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Risk Assessment of Grape Berry Moth and Guidelines for Management of the Eastern Grape Leafhopper

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INTRODUCTION AND BACKGROUND

Several factors have prompted the reevaluation of control recommendations for key pests of grapes in recent years. First, the costs of insecticides and their application have risen substantially. Growers who improve the efficiency of their use of pesticides can realize significant savings in production costs. Second, grape processors have responded to consumer desires to minimize pesticide residues in food by promoting judicious use of pesticides. Finally, increased governmental restrictions regarding what pesticides can be used in vineyards and how they may be used may increase the overall difficulty that growers encounter when using pesticides. The result of these factors is that while producers and processors continue to require control of economically-damaging pests, this now must be achieved with the least amount of pesticide possible. The Grape Berry Moth Risk Assessment Program was developed to address these concerns. In this publication we describe how Risk Assessment can be used to maintain acceptable control of grape berry moth and the Eastern grape leafhopper while minimizing use of insecticides.

Grape berry moth (GBM), *Endopta viteana,* is the most important pest of grapes in New York State. The larval stage of this small moth bores into grapes and feeds within developing berries. A long-standing recommendation for controlling grape berry moth was to apply three insecticide sprays, properly timed, to kill eggs and newly-hatched larvae before they bore into the fruit. Recent research on GBM ecology and control revealed that an estimated 50 percent of the insecticides used to control GBM could be eliminated by using the newly-developed GBM Risk Assessment Program. GBM Risk Assessment was first presented to growers in 1987 in the New York Food and Life Sciences Bulletin No. 120. Since 1987, this method of GBM control has undergone extensive testing in commercial vineyards throughout New York. Results of these vineyard trials are presented herein and demonstrate that, indeed, the Risk Assessment Program can provide the necessary control of GBM while substantially reducing insecticide use. Reducing insecticide use in vineyards has caused some growers to be concerned about the possibility that other pest problems might increase. They are concerned most about increases in damage caused by the Eastern grape leafhopper *(Erythroneura comes).* Research addressing this question, conducted in 1989 and 1990, showed that grape leafhoppers can easily be monitored and controlled. In this bulletin we summarize three years of implementation of the GBM Risk Assessment Program and present complementary guidelines for management of the Eastern grape leafhopper. Use of these methods will constitute another step taken by grape growers to move away from past practices of routine application of preventative insecticide treatments.

WHAT IS THE GRAPE BERRY MOTH RISK ASSESSMENT PROGRAM?

Risk Assessment for grape berry moth control is a method of classifying vineyard blocks based on factors that influence

GBM populations and adjusting control programs to account for the risk of economically damaging GBM infestations. Long-standing spray recommendations have treated vineyards as if they all had the same risk of berry moth damage. However, observers have long noted that GBM damage can vary greatly within a single vineyard, from vineyard to vineyard within a single growing region, and that damage also varies between grape-growing regions. Thus the need to apply insecticide treatments varies within large vineyards, from vineyard to vineyard, and from year to year. Research since the mid 1980s has identified factors that are associated with high or low risk of GBM infestations. Risk assessment involves using these factors to classify vineyards or areas within vineyards as high, intermediate, or low risk areas. Once the risk status of vineyards is determined, control programs tailored to the risk classification may then be applied.

FACTORS AFFECTING RISK OF GBM DAMAGE

Specific vineyards or areas within vineyards often have consistently high or low damage from GBM year after year. Three major factors that predict GBM damage severity in a vineyard are: (1) whether vineyards are bordered by wooded areas or hedgerows; (2) winter temperature and snow cover in the vineyard; and (3) GBM infestation history in the vineyard.

Wooded Edges—The presence of woodlots or hedgerows at the perimeters of vineyards strongly influences the risk of GBM infestations and where the damage occurs within vineyards. While this fact was observed first around the turn of the century, only recently have studies shown how strong this "edge effect" is. Figure 1 shows GBM damage at different distances from the wooded edge of a vineyard. The higher damage levels present at the vineyard edge extend approximately three vines (one post length where rows are perpendicular to edge; two rows where rows are parallel to wooded edge) into the vineyard. Figure 2 illustrates the point that vineyards with wooded edges receive heavier damage than vineyards without wooded edges. One reason this edge effect is thought to occur is because wild grapes growing in wooded edges are an excellent host for GBM and, therefore, serve as a source for GBM infestations. However, additional factors are also involved, since research has shown that these "edge effects" can also occur at sites where there are no wild grapes in adjacent wooded areas.

Climatic Factors—Winter temperature and snow cover conditions vary within and between different grape-growing regions in New York and can influence how GBM populations survive the winter in vineyards. In the fall, GBM larvae form cocoons either within folded grape leaves or leaves of grapes. For this reason, we suggest giving all high-value wine and table grape varieties ratings of high risk for GBM damage.

