PROJECT SUMMARY FORM

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PROPOSAL TYPE

For National Research Initiative Competitive Grants Program Proposals Only

[X] Standard Research Proposal
[ ] Conference
[ ] AREA Award
[ ] Postdoctoral
[ ] New Investigator
Strengthening:
[ ] Career Enhancement
[ ] Equipment
[ ] Seed Grant
[ ] Standard Strengthening

For Higher Education Program Proposals Only:

Need Area: ______

Discipline: ______

Project Title: Establishment of a Multi-Regional Working Group on Sooty Blotch and Flyspeck of Apple in the U.S.

Key Words: integrated pest management, apples, summer diseases

The sooty blotch and flyspeck disease complex (SBFS) is one of the most important apple diseases in humid production regions, including the Eastern and Midwestern U.S. Management of the disease presently consists of regular fungicide applications, from two to seven depending on environmental conditions, apple variety, fungicide, and market. Integrated pest management (IPM) tactics have been developed for SBFS management, but grower adoption has been sporadic and limited. Largely, this is the result of variability and inconsistent performance of the various forecast and management models that have been developed, and limited grower knowledge of the management models and alternative cultural methods that can enhance control.

Fungicides most frequently used for SBFS management include materials that EPA lists as potential B2 carcinogens, and that consumer groups have listed as problematic. Organic growers have limited options for SBFS management, and must make several applications of materials that may reduce fruit quality. Several new fungicides for SBFS management that either have received or have the potential to receive organic certification have been developed recently. However, programs for their effective use have not been developed. In addition, the full potential of conventional, low-risk fungicides for use in SBFS management has not been fully realized.

This project brings together a group of the most active researchers, Extension professionals and private consultants involved in SBFS management to develop a more effective IPM approach for the disease. This Working Group will engage scientists and educators from the Midwest, Northeast and Southeast in order to coordinate and enhance research and educational efforts. It will develop web-based information resources on the disease, and will prioritize research needs. This project will lay the foundation for development of more advanced IPM methods for SBFS and for improved educational programs for growers. Ultimately, this will reduce the amount of fungicide needed to manage SBFS in Eastern and Midwestern production regions, enhancing grower profitability and environmental sustainability.

Establishment of a Multi-Regional Working Group on Sooty Blotch and Flyspeck of Apple in the U.S.

Project Description

Problem, Background and Justification

Crop and pathogen system

Apples are a high value crop in the eastern and midwestern United States, with an annual farm-gate value in the twenty-five states of nearly $650 million (USDA 2007). New York, Michigan, Pennsylvania and Ohio ranked second, third, fifth and seventh in apple production in the U.S. in 2006, growing over 1.18 billion pounds, while the remaining states in the Northeast, Southeast and upper Mid-west produce over 393 million pounds. Apples in this region are grown for both fresh and processing markets and are an important part of the diets of infants and children.

In contrast to the western US, mid-western and eastern growing regions have a moist, humid climate, and numerous arthropod pests and diseases of apples. This requires growers to apply multiple sprays to realize commercially acceptable fruit. One of the most important disease problems on apples in humid growing regions is a disease complex caused by several fungi, the summer blemish diseases individually named sooty blotch and flyspeck (SBFS) (Cooley 2000; Williamson & Sutton 2000). The number and identification of pathogens involved in the SBFS complex has been in a state of flux in recent years. The American Phytopathological Society lists *Schizothyrium pomi* (Mont.:Fr.) Arx as the pathogen causing flyspeck, while sooty blotch pathogens include *Peltaster fructicola* (Johnson, Sutton, Hodges), *Geastrumia polystigmatis* Batista & M. L. Farr, *Leptodontium elatius* (G. Mangenot) De Hoog, and *Gloeodes pomigena* (Schwein.) Colby (Jones 2000). However it recently has been shown that a number of other fungi from the East and Midwest also can cause SBFS symptoms (Batzer et al. 2005; Diaz et al. 2007). This pathogen diversity may have important management repercussions, but presently SBFS is managed as if it were a single disease.

