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PHEROMONAL CONTROL OF THE GRAPE BERRY MOTH: AN EFFECTIVE ALTERNATIVE TO CONVENTIONAL INSECTICIDES

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INTRODUCTION AND BACKGROUND

Many factors acting together have heightened interest in alternatives to broadly-toxic pesticides used in agriculture. The public has called for reduced pesticide residues in agricultural products. Growers must deal with increasingly complex regulations governing pesticide use: regulations focusing on pesticide-related damage to the environment, especially ground water and wildlife, and exposure of farm workers. While it is recognized that the imperatives of modern agriculture and public health continue to necessitate use of conventional pesticides to prevent crop loss from pests, researchers the world over are striving to develop feasible alternatives to broadly-toxic chemicals. In most situations where environmentally-safe alternatives to conventional pesticides are available, they are implemented within the context of integrated pest management (IPM) program s. These programs foster the use of pest monitoring procedures and pest density or crop injury thresholds coupled with optimization of non-chemical methods such as biological and cultural control (e.g., sanitation and cultivation). Such is the case with pheromonal control of grape berry moth (GBM) in New York vineyards, where complementary research programs in plant pathology, viticulture, and entomology are focusing on development and integration of alternatives to pesticides.

Cornell University scientists have conducted research on pheromones of the grape berry moth for nearly 20 years. These efforts provided a foundation for the development of the Isomate-GBM®* pheromone product. This product received EPA and New York State registrations in 1990. The purpose of this bulletin is to describe the impressive results obtained with the Isomate-GBM® pheromone in large-scale field trials conducted throughout New York, and to provide instructions on how to use the pheromone product most effectively.

MATING DISRUPTION WITH PHEROMONES

Insect pheromones are naturally occurring chemicals that insects use to communicate with individuals of their own species. By releasing minute amounts (often less than one billionth of an ounce) of pheromone, very specific biological messages are conveyed from the insect releasing the chemical to the insect receiving it Most synthetic pheromones, like that of the GBM, are essentially non-toxic (toxicity similar to many foodstuffs), and are mixtures of the very same chemicals naturally produced by the female moths. Pheromones are commonly used by insects as a very efficient method for attracting mates for reproduction. Female moths of many different species are able to attract male moths from long distances by releasing minute amounts of volatile pheromone. Male moths, using sensors on their antennae, detect the chemical released by females and fly to the females and mate. Just as aircraft use radar signals to guide them toward an airport, male moths use the chemical signal of the pheromone to direct them toward a female moth.

Disruption of sexual communication, called mating disruption, can be accomplished by releasing pheromone in fields or vineyards from artificial sources such as the Isomate-GBM® pheromone dispenser. By producing an invisible "cloud" of pheromone throughout vineyards, male moths are thought to perceive the pheromone in many directions and, therefore, become confused in their attempt to orient toward female moths. The end result of mating disruption is an environmentally safe form of insect birth control; female moths are prevented from producing the next generation of the pest. Whereas grape growers may apply pounds of insecticide (e.g., from 6 to 12 pounds of carbaryl) to vines each season to control GBM, less than 0.2 lbs of pheromone dispensed in Isomate-GBM® pheromone ties has been shown to provide season-long control of this pest.

***Isomate-GBM is a trademark of Pacific Biocontrol Corporation. Environmental Protection Agency registration number 50675-9**

THE ISOMATE-GBM® PHEROMONE TIE

The Isomate-GBM® pheromone tie looks much like an oversized "twist-tie" of the sort that is used to close garbage bags. It is eight inches long, less than 1/8 inch wide, and contains a wire embedded within the polyethylene plastic (Photo 1.). Liquid pheromone is contained within a closed channel that runs along the wire for the entire length of the tie. Slow release of the pheromone is achieved over the course of approximately 100 days as the pheromone moves through the plastic walls of the channel and is released into vineyards. Mating disruption is achieved with the Isomate-GBM® pheromone product (Photo 2.) by placing 200 to 400 pheromone dispensers (called "ties") within an acre of vineyard. Ties are placed within vineyards during the second week of May by twisting them onto the upper trellis wire of vines (ca. 3 to 5 feet from the ground). Rates of 200 to 400 ties per acre have resulted in excellent control of GBM. Based on conventional vine spacings employed in New York, one person can dispense pheromone ties for about two acres of vineyard in one hour, at the treatment rate of 200 ties per acre.