RESULTS OF THREE YEARS OF FIELD EVALUATIONS OF RISK ASSESSMENT

The GBM Risk Assessment Program has been extensively tested in New York vineyards over three years, involving more than 600 acres of vineyards. Table 2 summarizes

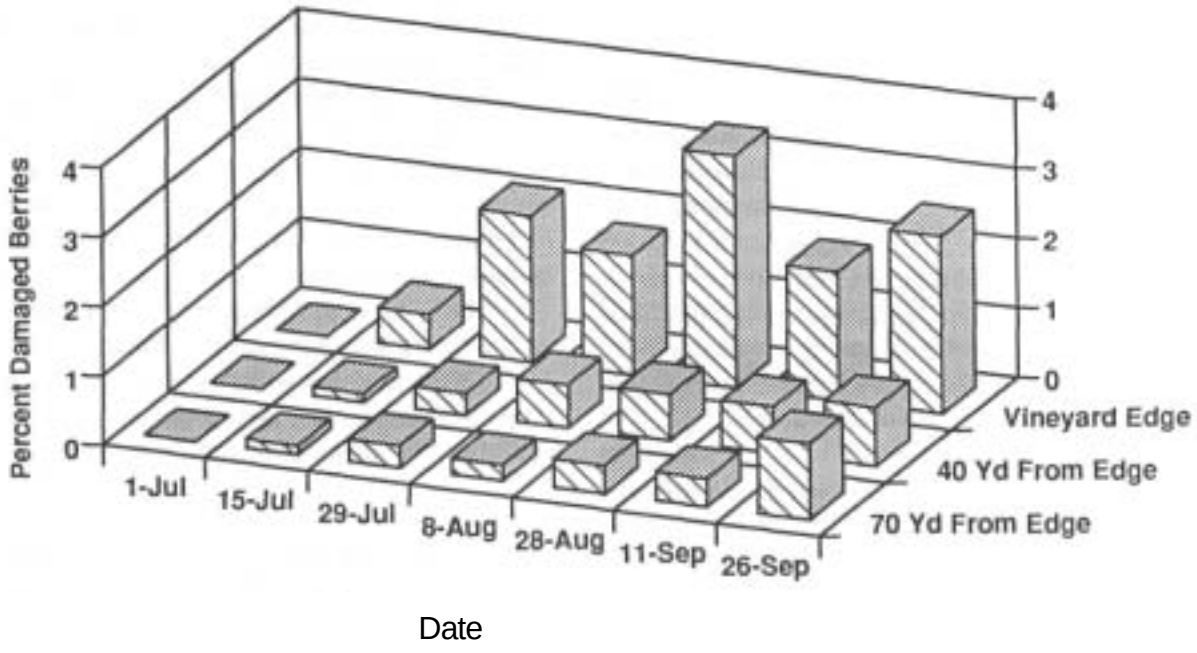


Figure 1. Grape berry moth damage is much greater at the edges of vineyards than in the interior portions.