SBFS produces dark specks and blemishes on fruit surfaces and can significantly reduce the USDA grade and hence the value of apples. The West Virginia Apple Crop Profile states "During wet growing seasons, losses of 25 percent or more are commonly found even in orchards treated with fungicides." (Hogmire & Biggs 2003). Similarly, the New England Apple Crop Profile reports normal losses of 1%, with up to 100% if orchards are not treated (Koehler et al. 2003), and IPM profiles from other states in the East are similar. A report on apple pest incidence in the middle Mississippi River Basin states SBFS is the fourth most common problem in that region, behind scab, fire blight and European red mite (Bessin et al. 1996).

Fungicides and the SBFS complex

Today fungicide use on apples in the U.S. exceeds that in almost any other food crop (Gianessi & Marcelli 2000). Apples in the East and upper Mid-west typically require at least seven to ten applications of fungicide per year (Gianessi & Phillips 1994; Cooley & Autio 1997). While most of these applications target apple scab (caused by *Venturia inaequalis* Cke.), approximately 40% of fungicide applications in New England are aimed at SBFS (Cooley 2000), and applications in the Midwest are similar (Babadoost et al. 2004)In the Southeast, applications to manage the disease may be required every two weeks from May through September

(Williamson & Sutton 2000). Even with intense fungicide use, poor timing can lead to significant SBFS epidemics, particularly late in growing season (Rosenberger 2003).

The ethylene-bis-dithiocarbamate (EBDC) fungicides developed during the 1940's and 50's proved very effective against SBFS, and were used routinely. But the EBDCs have been classified as B2 carcinogens (EPA 2005) and in 1989 EPA restricted the amount of EBDC fungicides that could be used in an orchard during a season, and lengthened the interval between last EBDC application and harvest to 77 days, essentially precluding their use in summer. This in turn made it more difficult to manage SBFS because the remaining fungicide options are less effective. Ultimately this has made SBFS a more significant disease problem, and led to an overall increase in fungicide use in apples (Cooley & Manning 1995; Williamson & Sutton 2000).

Today, effective options such as the strobilurine fungicides are available, but these recently-developed chemicals generally cost significantly more than fungicides developed decades ago, including captan and thiophanate-methyl. Rosenberger pointed out that the cost of pest management is one of the few expenses that growers can control, and given the thin margin between profit and loss for U.S. apple growers, they will opt to use less expensive chemicals (Rosenberger 2003). Unfortunately, captan is also classified as a B2 carcinogen (EPA 1999). One usage estimate (Felsot 1998) indicates that even after limits on EBDC use, the EBDCs and captan make up 58% of the total fungicides applied to apples in the U.S. This has led policy makers, food processors and consumer groups to look for ways to decrease the use of these fungicides in apples (Hettenbach & Wiles 2000; Jensen 2006).

From the growers' perspective, periodic failures using present management methods means there is a need to better understand the disease and to find better ways to manage it. For example, the New England Apple Strategic Plan developed through the New England Pest Management Network (Gottlieb & Kingsley-Richards 2003) established the following needs for SBFS research:

- Develop predictive models that are easy to use and applicable to New England conditions.
- Better understanding of epidemiology.
- Develop a site-specific risk assessment protocol to characterize individual orchards and the surrounding habitat as disease harborage.

The New York State IPM Program identifies SBFS as a significant problem, requiring research on "biology and management" (Carroll & English-Loeb 2006).

Organic producers face an even larger challenge from SBFS. Some fungicides approved by the Organic Materials Review Institute or similar organic certification boards, such as sulfur or copper compounds, can reduce SBFS incidence, but they also tend to be significantly less effective than conventional fungicides (Babadoost et al. 2004; Travis et al. 2006; Travis et al. 2006; Rosenberger & Meyer 2007b). Often, to get effective disease control, these products must be applied more frequently or at rates and times that can cause russet, a rough, brownish callus on the skin of apple fruit. Phosphorous acid fungicides, which have low non-target toxicity, have been tested for efficacy against SBFS. In North Carolina trials, neither phosphorus acid nor captan when used alone controlled symptoms, but applied together they were highly effective (Sutton et al. 2006; Sutton et al. 2007). Similarly, calcium salts, which are commonly sprayed on some apple varieties to improve fruit firmness, do not significantly reduce SBFS if applied alone, but they do enhance captan activity if applied together, allowing captan rates to be reduced (Cooley et al. 2007). The bio-fungicide Serenade (a strain of *Bacillus subtilis*) significantly reduced SBFS severity to 28% compared with severity in controls of 52%, but captan reduced severity significantly further to 15% (Sutton et al. 2007). While organic or biorational fungicides alone may be only moderately effective, these tests indicate that they have potential to reduce the need for more problematic fungicides, particularly captan. Yet, much more work is needed to develop ways to use these fungicides in ways that can produce commercially acceptable fruit.

