Final Report to the New York Corn and Soybean Growers Association – February 1, 2013

PROJECT TITLE: Enhancing integrated options to better manage soybean white mold using a biological fungicide

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Abstract:
Field studies were conducted in two commercial and one Cornell research farm soybean fields to evaluate the effect of the biological fungicide Contans® WG (SipCam) on white mold of soybeans caused by *Sclerotinia sclerotiorum*. Our highest criteria priority was for field selection was to have at least a few sclerotia observed on the soil surface. Unfortunately, sclerotia were difficult to find on *any* candidate fields. Given the difficulties in easily finding sclerotia on candidate fields, our experimental field selection became heavily weighted towards fields with a previous recent history of *severe* economic losses from white mold disease within the past three years. Each field selected for study met these criteria and was divided into two and randomly assigned a spring application of either Contans® WG at a 4 lb. / acre rate or left as an *untreated* control (UTC) plot. Contans® WG was applied by cooperators prior to planting soybeans according to label instructions after soil temperatures reached a minimum of 50 F. Fields were assessed for presence of white mold apothecia and level of disease incidence beginning at initiation of soybean bloom (approximately mid July) until harvest. The 2012 growing season in our western New York study locations was marked by below normal precipitation and drought conditions. The dry weather was not conducive disease development in any experimental field. Irrigation applications at the Cornell site also did not result in disease development. In our current study, numbers of apothecia and yields of soybeans in plots treated with Contans were not different from the untreated check (UTC). Unfortunately, without white mold being present in plots it was impossible to critically evaluate the effect of Contans on disease incidence under field conditions this season. Under suitable conditions soybean white mold disease can be devastating. When the disease is present control options are limited, efficacy of current management strategies are variable and there are implications for long term disease management. While these studies have not provided the data and insights we had hoped for, they did provide the opportunity to gain experience with use of this biological product, have stimulated additional interest in this area of research and have enhanced our outreach efforts on soybean disease education and management. Given the importance of environmental conditions and difficulties in obtaining significant disease under natural field conditions, it may be that future evaluations of

this and other products for management of soybean white mold will necessarily rely on additional studies, producer field trials of various products, including new biocontrol materials and novel strategies compared to untreated checks. Clearly additional alternatives are needed to enhance an integrated management approach towards soybean white mold.

Project Background:

Sclerotinia sclerotiorum, the causal agent of white mold also known as Sclerotinia stem rot, is a destructive pathogen with a host range exceeding 400 plant species worldwide (3). In addition to soybeans, the pathogen has an extensive host range causing diseases on a wide variety of crops such as sunflower, dry and snap bean, canola, alfalfa, buckwheat, lupine, mustard, potato, Jerusalem artichoke, safflower, lentil, flax, field peas, many vegetables and several ornamental crops. There are also many common broadleaf weed hosts such as marsh elder, lambsquarters, pigweed, ragweed, velvetleaf, Canada thistle and wild mustard.

White mold of soybeans has been described as a "high yield" disease, favoring well-managed high-density fields with the greatest yield potential. As soybean producers adopt management practices that seek to maximize yield, white mold issues, caused by *Sclerotinia sclerotiorum* can become a higher risk. Yield losses can range from 0.25 to 0.5 bu/A for every 1% increase in disease incidence (11).

White mold management is difficult when environmental conditions are favorable for disease development. The sclerotia can remain in the soil for several years and lose their viability slowly. A long-term solution to white mold management lies in the development and use of highly resistant soybean varieties; however, only varieties with moderate resistance or tolerance are currently available (16, 17). In the interim, white mold must be managed by careful variety selection (for the best available resistance) and modifying crop management practices. Variety selection, crop canopy modification, row spacing, planting date, crop rotation with non-hosts such as small grains and corn or fallowing fields, tillage systems, fungicides and weed management systems are examples of tactics that can be modified for management of this disease on individual farms (16, 17, 19).

Since sclerotia can survive for many years, crop rotation is not effective for complete control of white mold. Given the large number of potential white mold host species, crop rotation will reduce populations of sclerotia in soil, but will not entirely eliminate the pathogen. Research has demonstrated that shorter two- or three-year rotations to non-host crops such as corn and small grains can be highly effective in reducing sclerotia in the soil and should be considered as part of any overall white mold management strategy. University of Wisconsin plant pathologist Craig Grau recommends a rotation of corn—soybeans—small grains (in that specific order)—using oats, wheat, or barley as the small grain crop (16).

In-season attempts to control diseases caused by *Sclerotinia sclerotiorum* are normally aimed at stopping ascospore infection of susceptible tissue. Management strategies typically include fungicide applications aimed at protecting susceptible tissues which typically include flowers, stems, and wounded tissues. Fungicide use decisions should consider past field history, finding sclerotia, weather forecast and relative susceptibility of variety (12, 14).