Photo 1.

Photo 2.

EXPERIMENTAL METHODS FOR EVALUATING THE ISOMATE-GBM® PHEROMONE

Experimental plots and pheromone treatment rates

During 1988 and 1989, studies were conducted in the Lake Erie and Finger Lakes regions. Most vineyards in 1988 and all vineyards in 1989 had at least one vineyard edge that fit the criteria for high GBM risk (i.e., that had a wooded edge, and/or areas of prolonged winter snow cover). Our intention was to evaluate the pheromone at vineyards with "high risk" areas in order to test it under severe GBM pressure. A total of approximately 100 acres of vineyard were employed in tests each year. Additionally, small trials were conducted by A. Wise (Cornell Cooperative Extension) on Long Island.

The objective of our trials was to evaluate the control of grape berry moth in large plots treated with the Isomate-GBM® pheromone and contrast it with control of GBM observed in adjacent vineyards treated by growers with their normal insecticide programs. Conventional programs employed by growers usually comprised two or three treatments of either parathion or carbaryl. Exceptions were Trials 6 and 17 (Figs. 1 and 2) which received no insecticide in the check plots. The size of pheromone-treated plots varied from three to seven acres. Most pheromone plots were treated with Isomate-GBM® dispensers at rates of 200 ties per acre (approximately 1 every 3 vines) throughout the vineyard interior. For sampling GBM, edges of vineyards were defined as either the first three vines in rows running perpendicular to wooded areas, or the first 2 rows of vines arranged parallel to the edge. The first six vines (or two post lengths) from vineyard edges were treated at a rate of 400 ties/acre. This higher rate of pheromone used along vineyard edges was used to compensate for the fact that berry moth damage, if it is a problem at all, is usually greatest along edges, especially when vineyards are bordered by woods or hedgerows. Trials 8 and 9 were treated throughout with rates of 400 ties per acre.

Grape berry moth damage in pheromone-treated plots and adjacent commercial plots

The most meaningful measure of the effectiveness of GBM mating disruption is provided by direct counts of the percentage of berries in treated versus untreated vineyards that are damaged by this pest. Pairs of pheromone-treated and insecticide-treated (control plots comprised of the grower's normal insecticide regime) plots were sub-divided each into three to five sub-plots. Within each of the sub-plots, four sampling sites were identified: two within the interior of the vineyard and two along the edge. At each sampling site five vines were selected randomly and the fruit on 10 clusters on each of the five vines was examined for GBM damage. Evaluations of damage began in mid-July and continued at three-week intervals until harvest.