Organic growers have planted scab-resistant apple cultivars in order to eliminate the need for scab fungicides. However eliminating scab fungicides in orchards of scab-resistant apples apparently makes SBFS damage more severe (Rosenberger et al. 1996). Sources of resistance to SBFS have not been identified.

Cultural options for SBFS management

In general, cultural practices that reduce the relative humidity in apple canopies will reduce SBFS incidence. Hence SBFS is reduced by winter pruning (Ocamb-Basu et al. 1988) and summer pruning (Cooley et al. 1997). Pruning also improves spray deposition if fungicides are applied (Cooley & Lerner 1994). Keeping grass mowed between trees is also generally recommended as a way to keep relative humidity relative lower. Removing trees and reservoir hosts that are close to apples may also both reduce humidity and decrease pathogen inoculum (Tuttle et al. 2002).

After harvest, SBFS signs can be removed from apples, leaving the fruit unblemished. Hendrix found that dipping apples for 7 minutes in 500 ppm chlorine, then brushing and rinsing with fresh water reduced sooty blotch from 100 to 0% and flyspeck from 100% to 27% (Hendrix 1991). Batzer et al. examined several disinfestation methods, showing that a 7 minute dip in 800 ppm chlorine, followed by brushing and rinsing, improved USDA grades from an average of 40% Extra Fancy to 100%, increasing the market value of the fruit by over 20% (Batzer et al. 2002). Lower rates of chlorine were also effective, demonstrating that this postharvest treatment can used as a backup and supplement to preventative fungicide sprays, allowing growers to take more risks with SBFS management.

Forecasting models for SBFS management

Disease forecasting models can be used to time fungicide applications, so they are made only when needed. The utility of these models often depends on the availability of eradicant fungicides that may be applied after an infection has started but before symptoms develop, which is the case with SBFS. Benzimidazoles can eradicate SBFS, stopping the development of signs after it is applied (Hickey 1977; Rosenberger et al. 1990). If benzimidazoles are applied prior to development of signs, then fruit can be kept blemish-free. Researchers in North Carolina developed a model to predict when the first appearance of SBFS signs occurs (Brown & Sutton 1995). From 1987 to 1994, they collected weather data and determined that SBFS first appeared after 273 accumulated hours of leaf wetness (ALWH), starting with the first rain to occur 10 days after petal fall, and counting only wetting that lasted 4 hours or longer. Based on this, they recommended application of a benzimidazole just prior to the predicted appearance of signs, at a threshold of 200 to 225 ALWH. After this initial application, they recommended regular fungicide applications at roughly two-week intervals through the rest of the season. The model generally saved one to two applications per season, because growers could confidently begin summer fungicide applications several weeks later than they normally would using a standard calendar schedule.

Researchers in Kentucky modified the North Carolina model, using a 175 ALWH, with no minimum length of wetting required, starting after the first post-petal-fall fungicide application (Hartman 1995; Smigell & Hartman 1997). They suggested that the difference in ALWH was caused by a difference in wetness sensors, because string-based sensors were used in North Carolina while electronic sensors were used in Kentucky. This approach saved up to four fungicide applications over calendar-based spraying in Kentucky (Williamson & Sutton 2000), and an average of three applications in the upper Midwest (Babadoost et al. 2004).