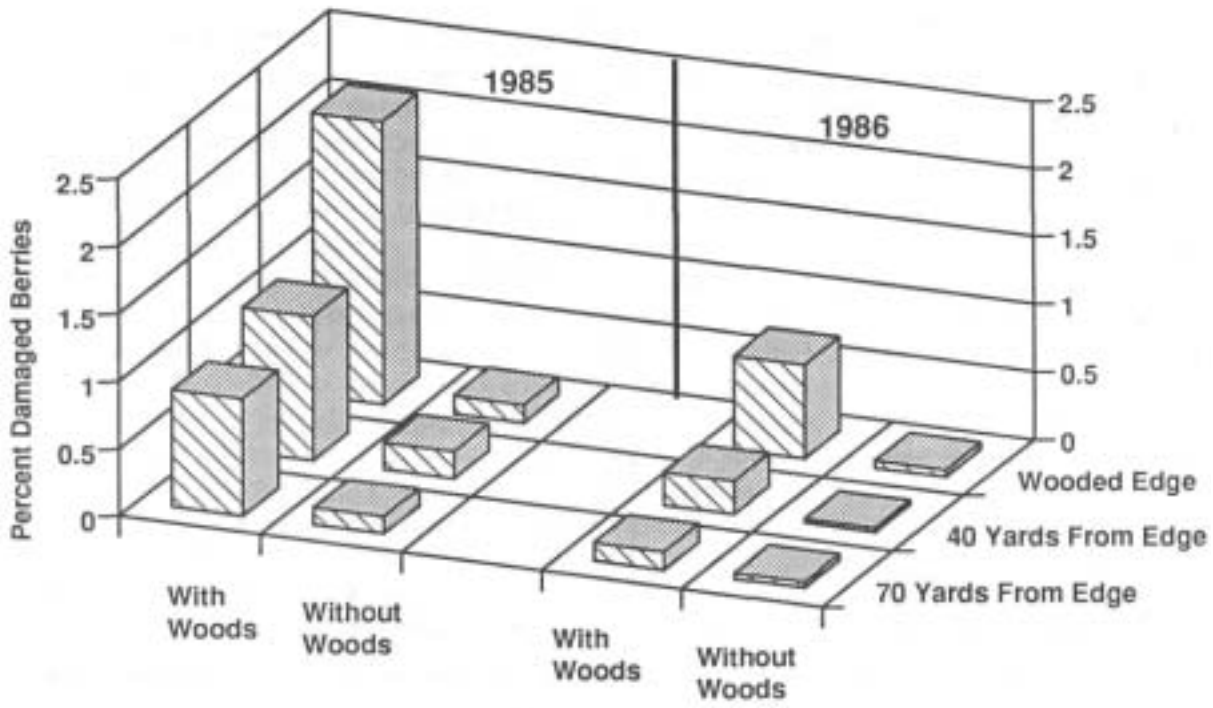


Figure 2. Grape berry moth damage is often much greater along wooded edges of vineyards than along non-wooded edges.

results of these trials. In these field tests, two-thirds of all vineyard sites (67%) were "low-risk," 23 percent were classified as "high risk," and the remaining nine percent were "intermediate-risk" sites. By using Risk Assessment, participating growers were able to reduce their insecticide applications by 65 to 72 percent overall (Table 2). Yet the Risk Assessment Program did not result in unacceptable GBM damage. In every case, evaluations at harvest time showed damage well under the processing industry standard of two percent damaged berries.

USING GBM RISK ASSESSMENT IN YOUR VINEYARDS

There are two steps to putting Risk Assessment for GBM into practice in vineyards. The first step is to assign a risk rating to each vineyard block. The second step is to tailor insecticide treatments to correspond to the risk classification of each block.

A series of questions to answer to classify a vineyard site is outlined in Figure 4. When vineyards are composed of

Table 1. Influence of snow cover and leaf-litter on survival of overwintering pupae of grape berry moth.

Location of grape berry moth pupae	Percentage of pupae surviving exposure outdoors from December to April	
	1986-1987	1987-1988
Under snow	82%	55%
Under leaf litter	88%	51%
On soil surface	64%	45%
One meter above soil surface	0%	4%

Grape Berry Moth—Select four areas in the vineyard to be sampled: two in the center of the vineyard (1 and 2) and two on the edge of the vineyard (3 and 4). Visually inspect, at random, 10 clusters on each of five vines (a total of 50) in each of the four areas. Record the number of GBM-damaged clusters in each area. Compute separate totals for areas 1 and 2 (center) and 3 and 4 (edge) to determine the percent damaged clusters. For the July sampling date (low-risk and intermediate risk sites), treatment should be applied if the percentage of the clusters with damage exceeds six percent. For the August sampling date (high-risk vineyards), treatment should be applied if the percentage of damaged clusters exceeds 15 percent. See the IPM fact sheet #1 on Grape Berry Moth for photographs of damaae.	**Eastern Grape Leafhopper**—First observe whether or not leaves have stippling damage. If stippling is present, the block should be sampled to estimate the number of leafhopper nymphs per leaf present. Counts should be made at the same 4 locations used for GBM counts. At each area, examine the undersides of the third through seventh leaves of one shoot (leaf one is the first leaf at the base of the shoot) on each of five vines. Divide the total number of leafhopper nymphs by 100 to compute the number of leaf hoppers per leaf. If more than five nymphs per leaf in the third week in July or 10 nymphs per leaf in the fourth week in August are found, an insecticide treatment should be applied. See the IPM fact sheet #4 for photographs of leafhopper nymphs and damage.

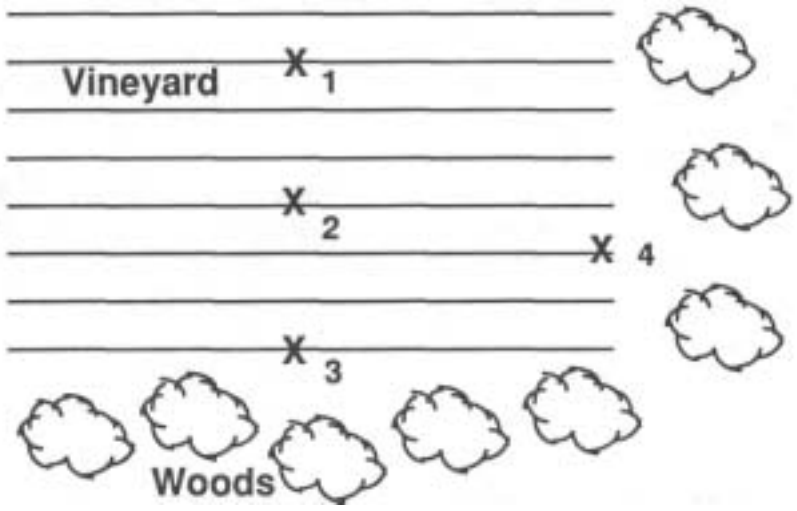


Figure 3. Sampling procedures for Grape Berry Moth and Eastern grape leafhopper.

distinctly different areas they should be subdivided into smaller blocks and assigned different risk ratings. For example, the area (e.g. the first six rows) adjacent to a wooded edge could be classified as "high risk," and the remainder of the vineyard could be rated "low risk" (See inset [Fig. 5] on subdividing vineyard blocks).

