GRAPE RESEARCH NEWS

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USING TEMPERATURE ACCUMULATIONS (DEGREE-DAYS) TO PREDICT THE RISK OF DAMAGING EASTERN GRAPE LEAFHOPPER INFESTATIONS

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Research has shown that New York and Pennsylvania grape growers can sharply reduce insecticide use for grape berry moth by using the *Grape Berry Moth Risk Assessment Program*, which targets insecticide applications at "high-risk" portions of vineyards. As growers adopt risk assessment, management of eastern grape leafhopper (Fig. 1) has assumed greater importance. Our research program over the past four years has focused on determining what factors influence the abundance of leafhoppers in vineyards, and on developing management guidelines that minimize insecticide use while preventing economic injury to grapevines. One important factor that has a strong influence on leafhopper abundance is year-to-year variation in temperature accumulations. Temperature accumulations (i.e., degree-day accumulations) affect the potential for leafhopper population growth. We are devising a model relating leafhopper development to temperature. This model can be used early in the season to assess the risk of severe late-season leafhopper injury and to guide treatment decisions.

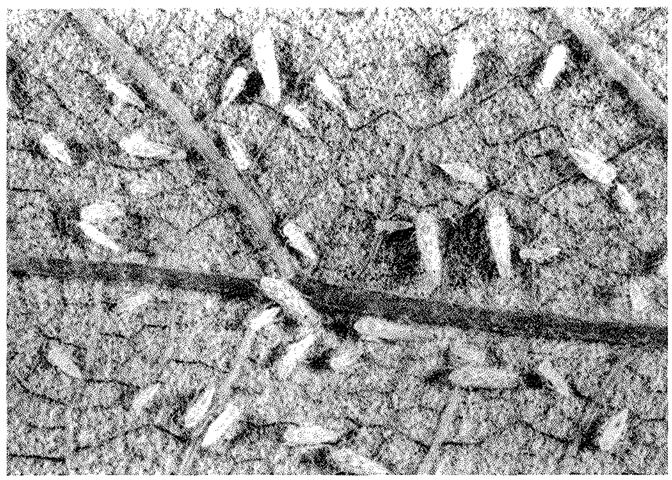

Figure 1. *Eastern grape leafhopper nymphs and adults. Temperature strongly influences the rate at which leafhoppers pass through their developmental stages. Our knowledge of degree-day requirements for leafhopper development has been incorporated into a model that helps us predict seasonal timing of leafhopper infestations.*

Leafhopper abundance varies widely among years. Before effective synthetic insecticides were introduced in the late 1940s, regional outbreaks of grape leafhopper tended to occur in cycles of two to three years, followed by several years (five to eight) in which leafhopper populations were low, and damage was considered to be economically unimportant. In the Lake Erie grape belt, "outbreak" years occurred in 1900–1902, 1910–1911, 1920–1922, and 1938–1947. Researchers attributed the differences in leafhopper abundance largely to weather patterns— namely, year-to-year differences in temperature and rainfall. Our studies more recently confirmed the observation that leafhopper populations often fail to develop to economically significant levels, even when no insecticides are applied. In a four-year survey of 20 to 40 untreated vineyards, we found that leafhopper populations exceeded a conservative economic threshold of five nymphs (immature leafhoppers) per leaf in only 2% to 25% of vineyards. Only a relatively small proportion of vineyards required treatment to control leafhopper. The survey led us to investigate how temperature might influence the rate at which leafhopper populations increase.

Temperature influences leafhopper population growth. Leafhoppers, like most insects, are cold-blooded. This means that the rate of most metabolic processes depends on temperature in a predictable way. In particular, the length of time that an insect requires to complete its life cycle— from egg to reproducing adult— depends on how fast a sufficient amount of thermal units, or degree-days, accumulate. For this reason, seasonal timing of population development can vary greatly from year to year. In a hot growing season, development is accelerated, and all events—from egg hatch and growth of leafhopper nymphs to egg-laying—occur earlier in the year and over a shorter period of time. In a cool season, development slows and leafhopper growth and reproduction are delayed. Depending on temperature, timing of developmental events can vary by as much as three to four weeks. Knowledge of how temperature determines leafhopper growth and reproduction can therefore be used to predict when leafhopper populations will develop.