New York researchers have suggested that 270 ALWH (no minimum wetting required; accumulation starting at petal-fall) predicts not only the first appearance of SBFS symptoms, but also the time from infection to spore production in the SBFS fungi (Rosenberger & Meyer 2007a). In commercial orchards where scab sprays are applied one to three weeks after petal fall, fruit are also protected from new SBFS infections until the fungicide residue from these sprays is depleted. The flyspeck pathogen, *S. pomi*, overwinters in reservoir hosts that surround orchards, and ascospores of *S. pomi* develop and release over a discrete period each year corresponding to apple development, from bloom through early fruit set (Cooley et al. 2007). These ascospores may not be able to infect apples protected with scab fungicides, but they can cause more infections on the reservoir hosts. Rosenberger suggests that these infections will develop to produce conidia after 270 ALWH, and the conidia can be blown into the orchard. If a conidium lands on an apple, it will take an additional 270 ALWH for symptoms to appear on unprotected fruit. Rosenberger has suggested that this would greatly extend the period during which fungicide applications would be unnecessary, perhaps to as much as 540 ALWH after petal-fall, depending on the fungicides used (Rosenberger et al. 2005; Rosenberger 2006; Rosenberger & Meyer 2007a).

Orchard architecture, distance to inoculum sources and other physical factors in orchards can also affects SBFS development (Ellis et al. 1999; Tuttle et al. 2002). Ellis et al. showed that non-sprayed, fully dwarf apple trees in well-maintained orchards that are not near reservoir hosts, for example, did not develop SBFS signs until over 450 ALWH, while in the same area standard trees growing near inoculum sources developed SBFS between 225 and 241 ALWH.

These studies show that there is significant variation in the ability of forecast models to predict SBFS, and perhaps more importantly from and IPM perspective, manage the disease. These forecast models are developed empirically. The weakness of empirical models is that they may not be as effective in one region as they are in the region in which they are developed. A better understanding of SBFS epidemiology would eliminate this problem.

The critical issues in IPM of SBFS

As shown above, there are a number of critical issues associated with using IPM to manage SBFS. These may be briefly listed as a set of needs.

1. Resolve differences in forecast models for SBFS.
    - What is an appropriate accumulated LWH interval to a treatment threshold in commercial orchards?
    - Are differences in calculating wetting hours important? Can all wetting hours be used, or short wettings periods (<4 hrs.) be ignored?

- Are differences in methods of recording wetting, i.e. string vs. electronic wetting recorders, important?
- What is an appropriate biofix points for a forecast model, e.g. starting at PF or at PF+10 days. "last scab fungicide" biofix.
- After the first SBFS fungicide, can a model be used to predict the need for the next one? If so, should it be based on fungicide depletion, pathogen development or both?

2. Resolve the best approach for using models in commercial orchards.
    - How will IPM approaches to SBFS best integrate with other summer management practices?
    - Can the model inputs and outputs be simple enough that than can be easily used by growers and consultants?

3. Resolve best cultural approaches to SBFS management
    - Can we spray a lot less in high-density dwarf blocks that are removed from inoculum sources?
    - Can areas adjacent to orchard borders be modified to reduce SBFS, and would such modifications be economical?
    - Is summer pruning economical?

4. Identify realistic alternatives to captan, Topsin and petal-fall EBDCs
    - What are the advantages and disadvantages to strobilurines and other conventional pesticides in terms of efficacy, resistance management and cost?
    - What is the potential for biorational and organic alternatives such as phosphites, Ca salts, Serenade, and lime sulfur, alone or in combination, in SBFS management?

A need to review, revise and research

The fundamental problem with present IPM systems for SBFS is that while helpful, they do not work consistently well, and they have not reduced use of some problematic fungicides. Faced with uncertainty, growers often revert to a conservative, calendar-based spray schedule, leading to over-spraying. If they use forecast models, failures particularly in the late season can lead to explosive SBFS outbreaks, creating financial losses. There is no consensus on which model is best, nor do growers generally understand how to use them.

The primary fungicides used against SBFS concern consumers. Because they are used in the growing period immediately before harvest, they also have the highest risk of being present on fruit after harvest. Yet alternatives to them are either expensive or, in the case of biorational pesticides, have not been extensively tested.

