Research report submitted to:

Organic Farming Research Foundation
P.O. Box 440
Santa Cruz, CA 95061
831-426-6606
www.ofrf.org

Date: October 6, 2000

Title: ***Evaluation of Kaolin-based Particle Film Coatings on Insect and Disease Suppression in Apples***

Principle Investigator:
Andrew L. Thomas
University of Missouri-Columbia
Agricultura Experiment Station
Southwest Research Center
14548 Highway H
Mount Vernon, MO 65712
(417) 466-2148
ThomasAL@missouri.edu

Project period: 2000

Project budget: $7,270

Funding provided by OFRF: $3,479

OFRF project number: 99-46, awarded Fall 1999

The Organic Farming Research Foundation of Santa Cruz, CA generously provided a grant of $3,479 in 1999 to initiate this study at the Southwest Research Center, Mt. Vernon, MO. The 2000 growing season was completed September 28, 2000, and I am pleased to submit this final summary of our results. A proposal for the funding of the second year's research has been submitted to OFRF. The particle film technology tested in this study appears to offer tremendous potential in safely suppressing both insects and disease in Midwestern apple production.

Objective

The objective of the study was to evaluate and document the efficacy and potential of a kaolin-based particle film coating in suppressing plum curculio, codling moth, red-banded leafroller, oriental fruit moth, and certain bacterial and fungal pathogens in apples, while fine tuning application recommendations for Midwestern growers.

Background

Organic production of quality apples remains extremely difficult in the Midwestern USA, while demand for high-quality organically-grown fruit continues to increase. Commercial apple production typically requires as many as 17 applications of pesticides annually that still do not always achieve adequate pest control. Many of these pesticides are toxic and may pose a threat to workers, consumers, neighbors, beneficial insects, animals, and the environment. Organic growers need better methods of controlling devastating insect pests in apples, while conventional growers would likely embrace pest-control products that are effective yet safer to use in their overall pest management programs.

Particle film technology is an exciting recent development with tremendous potential in organic and integrated pest management of agricultural and horticultural crops. This technology may be capable of suppressing pests and diseases that have historically been very difficult to control. Fine film coatings of safe, microscopic particles are sprayed onto leaves and fruit to form a protective barrier that controls or suppresses many insects and mites simply by repelling or irritating them. Beneficial insects such as lady beetles and honey bees that do not feed on the leaf or fruit remain unharmed. The films may also be able to confound the infection and propagation mechanisms of certain fungal and bacterial pathogens. At the same time, the particles can provide physiological benefits to crops by lowering canopy temperature, reducing heat stress to leaves, and protecting fruit from sunburn.

One of the most promising particle films is manufactured from kaolin, a naturally-occurring clay mineral that is so safe, it has been approved by the U.S. Food and Drug Administration as a human food additive. Scientists with the U.S. Department of Agriculture have developed and researched these coatings during the last four years under a Cooperative Research and Development Agreement with Engelhard Corporation, Iselin, NJ. Engelhard has modified the kaolin mineral to make it uniform, sprayable, and of optimum size for insect adhesion and irritation while allowing the passage of photosynthetically-active radiation and reflection of infrared radiation. Sales of its kaolin-based plant protection product began this year under the trade name "Surround WP Crop Protectant". Surround WP has now been federally labeled for use on many important horticultural crops. It is safe and legal to purchase and use, according to directions, in nearly all states. Additionally, on March 7, 2000, the Organic Materials Review Institute (ONM) officially listed the Surround WP product as "allowed" in organically-certified farms.

Plum curculio, codling moth, oriental fruit moth, and red-banded leafroller are four of the most important apple insect pests in the Midwest, often rendering organic apple production unfeasible. If not kept in check, they can easily and rapidly ruin an entire crop. Earlier research has suggested that some

control of these pests may be possible if adequate kaolin particle films are present on leaves and fruit at times when insects are vulnerable, such as during oviposition, hatch, or feeding. However, detailed data is needed on the residue levels required, optimal percentage of leaf and fruit coverage, and timing of application in relation to pest population levels in order to achieve adequate pest control. This much-needed information is key to confidently recommending safe particle film technology to both organic and conventional growers, and prompted this study.