Several fungicides are registered that can provide some level of disease suppression if applied during flowering and early pod formation, but proper timing at early bloom, adequate canopy coverage, and product penetration into the lower regions of the canopy to protect flowers and pod tissues are critical for successful control (12, 25). In areas of New York with a past history of intense white mold, single fungicide applications to soybean made at early bloom have not consistently reduced yield losses due to white mold (1). Unfortunately, once the disease is found in the field in a given season management options are limited. Thus, an integrated strategy for white mold management is critically needed in New York and other areas of the Northeast. An additional incentive for incorporating multiple management tactics is to delay or prevent selection in local populations of *Sclerotinia sclerotiorum* for insensitivity to benzimidazoles (includes thiophanate methyl, the active ingredient in Topsin M) and other classes of fungicides used in white mold management (1).

Viability of the overwintering white mold sclerotia naturally declines in soils over time, and certain organisms have been associated with the decline. These hyperparasites include *Bacillus subtilis, Gliocladium virens*, *Streptomyces lydicus*, *Trichoderma* spp., *Talaromyces flavus*, and *Coniothyrium minitans* (2, 15, 18, 20, 27) A formulation of *C. minitans* is available as the commercial product Contans® WG (5). Contans® is Organic Materials Review Institute (OMRI) listed and approved for use in the United States on a wide range of crops, including soybeans. Contans has shown promise as a biological control agent and potential alternative to control white mold in a number of vegetable crops. In a preliminary trial conducted on snap beans in New York, fewer sclerotia of *S. sclerotiorum* were recovered from plots treated with Contans compared to the untreated control plots (7, 8). Similar results were reported on snap beans in Wisconsin (23). Efforts to explore use of Contans in soybeans are underway in several states but results are limited at this time (10, 20, 28).

By targeting the overwintering sclerotia, Contans essentially provides long-term control of primary inoculum, as opposed to protectant fungicides that provide in-season control of ascospore infections. This option fits into an IPM management system where fields are scouted and areas of white mold infection are marked for post-harvest application of *C. minitans*. Assuming that the treated fields will be rotated with non-susceptible crops during the next year or two, it should be possible to then plant white mold susceptible crops into these fields with greatly reduced risk to white mold (23). A better understanding of the effect of *Coniothyrium minitans* alone and in combination with crop rotation with a non-host on soybean white mold incidence would enable more effective management of this disease by farmers. Additional locally developed information on soybeans would provide critical information to refine management recommendations regarding use of this technology and for growers to make informed management decisions leading to potential adoption of this pest management option.

The main objective of this study is to evaluate the effect of *C. minitans* (Contans) on white mold incidence and soybean yield under commercial field conditions in a New York State soybean production area where Sclerotinia disease has caused significant economic loss to farmers. NY Corn and Soybean Growers Association funded studies in 2011 observed soybeans treated with 4 lb. / A of Contans had fewer apothecia / sq. yd. and lower disease incidence than plots treated with 2 lb. / Acre Contans or an untreated check. Our data was mostly inconclusive due to variability in disease incidence and pathogen population across the field. Excessively dry conditions during flowering time were not conducive to disease development limiting over all disease incidence and reducing magnitude of treatment comparisons. While we were able to replicate within field, it is possible that the selected plot width may have allowed ascospore movement across treatments, which resulted in some interference among plots. Overall sclerotia numbers decreased from time of pre treatment to post harvest sampling. Significant yield differences were not observed (24). Our hypothesis is that use of this biological control agent (*C. minitans)* targeted at decreasing soil inoculum density could be combined with other management actions such as variety selection, tillage, and row spacing to reduce white mold incidence and protect soybean yields.

Objectives:

1) Evaluate the effect of soil applied *C. minitans* (Contans) on soybean white mold disease incidence and severity caused by *Sclerotinia sclerotiorum* under commercial field conditions in New York.
    a. Assess preseason and pre-harvest sclerotia populations in treated and untreated control plots in soybean study fields
    b. Scout for presence and density of apothecia production in treated and untreated control plots
    c. Evaluate soybean white mold disease incidence and yield

2) Present research findings to soybean producers through collaborative efforts with Cornell Cooperative Extension specialists.
    a. Conduct extension field days to show and demonstrate the results of the research trials in commercial fields
    b. Communicate the results regularly through extension newsletters and publications
    c. Extend research findings at annual NY soybean grower extension meetings such as the Annual New York Cooperative Extension Soybean Congresses

Results / Procedures:

Objective 1. Field Studies May 2012 – April 2013

Commercial Farm Field Selection:

Candidate experimental/ study fields had a history of severe soybean white mold within the last 3 years, were to be replanted to soybeans in 2012, were approximately 20 acres and were within 1.5 hours driving distance from Geneva, NY. Mike Stanyard, Cornell Cooperative Extension field crop specialist, identified commercial soybean production farms in Geneva, Avon, Clyde, Shortsville, and Mt. Morris, NY to evaluate as potential white mold research study sites. Fields in Geneva (NYSAES), Avon (Joe Morgan) and Clyde (Scott Arliss) NY were determined to meet study criteria. The Geneva field was located on Cornell Universities NYSAES Vegetable and Fruit research farm. This field (no. 49) had a history of a severe *Sclerotinia sclerotiorum* white mold infestation when planted to sunflowers in 2010. This site had irrigation available for application if needed to enhance environmental conditions more favorable for disease development. The fields in Avon and Clyde were on commercial farms.

a. Pre-plant sclerotia assessment.