The positive aspect of these problems is that significant research has been done on SBFS epidemiology, etiology and management in recent years. In order to take advantage of this research, it is time to gather those who have done it to discuss key issues and reach a consensus on the best approach to SBFS management based on present knowledge, and outline best way to fill gaps in that knowledge in the next five years. This should provide immediately useful IPM tools for apple growers, and longer term improvement in those tools.

The ultimate beneficiaries of such a meeting would be both consumers and growers. Elimination or significant reductions of captan, benzimidazoles and EBDCs for SBFS management would eliminate food safety issues associated with these fungicides. Alternatives to them, in some cases, would improve the ability of organic producers to grow apples in the East and Midwest. Improved forecast models would increase grower confidence in them, increase their use, and reduce overall fungicide use while improving SBFS control.

Objectives and Anticipated Impacts

Objectives

The purpose of this proposal is to fund establishment of a working group of researchers, Extension professionals and consultants from three regions, the Northeast, South and North-Central, to clarify issues surrounding SBFS management in apples. It has the following objectives.

1. Form a national Working Group to improve IPM methods for the SBFS complex of apple.
2. Establish consensus on the most viable IPM and organic strategies for managing SBFS.
3. Develop recommendations to be used in the short-term based on present knowledge.
4. Define critical knowledge gaps in our understanding of SBFS with respect to improving IPM approaches to SBFS management.
5. Facilitate flow of information on SBFS management between growers, consultants, Extension professionals and researchers.

Impacts

Type of Impact	Potential Impacts
Safeguarding human health and the environment	a. Decreased use of B2 carcinogen, or high-risk, pesticides on apples, a fruit consumed in relatively high proportion by infants and children. b. Overall reduction in fungicide use in eastern and midwestern orchards. c. Increased use of a revised and simplified set of IPM practices for SBFS by growers.
Economic benefits	a. Improved production of high-quality fruit (USDA Extra Fancy). b. Decreased fungicide costs if fewer applications are needed and alternative fungicides can be identified which are not significantly more expensive than captan. c. Improved quality for organic producers through identification of new acceptable fungicides and non-fungicidal practices. d. Clarification of which cultural practices, such as border removal and pruning, are cost effective in terms of SBFS.
Implementation of IPM	a. Improved SBFS management would potentially impact approximately one-third of the apple production in the U.S. b. Forecasting weather stations and internet services that presently provide SBFS forecasts would have improved performance if they adopted an improved model. c. Improved understanding of a model and other SBFS IPM methods that are consistent across production regions and supported with educational materials.

Approach and Procedures

1. Form a national Working Group to improve IPM methods for the SBFS complex of apple.

Researchers, Extension professionals and consultants who have worked on SBFS management have been, and have agreed to participate as a core for the Working Group (see attached letters). With funding, invitations will be extended to others identified by the core group. The group will establish a web site and a list server at the University of Massachusetts Amherst. The web site will be available to the public and will post information related to SBFS management as well as information about the Working Group. Individuals will be added to the list server by their request.

Task completed by **1 June 2008**.

2. Establish consensus on the most viable IPM and organic strategies for managing SBFS.

The core group will plan and hold a meeting in the summer of 2008, Tentatively 15-17 July 2008. Planning will be done via telephones and email. The initial session in the meeting will consist of presentations describing present management options for SBFS. It will be followed by a session that discusses the pros and cons of different management options. The goal of this part of the meeting will be to determine whether a single set of SBFS management options can be recommended for all apple production regions with significant SBFS pressure. If so, then the group will formulate the list of management practices. If not, the group will identify a general set of practices appropriate for all regions and specific practices as required for individual areas.

In the planning stages for this meeting, the group will determine whether we need to hire a meeting facilitator, or alternatively provide our own facilitation from within the group or within the participating institutions.

Task completed by **1 August 2008.**

3. Develop recommendations to be used in the short-term based on present knowledge.

Based on Objective 2, the group will develop written recommendations that will be posted as PDF files on the Working Group web site so that they may be easily printed and used in educational programming. The material will be developed during the three months following the Working Group meeting.

Task completed by **1 November 2008**.

4. Define critical knowledge gaps in our understanding of SBFS with respect to improving IPM approaches to SBFS management.