After classifying your vineyards, the next step is to choose from Table 3 the control program appropriate to the risk rating. These control recommendations incorporate both calendar-based sprays for intermediate and high-risk vineyard blocks and sampling in July or August to determine if sprays are needed later in the season. Table 3 is the most important part of this bulletin, since it summarizes treatment and sampling recommendations for all three risk categories. The sampling procedure is simple and requires only 20 to 30 minutes per vineyard to complete. It involves examining 10 clusters for berry moth damage on each of five vines in four locations within the vineyard, two at the wooded edge, and two in the interior (Fig. 3). The percentage of clusters with GBM damage is computed separately for the two interior samples (100 clusters total) and for the two edge samples (100 clusters total). Vineyards or portions of the vineyards with

Table 2. Results of three years of field testing of the Grape Berry Moth Risk Assessment Program.

Year	Risk rating	No. acres[1]	Average number of s insecticide treatments		Percent reduction	Overall reduction
			Grower's previous program	After Risk Assessment	in insecticide use[2]	in insecticide use[2]
1988	high	50	3.0	2.0	33%	65%
	intermediate	5	3.0	1.0	83%	
	low	43	3.0	0.0	100%	
1989	high	45	2.2	1.4	36%	72%
	intermediate	20	2.0	0.5	75%	
	low	128	2.2	0.3	85%	
1990	high	52	2.5	1.8	28%	67%
	intermediate	35	2.5	1.2	52%	
	low	246	2.6	0.6[3]	77%	

1 Number of growers involved was one in 1988,15 in 1989, and 40 in 1990

2Reduction in insecticide use was calculated by comparing the numbers of insecticide treatments applied in the year preceding Risk Assessment versus the number of insecticides applied with the use of Risk Assessment. 3 All applications were directed at the Eastern grape leafhopper.

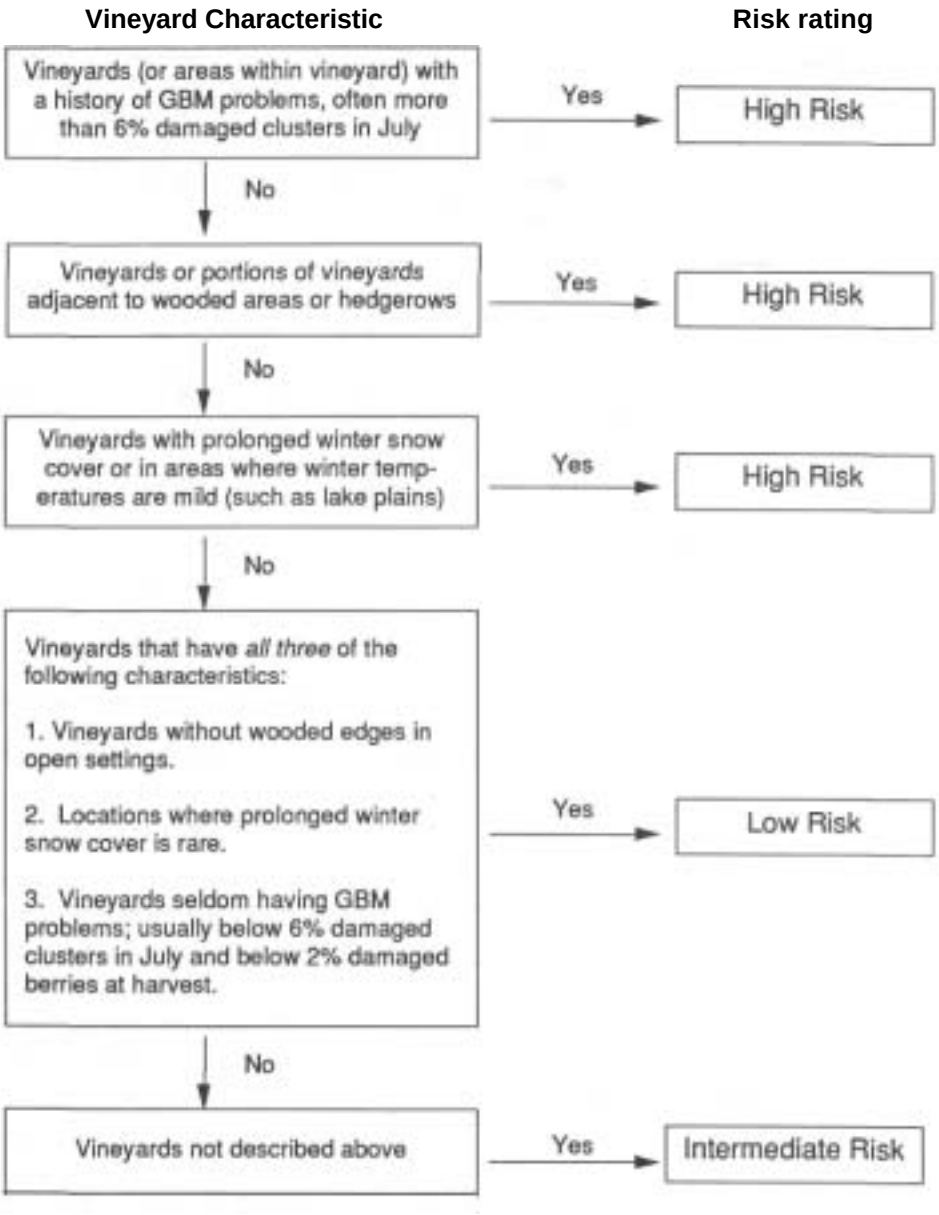
greater than six percent damaged clusters in the third week of July should be treated for grape berry moth in early August. Extensive field studies have shown that vineyards with less than six percent damaged clusters in the third week of July are extremely unlikely to exceed acceptable levels of GBM damage at harvest (based on the processing industry's standard of less than two percent damaged berries). When the percentage of damaged clusters at the edge exceeds six percent but damage in the interior is less than six percent, growers may consider applying insecticide only to edges (six rows or two post lengths). Using this sampling procedure as directed also provides the basis for obtaining an accurate infestation history over several years.