The Study

A block of 160 closely-spaced apple trees containing four cultivars was planted in 1993 at the Southwest Research Center, Mt. Vernon, MO, and another block of 60 trees with ten different cultivars was planted in 1997-98. The former block of trees is now mature, healthy and productive while the latter block is young and vigorously growing. While the trees were initially planted for other purposes, integrating the study into these established plantings has been ideal. Prior to the initiation of the study in 2000, the trees had not been sprayed with chemical pesticides during the previous four years. An organic fertilization program, using a locally-produced alfalfa based natural fertilizer (Bradfield Industries, Springfield, MO) was initiated in 2000.

The study was established using a randomized complete block experimental design, where blocks of trees received treatments of Surround WP at experimental rates and frequencies. Blocks of trees were randomly assigned one of five treatments: 50 lb/acre either weekly or every two weeks, 25 lb/acre either weekly or every two weeks, or untreated control. Applications began at petal fall, April 25, and continued through August 1. Insect traps for plum curculio, codling moth, oriental fruit moth, and red-banded leafroller were placed throughout the orchard and refreshed once per month during the growing season. Trapped insects were removed and counted weekly to document insect population patterns throughout the season (Figure 1). Detailed observations and data were collected periodically throughout the growing season on insect damage to both leaves and fruit, and disease presence and severity. The most important data, however, including fruit grade and yield, were collected upon harvest (August 7-1 1) when fruits were picked and individually examined and cut open to ascertain precisely what type of damage had occurred. Final leaf data were collected September 28 to document what type of damage had accumulated throughout the entire growing season.

At harvest, apples were scored for the following damage: Fungal diseases flyspeck *(Zygophiala jamaicensis)* and sooty blotch *(Gloeodes pomigena),* and insects plum curculio *(Conotrachelus nenuphar),* codling moth *(Cydia pomonella),* and leaf rollers *(Argyrotaenia velutinana, el al.).* A category of "other insect" was used to document probable insect damage that could not be accurately confirmed as damage from the three target insects. Oriental fruit moth *(Grapholitha molesta)* damage was not evaluated because of the unexpectedly low population of these insects in the orchard. Apples were then graded, with "1" being a near perfect marketable apple, "2" being an apple of good quality suitable for cider, and "3" an unusable apple. Apple yields were also documented. Leaves were examined for the fungal disease cedar apple rust *(Gyninosporangium juniiperi-virginianae)* and for general leaf chewing and skeletonizing insect damage.

Results

Two of the mature apple cultivars, Liberty and Jonafree, produced fruit in 2000, while Ultragold and Jonagold unfortunately did not. Fruit data from the two bearing cultivars were analyzed separately, and cultivar by treatment interactions were evaluated. Up to 100 apples were harvested from individual treated trees and evaluated. In most cases, however, 50 apples were evaluated, and in cases where less than 50 apples were produced, all apples were evaluated. For final leaf data, 100 leaves were examined

per treated tree or group of trees. For statistical purposes, least squares means were calculated and analyzed.

An analysis of variance detected significant differences between cultivars and among treatments for both flyspeck and sooty blotch. However general cultivar by treatment interactions were not detected for those diseases. For plum curculio, significant differences were detected among treatments ($P \leq .0001$), but not between cultivars, nor was there a treatment by cultivar interaction. Neither codling moth nor leafrollers were affected by treatment, but were different between cultivars. Other insect damage was significantly influenced by treatment. The number of Grade 1 apples was influenced by both cultivar and treatment and a cultivar by treatment interaction was detected. Grades 2 and 3 were determined by treatment. Yield was affected by neither treatment nor cultivar. No differences were detected among treatments for general leaf chewing and skeletonizing insects. For cedar apple rust, untreated trees of the cultivar Jonafree had significantly more diseased leaves than any of the treated trees. Little rust occurred on the other cultivars, therefore no treatment affects were detected.