The third session of the Working Group meeting will be devoted to identifying areas for potential research on improved SBFS management. These will be listed and prioritized by the Working Group, and posted on the web site.

Task completed by **1 August 2008**.

5. Facilitate flow of information on SBFS management between growers, consultants, Extension professionals and researchers.

Accomplishing the objectives above should provide the tools necessary to improve communication among professionals interested in IPM methods for SBFS. The Working Group will be coordinated initially by a member of the group at the University of Massachusetts (Cooley), and it will be his responsibility to oversee early development of the web site and list server. He will also coordinate meeting planning, including arranging conference calls and follow-up emails.

On-going.

Evaluation

This one-year project establishes a means to accomplish the broader impacts listed above. In itself, the Working Group will simply lay the foundation for increased adoption of IPM practices related to SBFS management, and establish collaborative groups that will propose research projects in ensuing years. Hence, we anticipate the need to establish baseline data of SBFS management practices during 2009, to be funded in a separate proposal. This proposal would also propose further support for educational tools, such as the web site, and a survey to determine the rate of adoption of practices and the impacts on fungicide use and fruit quality for 2010 and 2011.

References

Babadoost, M., P. S. McManus, S. N. Helland and M. L. Gleason (2004). Evaluating a wetness-based warning system and reduced-risk fungicides to manage sooty blotch and flyspeck of apple. HortTech. 14(1): 51-57.

Batzer, J. C., M. L. Gleason, T. C. Harrington and L. H. Tiffany (2005). Expansion of the sooty blotch and flyspeck complex on apples based on analysis of ribosomal DNA gene sequences and morphology. Mycologia 97(6): 1268-1286.

Batzer, J. C., M. L. Gleason, B. Weldon, P. M. Dixon and F. W. Nutter (2002). Evaluation of postharvest removal of sooty blotch and flyspeck on apples using sodium hypochlorite, hydrogen peroxide with peroxyacetic acid, and soap. Plant Dis. 86(12): 1325-1332.

Bessin, R., L. Weston and R. Foster (1996). Implementation of a multi-state IPM program for widely scattered apple growers in the mid-Mississippi River watershed. http://www.uky.edu/Ag/IPM/appleipm/appleipm/frept96.php

Brown, E. M. and T. B. Sutton (1995). An empirical model for predicting the first symptoms of sooty blotch and flyspeck of apples. Plant Dis. 79(11): 1165-1168.

Carroll, J. and G. English-Loeb (2006). 2006 fruit IPM stakeholder research priorities for New York State. New York State Integrated Pest Management Program, Cornell University http://www.nysipm.cornell.edu/grantspgm/rfp_ag/fruitpri_06.asp

Cooley, D. R. (2000). Flyspeck management: progress and challenges. Annual Meeting of the Massachusetts Fruit Growers' Association, Sturbridge, MA, Massachusetts Fruit Growers' Association.

Cooley, D. R. and W. R. Autio (1997). Disease-management components of advanced integrated pest management in apple orchards. Agric. Ecosyst. Environ. 66(1): 31-40.

Cooley, D. R., W. R. Autio and J. Krupa (2007). Calcium salts and other alternatives to conventional fungicides for management of the summer disease complex of apple, 2006. PDMR (online), The American Phytopathological Society. 1: Rept. 1: PF051

Cooley, D. R., J. W. Gamble and W. R. Autio (1997). Summer pruning as a method for reducing flyspeck disease on apple fruit. Plant Dis. 81(10): 1123-1126.

Cooley, D. R. and S. M. Lerner (1994). Summer pruning increases pesticide coverage in apple canopies. Phytopathology 84: 1370.

Cooley, D. R., S. M. Lerner and A. F. Tuttle (2007). Maturation of thyriothecia of *Schizothyrium pomi* on the reservoir host *Rubus allegheniensis*. Plant Dis. 91(2): 136-141.

Cooley, D. R. and W. J. Manning (1995). Estimating the risks and benefits of pesticides - Considering the agroecosystem and integrated pest management in the use of EBDC fungicides on apples. Environmental Pollution 88(3): 315-320.