Because high-risk vineyards are given two calendar-based treatments of insecticide, one at 10-days post-bloom and one in early August, there is no need to sample them during the third week of July. However, high-risk vineyards should be sampled during the fourth week in August, and locations with greater than 15 percent damaged clusters at that time should be treated again immediately. Research has indicated that a third treatment will rarely be needed, and required only during years when GBM populations are extremely high.

The GBM Risk Assessment Program is self-correcting. If the procedures outlined in Table 3 are followed, every block, whether high, intermediate, or low-risk, will be sampled for GBM once each year. The sampling results (percent damaged clusters in each block) can then be used to re-evaluate the risk-rating assigned to each block. If, for example, a block is classified as' 'intermediate risk," but consistently has less than 6 percent damaged clusters in July, the rating can be changed to "low risk" the following year. Because infestation history is the best guide for assigning risk, growers who sample their vineyards for a few seasons will be in a position to assign risk categories confidently. Similarly, if the rating assigned to a vineyard block is too low, cluster counts obtained by sampling will allow growers to detect the problem, take corrective action, and avoid unacceptable GBM damage. In these cases the risk rating should be increased for the following years.

PROVISIONAL MANAGEMENT GUIDELINES FOR EASTERN GRAPE LEAFHOPPER.

By using Risk Assessment to guide decisions on when it is necessary to apply insecticides to control GBM, New York grape growers can substantially reduce insecticide use while maintaining control of this pest. However, growers have expressed concern that reducing insecticide use will result in increased damage from the Eastern grape leafhopper. Research currently under way is determining how often leafhoppers will reach economically damaging levels during seasons when growers use no insecticides in their vineyards. Though



* These risk categories apply to processing grapes, where the industry standard for acceptable GBM Damage is 2% damaged berries. Table grapes and premium wine grapes should always be classified as high-risk.

Figure 4. Classifying vineyards for risk of grape berry moth infestation.

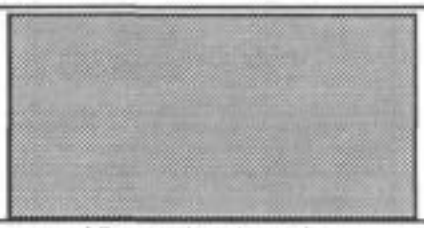
a final answer to this question awaits further research, results from 1989 and 1990 evaluations (shown in Fig. 5) revealed that leafhoppers will not cause problems in most unsprayed vineyards during most years. Only two percent of our unsprayed study sites had leafhopper populations above conservative threshold of five nymphs (immature leafhoppers) per leaf in 1989 (Fig. 6). In 1990, a more favorable year for leafhopper development, only seven of 28 unsprayed sites (25 percent) had populations exceeding the provisional threshold. It is important to emphasize that these measurements were made in vineyards where no insecticides were used. Where the number of insecticide sprays was reduced, but not entirely eliminated, we would expect fewer leafhopper problems to arise.