Sclerotinia sclerotiorum sclerotia populations in test fields were visually assessed pre-treatment in the spring 2012. Our highest criteria priority was for fields to have at least a few sclerotia observed on the soil surface. Unfortunately, sclerotia were difficult to find on *any* candidate fields. Given the difficulties in easily finding sclerotia on candidate fields, our field selection became heavily weighted towards fields with a previous recent history of *severe* economic losses from white mold disease. Given the low number of sclerotia observed on the soil surface, the value in soil sampling to determine the pre-plant relative sclerotia per 2000cc sample areas was re-evaluated. Upon reflection our revised approach would be to conduct an end of season soil sampling to determine the relative sclerotia number present should significant white mold disease be observed.

While there was no absolute guarantee of disease development under these natural infestations, it was felt that the previous history of significant white mold disease and the long term viability of sclerotia in historically infested fields offered sufficient potential for disease development in the experimental fields should suitable environment conditions occur. In addition to meeting the potential disease risk criteria, the NYSAES field had access to irrigation to help foster conditions favorable to disease development.

b. Date of planting and Contans application

Each field selected for study was divided into two units and randomly assigned a spring application of either Contans® WG at a 4 lb. / acre rate or left as an *untreated* control (UTC) plot. Each of the three fields will serve as a replication. It was theorized that the large field-scale trials would minimize the chance for ascospores produced in one treatment to contaminate the other treatment. Treatment effects will be analyzed by analysis of variance. Contans® WG was procured by Blowers Agra Service, Inc. (Hall NY) who donated 50 lbs. of the material for this study. Contans® WG was applied by cooperators according to label instructions prior to planting soybeans after soil temperatures reached a minimum of 50 F. Date of planting and Contans application is presented in Table 1. Additional field record information is presented in the appendix.

Table 1. Date of planting and Contans application information

Farm	Total Field Acreage	Acres Treated	Date Treated	Planted
NYSAES, Geneva, NY	1	0.5	June 1, 2012	June 7, 2012
Joe Morgan, Avon, NY	20	10	May 26, 2012	May 26, 2012
Scott Arliss, Clyde, NY	36	4.73	May 12, 2012	May 12, 2012

c. Field evaluation for presence of white mold apothecia and disease incidence
Fields were visited throughout the season to assess presence of white mold apothecia and level of disease incidence beginning at initiation of soybean bloom (approximately mid July). Intensive sampling data was recorded in mid to late August at early to mid pod fill stages to document white mold presence and disease incidence.

Assessments were taken from ten randomly selected 1 sq. yd. areas in the interior along the full length of each plot. Number of apothecia within each sample site were recorded. Apothecia assessment was as described in Snap Bean Pest Management: A Guide to Regular Field Monitoring in New York (20). Disease incidence was assessed by evaluating 10 randomly selected plants in 10 locations per treatment along the full length of each plot for signs or symptoms of disease. Disease incidence was recorded. Very little to no white mold disease was observed in treated or untreated areas of any experimental field (Table 2).

Table 2. Sclerotinia apothecia and white mold disease incidence by location

Farm Location	Variety	Ascospore Assessment[1]	Contans Treated		Untreated Check	
			Number Apothecia Found	% Disease Observed[2]	Number Apothecia Found	% Disease Observed
Geneva	Pioneer 92Y51	8/10/12	4	0	0	0
	Pioneer 92Y12		0	0	4	0
	Pioneer 92Y51	8/30/12	0	0	0	0
	Pioneer 92Y12		0	0	0	0
	Pioneer 92Y51	10/2/12	1	0	0	0
	Pioneer 92Y12		0	0	0	0
Avon	Asgrow 24-31	8/22/12	0	1.14	0	0.23
	Asgrow 24-31	10/2/12	0	0.45	3	0.45
Clyde	Seedway SG1711[3]	8/22/12	0	0	0	0

[1] Assessments were taken from twenty 1 sq. yd. areas randomly selected from the interior of each plot. Number of apothecia per sq. yd. [2] Disease assessment: percent of 400 plants evaluated showing signs or symptoms of white mold disease (20 sample sites, 20 plants per sample site). [3]Field harvested 9/27/12, no second apothecia, disease assessment.

d. Field evaluation for yield

Yields were measured by grower cooperators using yield monitors at time of harvest (Table 3). Yield map of the Clyde field showed uniform yield across the treatment plot and adjacent margins. As described in Table 2 very few apothecia and no white mold disease were observed in the Geneva field all season. Custom equipment would have had to be brought in to harvest the experiment. It was felt that given a lack of disease the yields would reflect varietal differences but would not show an effect of Contans on disease mitigation. Given the lack of disease and on-farm harvesting equipment the field was not harvested. Given the lack of white mold disease in study fields, seed subsamples were not collected to assess white mold sclerotia number, weight by volume and viability.

