headline, 8 fl oz + Topsin M, 4.5F 14 fl oz (A, B)	1.4 bcde	0.4 b	4.5 abc	4.6 abc
Elevate 50WDG, 1.5 lb + Topsin M 4.5F, 14 fl oz (A, B)	1.2 bcdef	0.1 b	4.6 abc	4.7 abc
Endura 70 WDG, 8 oz + Topsin M 4.5F, 20 fl oz (A)	-	-	-	-
Topsin M 4.5F, 20 fl oz + Headline, 8 fl oz (B)	0.7 cdef	0.2 b	5.1 a	5.1 ab
LSD ($P \leq 0.05$)	1.1	2.3	0.9	0.9

[z] Application dates: A=10% bloom, 26 Jul; B=100% bloom + pins, 2 Aug.

[y] Means in the same column with different letters differ significantly according to Fisher's Protected LSD ($P \leq 0.05$).

SNAP BEAN (*Phaseolus vulgaris* 'Gold Mine') A.C. Cobb, J. Strauss, and H.R. Dillard
White Mold; *Sclerotinia sclerotiorum* Dept. Plant Pathology, NYSAES, Cornell Univ.
Gray Mold; *Botrytis cinerea* Geneva, NY 14456

Evaluation of fungicides for control of white and gray mold in snap beans, field RN31, 2007.

The trial was conducted at the Agricultural Experiment Station in Geneva, NY, in a Honeoye silt loam soil with a pH of 7.0. On 22 May, snap beans were seeded (in an east west direction) using a Monosem planter at 8.7 seeds per ft at 30-in. row spacing. Fertilizer (10-10-10 with supplemental manganese and zinc) was banded at planting at 300 lb/A. Dual Magnum (1.0 pt/A) was applied postplant on 23 May. The fungicide treatments were arranged in a randomized complete block design with four replications. The treatments consisted of single row plots that were 32 ft long with 2 ft of untreated beans as a buffer zone between blocks. Orthene 75 S (0.75 lb/A) was applied on 12 Jul to control leafhoppers and Mexican bean beetles. On 25 Jun, single rows adjacent to the plot and 3 ft of row on each end of the plot were damaged by crushing with two bricks. Subsequently, *B. cinerea* was applied at 2.2 x 10^7 spores/fl oz to the damaged plants using a Swiss-Mex SP1 backpack sprayer with a single 8003 nozzle at 25 gal/A. A CO_2 backpack, single row sprayer calibrated to deliver 68 gal of water per acre at 1.8 mph, 50 psi, and using three 8002 flat fan nozzles was used for both chemical sprays and all other spore applications except as noted below. The sprayer was configured with one nozzle over the top of the row and a 9-in drop nozzle on each side of the row angled into the canopy. The first fungicide spray "A" was applied on 6 Jul at 28% bloom. The second fungicide spray "B" was applied 12 Jul at 100% bloom to pin pod stage. Percent bloom was calculated by summing the number of plants with one or more open blossoms from 10 consecutive plants in 10 areas of the field and averaging the results. On 6 Jul after the first fungicide application had dried, the same sprayer was used to apply a mixture of *B. cinerea* at 1.2 x 10^7 spores/fl oz and *S. sclerotiorum* at 1.1 x 10^6 spores/fl oz. The plots were inoculated again with *B. cinerea* at 2.0 x 10^7 spores/fl oz and *S. sclerotiorum* spores at 2.2 x 10^6 spores/fl oz 10 Jul. Then on 12 Jul the plots were inoculated a third time, after the second fungicide application had dried, using the Swis-Mex sprayer with *B. cinerea* at 2.2 x 10^6 spores/fl oz and *S. sclerotiorum* at 7.2 x 10^5 spores/fl oz. On 12 Jul, following the second fungicide application and third inoculation, several strips (26 ft by 200 ft) of Aluminet (double faced aluminum coated shade cloth with a 40% shade factor) were laid over the entire plot until harvest. The shade cloth was used to keep the plants cooler and maintain moisture in the plant canopy to encourage disease development. Snap bean pods in 20 ft of row were harvested and evaluated 30 and 31 Jul and 1 and 2 Aug. Pods were categorized as healthy, gray mold infected, or white mold infected, and counted and weighed. Disease incidence and yield were calculated. Mean monthly minimum and maximum temperatures (°F) were 46 and 69 in May, 56 and 80 in Jun, and 59 and 79 in Jul, respectively. Total monthly rainfall (in.) was 1.6, 1.6, and 2.6 for May, Jun, and Jul, respectively. To enhance plant growth and encourage disease development

in a very dry season, irrigation was applied 3, 5, 13, 16, 18, 20, 23, 25, and 27 Jul (6.5 in. total) using an irrigation gun pumping water from a pond.