Leafhopper damage becomes visible long before the damage causes economic reductions in grape yield or quality, and well before there are any long-term effects on vine health. In most cases, leafhoppers can be effectively controlled with one insecticide application when they reach damaging levels. Even when no insecticides are applied for GBM control, it is

Because GBM damage is much higher along wooded edges than in the center of a vineyard, it is possible to divide vineyard blocks into high and low risk areas, and to limit insecticide treatment to only a portion of a vineyard block. Whether or not this is practical depends on whether or not the trellis runs parallel or perpendicular to the wooded edge, and on the size of the vineyard block. If the rows are parallel to the wooded edge, insecticide treatments can be limited to the first six rows along the edge. If rows are perpendicular to the wooded edge, treating only the edges of the block may not be practical.

The size of the vineyard block should be considered in deciding whether to subdivide the block into smaller units with different risk classifications. Smaller vineyard blocks have a greater proportion of "edge" than larger blocks. The table below shows the relationship between acreage and percentage of the block that may be high risk. For example, in a square three acre block with one wooded edge, the high-risk area (first six rows from the wooded edge) would comprise 13 percent of the vineyard block. Only five percent of a 20 acre block with one wooded edge would be high risk. For this reason, it is more practical to subdivide a larger block into high and low risk areas than to subdivide a smaller block.

Vineyard shape[1]



Vineyard size (acres)	Vineyard square		Vineyard rectangular (twice as long as wide)			
			Short side wooded		Long side wooded	
	% of vineyard that is high risk	Number of Acres	% of vineyard that is high risk	No. Acres	% of vineyard that is high risk	No. Acres
3	13	0.4	9	0.3	19	0.6
5	10	0.5	7	0.4	15	0.7
10	7	0.7	5	0.5	10	1.0
15	6	0.9	4	0.6	8	1.3
25	5	1.1	3	0.8	6	1.6

[1] High risk area is defined as the area 48 feet wide (6 rows or two post lengths) adjacent to a wooded edge.

Figure 5. Subdividing Vineyard Blocks into High- and Low-Risk Areas.

relatively easy to avoid applying calendar-based treatments for leafhoppers, and instead treat only those vineyard blocks that need it. The key to this approach is periodic sampling for leafhoppers in vineyards. In this section we present a method for sampling for leafhoppers and provide provisional guidelines for determining when an insecticide treatment is needed to control leafhoppers.

EASTERN GRAPE LEAFHOPPER LIFE CYCLE AND DAMAGE

Eastern grape leafhoppers over winter as adults in leaf litter in or around vineyards. In early June, they begin feeding, mainly on basal leaves of grapevines, and they start to lay eggs shortly thereafter. Nymphs (immature leafhoppers) first appear in mid June and require 20-30 days to develop into adults. In years when leafhoppers builduptodamaginglevels, peak populations of nymphs usually occur from mid-July to mid-August. Adults of the first generation start to appear in mid-July, and continue to produce offspring throughout the rest of the season. If conditions are favorable, a second generation of nymphs will be produced from early August to the end of the growing season. Though adult leafhoppers are thought to stop laving eggs in mid-August, nymphs and adults are often present until leaves are dropped in the fall.

Leafhoppers do not feed directly on fruit. Rather, they cause indirect damage to grape yield and quality by feeding on leaves, which reduces their photosynthetic output. The severity of this damage is directly related to the amount of stippling visible on the leaves. Severe leafhopper damage can reduce vine health and result in early defoliation of vines.

Table 3. Management Procedures for Grape Berry Moth and Eastern Grape Leaf hopper.

GBMrisk category	Recommended Sampling Times and Treatment Thresholds				Recommended Time to Spray[2]	
	Grape Berry Moth		Eastern Grape Leaf hopper[1]		Grape Berry Moth	Eastern Grape Leafhopper
	Sampling	Threshold[1]	Sampling	Threshold		
High risk	•4th week of August	•15% damaged clusters	•4th week of August	^10 per leaf	•Ten days post bloom •Early August • BOS Late August	BOS Late August
Intermediate risk	•3rd week of July	•6% damaged clusters	•3rd week of July •4th week of August	•5 per leaf •10 per leaf	•10 days post-bloom •BOS Early August	•BOS Early August •BOS late August
Low risk	•3rd week of July	•6% damaged clusters	•10 days post-bloom •3rd week of July •4th week of August	•Stippling + adults •5 per leaf • 10 per leaf	•BOS Early August	•BOS 10 days post-bloom •BOS Early August •BOS Late August

[1] An insecticide treatment is recommended if damage levels exceed the stated threshold. Consult Cornell Pest Management Recommendations for selection of appropriate insecticide.

[2] BOS = Based On Sampling. BOS sprays are those made only when the results of sampling confirm that damage exceeds the stated threshold. Sampling often will demonstrate that a BOS treatment is not needed.