Reproductive diapause influences leafhopper population growth. Eastern grape leafhopper overwinters in the adult stage in a physiological condition known as reproductive diapause. After a certain point in the growing season, leafhoppers that pass from the nymphal stage to the adult stage fail to develop reproductively. They continue to feed, but instead of using the food nutrients to produce eggs, they use them to produce reserves (mostly lipids) that allow them to survive cold temperatures during the winter. These overwintering adults fail to produce eggs until the following growing season.

Our studies have shown that decreasing day length is the most important factor causing the "switch" from reproduction to diapause. Leafhoppers molting to adulthood after 1 August (as days begin to shorten) enter into reproductive diapause and fail to produce a second leafhopper brood. Those that mature before 1 August will continue to lay eggs throughout August and will produce a second leafhopper generation. This has important implications, because each female leafhopper that becomes reproductively active is capable of laying 80 to 100 eggs. Leafhoppers in reproductive diapause represent much less of a threat, because they do not produce eggs until the next season and are also probably subject to heavy mortality over the winter.

Degree-days and reproductive diapause influence the size of the second leafhopper brood. The combination of these two factors—degree-day accumulations and day length—can greatly influence the size of the second leafhopper generation and the amount of late-season injury caused by leafhoppers feeding on grapevines. This is because, while the day-length timing of the "switch" to reproductive diapause occurs at the same date every year, temperature accumulations vary from year to year. In cool years, leafhopper development is delayed and very few first-generation leafhoppers become reproductively mature. In such years, only one leafhopper generation is produced, and the population growth potential is low. In hotter-than-average years, however, most of the first-generation leafhoppers mature before 1 August, and produce a second generation. These hot years are those having greatest potential for severe late-season injury associated with high leafhopper populations.

Degree-day model. We have used knowledge of these factors—degree-day requirements for development and timing of reproductive diapause—to develop a model that allows prediction of the timing of leafhopper population development and the potential for late-season population growth. This model uses cumulative degree-days above a base temperature of 50°F to predict when leafhopper nymphs will appear during the growing season, and the potential for late-season population growth.

The ability of this model to help predict the timing of leafhopper population development is illustrated by data collected in years representing extremes in hot (1991) and cold (1992) growing seasons. Figure 2 (top) shows leafhopper population trends at a vineyard in 1991 and 1992. The 1991 plot shows two peaks, one in late -June and one in mid -August, indicating that there were two distinct leafhopper generations. In contrast, in 1992 there was only one distinct generation, peaking in mid-July, three weeks after the first 1991 peak. Figure 2 (bottom) shows these same data, with cumulative degree-days instead of calendar date. Note that the first generation peaks from both years occurred at the same degree-day accumulations. Closeness of the trends predicted by the model (dashed lines, both figures) to the observed population trends (solid lines) demonstrates that degree-day accumulations are quite accurate if used to predict when leafhopper populations will develop.

Predicted dates for leafhopper population development. Using this degree-day model, we can predict the timing of important population events, under both average climatic conditions and extreme conditions, i.e., both hotter and cooler than average. Table 1 illustrates timing of leafhopper developmental events under average climatic conditions of the past 30 years and under the extremes observed in the hot 1991 season and the cool 1992 season. Note that the timing of leafhopper population development can vary by as much as a month between "hot" and "cool" growing seasons. Note also that few leafhoppers reach adulthood before 1400 degree-days accumulate. This means that more than 1400 degree-days are required by 1 August for eastern grape leafhopper to produce even a partial second generation, because leafhoppers maturing after 1 August enter reproductive diapause. The average date at which 1400 degree-days are accumulated falls on 25 July in western NY, and on 30 July in the Finger Lakes region (Table 1). What this means