Table 3. Field trial yields by location

Farm	Yield Treated	Yield Untreated	Harvest Date
NYSAES, Geneva, NY	N/A[1]	N/A	N/A
Joe Morgan, Avon, NY	59.2[2]	59.4	October 13, 2012
Scott Arliss, Clyde, NY	64.1[3]	64.1	September 27, 2012

[1] N/A = not available. The Geneva site was not harvested. For comparison, yields at a nearby Ontario County NY Pioneer soybean trial (D. Freier) harvested 10/13/12 were: 92Y12: 53.2 bu @ 12.5% moisture, 92Y51: 51.6 bu @ 12.8 % moisture. (http://www.pioneer.com/yield/?q=14456&c=soybeans&radius=15).
[2]12.7% moisture, [3]12.2 % moisture

e. End of season assessment of sclerotia of *Sclerotinia sclerotiorum* in study

Due to the lack of appreciable numbers of apothecia and white mold disease incidence in *any* experimental field, end of season evaluations of the *Sclerotinia* sclerotia population were not conducted.

f. Weather conditions during the 2012 growing season

Each year, the development of white mold is heavily dependent on weather conditions during soybean flowering and early pod development when apothecia and spores form. Rain, cool temperatures (less than 85 F), high relative humidity and moist soil favor the growth of the fungus if it is present. When the soil is moist, sclerotia in the upper 5 cm of the soil profile germinate and form apothecia that release airborne ascospores, which initiate the disease. Ascospores deposited on flower petals germinate when *free water* is present on plant surfaces, utilizing the petal as a nutrient base.

The 2012 season's weather was marked by generally lower than normal precipitation and slightly higher than normal temperatures. A summary of weather data for May - September 2012 for treatment locations and New York State is shown below in Table 4 and Figure 1.

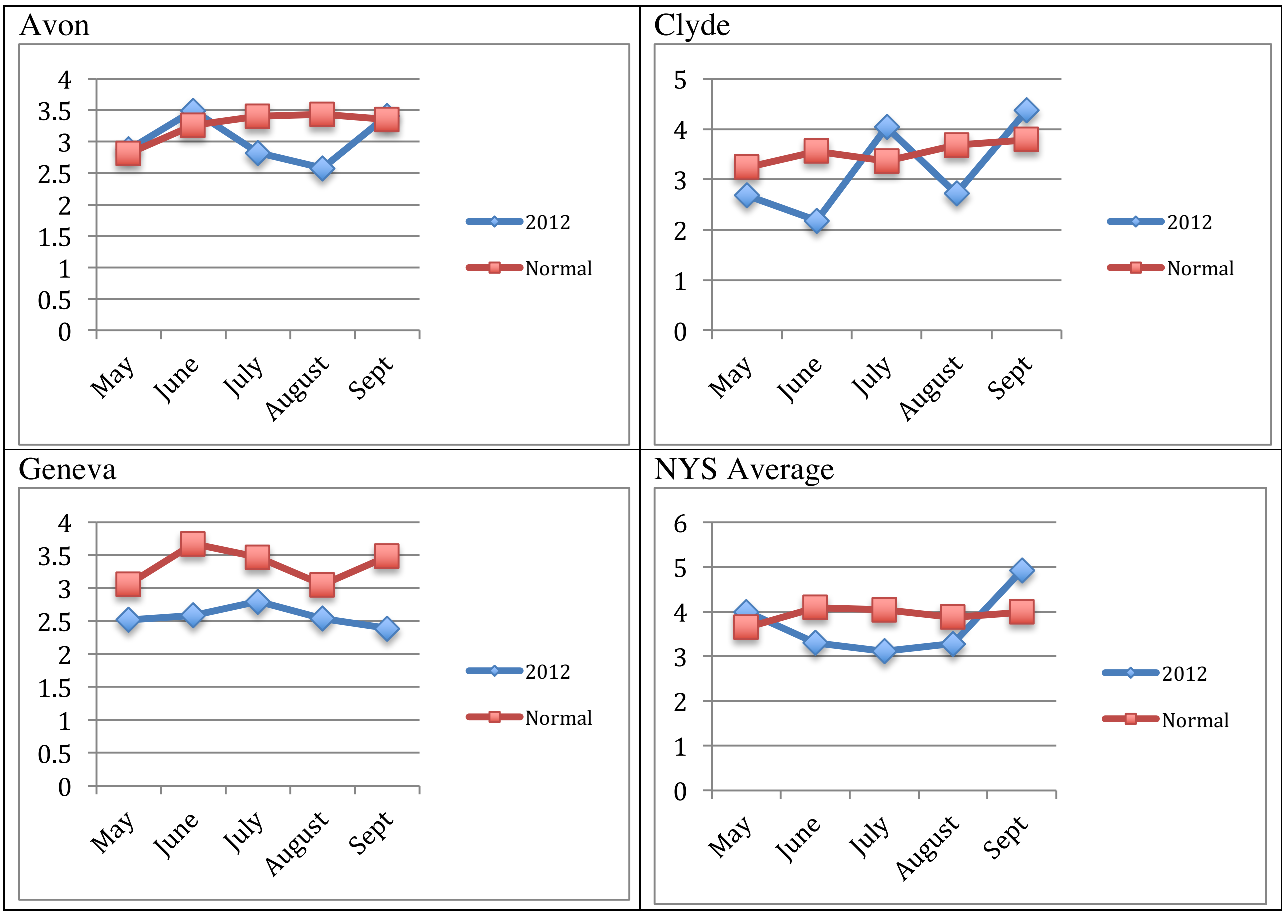
Table 4. Temperature May – September 2012 at NY Contans experiment locations.