Duncan's Multiple Range Tests revealed some very interesting results from the experiment. Because we are not particularly interested in differences only between the cultivars, I will not describe those results further here. Differences between treatments across cultivars were dramatic for some traits. Table I lists means for the various traits as affected by treatment. For the diseases flyspeck and sooty blotch, statistically significant reduction in disease presence was achieved, with trends toward less disease with the highest and more frequent applications. For example, 90.1% of untreated apples had flyspeck, whereas only 50.4% of apples treated weekly with 50 lbs/acre Surround WP were infected. The insects codling moth and leafrollers were not affected by treatment. We had very little codling moth in the orchard which perhaps did not allow for a good test against that particular pest. However plum curculio was dramatically affected by treatment. 68.1% of untreated apples were infested by plum curculio, which was significantly worse than any of the treated apples, regardless of rate or frequency. Plum curculio infection rates of treated apples ranged from 13.8% to 28.7%. Results of damage from other unidentifiable insects is rather ambiguous with no discernable pattern. I suspect that somehow we were more easily able to identify specific insect marks with some treatments over others, perhaps causing this ambiguity.

Grading of apples was significantly affected by treatment versus control. No untreated apples were classified as Grade 1 whereas 10.9% of apples treated weekly with 50 lbs/acre were Grade 1. For Grades 2 and 3, significant differences were detected between untreated apples and any of the Surround WP treatments, regardless of rate or frequency. Even though differences were not detected among Surround WP treatments, the trends toward the better quality apples were with the highest rate and frequency. For example, 74.7% of untreated apples were classified as Grade 3, whereas only 15% of apples treated weekly with 50 lbs/acre were classified as Grade 3 or unusable. Yield by weight was not affected by treatment.

Orthogonal comparisons were next used to more precisely sort out differences among the various treatments for specific diseases and insects that were affected by Surround WP. For both flyspeck and sooty blotch, significant differences were detected between weekly versus biweekly treatments ($P \leq 0.011$ and 0.023, respectively), but not between the 25 and 50 lb rates. But for plum curculio suppression, rate was much more important ($P \leq 0.029$) than frequency, which was not significant.

Conclusions

During the first season of testing, the Surround WP product has been extremely effective at suppressing plum curculio, one of the most devastating and difficult-to-control apple pests for organic

orchardists in the Midwest. The codling moth, another very serious pest of apples was trapped in the orchard only in very small numbers. While we did find some codling moth damage, we believe there simply were not enough insects to make a fair conclusion of the product's effectiveness against that pest. Leaf rollers, on the other hand, were commonly trapped throughout the season, and were not significantly affected by Surround WP treatments. Much of the leafroller damage was caused early in the season when coverage of the small fruit with the material was perhaps less effective. Surround WP also significantly suppressed both fungal diseases flyspeck and sooty blotch. These are superficial fungal diseases that ruin the appearance of the apple, reducing their market value. The foliar disease cedar apple rust was significantly reduced on one cultivar only suggesting an interesting relationship between cultivar and treatment.

Perhaps most intriguing are the conclusions that frequency of application is more important than rate in suppressing fungal diseases whereas rate of application is most important for suppressing the insect plum curculio. There could be many speculative reasons for this phenomena, but it seems logical that a constant but not necessarily strong coating of film on the fruit may somehow interfere with fungus development, while a good strong dose of film is required to repel insects such as plum curculio. This hypothesis tends to agree with the data in that a high dose sprayed frequently tends to repel the curculio better.

An interesting question raised by this study that cannot be presently answered is the following: If an entire orchard were treated, thereby leaving no unsprayed "control" trees for insects to find and easily attack, would the insects be forced to "break through" the particle film barrier to feed and lay eggs or would they be completely repelled from the entire orchard?