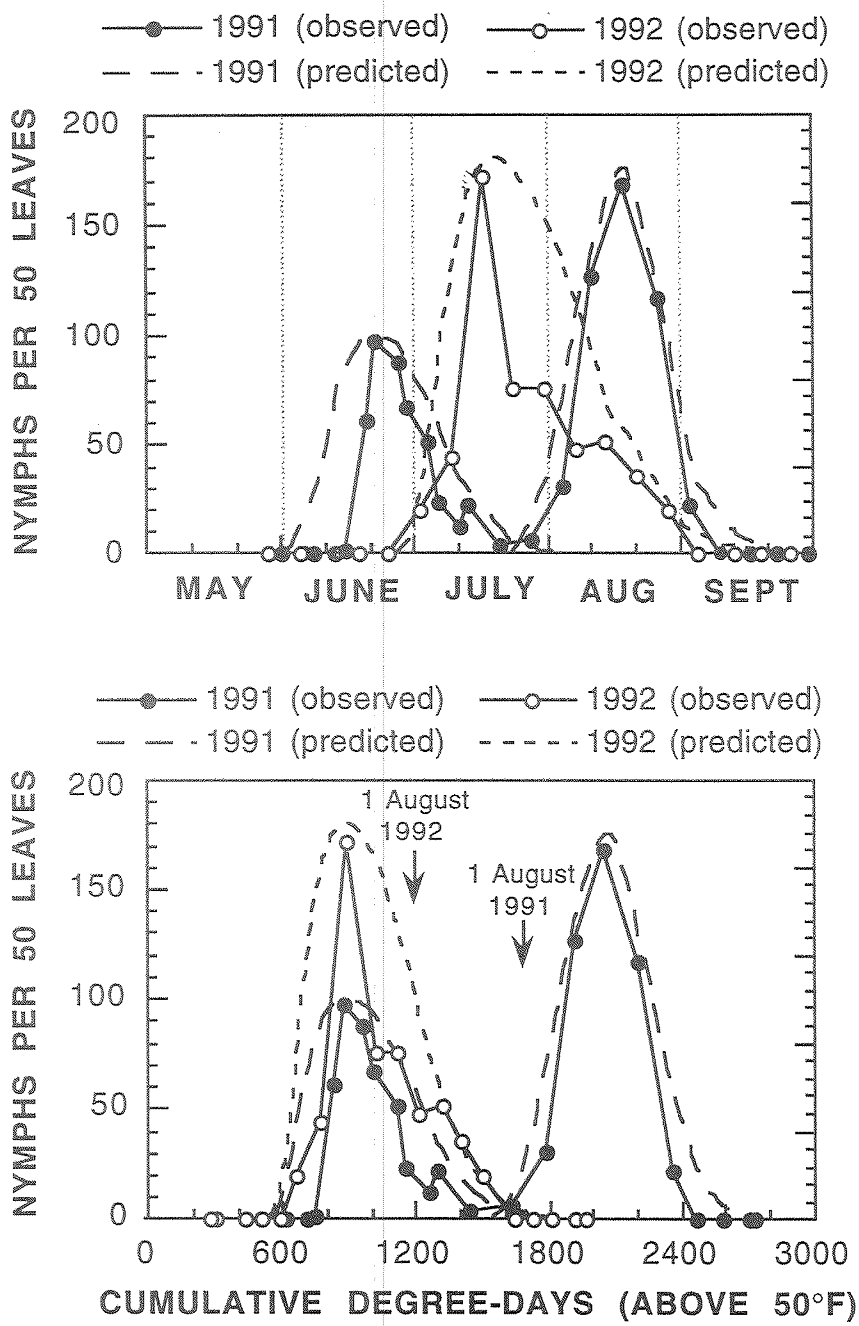

Figure 2. Population trends of eastern grape leafhopper nymphs in 1991 and 1992. Figures show observed population trends in 1991 (solid circles) and 1992 (open circles) and model predictions (dashed lines). Trends are plotted against calendar date (top figure) and cumulative degree-days (bottom figure). Note that population development in 1991 occurred three weeks earlier than in 1992 (top figure) and that two "peaks" were observed in 1991, while one 'peak' was observed in 1992. When plotted against cumulative degree-days (bottom figure) population trends from both years coincide. Observed trends corresponded well with those predicted by the degree-day model.

is that under "average" conditions, only a partial second generation of leafhoppers is produced. When hot temperatures accelerate development, however, a full second generation is produced. At the other extreme, in cooler-than-average years such as 1992, we expect that virtually no second generation will be produced, because the first-brood leafhoppers begin to molt to adulthood after 1 August. Thus, even small shifts in temperature accumulations can greatly influence the size of the second brood and the potential for late-season population growth.

Using degree-day accumulations as indicators of the risk of late-season population growth. Our understanding of how temperature influences leafhopper population growth provides an important tool for assessing the risk of late-season leafhopper outbreaks. We know that more than 1400 degree-days by 1 August are required to produce even a partial second generation. Because most of the variation in degree-day accumulations occurs during May and June, degree-day accumulations by mid-June, or bloom date (also influenced by temperature) can be used as early warning signals to indicate the risk of damaging late-season population explosions.