Station	**Avon**				
Precipitation	May	June	July	August	Sept
2012	2.88	3.49	2.82	2.58	3.41
Normal	2.81	3.26	3.4	3.43	3.35
Ave Temp	May	June	July	August	Sept
2012	62.6	67.7	73.7	70.2	62.2
Normal	56.6	66.3	70.5	68.6	61.4
Station	**Clyde**				
Precipitation	May	June	July	August	Sept
2012	2.68	2.18	4.04	2.72	4.37
Normal	3.24	3.56	3.36	3.68	3.79
Ave Temp	May	June	July	August	Sept
2012	65.4	71.6	78.3	71.6	62.4
Normal*	57.5	66.9	71.3	69.8	62.9
Station	**Geneva**				
Precipitation	May	June	July	August	Sept
2012	2.52	2.59	2.8	2.54	2.39
Normal	3.06	3.67	3.47	3.05	3.48
Ave Temp	May	June	July	August	Sept
2012	62.7	66.9	73.9	70.5	62.4
Normal	56.7	66.2	70.5	68.9	61.4

Station	New York State				
Precipitation	May	June	July	August	Sept
2012	4	3.3	3.12	3.28	4.93
Normal	3.65	4.09	4.04	3.87	3.99
Ave Temp	May	June	July	August	Sept
2012	60.7	64.9	71.7	68.8	60.2
Normal	55.29	64.41	68.81	67.18	59.62

*Clyde location "normal" temperature data not available, this Climod data from Sodus Center. NOAA NE Climate Center Data, Courtesy of Jessica Rennels, Cornell University

Figure 1. Total accumulated precipitation May – September 2012 in NY Contans experiment locations.



Objective 2. Cooperative extension, consultants, agricultural business field personnel, producers and other appropriate clientele were informed of soybean white mold management and updates on white mold research activities through Cornell Cooperative Extension outreach. Our 2011 and 2012 Contans White Mold studies have not had conclusive results. As a result, we have not had locally generated data to present regarding effectiveness of Contans as a means to mitigate Soybean White Mold issues. Outreach to soybean producers has continued on correct

identification and management of soybean diseases. Soybean white mold has been included as a topic in presentations given by Dr. Gary Bergstrom at: the Field Crop Dealer Meeting, Syracuse NY, “New developments in soybean diseases” 12/12/12; CCE Soybean Meeting, Richfield Springs NY, “Soybean diseases and control” 3/1/12; the Southern Tier CCE Field Crops Meeting, Horseheads NY, “New challenges with field crop diseases” 2/28/12; the Finger Lakes Soybean and Small Grains Congress, Waterloo NY, “Disease challenges to sustainable soybean production in New York” 2/9/12; the Western New York Soybean and Small Grains Congress, Batavia NY, “Disease challenges to sustainable soybean production in New York” 2/8/12; the Carolina Eastern Crocker LLC Invitational Grower Meeting, Mt Morris NY, “New challenges with field crop diseases”, 1/31/12; the Madison County Crop Congress, Cazenovia NY, “New challenges with field crop diseases” 1/11/12; Keith Waldron at: the Cornell Cooperative Extension Field Crop Educator In Service, Ithaca NY (11/13/12); and Mike Stanyard at: Monsanto Research Update, Canandaigua, NY, “Corn and Soybean Diseases and Insects” 1/7/12, Monroe Tractor Customer Ag Day, Batavia, NY, “Identification of Common Corn & Soybean Diseases & the Impact on Yield” 3/23/12, Crop Protection Service Grower Meeting, Geneva, NY, “Identification of Common Corn & Soybean Diseases & the Impact on Yield” 3/22/12 and Oxbo/BASF Grower Meeting, Byron, NY, “Identification of Common Corn & Soybean Diseases & the Impact on Yield” 2/1/12.