Diaz, M. M., J. C. Batzer and M. L. Gleason (2007). Biogeography of the sooty blotch and flyspeck complex on apples in the eastern and central U.S. (Poster). Annual Meeting of the American Phytopathological Society. San Diego, CA.

Ellis, M. A., L. V. Madden and L. Wilson (1999). Evaluation of an empirical model for predicting sooty blotch and flyspeck of apples in Ohio. Ohio State University Research Bulletin - Research Circular 299-99: 1-6.

EPA (1999). Reregistration eligibility decision (RED): Captan, EPA-738-R-99-015. U. S. E. P. A. O. o. P. Programs. Washington, DC, US Government Printing Office: 49.

EPA (2005). Reregistration eligibility decision for mancozeb: EPA 738-R-04-012. U. S. E. P. A. O. o. P. Programs. Washington, DC, US Government Printing Office: 169.

Felsot, A. S. (1998). Does FQPA fallout mean major risks to minor crops? . Agrichemical and Environmental News, Wash. St. Univ. (144): 18-21.

Gianessi, L. P. and M. B. Marcelli (2000). Pesticide use in U.S. Crop Production: 1997. Washington, DC, National Center for Food and Agricultural Policy.

Gianessi, L. P. and M. Phillips (1994). Pesticide use in U.S. apple orchards: a short history. Washington, DC, National Center ofr Food and Agricultural Policy.

Gottlieb, A. and S. L. Kingsley-Richards (2003). New England Apple Strategic Plan, New England Pest Management Network: 63.

Hartman, J. R. (1995). Evaluation of fungicide timing for sooty blotch and flyspeck control, 1994. Fungic. Nematic. Tests 50: 10.

Hendrix, F. F. (1991). Removal of sooty blotch and flyspeck from apple fruit with a chlorine dip. Plant Dis. 75(7): 742-743.

Hettenbach, T. and R. Wiles (2000). A few bad apples...pesticides in your produce. Washington DC, Environmental Working Group: 27.

Hickey, K. D. (1977). Sooty blotch and flyspeck suppression with two late-season fungicide sprays. Fungic. Nematic. Tests 34: 8-9.

Hogmire, H. W. and A. R. Biggs (2003). Crop profile for apples in West Virginia. http://www.caf.wvu.edu/kearneysville/profile/profiletoc.html

Jensen, T. (2006). Common fungicides used in apple production and their evaluation utilizing four eco-labeling group standards. Center for Integrated Agricultural Systems. http://www.thinkipm.org/apples/fungicide.pdf

Jones, A. L. (2000). Diseases of apple (Malus x domestica Borkh.). Common Names of Plant Diseases American Phytopathological Society. http://www.apsnet.org/online/common/names/apple.asp

Koehler, G., N. Clifton, W. Lord, L. P. Berkett and A. Gottlieb (2003). Crop profile for apples in New England. http://www.ipmcenters.org/cropprofiles/docs/NewEnglandApples.pdf

Ocamb-Basu, C. M., T. B. Sutton and L. A. Nelson (1988). The effects of pruning on incidence and severity of *Zygophiala jamaicensis* and *Gloeodes pomigena* infections of apple fruit. Phytopathology 78(7): 1004-1008.

Rosenberger, D. A. (2003). Factors limiting IPM-compatibility of new disease control tactics for apples in eastern United States. Plant Health Progress.

Rosenberger, D. A. (2003). Recent developments in apple disease control. Annual Meeting of the Massachusetts Fruit Growers' Association, Sturbridge, MA, Massachusetts Fruit Growers' Association.

Rosenberger, D. A. (2006). Timing sprays for flyspeck and sooty blotch. Scaffolds Fruit Journal 14 no. 14(14).

Rosenberger, D. A., C. A. Engle and F. W. Meyer (1996). Effects of management practices and fungicides on sooty blotch and flyspeck diseases and productivity of liberty apples. Plant Dis. 80(7): 798-803.

Rosenberger, D. A. and F. W. Meyer (2007a). Timing summer fungicides to control flyspeck disease on apples. NY Fruit Quarterly 15(1): 11-14.