This study has been very exciting and challenging. We are anxious to complete the second season of the study in 2001 which will make our results scientifically valid. From there we look forward to providing specific guidance to organic orchardists wishing to try this new and extraordinary technology.

Figure 1. Total number of insects trapped weekly within ten traps at the Southwest Center apple orchard during Summer, 2000.

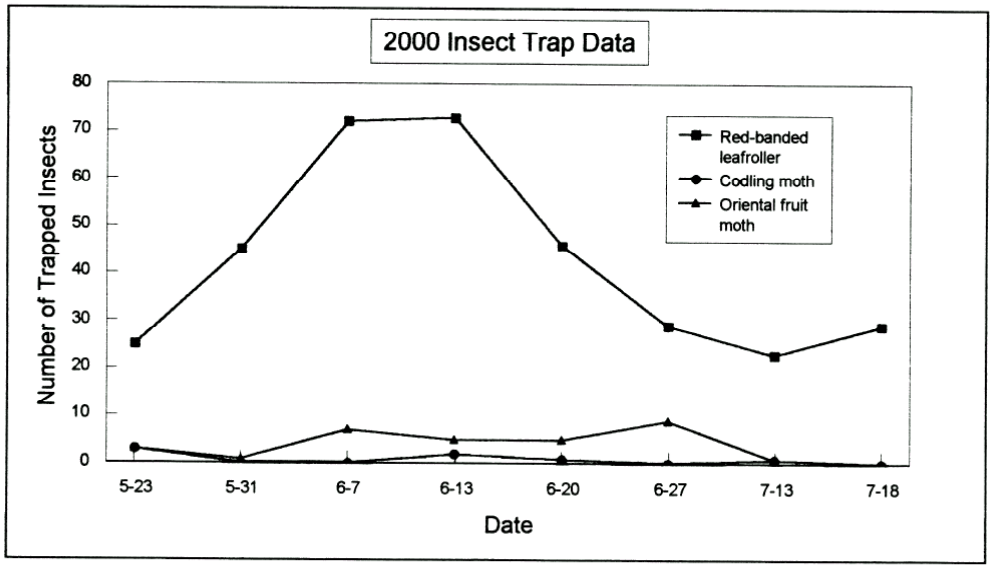

Table 1. Percent of examined apple fruits or leaves affected by insects and diseases across cultivar (except for cedar apple rust), and grade and yield of fruit as affected by treatment, Southwest Center, Summer, 2000.

Treatment	Flyspeck	Sooty Blotch	Plum Curculio	Codling Moth	Leaf Roller	Other insect
Control	90.1 a**	89.4 a	68.1 a	3.2 a	19.5 a	40.0 b
25 * Biweekly	74.2 ab	74.1 ab	28.7 b	5.1 a	20.9 a	54.3 ab
50 * Biweekly	71.2 abc	67.3 b	13.8 b	2.1 a	15.6 a	68.4 a
25 Weekly	58.0 b	59.4 b	25.4 b	3.5 a	22.8 a	55.7 ab
50 Weekly	50.4 c	59.0 b	15.1 b	3.2 a	24.9 a	43.4 b

Treatment	Grade 1	Grade 2	Grade 3	Yield (lbs)	Cedar Rust Jonafree	Leaf Chewing
Control	0.0 c**	25.3 b	74.7 a	17.2 a	40.7 a	8.7 a
25 * Biweekly	1.9 bc	66.1 a	32.0 b	26.7 a	10.7 b	12.3 a
50 * Biweekly	2.0 bc	59.5 a	38.5 b	28.6 a	5.7 b	7.7 a
25 Weekly	3.0 b	66.5 a	30.5 b	34.1 a	6.0 b	7.2 a
50 Weekly	10.9 a	74.1 a	15.0 b	22.1 a	6.0 b	7.0 a

* Treatments of 25 or 50 lbs/acre
** Numbers within a column having different letters are statistically different.