Discussion:
Results of this field study are considered inconclusive and not for publication pending further investigation.

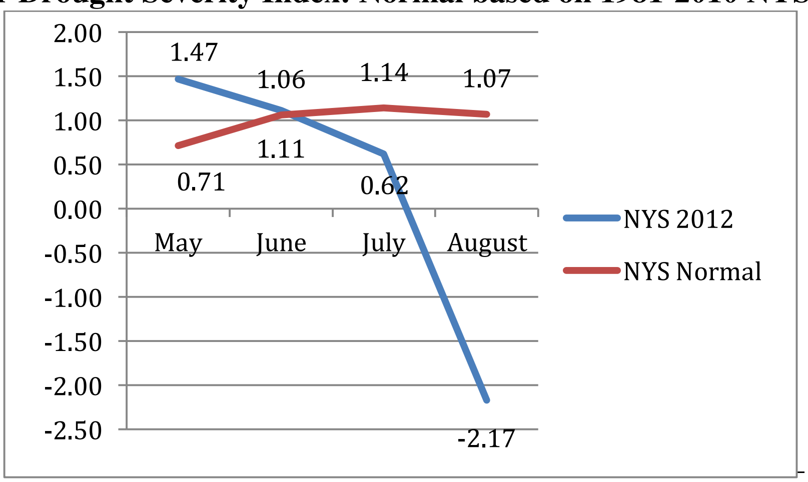
Fields selected for Contans® WG (Contans) studies had a history of severe soybean white mold within the last 3 years and were replanted to soybeans in 2012. Our highest field selection criteria priority was for fields to have at least a few sclerotia visibly observed on the soil surface. Unfortunately, sclerotia were difficult to find on *any* fields evaluated for further study. Given the difficulties in easily finding sclerotia on candidate fields, our field selection became heavily weighted towards fields with a previous history of *severe* economic losses from white mold disease in the previous soybean crop.

Sclerotinia sclerotia are known to remain viable and pose a high level of risk to susceptible hosts for years after initial field infestation (4, 9, 11, 16, 28). Each year, the occurrence of white mold is heavily dependent on weather conditions during soybean flowering and early pod development when apothecia and spores form. Rain, cool temperatures (less than 85 F), high relative humidity and moist soil favor the growth of the fungus if it is present. While there was no absolute guarantee of disease development under these natural infestations, it was felt that the long term viability of sclerotia in historically infested fields offered sufficient potential for disease development in the experimental fields should suitable environment conditions occur. In addition to meeting potential disease risk criteria, the NYSAES field had access to irrigation to help foster conditions favorable to disease development should they be needed.

The biological control organism *Coniothyrium minitans* was applied as the commercially available product Contans® WG (Contans) for the control of *Sclerotinia sclerotiorum* sclerotia. Contans applications were made in accordance with manufacturer label instructions and recommendations (5). Contans was applied early in the spring, to the top 1-2 inches of the soil profile so that it would come into contact with the active sclerotia populations that form apothecia that then form the ascospores.

Soybean flowering began this summer in study sites about July 1st. The Avon site began the 2012 season with slightly higher than normal precipitation, however, faced drought conditions in July and August. The Clyde site was dry May and June, higher than average in July and dry in August. The Geneva site had below normal precipitation all summer May – August (Table 4, Figure 1). All sites were affected by drought at some point this season during much of their flowering and pod fill season. A summary of precipitation data for May - September for each treatment location and the New York State 2012 and normal is shown in Table 5 and Figure 1. The NY Palmer Drought index, an indication of how monthly moisture conditions depart from normal is shown in Figure 2. The Palmer Index is most effective in determining long-term drought—a matter of several months—and is not as good with short-term forecasts (a matter of weeks). It uses a 0 as normal, and drought is shown in terms of minus numbers; for example, minus 2 is moderate drought, minus 3 is severe drought, and minus 4 is extreme drought.