The processor imposed threshold for rejection of beans at the processing plant ranges from 3 to 6% pods with mold. Disease pressure was moderate for both gray mold incidence (4.9%) and white mold incidence (4.5%) on the pods in the inoculated check treatments. All treatments were effective at controlling white mold except for Bravo alone. The most effective gray mold materials as well as combinations to control both molds were Endura, Endura + Topsin M at 14 or 20 fl oz, Rovral, Rovral + Bravo, Rovral + Topsin M, Bravo + Topsin M, Bravo, Endura + Trilogy, Elevate + Topsin M, and Endura + Topsin M "A" followed by Topsin M + Headline "B". Rovral had significantly higher marketable yield than the control. No treatments were significantly better than the control for total yield. Phytotoxicity on the foliage was observed with Endura + Trilogy, but the damage did not adversely affect yield.

Treatment, rate/A, Application timing ( )[z]	Gray mold (%)	White mold (%)	Marketable yield (t/A)	Total yield (t/A)
Untreated Control	4.9 bc[y]	4.5 a	3.2 b	3.5 ab
Endura 70 WDG, 5 oz (A, B)	0.8 e	0.3 c	3.8 ab	3.8 ab
Endura 70 WDG, 5 oz + Topsin M 4.5F, 14 fl oz (A, B)	1.1 de	0.0 c	3.8 ab	3.8 ab
Endura 70 WDG, 5 oz + Topsin M 4.5F, 20 fl oz (A, B)	0.7 e	0.0 c	3.6 ab	3.6 ab
Rovral 4F, 2 pt (A, B)	0.8 e	0.4 c	4.2 a	4.3 a
Rovral 4F, 1.5 pt + Bravo WS, 3 pt (A, B)	0.7 e	0.3 c	3.7 ab	3.8 ab
Rovral 4F, 1.5 pt + Topsin M 4.5F, 14 fl oz (A, B)	1.2 de	0.0 c	3.1 b	3.1 b
Topsin M 4.5F, 20 fl oz (A, B)	9.7 a	0.0 c	3.5 ab	3.9 ab
Bravo WS, 3 pt + Topsin M 4.5F, 14 fl oz (A, B)	1.9 de	0.0 c	3.4 ab	3.5 ab
Bravo WS, 3 pt (A, B)	1.2 de	2.9 ab	3.6 ab	3.7 ab
Endura 70 WDG, 5 oz + Trilogy, 5.4 pt (A, B)	0.1 e	0.2 c	3.6 ab	3.6 ab
EF400, 4.1 pt + Topsin M 4.5F, 20 fl oz (A, B)	5.6 b	0.1 c	3.9 ab	4.2 a
EF400, 4.1 pt (A, B)	4.2 bc	2.4 b	3.3 b	3.5 ab
Headline, 8 fl oz + Topsin M 4.5F, 14 fl oz (A, B)	2.9 cd	0.0 c	3.8 ab	3.9 ab
Elevate 50WDG, 1.5 lb + Topsin M 4.5F, 14 fl oz (A, B)	1.7 de	0.2 c	3.7 ab	3.7 ab
Endura 70 WDG, 8 oz + Topsin M 4.5F, 20 fl oz (A)	-	-	-	-
Topsin M 4.5F, 20 fl oz + Headline, 8 fl oz (B)	1.6 de	0.3 c	3.7 ab	3.7 ab
LSD ($P \leq 0.05$)	2.0	1.8	0.9	NS

[z] Application dates: A=28% bloom, 6 Jul; B=100% bloom + pins, 12 Jul.

[y] Means in the same column with different letters differ significantly according to Fisher's Protected LSD ($P \leq 0.05$).

White mold – Fine-tuning whether/when to spray

Ann Cobb and Helene Dillard, Cornell University, September 6, 2007

Sclerot

Apothecia-baby

Apothecia ejecting

Management strategies to minimize disease:
Select fields with good air drainage to facilitate drying of foliage.
Avoid plant injury.
Control weeds to minimize sites for sporulation and favorable microclimate for infection.
Rotate with grains, corn, and other nonhosts.
Incorporate debris immediately following harvest to encourage microbial decay of the sclerotia.
Contans (a product containing a mycoparasite) can be used to kill sclerotia to reduce available inoculum.

Chemical control:
Dry bean grower trials 2006: increase of 7.3 bu/A reds and 20 bu/A blacks-more than paid for application.
Decision tree: indicators a pesticide application will be cost effective = early canopy closure + large (lodging) plants + high potential yield + wet conditions near bloom and later.

Infection is a two-step process and is ahead of what you can see:
Step 1. Infection of blossoms and penetration of fungus into the bean plant.
Step 2. Disease progression where fungus grows enough to be visible to the naked eye.
Topsin M is a protectant fungicide and is effectively used during step 1 before the white mold fungus has penetrated the plant. Spray before you see disease or you will be too late!

Timing: Percent bloom is determined by examining 10 consecutive plants and counting the number that have 1 or more open blossoms. For example: If 3/10 plants are blooming x 100 = 30 % bloom. Do this in 5 to10 areas of the field and average the results. Percent bloom can increase by 20% per day.

For a 2-spray program apply Topsin M at about 30% bloom and 7 days later; for a 1-spray program, apply at near 100% bloom (pins may be present, but no large pods).