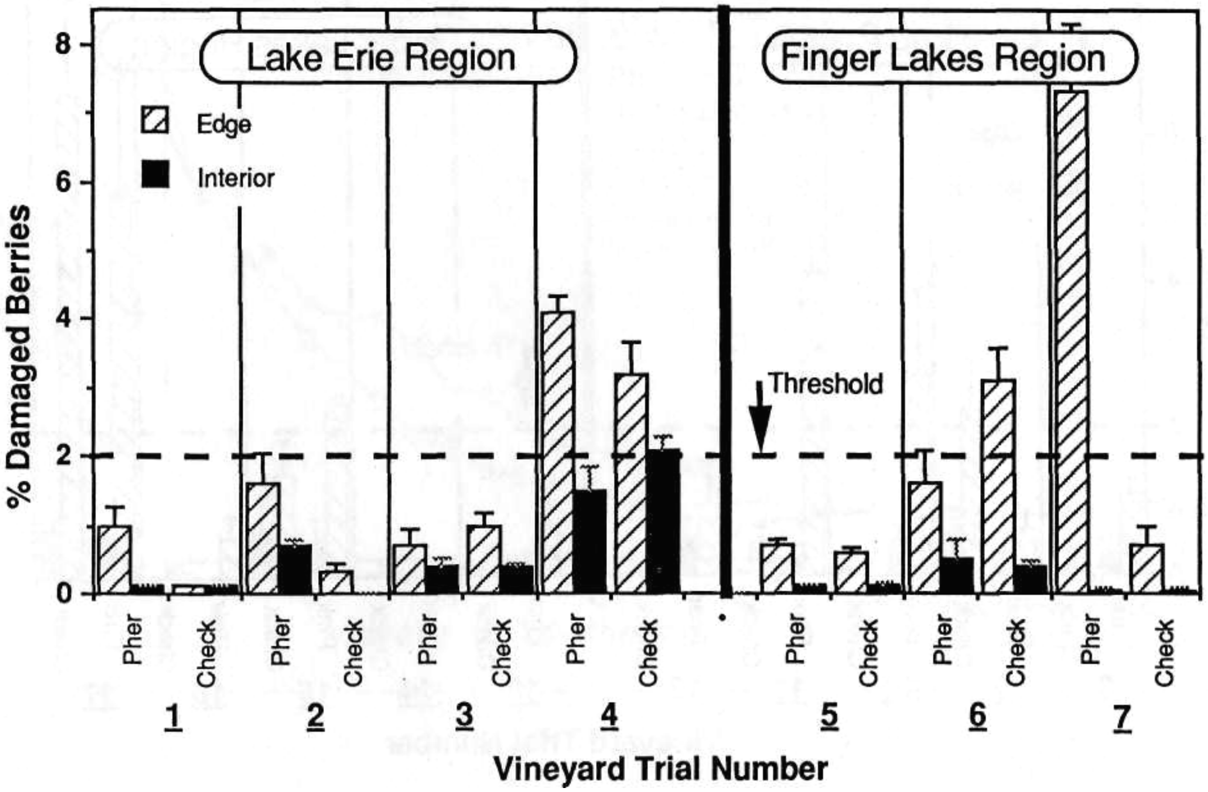

Figure 1.—1988 Evaluations. Damage by grape berry moth at harvest in four vineyards in the Lake Erie region and three vineyards in the Finger Lakes region of New York treated with Isomate-GBM® pheromone compared with adjacent check plots treated by the growers with conventional insecticides. The arrow denotes the threshold for grape berry moth damage (2% damaged berries). Vertical bars denote +1 standard error of the mean.

Emission rates of the Isomate-GBM® dispenser

Season-long disruption of mating requires that specific amounts of the volatilized pheromonebe present within vineyards from approximately mid-May through August or early September. Measurements were conducted of the rate of release of pheromone from Isomate-GBM® ties in order to characterize how they release pheromone throughout the season and, therein, to determine if modifications were necessary in the design of the pheromone dispenser. On May 16,1986,50 pheromone ties were placed at the height of the top trellis wire of the vineyard at the New York State Agricultural Experiment Station's Vineyard Research Laboratory, Fredonia, New York. Weight of each of the 50 ties was recorded weekly through September 9,1986. On June 8,1988,500 Isomate-GBM® dispensers were placed on the top trellis wire of a vineyard located at the New York State Agricultural Experiment Station, Geneva, New York. At weekly intervals during the summer, biweekly intervals during the fall, and monthly intervals during the winter and spring, groups of 20 pheromone ties were sampled from this collection of ties. Weight of each of the 20 ties was determined on each sampling date.