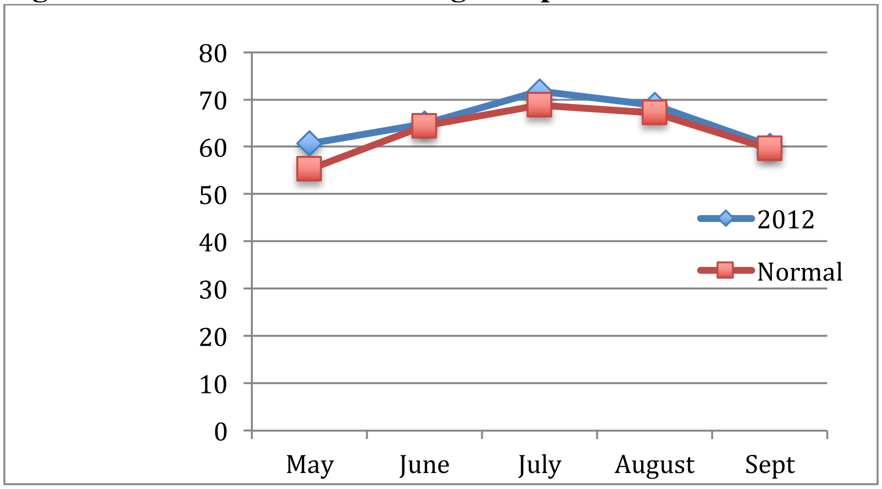
Figure 2. Palmer Drought Severity Index: Normal based on 1981-2010 NYS data



NOAA NE Climate Center Data, Courtesy of Jessica Rennels, Cornell University

New York State Average temperatures for 2013 were slightly higher than normal based on 1981-2010 NYS data (Figure 3).

Figure 3. New York State Average temperatures 2012



NOAA NE Climate Center Data, Courtesy of Jessica Rennels, Cornell University

As mentioned above the development of white mold is heavily dependent on weather conditions during soybean flowering and early pod development. Rain, moderate temperatures (<85F), high relative humidity and moist soil favor the growth of the fungus if it is present. When the soil is moist, sclerotia in the upper 5 cm of the soil profile germinate and form apothecia that release airborne ascospores, which initiate the disease. Ascospores deposited on flower petals germinate when *free water* is present on plant surfaces, utilizing the petal as a nutrient base.

Knowing local environmental conditions can greatly influence disease development, experiment locations were chosen in several areas across western NY to increase probability of obtaining conditions favorable for disease development. Unfortunately, overall environmental conditions in western NY this summer were dry from mid to late summer. Our efforts to enhance disease at the Geneva site through irrigation and use of two soybean varieties with different maturity groups were also not productive. The Geneva site was irrigated five times (7/10, 7/18, 8/06, 8/23, & 8/27) with approximately ¾" of irrigation applied each time. Several apothecia were confirmed August 10 while soybeans were approximately at early pod fill stage (R3). Unfortunately, this field was mistakenly cultivated 8/13/12 between the rows to control broadleaf weed escapes. Apothecia and white mold disease were not observed during subsequent field visits.

All fields were assessed for disease incidence throughout the season with systematic disease assessments conducted in late August during late pod fill stage and again prior to harvest and yield assessment. All study locations were affected by this drought, conditions not conducive to white mold development. Very little, if any, white mold was detected in any of the study fields. An objective of this study was to evaluate the potential of Contans as part of a long-term IPM strategy to better manage soybean white mold. Unfortunately, without white mold disease being present in our experimental plots this season it was impossible to critically evaluate the effect of Contans under field conditions. In our current study, yields of soybeans treated with Contans were not different from the untreated check (UTC). The 2011 study determined the 4 lb. / A rate of Contans treatment was associated with a lower number of apothecia and lower disease incidence, although the data from that 1 year field study was considered preliminary and also inconclusive.

While our NY studies have been inconclusive on the effect of Contans applications on soybean white mold mitigation, we believe these results can be explained, at least in part, by a lack of suitable environmental conditions to encourage disease development. Zeng et al (28) found similar results with soybean yields in plots treated with various biological control agents (BCA's) compared to untreated controls. This was partially due to the low incidence of Sclerotinia stem rot in their trial. These researchers stated: "Efficacy of BCAs is affected by disease pressure, and soil conditions. In our study, BCAs were more effective when disease pressure was high. Factors such as soil temperature, moisture, and microbial diversity affect BCAs for germination and colonization, which affect their efficacy. Early application, such as at fall versus at spring, benefits the establishment and growth of biocontrol strains in soil. Application of BCAs prior to tillage are preferred because tillage can enhance the even distribution of BCAs in soil and help direct contact between BCAs and pathogen. In addition, external sources of inoculum (ascospores) can impact Sclerotinia stem rot development in any susceptible crop as Hammond et al. (13) reported; despite local reduction in inoculum crops remain at risk and some measure of integrated crop protection may be warranted."

Under suitable conditions soybean white mold disease can be devastating. When the disease is present control options are limited, efficacy of current management strategies are variable and there are implications for long term disease management. While these studies have not provided the data and insights we had hoped for, they did provide the opportunity to gain experience with use of this biological product and have stimulated additional interest in this area of research and have enhanced our outreach efforts on soybean disease education and management. Zeng et al (28) state: "Theoretically, indirect control of Sclerotinia stem rot of soybean through the impacting the survival of sclerotia of *S. sclerotiorum* would be a good option, since the sclerotia are the source of apothecia and ascospores, are relatively static in the soil, and can be easily targeted by biological control agents due to their large size, position in the upper soil profile in minimally cultivated soils and relative abundance in affected soils. In addition, a long period for scheduling the application before planting makes the management more flexible. There are several disease-management strategies that focus on the elimination or reduction of the source of inoculum (the sclerotia). Crop rotation using non-host crops for example breaks the disease cycle to reduce the accumulation of sclerotia of *S. sclerotiorum* in the field and enhances temporal degradation of sclerotia by microorganisms in the soil. However, one- or two-year rotations are inefficient and unpractical because sclerotia of *S. sclerotiorum* can survive in soil up to eight years and have a broad host range (4)."