Table 2 illustrates how degree-days can be used as a risk indicator. In the table the risk of late-season population growth is divided into three categories. The *LOW RISK* category (below 1400 degree-days by 1 August) corresponds to years in which only one leafhopper generation occurs, thus indicating a very low potential for late-season population growth. The *AVERAGE RISK* category (1400–1600 dd by 1 August) corresponds to years in which only a partial second generation is produced, indicating that moderate population growth can be expected during the latter half of the growing season. The *HIGH RISK* category (above 1600 dd by 1 August) represents the rare conditions under which we expect a full second leafhopper generation—and potentially explosive late-season population growth.

In reviewing weather data from both the Lake Erie and Finger Lakes regions, we found that the percentage of years in each risk category was very different for the two regions (Table 2). In both regions, about half of the years fell into the "average" category. However, the Finger Lakes had more cool, "low-risk"

Table 1. Degree-days required for eastern grape leafhopper development and seasonal timing in average, hot, and cool growing seasons.

Region	Developmental event	Accumulated degree-days (Base 50° F)	Calendar Date: Average 1963–1993	Calendar Date: 1991 (Hot)	Calendar Date: 1992 (Cool)
Lake Erie	10% egg hatch	725	22 June	10 June	30 June
	50% egg hatch	950	4 July	21 June	11 July
	Peak 1st-brood nymph population	1175	14 July	2 July	24 July
	10% of 1st-brood adults appear	1400	25 July	13 July	7 Aug.
	50% of 1st-brood adults appear	1600	3 Aug.	21 July	21 Aug.
Finger Lakes	10% egg hatch	725	27 June	12 June	6 July
	50% egg hatch	950	9 July	24 June	19 July
	Peak 1st-brood nymph population	1175	20 July	5 July	3 Aug.
	10% of 1st-brood adults appear	1400	30 July	16 July	19 Aug.
	50% of 1st-brood adults appear	1600	10 August	23 July	31 Aug.

Table 2. Ranges of degree-day (dd) accumulations indicating low (below 1400 dd), normal (1400–1600 dd) and high (above1600 dd) risk of large second-brood leafhopper populations, and the appropriate insecticide treatment.