PROVISIONAL LEAFHOPPER SAMPLING PROCEDURE AND DAMAGE THRESHOLDS

To simplify sampling for leafhoppers, we have designed an easy procedure that is to be conducted at the same locations and times as GBM sampling for Risk Assessment. This combination of leafhopper monitoring with GBM Risk Assessment sampling means that the two most important insect pests in grape can be managed with minimal effort and expense. The three important periods for sampling grape leafhopper populations coincide with GBM sampling periods: Ten days post-bloom, the third week in July, and mid-August. Ten days post-bloom corresponds with the time when leafhopper adults that survived the winter begin to lay eggs in grape leaves. Mid-July and mid-August are the times when the peak numbers of first-generation and second-generation nymphs are present, respectively.

Ten Days Post-bloom—At this time of the growing season, only adult leafhoppers are present in the vineyard, so it is not necessary to count them. If adult leafhoppers are present, you will see visible stippling damage (See Cornell IPM fact sheet No. 4 for photo of stippling damage) on the lower "sucker" leaves and interior leaves of the grape canopy. Shake the vines. If adults are present they will fly around the vine. If you see stippling damage on vines throughout the vineyard, we recommend an insecticide application to prevent later damage from occuring. Early season damage indicates that leafhopper populations may potentially buildup to damaging levels later on in the season. If populations that increase early in the season are treated at 10 days post-bloom, it is highly unlikely that leafhoppers will cause significant damage later in the season. In trials completed in 1991, a single insecticide application at 10 days post-bloom in small plots (15 vines per row by five rows) suppressed leafhopper populations through late August. It is important to emphasize that there is no need to scout for leafhoppers at intermediate and high-risk sites, because insecticides are applied at these sites at 10 days post-bloom for GBM control (Table 3). Only low-risk sites need to be sampled for leafhopper infestations at 10 days post-bloom.

Third Week in July—By mid-July, much of the first-generation of nymphs (immature leafhoppers) have been produced and are feeding on the undersides of grape leaves.