Observations of Secondary Pests in Pheromone Plots

Since pheromones do not kill pests like conventional insecticides, an important issue is whether pest species that in past years have been inaflvertently suppressed by insecticide treatments for berry moth will become much more serious problems when pheromones are used. Specifically, growers are most concerned about damage from Eastern grape leafhopper *(Erythroneura comes).* Our five years of field trials showed that the use of pheromones would not result in predictable or consistent problems from leafhoppers. Multi-year field studies were begun in 1989 to derive improved estimates of the degree to which leafhoppers and other secondary pests are problems in vineyards treated with pheromone (or vineyards treated with no insecticides). Estimates of the severity of leafhoppers and other secondary pests were made in 26 pairs of pheromone-treated and adjacent insecticide-treated vineyards. Throughout the season, secondary pest damage was rated every two weeks for three categories: grape leafhopper, Japanese beetle, and other pests. Damage ratings were: 0=none, l=low, 2=moderate, 3=severe. We estimated that most growers would not be concerned with populations assigned ratings of none or low. However, we assumed that most growers would be inclined to spray secondary pest populations we rated as moderate or severe. In addition to the comparisons of pheromone- and insecticide-treated vineyards, a state-wide survey was conducted in which 73 vineyards, 41 not treated with conventional insecticides, were monitored for leafhopper densities.