Risk category (DD accumulations by 1 August) [a]	Percent of adults in diapause	Percent of years in risk category: Finger Lakes	Percent of years in risk category: Lake Erie	Risk indicator: DD by 15 June	Risk indicator: DD by 30 June	Risk indicator: Bloom date	Insecticide treatment
Low (<1400)	>90%	40%	15%	<450	<740	>23 June	Sample if damage seen; no treatment likely.
Average (1400–1600)	50%–90%	50%	55%	450–630	740–910	17 June (Ave.)	Sample if damage seen; apply treatment if needed in early August.
High (>1600)	<50%	10%	30%	>630	>910	<10 June	Apply treatment at 10-day post-bloom.

[a] Based on weather data (base temperature 50°F) from 1963–1993 from Geneva (central NY) and Fredonia (western NY) weather stations.

seasons, while Lake Erie had more hot, or "high-risk," seasons. This suggests that leafhoppers should more often reach damaging population levels in western New York than in central New York vineyards. Our experience with growers' assessment of their pest problems and in assessing leafhopper damage in vineyards over the past four years bears out this observation.

Most of the year-to-year variability in degree-day accumulations occurs in May and June, the early part of the growing season. For this reason, it is possible to predict by mid-to late-June the degree-day accumulations expected by 1 August. Table 2 shows degree-days for 15 and 30 June that correspond to the three risk categories. For example, if there are fewer than 450 degree-days by 15 June, it is very unlikely that more than 1400 degree-days will accumulate by 1 August. However, if by 15 June more than 630 degree-days accumulate, it is very likely that there will be over 1600 degree-days by 1 August, and that a full second brood of leafhoppers will be produced, leading to higher-than-average population growth. Using degree-day accumulations to gauge the likelihood of damaging leafhopper injury is a simple, cost-effective way to assess risk, particularly as on-site weather monitoring equipment becomes available in vineyards.

An alternative to using degree-day calculations is to monitor bloom date. It is a simple and useful indicator, because the timing of vine development is also closely related to variations in temperature accumulations that occur early in the season. Cool temperatures that delay bloom date by one week or more (bloom date after 23 June for Concord) are likely to result in a "low risk" season, while early bloom (before 10 June) is a good indicator of a high-risk situation for late-season population growth.

Application to Management. Our studies over the past several growing seasons have shown that during seasons with average degree-day accumulations, only about 10% of Concord vineyards will require treatment for leafhoppers. In many vineyards, leafhopper populations remain at relatively low densities, and stippling injury to leaves is minimal. In part, this is because, under normal conditions, leafhoppers complete only one full generation and a partial second generation. Only in warmer-than-average seasons do leafhoppers have a high potential for explosive population growth. Other factors, such as natural enemies (parasites and predators), also have the potential to further reduce population growth. One naturally-occurring egg parasite, *Anagrus epos*, has been observed to parasitize up to 85% of grape leafhopper eggs in area vineyards.

To avoid unnecessary insecticide applications, it is often best to delay treatment for leafhoppers until after a mid-season assessment of leafhoppers is done, rather than to make an early (10-day post-bloom) insecticide application. However, in warm or dry years, in which leafhopper injury is more damaging to grapes, an early-season application may be the best strategy for preventing leafhopper injury and possible yield reduction. By using temperature accumulations as a tool for assessing the risk of late-season population growth, growers can safely gauge the need for early-season treatments and safely postpone applications until August or avoid them entirely in low-risk or average-risk years. The low temperatures of this spring were followed by a hot dry early-June.

FROM THE EDITOR

Martin Goffinet

Budget discussions in Albany include the annual allocation earmarked for the New York Wine and Grape Foundation to fund its programs and to assist in funding a significant part of Cornell University's grape-related research with matching State dollars. This means, of course, that much research in these areas relies on grant money generated by the grape industry and its supporters, such as the New York State Grape Production Research Fund, the Lake Erie Regional Grape Program Fund, and the John Dyson Fund. These dollars provide for research in grape breeding, culture and management, pest and disease control, and juice and wine quality at Cornell, New York State's land-grant university. Recently, Penn State, the land-grant university of Pennsylvania, has also been contributing research efforts on Lake Erie grape problems that are shared by New York growers and processors, and one grant to Penn State is supported by some of these dollars. Such funding is critical to the research needed to keep our grape and wine industry competitive. The actual amount available to researchers will vary each year, depending on Albany allocations and dollars put up for match by supporters.