Nationally, there are limited data available to document the efficacy of *C. minitans* for white mold management in soybean. Peltier et al (20) state: "most studies published to date have focused on crops other than soybean. From the limited research, sclerotia numbers have been reduced by as much as 95% and Sclerotinia stem rot incidence has been reduced from 10 to almost 70% (2, 22, 28). Biological control will not eliminate all sclerotia; plants in fields heavily infested with sclerotia may continue to become infected by *S. sclerotiorum* until the number of sclerotia in the soil is further reduced."

Given the importance of environmental conditions and difficulties in obtaining significant disease under natural field conditions, it may be that future evaluations of this and other products for management of soybean white mold will necessarily rely on producer field trials of various products, including new biocontrol materials, and novel strategies compared to untreated checks. Positive relationships with grower cooperators in these two years of NY Contans studies and documentation of our experimental field histories may provide opportunities for further evaluation of potential longer term impacts of *Coniothyrium minitans* applications on subsequent soybean white mold disease development in those experimental field locations.

Additional knowledge could be gained from future research on optimum application methods (i.e., application to infested debris before incorporation, application in the spring to debris and bare ground, etc.) and integration of various cultural controls, such as rotation with a small grain to help reduce sclerotia inoculum during rotations, with use of biological controls. Field and greenhouse data on Contans efficacy from on going efforts in other regions will also enhance our understanding and use of this and similar materials.

As mentioned earlier, white mold of soybeans has been described as a "high yield" disease, favoring well-managed high-density fields with the greatest yield potential. As soybean producers adopt management practices that seek to maximize yield, white mold issues, caused by *Sclerotinia sclerotiorum* can become a higher risk and should remain a high research priority for NY soybean producers. Clearly additional alternatives are needed to enhance an integrated management approach towards soybean white mold.

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Appendix. Field record summary by location

Date	Activity
NYSAES	
6/1/12	Contans was applied at 4 lbs / acre to 0.5 acres of the east half of the field and lightly disk incorporated.
6/6/12	RoundUp herbicide was applied, at 22 fl. oz./A
7/7/12	Two soybean varieties with slightly different maturity groups were planted to increase chances of susceptible tissue (flowers) being present for infection. Pioneer 92Y51 (MG 2.5, white mold rating "6") and 92Y12 (MG 2.1, white mold rating "5")) each randomly assigned to two alternating individual strips, 135,000 seeds / ac seeding rate in 30 inch rows.
7/26/12	Field treated with "Hero" insecticide for Potato leafhopper (PLH) at 6 fl oz/A
8/13/12	Field Cultivated for weed control
	Irrigation Dates: 7/10, 7/18, 8/06, 8/23, & 8/27. Approximately ¾" of irrigation each time.
Avon	
5/26/12	Contans was applied at 4 lbs / acre to 10 acre block of field in a volume of 10 gpa. Contans immediately incorporated approximately 2 inches deep with one pass of a Case 330 turbo disk. Field was planted shortly thereafter on the same day. Soybean variety: Asgrow 24-31 (MG 2.4, GENRR2Y) was planted shortly thereafter on the same day @ 140, 000 seeds / ac in 30 inch rows. Asgrow's white mold rating for this variety is "5" (Above Average). Total field size including untreated check was 20 ac. Additional activities: Pendemethalin applied preplant and incorporated @ 32oz/acre, 4lb/gal glyphosate applied @48oz/acre @V6/V7
Clyde	
5/12/12	Contans was applied at 4 lbs / acre to 4.73 acres in a volume of 20g/A, treated. Total field size including untreated check was 40.19 ac. Soybeans Seedway SG2111 (MG 2.1) (borders) and Seedway SG1711 (MG 1.7) (interior of field, including treatment plot) were planted on the same day at 140,000 seeds / ac in 30 inch rows. Herbicides: Pre-Emerge Soybean: 5.0 gal/ac, Request (0.04 gal/ac), Synchrony XP (mp) (0.02 lb/ac), Valor (0.12 lb/ac) and RoundUp 0.14 gal/ac were applied at planting. Additional pesticides: 7.25.12. Spider mite infestation – 3.26 ac mostly eastern border along road treated with insecticide Avaris (12.8 floz/ac), Hero (10.00 floz/ac), Induce (0.02 gal/ac), and Megafol (1 pt/ac). This area was outside the Contans treated plot.