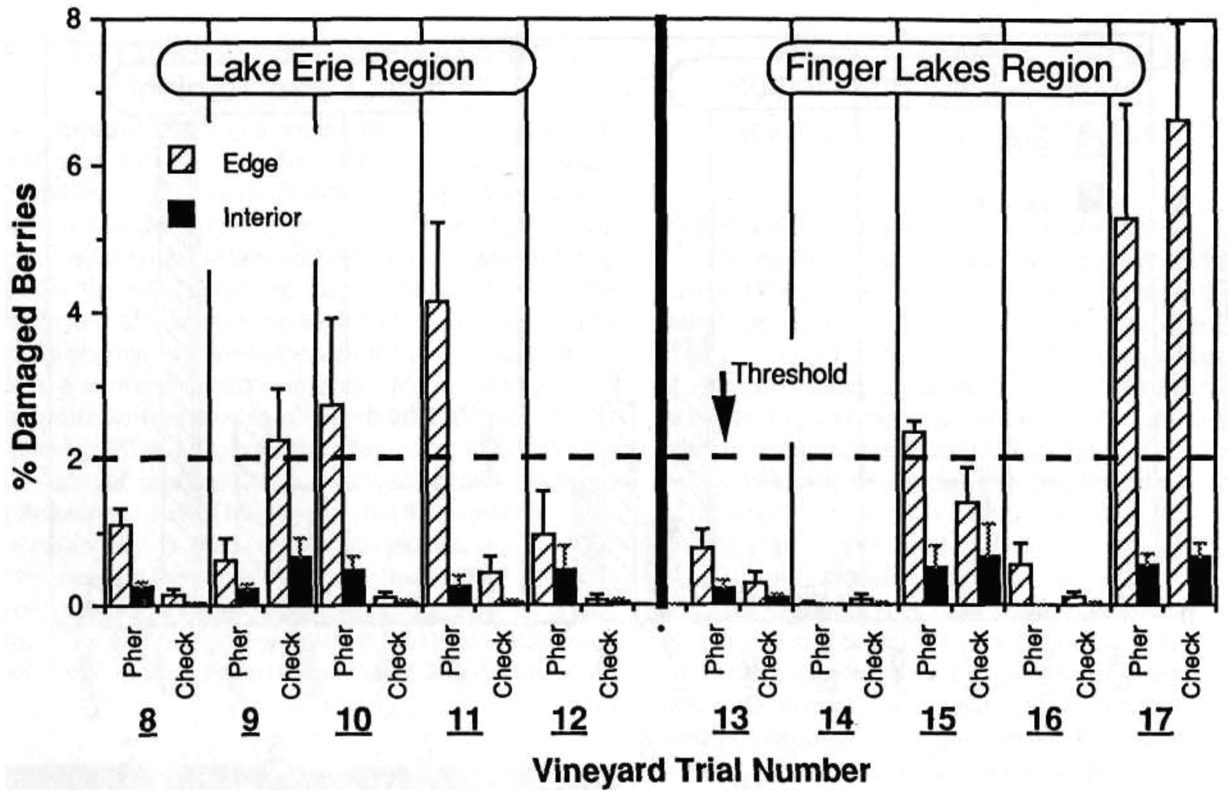

Figure 2.—1989 Evaluations. Damage by grape berry moth at harvest in five vineyards in the Lake Erie region and five vineyards in the Finger Lakes region of New York treated with Isomate-GBM® pheromone compared with adjacent check plots treated by the growers with conventional insecticides. The arrow denotes the threshold for grape berry moth damage (2% damaged berries). Vertical bars denote ±1 standard error of the mean.

RESULTS OF VINEYARD TRIALS: 1988 AND 1989

Grape berry moth damage within the interior of pheromone treatments

Damage by grape berry moth in the interior area of vineyards was below the threshold of two per cent damaged berries at harvest time in 17 of the 18 plots treated with pheromone in 1988 and 1989 (Figs. 1 and 2). Thus, the pheromone provided excellent results in interior areas, even in vineyards with high-risk edge areas. However, it is important to note that overall damage within the interior of the pheromone-treated plots was somewhat higher than in insecticide-treated plots, though still below threshold and very acceptable.

One insecticide-treated plot (Fig 1: Trial 4) had damage at harvest time in the interior of the vineyard that slightly exceeded the threshold of two per cent damaged berries. Results of trials conducted at this same location in the following year, 1989, are not included in Figure 2 because monitoring of this trial in July 1989, showed that *both* the insecticide and pheromone treated areas of the vineyard had unacceptably high GBM damage. Therefore, in August 1989, this vineyard was sprayed with insecticide, and the pheromone trial was terminated at this location. TheTrial4 location represented the most extreme high-risk situation for GBM. The pheromone- and insecticide-treated plots at this location each were less than three acres in size and nearly surrounded by wooded areas containing wild grape. Though the pheromone performed satisfactorily at this location in 1988 (Fig. 1), it is important to reiterate that it failed here in 1989. The narrow configuration of this vineyard conferred a vineyard-edge effect to the entire plot, due to close proximity of wooded areas. Though all of the vineyards tested in 1989 had at least one edge with high risk of GBM damage, unacceptable damage occurred in the interior of only this one vineyard. We conclude that small, extreme high-risk locations, like the Trial 4 site, are not appropriate for GBM mating disruption because female moths that mate outside the vineyard have the potential to cause unacceptable damage. Having noted this extreme situation, our data demonstrate clearly that mating disruption will give very satisfactory results in the interior areas of vineyards of 5 acre size, or larger, even when a high-risk edge is present.

Grape berry moth damage at the edge of vineyards treated with pheromone

Grape berry moth damage was below the harvest-time threshold of two per cent damaged berries at the edges of 11 of