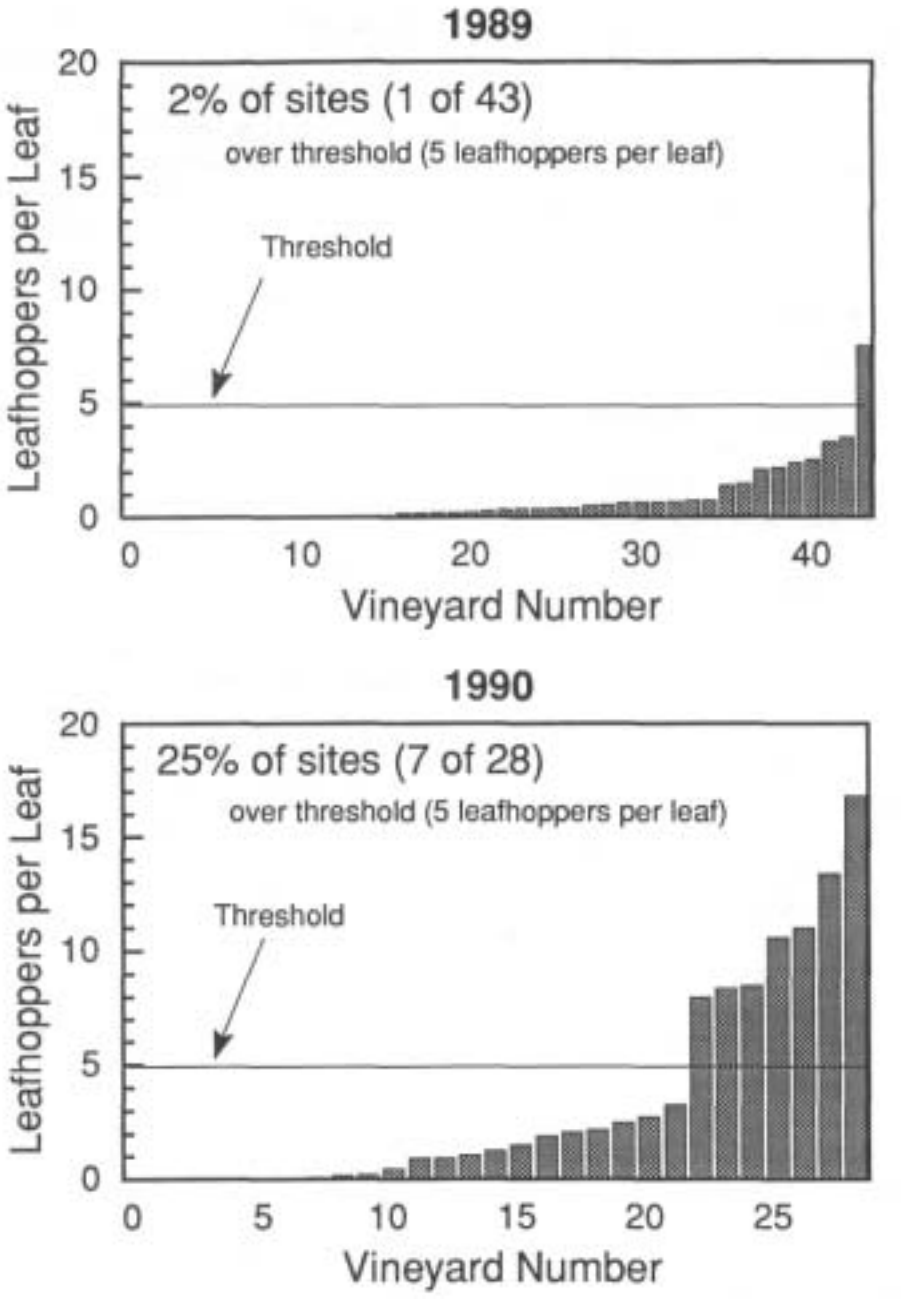


Figure 6. Example of how grape leafhopper populations differ from year to year and from location to location in New York. Note that even in a 'bad' year for leafhoppers, like 1990, fully 75% of vineyards sampled had end-of-season damage levels below the conservative threshold of 5 nymphs/leaf

At this time, the need to apply a treatment for leafhopper control should be determined in all low and intermediate-risk vineyard blocks (Table 3). Sampling for both grape berry moth and grape leafhopper can be done with a single pass through the vineyard. Because high-risk blocks get sprayed in early August, there is no need to sample them at this time.

The first step in evaluating leafhopper damage is to look for stippling on leaves while you are doing counts of GBM damage. Most of the damage will be found on the first seven leaves from the base of the shoot. If no stippling (or only minor damage) is visible on the leaves, there is no point in counting how many leafhoppers are present. If moderate to heavy stippling is seen, then it is necessary to do counts of leafhopper nymphs to determine if damage levels warrant expenditures on an insecticide treatment. The sampling procedure for leafhoppers (Fig. 3) requires counting all leafhoppers on the undersides of the third through seventh leaves (leaf one is at the base of the shoot) of one shoot on each of five vines. As with GBM sampling, sampling for leafhoppers should take no more than 15 to 20 minutes per vineyard.

Fourth Week in August—In years when leafhoppers do build up to damaging levels in vineyards, it is most common for them to do so in late August. Table 3 shows that sampling for leafhoppers during the fourth week in August is recommended for high, intermediate, and low-risk locations. Vineyards that have greater than 10 leafhopper per leaf at this time should be treated with an insecticide. Again, if there is very little stippling visible, it is not necessary to use the sampling procedure. If *any* insecticide applications have been made during the season, it is highly unlikely that any treatment will be necessary at this time.

Treatment Threshold—It is relatively difficult to determine when grape leafhopper causes economically important injury, because leafhoppers only damage the plant indirectly by reducing the amount of photosynthesis (leaf function). We know, however, that it takes a large amount of leafhopper damage to affect yields. If enough leaf area is affected, yield, sugar content, and pruning weights may ultimately be reduced. The scientific challenge has been to determine at what point leafhopper damage begins to significantly affect yield or quality sufficiently to justify expenditures on insecticides. Extensive studies currently in progress are aimed at measuring the short- and long-term effects of leafhopper damage on yield, quality, and pruning weights, under current high cropping loads. Until these studies are completed, we are recommending the use of very conservative damage threshold for leafhoppers. We recommend treating for grape leafhoppers when populations exceed an average of five leafhopper nymphs per leaf before August 1, or 10 nymphs per leaf thereafter. These provisional treatment thresholds are unquestionably lower than the level that economically justifies an insecticide treatment. As more results are obtained from our field experiments presently under way, these treatment thresholds will be modified, undoubtedly to higher levels.

CONCLUSIONS

Research has shown that the risk of incurring damaging GBM infestations at specific vineyards can be predicted by evaluating three factors: the presence of woodlots or hedgerows bordering the vineyard, winter severity and snow cover, and the infestation history. The GBM Risk Assessment Program provides growers with a simple method for determining the risk rating of their vineyards and specific treatment recommendations for low, intermediate, and high-risk vineyards. Field tests have achieved overall reductions in insecticide use of at least 50 percent by using GBM Risk Assessment.

Provisional guidelines for control of Eastern grape leafhopper have been designed to require a minimum of time, and sampling can be done at the same time and in the same locations as sampling for GBM Risk Assessment. While we expect that the major reductions in insecticide use brought about by use of GBM Risk Assessment will allow some increases in leafhopper populations, leafhoppers are easily managed by using the procedures described herein. Most importantly, our studies have shown that, even when no insecticide is used, most vineyards will not require treatment for leafhopper control. By monitoring vineyards, growers can easily detect those locations that do need a single treatment for leafhoppers or other occasional pests that occur in vineyards.

Use of the Grape Berry Moth Risk Assessment Program and the guidelines for management of grape leafhopper described herein will constitute yet another step taken by grape growers to move away from past practices of routine use of preventative insecticide treatments. By adopting these practices, which limit insecticide use to situations where the pest damage warrants control, growers can avoid unnecessary expenditures on insecticide treatments.

ACKNOWLEDGMENTS

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