The New York State government has supported the Foundation each year. Albany has again decided to fully fund the Foundation this fiscal year, even in these times of decreasing bugets. About 30% of the Foundation's budget goes for research, mostly through matching funds generated by the grape industry, with only a small proportion generated by the wine industry. Even so, in the new strategic plan for the Cornell Institute of Food Science, the enology reseach and extension program figures prominately as a "Specialized Program Area." The plan is to lend support and to direct the effort of both Geneva and Ithaca Food Science faculty into reaching goals and strategies appropriate to the enology program. The State also funds an area called Wine and Health that allows for some research in that area. However, Dr. James Hunter, Director of the Agricultural Experiment Station in Geneva, has pointed out that most State money for research comes to the experiment stations at Ithaca and Geneva as part of the SUNY budget. SUNY likely will have taken a significant cut in its State funding by the time you read this, with any shortfalls passed on to the member SUNY campuses, including the agricultural experiment stations. As State cuts continue year after year, it is clear that "business as usual" for university-based grape and wine research means that researchers will have to rely more and more on funding support from the very industry they must serve.

The table below summarizes grape research projects that are supported by matching funds from the New York Wine and Grape Foundation for 1995–96. The Wine Analytical Laboratory, Department of Food Science and Technology, at the New York State Agricultural Experiment Station in Geneva, is also subsidized by the Foundation to minimize costs to wineries submitting samples for analysis. And, of course, "Grape Research News" is funded by Foundation dollars to keep you apprised of current grape research that benefits our industry.

Grape-related research projects funded for 1995–96 by the New York Wine and Grape Foundation through matching money contributed by the grape industry.

Researcher	Department/Organization	Project
Thomas Burr	Plant Pathology, Geneva	Cultural and biological management stategies for crown gall
Richard Derksen	Agricultural & Biological Engineering, Ithaca	Vineyard spray application systems
Gregory English-Loeb	Entomology, Geneva	Biological and chemical control for leafhopper; Evaluating impact of banded grape bug cluster feeding
David Gadoury	Plant Pathology, Geneva	Developing a practical model for management of powdery mildew
James Kamas	Lake Erie Grape Program, Fredonia, NY	Grapevine nutrition results and demonstrations
Alan Lakso	Horticultural Sciences, Geneva	Supplemental irrigation-pruning interactions on vine performance and economic feasibility in NY vineyards
		Understanding the basis of differences in productivity of minimal- vs. conventional-pruned Concord vines
Robert Pool	Horticultural Sciences, Geneva	Increasing Concord production efficiency via canopy spacing and mechanization of production systems
		Testing vinifera clones and varieties and their suitable rootstocks for commercial production in New York
Barry Shaffer	Lake Erie Grape Program, Fredonia, NY	Use of planting tubes in vineyard establishment
James Tavis & David Truxall	Plant Pathology, Penn State	Secondary inoculum and risk associated with black rot
Wayne Wilcox & Dennis Gonsalves	Plant Pathology, Geneva	Studies on possible viral or MLO cause of millerandage (shot berries) in Lake Erie and Finger Lakes regions
Wayne Wilcox & Harvey Hoch	Plant Pathology, Geneva	Epidemiology, biology and control of black rot
Wayne Wilcox, Robert Seem & David Gadoury	Plant Pathology, Geneva	Effective and sustainable use of sterol-inhibitor fungicides for control of powdery mildew; resistance management and factors affecting performance
Alice Wise	Long Island Horticultural Research Institute, Riverhead	Evaluating vinifera clones and varieties by fruit analysis and small-lot winemaking