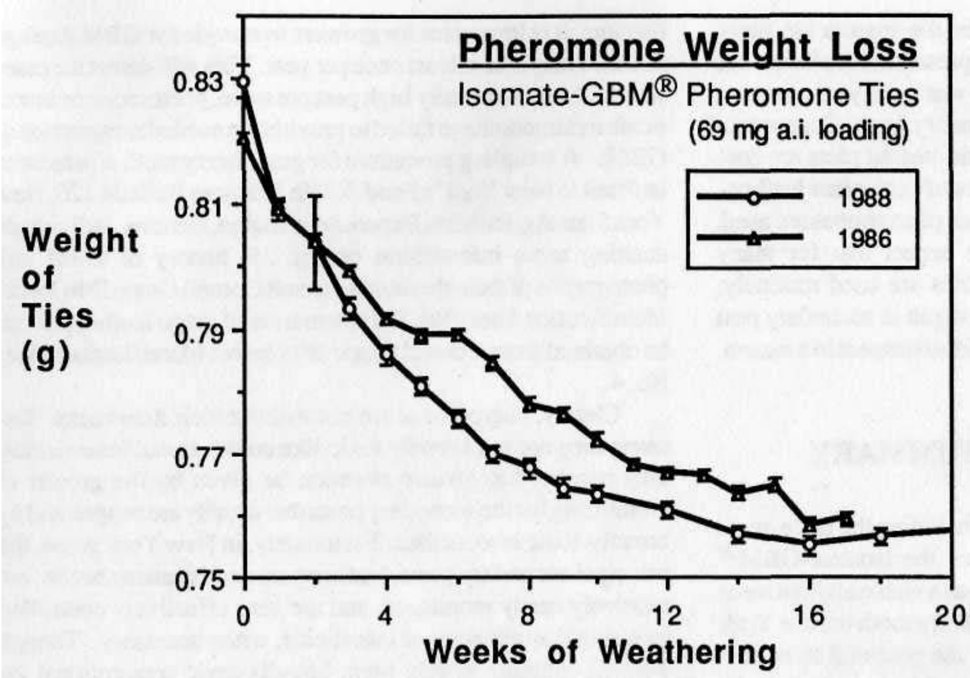

Figure 3.—Loss of pheromone from the Isomate-GBM® dispenser after field weathering during the 1986 and 1988 growing seasons. Ties contained 69 mg of pheromone.

18 vineyards treated with pheromone in 1988 and 1989 (Figs. 1 and 2). Nine of the 17 vineyard trials depicted in Figures 1 and 2 had below-threshold levels of damage in both the insecticide treatment and the pheromone treatment. However, in six of these cases where both treatments gave satisfactory control of GBM, damage was appreciably lower along the edge of the insecticide treatment than in the pheromone treatment. In the edge areas of two of the 17 trials (Fig 1: Trial 4; Fig. 2: Trial 17) both the pheromone and insecticide treatments failed, with berry damage ranging from three to seven per cent. As previously noted, one trial conducted in 1989 was terminated (sprayed-out) mid-season when monitoring detected failure of both the pheromone and insecticide treatments. This location, when combined with those depicted in Figures 1 and2,madea total of 18pairwisecomparisons of grower insecticide treatments and pheromone treatments conducted in 1988 and 1989.

In two cases, the edges of pheromone treatments had acceptable control (below 2% damage) while the edges of grower-treated plot had greater than two per cent damage (Fig. 1: Trial 6; Fig. 2: Trial 9). In four of the 17 trials depicted in Figs. 1 and 2, GBM damage along the perimeter of the pheromone-treated plots was above the two per cent threshold, but was well below threshold along the edges of the insecticide-treated plots (Fig. 1: Trial 7; Fig. 2: Trial 10, Trial 11, and Trial 15). In three of these cases, the difference in edge damage of pheromone- versus insecticide-treated plots was considerable. Importantly, in the three cases where edge damage was comparatively high in pheromone treatments, the vineyards fit the description of *very* high-risk sites for GBM damage. Such locations (Trial 7, Trial 10, Trial 11) had wooded edges very close to the vineyard edges and were areas where snow accumulated for prolonged periods during winter, facilitating high survivorship of GBM.

In summary, over the course of two years of evaluation of approximately 100 acres of pheromone test per year, unacceptable levels of damage were observed along the vineyard edges of 6 of 18 pheromone trials. In each instance where the pheromone gave unacceptable results, damage was confined to the vineyard edge that was adjacent to a wooded area or other typical high-GBM-risk area. From these findings we conclude that when high-risk areas are treated with pheromone, the two or three rows of perimeter vines along the wooded edge should be sprayed with conventional insecticides using established protocols for high risk vineyards.

Emission rates of the Isomate-GBM® dispenser

Based on measurements of weightloss in 1986 and 1988, the Isomate-GBM® dispenser provided sustained release of pheromone for somewhat greater than 15 weeks, under New York vineyard conditions (Fig. 3). For ties placed in vineyards by our recommended date of May 15, the Isomate-GBM® dispenser (with a 69 mg a.i. loading) should provide sustained release of pheromone until early September. Since pheromone released before mid-May is wasted, we suggest that growers avoid putting Isomate-GBM® dispensers in vineyards before approximately the second week of May.