Rosenberger, D. A. and F. W. Meyer (2007b). Control of flyspeck with phosphorous acid, liquid lime-sulfur, and other fungicides, 2006. PDMR (online), American Phytopathological Soc.

Rosenberger, D. A., F. W. Meyer and R. W. Christiana (2005). Controlling summer diseases on trees left unsprayed for 50 days during June and July, 2004. Fungic. Nematic. Tests, American Phytopathological Soc. 60.

Rosenberger, D. A., F. W. Meyer and D. L. Rist (1990). Effect of spray timing on incidence and severity of sooty blotch and flyspeck on Liberty apple. Fungic. Nematic. Tests 46: 31.

Smigell, C. G. and J. R. Hartman (1997). Evaluation of fungicide timing for sooty blotch and flyspeck control, 1996. Fungic. Nematic. Tests 52: 31.

Sutton, T. B., E. M. Brown and O. Anas (2007). Summer disease control with reduced risk fungicides, 2006. PDMR (online) American Phytopathological Society.

Sutton, T. B., E. M. Brown, O. Anas and C. W. Meister (2006). Efficacy of phosphorus-containing fungicides on summer diseases of apples, 2005. Fungic. Nematic. Tests 61(PF004).

Travis, J. W., N. O. Halbrendt, J. Rytter, B. Lehman and B. Jarjour (2006). Evaluation of alternative fungicide programs for control of flyspeck and sooty blotch on Golden Delicious and Cortland apples in PA, 2005. Biol. Cult. Tests 21(N010): 1-2.

Travis, J. W., N. O. Halbrendt, J. Rytter, B. Lehman and B. Jarjour (2006). Evaluation of organic alternatives for control of apple scab, 2005. Biol. Cult. Tests 21(N009): 1-3.

Tuttle, A. F., C. Bergweiler, J. Hall, L. Reisner, S. Christle, W. R. Autio and D. R. Cooley (2002). Development of a model for predicting flyspeck risks in blocks of apple trees. Fruit Notes 67(1): 5-8.

USDA (2007). Noncitrus Fruits and Nuts 2006 Summary. N. A. S. Service. Washington, D.C.: 82.

Williamson, S. M. and T. B. Sutton (2000). Sooty blotch and flyspeck of apple: Etiology, biology, and control. Plant Dis. 84(7): 714-724.

Cooperation and Institutional Units Involved

To simplify the project, it is organized with a single Project Director, D. R. Cooley, and a single contracting unit, the University of Massachusetts Amherst, with other collaborators and their institutions participating as cooperators. All faculty have significant components of both Extension and research responsibilities. Letters from cooperators are included. While CV's for cooperators are not required, because they will play key roles in the project, CV's from some cooperators are included.

These collaborators will form the core of the Working Group, and work together with Cooley as PD to organize the first meeting. Additional members will be identified and invited to the initial meeting.

Land-Grant Research and Extension. Faculty involved in the project have extensive experience in applied apple disease management in general, and specifically in developing management options for SBFS. They have on-going programs studying the pathogens involved, the epidemiology of the disease complex, fungicide controls, cultural controls, and biorational/biological alternatives. They include Daniel Cooley, David Rosenberger, Keith Yoder, Turner Sutton and Mark Gleason.

Jon Clements is the State Tree Fruit Specialist for Massachusetts. He has nearly 20 years experience in Extension, in Vermont, Michigan and Massachusetts. He has expertise in web site development and maintenance and using web resources in Extension and in developing weather monitoring in support of IPM for apples.

Private sector. Glen Moran and Robin Spitko are owners and operators of New England Fruit Consultants, the largest consulting business working with apple producers in New England. The business recently celebrated its 25th anniversary, and among other activities, provides both IPM consulting to growers and pesticide testing to pesticide producers. Before forming the business, the partners worked in the University of Massachusetts apple IPM program.

Key Personnel

Daniel R. Cooley, Project Director, Associate Professor of Plant Pathology. Department of Plant, Soil and Insect Sciences, University of Massachusetts, Amherst, MA

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Mark Gleason, Cooperator, Professor of Plant Pathology and Horticulture, Department of Horticulture, Iowa State University, Ames, IA

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