The Fruit Testing Association Nursery Closes

The Fruit Testing Association Nursery, housed for decades at the NYS Agricultual Experiment Station at Geneva, NY, closed its nursery operation this spring. The Association will continue to advise fruit breeders and work with the experiment station to help publicize progress in the development of new fruit varieties. The changes in the Association come about primarily for financial reasons; propagation and distribution of large numbers of varieties of many different fruits, in very small quantities, was an expensive and complex task. The grape breeding program will be looking to make arrangements with commercial nurseries for the limited distribution of promising numbered selections. However, at present, no arrangements have been made and there will be no vines available for distribution in spring 1996. We appreciate the interest of the industry in our most promising materials. Some of our top wine grapes have been planted with a few cooperating growers and wineries in the Finger Lakes. Most of these trials are just reaching bearing age, and we hope our cooperators will help us to select the very best types for naming and general release. In future issues of "Grape Research News," watch for further updates on the availability of wine and table grape breeding program selections.

N.J. Shaulis Viticulture Scholar Named

John H. Brahm, chair of the Nelson J. Shaulis Fund for the Advancement of Viticulture, announced that the 1995 N.J. Shaulis summer scholarship has been awarded to Ms. **Danielle Bernard** of Fredonia, New York. Ms. Bernard comes from a grape farming family and has just completed a degree in biology from Fredonia State University. Over the summer she will be working under the joint guidance of Doctors Greg English-Loeb and Bob Pool at the Vineyard Laboratory. Her research project is to investigate the biology of the banded grape bug and its impact on grape vine and fruit development. In addition to conducting a research project, Shaulis scholars gain work experience with Cornell's grape research and extension staff. Bernard has expressed an interest in continuing her studies in graduate school, possibly in the area of entomology.

Dr. Robert Pool Receives Award

Dr. Robert Pool, Professor of Viticulture in Cornell University's Department of Horticultural Sciences, New York State Agricultural Experiment Station, in Geneva, received the "Research Award" from the New York Wine and Grape Foundation, at its annual meeting this past March. Pool was cited for his distinguished contributions to New York's wine and grape industry. He has served the industry through his research efforts in vine management and physiology. He represents the U.S.A. in the viticulture section of the national delegation of BATF to the Office International de la Vigne et du Vin (OIV). He serves on many other state, national and international committees related to grape germplasm, viticulture, and wines.

Cornell Enology Student Wins Awards

Aurea Carrasco, a Cornell graduate student in the enology program at the New York State Agricultural Experiment Station, Geneva, has been awarded the American Society for Enology and Viticulture Scholarship for 1995–96. Currently she also holds a scholarship from the Instituto Nacional de Investigaciones Agrarias of Spain in collaboration with USDA.

Grape Publications Recently Available

The following publications are available from Beverly Dunham, Bulletin Room, Jordan Hall, NY S Agricultural Experiment Station, Geneva, NY 14456. Contact the Bulletin Room for current prices and to get a full list of available publications . Phone: 315-787-2249 (mornings).

Proceedings of the Second N.J. Shaulis Viticulture Symposium: Pruning Mechanization and Crop Control: (Supplies very low)
Proceedings of the Third N.J. Shaulis Viticulture Symposium: Organic Grape and Wine Production.

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Question:

Gratitude is expressed to those organizations whose support makes possible ongoing and valuable research activities for the benefit of the State's grape industry. Major funding is provided by the
New York State Wine & Grape Foundation; the Grape Production Research Fund, Inc.; and the J.M. Kaplan Vineyard Research Program.

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Got A Question? We are trying to address the many questions from grape growers and processors that come to Cornell's grape research community. We invite you to write to us at *Grape Research News* to bring to our attention any questions you have about grapes. We will see to it that those questions are answered by someone knowledgeable in the area of your concern.
Save yourself a long distance phone call. Put it in writing on the back of form below, cut it out, and send it to us.

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