Observations of Secondary Pests **in Pheromone Plots**

Grape leafhopper and other secondary pests were of relatively minor importance in almost all vineyards we monitored in 1989, whether treated with pheromone, conventional insecticides, or no insecticides. In the 26 pairs of pheromone treatments and adjacent insecticide treatments, leafhopper populations were higher in the pheromone plots than in the insecticide plots. However, very little visible damage was present in the pheromone plots in 1989. It was obvious that 1989 was not a year of severe leafhopper populations, or of other secondary pests. Contrasts of pheromone-treated plots with insecticide-treated plots are continuing and will provide better estimates of how often leafhoppers will generally need to be treated when pheromones are used. Based on our current experience, we expect that for many vineyards, if no conventional insecticides are used routinely, possibly one or two years out of 10 will result in secondary pest infestations that call for a single insecticide treatment in a season.

CONCLUSIONS AND SUMMARY

Based on six years of field testing, including the large-scale trials described herein, we conclude that the Isomate-GBM® pheromone product has proven potential as a viable alternative to insecticides applied for control of grape berry moth in New York vineyards. If widely utilized, it offers the potential to reduce organophosphate and carbamate insecticide use in New York vineyards by an estimated 50 per cent or more. The product consistently has given excellent control of GBM at locations of low and intermediate risk of GBM damage, an estimated 70 per cent of New York vineyards. With few exceptions, the pheromone product has also given very good control of GBM at high GBM-risk locations. For growers wishing to use the pheromone at high-risk locations, it will be necessary for the two or three rows of vines adjacent to wooded edges to be sprayed with conventional insecticides according to protocols established by the GBM risk assessment program. Mating disruption should not be attempted in small (less than 5 acres), extreme high-risk vineyards such as those surrounded by wooded areas on more than one side.

Pheromone dispensers should be placed in vineyards during the second week of May and before May 15. We recommend using a rate of 200 dispensers per acre of vines (1 per 3 vines) and suggest that twice this rate (2 per 3 vines) be used along the perimeter of the vineyard. In our tests we normally doubled up on the pheromone treatment for the first six vines, or two post lengths from the wooded edge. In an hour, one person can apply pheromone ties on about two acres, at the treatment rate of 200 ties per acre. Dispensers should be placed on the top trellis wire, about four to five feet above the ground.

The results described herein illustrate that both mating disruption with pheromones and conventional insecticides fail in certain years under what are define as extreme high-risk conditions. Because of year-to-year and site-to-site variability in GBM damage, it is important for growers to sample for GBM damage in their vineyards at least once per year. This will detect the cases where, due to unusually high pest pressure, pheromone or insecticide treatments have failed to provide the needed suppression of GBM. A sampling procedure for grape berry moth is presented in detail in New York's Food & Life Sciences Bulletin 120, New York State Agricultural Experiment Station, Geneva. Individuals desiring more information on the life history of GBM and photographs of damage should consult Cornell Grape IPM Insect Identification Sheet No. 1. Information of grape leafhopper can be obtained from Cornell Grape IPM Insect Identification Sheet No. 4.

Clearly, pheromones are not without their drawbacks. Because they are not broadly toxic like conventional insecticides, they require that greater attention be given by the grower to monitoring for the secondary pests that usually are suppressed by broadly-toxic insecticides. Fortunately, in New York grape, the principal secondary pests, leafhoppers and Japanese beetle, are relatively easily monitored, and are very effectively controlled by a single application of insecticide, when necessary. Though we will continue to rely upon broadly-toxic conventional insecticides to 'clean-up' secondary pests and severe GBM problems, utilization of mating disruption for control of the grape berry moth could bring New York grape growers a long way toward fulfilling the call for reduced reliance on toxic chemicals in grape.

ACKNOWLEDGMENTS

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